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Proceedings of the

XI SCALOP Symposium

"Towards the International Polar Year and Beyond"

28 July 2004
Bremen, Germany

Proceedings of the

XI SCALOP Symposium

28 July 2004

Congress Centre, Bremen, Germany

Foreword

The XI SCALOP Symposium was held in conjunction with the COMNAP XVI and XXVIII SCAR meetings in Bremen on 28 July 2004.

SCALOP Symposia are held every second year when the COMNAP/SCALOP annual meeting is held in conjunction with SCAR meeting. These joint meetings enable national program managers and logistic operators to interact with the international science community and jointly consider logistics, operational and technical implications of major international projects.

The XI SCALOP Symposium was convened under the theme "Toward International Polar Year and beyond!" The International Polar Year in 2007/2008 is a great effort for national operators to make available "State of the Art" polar research platforms and advanced technologies for science and to perform operations in accordance with the regulations of the Environmental Protocol.

The XI SCALOP Symposium consisted of several elements. The National Display showed current logistic activities as well as mobile and stationary platforms run in Antarctica by national programs. Altogether 17 national operators displayed posters.

The Senator for Economics of the government of Bremen opened the Industrial Exhibition on 26 July 2004, and it was closed on 28 July 2004. The exhibition was organised under the topic "Engineering and Technology meet Antarctic Science and Operations". Altogether 45 commercial companies as well as national and international research agencies and institutions from 11 countries offered their latest and proven techniques, instrumentation, applications from space technology, support services such as shipping companies and aircraft operators, equipment, clothing, food etc.

For the first time in the history of SCALOP Symposia polar research aircraft were displayed at the conference from 26 to 29 July 2004. The new CASA 212 aircraft operated by Australian Antarctic Division (AAD) and both Dornier 228-101 aircraft operated by AWI were presented together with an exhibition of scientific instrumentation at Bremerhaven airport. One LC 130 aircraft of the 109th Airlift Wing, Stratton Air National Guard Base, US visited the airport Bremen to meet conference participants on 28 and 29 July 2004. The display of these aircraft was highly recognised by the conference participants. About 150 visitors at Bremerhaven airport and about 80 visitors at Bremen airport were recorded. This new element of the exhibition provided practical contacts between aircraft operators, commercial companies for scientific instrumentation and the scientific community at the COMNAP/SCAR meetings. All participants could directly get some practical insight into the potential of intercontinental and intra-continental aircraft operations for research and logistics in the Antarctic.

The Symposium sessions addressed the following topics:

- Latest development in energy storage and energy management.
- Technologies to enable science.
- Technologies to reduce environmental impact.

As alternative energy and energy management are crucial for running stationary platforms the SYMP working group requested support from EXCOM to invite keynote speakers. The Symposium Steering Committee invited Prof Detlef Stolten, Director of the Institute for Materials and Processes in Energy Systems of the Research Centre Jülich – Helmholtz Community (Germany), and Prof Pat Bodger, Director of the Electric Power Engineering Centre Christchurch (New Zealand).

Altogether 61 contributions have been submitted. The SCALOP Symposium Steering Committee reviewed all submitted papers, and 10 talks and 49 posters were selected. Unfortunately there were last minute cancellations for two oral presentations.

The first session covered the two invited presentations followed by 3 sessions for oral presentations. Finally the poster session was held in conjunction with the Industrial Exhibition next to the Industrial Exhibition.

Acknowledgement is given to the Symposium Steering Committee and EXCOM for advice and assistance to prepare the XI SCALOP Symposium. Likewise appreciation and gratitude is to Dr Saad El Naggar who did a great job to get organised both the Symposium sessions and the Industrial Exhibition.

Acknowledgement is also given to Kim Pitt from the AAD (Australia), to Eric Chiang from the NSF (United States), to Heinz Finkenzeller from DLR and Oliver Zielinski from Optimare GmbH (Germany) for arrange of the polar aircraft to be available.

Hartwig Gernandt
Head of Logistic Division
Alfred Wegener Institute for
Polar and Marine Research

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Opening Address

Hartwig Gernandt

Head of Logistic Division
Alfred Wegener Institute for Polar and Marine Research

Good morning Ladies and Gentlemen,

On behalf of SCALOP and the Symposium Steering Committee I welcome all of you to the XI SCALOP Symposium.

SCALOP – the Standing Committee on Antarctic Logistics and Operations – was established when COMNAP was formed as the body of national operators in 1988. SCALOP is tasked to provide COMNAP with advice on all elements of logistics and operations in Antarctica.

In 1988 SCALOP replaced the former SCAR Working Group on Logistics, which was formed in 1962, which was when the international co-operation began under the umbrella of the Antarctic Treaty System. In my perception this working group was the first international organisation to address the exchange of operational experience and to co-ordinate support and assistance between national expeditions in Antarctica.

Personally I first joined a meeting of the SCAR Working Group during the XVIII SCAR meeting held in Leningrad in 1982. Now, 22 years later, I have the great honour to open the XI SCALOP Symposium.

SCALOP Symposia are held every second year when the COMNAP/SCALOP annual meeting takes place in conjunction with the SCAR meeting. These joint meetings enable managers and logistic operators of national programs to interact with the international science community and jointly consider logistic, operational and technical implications of major international projects.

We have convened the XI SCALOP Symposium under the theme "Toward International Polar Year and beyond!". The International Polar Year in 2007/2008 is a great challenge for polar researchers from all over the world. It is also a great effort for national operators to make available "State of the Art" polar research platforms and advanced technologies for science and to perform operations in accordance with the regulations of the Environmental Protocol.

The XI SCALOP Symposium consists of several elements. The National Display shows the current logistic activities as well as mobile and stationary platforms run in Antarctica by national programs. Altogether 17 national operators are displaying their posters. The theme of the Industrial Exhibition, which opened on Monday, is "Engineering and Technology meet Antarctic Science and Operations". Altogether 45 commercial companies, as well as national and international research agencies and institutions, offer their latest and proven techniques, instrumentation, applications from space technology, support services such as shipping companies and aircraft operators, equipment, clothing, food etc.

For the first time in the history of SCALOP Symposia polar research aircraft are being displayed at the airports in Bremerhaven and Bremen during the conference. Since Monday about 80 visitors have already been at Bremerhaven airport. Today one LC 130 Hercules aircraft of the 109th Airlift Wing, Stratton Air National Guard Base, US landed at airport Bremen to meet conference participants on 28 and 29 July 2004. Wing Commander Colonel Max H Dellapia and his crew are ready to present the outstanding Herc to conference participants until Thursday. I consider the display of aircraft operated in the Antarctic as a very special highlight of this conference. My highest acknowledgement is to Kim Pitt from the AAD (Australia), to Eric Chiang from the NSF (United States), to Heinz Finkenzeller from DLR and to Oliver Zielinski from Optimare GmbH (Germany) to get this exciting event arranged for all of us. I like this new element of our exhibition very much, because we have never had such practical contacts between aircraft operators, commercial companies for scientific instrumentation and the scientific community at the COMNAP/SCAR meetings. All participants can directly get some practical insight into the potential of intercontinental and intra-continental aircraft operations for research and logistics in the Antarctic.

The following topics are addressed to the symposium sessions:

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The first session will cover the two invited presentations followed by 3 sessions for oral presentations. Finally we will have the poster session next to the Industrial Exhibition.

According to the tradition of SCALOP Symposia the Alfred Wegener Stiftung will publish all presentations in a special issue of the journal "Terra Nostra".

I would like to thank the Symposium Steering Committee and EXCOM for advice and assistance to prepare the XI SCALOP Symposium. Likewise my great appreciation and gratitude goes to Dr Saad El Naggar who made a great job to organise both the Symposium sessions and the Industrial Exhibition.

Ladies and Gentlemen,

I wish all of us successful sessions giving helpful results in order to meet the scientific and logistic challenges of the IPY and beyond.

Thank you for your attention.

Fuel Cell Technology for Sensitive Environmental Areas

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Abstract

The main advantages of fuel cells, high efficiency, quiet and continuous operation, low vibration and minimum emissions make them a very interesting technology also and especially for applications in sensitive environmental areas such as the Antarctic.

A feasibility study was carried out to conceder the application of different fuels and fuel cell types for the planned Neumayer III station.

The concepts include a wind power system to support the main part of the energy consumption of the station. In periods of overproduction the remaining electrical power will be used for hydrogen production by an electrolyser. In the case of low wind availability the stored hydrogen will be used by a PEM fuel cell. For emergency diesel generators provide the essential power.

The study demonstrates the ecological benefits, the economical disadvantages and the technical challenges of fuel cell systems for this application.

Introduction

The Alfred Wegener Institute is planning a new building of the Neumayer station in the Antarctic. The plants and processes used so far are checked in terms of technical improvements.

Actually several diesel generators and a small wind-power turbine guarantee the power supply. Their waste heat is used for heating, generating hot water and melting snow. However, this power supply has disadvantages in many respects. Combustion engines have a bad efficiency at part-load and produce emissions harmful to the environment.

Concerning this power supply environment-friendly systems are to be applied in the sensitive ecological area. By minimizing emissions the interference with scientific measurements will be reduced too. It is possible to realize these options using a fuel cell system and gaining high efficiency, quiet operation and low vibration as further advantages of the fuel cell. As a result to increased efficiency fuel cost for the power conversion system are reduced.

The main objective of the feasibility study was to assess if a fuel cell system could be used as a reliable power supply at the planned Neumayer III station under considering safety, high redundancy, low emission and reduced fuel consumption.

The parameters for the new station provided by the AWI were the basis of the investigation. Thereby both, the ambient conditions and transportation limitations had to be considered. The increased demand of energy in the new station should be compensated partly by the increased adoption of wind energy. Besides the current fuel, i.e. Arctic Diesel, alternative fuels were investigated and appropriate concepts developed.

The following data are the first basis for the further investigations:

El. peak power demand:	140 kW
Average el. power consumption:	75 kW
Average thermal power consumption:	60 kW
Max. power of the wind turbine:	60 kW (3 x 20 kW)

Fuel cell types

During the last years significant progress has been achieved and a large number of systems and field tests demonstrated the high potential of fuel cells. There are two main types of developed fuel cells:

The low-temperature Proton Exchange Membrane Fuel Cells (PEMFC) are under development mainly for automotive systems but also for portable and domestic power supply. The PEMFC (see Figure 1) operates with hydrogen or hydrogen rich gases, which have to be stored or produced directly on-site by a separate reformer. Various storage methods for pure hydrogen such as compressed or liquid storage are available. Others like metal hydrides and nanofibres are under development.

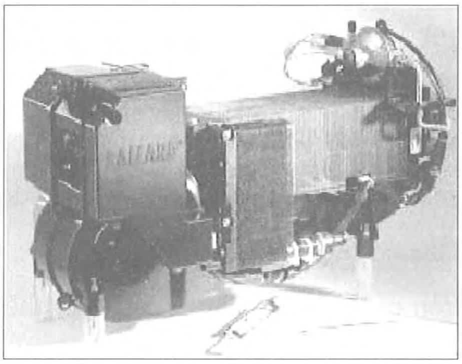

Figure 1: NEXA^{TM}-Module, a PEM Fuel Cell (source: Ballard

High-temperature fuel cells on the other hand provide the possibility to use hydrocarbon fuels directly. The HotModule® (see Figure 2), a Molten Carbonate Fuel Cell (MCFC) is fuelled with natural gas. This fuel cell type is used mostly for stationary applications. If higher hydrocarbons such as diesel are used as fuel for the MCFC, a fuel conditioning system will be required comprising a vaporiser, desulphurisation and possibly a pre-reformer unit.

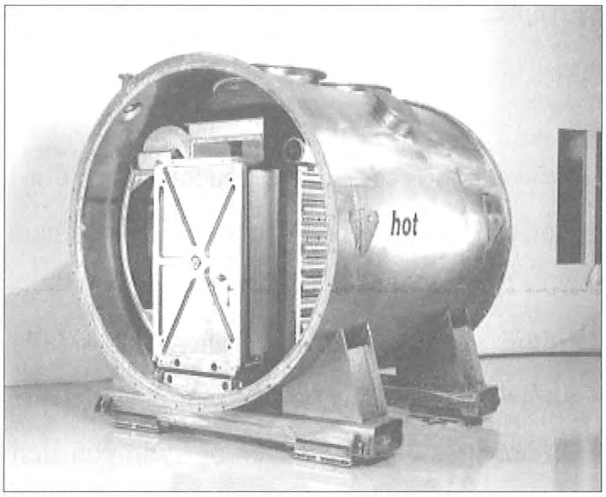

Figure 2: HotModule®, a Molten Carbonate Fuel Cell (source: MTU CFC Solutions)

The capability of the MCFC to produce hydrogen from hydrocarbons may be used as a fuel processing system for the PEM fuel cell. Thus, the MCFC works as an electricity-producing reformer for the PEMFC. The combination of MCFC and PEMFC, the so called CoCell® shows a potential for electrical efficiency beyond 55 %. By using the high-grade heat from the MCFC and the low-grade heat from the PEM fuel cell the overall fuel utilization will be over 75 %.

Concept 1: Operation with Arctic Diesel

On the basis of the existing fuel infrastructure investigations using Arctic Diesel for fuel cells were performed. A high specific energy density is the outstanding advantage of diesel compared to gaseous fuels and other lighter hydrocarbons. Therefore, the logistic costs would be minimized. But diesel contains more or less sulphur (e.g. Arctic Diesel: 0,1 %wt), which has to be reduced as low as possible to prevent damages to the fuel cells.Figure 3 shows the layout of Concept 1. The power supply will be provided by several energy converters including a combined MC-PEM fuel cell system.

The MCFC covers the basic load. Load variations will be balanced by the PEMFC. For the fuel cells the Arctic Diesel has to be prepared by a pre-reformer and a desulphurisation unit. The wind power device provides the energy to the bus bar as well. Remaining energy will be used to feed an electrolyser to produce hydrogen. This will be stored in pressure vessels and used to run the PEM fuel cell independently. In exceptional circumstances a diesel generator is able to provide the whole energy demand.

The thermal power supply will be covered by the high temperature waste heat of the MCFC and the low temperature waste heat of the PEM fuel cell. For emergency the diesel engine can provide the necessary thermal power.

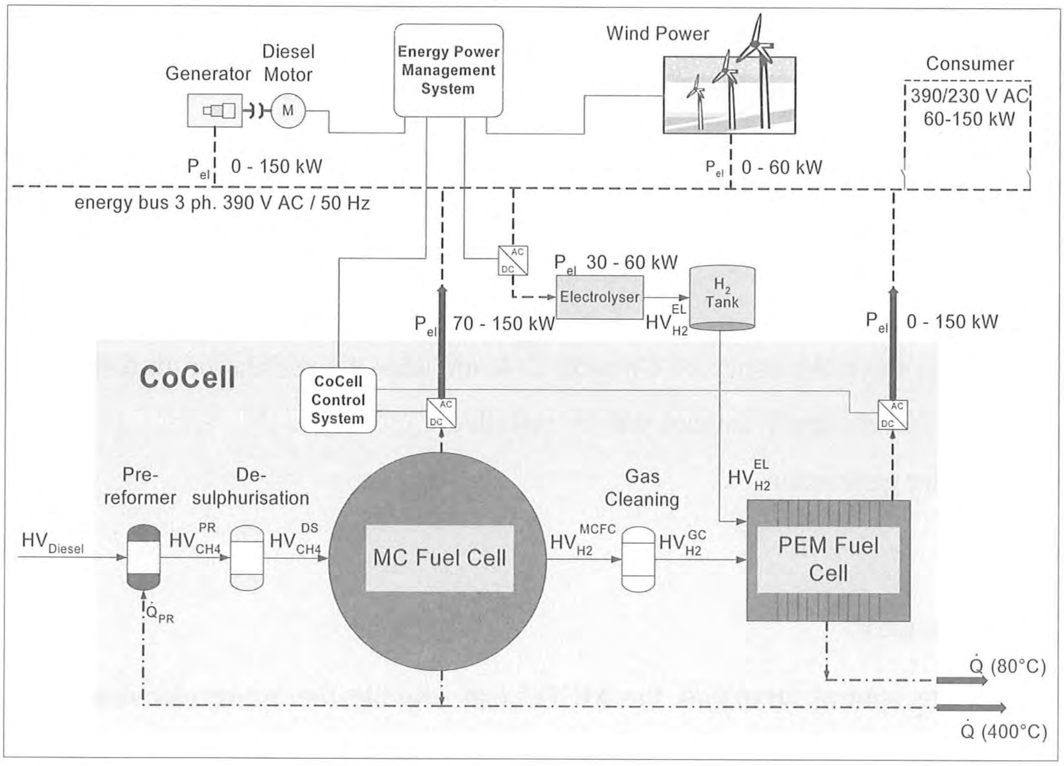

Figure 3: Layout of Concept 1 including a combined fuel cell system

An Electric Power Management System (EPMS) regulates the entire plant. With this concept four redundant energy converters with different combinations guarantee the power supply. The plant modules are integrated in insulated containers.

Advanced investigations on the feasibility of this concept under the basic conditions showed that a realization of the CoCell® technology within the given time frame at the end of 2006 is not possible. Within this period reliable diesel reformers and desulphurisation equipment will not be available.

Another item is the durability of the fuel cells. The HotModule®, developed for stationary energy supply is able to achieve a lifetime of about 40,000 hours. On the other hand, in the automobile sector the developments of PEM fuel cell technology are aligned to a lifetime of about 5,000 hours, which is enough for the product life of a car. For a continuously operating application like the plant devices for the power supply of the Neumayer station, it is a need to obtain higher lifetime levels.

Concept 2: Operation with Methanol

To evade the problem that there is no commercial diesel reformer available in the second concept the fuel cell system will run with methanol.

The advantages of methanol are that on the one hand it contains no sulphur and on the other hand it can be used more or less directly for fuel cells. Thus separate reformer and desulphurisation are not required. Contrary to hydrogen it is liquid and possesses a higher power density. Admittedly it is highly inflammable and poisonous, but water soluble and biodegradable. Burning methanol can be extinguished with water. The risk of handling methanol can be minimized by adequate operation in such a way as to use methanol similar to diesel.

Figure 4 shows the redundancy of Concept 2. It includes the realisation in different steps. In Phase 1 three power supply devices will be installed:

- Wind power generation
- MCFC
- Diesel generator

By appropriate control strategies the MCFC can provide the entire electrical and thermal power demand. The wind energy contributes to the basic demand. The diesel generator will guarantee the emergency supply.

In a second step PEM fuel cells will be installed providing the opportunity to integrate advanced fuel cells with high durability. They will be fuelled by hydrogen delivered by an electrolyser and temporary stored in pressure tanks. The electrolyser will convert surplus electrical energy from the wind power generation.

As an optional third step with supplementary equipment it is possible to combine both fuel cell types into a CoCell® system. Thus, the efficiency of the fuel cell system will increase and it is possible to run the PEM fuel cell with on-site generated hydrogen.

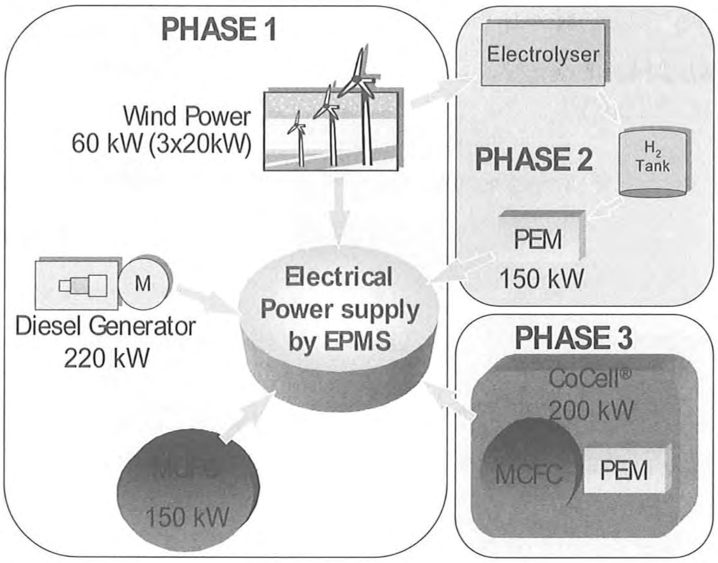

Figure 4: Phases of realisation for Concept 2

Further investigations showed that due to the lower power density of methanol in comparison to diesel the logistics expenses increased significantly. In addition, two fuel infrastructures have to be built up, because the vehicles used in the station will still run with conventional diesel. Therefore, from an economic point of view this concept is not beneficial.

Concept 3: Operation with Hydrogen

As a result of the previous investigations the basic parameters had to be changed. To increase the zero-emission generation of energy and both, to minimize the fuel costs and the costs for its transport, the portion of wind energy had to be raised. The increased electrical energy production will be used generating hydrogen on stock. Figure 5 shows the energy supply of the revised Concept 3.

The following data are the basis for the further remarks:

El. peak power demand: 140 kW

Average el. power consumption: 75 kW

Min. el. power consumption (at night): 60 kW

Average thermal power consumption: 60 kW

Max. power of the wind generator: 120 kW (6 x 20 kW)

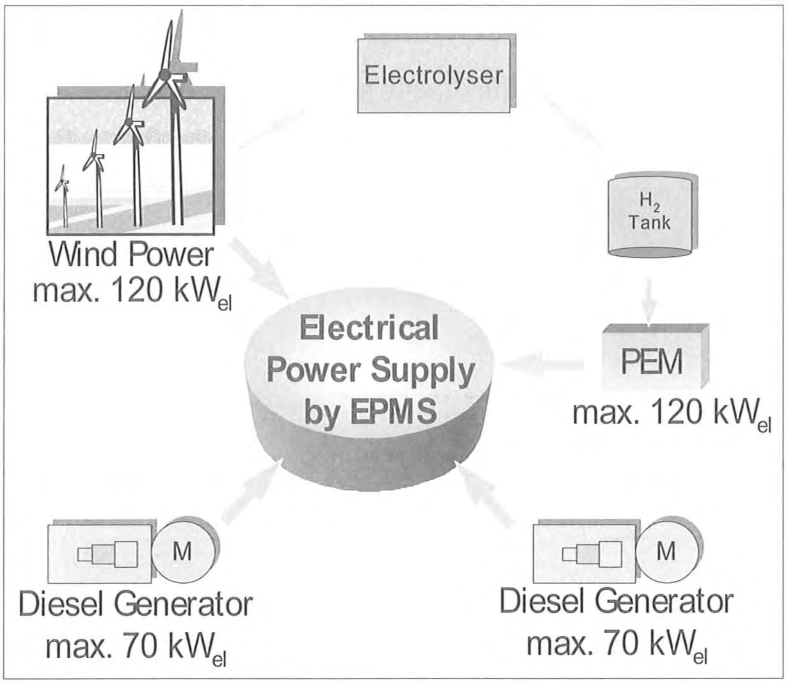

Figure 5: Electrical power supply of Neumayer III (Concept 3)

The main electrical energy demand will be supplied by the wind power generation. One diesel engine runs continuously to balance the load variations and additionally provide the main heat demand. In addition installed electrical heaters compensate high thermal supply during phases of low electrical demand. This offers a supplementary load management. Figure 6 shows the different options for the thermal energy supply.

Remaining energy - especially at night - will be used to feed an electrolyser to produce hydrogen. With a consumption of about 5 kWh per produced standard cubic meter (scm) of hydrogen an electrolyser is able to generate about 70 scm hydrogen per day. This depends highly on the wind availability. The Electric Power Management System (EPMS) controls the electrolyser according to the remaining power.

In case of low or no wind the PEMFC will provide the supplementary electrical power to the grid. The period of supply depends on the storage volume. For the calculation of the needed hydrogen storage volume it was assumed that the PEM fuel cell can provide the whole electrical demand for 10 days. This results in a hydrogen storage volume of about 12,000 scm.

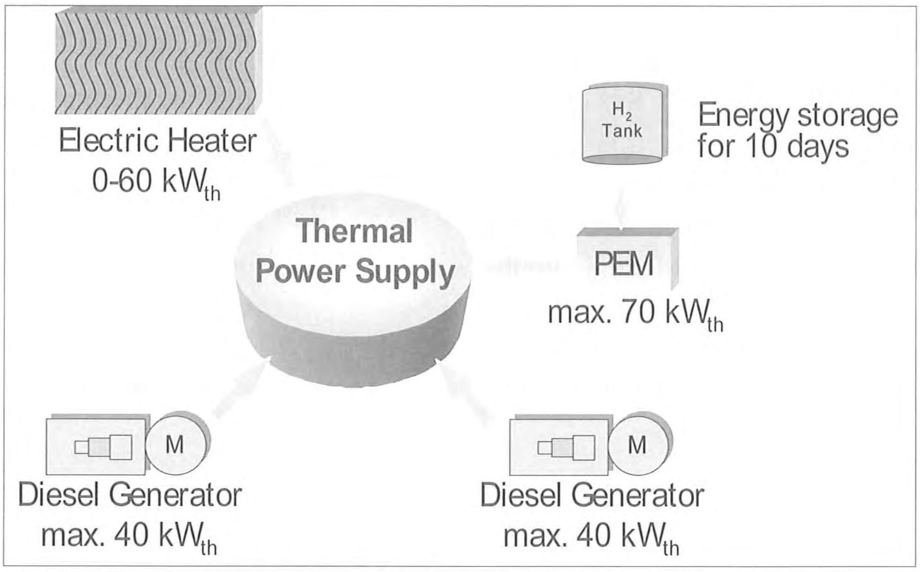

Figure 6: Thermal power supply of Neumayer III

For the storage various options were investigated. To store hydrogen as a liquid implicates a high energy consumption for the liquefaction (about 30% of the energy content of hydrogen) and therefore it was not short-listed. Because of the transport limitations of max. 10 tons per unit (size: 20-ft container) most of the options are not feasible. Table 1 shows a table with the extant possibilities containing various pressure vessels.

pressure	50 bar	200 bar	300 bar	350 bar
number of vessels	17 pcs pressure vessel	30 pcs 10 m -tubes	20 pcs 11 m -tubes	200 pcs light tank 4 x 20'-container
overall weight	170 t	72 t	74 t	17 t
transport volume	650 m³	220 m³	150 m³	150 m³
needed area	250 m²	88 m²	92 m²	75 m²
costs for storage (and container)	1.0 Mill. EUR	1.3 Mill. EUR	1.1 Mill. EUR	3.9 Mill. EUR

Table 1: Characteristics of various storage vessels

According to the different items a 300 bar pressure system will be the most suitable solution. Independent of the selected storage concept the electrolyser needs about 170 days to fill up the complete volume of the vessels.

The maximum power of the PEM fuel cell is designed to substitute the wind power generation. Running on this maximum level the fuel cell can produce up to 85 kW thermal power (80 °C) additionally. In this case it is possible to substitute the thermal power supply of the diesel engine for a short period.
Only a few companies are able to supply well tested PEM fuel cell systems. Table 2 shows fuel cell systems of three potential suppliers including the fuel cell's lifetime and the costs. Both items shows big differences.

Supplier	A	B	C
Power of the PEMFC-stack	2 x 64 kW	5 x 25 kW	120 kW
Efficiency	approx. 45 %	approx. 52 %	approx. 58 %
Lifetime (status 2003)	2,000 hours	4,000 hours	7,000 hours
Costs (2003)	1.7 Mill. EUR	3.2 Mill. EUR	3.0 Mill. EUR

Table 2: Comparison of different PEM fuel cell systems

Because of the limited generation of hydrogen from the remaining energy of the wind power supply, the PEM fuel cells will only run during low or no wind phases. With the available hydrogen the fuel cells can operate about 500 hours per year. Thus, according to the specification of the different suppliers, the PEMFC-system will run at least 4 - 14 years. In addition, further developments on fuel cells will also result in an increased lifetime.
In exceptional circumstances or during maintenance of the other systems the second diesel generator is started. It is able to provide the whole energy demand together with the continuously running diesel generator.
For the whole power supply system, without the wind power supply, four 20-ft containers are required plus the vessels for hydrogen storage.
According to the different suppliers of the fuel cells the total budget of the power supply system without the wind power generation will be between 4.0 and 5.5 Mill. EUR (status 2003). This includes the whole equipment, the hydrogen storage vessels and the container for installation of the equipment. It comprises factory mounting and set up for tests and qualification.

Ecological Aspects

Implicating the fuel cell system, investigated in Concept 3, less fuel will be consumed and less emissions harmful to the environment will be produced.

The reduction highly depends on the wind availability. Operating a 20 kW wind power device at the Neumayer II station there is a actual reduction of fuel consumption of about 10,000 l diesel per year. The increased wind power supply of Concept 3 will generate remain energy, especially at night, which is not useable if not stored as generated hydrogen. By the application of a fuel cell system using this remain energy the annual fuel consumption will be reduced between 5,000 … 10,000 l diesel. The operation of a 120 kW wind power device will result in a reduction of fuel consumption between 30,000 … 50,000 l diesel per year.

Figure 7 show the corresponding minimum and maximum absolute reduction of emissions by running the fuel cell system using the remaining energy of the wind power supply instead of operating a diesel engine. According to the decreased fuel consumption the reduction of emissions will be between 2.5 ... 5 % of the total energy demand by running the fuel cell system. The reduction of emissions by operating the wind power device will be about 15 … 25 % of the total energy demand.

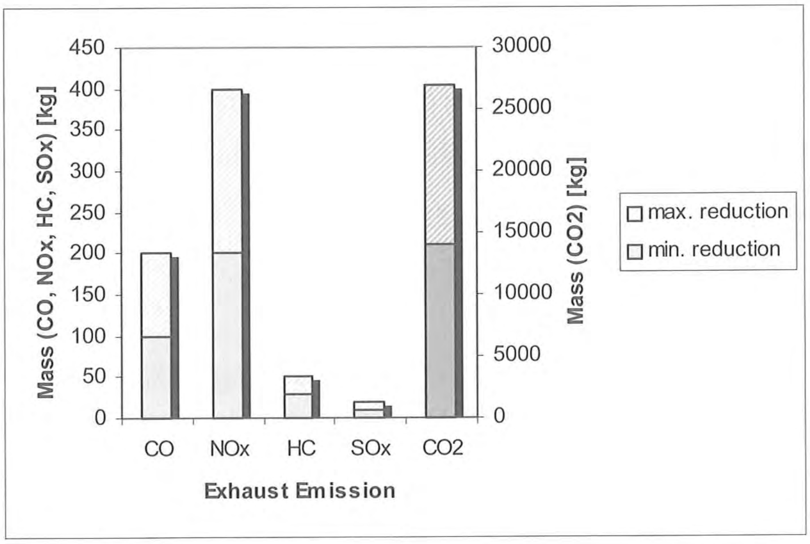

Figure 7: Estimated absolute reduction of emissions by the power supply using a fuel cell system instead of operating a diesel engine

Conclusions

For the realization of a new power supply concept for an Antarctic station like the Neumayer III various important items beside costs and durability have to be considered:

- Reliability of the equipment

- Redundancy of the system
- Transport limitations and ambient conditions

Regarding these issues it is not possible to use Arctic Diesel as fuel for fuel cell systems at the moment, because there is no reliable and commercially available reformer. The use of methanol is not economical due to the high logistics expenses and the need for two fuel infrastructures.

By increased use of wind power generation it is possible to supply most of the daily power demand of the new station Neumayer III. Converted in hydrogen the excess energy can be stored and converted into electrical power by fuel cells during the time of low wind availability. For higher redundancy and emergency the system includes small diesel engines.

Until now the achievable lifetime of PEM fuel cells is too short to realize a continuously running system for this stationary application, but these fuel cells are able to complement the wind power supply for emission-free power generation in a sensitive environmental area like the Antarctic.

From the ecological point of view the fuel cell technology will be the best solution in the future to provide energy independent of the wind availability. The feasibility study shows that a reliable fuel cell system is not yet proven and at the moment not economical. As a first step a combination of wind generators and diesel generators will be the best economical and ecological solution. Sophisticated fuel cell systems are able to substitute the diesel generators in the future by a modular designed energy supply.

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The Application of Unmanned Aerial Vehicles in Antarctica

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1. Introduction

Manned aircraft have been used in Antarctica since the 1960's to enable photographic, scientific and aerial survey missions to be flown. The cost of operating a manned aircraft is significant and there are operating restrictions because of environmental conditions, payload and pilot hours. Unmanned aerial vehicles (UAV) offer the potential to fly missions for extended periods and during the Antarctic winter. If survey equipment is matched to the capability of the UAV platform, there is the possibility of reducing operating costs when compared to manned aircraft. In this paper the current state of the UAV market is presented and opportunities for using UAVs in Antarctica are reviewed.

2. The Role of Manned Aircraft

Manned aircraft are used to carry passengers and equipment on intercontinental links, to and from Antarctica. These aircraft, which often have 4 engines, have a high cost of operation and are not usually used for airborne survey missions.

Within Antarctica, smaller 2 engine aircraft are deployed to deliver and support field parties. These aircraft are often also used for airborne survey. Aircraft used in this role include the ubiquitous de Havilland DHC-6 Twin Otter and the Dornier 228. The aircraft used for in-theatre activities are often low use and in consequence the hourly rates often exceed Euros 750.

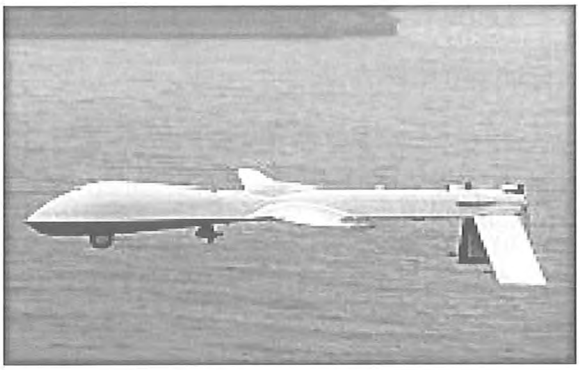
Manned aircraft have been used successfully in Antarctica for photographic survey. They have also been fitted with magnetometers, gravimeters, ice depth radars, laser altimeters and meteorological installations. Extensive mapping of the Antarctic land mass would not have been possible without airborne survey. Despite the completion of many successful surveys, there are problems and restrictions when using manned aircraft.

- As manned aircraft require pilots to fly them, there is a restriction on the number of hours an aircraft can be used for survey work unless spare pilots are available. Under UK CAA rules a pilot can only work for 100 hours in a 28 day period; the British Antarctic Survey (BAS) has a dispensation up to 125 hours if certain criteria are achieved.
- Manned aircraft have a restricted range/payload due to the intrinsic weight of the airframe and the need to carry a pilot and equipment operators.
- Manned aircraft cannot normally be used during the Antarctic winter for survey work due to safety implications.
- Manned aircraft use hydrocarbon burning engines which can impair meteorological based surveys unless care is taken with inlets.
- The cost of operation is often high with significant maintenance requirements.

Many of the manned aircraft used in Antarctica are nearing the end of their useful economic life, often being in excess of 20 years old. Replacement aircraft including the CASA 212 and the Polish M28 SKYTRUCK are under consideration but these still are subject to the disadvantages identified above.

3. Unmanned Aerial Vehicles

Fixed wing, unmanned aerial vehicles were pioneered in the 1980s by the Israelis for surveillance work. The first Gulf War and other conflicts accelerated the development of UAVs for military applications. The US military are predicting that Joint Strike Aircraft will be the last manned combat aircraft. In the west, spending by the military on UAVs will be Euros 1.5 billion in 2004 and reaching Euros 4.5 billion by 2012.



The remote controlled Predator produced by General Atomics Aeronautical Systems of San Diego is probably the most well known UAV. With a wingspan of 15 metres and a length of 8.25 metres, the aircraft has a loiter time of up to 40 hours and a maximum ceiling of 25,000 feet. Powered by a four cylinder Rotax engine, a system comprising the aircraft and controllers is approximately Euros 22.5 million.

There are many UAVs now available for military applications, many of which are optimised for specific roles. Their development has however spawned other UAVs which can be used in commercial and research applications

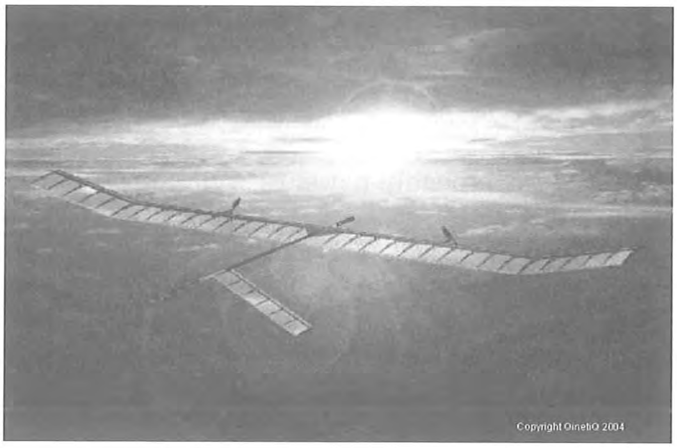
4. High Altitude UAV Platforms

The high altitude environment is harsh as aircraft have to operate in extremely cold temperatures as well as being exposed to high levels of solar radiation.

Operating at altitudes of up to 20000 metres, the Northrop Grumman RQ-4 Global Hawk has a duration of 42 hours. It has a baseline payload optimised for a SAR.

Although this UAV and similar HAE platforms would have an application in Antarctica for the ground truth of satellite systems or aerial photography, the cost of HAE systems is generally prohibitive for most Antarctic applications.

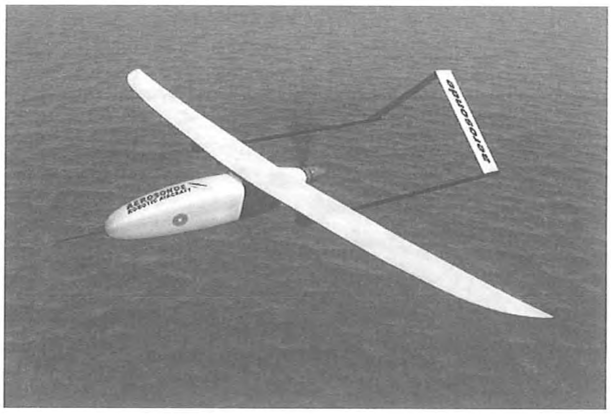
One HAE UAV that may however have an application for Antarctica, is the Zephyr HALE from the UK research organisation Qinetiq. Zephyr was developed as a concept to support a manned balloon world record attempt. A full size, ultra lightweight solar-electric aircraft was built in 2002. Two further aircraft are now in construction. With a 17 kg all up weight, a 1 kW solar array and a 12 metre wingspan, the Zephyr is able to carry a 2 kg payload indefinitely whilst there is solar radiation on the panel array.



The Zephyr is launched from the ground attached to a balloon. At an appropriate height the aircraft is released. UHF telemetry is used to control the UAV over a distance of up to 300 kms. The Zephyr has a suite of low weight instruments including cameras and a LIDAR that enable the aircraft for survey work.

5. Long Duration UAVs

For many survey applications, long duration is a requirement. The Aerosonde Company based in Victoria, Australia, has developed a range of UAVs optimised for long duration survey. One of their aircraft with a wingspan of 2.9 metres, a weight of 15 kg and a range in excess of 3000 kms, crossed the Atlantic Ocean powered by a 24 cc fuel injected engine.



Aerosonde have already completed science missions in Alaska and Japan using lightweight instrumentation for meteorological and airborne particle measurements. They have also deployed their UAVs for routine customs observation in a marine environment.

6. Ship Launched UAVs

For many applications, a ship launched UAV would be of significant benefit in the Antarctic. By launching a UAV from a ship, areas away from routine survey using manned aircraft, can be accessed. The launch of a UAV from a ship presents some challenges but recovery can be very difficult.

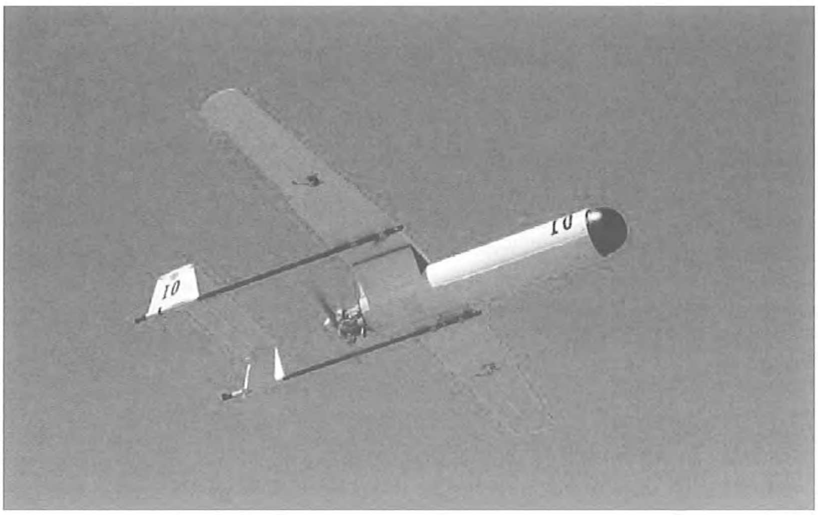
Seascan based in Washington State, USA, have developed a range of UAVs optimised for marine applications. The original UAV called Seascan, has an integral digital camera with an inertially stabilised pan and tilt turret. A catapult is provided for ship launch and a sky-hook mechanism is available to snag an aircraft at approach speeds in excess of 25 m/s. The aircraft weighs 15 kg and has a flight duration of 15 hours. With a design life of 200 flights, two aircraft, a launch and recovery system and control cost approximately $350K.

Future developments include a system called Geoscan optimised for geo-scientific surveys. The system will have a magnetometer fit and interfaces to other instruments.

7. Low Cost UAVs

Many of the UAVs provided by commercial suppliers have a significant capital cost. Although costs are reducing as new systems are developed and economies of scale are realised, the costs are sufficient to ensure that careful budgeting is needed to demonstrate cost effectiveness.

An UAV developed by Southampton University has material costs of Euros 3000. All design and assembly is completed by MSc students to reduce costs. With a wingspan of 2.6 metres, a ceiling of 1500 metres, and a predicted duration of 400 kms, the UAV flies at up to 60 knots and can carry a load of up to 3 kgs. The aircraft has completed several proving trials and continues to be developed.



8. Airships

Another form of UAV which has been in existence for many years, is the airship. Airships were originally developed using funding from military projects although there was also craft that carried passengers including the R101 and the Hindenburg. The demise of both of these craft, helped lead to a loss of confidence in this form of construction.

Helium filled airships are now used for surveillance work and to carry survey instruments. They are used in a tethered mode or in controlled and powered flight. Most modern airships are non-rigid construction, maintaining shape through the pressure of the helium in the envelope. Earlier airships used a frame which encased air bags.

The advantages of airships are:

- Lower cost of operation than fixed wing aircraft.
- They can remain stationary or operate with almost no vibration at low speeds to provide a platform for installations such as large-aperture radars.
- They can stay airborne for long periods, often for many days.

The SkyShips Cirrus 1000 has a length of 9.5 metres and a maximum diameter of 2.5 metres. With an operating ceiling of 120 metres (capable of a significantly higher operating ceiling), the airship is able to carry a load of 7 Kg . Two 1000 watt electric motors propel the airship to a speed of 30 knots. Duration is dependent on the battery packs carried.

Whilst airships can be used in most environmental conditions, they are susceptible to strong wind gusts until the motors can compensate. More importantly, airships cannot be launched with wind-speeds in excess of 30 knots.

9. Instrumentation and Control

Instrumentation installed in manned aircraft is often heavy, power hungry and a development of land based instrumentation. For airborne science surveys to be effective when mounted in a UAV, small low power instruments are needed. Modern electronic instrumentation and in particular camera are now very small, low weight and need little power. Not only are camera being reduced in size, there is significant development in geophysical instrumentation and also instruments such as the LIDAR. A 12kg LIDAR is available that can cover a 2km swath at 20km altitude. By using modern instrumentation, for some applications, a UAV can provide a platform that is more cost effective and capable than a system in a manned aircraft.

Unless operating on a pre-planned mission, all UAVs require a command and control system. On-board GPS give real-time position of the aircraft, UHF telemetry provides the process to command the UAV and to retrieve real-time data. Links with ranges up to 300 km are available.

10. Operational Issues

UAVs operating in the crowded skies of the northern hemisphere are subject to the controls of air authorities. In the UK the CAA limits the ceiling of UAVs to 400 feet and there are restrictions on operating areas to avoid UAVs falling on housing and built-up areas. In the Antarctic there are no restrictions on operating limits. There is significant interest by some manufacturers in using UAVs in the unrestricted airspace of the polar regions.

Most UAVs are relatively lightweight and have small powerplants to increase duration and ceiling height. There are restrictions on weather windows which are primarily related to wind speed. One advantage the UAV does have is that it can be operated in the polar winter when manned aircraft.

11. Conclusions

UAVs provide an opportunity for the Antarctic community to move forward on airborne survey capability. By working together, a UAV could be optimised and manufactured in quantity.

Antarctica can be used to test UAVs and provide an opportunity to take forward the development of low energy demand systems.

Assessment of Non-fossil Fuel Energy and Waste Minimisation Research Opportunities for Antarctica New Zealand

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Abstract

Antarctica New Zealand (AntNZ) has identified a need for energy systems that are not reliant on fossil fuels, and field waste minimisation solutions. A visit was made to Scott Base and relevant NZ field sites, and US McMurdo Station and US Antarctic Program (USAP) field stations to better understand the issues and identify areas in which the College of Engineering at the University of Canterbury (UC) could provide solutions through research projects.

Overall, an impression has been gained that significant consideration has already been given to the use of renewable resources for electricity generation, in the form of wind power and solar energy, especially at the USAP field sites. There are already working schemes that are in place and they are effective. There exists both immediate and longer term opportunities for AntNZ to adopt the use of these technologies to achieve their aims.

There are also a number of schemes associated with water supply and waste treatment and minimisation. In a manner similar to the use of non-fossil fuel energies, a study of these can be undertaken and alternatives considered.

The programme has shifted to the University of Canterbury where a number of projects have been initiated to address specific requirements for Scott Base and existing fixed site AntNZ field stations, and to look at designing modular systems for mobile stations for use in the field. In addition, more extensive considerations are being made towards reducing fossil fuel use and waste minimisation at the USAP McMurdo station.

Introduction

Antarctica is considered as the last great wilderness area on earth. It is generally regarded as the remotest, coldest, driest, windiest, and highest continent on the planet, with 24 hour sunlight in the height of summer changing to complete darkness in winter. These physical characteristics to a large extent, determine the human impact on the environment, and what is designed and used in terms of human existence.

Antarctica has been substantially less affected by human commercial endeavour than other continents. However, human impact is likely to increase. It has been the domain of explorers and intrepid adventurers, and now the destination for an increasing number of tourists. A plethora of scientists have studied the natural geology, geography and ecology of the area. It is increasingly being used for the study of human modification of the planet as a whole, and for the exploration of the solar system and the origins of the universe.

Even without commercial exploitation, all human activity in the Antarctica has been and is sustained through the use of harnessing energy from some source. Almost exclusively, this is through the consumption of fossil fuels, namely diesel and petrol. These are used directly for the generation of electricity, for space and water heating, for water supply, for waste treatment and removal, and for transport. All scientific research and programme operation relies on these essential services. They allow equipment to function and people to survive. Any material good transferred to the continent for any use is the result of the consumption of fossil fuels somewhere else on the planet.

Antarctica New Zealand (AntNZ) has identified a need for energy systems that are not reliant on fossil fuels, and waste minimisation solutions. There are three ways to reduce fossil fuel use. The amount used can be reduced. This is the most effective in terms of impact and can imply designs of buildings and energy systems that are effective in their energy use. What is used can be used as efficiently as possible. Also, fossil fuels can be substituted by the use of renewable energies. This is essentially a trade off of the capital cost of an alternative for the operational costs of burning fossil fuels. It means the carbon emissions associated with manufacture are made elsewhere on earth. With respect to waste management, compression of what is produced to small amounts for transport and removal are desirable.

In December 2003 a visit to AntNZ's Scott Base and relevant field sites was made to better understand the issues, to look at partial solutions the United States Antarctic Program (USAP) have installed, and to identify areas in which the College of Engineering at the University of Canterbury (UC) could provide alternative solutions through research projects. This paper summarises the activities undertaken, the places visited, the systems currently in use, and projects that could be undertaken to address the needs of AntNZ.

2. Endeavours and Achievements

The first 2 days in Antarctica were associated with Antarctic Field Training, a necessary and useful exercise in gaining an appreciation of the physical environment in which Scott Base and field stations exist, the potential hazards associated with that environment, the basic glacier travel techniques that are used in traversing the physical environment, the survival techniques that can be used in the event of adverse, particularly weather, conditions, and basic overnight living. This allowed frequent subsequent visits to areas away from Scott Base along designated travel ways to further experience the natural environment, its pristine nature and the requirements to maintain it as such in the face of encroaching development, study and visitation. It also provided an appreciation of the rigours of unassisted travel over the landscape.

2.1 USAP McMurdo Station

McMurdo station is the main base for the USAP. It supports scientific research at the base and out in the field, and the logistics of transport and supply for these. It also supports the South Pole Station and provides air transport and energy supply for AntNZ at Scott Base. McMurdo has a summer population of about 4000 people. Over winter it hosts about 800 people. The base is a significant complex of buildings, roadways, storage areas and communications facilities, as well as a depot for the fossil fuel energy supplies for all its activities. It maintains three local aircraft runways and port facilities for supplies coming in by ship. The McMurdo Station in total has a diesel power plant capable of generating over 4MW of electricity. No study was made of fuel use, but it is sufficient to say that McMurdo has all the infrastructure and operation of a small town.

A visit to USAP McMurdo Station was to the Scientific Support Centre to look at small wind generators that were being used in the field. In addition there was a selection of fixed and portable solar panels, and power electronic converters for changing direct current into alternating current for the convenient use of equipment, instrumentation and appliances.

This visit emphasised the existence and current use of small wind and solar electricity generation equipment that is commercially available. Future study can source alternative suppliers of this type of equipment.

2.2 AntNZ Cape Bird Hut

A visit to Cape Bird hut gave an insight into AntNZ's use of solar energy to complement petrol generation at a small, fixed location field station. Two solar panels were mounted on the roof and a third was used as a portable unit for the field. Also observed were the basic requirements of space heating, water supply, water heating and waste disposal. At present both water supply and waste disposal are labour, and in the case of fresh water, energy intensive. There appears to be opportunities to consider solar thermal solutions to these services. A larger and more effective photo-voltaic electricity supply system can be considered, as well as some potential for wind generation.

2.3 AntNZ Scott Base

A day at Scott Base gave an overview of the electricity use, space heating, water supply and waste disposal issues for a much larger operational base. Here there is a diversity of energy use reflecting the higher live-in population complemented by people in transit to and from field camps and New Zealand. The facilities required for this operation involve a combination of domestic (kitchen and mess facilities, sleeping quarters, ablution blocks, recreational and social areas), logistic (management and operation suite, briefing room, field support equipment storage) and small industrial (power supply, communications, electrical, mechanical and carpentry workshops, garage and transport facilities, water supply, waste management) services reflecting the relatively self contained nature of a base station. These aggregate to give a comprehensive service supply, some of which operate on a continuous basis. It is appropriate to study the overall use patterns for planning purposes, although a more detailed audit may reveal opportunities for gains in the efficiency of supplying these services.

2.4 USAP Field Stations

A visit was made to the unmanned USAP Mt Newall seismographic repeater and weather station on the Asgard Range in the Dry Valley region. Here a combination of a wind generator and horizontally mounted photo voltaic (PV) panels provide electricity to be stored in a battery bank. The stored energy is then available through conversion, for the operation of weather monitoring instrumentation and the relaying of data to McMurdo. The wind and solar electricity supply is backed up by a diesel generator, although the use of this is infrequent as the scale of the former matches the demand well. AntNZ has its own small meteorological and communications system in a separate dwelling. This uses a solar panel for electric power.

Lake Hoare in Taylor Valley is a USAP scientific field station supporting a large variety of scientific measurement programmes in the area. The population typically varies between about 6 and 16 people over the summer months. Electricity is primarily provided by banks of PV panels that are mounted at about 60 degrees to the horizontal. They can be manually rotated to increase the total solar incidence throughout the day. There is a largely unused diesel generator as a backup. Space heating, water heating and cooking, use fossil fuels in the form of diesel and natural gas. This field station has two propane sewage incinerators that significantly reduce the amount of material that needs to be transported from the area to McMurdo for ultimate disposal. However, this involves the burning of a fossil fuel and consequent carbon emissions into the atmosphere.

A final visit was to the USAP satellite station on Black Island. Here there is an 11m satellite communications dish for contact with a geosynchronous satellite above the equator. This gives data and communications links for NASA. The electricity supply is a combination of wind power and solar PV, with diesel generation as backup. There are 4 wind generators, 3 solar panel banks mounted horizontally on the roof and 3 diesel generators. There is a large battery bank for electricity storage and 4 dc to ac converters to supply the power needed by the satellite communications, associated electrical equipment and station appliances. The batteries have had 8 years of operational life, which is significantly less than the design life of 15 years due to shallow charge and discharge cycles. This station also has a grey water evaporation pond to reduce the material that must be disposed of.

3. Service Considerations

The physical characteristics of the Antarctica offer consideration of the use of renewable energies, particularly wind and solar, to supply at least in part some of the energy needs associated with electricity use, space and water heating, water supply and waste treatment. Correctly sized, renewable energy systems could entirely replace the use of fossil fuels.

Realistically, this could be implemented initially at mobile and fixed field camps. Complete substitution of fossil fuels for these same needs at base stations will require very large systems. More extensive research will be needed to identify if systems already exist to allow such an option.

New technologies, such as fuel cells and hydrogen, are yet to be shown as commercially viable alternatives. While still reliant on either fossil fuels or primary electricity, they may offer gains in efficiency and hence partial reduction of fossil fuel use. They may also provide some control of carbon emissions and waste disposal.

4. Project Proposals for AntNZ

The programme has now shifted to the University of Canterbury where a number of projects will be initiated to address specific requirements for existing fixed site AntNZ stations, and to look at designing modular systems for mobile stations for use in the field. The details of these projects have been formulated according to the time line of undergraduate course assignment requirements and the availability of other personnel to undertake more significant and extensive research.

Specific projects include:

- a pattern analysis of energy and water use for Scott Base using existing records to provide a quantitative summary measure of these services for future planning.
- an energy audit of Scott Base to ascertain the detailed use and loss of energy with a goal of conserving fossil fuel use for existing operations
- a technical design of an energy management system for Scott Base for improving the efficiency of what is used
- a feasibility study of wind and solar power electricity as a substitution for diesel generation at Scott Base
- a technical design of wind and solar power electricity at Cape Bird Hut
- a technical design of an integrated wind and solar electricity system for a modular container for mobile field stations. Where joint NZ/US programmes are envisaged, field stations accommodating supplies for both electrical systems can be incorporated.

- a technical design of the use of solar for space heating, water heating, fresh water supply, and human waste and grey water volume reduction at both Cape Bird hut and mobile field stations
- portable systems for tent camps

These projects have been undertaken by undergraduate students in Design and Management. This is a compulsory class of some 90 students in their second professional year in the Department of Electrical and Computer Engineering (ECE). Their brief was to choose one of the projects and to consider themselves as consulting engineers hired by AntNZ to make recommendations on which the board could make decisions. Their goal was to achieve support and financial commitment for the project. The reports cover not only the details of the engineering and associated costs, but also the planning and information presentation and reporting for the project. Their aim was to convince AntNZ or USAP that what was offered was worth commitment and funding, i.e. they were to market their engineering project management ideas and skills.

Their reports were to cover the following topics:

- present a detailed technical design of the engineering required, including a location map and site plans where relevant.
- where appropriate, the policy, environmental and social impacts of and constraints on the engineering project.
- a description of the general activities required to allow the project to be undertaken
- a management plan to satisfy the project engineering, policy, environmental, social and economic requirements for the project. This was to include resources, personnel and time schedules for each major step in the achievement of the project. In the preparation of the plan for the project the tasks that make up the overall plan and the relationships which tie them together were to be identified.
- develop networking charts such as PERT, Gantt and Work Breakdown Schedules which show the task interdependencies and time relationships, and identifies the critical time path. Resource requirements (materials, equipment, labour, energy, etc) were to be presented.
- present a project progress reporting plan which identifies key milestones (acceptance meetings, progress meetings) and define how progress on the project is to be

monitored and reported to the various management levels.

- an economic costing of the project plan and a proposal as to how it could be financed. This was to include cashflows.

Assessment of these projects was being undertaken as a class exercise by some 20 College of Engineering, Masters of Engineering Management students. This was to be overseen by the Director of the programme. From there, the best contributions would be forwarded to AntNZ for final selection.

Many of the projects are suitable for any engineering student with technology and management experience and an interest in applying their skills to a region which presents unique policy and environmental considerations alongside engineering and economic alternatives. Some specific activities have already been undertaken or initiated with these projects in mind.

- One of the students on the Gateway Antarctica (a Centre of Research Excellence at UC), Graduate Certificate in Antarctic Studies, undertook her supervised project on the Future of Scott Base. She has addressed many issues associated with the aims of this proposal, particularly through building design.
- A current Gateway Antarctica PhD student is studying lean project management methods for remote locations, with Antarctica as a case study.
- A student has commenced studies for a Masters degree in ECE, to implement and test a solar thermal heater which has sun tracking capability. This could also be used to provide photovoltaic electricity. As an initial investigation to its appropriateness for Antarctica, 2 panels with 3 different reflecting surfaces were mounted at Scott Base to determine their weathering effect over summer and winter.
- The Electric Power Engineering Group (EPEG) in ECE, UC, has a programme on small power system development and specific component design. These technologies can be looked at with respect to their integration into the various systems for use in Antarctica. Associated with this, the Electric Power Engineering Centre (EPECentre – a Centre of Research Excellence supported by the electric power utilities of New Zealand) has adopted the programme for addressing the AntNZ needs.

- Some of the projects may be best undertaken in other departments within the College of Engineering, namely Mechanical, Civil and Natural Resources. To this end the project descriptions have been made available to senior staff in those departments. A Masters of Fire Engineering is to look at this aspect of Scott Base facilities.

5. Project Proposals for USAP

The projects and systems proposed for AntNZ can be a template for more extensive considerations of reducing fossil fuel use at the USAP McMurdo station. While there are projects that are similar to those described for the AntNZ programme, some specific starting projects have been identified. These projects all require a study of the existing technology and infrastructure that exists at McMurdo station, a suggestion of alternatives, a description of the technology required and an economic comparison of the alternatives with the current operation. They have been included in the assignment to the Design and Management students and one (5.4) is being studied by a final year ECE student as his major project.

5.1 Non-Fossil Fuel Electricity Supply

Akin to the project proposed for Scott Base, a study of the electricity supply for McMurdo Station can be undertaken and alternative technology systems suggested for the generation of electricity. The existing power plant at McMurdo uses diesel generators and delivers up to 4MW. Non-fossil fuels such as wind and solar, have immediate application.

5.2 Instrumentation for mass/energy audit

Before an audit of McMurdo can be undertaken, an analysis of what needs to be measured and what can be measured needs to be undertaken. All measurements require some form of instrumentation. The project is to take a global look at the McMurdo station and identify from its layout and operation, the points and processes that best reflect the use of energy, the transfer of material goods, the supply of water and the disposal of waste. Where measurement systems are not in place, recommendations will be made as to what instrumentation needs to be procured and how this will be installed to isolate pertinent measurable quantities. It will be from the data collected that what is used and discharged can be identified, and alternative solutions then considered.

5.3 Electric Vehicle use at McMurdo Station

Motor vehicles at McMurdo station are run on either diesel or mogas (petrol). Both of these are derived from fossil fuels. An alternative is to use some of the output from the McMurdo electric power plant to charge electric vehicles. The generators can be loaded to maximise their efficiency in converting to electricity. Also, by having a centralised conversion facility, the waste heat of conversion can be captured for space heating in buildings. This heat is not available in fossil fuel vehicles where waste heat is discharged into the atmosphere. This study should include a comparison of the efficiency of energy capture between a central, highly efficient power plant and an individual vehicle engine. As well, consideration will have to be given to the likely efficiency of electric vehicles in the cold ambient conditions of McMurdo station.

5.4 Washing Machine Efficacy

With such a large number of people living in a close community, there are over 100 washing machines for public use. These are all top load commercial models which use a significant amount of fresh water; that water being generated from a large reverse osmosis plant that supplies the entire station. Accompanying the washers are over 150 commercial dryers. All the electrically-generated heat and the moisture from these is discharged directly into the atmosphere. There is an opportunity to improve the energy requirements of this entire facility by the use of alternative technology that is more efficient and that uses less water. Also waste heat may be recovered for space heating and perhaps water vapour for fresh water supply.

6. Recommendations

Concurrent with specific projects that have been identified for immediate study, there are field activities that could be implemented during the next summer season

- the pattern analysis of energy and water use for Scott Base using existing records is being undertaken by a Post-doctoral Fellow in ECE. As a follow up to this, an energy audit of Scott Base could be undertaken to ascertain the detailed use and loss of energy with a goal of conserving fossil fuel use for existing operations.
- A technical design of an integrated wind and solar power electricity system for Cape Bird Hut has also been undertaken, independently of the undergraduate assignment. If the design is acceptable, then installation could be undertaken during the next summer season. The EPEG has a number of staff with industry and consulting backgrounds to

enable professional and technical support for this project, or training of AntNZ Scott Base staff.

- The survey of instrumentation for the mass/energy audit project at the USAP McMurdo base station could also be undertaken during the 2004/5 summer season using a team of staff and students from the ECE department.
- Pending the outcome of the various technical design projects undertaken throughout the academic year, recommendations will be made as to how these can be progressed. These could range from more detailed technical designs, to the overall management of larger scale projects, which may involve outside suppliers, contractors and consultants.
- For the USAP programmes, a separate set of recommendations for the implementation of accepted projects can be supported through both technical and management programmes run at the UC.

7. Conclusions

While the presentation of this paper focuses on the very real engineering options of reducing fossil fuel use and waste minimisation, the underlying topic is that of the potential for collaboration of interested parties in addressing issues that have direct environmental impacts in Antarctica.

AntNZ has a commitment to support education. It has been doing this directly through Gateway Antarctica, a multi-discipline research centre of excellence based at UC. This interaction has now been extended to include the EPECentre, which brings expertise in electric power engineering. It also ties in the College of Engineering. Through its staff and students, these offer fresh perspectives to engineering solutions which consider environmental and social constraints alongside economic and technical considerations. To a fair degree they have the capability of design and implementation of these solutions.

Practical projects make for excellent educational learning. Students, the future scientists, engineers and project managers of the world, are firmly focussed on real world issues. The Antarctica offers a unique combination in considering the environment, while maintaining human survival necessity. The partnership of Antarctica programme supporters and universities offer a way of addressing these issues.

A new automatic dehumidification system for trace gas concentration measurements

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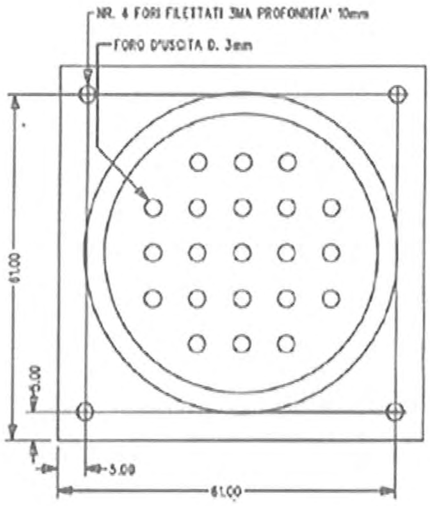
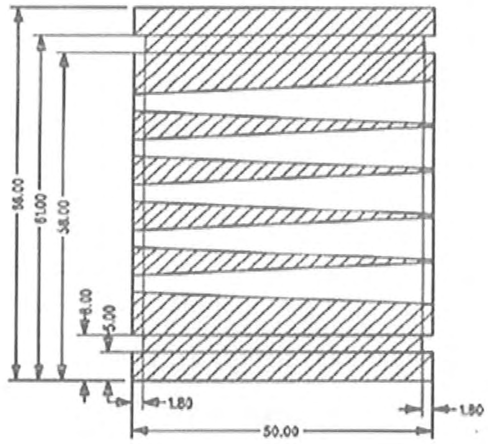
1. Introduction.

The Non-Dispersive Infrared Absorption (NDIR) is a technique widely used since '50 to carry out CO_2 measurements. These instruments are generally highly sensitive to the presence of water vapour. As a consequence, a common methodology to dry cryogenically the sampled air have been adopted and the CO_2 concentration have been expressed with respect to the dry mixture. Even if modern analyzers are equipped with detectors which minimize the water vapour interference, methodology to dry cryogenically the sampled air is regularly used at all CO_2 measurement stations in order to have consistent values even though different relative humidity intensities occurr. Generally, the air drying system consists of an "U" band glass pipe, blown in such a way as to be uneven within in order to make the flow turbolent and increase the contact surface. The pipe is placed in a freezer maintained at the required temperature of about -60 °C. This water vapour trap presents two great disadvantages: (i) when the pipe is full of ice a manual intervention is required to change it and (ii) the life of the expensive freezer devise is normally relatively short. With the aim to improve the accuracy, completely automate and reduce the costs of the CO_2 measurements carried out by NDIR technique at the Italian base of Terra Nova Bay (75°S), a new dehumidification system based on the Peltier effect have been developed.

2. The inner-core

The central core of the dehumidification system is based on a cooled metallic body condensing the humidity contained in the air that, flowing through it, impacts on a wide surface. The metallic body is a parallelepiped with square section of **66 mm side** and **50 mm height** (Figure 1), on which **21 cone shaped holes** have been made in order to obtain in a reduced volume a wide impact surface, a high residence time and a high capture efficiency homogeneous throughout the path of the air flux (Figure 2).





-The inner-core, top vision - The shape holes through witch air flows.

In comparison with a U-shaped impactor made of Pyrex tubular glass, **25 mm** inner diameter and **35 cm** air flux path (representing a working impact surface of about **35 cm^2** on a total of **350 cm^2**), the central core with cone-shaped holes and entrance and exit holes of **7.5 mm** and **3 mm** diameter respectively, provides a total impact surface of about **183 cm^2**.

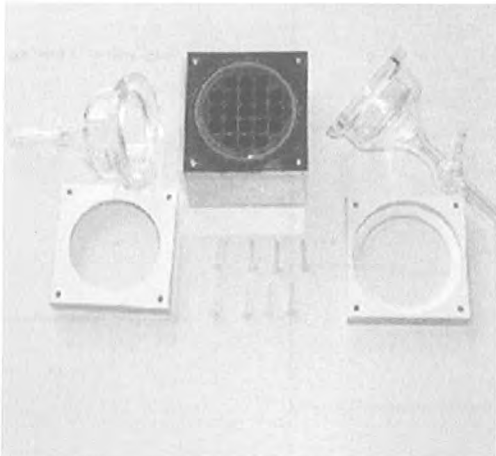


Figura 3 – The inner core and the pyrex convenyors

The dehumidifier is placed at the centre of a solid state symmetric cooling system constituted by **two double stage Peltier effect slabs** able to generate a **DT of about 80 °C** between the external heat sink and the inner impactor body. The central core is linked by Pyrex conveyors to steel connectors for sampling air and for discharging the water produced by melting the accumulated ice (Figure 3). In the upper part a differential pressure sensor is located to transmit to the control unit the obstruction level of accumulated ice.

3. The Peltier module and the control system

The **Peltier effect modules** are powered at DC voltage by a self oscillating switching regulation system operating at a frequency of **about 0.5 Hz** with a variable duty cycle, which depends on an analog voltage level generated by the acquisition and control unit. This powering circuit presents a high efficiency, a low heat dispersion and is able to maintain the temperature differences **DT**, between the **central core** and the **intermediate body** and between the **latter** and the **external heat sinks**, balanced and almost equal each other (Figure 4). In fact, three thermocouples respectively placed on the inner core, on the intermediate body and on the external heat sink provide the signals of the two temperature differences **DT** (Figure 4), while a **PT100** sensor placed on the dehumidifier's external body gives its absolute temperature signal. Consequently, the control unit can calculate the three temperatures and change the analog voltage control level according to the slow variation of the inner body's temperature. This way, the functions of controlling the inner temperature, melting accumulated ice, discharging water and restoring the initial conditions for a dehumidified air flux can be automatically accomplished. The electronic circuit to condition the temperature and pressure signals and to power the Peltier slabs is placed in the dehumidifier's front hollow. A display panel allows operator to monitor the state of the system.

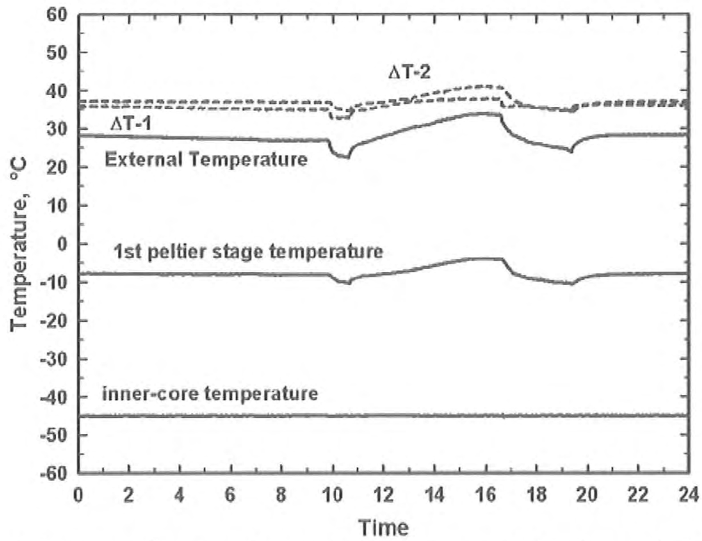


Figure 4 - External, intermediate and core temperatures behaviour during normal operation. The target temperture was fixed to 45 °C. The temperature differences between external and 1st peltier stage (ΔT-1) and 1st stage peltier and inner-core (ΔT-2) are also shown.

The beginning of the melting phase is deter-mined by the pressure sensor pneumatically linked to the impactor, where ice formation pro-gressively obstructs the air flux leading to an increase in differential pressure. When the thre-shold level is exceeded, the control unit begins the melting phase. At the external sides two heat sinks are maintained at room temperature by means of two big fans (Figure 5).

4. Conclusions

The comparison of CO_2 measurements conducted in laboratory by applying this new instrumentation and standard methodology gave results coherent within a range of 0.1 ppm. Thanks to this new dehumidification system, the CO_2 measurements have been completely automated.

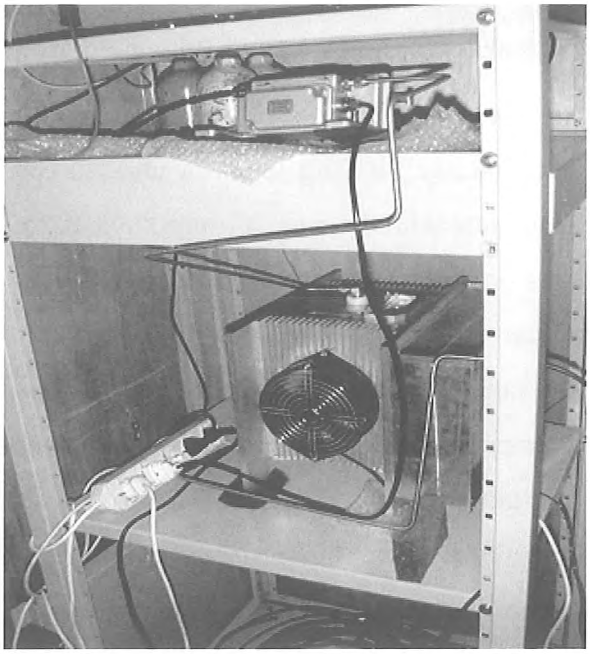


Figure 5 - The dehumidification system during it operation in Antarctica. It is possible to see the big fan.

The pressure sensor signal is transmitted to an external PC that controls the electrical valves used to switch between the different phases of the measurement procedure (reference, zero and span). When the dehumidification system change from norma state to deicing state, the PC stop measurements until the dehumidification inner core temperature returns to the fixed operational temperature. The system is operating three years in Antarctica allowing us to obtain accurate and stable measurements of CO_2 concentration.

Wind-generator system applied to scientific instrumentation in remote Antarctic sites

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1. Introduction

The scientific interest in instruments working autonomously for long times in unperturbed Antarctic sites is increased in the last years at the same rate with the need to improve data for a larger number of physical and chemical parameters on a regional and continental scale. At the moment, one of the greatest limitations of an automatic measurement station lies in the power supply: integrated wind-battery systems can supply during the Antarctic winter few tens of watts at maximum.The necessity to extend atmospheric physics measurements for the whole year at the Mario Zucchelli summer Italian station (MZS, former BTN-Terra Nova Bay), led to study and develop a power module able to provide continuously several hundred watts of '*clean*' energy, by means of a windy-solar-battery integrated system.

2. The wind-generator

The wind-energy unit is a vertical axis system with a turbine that comprises two blades and a central nucleus sandwiched between a top and a bottom plate (Figure 1). The generator is located inside the nucleus form. The turbine presents to the wind action a swept active area of more than **7 m^2 at 5 m** above the ground. The well-known working principle of this unit, although considered less efficient in comparison with the classic wind systems, makes this unit more suitable for working in the extreme operating conditions of Antarctica. The turbine, patented for its new aerodynamic shape, solves the issues related to the low start up mechanical torque typical of the vertical axis turbines. At the same time, it doesn't need any kind of braking or security device. The vertical axis wind-energy unit allows power to be produced starting from a minimal wind intensity of

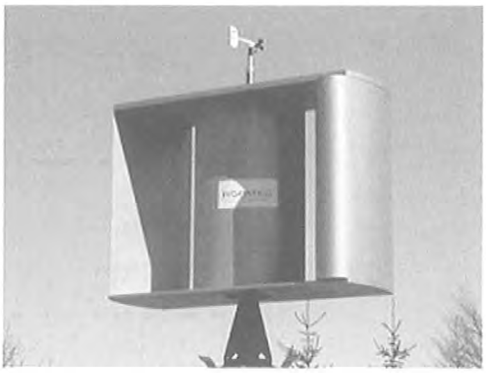

Figure 1 – The turbine of the vertical axis wind generator. Note the anemometer on the top.

2m/s up to **14m/s**, where the nominal power supplied attains to **3 KW**. If wind rises above **14 m/s**, although at turbine saturation regime, the power supplied continuously and slowly increases until a wind speed of **70 m/s** (limit of the mechanical resistance).

Several improvements were produced to make the system more resistant to mechanical stresses: all elements were built with stronger and thicker materials, the turbine's blades were filled up with polyurethane and the supporting shaft was strengthened to resist up to **300 km/h** of wind speed. The rotor was placed inside the turbine along the shaft axis for compacting the structure (Figure 2). Shaft was hollowed and lengthened to support meteorological sensors and to allow the acquisition system to be placed into the base. The base was made much stronger that usual, by using supporting steel angles, thicker sheets and L structural steel. Moreover, the wind generator was well insulated (Figure 3). Our tests in Italy indicate that the starting wind speed is negligibly increased by these modifications.

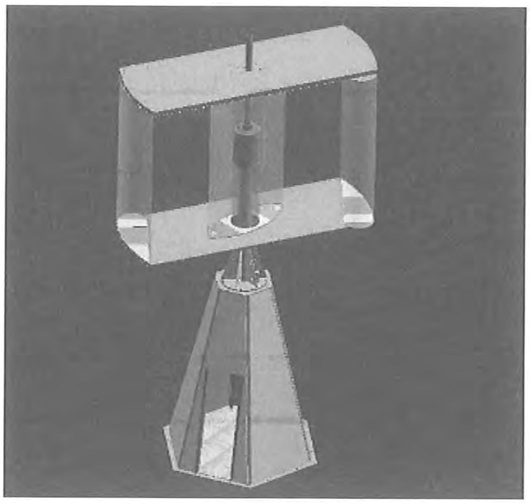

Figure 2 - Schematic view of the rotor.

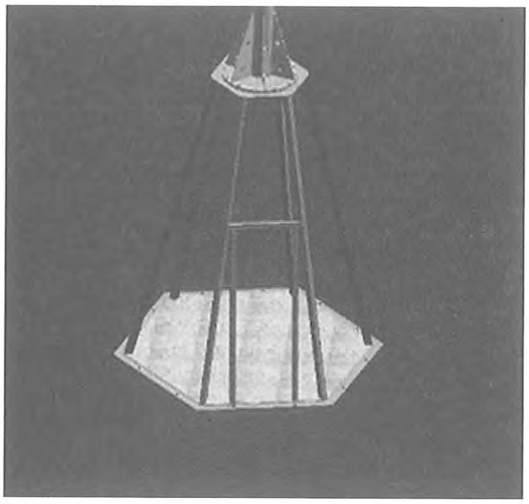

Figure 3 - The pyramidal shelter structure

3. The control unit

A special electronic system to control the battery charging and the load switching was realized, including a **dynamical system of the dissipative loading modulation** in order to track the maximum power point determined by the wind regime (Figure 4). This control device will allow us to obtain a large increase of the efficiency in the energy transfer from the wind generator to the battery pack and at the end to the laboratory. This technological target will be achieved also when the alternator voltage will be lower of the battery pack voltage. Moreover, any surplus of energy will be used to warm the laboratory, computers and instrumentation (when necessary). Using such a scheme will permit the use of a reduced

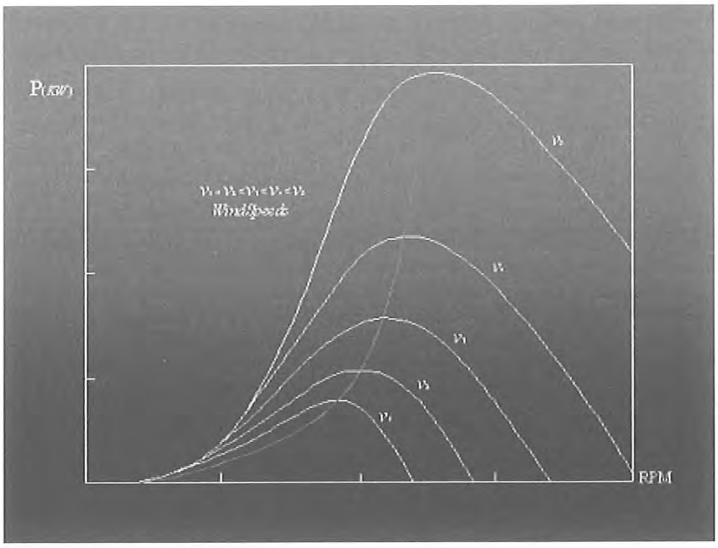

Figure 4 – Power supplied by the wind generator vs. alternator r.p.m. for different wind regimes.

battery pack and of a smaller capacity generator than that might be otherwise necessary for a given set of wind parameters.

In order to develop the control unit, a small wind-generator, having a nominal power of **500 W** at **12 m/s**, with a **1,5 m** diameter and **1 m** height rotor, was installed on the top of Mt. Cimone (2170 m a.m.s.l.) near the ISAC - CNR "O. Vittori" Research Station in spring 2002. The numerous episodes of violent storms, wind up to **60 m/s**, winter snow loadings, temperatures lower than **–20°C** and most of all bulky ice formations subjected the wind-energy unit to the hardest test. In spite of some failures, the achieved results were satisfactory for the strength of the whole structure and for the power supplied, which reached in several occasions **1300 W** with wind speed more than **50 m/sec** and with turbine speed more than **700 rpm** (more than the double of the nominal saturation speed). Numerous sensors provided mechanical, electrical and meteorological parameters

The wind-energy system will operate during the winter period with a load of **300W** in addition to a **variable load opportunely switched for the maximum power point tracking at any wind regime**. The real time control of dynamical, electrical and mechanical data will allow the best use of the whole unit, while the acquisition and signal processing from a series of sensors will permit to estimate the capability of auto regulation and the availability of power and autonomy for the instrumental loading. The battery pack will permit an autonomy of **three days** without supply from the wind generator. Power supply to laboratory will be interrupted if battery voltage will lower below **43 V**. In any case, scientific equipments will be arranged to have no problems in case of 'blackout' and to start again when the wind will allow the battery pack to be recharged. A group of thermistors will avoid any thermal shock to the instrumentation and computers. **RS422** and **modem** connections between wind-energy unit, Icaro Camp and the PAT module at the Base will permit to transmit the most significant parameters to Italy. The block diagram of the whole system is given in Figure 5.

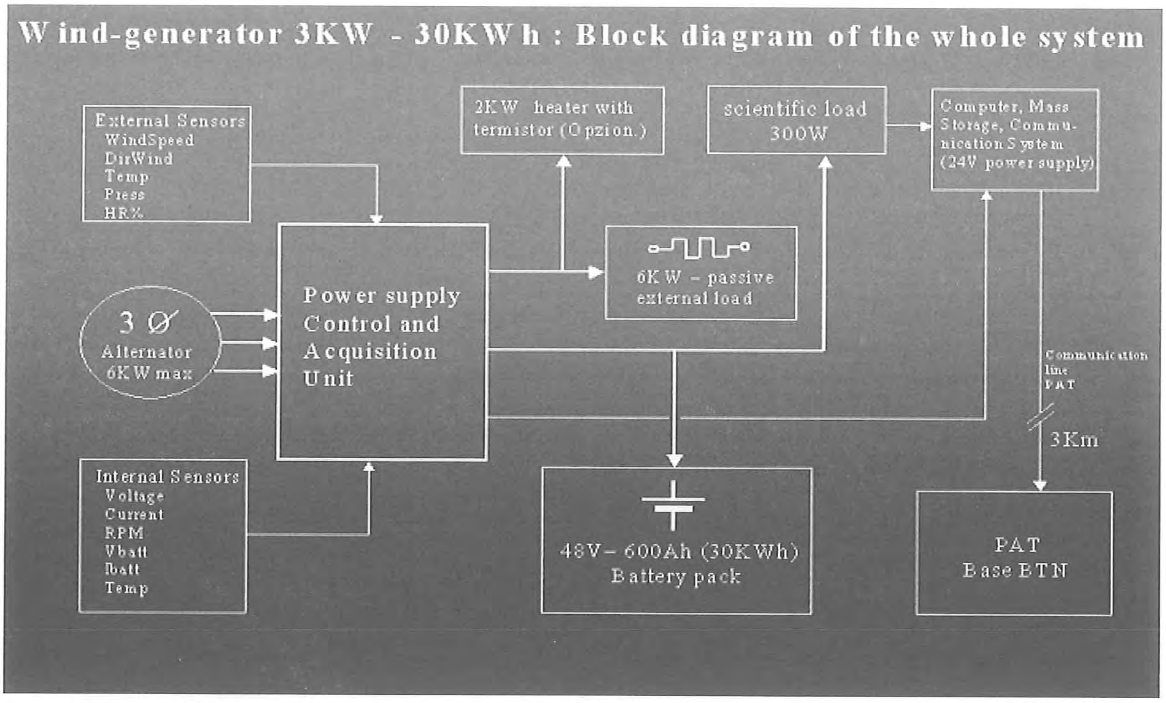

Figure 5. – The block diagram of the system that will supply power to Icaro Camp Automatic Geophysical laboratory (AGO).

4. Conclusions: the installation at Icaro Camp

The wind-energy system will be installed at Icaro Camp, located on the coast **2.5 km** southward from the MZS Italian base, where great part of atmospheric physics measurements are carried out (Figure 6). During the 2003-2004 expedition the basement was built, fixed into the permafrost with threaded steel bars of around **130-150 cm** (Figure 7) and the connection between Icaro Camp and the winter module at MZS was tested.

Figure 6 - The place where the wind-generator will be placed at Icaro Camp.

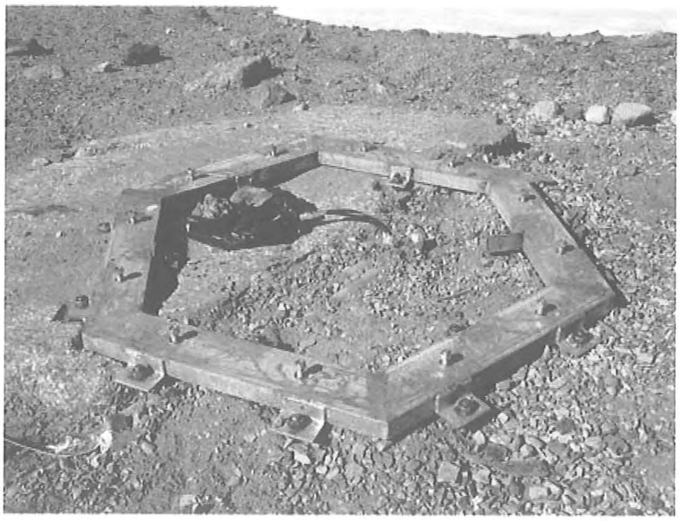

Figure 7 - the basement installed during the 2003-2004 Campaign.

During the 2004-2005 expedition the installation will be completed. The wind generator, installed for tests at the ENEA-Brasimone Center, will be dismounted and stored in an **ISO20**. In Antarctica, all batteries, the acquisition system (a Campbell CR10) and the control unit will be stored in a pyramidal shelter structure. Power supply (**48V**) will be given to Icaro Camp Lab's containers and transformed to lower voltages for scientific instruments and computer. Data from CR10 will be stored by the Icaro Camp computer and subsequently sent to PAT module and to Italy.

Operational Weather Forecast in Dronning Maud Land

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Introduction

For the second summer season the meteorological observatory of the German Antarctic station Neumayer (70°S, 008°W) offered a detailed and individual weather forecast service for all activities in Dronning Maud Land. This service is performed in close cooperation between the Alfred-Wegener-Institute for Polar and Marine Research (AWI) and the German Weather Service (DWD). The increasing flight activities, see Fig. 1 within the Dronning Maud Land and especially the intercontinental air link between Cape Town and Novolazarevskaja made the establishment of this service mandatory.

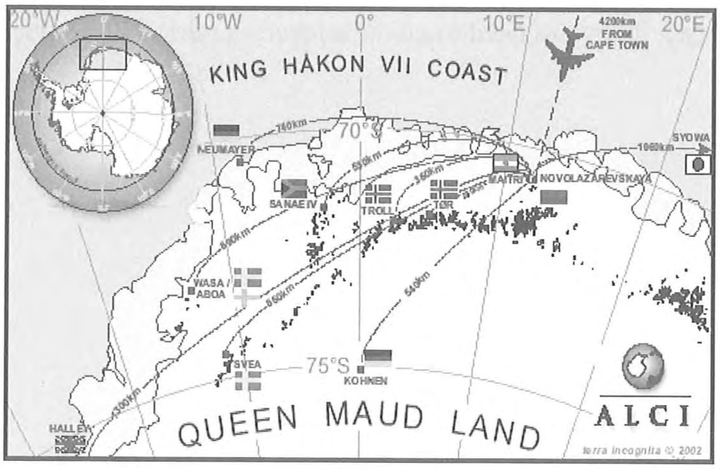
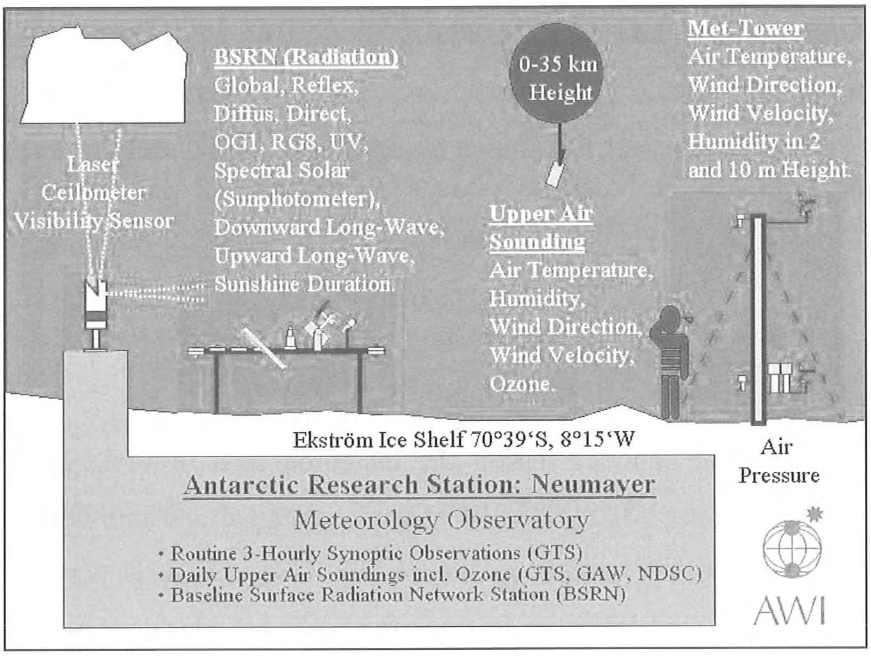


Fig. 1: Typical flight activities within the Dronning Maud Land

Neumayer Neumayer station was chosen for the forecast service due to its central position within the Dronning Maud Land, its good communication facilities including a permanent satellite data link (128 kb, Intelsat), and the modern infrastructure of the meteorological observatory, see Fig. 2.

Fig. 2: Structure of the meteorological observatory of Neumayer



Available Forecast Modell Outputs The forecasts base on special model outputs from the European Centre for Medium-Range Weather Forecasts (ECMWF, Fig.3), the Antarctic Mesoscale Prediction System (AMPS) and the Global-Model (GME of DWD). New outputs are available twice a day. They are used to cover a forecast period up to one week.

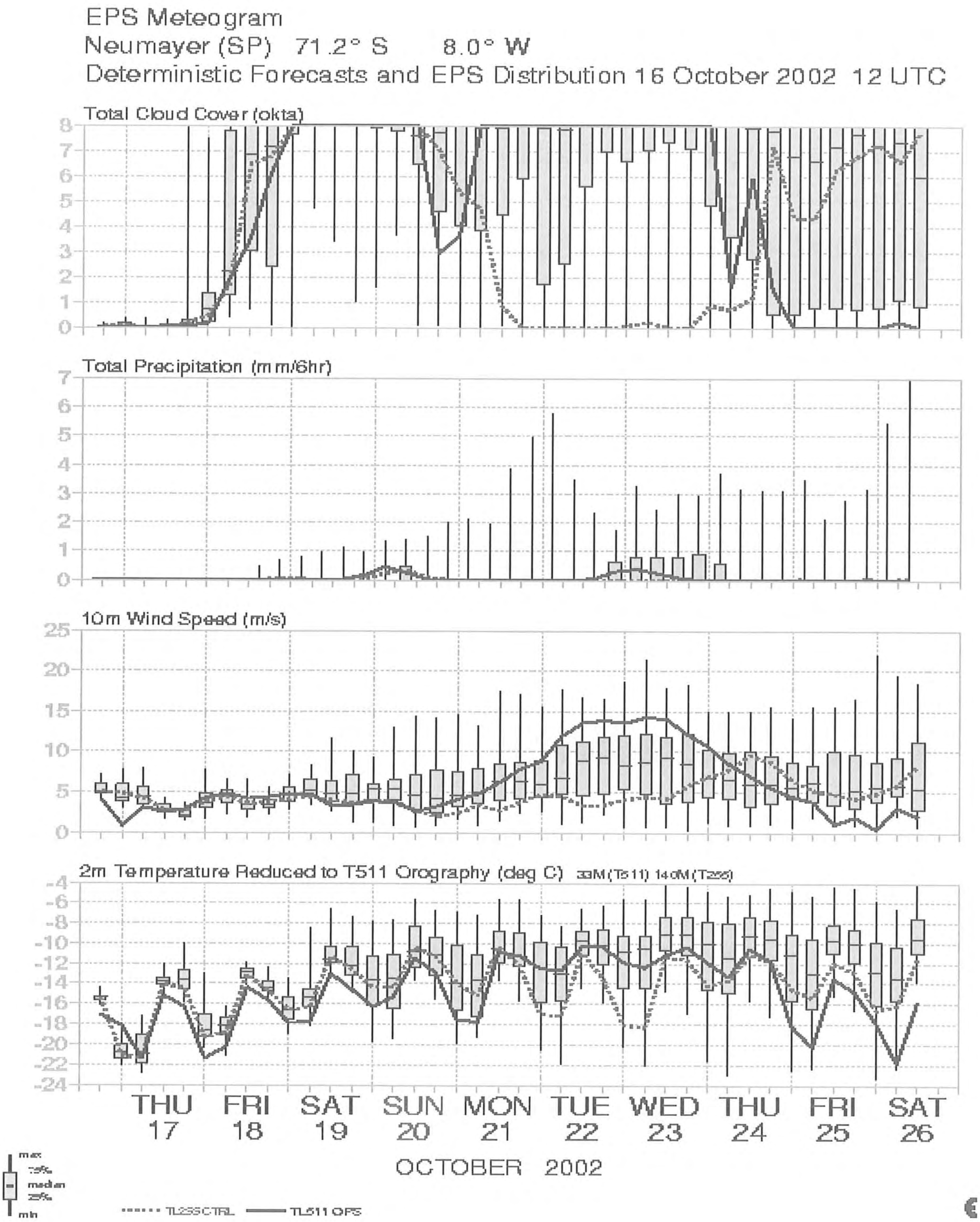


Fig. 3: Example of an EPS meteogram for Neumayer from ECMWF

Available Satellite Pictures

For short-term forecasts and flight-following activities the satellite picture receiving station from Neumayer (HRPT, SeaSpace) is of great importance. Up to 20 satellite passes can be obtained daily (NOAA 12, 14, 15, 16, 17, DMSP 12, 13, 14, and 15). Visual as well as infrared pictures get geocoded automatically on a variety of masters covering the synoptic scale (2500 x 5000 km, Fig. 4) down to local scale with a spatial resolution up 500 x 500 m at any place in the Dronning Maud Land, see Fig. 5.

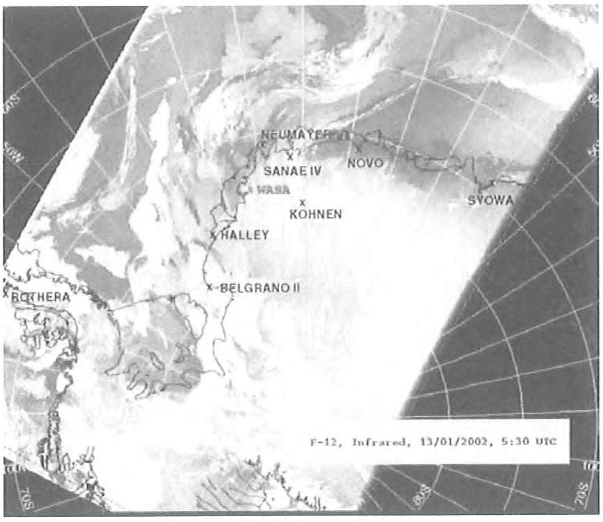


Fig. 4: Full-scale satellite picture

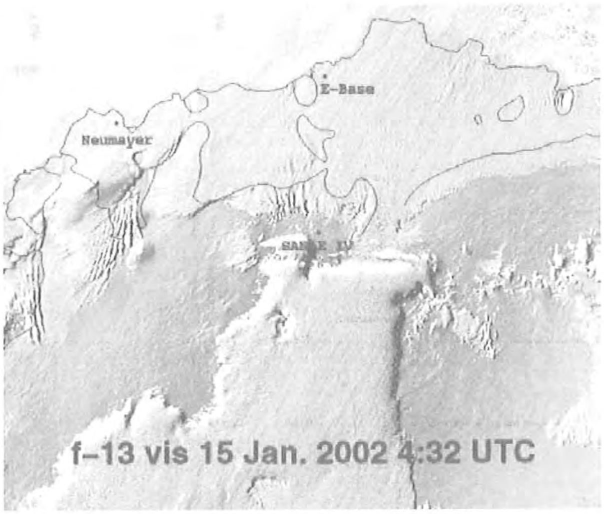


Fig. 5: Local-scale satellite picture

Additional Data

Additional, all information from the Global Telecommunication System (GTS) including the 3-hourly synoptic observations and daily upper air soundings are available via the permanent data link at any time. Information from surrounding automatic weather stations transponding via ARGOS but not included into the GTS get extracted automatically from the NOAA-satellite information.

Forecast Services

Due to many previous voyages on board of the German RV POLARSTERN the forecaster of Neumayer is well experienced with the typical weather phenomena of Antarctica and its surrounding oceans. At Neumayer, the forecaster can be reached at any time from all DROMLAN members by mail, fax, telex, phone, and by short-wave communication. While the forecaster is not at the station his service can be obtained via Iridium. During one summer season typically more than 1500 forecasts gets performed for about 20 different filed parties, ships, stations and especially aircrafts. It is obvious, that this service contribute considerably to increase the safeness of the ambiguous projects going on in the Dronning Maud Land. Furthermore, it helps to reduce weather induced idle times of expensive flight operations to a minimum.

Fig. 6: Iljushin76 at Novo Airbase

Autosub Under Ice: using AUV technology for polar science

K. Collins

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Introduction

Autosub Under Ice is a five-year, £5.86 million programme to explore the marine environment beneath floating ice shelves using Autosub, an autonomous underwater vehicle (AUV). This thematic programme funded by the UK Natural Environment Research Council, brings together oceanographers, glaciologists, biologists, modellers and engineers from fourteen institutions to investigate the role of sub-ice shelf processes in the climate system. AUVs such as Autosub are capable of collecting data from areas that are inaccessible to other platforms such as ships or Remote Operated Vehicles (ROVs). Autosub's science payload includes a CTD, upward- and downward-looking ADCPs, swath bathymetry, sub-bottom profiler, water sampler and digital camera.

Autosub specifications

Dimensions: Length 7 metres, 0.9 metres diameter.

Batteries: ~5,500 D-cell Mn alkaline providing more than 500 km range or 6 days endurance in optimal conditions.

Depth rating: Carbon fibre pressure vessels rated to 1600 metres.

Propulsion: DC brushless motor driving 5 blade propellor with no reduction gearing and seawater lubricated bearings.

Navigation: Bottom or ceiling tracking using doppler log from 150 kHz ADCP with 500 m range. Inertial navigation system provides navigational accuracy of 0.2 per cent of distance travelled.

Standard sensors: Seatex MRU 6 attitude sensor for magnetic heading, pitch and roll. Digiquartz 430 kT 700 bar pressure sensor for depth data. Simrad Mesotech 808 echo sounder with 300 metre range for altitude information and collision avoidance. Seabird SBE9 CTD and 150 KHz RDI ADCPs.

Scientific payload: 1 cubic metre or 100 kilograms in water.

Optional sensors: a variety of commercial and tailor-made packages can be fitted including a fluorometer, transmissometer, oxygen sensor, in situ manganese sensor, flow cytometer, 50 x 0.5 litre water sampler, turbulence probe, additional ADCPs, upward-looking sonars, sidescan sonars, swath bathymetry and digital cameras.

Amundsen Sea, March 2003

Autosub Under Ice has completed one field season at the entrance to Pine Island Bay in the Amundsen Sea on Cruise JR84 of the *RRS James Clark Ross*. As sea ice conditions prevented access to Pine Island Glacier, the cruise focussed on a seabed trough cutting the Amundsen Sea shelf break at 113-115°W – the furthest west the ship had ever been. The trough may be a conduit for warm deep water to reach the ice shelf and hold records of past ice sheet dynamics.

Marine geophysical surveying mapped 10,000 km^2 of seafloor during the cruise - while the oceanographic team conducted a programme of 44 CTD casts. Autosub undertook 18 missions, comprising open water tests and runs beneath multiyear sea ice. The cruise also included work on sea ice floes, before returning to Stanley on 4 April. The AUI newsletter (No.3, Nov. 2003, available at this meeting) reports some initial results from the cruise, with an article on the oceanography of the shelf break by Jenkins et al., details of the marine geophysical work by Dowdeswell *et al.* and sea ice observations by Brandon *et al.*

Greenland, August-September 2004

The next Autosub Under Ice field campaign will form Cruise JR106 of the *RRS James Clark Ross*. Four projects funded by the programme are involved:

Dowdeswell *et al.* (Scott Polar Research Institute, University of Cambridge) - Marine geological processes and sediments beneath floating ice shelves in Greenland and Antarctica: investigations using the Autosub AUV.

Wadhams *et al.* (University of Cambridge, Scottish Association for Marine Science) and Willmott *et al.* (University of Keele) - Observations and modeling of coastal polynya and sea ice processes in the Arctic and Antarctic.

Heywood *et al.* (University of East Anglia) - ISOTOPE: Ice Shelf Oceanography, Transports, Oxygen-18 and Physical Exchanges

Tyler *et al.* (University of Southampton, Southampton Oceanography Centre) - Controls on marine benthic biodiversity and standing stock in ice-covered environments.

The expedition will undertake sea ice and polynya studies off northern Greenland/ Fram Strait (~80-82°N) then target the floating glaciers of Kangerdlugssuaq or Scoresby Sund, depending on conditions, for Autosub missions beneath ice shelves. Autosub will be equipped with some new systems for the Greenland campaign, including a homing beacon system to shepherd the vehicle towards its rendezvous with the ship at the end of missions. The vehicle will also carry a digital camera for seabed photography as part of the biology project. The Autosub technical team undertook trials in May on the shelf edge 180 Nm west of Brest and in June off the Scilly Isles and Plymouth to prove the range of systems that will be deployed in future AUI missions.

Weddell Sea, January-March 2005

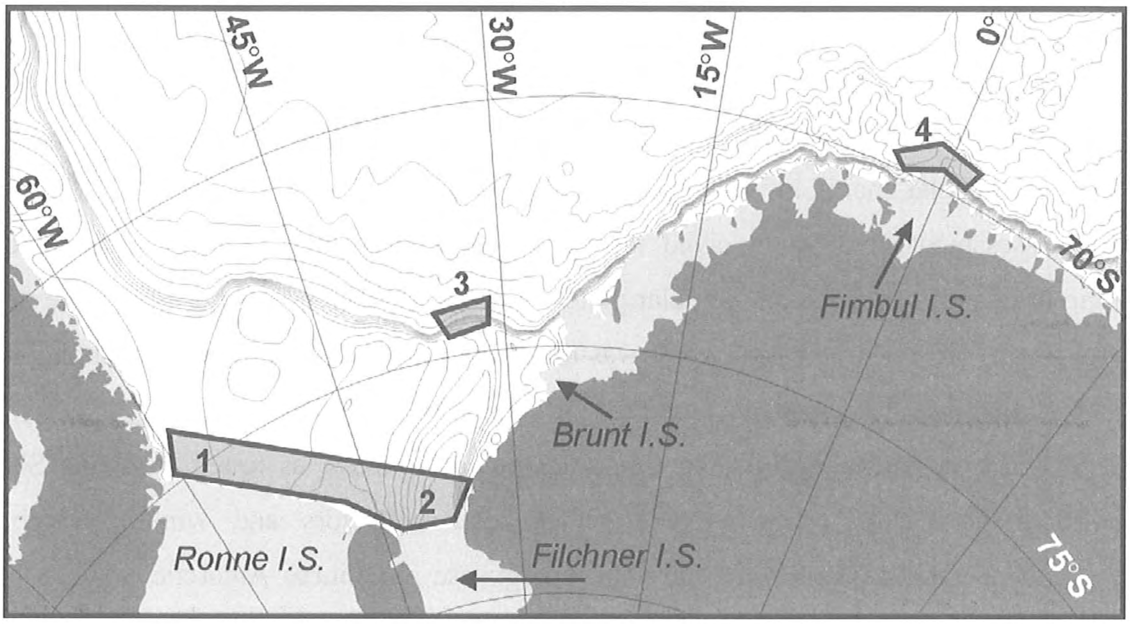
Four of the AUI funded projects will be represented on cruise JR097 of the *RRS James Clark Ross*:

Nicholls *et al.* (British Antarctic Survey , UMIST, UCL), studying processes beneath the north and western Ronne Ice Shelf, linking Autosub data with long term mooring data from boreholes drilled through the ice shelf over the last fourteen years.

Heywood *et al.* (University of East Anglia, POL) will be using Autosub data in combination with ship-based CTD surveys to calculate the rate of melting of different areas of the ice shelf. They also hope to undertake a CTD section along the continental shelf break of the southern Weddell Sea, given favourable sea ice conditions.

Tyler *et al.* (University of Southampton, Southampton Oceanography Centre) aims to study the contrasts in the megabenthos living beneath permanent ice, seasonal ice, and ice-free areas. They will be photographing the seabed from the ship and Autosub, and they hope to do some dredging and bottom trawling.

Wadhams *et al.* (Universities of Cambridge and Keele) studying processes in polynyas (in this case the shorelead in front of Ronne Ice Shelf), and at the northern boundary of the polynya, where frazil ice formed at the sea surface and driven by the wind collects at the edge of the sea ice.



Weddell Sea options for AUI study areas in order of priority

Utilization of solar energy in vehicles operating in Antarctica

Cong Kai[1] and Han Shaoliang[2]

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In 2000 the Chinese Antarctic Research Expedition began an investigation to estimate and assess the use of solar energy in vehicles operating in Antarctica.

The first assessment in 2000 involved testing a new solar power collector in a vehicle operating in inland Antarctica on the polar plateau inland from Zhong Shan Station. The new collector was a vacuum water heater that was metal lined with 150mm pipes. Technological data indicating power output was recorded for the solar power collector.

In the second experiment in 2002 the new solar power collector as tested at Zhong Shan Station and the results compared with other solar collectors and wind generators. Subsequently the potential of wind and solar energy use at Chinese Antarctic Stations has been assessed.

It is proposed to integrate solar energy sources into vehicles that will undertake traverses of the polar plateau in Eastern Antarctica in 2005.

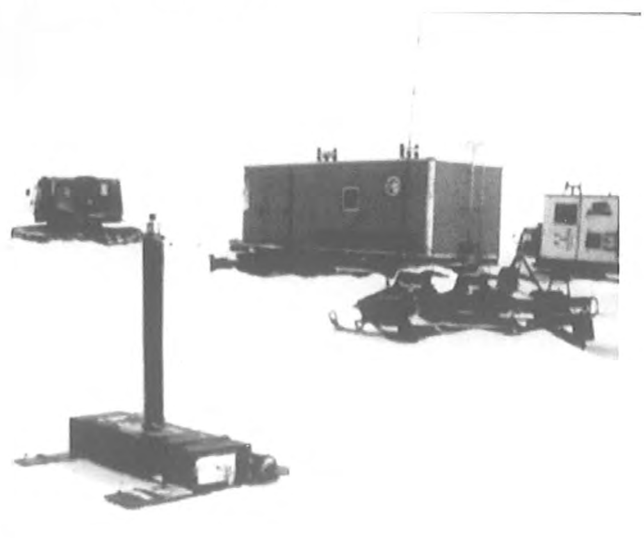


Fig 1: Vacuum Tube solar Energy collector was tested in Antarctica

VACUUM TUBE SOALR ENERGY COLLECTOR WAS TESTED IN ANTARCTICA

DATE	TIME	LATITUDE	LONGITUDE	ELEVATION	WINDSPEED	AIR TEMPERATURE	WEATHER	WATER TEMPERATURE
				M	M/S	•		•
7-Jan-00	21:00	E 75• 09• 28	S 72• 54•	2100	6.0	-15.0	cloudy	22.0
7-Jan-00	22:00	E 75• 09• 28	S 72• 54•	2100	8.0	-16.5	some sunshine	30.0
7-Jan-00	23:00	E 75• 09• 28	S 72• 54•	2100	7.0	-17.5	clear sky	34.3
8-Jan-00	0:00	E 75• 09• 28	S 72• 54•	2100	6.0	-18.5	clear sky	34.8
8-Jan-00	1:00	E 75• 09• 28	S 72• 54•	2100	6.0	-19.5	some sunshine	34.5
8-Jan-00	2:00	E 75• 09• 28	S 72• 54•	2100	7.0	-20.5	cloudy	34.0
8-Jan-00	3:00	E 75• 09• 28	S 72• 54•	2100	8.0	-21.0	snow	33.5
8-Jan-00	4:00	E 75• 09• 28	S 72• 54•	2100	9.0	-21.0	some sunshine	33.0
8-Jan-00	5:00	E 75• 09• 28	S 72• 54•	2100	9.0	-21.0	some sunshine	34.0
8-Jan-00	6:00	E 75• 09• 28	S 72• 54•	2100	10.0	-21.5	some sunshine	36.7
8-Jan-00	7:00	E 75• 09• 28	S 72• 54•	2100	11.0	-21.0	some sunshine	39.7
8-Jan-00	8:00	E 75• 09• 28	S 72• 54•	2100	12.0	-20.5	clear sky	47.5
8-Jan-00	9:00	E 75• 09• 28	S 72• 54•	2100	11.0	-19.8	some sunshine	53.5
8-Jan-00	10:00	E 75• 09• 28	S 72• 54•	2100	12.0	-18.5	cloudy	60.6
8-Jan-00	11:00	E 75• 09• 28	S 72• 54•	2100	13.0	-18.0	cloudy	68.8
8-Jan-00	12:00	E 75• 09• 28	S 72• 54•	2100	13.0	-17.0	cloudy	78.1
8-Jan-00	13:00	E 75• 09• 28	S 72• 54•	2100	13.0	-16.0	some sunshine	86.8
8-Jan-00	14:00	E 75• 09• 28	S 72• 54•	2100	13.0	-15.5	some sunshine	93.0

It was tested in Grove Mountains of Antarctic at Chinese field huts.

The inter liner has a capacity of 25 liters

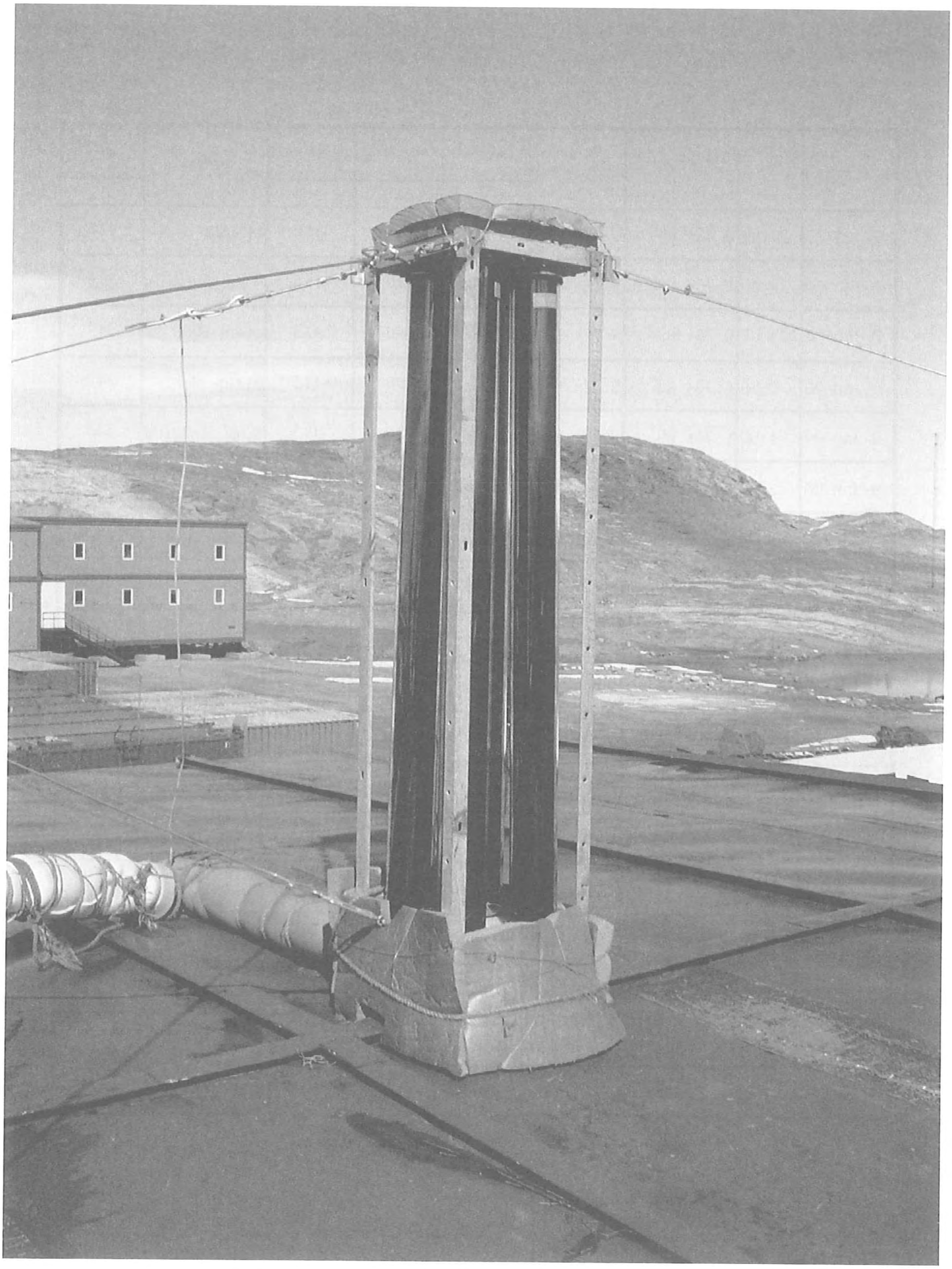
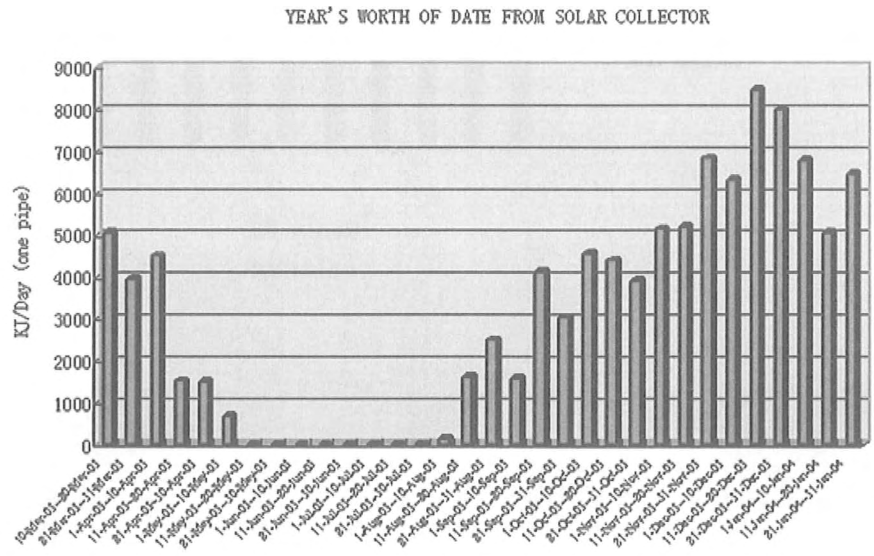
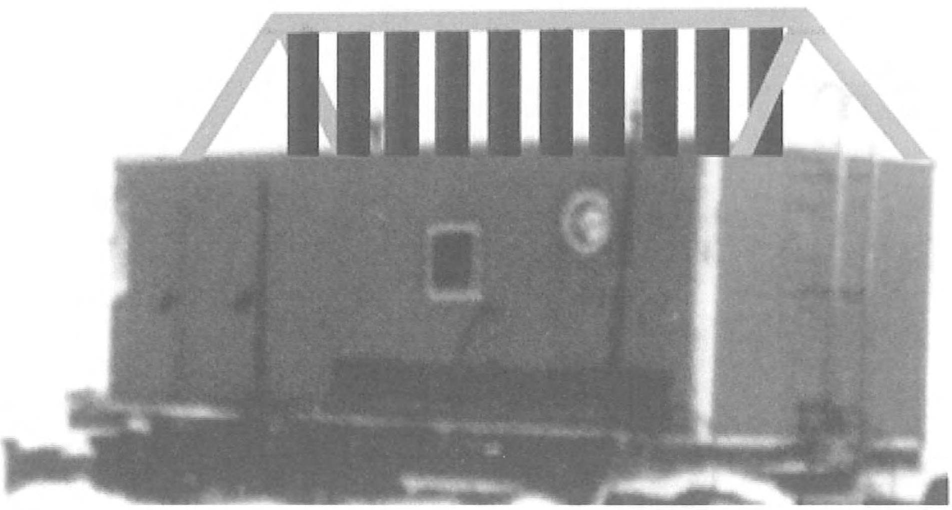
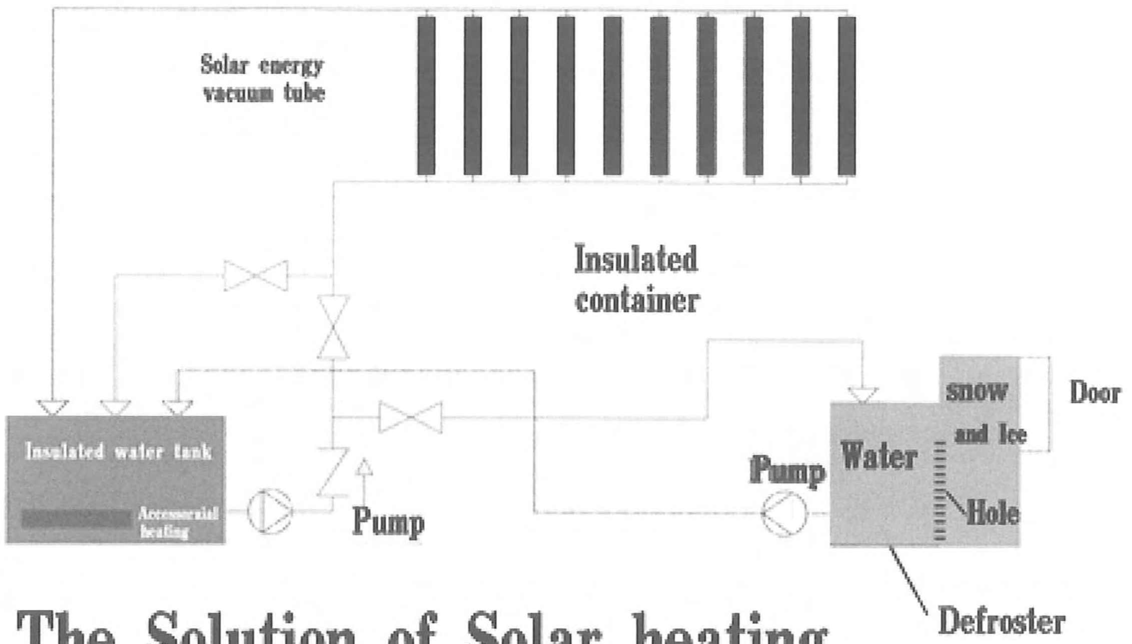


Fig 2: Vacuum Tube solar Energy collector was tested in Antarctica ZHANSHAN STATION



Here is a year' s worth of date from the vacuum tube solar energy collector as tested at ZhongShan Station in 2003.





The Solution of Solar heating system for product drinking water in the traverse vehicle

Oil spill contingency plans for Chinese Antarctic Stations

Cong Kai[1] and Wu Jun[2]

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Abstract

Chinese Antarctic Research Expedition has taken steps to develop an Oil Spill Contingency Plan to prevent hydrocarbon contamination of station environs and operational areas.

In 2002 experiments were conducted using dispersing agents, oil spillage shrinking agents and oil spillage treating concentrating agent at Zhong Shan Station. It is proposed to use these products if accidental spills occur.

By 2005 it is proposed to enclose fuel tanks and fuel pumping equipment in a reinforced concrete compound. Additionally oil absorbent booms and pillows will be installed at Chinese stations.

Oil waste and contaminated ground will be collected and that which cannot be incinerated will be returned to China for disposal.

Brief Introduction

This poster will illustrate the details of the Oil Spill Contingency Plan.

1. This purpose of this plan is to reduce loss and damage resulting from oil spills and keep station environs pollution free thus protecting the Antarctic environment.
2. Prevention of marine pollution has been the subject of recommendations of the Antarctic Treaty Consultative Parties, in particular Recommendation XV-4 and Annex IV of the Madrid Protocol. Most of the requirements are consistent with MARPOL with which China is obliged to comply.
3. This contingency plan covers the facilities enclosed by the station limits shown on the station area map It is not anticipated that other nations will become involved in the management of this plan unless assistance is accepted from shipping of those nations or

damage to a vessel of their flag that occurs at or near Chinese station and specialised equipment relating to that vessel is needed. It does not including plans for vessels carrying oil because Chinese vessels have separate oil spill contingency plans.

4. Potential risks at Chinese stations are identified as follows;

(a) bulk fuel farm,

(b) fuel pump station,

(c) power house and fuel settling tank and

(d) boiler house and fuel settling tank.

5. In future years (2005-2006) the following items are planned;

(a) buildings to enclose bulk fuel tanks and fuel pumping equipment in a reinforced concrete compound and

(b) flowdrum skimmer or flowmop skimmer and peristaltic pump.

6. Response equipment and materials will include;

(a) oil absorbent booms and pillows,

(b) oil dispersing agents, oil spillage shrinking agents,

(c) oil spillage treatment concentrating agent,

(d) pipes and pumps and

(e) emergency storage tank.

These will be stored in the fuel pump station, power house and garage.

7. Any clean up of oil spills will, to the maximum extent practicable, be collected by nets or other machines to minimise using oil dispersing agents.

8. The Chinese Arctic & Antarctic Administration will be the combat Authority responsible for the combat of a pollution incident. The Station leader will act as the On Scene Coordinator (OSC). The Specific duties of the OSC are;

(a) assess the spill and its potential impact,

(b) determine the priorities for protection,

(c) determine the level of response and scale of the response,

(d) ensure that safety equipment being used is correct,

(e) initiate and direct response measures and ensure that clean up and disposal activities meet the environmental requirements,

(f) ensure that situation reports are provided to the Chinese Arctic & Antarctic Administration,

(g) maintain a record of all consumable materials used in the response activity and

(h) supervise the clean-up and return of equipment.

9. The Specific duties of the Deputy Leader are;

(a) provide advice and recommendation to the Station Leader,

(b) participate in the clean-up and advise the Station Leader on progress of the clean up,

(c) ensure safety of personnel and

(d) participate in the debriefing process and co-ordinate the incident report.

10. The Station Environment Officer must participate in clean-up and;

(a) note the initial and potential extent of the spill,

(b) record the measures employed to control it and

(c) maintain an ongoing assessment of the environmental impact of the spill.

11.The Power Chief, Mechanic, Plumber and Plant Inspector will:

(a) bring the source of the spill under control and direct equipment deployment to meet the Station Leader's strategy and

(b) supervise the transfer of equipment and direct its use.

12. The person first discovering the oil spill must immediately halt source of spill if possible and if it is safe to do so report the spill to station leader or if unavailable to the Deputy Station leader or Station Environment Officer by telephone or VHF. All oil spill in excess of 50 litres must be reported to the Chinese Arctic & Antarctic Administration.

13. All expeditioners will undergo a training exercise before go to Antarctica including;

(a) an introduction to oil spills in Antarctica,

(b) types of oil and their physical and chemical characteristics,

(c) the Oil Spill Contingency Plan and

(d) equipment types and their use.

14. Oil waste and contaminated ground will be collected and that which cannot be incinerated will be returned to China. Final disposal will be arranged through the reception centre in Shanghai.

References

Protocol on Environmental Protection to The Antarctic Treaty 1991

Guidelines for Oil Spill Contingency Planning 1992

Marine Environmental Protection Law of the People's Republic of China 1982

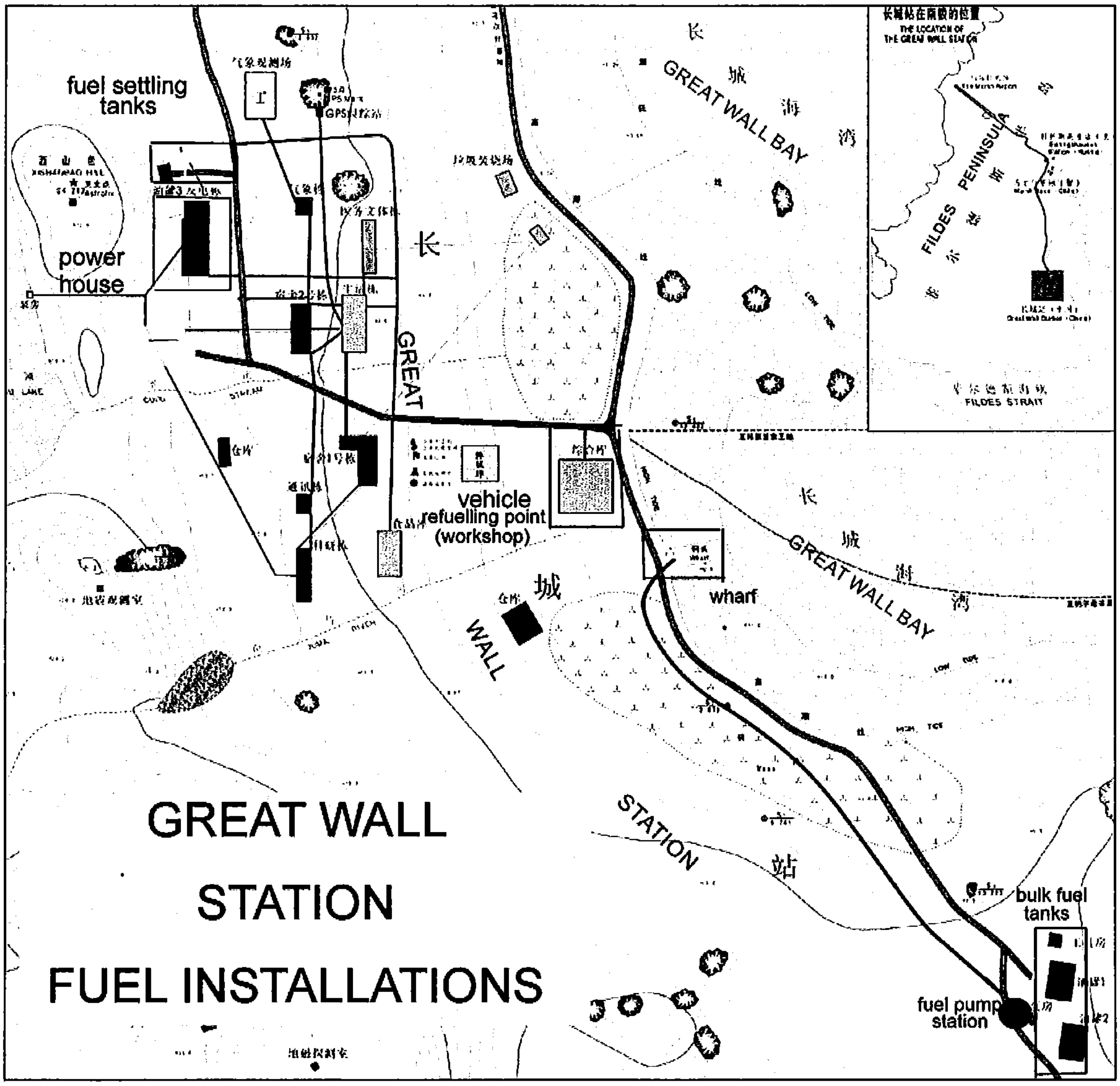


Fig 1 Chinese Great Wall Station Map

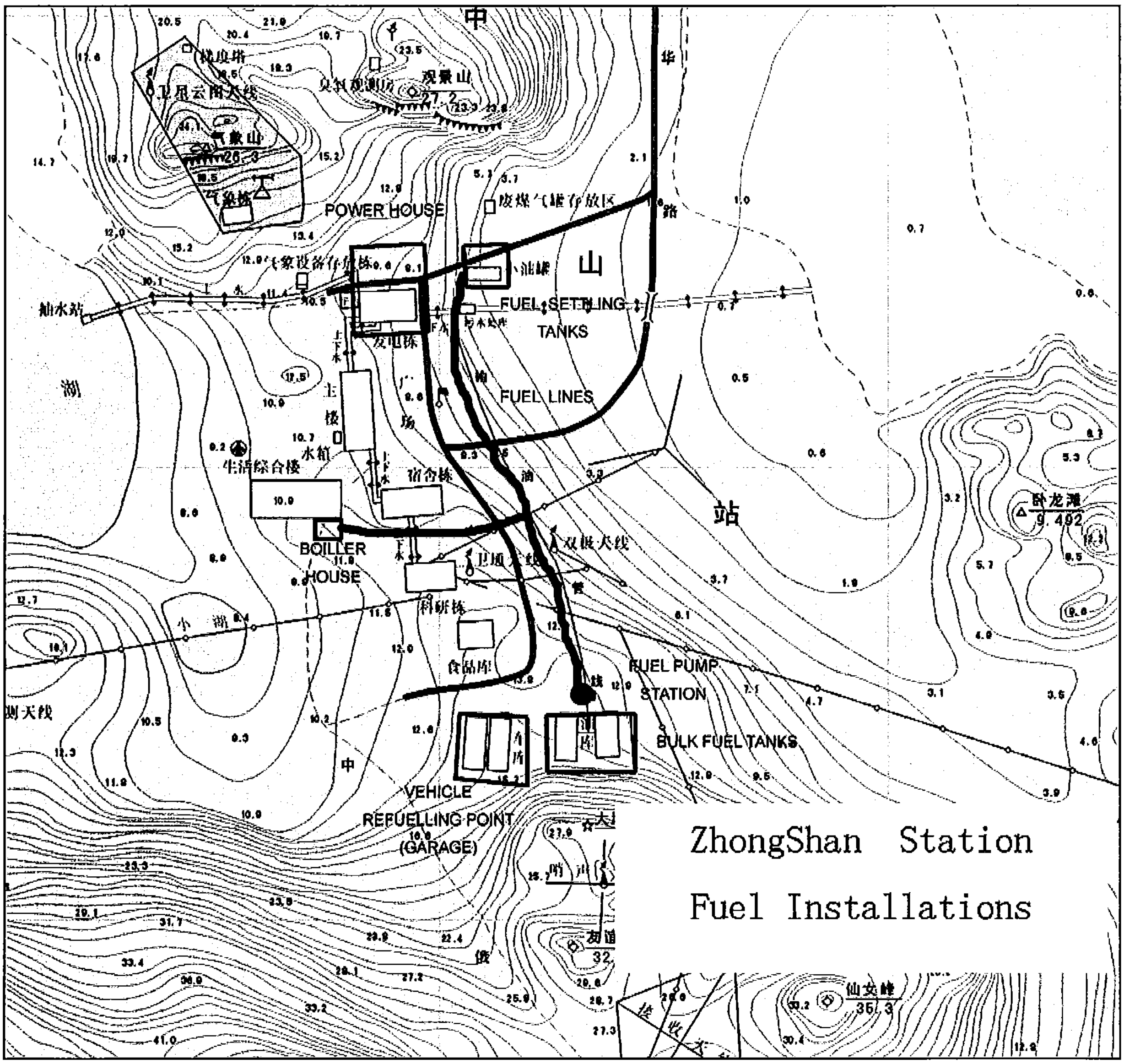
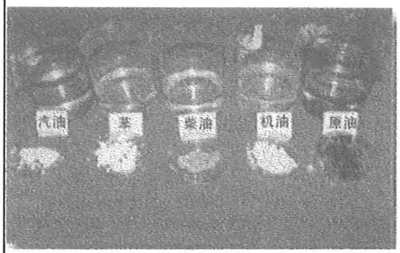


Fig 2 Chinese Zhong Shan Station Map

OIL SPILLAGE TREATING AGENTS



BRIEF INTRODUCTION

Oil Spillage Treating Agents include two products: Shrinking Agents （SA）and Concentrating Agents （CA）.
SA:Liquid, Organic Compound.
CA:Powder-like Compound.

BASIC THEORY

SA, by reducing water surface tension, makes spilled oil film contract then controls the spreading direction or reduce the spilled oil's area. CA can turn oil into floating solid or semisolid material in 5-10 minutes which can be easily collected by nets or other machines.

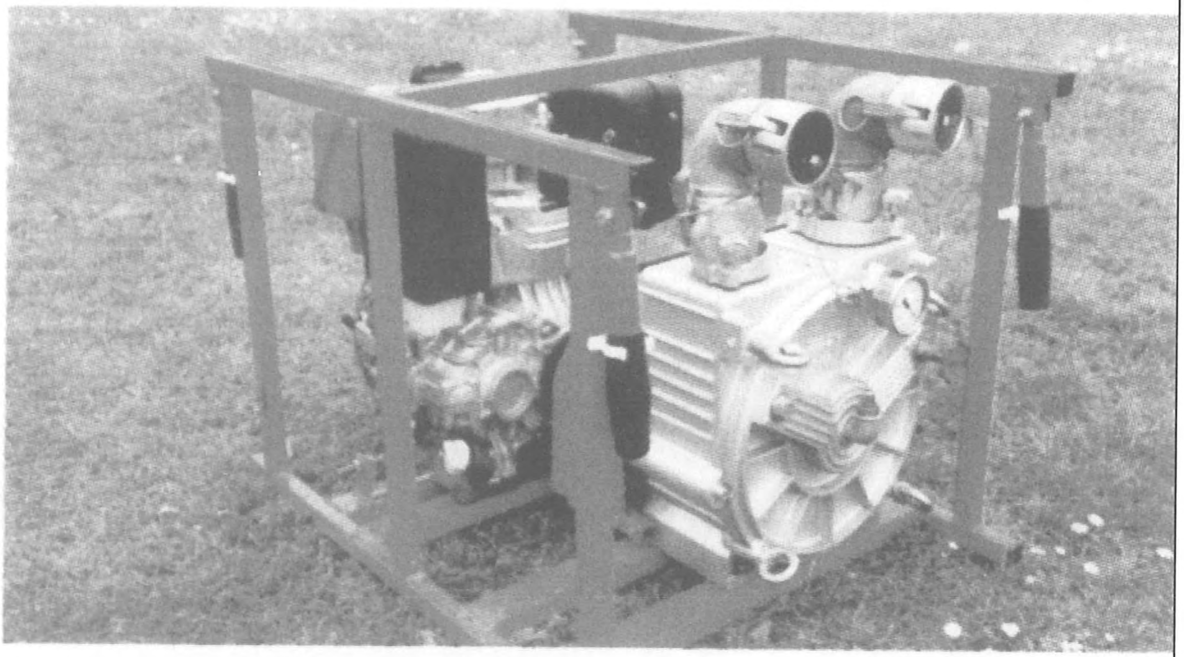
FEATURES

1.The shrinking of SA is fast(<5mins)and lasts long. After SA being added,the oil area can be reduced to 30% of its original size in 72hrs;the solidification time of CA is short (5~10mins) and is suitable for a wide range of oil, such as all kinds of mineral oil, vegetable oil,benzene,etc.
2.Unsolvable in oil or water ;becoming solid state after reaction with spilled oil which can be easily separated from water.
3.Safe and innoxious;Easily be decomposed;Without causing second pollution,belongs to Green Products.
4.Easily be produced and be used.

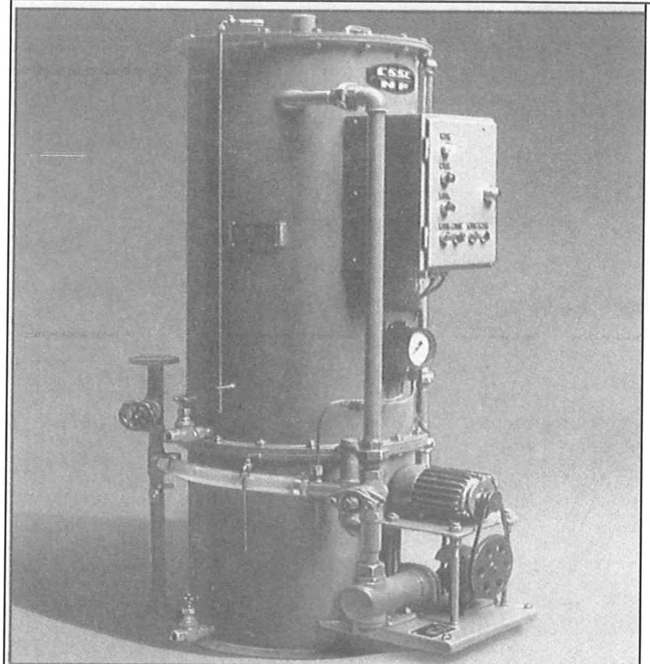
Main uses of the products

1.Reclaiming agents for oceanic oil spill incidents;
2.Treatment of wastewater from harbors,docks and ship plants;
3.Treatment of wastewater from drilling platforms;
4.Treatment of wastewater from oil fields, oil refineries and synthetic resin plants;
5.Treatment of other oil-containing industrial wastewater;
6.Treatment of vegtable oil, benzene and other oleo-matters.

Fig 3 Response equipment and materials



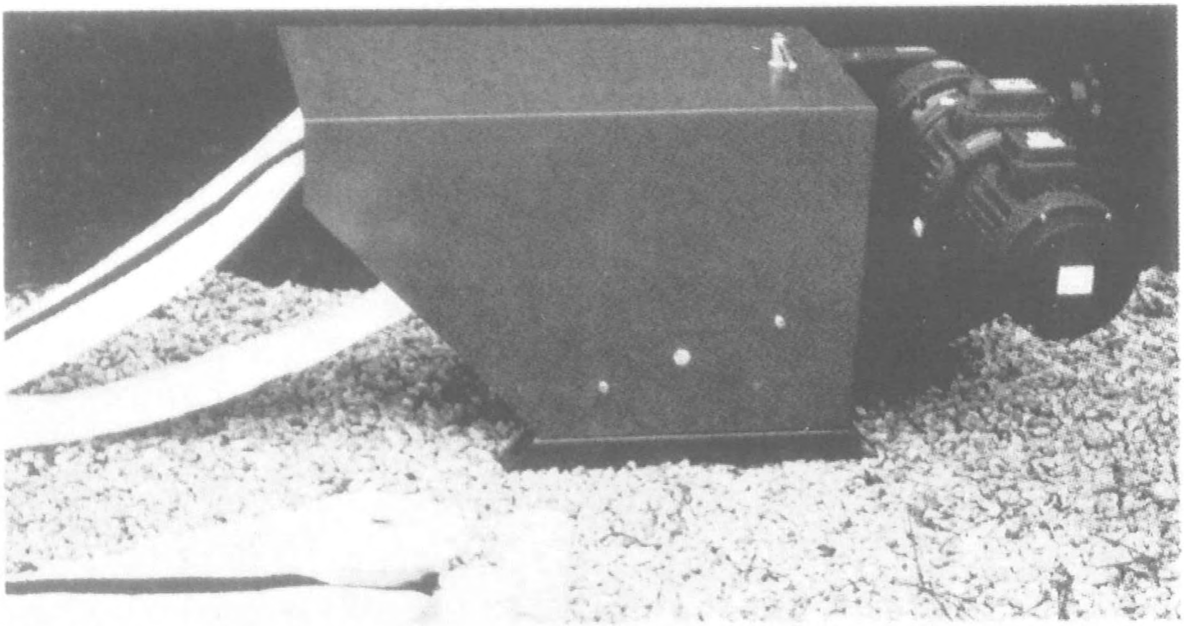
Peristaltic Pump



C Y S C-0.5 油水分離器

CYSC-0.5 oily water separator

Fig 4 Response equipment and materials



Rope Mop Skimmer

Oilsorb-Ultra Absorbents

Fig 5 Response equipment and materials

New Chinese Antarctic Station Wastewater Treatment Plant

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Chinese Antarctic Research Expedition has decided to upgrade the wastewater treatment plant at Zhong Shan Station. The upgrade was considered necessary because:

1 The current treatment plant at Zhong Shan Station discharges to the intertidal zone and consequently at times not directly to the ocean.

2 While the current disposal system meets the requirements of the Antarctic Treaty guidelines it does not comply with Chinese disposal standards.

The new sewage treatment pant will divide waste into 'black' water (faces, urine, kitchen wastewater) which will be treated such that there will be no disposal to the ocean and 'gray' water which will be sterilized and discharged to the ocean by a submarine pipe.

The selected treatment technology involves new membrane separation and intermediate water circulating technology. This technology has been very successful in China and has become a popular method of treatment. The technology has many advantages including energy savings and operating at room temperature.

The new treatment system will significantly improve ocean water quality in the near shore and ocean waters in the vicinity of Zhong Shan Station. It is proposed to ship the treatment plant to Zhong Shan Station in December 2005 and commission the plant in 2006.

Membrane Bioreactor (MBR) Module

The Membrane bioreactor (MBR) is a recent but increasingly utilized technology for treating municipal and high organic industrial wastewater by combining the highly efficient separation technology of hollow fiber membranes within a compact activated sludge process.

Flat plat PVDF based MF membrane is the optimum choice for system designers and end users alike for continuous immersion in activated sludge.

The liquid-solid separation by membrane replaces the conventional settling process and effectively removes suspended and organic solids producing bacteria tree water.

MBR allows for the activated sludge to be maintained at much higher levels of mixed liquor suspended solids (MLSS) than conventional systems and because of the membrane interface, bacteria are retained longer within the activated sludge enhancing the decomposition of the organic matter.

MBR is a modern, highly effective water treatment system that can deal with the ever increasing demands of municipal wastewater quality and increasing treatment volumes.

MBR is another easy to operate, automatic, modular based treatment process delivering the following benefits:

- Allows 50% footprint saving over conventional treatment systems
- Can maintain a high MLSS (<15g/L) & long sludge retention time (<60days)
- Consistent effluent quality with varying influent conditions
- Less sludge production and reduced disposal costs
- Low energy consumption and simple membrane cleaning delivers low operational cost

Hollow fiber MEMBRANE & modules

中空纤维膜及其组件

MOTIMO manufactures modules of hollow fiber UF and MF membrane using PS, PES, PAN, PE and PVDF. Membrane pore size ranges from 0.01 to 0.2 microns. **MOTIMO**'s technical advantage lies with the development of their PVDF (polyvinylidene fluoride) fibers that have key advanced properties which:

我公司制造各种材质、规格和用途的中空纤维型超滤膜和微滤膜组件，材质为PS、PES、PAN、PVDF、PE等，过滤孔径从0.01 ~ 0.2 μm，规格从实验型到大型工程所需的应用型膜组件。其中最具竞争力的是PVDF膜产品，该产品具有以下特性：

- Increases resistance to oxidative chemicals used to limit bacteria
  耐氧化性清洗
- Improves anti-fouling , allowing high flux
  抗污染，通量高

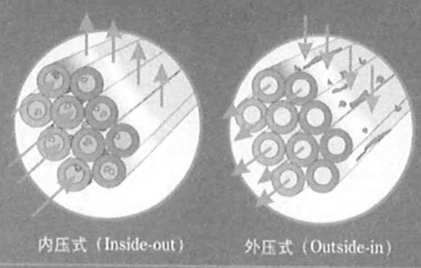
This results in the following benefits:
因此，该产品具有如下优势：

- Pollutants more easily removed
  易清洗
- Longer membrane life
  使用寿命长
- Reduced operating costs & maintenance
  运行费用低廉、易维护

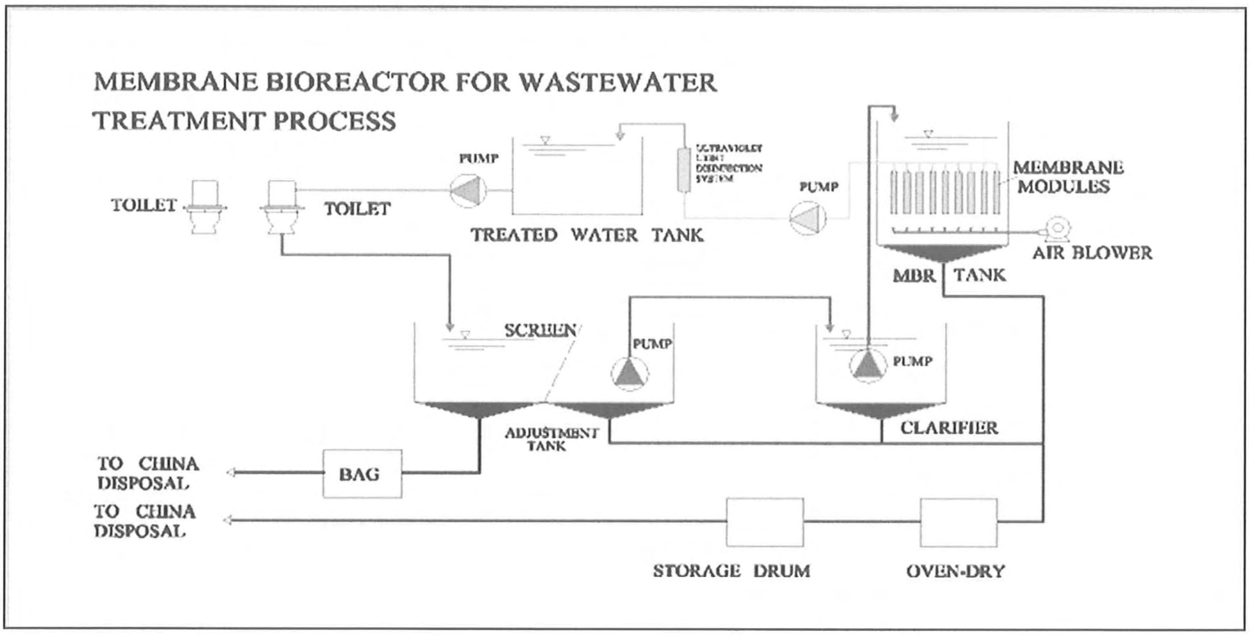
MOTIMO's membrane technology is widely used for filtration solutions in the following fields:
我公司的膜技术广泛应用于解决以下领域的净化、过滤、分离问题：

- Recycling and treatment of municipal & industrial wastewater
  市政、工业废水的处理、回用
- Purification of drinking water, ground and surface waters
  饮用水、地下水、地表水净化
- Pretreatment for large scale Reverse Osmosis systems
  大型RO系统的预处理
- Concentration, separation and clarification of liquids in biopharmaceutical, foodstuff and beverage processes
  生物、制药、食品、饮料等领域的料液浓缩、分离、澄清

中空纤维膜过滤方式
Hollow fiber membrane filtration methods

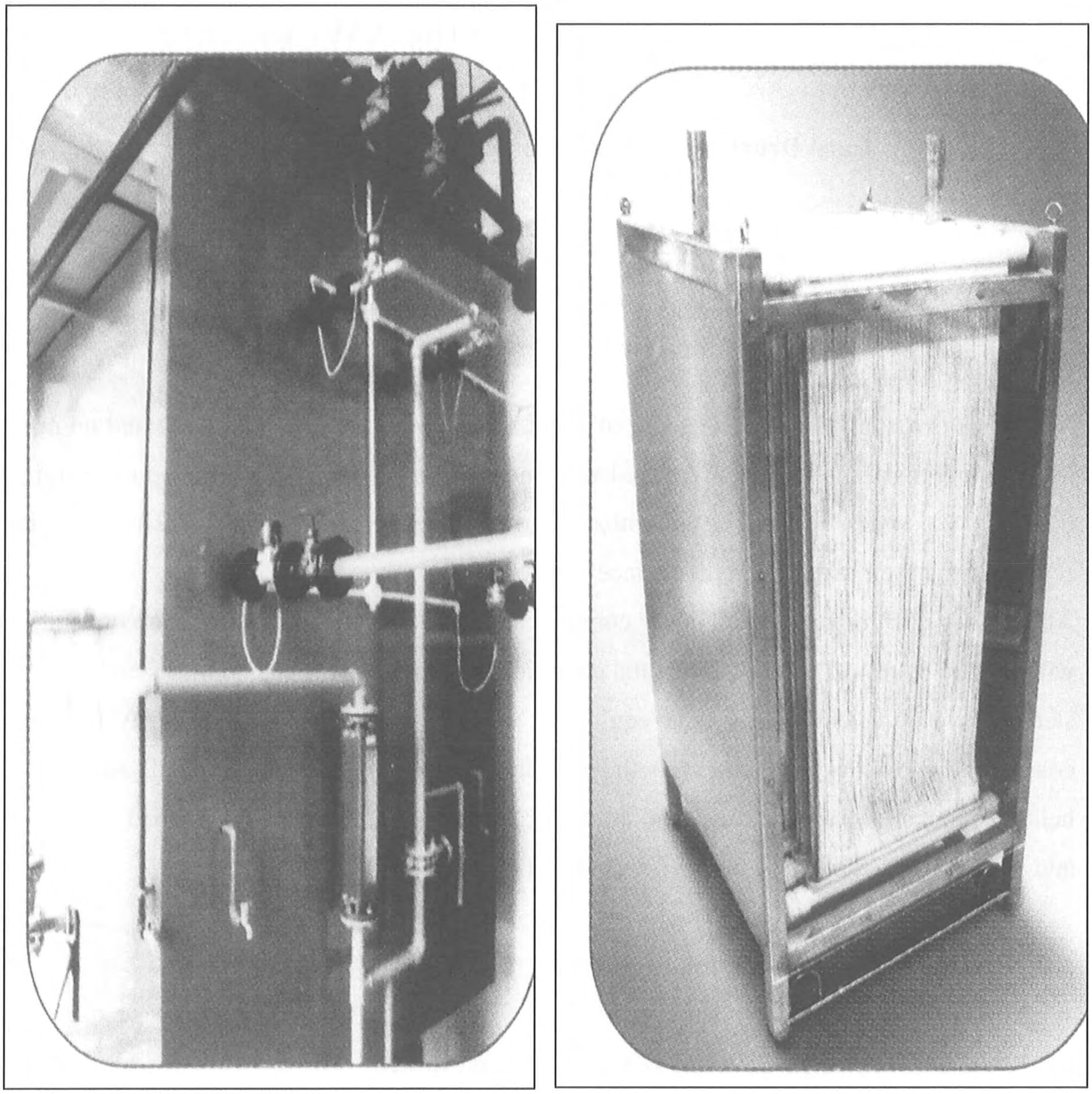


MBR module



	CODcr (mg/L)	BOD5 (mg/L)	SS (mg/L)	NH3-N (mg/L)	Faecal coliforms (cfu/100mL)
Sewage	≤450	≤250	≤200	≤25	
Effluent quality	≤20	≤5	0	≤1	≤3

MBR operating system



Typical MBR operating system and module

Surface Transport Logistics of the AWI in Antarctica

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Summary

Antarctica is a continent with a square of about 13660 km2. There are no roads and no rails. More than 99% of the surface is covered with snow. Human activities are limited to scientific purposes. For access to sites in the outback and for investigations along routes mobility for scientists and their material on the surface is essential.

Alfred Wegener Institute (AWI) uses commercial vehicles and adapted them in cooperation with manufacturers to the environmental conditions of Antarctica. These vehicles and specific sledges provide scientists and their equipment with mobility. Locations far away from the coast can be reached and bases on the inland ice can be built and supplied. Aircraft or helicopters cannot transfer large amount of cargo over long distances due to bad efficiency and low infrastructure (missing airports and fuel depots).

AWI uses track vehicles of the following types:

- 2 Chieftain made by Canadian Foremost
- 30 Ski Doo Alpine (Type II and III) made by Bombardier
- 7 Pisten Bully PB 260 made by Kässbohrer
- 4 Pisten Bully PB 300 same manufacturer

and the following sledges

- 80 Container sledges for payloads up to 25 to
- 35 Nansen Sledges for payloads up to 550 kg

The vehicle fleet of AWI is located at Neumayer Station (70°39'S, 008°15'W) the permanent base in Antarctica. One Kässbohrer Pisten Bully 260 and two Ski Doo Alpine II are stored in the snow garage at Kohnen Station (75°00'S, 000°04'E). Storage temperatures during winter in an altitude of 2900 meter are - 70° C and lower.

Track Vehicles

Chieftain

Both Chieftains were purchased in 1980. In 1986 Mercedes Benz engines replaced the Detroit Diesel Engines in Bremerhaven. Since then they serve at Neumayer Station with their powerful hydraulic cranes for construction works. For very heavy loads (e.g. loaded 20 ft container) sometimes both cranes are used parallel. Their towing capacity is limited due to the high ground pressure. Users have to be trained and use is limited to the technical and construction crew at Neumayer.

Specifications:

Dimensions:	9.9 X 3.2 m
Weight:	19.5 to
Max. Payload:	13.0 to
Ground Pressure empty:	0.15 kg/cm^2
Crane Capacity:	3.6 to at range 3.1 m and 0.6 to at range 10 m
Crane Torque:	11.1 to 1.0 tm

Ski Doo

Their age is between 1 and 15 years. They are working not only in Antarctica but also in Greenland, Spits Bergen, Siberia, or other snow covered areas. All expedition members use them after instruction for quick transport of persons and/or material. Some traverses were also performed with these vehicles. Traverses that depart more than 500 km (depending on the amount of scientific equipment carried along) from the logistic base need fuel support by heavy vehicles or by air. Both types are able to work even in very soft snow. 8 vehicles of the type Alpine III are located at the winter over Base Neumayer. 2 or 3 of them are exchanged per season and overhauled in Bremerhaven. . All other Ski Doo have maintenance and overhaul at the end of the project they have worked for.

Two vehicles of type II are located at the summer base Kohnen. They have to withstand storage temperatures down to -70°C.

Specifications

Alpine III:

Dimensions:	3.0 X 1.3 m

Weight:	320 kg
Horsepower:	50 hp
Max. Payload:	120 kg
Ground Pressure empty:	0.03 kg/cm^2
Max. Towing capacity:	2 loaded Nansen Sledges each max. 500 kg
Fuel consumption:	0.4 l/km

Alpine II:

Dimensions:	2.8 X 1.2 m
Weight:	310 kg
Horsepower:	40 hp
Max. Payload:	100 kg
Ground Pressure empty:	0.025 kg/cm^2
Max. Towing capacity:	2 loaded Nansen Sledges each max. 500 kg
Fuel consumption:	0.3 l/km

Pisten Bully

Pisten Bullies are originally designed by Kässbohrer Geländefahrzeuge AG www.pistenbully.com to prepare ski slopes for tourist purposes . These machines move large amount of snow with its dozer blade and prepare the snow surface as desired with the snow miller at its rear end. This work has to be done on steep slopes downhill as well as uphill.

Since Pisten Bullies are used in Antarctica many modifications were made by the manufacturer and AWI to adapt them to the needs of polar research and the Antarctic environment. AWI uses two types of these vehicles

Specification

Pisten Bully 260:

Dimensions:	5.6 X 4.2 m
Dimension with front blade:	6.5 X 4.2 m
Weight:	7200 kg
Horsepower:	260 hp
Ground Pressure empty:	0.055 kg/cm^2
Max. Towing capacity:	2 loaded Container Sledges
Fuel consumption:	3.5 l/km with full load

Pisten Bully 300:

Dimensions:	5.9 X 4.2 m
Dimension with front blade:	6.8 X 4.2 m
Weight:	7500 kg
Horsepower:	330 hp
Ground Pressure:	0.056 kg/cm^2
Max. Towing capacity:	3 loaded Container Sledges
Fuel consumption:	4 l/km with full load

Four vehicles are equipped with hydraulic cranes of the Type Partek 090. They are able to lift loads with 1700 kg to at a range of 4 m and 360 kg at a range of 12 m.

Basic modifications on Pisten Bullies for use in Antarctica:

- mounting tow hooks for pulling heavy sledges
- installing autonomous (fuel) and electric (220V) preheaters for lubricants and coolant
- mounting hydraulic cranes for lifting cargo
- mounting passenger cabins for shelter and safety and scientific equipment
- mounting roof hatches on the drivers cabin for safety reasons
- installing communication and navigation equipment
- Replacement the standard hydraulic fluid one that is biological degradable according CEC-L-33-A-93 and has lower viscosity.
- Replacement of some of the hoses fitting to the different hydraulic oil.

Trained persons drive Pisten Bullies, technicians of the winter crew have a one-week training in operation and maintenance by the manufacturer.

Sledges

Container sledges:

The cargo transport system of AWI for sea transport as well for the supply of bases and for traverses is based in general on different kind of ISO Norm 20 ft Container units. AWI does not use 40 ft Container in Antarctica. Different kinds of Containers are in use:

- General purpose Container for all kind of boxes and equipment.

- Reefer Container for provisions (+5°C and -20°C) and ice cores on the way back home (-25°C).
- Tank Container with up to 22 m^3 capacity for fuel and other liquids (e.g. drilling liquid).
- Caravan Container for accommodation, cooking and communication.
- Platforms with 20 ft size for construction material with excess length.
- Laboratory container for specific scientific projects.

With this system complete resupply of Neumayer Station including fuel supply and waste disposal can be done in two days. Therefore all heavy sledges are able to take theses standard units to minimise time consumption at the interface sea transport / terrestrial transport. The sledges are build by different companies according drawings. Actual manufacturer is Lehmann Maschinenbau, Jocketa, Germany. www.lehmann-jocketa.de .

Specifications

Dimensions of sledge:	8.2 X 2.6 m incl. drawbar.
Dimension of load platform:	6.1 X 2.6 m
Weight:	3700 kg
Max Payload:	25000 kg
Ground Pressure empty:	0.055 kg/cm^2
Ground Pressure full loaded:	0.42 kg/cm^2

ISO Norm 20 ft units are lashed with 4 twist locks on the sledges. Instead of a 20 ft Container also 48 standard 200 l drums (0.6 m diameter and 0.9 m height) fit on the platform. The sledges may be equipped with gates for drums and conventional cargo.

Nansen Sledges

G. Fossum Skifabrik in Minnesund, Norway builds Nansen Sledges. It is a typical historical development. The sledge was modified by many users since more than 100 years under many different circumstances but never designed by an engineer. With a weight of 50 kg and a payload of 500 kg the ratio of weight / payload is excellent. They are available in different widths (0.6 m and 0.8 m) and different length (2.7 m and 3.6 m). AWI uses these sledges for quick transportation of persons and/or small amount of cargo and on traverses towed by Ski Doo.

Traverses

Traverses are made for transfer of large amount of cargo over long distances and/or for scientific investigations along a route or on a grid net. Efficient traverses are absolutely necessary for erecting and running a base on the Plateau of the Antarctic Ice Sheet.

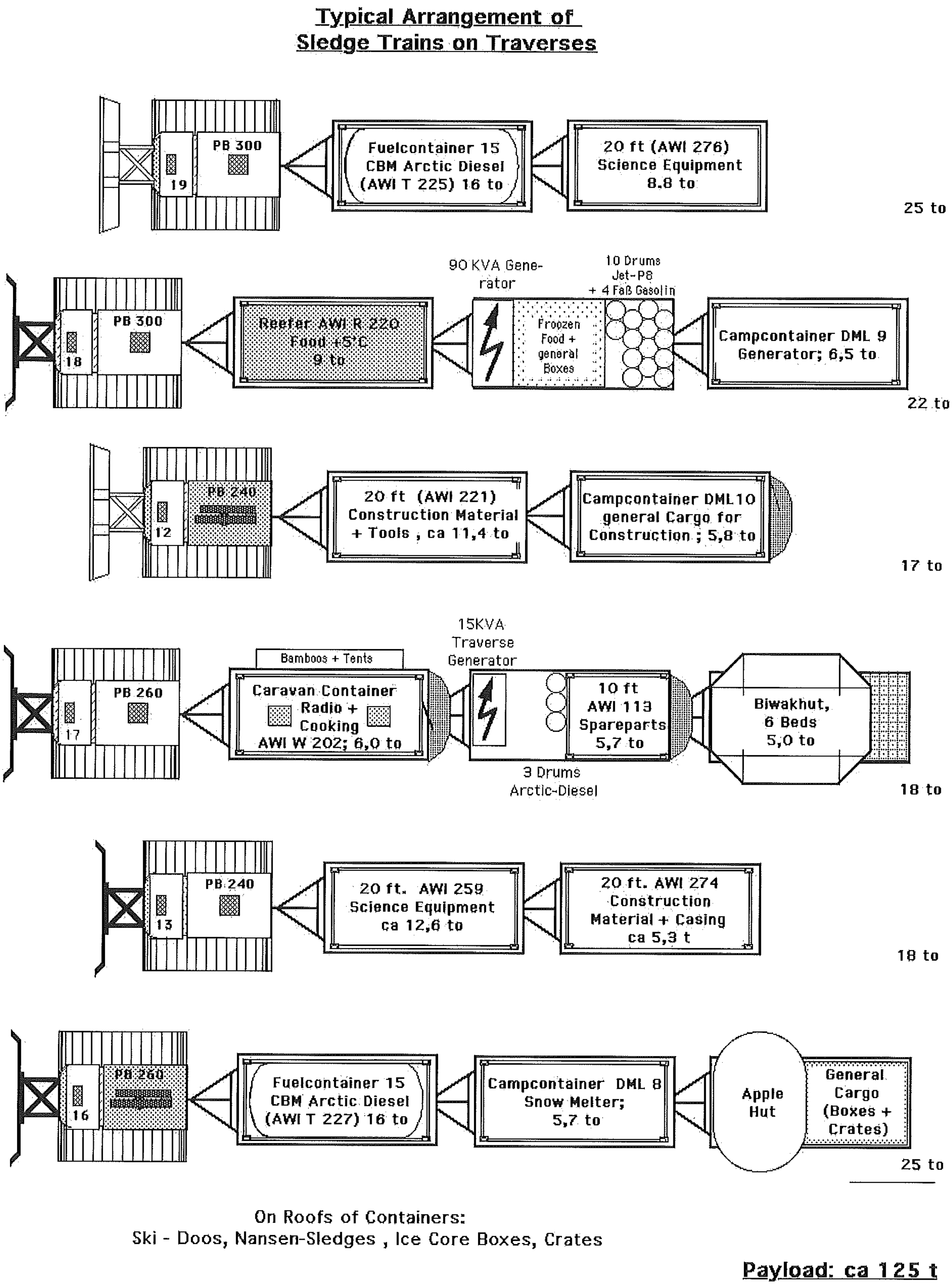
First AWI traverses took place in 1986 to Heimefront Fjella some 500 km south of Neumayer Station for geological and geophysical investigations. Since 1998 AWI has built and is now supplying the Kohnen Station at regular intervals some 750 km south of Neumayer (see map in Figure 1). Annually between 150 t and 200 t are transferred from the coast to the inland ice with two traverses to an altitude of 2900 m ASL. More than 50 % of this mass is liquid (fuel and bore hole liquid) and transported in 20 ft tank containers. A typical traverse arrangement with towing vehicles and sledges is shown in Figure 1.

Traverses are moving with a speed between 80 km/d (uphill, full loaded at high altitude and on soft snow) and 130 km/d (downhill, minimal load at sea level on hard surface).

Efficiency of Traverses

Traverses are extensive in terms of manpower, costs and time so efforts have to be made to increase the efficiency as much as possible. Efficiency of traverses means transporting large amount of cargo (mass and volume) over long distances in short time with few persons and low fuel consumption. The average fuel consumption per vehicle for the round trip Neumayer - Kohnen - Neumayer is 3.5 l/km.

In Season 02/03 complete operation of the Kohnen Station needs 68 m^3 of Arctic Diesel; 46 m^3 were burned by the traverse vehicles and 22 m^3 by the Station itself. This shows that traverses are more complex compared to the base operation itself.



Figur 1: Arrangement of a traverse

Efficiency of traverses is influenced mainly by the following factors:

- density and temperature of the snow surface

  Condition of the surface cannot be influenced but may change with time of day or season. Sometimes driving by night in colder temperatures is advantageous. Driving in fresh trails is inefficient and sledge trains may be stalled. Driving in old hard tracks (age more than one cold night) makes the sledge train about 10 % faster and reduces the fuel consumption.

- tractive force of the vehicle

  Vehicles with high power, strong grip of the tracks and low ground pressure are able to pull high loads even on soft snow without slipping tracks.

- friction of the sledges

  Skids of the sledges should be covered with low friction material from below (e.g. high density polyethylene) to reduce the towing forces. Skids of sledges should have white paint from the top to avoid energy absorption and melting and refreezing when the sledge is parked.

- ratio gross weight / net weight

  The Weight of the permanent traverse equipment that is not part of the payload (vehicles, sledges, packages, living quarters etc.) should be as low as possible.

- a safe route without crevasses and steep slopes

  A continuously moving traverse is faster than a traverse that has to manage problems with crevasses and/or steep slopes. Choosing a route without these problems is essential special if the same route has to be used for many years and not only for a single season project.

- the experience of drivers and mechanics

  On AWI traverses nearly all drivers are also mechanics. One of the drivers is a special skilled person hired from the manufacturer of the towing vehicles. This makes sure that all faults that may arise will be found and can be repaired. Drivers have to be able to use all capabilities of the vehicles fully and treat the machine fair.

- organisation of workflow on traverses

  With respect to the duration of traverses organisation has to avoid exhaustion of the drivers/mechanics. AWI traverses refuel in normal case 3 times per day after 4 hours driving. Refuelling from on of the tank containers takes 30 minutes. Tank containers have a capacity of 14.5 m^3 and are equipped with filter, pump, volume counter and a 20 m hose with a safety valve at the end. The pump is either working with 24 V DC from the Pisten

Bully or with 220 V AC from the generator. Another 30 minutes are taken for rest and small meals and hot drinks prepared by the cook. Downhill needlessly Pisten Bullies are loaded on empty container sledges to save drivers and fuel.

- reliability of vehicles and sledges and sufficient spares

  Damage and following repair works can delay a traverse; in worst case the whole traverse can be stuck if suitable spare parts are not available. AWI traverses carry 3500 kg of tools, equipment, consumables and spare parts for all machines, sledges etc. along.

- reliability of navigation even in bad weather condition

  Low visibility in snowstorms can delay a traverse or even bring all vehicles to standstill. Reliable GPS receivers are necessary in each vehicle and all drivers have to be trained on it to be able to trust it in poor visibility condition.

- altitude of the route

  In high altitudes combustion engines loose power because of less oxygen available for the engine. Power loss of turbo charged engines is about 0.2 %/100 m at altitudes above 1000 m. Suction engines are not suitable in high altitudes because their power loss is about 1.0 %/100 m in altitudes above 1000 m.

- small crews on traverses

  AWI traverses operate with one driver/mechanic per vehicle and temporary a cook and a physician. This crew also takes care of maintenance and repair works en route and at the bases. In some cases the physician was also working as a driver.

AWI has achieved a certain amount of efficiency on traverses. The fuel consumption for the transport work between Neumayer and Kohnen Station is about 400 l per 1 to Payload over a distance of 1000km.

Communication Facilities For Antarctic Operations Used By The Alfred Wegener Institute

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1. Introduction

To support research platforms in polar regions with reliable technologies, great investigations and infrastructure are needed. Instruments and equipments from the shelf can usually not be used there without modifications. Reliability and redundancy of the equipments at the research platforms are the major concern. Therefore, AWI is only using an approved and tested technologies. Modifications and tests are usually carried out by the producing companies. Long term tests are carried out at AWI by using the equipments in parallel to old systems.

The used technology for communication is here presented.

Neumayer-Station (70° 39' S; 08° 15' W) is supported with different communication systems to guarantee the redundancy and the reliability.

2. System Used

The main system is a permanent data link between Neumayer-Station and Bremerhaven using the INTELSAT satellite IS 901 (18° W) and the receiving station in Raisting, Germany as gateway. The link was established on February 13th 1999 with a bidirectional capacity of 64 KBPS and was upgraded on May 2003 to 128 KBPS. The maximum available capacity by the used hard is 384 KBPS.

The System is operated by AWI and by the German company for telecommunications PLENEXIS GmbH and provides data transfer, two telephone lines and a fax line.

The used configuration and components are:

INSTALLATION	FEBRUARY 1999, 64 KBPS
UPGRADE	MAY 2003, 128 KBPS
OPERATION	AWI, GER. TELECOM, PLENEXIS

ANDREW	3.7 m C-BAND-ANTENNA
RATECH-RADOM	5.3 m
TRANSCEIVER	CSTAR, 20 W; SSE, C-Band
LNB	CSTAR
SATALLITENMODEM	COMSTREAM, CM 701
NETPERFORMER	ACT, NETWORK, SDM-9400
FOUNDATION	SPECIAL ICE CONSTRUCTION

MAXIMUM RATE:	384 KBPS
INTELSAT-SATTELITE:	IS 901, 18° WEST
GATEWAY:	RAISTING, GERMANY, SHARED 30 m ANTENNA
LEASED DATA LINE:	RAISTING <----> BREMERHAVEN, 128 KBPS
CONTROLLING:	PLENEXIS, OC HAMELN, AWI

The second system is based on IRDIUM system (EUROCOM MARITIME SAILOR SC 4000) and MOTOROLA 9500 and 9505. This system is providing an economical communication within Antarctica to the different land expeditions and aircrafts.

In addition to the HF communication system (Rohde&Schwarz), we are still using at Neumayer a INMARSAT - A system as buck-up.

The RV "POLARSTERN" is using a specially developed and WEB-based mail system (WERUM GmbH) to provide the user with a comfortable and reliable system, which can operate with INMARSAT and IRIDIUM at high latitude.

Fig. 1: The used Intelsat-Antenna at Neumayer-Station

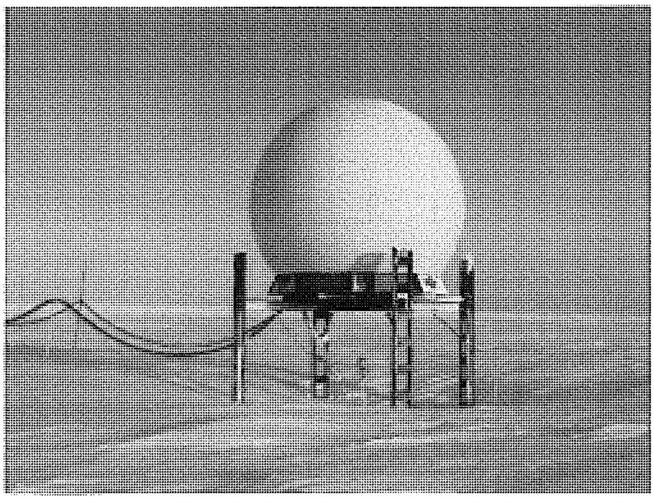


Fig. 2: The used HF-Antenna

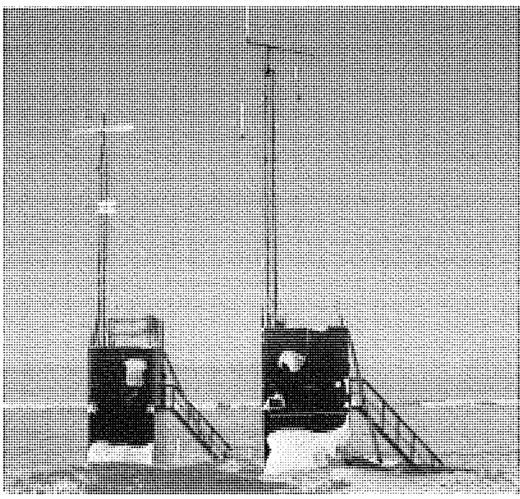
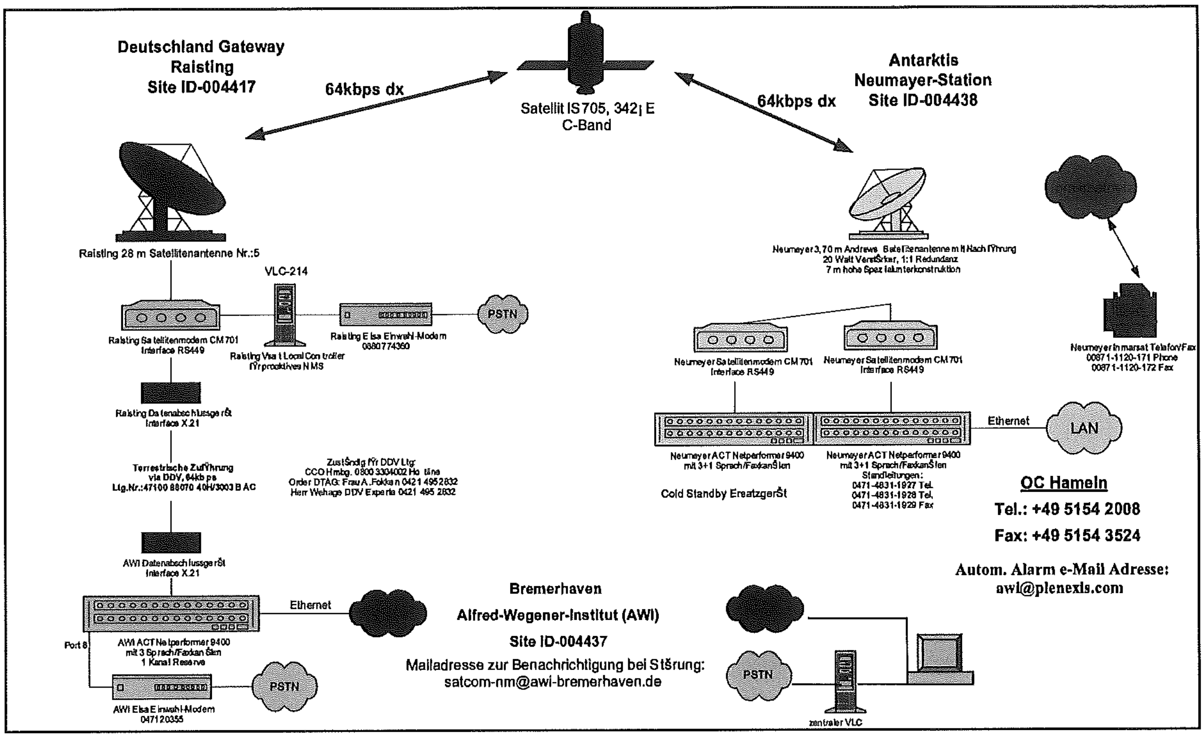


Fig. 3: Schematic of the Intelsat-Link between Neumayer-Station and Bremerhaven, Germany



Rebuilding Neumayer Station - a comprehensive approach to a multipurpose facility in Antarctica

Dietrich Enss[1], Hartwig Gernandt[2] and Ralf Siegmund[2]

(1) Polar Engineering & Consulting, Hamburg, Germany
(2) Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

The Alfred Wegener Institute is operating the all-year Neumayer Station near Atka Iceport in Dronning Maud Land since 1981, one of the very few stations in Antarctica located on an ice shelf. Neumayer has long since developed into a significant research platform with meanwhile four observatories, and represents an important logistic base for various activities in the surrounding areas and on the inland ice sheet. The original base had been built by the sub-surface tube design well established at the time. Although the limited life span of this design was known, and the ever increasing overburden loads and ice deformation made a second Neumayer Station necessary already in 1992, this station again was placed in steel tubes underground. The reasons can be listed in short as follows:

- There was a lack - or at least a shortage - of proven other designs;
- A location in the vicinity had been found with much lower ice deformation rates;
- Experience with the design and knowledge gathered on improvements;
- Funding was based on investment costs only.

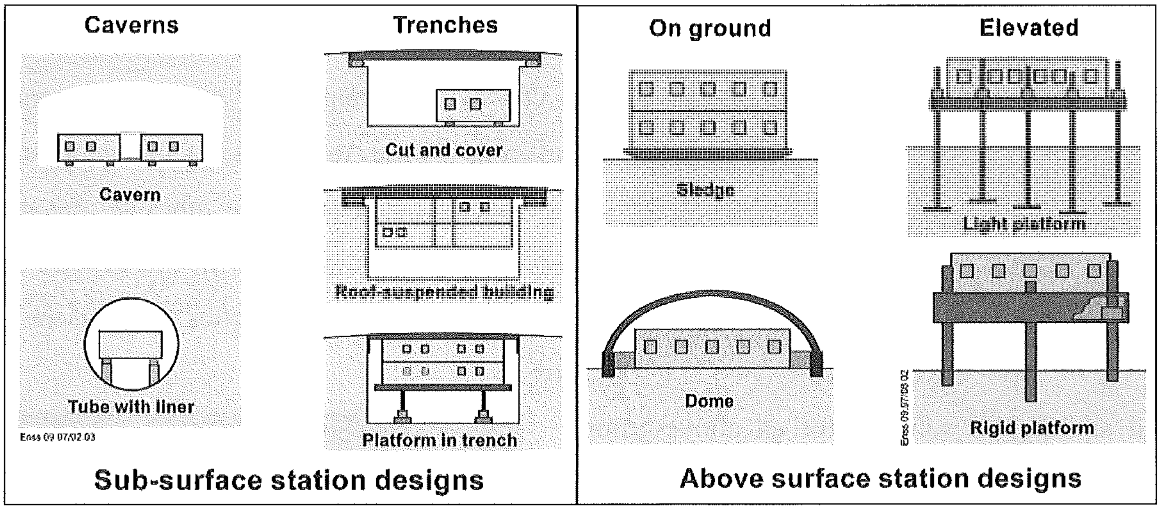
In 2001 it was established by a thorough survey that Neumayer Station II will safely last the planned time which will end in 2007, but not much longer. There was little doubt that a new base should be erected at Neumayer with strong reasons for continued scientific observations and with increasing logistic tasks.

Meanwhile the Madrid Protocol had been enacted with considerable bearing on new construction in Antarctica. Designs calling for extremely expensive retrogradation or even the eventual permanent release of major components of the structures to the Antarctic environment would not be economic any longer or not be permitted to realise. Also the fixation on investment costs had given way to a more comprehensive analysis of economics, taking a sharp look at maintenance costs and the service life of the building.

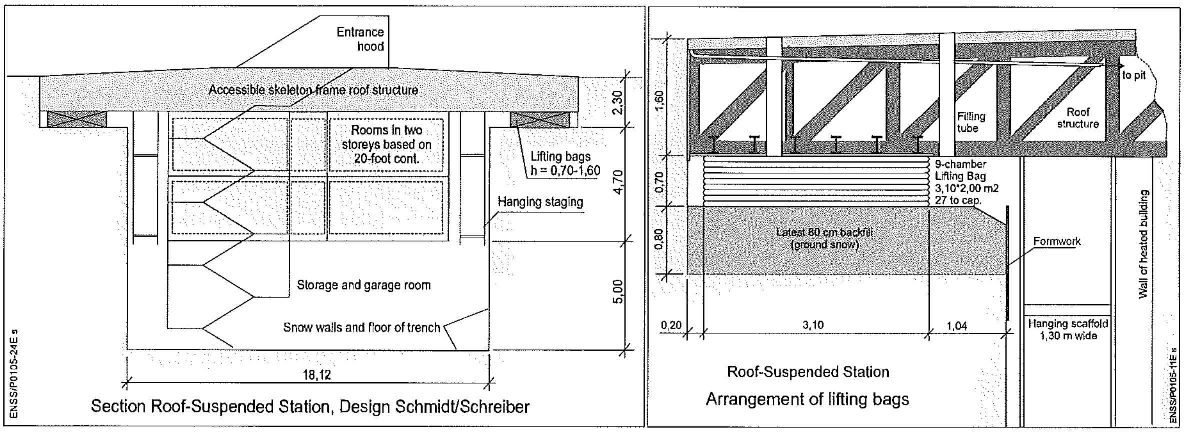
The main general criteria for the new design can thus be listed as follows:

- Low maintenance expenditure, to be achieved to a substantial extent by reducing essential works like those caused by snow level increase and snow tails;
- Prolonged service life, minimum 25 years;
- Easy access to all structures for dismantling and removal;
- Competitive overall economy.
- Specific requirements have been compiled to meet these criteria and to cope with the enhanced spectrum of station functions:
- Reduced susceptibility to ice deformation;
- Avoidance of high snow loads;
- Integration of summer accommodation for 36 persons, to be idle in winter;
- 1,300 square meters of heated rooms in winter station part (+ 65 percent);
- 1,900 square meters of garage and cold store room (+ 51 percent).

The wishes for increased room and storage area seem to be a law of nature with station rebuilding. This law we had been following already at Neumayer II. But here at Neumayer III there are well substantiated demands for more room based on increased research and logistic activity. Overloading of storage spaces and keeping of goods in the open have proved to be uneconomic in Antarctica.



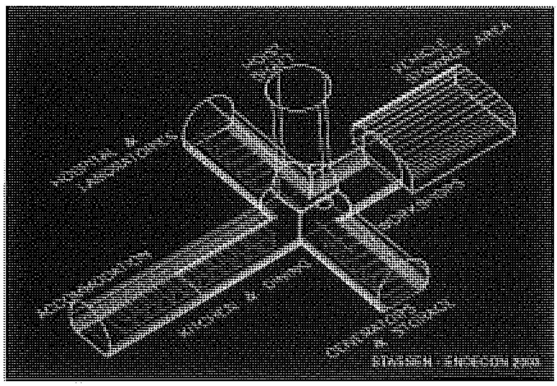
In a first survey the known building methods were screened for suitability. Then all feasible designs able to satisfy the AWI demands, altogether 9 variants, were rated by overall compliance, costs, and appeal. One design, called Roof-Suspended Station, caught the interest of all concerned due to its innovative approach.



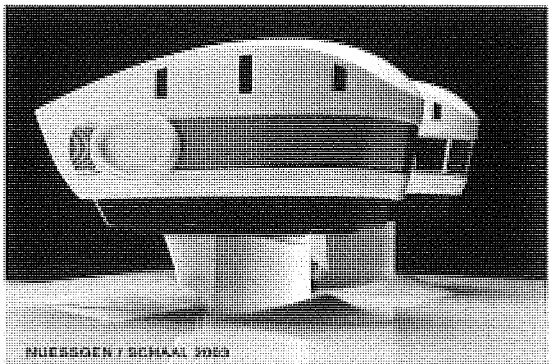
Roof-suspended station, section and detail of lifting bag arrangement

The station building proper here is hanging from the roof structure which spans an 18 m wide and 12 m deep trench in the snow. The loads are transferred to the snow banks by pneumatic lifting bags serving as foundation and jacking elements. The unheated room underneath the structures, unobstructed by any columns or other construction aside from some stairs, can be used for storage and as garage. When assessing this solution further it became apparent, however, that too many open questions as to the reliability and performance remained.

Also the works to move the station up for adjustment to the ever increasing snow level turned out to be very time consuming because of the rather difficult backfilling of snow under the cushions.



Another design has been proposed by Hennie Stassen of Endecon in South Africa. Four tubes in crosswise arrangement meet at a central shaft, big enough to hold a lift for vehicles. A soft space filler around the tubes is meant to protect against deformation in the ground and to enable easy dismantlin after 25 years in the snow.

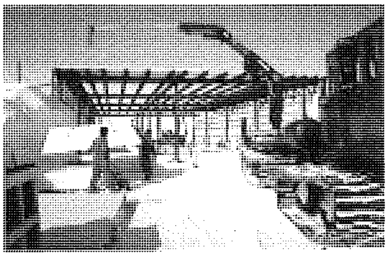
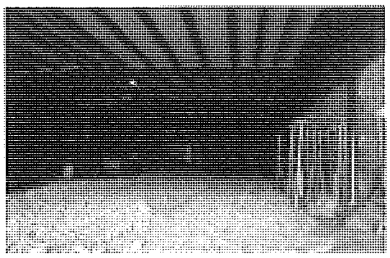
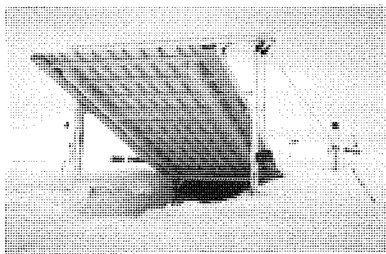


And an original solution for an above-ground base has come from architects Nuessler/Schaal, who let their building climb up a massive central support consisting of snow. Even if perhaps a bit early for a full-fledged station, the idea could easily be tested at an outstation. The two young architects were looking for a drift-supported snow transport system to supply the pillar. Something we also look out for since long to fill our snow smelter.

Eventually two designs were chosen for further examination:

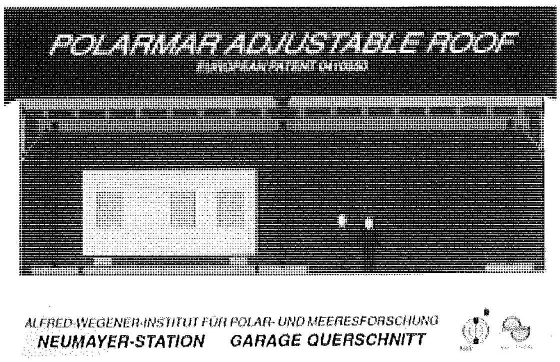
- A sub-surface station in a covered trench called "Block Station", and
- A compact, two storied jackable platform station structure with a sub-surface garage placed somewhere nearby.

Trenches have a long history in polar construction, but a new construction variant has been introduced by the AWI in 1992 when the adjustable roof was realised in the Neumayer II garage building.

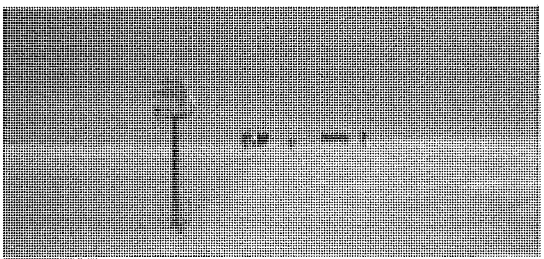




Neumayer Station garage building

Based on the observation that no drift snow accumulates on or behind flat surfaces held in the snow level, the garage roof is being moved up from time to time - every second year lately - and thus kept at or slightly above the surrounding snow level.



As no snow piles up on the roof, the structure can be designed extremely light. The garage building also causes no windtails and is therefore almost not visible as can be seen on the air photograph, where the open ramp cover is the only indicator.



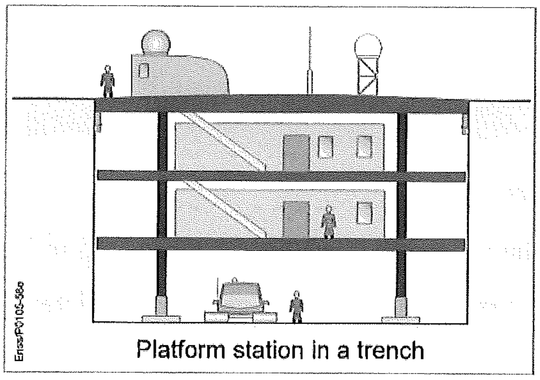
Here you can see the edge of the garage roof in winter shortly before it has to be lifted up. Of course the floor of the trench must be filled with snow in accordance with the raising of the roof.

Most of this work can be done by help of dozers or, as is the case at Neumayer, snow vehicles with blade attachment.

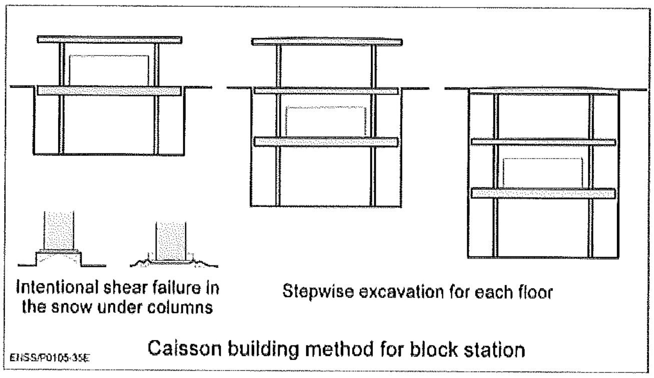
The Neumayer Block Station is a logical development of the Neumayer garage design and consists of a platform carrying the station proper placed in a trench with bare walls.

The room between trench floor and platform can be used for storage and garage as in the Roof-Suspended Station. The design thus stands for a very compact all-in-one station. The heated part is two-storey and is supported together with the roof by jackable columns resting on the trench floor.

Both spread footing or pile foundation is possible for the legs, with the only restriction that the foundation must be sufficiently retractable within the confined space in the trench to allow backfilling with snow.

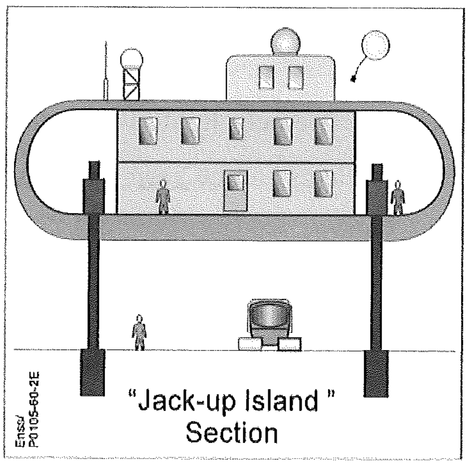


Platform station in a trench

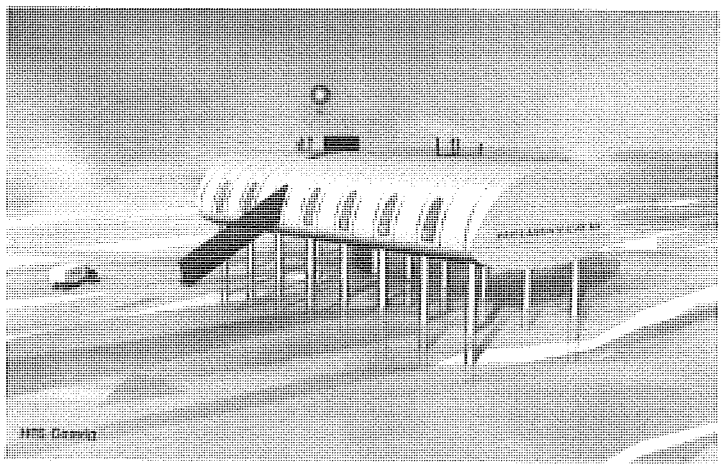


Caisson building method for block station

The large trench dimensions for the Block Station may cause problems in the construction phase - you all know how quickly such trenches fill up with drifting snow. To overcome this difficulty a variation of the caisson building method has been proposed. When a new storey has been assembled above ground, the whole structure is relatively quickly lowered into the trench in a controlled manner by removing snow from the floor.



"Jack-up Island "
Section

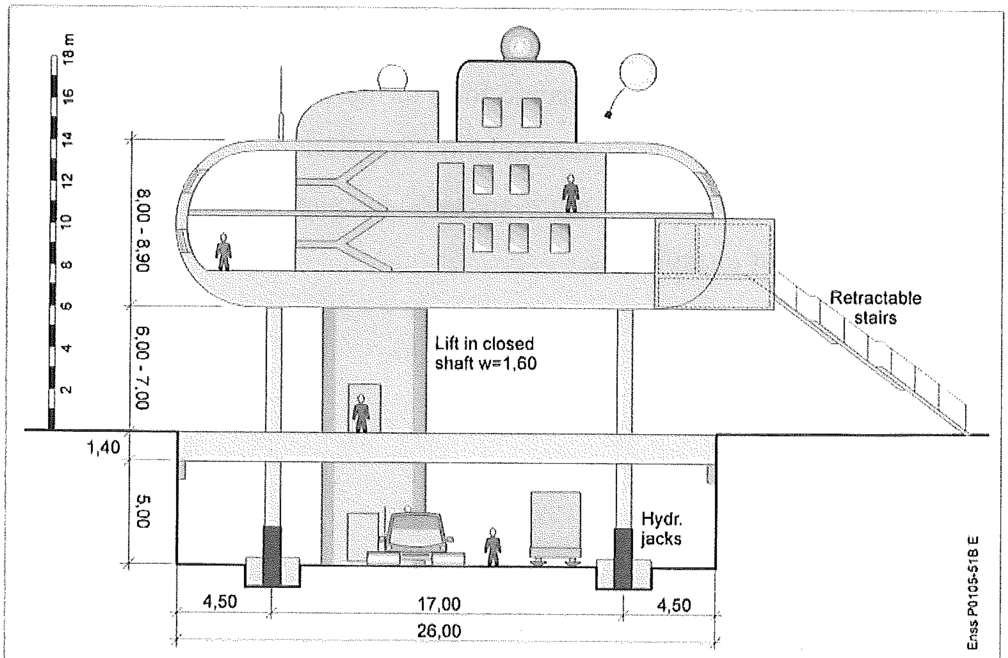


The platform station comprises a two-storied station building on a very rigid, elevated platform. In the AWI this solution is called Jack-up Island to distinguish it from platform stations of the Filchner, Halley V and Kohnen Station design. The stiffness of the platform is required to reduce the number of legs to a practical minimum, and - more important - to make it possible to retract any one of the legs at a time for resetting without extra support to the platform.

The jacks for the legs are best placed at platform level respectively in the platform body, and they must be double-acting. Pile foundations will best serve the purpose of load transfer to the snow ground.

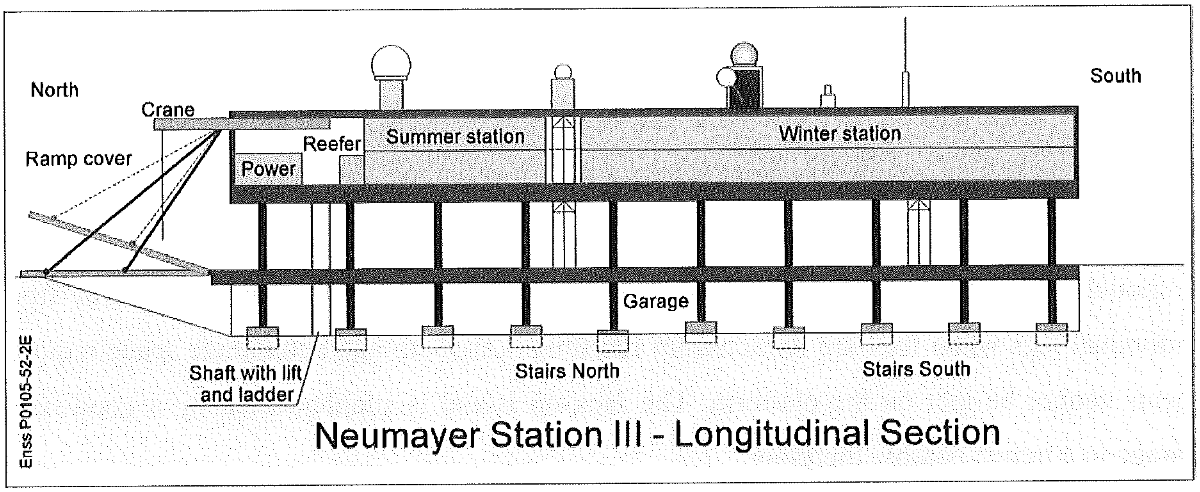
It should be noticed that horizontal loads by deformation in the ground are taken away from individual legs when they are retracted for resetting. Large storage and garage space requirements cannot be met on the platform. The Jack-up Island is supplemented by a good-sized garage in a trench nearby, therefore.

When comparing these two designs there was found no clear advantage of one over the other. While the Block Station would be easiest to build and cause the least disturbance at the surrounding surface, there were some doubts about the capability to keep a snow pit of the required dimensions free from drifting snow during construction. The Jack-up Island would provide windows and daylight, rated high by many. But it would also double the effort for jacking as two separate structures would have to be raised and adjusted for settlements. Then a combination of the two designs was proposed.



Neumayer Station III - Combi-Station Design Section

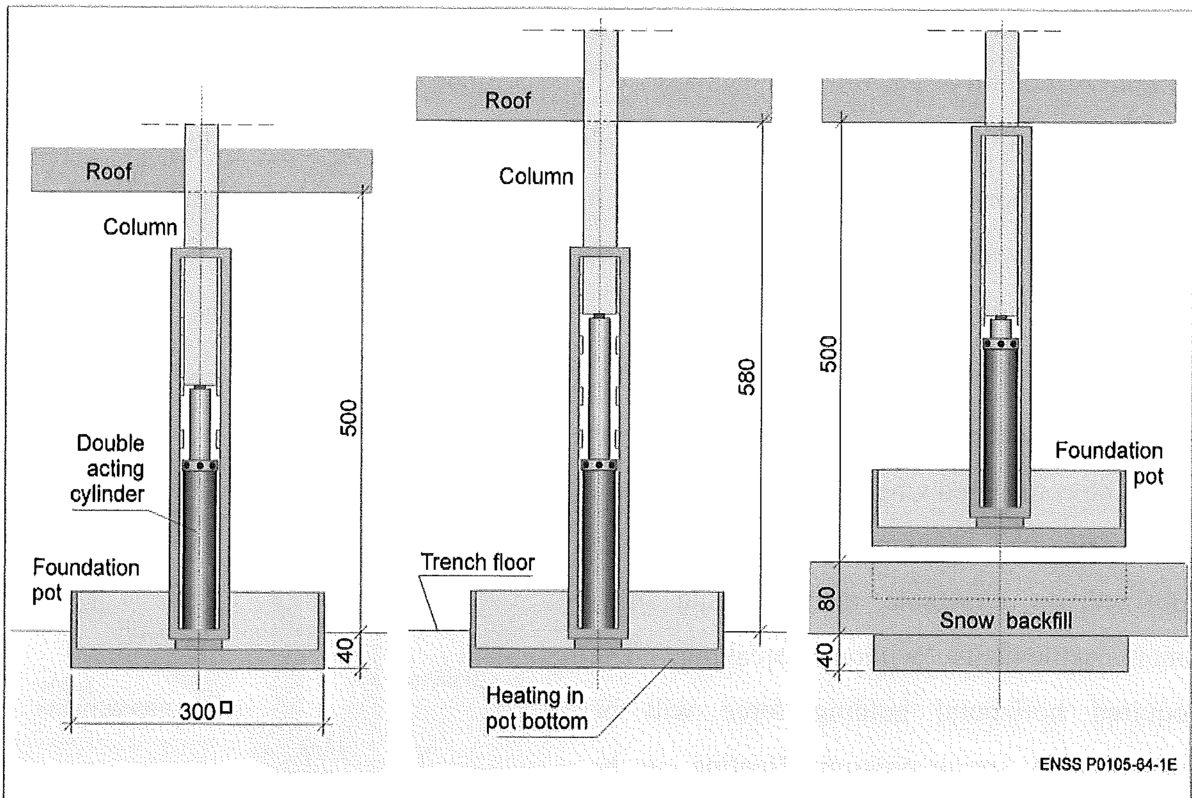
This combination of the two preselected designs was termed "Combi-Station" and became a favourite quickly. The station facilities are close together as in the Block Station, and garage roof and platform can be jacked up together. The firm roof will prevent scouring under the platform.



There are several ways feasible to arrange for the jacking, with jacks near the foundations in the trench or on the platform, and with a garage roof either permanently fixed to the legs or made moveable over a certain height along the legs.

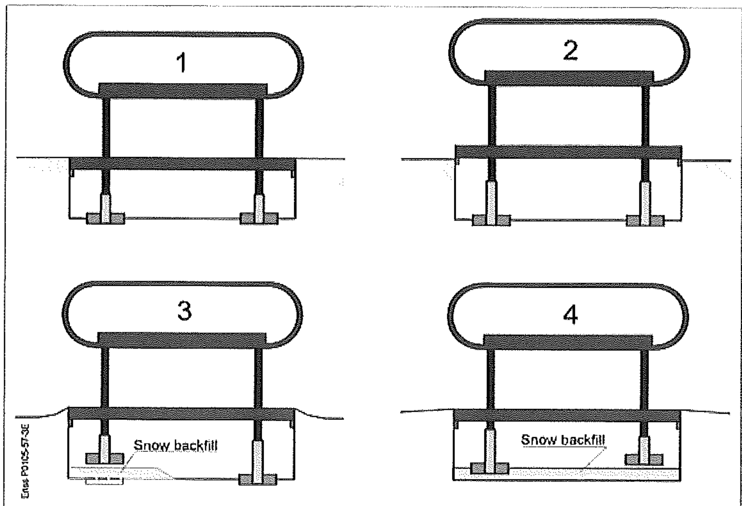
The final decision here will probably be left to the detailed design, but a preliminary preference has been given to the firm connexion of the roof to the legs and jacks arranged in the trench. The trench will be accessible over a ramp at the northern end and by a lift reaching up to the platform.

The above ground part of the Combi-Station is being tested in a wind tunnel at Hamburg University for optimisation of the aerodynamic form of the shell and for the determination of the platform height to produce the least accumulation in the windtail inevitably to be expected at the lee side of the structure. Many more answers are hoped for with regard to optimal placement of stairs and roof installations.



Combi-Station Neumayer III - Jacking procedure

Open top steel pots or boxes about 3 m across are proposed for foundations. Approximately 40 cm foundation depth measured from trench floor level, partly generated by compression while putting on the load, will be sufficient to produce enough bearing strength of the snow. And if settlements are getting too big, each individual foundation pot can hydraulically be pulled up and its pit backfilled with snow. Smaller and deeper foundations would make it difficult to lift them high enough in the confined space of the garage to enable backfilling and placing a new layer of snow on the floor.

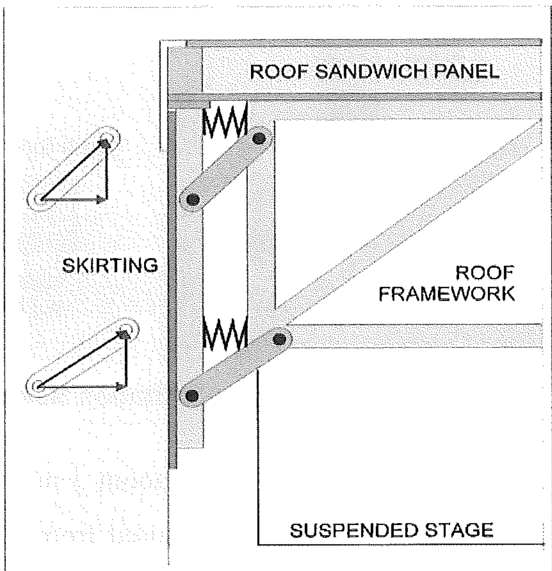


Annual raising of the station for adjustment to snow level

The best sequence of jacking and backfilling is given when the required adjustment to the snow level is done before snow is brought in for filling up the floor. Not only can the nominal clearance be kept at all stages, but the method also allows for much settle-ment of the foundations because only a small part of the capacity of the jacks is used between raising operations. Of course the loads will not rest on oil all the time, the cylinders will be equipped with lock nuts.

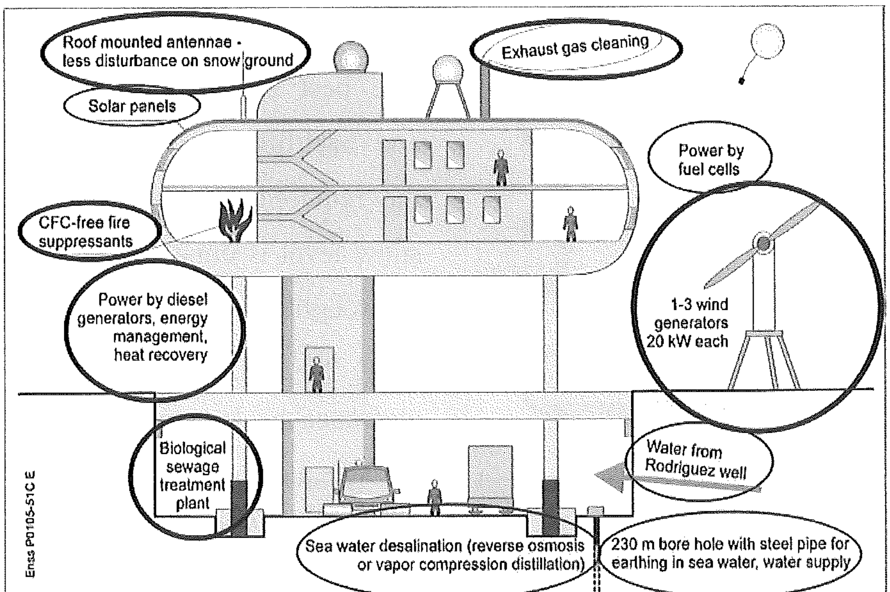
The backfilling is simple in so far as the surface is to be prepared to one level throughout only. Foundations can be pulled out in pairs across the trench - with the exception of those in the corners - which allows straightforward snow works. The foundation pots can easily be fitted with heating, so that their extraction should pose no problem. The pots - by the way - are a good safety measure against pollution by leaks in the hydraulic system.

Friction and adhesion of the snow at the roof has to be considered when raising the structure. The segmented skirting running around the roof will be retractable, therefore, and allow small settlements without breaking. The required horizontal holding force will be controlled by spring pressure. Heating can be applied to individual segments if need be.



PROPOSAL FOR SKIRTING

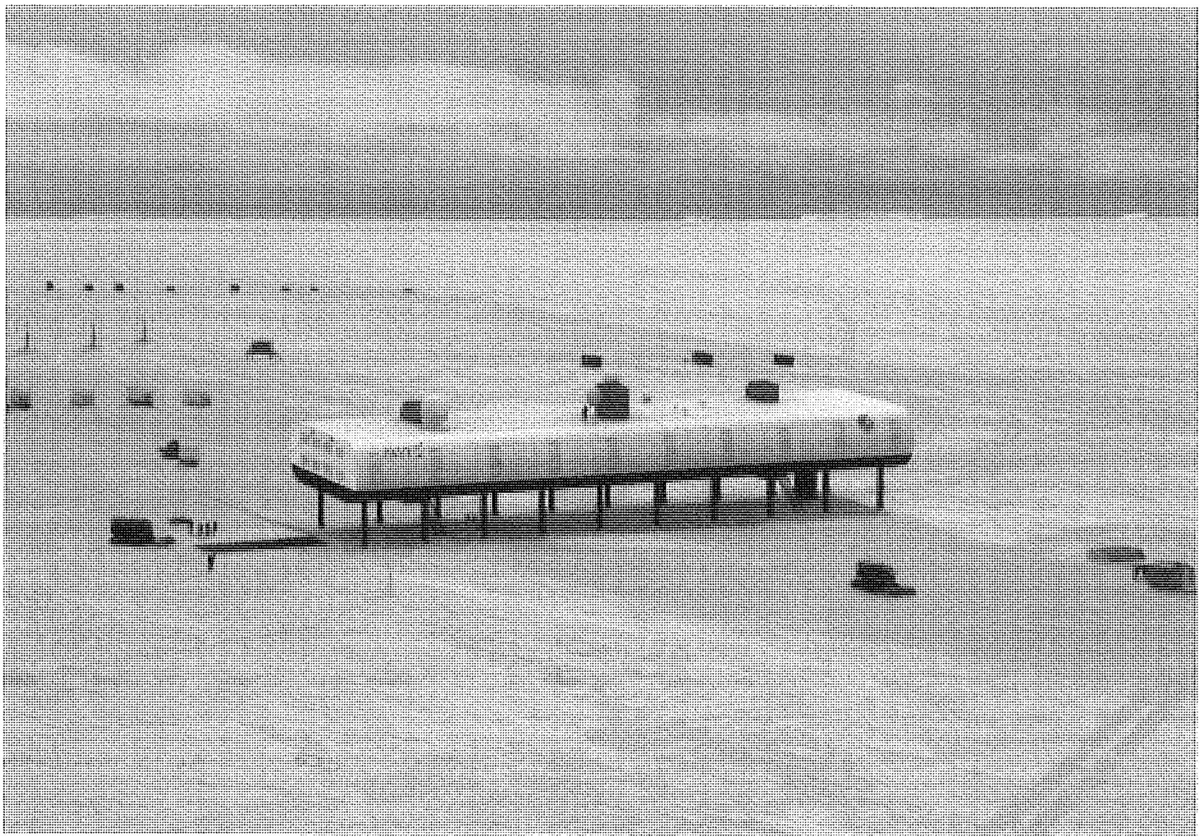
The technical building services will be designed or chosen under consideration of 22 years' experience at Neumayer and reflect the state of the art. Modern technology is to be balanced against safety of operation and maintenance constraints at a remote place. Neumayer has been operated all the time with an extremely small but highly qualified technical team.



Neumayer Station III Technical Services Survey

Advance technologies have been surveyed with enthusiasm, some of them for the third time at the third station, and progress noticed. What has passed the tests is thickly marked, and features with thin rings have been rejected for this time.

There is a high probability, however, that solar panels will be seen on the roof at some time during the hopefully long life time of the station.



On this photograph - made by help of digital warp-time technology - you can see the three wind generators producing power for an also aesthetically appealing Neumayer Station III.

TRAVERSES in ANTARCTICA

Information from the surface transport system Set up for servicing the Dome C site

P. Godon[1] and A. Cucinotta[2]

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Two important scientific projects undertaken in the Dome C region of the Antarctic Plateau (The Concordia Station and the European Ice drilling project EPICA) have required the transportation to the site, 1100 km inland, of 4000 ton of building components, scientific instruments, food and fuel. Thereafter, the annual operation of the site (wintering and summer campaign) will require the annual transportation of about 400 ton of consumables and additional equipment.

The surface traverse option, rather than air transport, was chosen for the movement of this cargo from the coast to the Dome C site. The traverse option is more economical but also has a lower environmental impact.

This type of traverse organization has to operate as a transport company, having to deliver goods (and sometimes personnel) to the site in good condition and according to a set schedule. In addition, successive traverse expeditions, each season, of 8 to 10 tractors towing a total of 25 to 30 sleds or trailers has required a new approach and dedicated organization. The logistic traverse organization became a project of itself within the Concordia project.

This paper will describe this new approach and the organization that was established, addressing many issues such as vehicle adaptation to the track surface and to the weather conditions, navigation systems, daily work schedule during traverses, safety rules, daily and yearly maintenance and turnover of equipments, winter storage, personnel training and traverse support team at the coast....

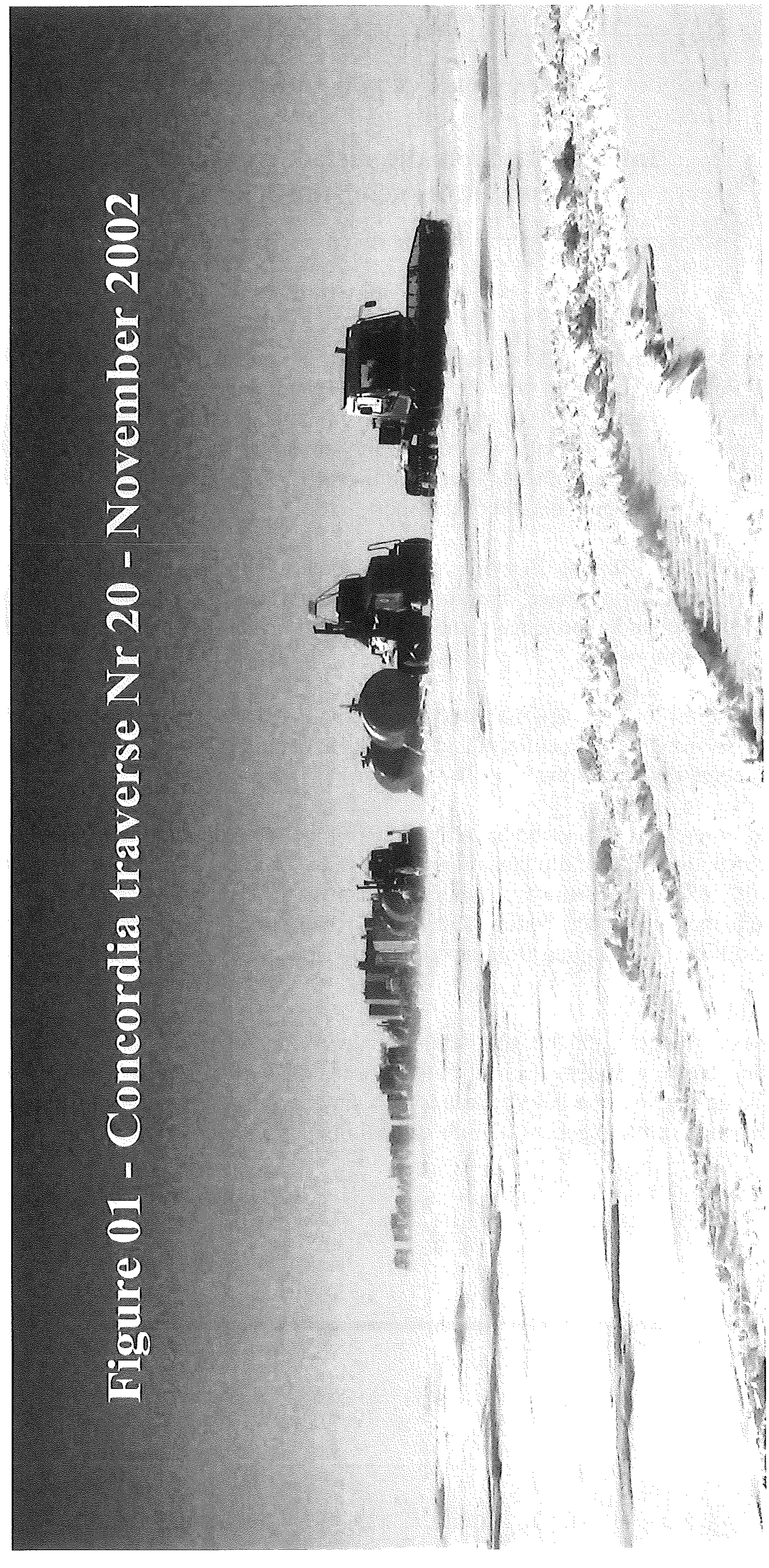


Figure 01 - Concordia traverse Nr 20 - November 2002

TRAVERSES in ANTARCTICA

Information from the surface transport system Set up for servicing the dome C site

- Foreword -

The project to construct the Concordia wintering station at Dome C (CONCORDIA) and the associated European Program for Ice Coring in Antartica (EPICA) have involved the initial transportation of about 3300 T of equipment to the site, 1120 km inland. Subsequently, normal operation and yearly maintenance will require the annual transportation of about 400 T of supplies (food, fuel and sundry equipment). These requirements have given cause for reflection over time as to an optimal system and method of transport.

Operations between Dumont d'Urville and the Dome C site commenced in 1993, when the first return trip by vehicle took place. The first transport traverse of equipment took place in 1996 and the equipment used and experience gained have already been the subject of an oral presentation at the Cambridge Symposium.

This new edition of the original document published in 1996, highlights the attempts at rationalisation brought to the concept and presents in detailed fashion both purely technical as well as organisational developments.

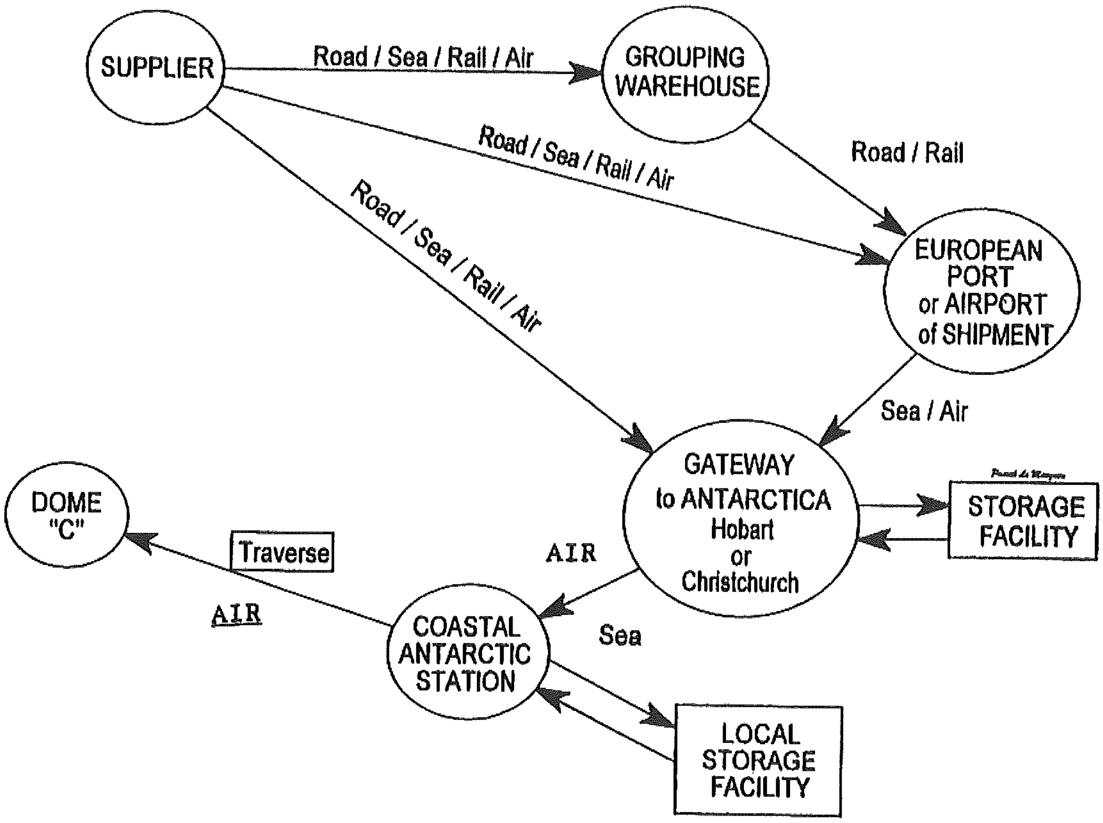
It will be of interest to those who have read the original version, who will see in it a system under continual evolution and a rationalisation of the study process, and also to those who have come more recently to the problem of transportation across the Antarctic continent. All will be able to benefit from the experience which is still being gained, and those considering transport under similar conditions, or changing from air to land transport, may avoid a lengthy process of trial and error.

Each case is, of course, unique, and whilst our work in progress is not completely transferable, many amongst you may distil from it both in terms of work completed and in terms of projects, currently being studied or trialled, ideas which may permit a reduction in establishment costs, or fuel consumption or more generally in the global impact of their activities.

A – INTRODUCTION

There is a beginning to everything. In our case someone arrives and asks you to build something at a location or asks you to transport people and equipment from one point to another. In short he gives you (or you ask him for) an overall specification corresponding to his requirements.

What was our brief? To build and bring to life a new station on the Antarctic continent. This simple phrase sets the groundwork for the task and, in the absence of particular specifications, if they are lacking, are sufficient for you, the logistics technician, to go looking for the necessary information. If you don't receive specifications, then you go in search of them. Hence the traverse, in the case of Concordia, as the following diagram shows, is the last stage of a global transport operation which commences in the workshops of the manufacturers of the equipment to be delivered.



- Figure 2 -

It goes without saying that if you say traverse, you have already made the choice of surface as opposed to air transport, or at least, you are asking yourself, you would already like to know on paper what the surface transport option will give you.

A.1 - Specification brief

It can be very simple and be presented thus:

Geographic data:

- Characteristics and location of the departure point
- Characteristics and location of the point of arrival
- Characteristics of the terrain between these two points, possible breaking points

Meteorological data:

- Speed, occurrence and direction of the prevailing wind
- Density of days with cloud cover
- Diagram of temperatures

Economic data

- Nature and mass of the cargo to be delivered
- Particular characteristics of the cargo / Fragility, away from ice, dangerous.
- Time in the year and number of usable days annually
- Delivery constraints (when, how....)
- Sustainability of the operation (punctuality, renewable annually)
- Choice of maintenance policy
- Organisation of stopover zones

Environmental data:

- Protection status of zones traversed

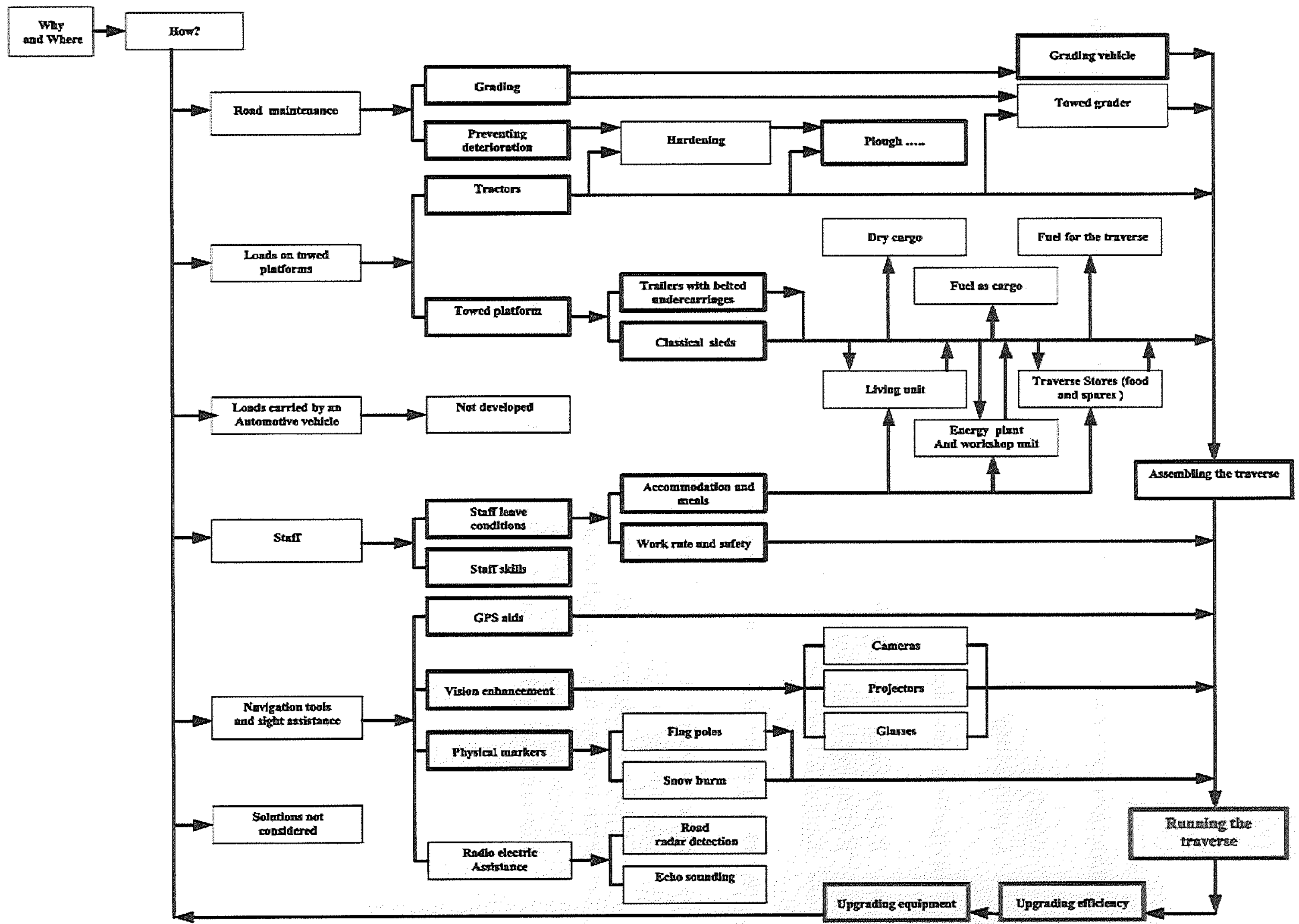
A2 – Implications of specifications brief

It is clear that these specifications engender an awareness on your part, that is you undertake to be the last link in the chain shown on **Figure 2**. You become a professional transport organisation with an obligation to produce results, at least an obligation of means. Thus you will deliver the cargo, on time, in good condition, at the best price and you will be able to repeat the operation to the desired rhythm.

The diagram **Figure 3 next page** shows the theoretical links between the thinking and design process you will have to go through, that is, that you will have to choose between:

- Vehicles with or without contact with the ground / air cushion or direct contact with the ground
- Load carrying or towing
- For towed loads, opt for or choose between machines on wheels or sliding

Figure 03 - Diagram of the theoretical framework / logistical process



You need to:

Manage staff issues:

- What training is required?
- Living conditions / Meals, sleeping arrangements, hygiene, comfort
- Driving rhythm
- Keeping a watch on group cohesion
- Safety considerations
- Communications

Managing problems of maintenance and preparation of the track to be followed:

- Grading
- Compacting

Navigating, that is:

- Positioning, finding one's way
- Refinding one's route
- Keeping free of bad weather

Working efficiently and methodically:

- Determining the order of the cargo train
- Organising the convoy
- Organising maintenance
- Plan loading and unloading operations
- Choose and adopt a consistent packaging system from one end to the other of the chain in **Figure 2**, in order to avoid direct handling of cargo.

B – CHOICE OF EQUIPMENT

B.1 – Vehicles

Two options were possible: load the cargo on the deck of a self-propelled vehicle, or load it on sleds or trailers towed by a tractor. In either case, there were no vehicles readily available on the world market for traverse operation. Our choice criteria were:

- Adaptability to the environmental conditions;
- Ease of use;
- Reliability;
- Ease of finding and obtaining spare parts close by our base or close by Australia and/or New Zealand;
- Usability with respect to ground conditions (ground pressure, operational speed, ground levelling requirements);
- Load capacity, towing capacity;
- Fuel consumption.
- Costs

When we embarked on the project of building a transport system, we decided at the outset, in order to avoid delays in implementation, not to get involved in the design of a prototype, but to look for commercial vehicles to adapt to our requirements.

We have, actually, since revised this concept, and we think that transport is a really critical and irreducible element in a project such as Concordia. In fact transport in Antarctica which sustains/supports the life and permanence of a station merits particular study. That said, in 1990, we were not at that stage of reflection or competence. Our intention was to see what the market would provide. Of course we did not find any suitable machines which met our practical requirements. Self propelled decked vehicles were eliminated early on as, much as we might want to transport considerable loads, this type of vehicle very quickly attains dimensions beyond our transport capability and our ability to handle the vehicle itself. Similarly, the choice of tractors useable on snow and ice in low temperatures is quite limited. Our search for tractors was concentrated on:

- Civil engineering tractors;
- Agricultural tractors;
- Ski field snow grading tractors, but specialized for snow;

While our search for towable load carriers concentrated on:

- Sleds;
- Tracked trailers.

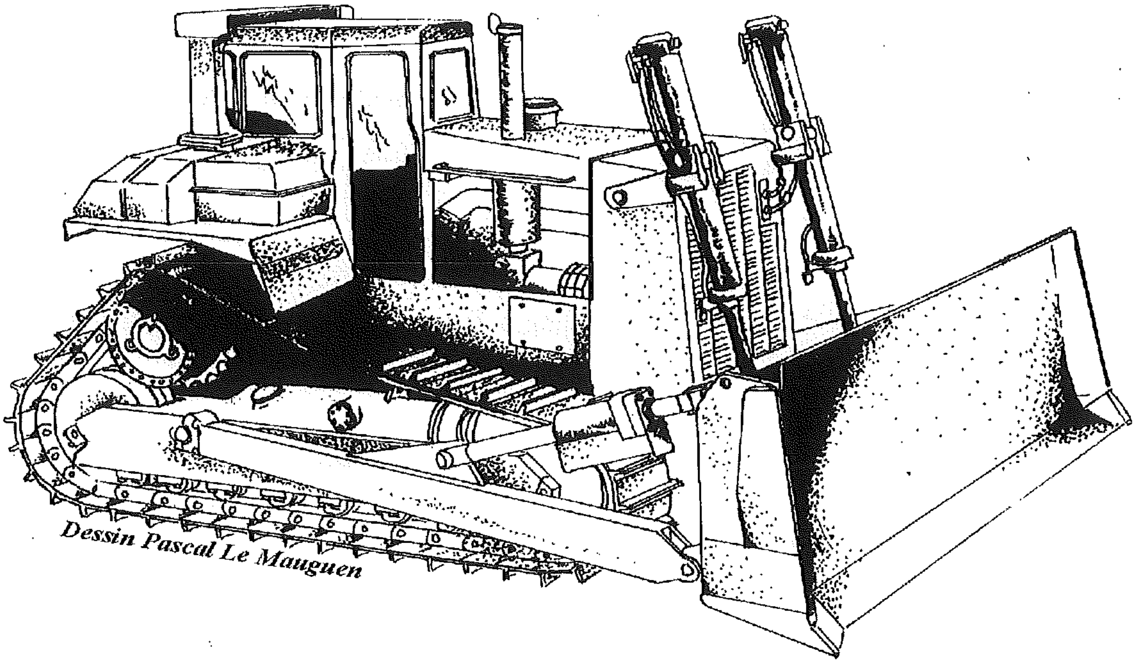
B.1.1 – Traction machines / tractors and levelling machines

At the time when we commenced the project and the search for equipment, there were only 3 categories of tractors on the world market which held our attention:

- The Caterpillar D series "pushing" tractors bulldozers **(Figure 04)**
- The Caterpillar Challenger series agricultural "towing" tractors **(Figure 05)**
- The Kassbohrer Pisten Bully (PB) series "snow grading" tractors **(Figure 06)**

The Caterpillar D series tractors (Figure 04), although being excellent machines, ended up being ruled out because of their high price and their low speed. The Caterpillar Challenger series tractors are agricultural tractors with rubber tracks designed to tow loads on soft ground. Simple modifications allow their use in summer on the Antarctic continent. The Kassbohrer PB series tractors are not towing machines. They are built to grade snow on ski fields and have an incomparable ability to work with their blade. They have very low ground pressure.

Figure 04: Caterpillar D series tractor



The Caterpillar Challenger series tractors, 65x series (Figure 05), take advantage of the Caterpillar savoir-faire in civil engineering machinery. They have low ground pressure (300 hPa), a powerful engine (215 to 240 kW), and a simple robust design. With a conventional direct drive powershift transmission (hydraulic clutch, semi automatic gear box), the Challengers have an operating weight of 15500 kg, a maximum speed (with no load) of 30 km/h and an operational cruising speed of 07 to 18 km/h when towing loads. They are designed to tow loads and it is possible for them to tow loads continuously without any durability problem. But they can lose some towing capability in dry "little-cohesive" snow. Being of simple robust design, they are low maintenance. They are not originally equipped with a blade, and attempts to fit one were not successful (pitching too great, lack of visibility) without a complete modification of the machine. They can (mechanically) safely tow at maximum capacity as track slip will occur before any excessive mechanical stress. Towing at maximum capacity can occasionally cause the tractor to get bogged in irregular ground (bumps, sastrugis...). This difficulty, inherent in a surface of inferior quality such as névé, has however been overcome by attaching machines in tandem and redistributing loads between them.

Figure 05: Caterpillar Challenger 65x series)

The Kassbohrer PB series (Figure 06) are snow grading machines designed for use in the ski fields. The PB 330 or 300 units are powerful (240 kW) to be able to push large amounts of snow and light (9000 kg) to be able to go up steep slopes. The ground pressure is extremely low (80hPa) so that the machines won't compact snow too much on the ski runs. Transmission is via hydrostatic pumps and motors, with electronic controls. The blade, very easy to handle, is designed for snow. The maximum speed is of about 17 km/h with no load. They are designed to move on all types of snow, but lose some towing capability because of their low ground pressure on very light snow. Their technical sophistication makes them fragile for such a use far from well equipped workshops. The interval between major service operations, in Antarctica, is only of about 1500h. Our experience shows that towing heavy loads with a PB is damaging to the hydrostatic transmission.

Figure 06
Kassbohrer PB series

Loaded, both types of machines use about 6 litres of diesel fuel per kilometre. With no load, consumption falls to 2 L/km for the Challenger and to 4 L/km for the PB due to its hydrostatic transmission. In summary: in spite of our wish to standardise equipment and simplify maintenance on the convoys, we concluded that the machines were complementary and we use them both, the Challengers for pulling, the PB to grading and associated tasks.

B.1.2 - Sleds

The traditional tow used to carry loads on snow or ice is the sled. The sled was invented in prehistoric times and preceded the wheel. By instinct the first designers had conceived a simple low ground pressure device taking advantage in snow fields of the low friction of the snow.

All traverses on ice caps have used sleds. If about every expedition had its own design of light sled, there are only few heavy sled designs. We have used Otaco and Aalener articulated models but these have been either too heavy or too fragile. We now use models of our own design:

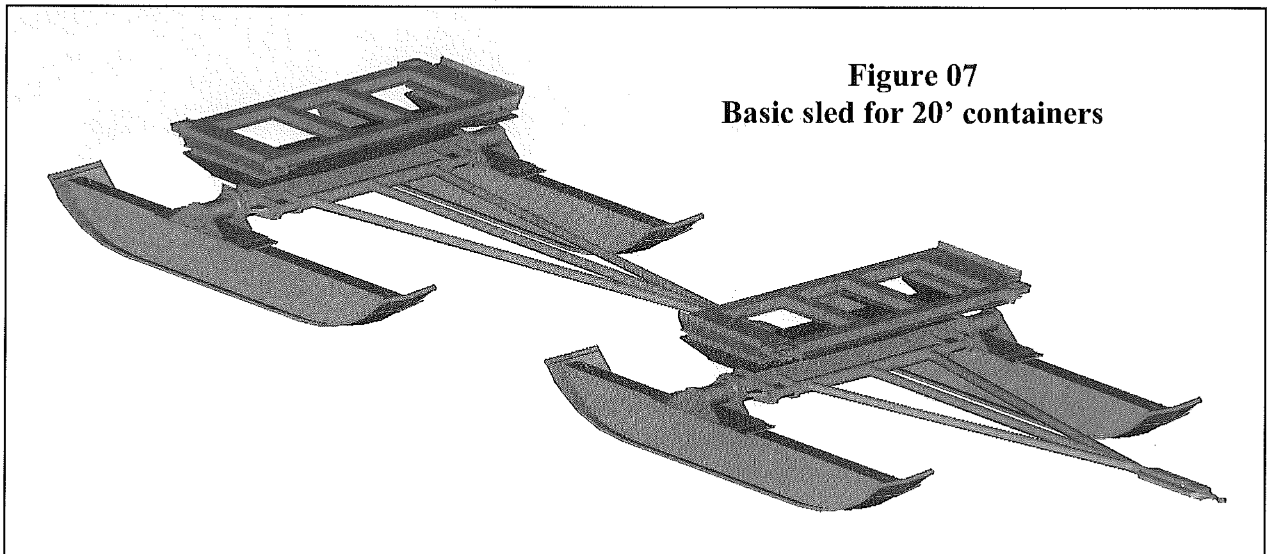


Figure 07
Basic sled for 20' containers

- An articulated sled (**Figure 07** previous page) of 12 t capacity for dry cargo of which we have two versions: a decked version and a container carrying version. of the track. This sled has also evolved from a very simple base model to the current, more sophisticated version (**Figure 08**) which is just as reliable and in particular has a reduced impact on the quality.

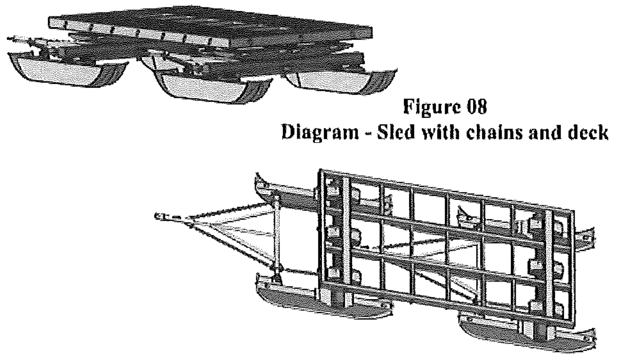


Figure 08
Diagram - Sled with chains and deck

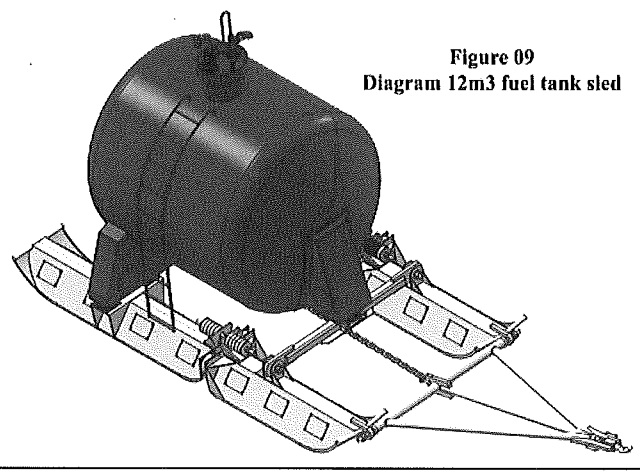


Figure 09
Diagram 12m3 fuel tank sled

- Three models (**Figures 09, 10 and 30 page 35**) of tank sled are dedicated to the transportation of fuel, the product most transported on the traverse. The first model, a relatively small 12 m^3 tank sits on a single pair of articulated skis via elastic devices. This first model is now mainly dedicated to the fuel of the traverse itself. The second tank sleds, of $26m^3$ capacity, is principally used for transport of fuel to the site. The third model currently only exists on paper but will eventually replace the first model, used for transport of the convoy's fuel. Its capacity is $14m^3$ and the majority of its parts are common to the most recent version of the cargo sled.

All these sleds have in common a good net weight / grossweight ratio and almost no mechanical articulation whilst underway. This technological choice greatly reduces maintenance problems.

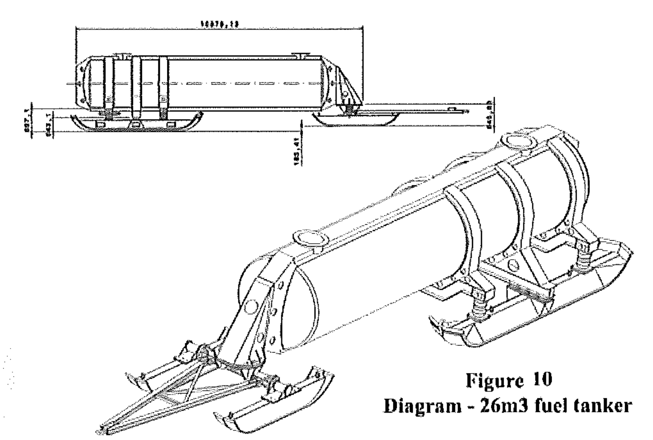
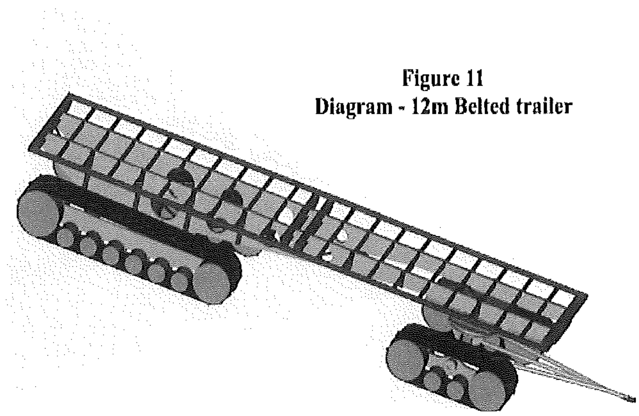


Figure 10
Diagram - 26m3 fuel tanker

Figure 11
Diagram - 12m Belted trailer



B.1.3 - Tracked trailers (Figure 11)

Historically, rolling succeeded sliding. It makes sense to try to replace skis by a rolling system involving less towing resistance. Rolling on soft ground can be achieved using tracks. The tracks make the link between rotating wheels and the soft ground, spreading the weight over a large area to achieve low ground pressures. Tracks are a well known solution for traction in self propelled vehicles, but were practically unknown as passive option in towed vehicles. The spread of passive tracks was triggered by the availability of continuous rubber tracks, appearing in the late eighties in several manufacturers' catalogues. Up until then there were only tracks made of steel elements connected together or tracks made of elastomer strips placed side by side and mechanically connected. The continuous rubber track came with high mechanical reliability and a motion resistance lower than skis on hard terrain.

A prior technical decision led to these two apparently competing systems being developped and tested at the same time. Experience has proved sleds and trailers to be complementary. The design of tracked trailers comes from road vehicle design combined with technical study uninfluenced by the usual solutions for sled design, has produced transport platforms of unusual design in the Antarctic. In fact the tracks function well and deserve their robust reputation. On the other hand, they have not been able to fulfill all the hopes put on them in the beginning due to two specific problems:

- Although the track is moulded in an elastomer with a flexibility rating of up to -35, it does harden appreciably as the temperature falls.

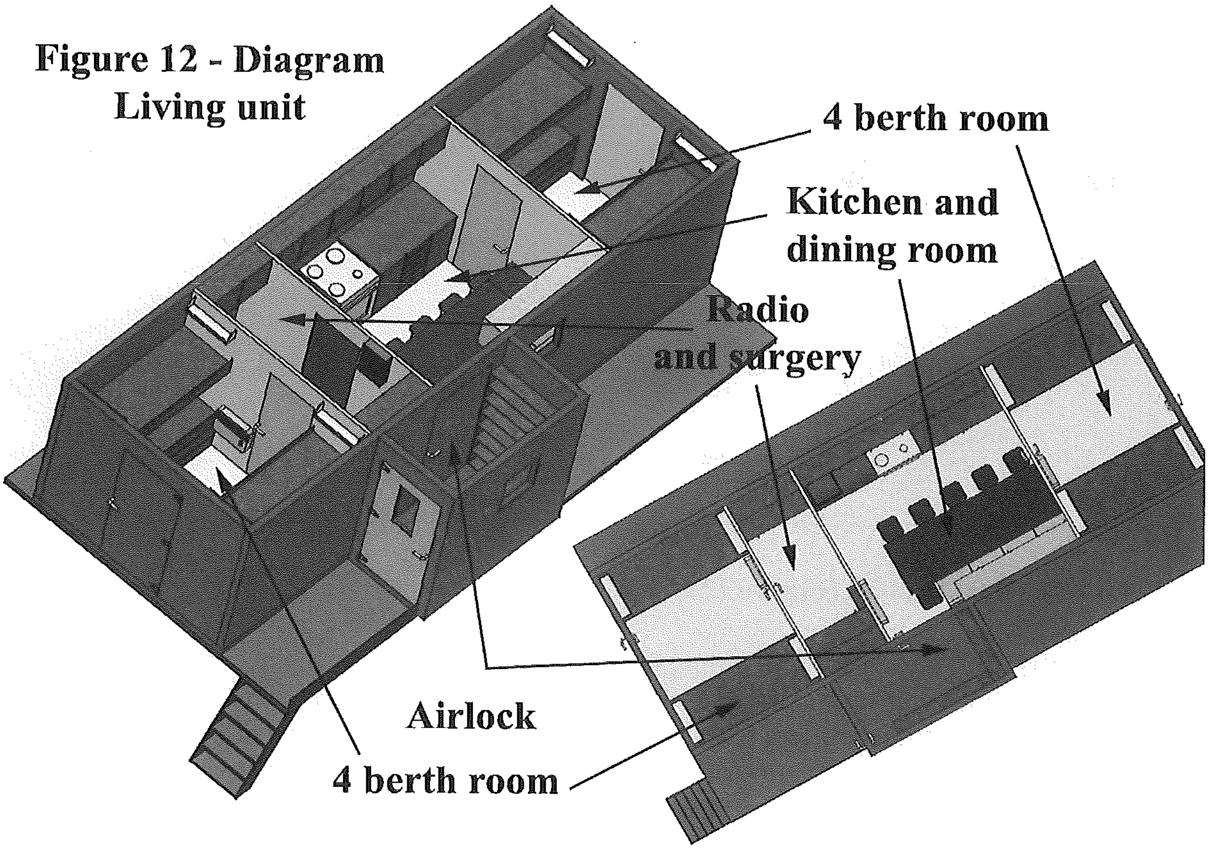
- Pressure exerted on the ground when the track is used at maximum capacity is too great – around 0.5 kg bar

B.1.4 -Living arrangements – Accommodation and facilities

Traverse operation and work on the convoy involve 15 to 16 hours of work each day. The personnel needs comfortable accommodation. Three units are assigned to personnel living needs. These comprise:

The "Living" module (Figures 12 and 13 next page) is divided into two sleeping cabins and one surgery/radio room, one kitchen/dining room and one cold porch.

Figure 12 - Diagram Living unit



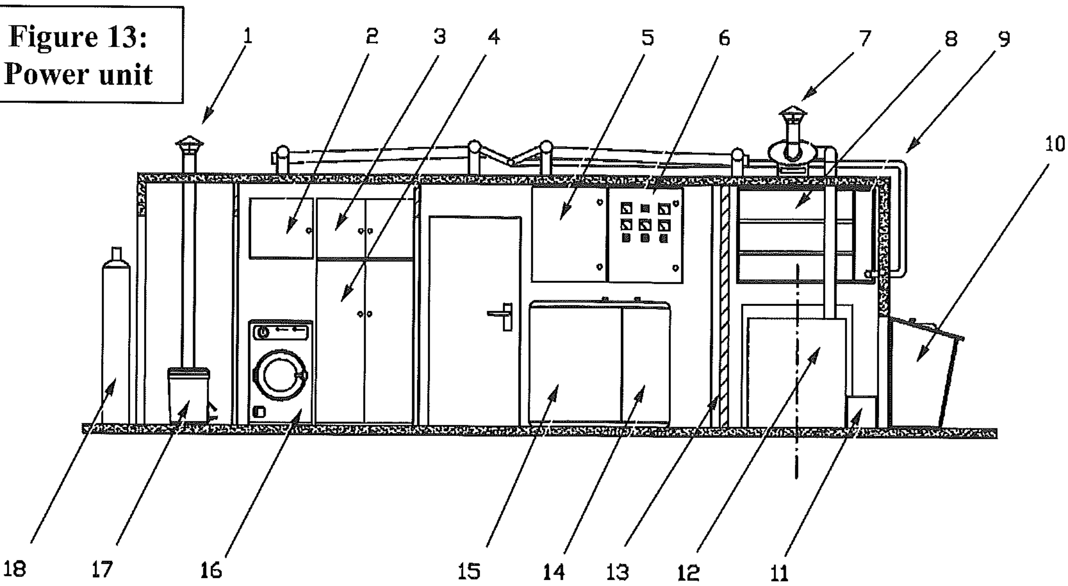
The "Energy" module (Figure 13 next page) houses the generator set, the water production (snow melter) and distribution systems, the workshop, bathroom and a warm store for medical supplies. The generator set rated at 65 kW powers the two "Living" and "Energy" modules as well as the tractor engine heaters during stops to keep machines warm.

A fuel pumping unit is located on the outside of the module and is used for refuelling the tractors which need 4 m3 a day. The unit includes filtering and metering of fuel.

The "Store" module is divided into two rooms, one for provisions and one for spare parts. For a one month traverse, the food and drinks needed represent 1200 kg or 2 m3.

The living and energy caravans are made of a sandwich panel reinforced by a metal armature embedded in their structure. Panel thickness is 100mm. Both caravans are built on a rigid transport chassis.

Figure 13: Power unit



1	Exhaust of the Incinolet electric toilet
2-3-4	Cupboards
5	Unit's electric board
6	Main electric board (or generator's electric board)
7	Exhaust of the generator's engine
8	Shelves
9	Pipes (for coolant liquid)
10	Snow melter (*)
11	Batteries' case
12	Onan turbocharged Diesel generator
13	Sliding wall
14 – 15	Oil tank (2 sides : 1 for engine oil, 1 for hydraulic oil) – (*)
16	Dryer for clothes, towels ...
17	Incinolet electric toilet
18	Compressed gases' cylinders (Nitrogen, acetylen, oxygen)

B.1.5 - Telecommunications

Each tractor as well as the "Living" module have fixed VHF transceivers for local communications within the traverse or with nearby parties. The fixed transceivers are completed by individual hand-held VHF radios fixed into a pocket or on a jacket collar.

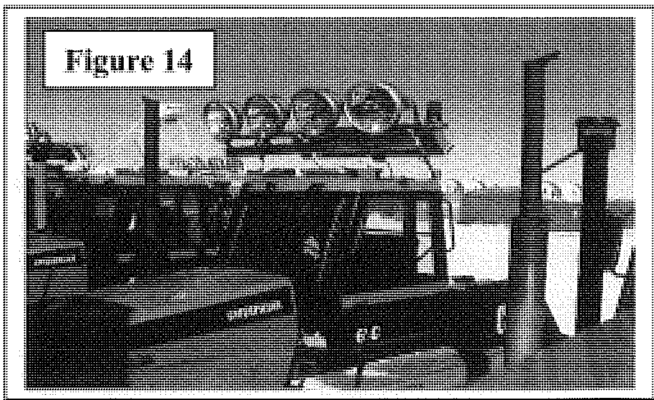
The traverse has four different systems for long distance communications.

- A fixed Irridium station for transmission of email messages. Irridium is the normal method used for sending all mail, both private and professional, in particular transmission of daily position. The Irridium station is also used for the telephone to fixed networks and other Irridium stations.
- An Inmarsat C, which, prior to installation of Irridium, was the primary method used to telex position reports and other general work messages. It has been retained as a safety back up to the Irridium, which although certainly economical can have irregular transmission quality.
- An INMARSAT M which is used for fax and telephone as an alternative to the Irridium network.
- A Traditional HF radio is also used as back-up of all satellite systems but also for regular HF voice communications with the stations when out of range of the VHF system (about 20 km). There are three HF radio units, one in the "Living" module and two in different tractors.

B.1.6 - Navigation

Navigation is based on use of the GPS and local, physical reconnaissance of the route taken. The head vehicle, whose task it is to locate and follow the route, is equipped with several electronic systems which allow it to pinpoint physical traces of the track and locate it. These include:

- A bearing GPS which locates the vehicle in space, notably providing the vehicle's azimuth before its starts moving.
- A second GPS whose electronical components have been chosen to reduce error due to noise from the apparatus, this second GPS only gives the position whilst the first only provides the vehicle azimuth,
- A pc equipped with plotting/route marking software followed by posting of GPS data – the screen shows the position in real time compared to the recorded route.
- Projectors (**Figure 14**) with a total power of between 6 to 12 kw – depending on the machine – powered by 220/380 V – 50 HZ generators connected either to the power take off, or in the case of the Kassbohrer, to the hydrostatic circuits. These projectors provide greater luminance than the sun and allow the ground to be seen under White out conditions.



- Attempts were made on the first few traverses to implant a series of physical markers in order to relocate the compacted track. The method now used is based on creation of an embankment or burm downwind of the track. The burm is created by adjustment of the blade on the grader. It is slightly visible from one year to the next and is sufficient to relocate the hardened ground from previous traverses.

The other vehicles are equipped with standard GPS which would allow each to chart a minimum route, should they become isolated by some incident. These GPS also allow the drivers to locate one another – there are sometimes 5km between the first and last vehicles in the convoy.

One vehicle (usually the second behind the head vehicle) is equipped with Radar, but this is for safety purposes and not a navigational aid.

B.2 - Equipment at stopover sites (departure and delivery)

The departure and arrival sites are transit areas where cargo for loading or delivery is managed. To simplify handling, each container or grouping of cargo when identified is loaded (if its mass is greater than 6 tonnes) on what is termed a 'handling sled'. A handling sled, as opposed to a traverse sled, allows heavy loads to be manoeuvred locally without using expensive and/or precision equipment (such as a track loader...) as the snow surface does not bear well. The handling sleds are either loaded along with the convoy or left at the loading site, indicating that they are needed at the delivery site.

B.2.1 - Departure Point (Cape Prudhomme)

Dumont d'Urville is separated from the continent by an arm of the sea 5km wide. Personnel working on preparation of the convoy is isolated most of the time from the station and must function autonomously. Living quarters, a power station, three workshops, a 200 m2 store, a 300 m3 fuel plant and an underground 500 m2 garage have thus been created. It is practically a second base.

Personnel not on the traverse maintain equipment and prepare cargo for the next traverse. Loading is conducted using an electric gantry crane of 15 T capacity, hydraulic cranes mounted on the back of three tractors and a 10 T excavator capable of being used as a crane.

Transfers from the supply ship's unloading area and the continent are carried out by the wintering personnel over the sea ice and by default, in summer, using a 50 T transfer barge.

B.2.2 - Delivery (Dome C)

Unloading is conducted entirely by convoy personnel using cranes mounted on the back of the Challengers, by the Cat 953 track loader and by the construction crane. A pit can also be dug to unload cargo which is too heavy for the loading engines' capacity. In this case the route sled is lowered into the pit and its cargo, still on the handling sled, is towed out onto the snow (**Figure 15**).

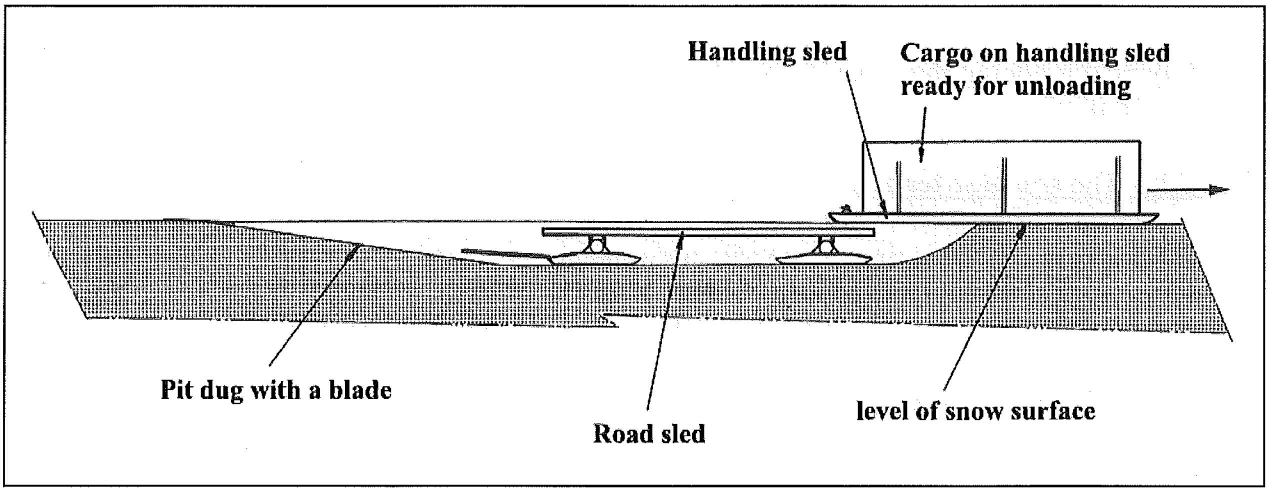


Figure 15: unloading Pit

C – GENERAL ORGANISATION - PERSONNEL and SAFETY

The choice of the number of tractors in the organisation of our system of convoys was made on three different grounds: technical, psychological and financial.

- Technical criteria included considerations such as convoy length, maintenance operations during stops, personnel accommodation requirements and probability of break-down.
- Psychological aspects concentrated on the organisation of a voyaging group needing to observe a regular routine. Both technical and psychological evaluations used our past traverse experience.

Actually, we consider it is difficult to efficiently lead a team of more than 10 to 12 persons and comprising more than 10 engines and 40 units of cargo.

A typical grouping thus consists of 7 tractors and 2 levelling vehicles operated by a team of about 9 to 10 persons.

C.1 – The traverse team

The traverse team requires a specific personality and profile. It must be able to perform many duties: drive, level the ground, determine its position and navigate, eat well, communicate, maintain and fix equipment, attend patients and form a coherent, responsible team.

C.1.1 - The work on the traverse

Some duties have to be fulfilled by all members of the team while some other duties only need to be fulfilled by one person.

- **Driving:** The team members must be able to drive a vehicle towing a load while being attentive to onboard indicators and instruments. They must in addition be intuitive and attentive to feel the machine and react promptly to any problem.

- **Levelling the Ground:** Four persons must be able to level the ground with the Kassbohrer's blade, continuously and well enough to provide a good track for the tractors that follow. This levelling determines the speed of the whole convoy. It is an exhausting job and the operator should be replaced every two hours. The driver of the head vehicle also needs to pay attention to the route and to navigation. In fact it is better that the relief driver be alongside him on a permanent basis to assist him in attending to the outside environment and his instruments.

- **Determining Position and Navigation:** Two persons must be able to set the GPS and the navigation software and also to understand simple astronomical phenomena. One person must be able to determine a position using a theodolite, the astronomical tables and a logarithm table.

- **Eat well:** One person must be able to organize, if necessary, proper meals for the team.

- **Communicate:** One person in charge of telecommunications must be able to use Inmarsat, Irridium, the email software as well as HF radio equipment.

- **Maintaining Equipment:** Seven persons (one per tractor) must be able to carry out basic maintenance on the tractors and their loads (refueling, cleaning, clearing snow, keeping loads secure, check couplings).

- **Fixing Equipment:** The traverse is a technical venture with 220 kW tractors, a diesel generator set, 22 to 30 loaded sleds or trailers. Four persons must have sufficient experience to intervene on a fully loaded sled or trailer deck which is damaged or in a difficult position. At least four persons must be experienced diesel mechanics, two of them must have a good knowledge of the Kassbohrer's hydrostatic systems. One person must be a good welder, and another an electrician/electronics specialist.

- **Attending Patients:** The presence of a medical doctor on the traverse is necessary.

- **Leading the team:** One person, similar to the ship's captain, needs to be responsible for the traverse team and to make daily and overall decisions in accord with project leader or institutional directives.

- **Forming a Coherent, Responsible Team:** In such an isolated and difficult environment, the team must be coherent and responsible. This requires careful choice of all members, but more importantly requires the presence of a very good assertive leader accepted by all, capable of taking initiatives and making decisions. This leader organizes the everyday life of the traverse and takes the decisions when problems occur.

C.1.2 Professional skills of the whole team

- **Four Diesel Mechanics,** for maintaining and repairing all mechanical equipment, with at least one skilled in hydraulics.
- **Four grading specialists**, who can also have other skills (mechanic, navigator, etc...)
- **One Navigator and Telecommunications Officer,** capable of maintaining his equipment. This member is usually the electrician / electronics engineer of the team. This position involves a fair amount of work during traverse stops.
- **One Medical Doctor,** who can possibly also be a Navigator or levelling specialist. He is usually in charge of the cooking. It is common practice to keep the doctor away from dangerous activities.
- **One Traverse Leader,** who can be one of the Diesel Mechanics, but cannot easily be the doctor. The traverse leader must have a good knowledge of the project. He must know all the equipment perfectly and be able to assess its condition in order to make the right decisions.
- **One to three supernumary Members,** who only have to be able to drive a tractor and have good physical abilities. They can be scientists doing en-route studies, journalists who will report on their trip, suppliers of equipment, VIP, technicians in training etc... They are usually there "au pair" rather than as full staff members. This "opens" the traverse to the outside world by allowing various members to join the team.

C.1.3 - Social considerations

As previously mentioned, the traverse team must be coherent and cohesive. Its members must really work "together". Personnel turnover should be low while still allowing the creation of a sufficient pool of experienced traverse personnel. The problem is to create a pool of experienced, rigorous professionals and avoid the succession of strong personalities coming along for the adventure without caring for the group. Both professional and personal qualities are essential. The cohesion of the team requires respect for each other, and the understanding that every action not carried out properly can result in extra work load, equipment failure and/or high risk situations for somebody in the course of future traverses.

Traverse work starts with the preparation of vehicles and loads before departing and ends with the conditioning of vehicles for the winter upon return of the last traverse of the season. Bad conditioning for the winter, rough operation of vehicles or postponed repairs will sooner or later show their due.

C.1.4 - Training

It is difficult on the employment market to find people with personal and professional capacities that can make them good "traversers". There are no formal selection criteria, but we consider aptitude to the environment to be an important issue and we tend to give preference to people that have the requested professional abilities along with a successful wintering past in Antarctica or mountain work experience. Then, we complement their skills as required by additional specialized training sessions. Such sessions include specific training on the Kassbohrer PB and Caterpillar Challenger tractors organized by the manufacturers, navigation courses at specialized institutions such as the French National Geographic Institute or first aid courses.

C.2 – Risk assesment

C.2.1 – Enumeration of the potential risks

Total safety can never be attained, but we are making every effort to reduce risks as much as possible. Risks can derive from the following sources:

- Crevasses
- Fire
- Loss of food stocks
- Loss of energy production systems
- A vehicle or the whole convoy getting lost
- Cold, Altitude, Sun
- Exhaustion
- Psychological disorders
- Illness
- Physical accidents

Crevasses: There are only two, very localized, crevasse areas relevant to the Dumont d'Urville Dome C traverses. One area is near the coastal zone and can be monitored each year by helicopter. A second zone is 200 km from the coast and is clearly visibly on Spot satellite photos.

Fire: Fire is the most serious risk as it can cause the loss of one of the three modules or one vehicle. To minimize risks, the main personnel facilities were divided into two modules that separate the energy production area from the living area. The two "Energy" and "Living" modules have no link and personnel has to go outside to get from one module to the other. The fuel tank for the generator set is on the outside of the Energy module. The third module is the "Store" which doesn't contain any dangerous combustible materials (no petrol, propane, diesel fuel...). The three modules are made of auto-extinguishing material classified "M0" or "M1". All electrical installations follow maritime regulations.

Loss of food stocks: This can be caused by fire or the accidental disconnection of the sled or trailer carrying the stocks. To prevent a total loss of the stocks, the food is usually divided in three lots placed in the living module, in the storage module and on a sled (safety stock).

Loss of energy production systems: This can be caused by fire or by a problem with the diesel fuel, such as congealing. To prevent total loss of energy production capabilities, the traverse has at least one 40 Kw generator installed on a tractor, and a separate propane stock, kerosene and petrol stocks. In fact, due to the requirements of the projectors fitted to three tractors, the convoy is equipped with three generators of 40, 20 and 12KW.

A vehicle or the whole convoy getting lost: Most of the time the convoy now follows the old track. However, there is nevertheless one GPS receiver in each vehicle and each driver has basic training in navigation. One of the tractors is also equipped with radar and is always placed in a position where it can monitor the entire convoy. Radar is mostly used in bad weather to guide the machines to their parking spot.

In case of a problem with the GPS system network itself and no visible previous track, the navigator is able to determine his position astronomically using the sun as reference.

Cold: The main risk is associated with the loss of heating capabilities following the loss of energy production systems. But there are also daily risks caused by loss of attention and risk awareness. The briefing of new traverse members on this aspect is necessary. Clothes are appropriate and each person has sufficient amount of clothes to get changed as needed.

Altitude: Altitude related risks are mostly for personnel reaching Dome C by plane, not by traverse. Nevertheless, there can be daily risks on the traverse caused by loss of attention and risk awareness, notably over-estimation of one's physical capabilities. The briefing of new traverse members on this aspect is necessary. The traverse is equipped with a compression chamber since the 95/96 season.

Sun: Sun related risks are mostly concerned with eyes and possible serious ophthalmia due to UV radiation, and personnel is provided with adequate sun glasses. The briefing of new traverse members on this aspect is necessary. On the forward leg to Dome C, "night sun" is especially problematic for drivers as it is at windscreen height.

Exhaustion: Exhaustion is highly dependent on the schedule adopted, the environmental conditions and the problems encountered. The medical doctor and the traverse leader should assess the level of exhaustion of the personnel and the traverse leader has all latitude to adapt the schedule and work program to the situation.

'sychological disorders: These problems, or the possibility of their occurrence, should be etected beforehand in the selection process.

lness: Traverse personnel is subject beforehand to thorough medical tests. The first main risk is ood poisoning. Food stocks are checked and sorted every year, and storage temperature quirements for refrigerated and frozen products are carefully enforced. The second main risk is ppendicitis, which the traverse medical doctor can deal with.

ıysical accidents: It is one of the most delicate problems. Physical accidents that would have nign consequences in a normal environment can take dangerous proportions in the traverse vironment. Traverse personnel must be aware of their isolation and take special care in any tivity.

Miscalculation of fuel consumption: Although the subject of frequent jokes, the 'dry breakdown' can become very serious in Antarctica. It is important therefore that the convoy leader pay it the closest attention.

C.2. 2 - Associated Prevention Measures

Safety is absolutely essential. There are several methods to prevent accidents and minimize their consequences. The actions taken to this end on the traverse are:

- Multiply the number of shelters in the convoy, spread clothes and sleeping bags.
- Spread food into several stocks
- Link all vehicles and shelters with VHF radio.
- Have several satellite and HF telecommunication systems spread in the convoy and regularly check them.
- Have several GPS positioning receivers spread in the convoy.
- Have enough Kerosene in the convoy to refuel an aircraft coming for a rescue operation.
- Have a medical doctor on the traverse, have experienced personnel, train one or two traverse members at first aid techniques.
- Have medical facilities
- Be equipped with radar
- Have an emergency refuelling point about 1/3 of the distance from the coast.

It is also worth mentioning the obvious: Use reliable vehicles and equipment so that personnel are not living in permanent fear of breakdowns and being exposed to dangerous repair operations.

The traverse members have to be trained, informed and permanently aware of their situation. It can seem obvious, but it should still be mentioned that on the traverse:

- In a blizzard, you should only go outside wearing sufficient clothing, you should inform the convoy leader of your intentions and wait for his permission, and possibly attach yourself to a safety rope.
- You should never open the door of one of the modules while the traverse is moving (if there is some personnel on rest when the traverse operates).
- You should check before starting the convoy that every person is there and where they should be.
- You should respect the planned schedule for sending radio messages reporting the traverse position.
- You should not stand beside a tractor under manoeuvre without ensuring that the driver has seen you,
- As the driver, you must take every precaution if a manoeuvre brings you close to people and in particular persons positioned between your tractor and an obstacle; this is particularly the case when connecting tractors to sleds.
- You must cede your place to a more experienced person if delicate manoeuvres require particular experience even if your natural reaction is to consider this situation objectionable.

Safety can't be neglected but imposing excessive safety measures is not necessary as it could give a false impression of security. The environment is hostile and the traverse personnel should always feel it.

C.3 - Organisation and management of food

The preparation and quality of food are important features of life on the traverse. The day is punctuated by three meals – breakfast, the midday meal and the evening meal. Meals are also convivial moments when one can relax and talk to colleagues. This is particularly important as personnel are alone in their vehicle and therefore have no one to speak to for long hours.

C.3.1 – Meals

Good nutrition, eating well, requires attractive dishes, but this requirement is difficult to meet due to the limited time for meal preparation – ¼ hour at midday, 1 hour in the evening. This problem has been overcome by preparing dishes to be consumed on the traverse in advance. The meals are cooked and packaged in advance for us, in Australia, then frozen, on the basis of 12 evening and 12 midday menus. The kit comprises the entree, main dish, dessert and disposable cutlery and dishes. Drinks, confectionery, condiments and cheese are obtained from the heated food store. The use of disposable crockery and pre-packaged meals for dishes for 10 persons considerably limits the dishwashing water used and hence the impact of the convoy on the environment. The dishes and plates are repackaged then repatriated as waste then extracts to the treatment zone.

C.3.2 - Drinks and confectionery

The food store includes a very large choice of confectionery available to everyone. This is mostly consumed during the hours driving. Apart from drinking water, drinks include a choice of non alcoholic drinks – fruit juice, teas, coffee, fizzy drinks - and alcoholic drinks, wine for meals, and beer on a ration of one per person per 2 days.

C4 – Leisure time

The traverse is not a work situation allowing much leisure time for the technicians who participate in it. Nevertheless the days are long aboard the tractors, particularly for the driver in second position. Bad weather, when occur, can also keep every one inside the caravans. For these situations, we record radio programs throughout the year which are humorous or of cultural interest, the traverse is also supplied with books and magazines, audio cds and DVDs on loan from Dumont d'Urville. The traverse also has several games, group games are preferred to computer games. In the case of a long stop, it is also possible to cook a meal other than the pre-prepared menus.

D - TREATMENT of WASTE

Waste can be divided into three categories, which are:

- Waste repatriated
- Excrement which is incinerated locally using an electric incinerator
- Washing water (mainly for personnel care as the kitchenware cleaning is very reduced)

Only washing water is released back into the environment. Its volume, for a team of 10 persons, is about 300 litres / day. Repatriated waste is composed of both domestic waste and industrial waste, both solid and liquid.

E – GENERAL ORGANISATION OF A CONVOY

Assembling a tractor and cargo in a train is not a priori particularly difficult to undertake and does not of itself merit a presentation. In our case the train has to be assembled and advance in unexplored terrain and on a new surface which is mechanically difficult to negotiate and where the weather itself makes new layers of snow. The ground surface is as much a product of the local weather conditions as the snow covered rock base. The terrain and the route to be taken, must both have undergone at the very least a pre evaluation.

The ground must be prepared and leveled on the first and on subsequent passages of the traverse as it will deteriorate with each use. If the convoy going through is very long, it will need to be prepared again even in the middle the convoy.

The ground is the other side of the transport equation, and the machines you plan must be built and modified as a function of that surface. This is where a difference can arise between the experience gained within the framework of the Dome C continental station. Experience gained within the context of Dome C is based on a particular snow type and particular weather conditions – wind, precipitation level, temperature range.

E.1 - Preparation and maintenance of the route

Prior to precise satellite imaging, exploration of the terrain was done empirically. With photographs, it is now possible to determine the route to be followed in advance. Once this mapping work has been completed and the route has been travelled and recognized, it must be able to be found at each voyage. Finding the route again after a winter is possible on the Antarctic plateau as frequently, snow cover is not too significant or has been blown away by the wind. Improving one's output means less fuel consumed, less equipment utilized, less impact on the environment.

E.1.1 - Choice of route

Choice of route refers to decisions which can be made with the aid of high altitude observations, with satellite observations being most useful. These allow an overall view, a picture of the whole region to be traversed, in 60 to 200 km sections. On the other hand, choosing the route when exploring in the field is very uncertain and there are not good methods for achieving a result.

Photographs taken when the sun shows features in good relief will provide precious information, as will the required precision. Precision is a function of the definition – pixels at 5m or greater – and the geo-referencing of the image. Pixel size can determine whether or not crevasses on the route are visible. Geo-referencing, where a visible point on the image (such as a building or depot) whose absolute position is known allows latitude and longitude to be fixed on the geodesic chart and removes error due to post treatment automatic positioning.

Illumination from the sun will highlight large ridges and Sastrugi zones. Large ridges are undulations several kilometers long by 50m in height difference. By taking these into account one can trace a route around them, so that the convoy can avoid having to climb, and then descend them later. Sastrugi zones visible on the image delineate areas of very strong winds. These must be avoided when parking at night. Parking for the night on uphill areas should also be avoided. This always leads to a tricky start in the morning.

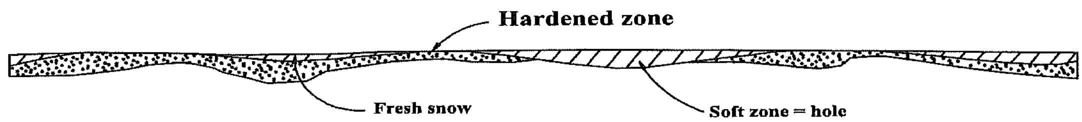
Starting with the fact that the route departs from the coast towards the interior, the best choice of route will be one which climbs continuously, that is without alternating steep rises and long flat zones and of course without unnecessary descents, often the consequence of a steep climb.

E.1.2 - Homogenisation of the road surface

Preparing the route means to flatten and harden it. It needs to be flattened, or graded, as a succession of ridges will reduce your speed, damage your equipment and can actually stop you. The route must be hardened as a hard surface allows your tractors better traction and your cargo has less resistance, whether it is loaded on skis or tracks.

In the case of Concordia, grading is carried out by Kassbohrer type machines, reasons for selection of these is explained in paragraph B.1.2. The train itself compacts the route, however the phases of succeeding trains and blades are not sufficient to produce uniform depth in the weight bearing top layer. The diagram **(Figure 16)** shows the surface obtained after passage of the grader and the following diagram (**Figure 17)** shows the result obtained after passage of the convoy:

Figure 16 –Diagram
Graded track without mixing



Unmixed / raw track behind the convoy

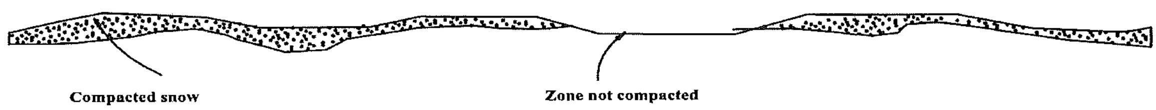


Figure 17: Track behind the convoy

In order to flatten and harden the surface, we have thought to use a plough. The plough **(Figure 18)** mixes up the layers of snow, working into a layer and also along a section of the track. It mixes up the strongly compacted and softer snow issuing from the repeated passage of the traverse train.

This operation is conducted once per season, on the return of Traverse No. 1. For the moment the plough is coupled to a Challenger and the levelling is done by the rear grader in the convoy.

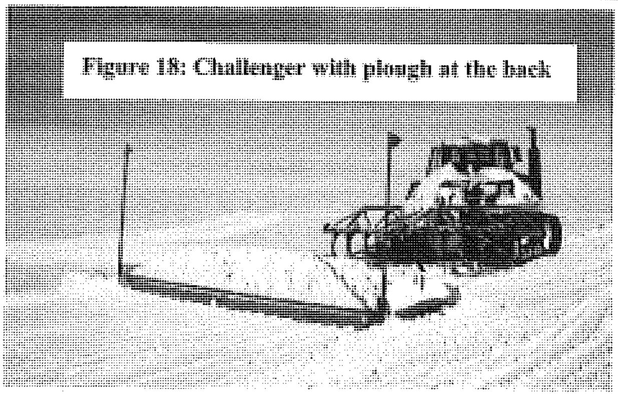
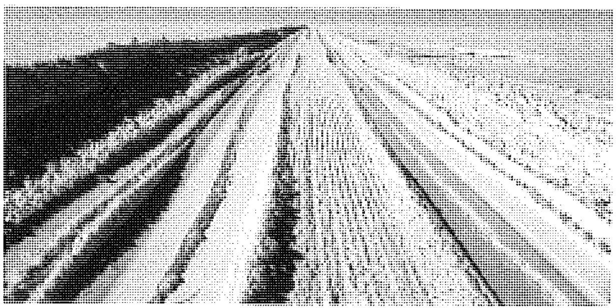


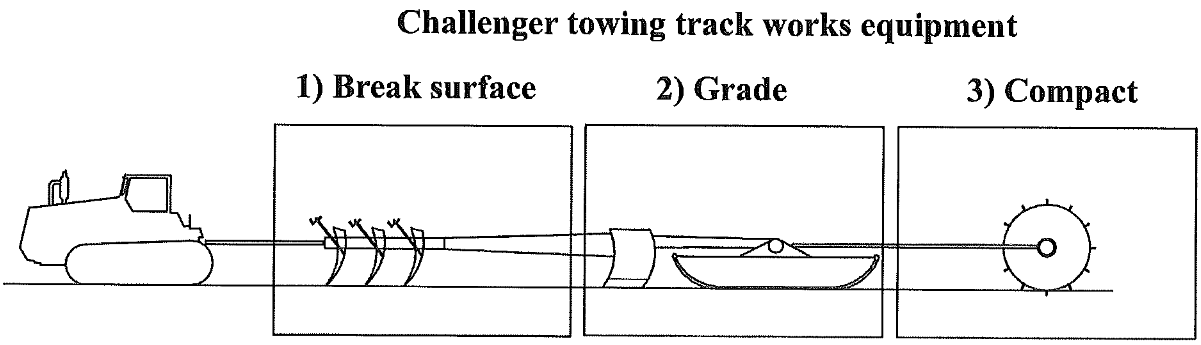
Figure 18: Challenger with plough at the back

Fig 19: View graded and mixed track behind the convoy



This brings us to automated grading. It is difficult to envisage an automated grading system at the head of the convoy as it would have to be pushed and adjusted continuously to differences in the order of a metre. More conceivable would be a towed system at the middle or end of the convoy. Blade tow tests have already been conducted as outlined in **Figure 20.**

Figure 20 – Diagram
Theoretical towed grading system



The ripper positioned under the chassis, in front of the blade, breaks up the more prominent moguls. The grading blade, guided automatically by the skis supporting it, spreads the material produced by the ripper. The smoothing device scores the surface.

E.1.3 – Automated levelling:

Levelling the track when it is new, or after storms, are tasks which it is difficult to avoid. However levelling the route after the convoy has gone by because the convoy itself has produced its own ridges is something which can be managed. Hence the notion of automated levelling. It is easy to observe that the ridges left by the passage of a convoy have a footprint related to the length of the skis. The explanation is simple, an all terrain vehicle adapts to the terrain, and using it on a soft surface juxtaposes two contrary systems which can't find an equilibrium as, having no common precept, they cannot find a point of automatic adjustment. So one has come up with the idea of limiting the degree of adaptation of trailers and sleds using powerful suspension devices. The diagrams shown are self explanatory.

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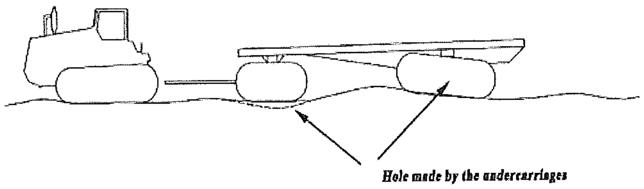
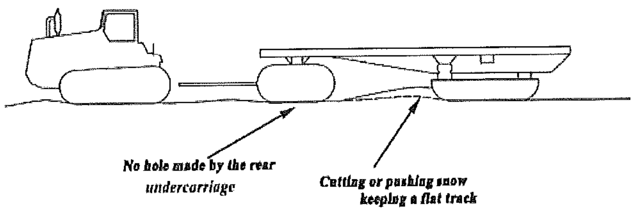
Figure 21 – Diagram
Trailer fitted with flexible articulations



On the diagram, the ski goes through the bump rather than going over it and digging a little deeper. It is certain that this particular ski will be slowed down, but on the other hand the following skis will not have to climb the obstacle.

The principle is to bring to the surface stresses which go against the direction of the deformation (**Figure 22**). Evidently this notion has come rather late. Devices have been designed for each type of cargo, and after a testing period, are now starting to be installed on the equipment. Thus, all the 12m3 tank sleds have had a movement limiting device fitted.

Figure 22 – Diagram
Trailer with damped articulations



The new 26m3 tanks are all built with the device shown in **Figure 10.** The trailers (**Figure 11**) will take longer to modify as the undercarriage has to be rebuilt and its fitting rethought. Finally, the retained kinematics in the so called chain sleds (**Figure 08**), whether the chain is crossed as on the Otaco or Aalener type sleds or on one side and other of a towing beam, as ours are, goes in this direction, as the head of the ski kept in alignment with the convoy by traction tends to flatten ridges and will not seek the bottom of the dips being formed

<u>E.2 - Order of assembly of convey components</u>

E.2.1 – Assembly information which facilitates traction of cargo

Cargo can be coupled in the classical manner – a tractor towing several loads (**Figure 23**) up to its slippage limit. This limit is found by trials, and for example for a Challenger 65, it is about four loads representing a total mass of 40 to 50 T, trailer included. This method however has its limit. As we have seen, the ground gradually deforms due to the loads themselves and the situation shown in **Figure 23** will occur from time to time. The skis / or tracked elements on all the loads all find themselves climbing at the same moment. Finally it's as if the whole train is climbing an equivalent slope. The tractor slips and if the driver doesn't understand what is happening, that he should not continue to try to pull, he has every chance of burying his machine. This phenomenon does not occur particularly often, once every two to three hours per train, but it is sufficient to retard progression of the whole convoy as one's colleagues obviously need to stop to provide assistance. In general the – wrong – response to this is to lighten the convoy, that is to take off a load.

Figure 23
Single tractor towing load

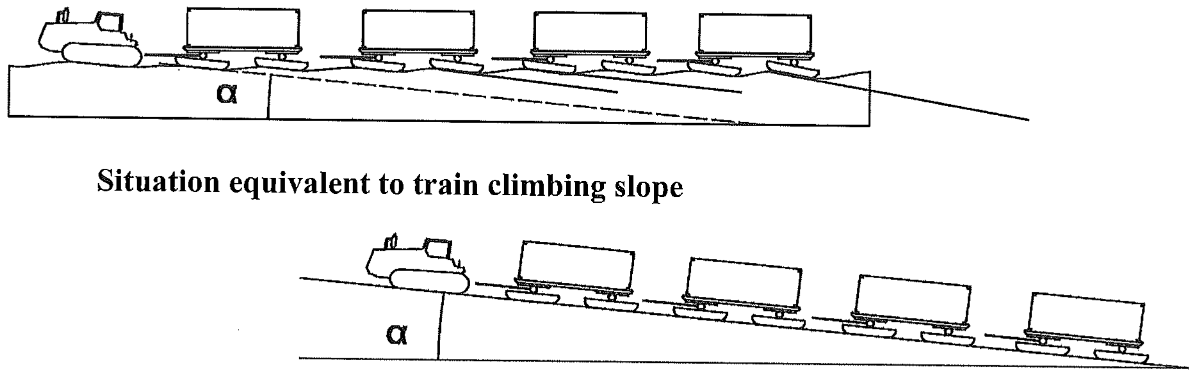
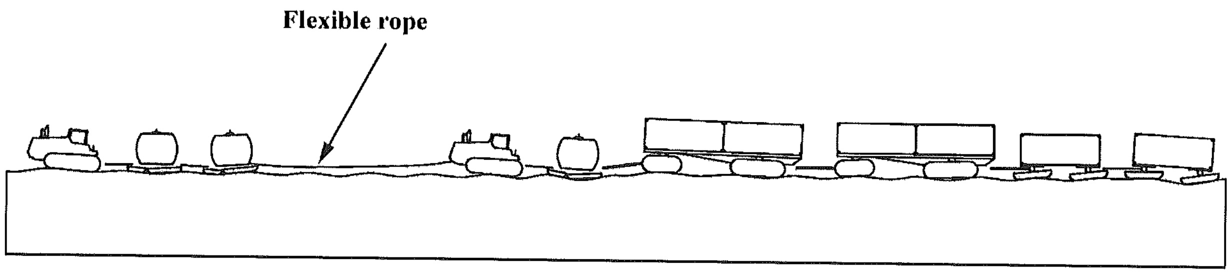


Figure 24 – Diagram
Tractors towing load in tandem



However there are two good solutions **(Figure 24)** to the problem which allow the load to be retained and preserve the driver's comfort :

- The first consists of grouping the trains in tandem and joining them with an elasticised rope and so that the first machine is efficient, one part of its cargo is transferred to the second machine. The assembly is the same but the machine at the front, via the elasticized rope, is always free in its movements. Whilst the second machine, which now cannot move alone, is held back further by its load, tending to stop, the kinetic energy of the first machine is sufficient to pull it out of a bad situation.

- The second solution, in the new configuration, is to mix loads of different lengths, hence the footprint of the load bearing elements will be different to the pattern of ridges produced by the preceding load.

E.2.2 - Information on convoy assembly facilitating organisation of stops

The Concordia convoys comprise three to four trains which after five or six hours of travel are spread over four to five km, - a difference of 0.5 to 1 km/hour will produce this gap. It is thus appropriate to position the train of caravans at the head of the convoy. At the beginning of the traverse, the caravans will have the benefit of a better ground surface – there is no need for kitchenware to fall out of cupboards – and they will be the first to stop at the stopover point. If the staff responsible for the meal, for example the doctor, is driving one of the two tractors in the train, he can prepare the meal, assisted by one of his colleagues, and everything will be ready when the last train arrives. This is certainly sensible at midday but also in the evening as it allows daily chores to be commenced without delay.

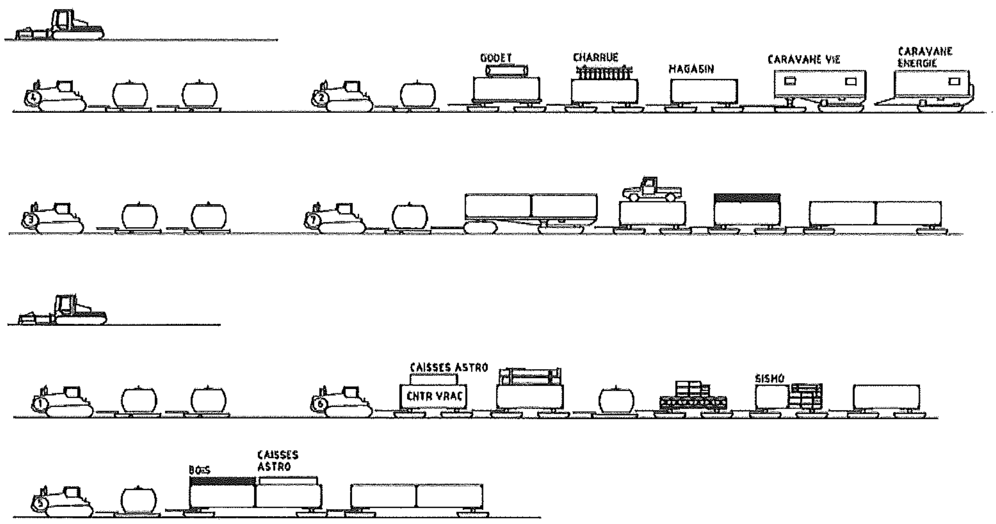


Figure 25 - Diagram
Draft of traverse assembly

E.3 - Along the route

The logistical convoy heads for a particular point, then returns, then starts another circuit. Getting from the departure point to the point of arrival uses up fuel, and fuel will be consumed again on the return. The load bearing elements transporting this convoy fuel are put at the head of each coupled unit and can easily be detached, handled and left on the edge of the route as the convoy progresses. These tanks will also contain the fuel for the return, in fact the fuel for the return is not taken to the final destination but dropped off as the convoy progresses. A convoy between Dumont d'Urville and Dome C, hence carrying 25 to 30 cargo units, will divest itself of 7 to 10 units along the 1150 km of the track. It is the convoy leader's responsibility to calculate the correct volume to set down. In fact one shouldn't drop off too much fuel as it would be sent back unnecessarily to the coast, decreasing the yield for the rotation. Dropping off too little fuel means the convoy cannot get back.

It is normal practice to put the units of fuel to be utilized in the train containing the caravan. The caravan train will be the first to have its load lightened. In fact, the tank in current use needs to be moved each evening over to the pumping station. If this operation can be done as soon as the evening's stop commences, before the others arrives, then that is all the more time saved. Once the caravan has been uncoupled from one to two tanks, the next tanks are transferred – proportionately – from the later trains to the train with the caravan. The tanks on the slowest train need to be chosen.

Progressively reducing loads as the convoy advances towards the delivery site allows it to gain some speed. The distance covered on the first days does not exceed 100 km whilst it can reach 120 km over the last days. The question usually raised at this point is whether depots could be established beforehand. When the project first began a fuel run was envisaged, however this was abandoned as soon as it became clear that the quality of the neve and adherence of tractors to the ground plummeted the further one climbed up the plateau. The lack of humidity in the atmosphere and the drop in average wind speeds are responsible for the lowering in the névé's cohesive qualities. Even the material on the traverse track compacted by successive passages of the convoy coheres less and affords tractors less ground adherence than at the coast. Hence it was concluded that dedicated fuel traverses were pointless due to the proportional loss in ground quality, and depositing fuel caches along the traverse was adopted instead.

E.4 - Progress of the day on traverse

The work day is long. Wake up time is usually set at 07H00, personnel have their breakfast, and use the bathroom if necessary. Work usually commences around 7H45. The mechanics start the engines and fold away electric heating cords while the rest of the team proceeds with tidying the caravans. At 08h00, people get into the vehicles and manoeuvre the machines, unloaded, to get them to the correct temperature. At 08.15 the machines are in front of their loads and connected. Once this work is done, the head of the convoy does a roll call and if everyone is agreed announces the departure.

The lunchtime stop is organised for the last train's stop at 13h30. The vehicles stop on the route, engines are switched off and thermal blankets unrolled. Those arriving first prepare the meal. The meal finishes at 14H15. Drivers are then in their vehicles at 14H30 after having again tidied the caravans, then the convoy leader proceeds once more with the roll call and departure

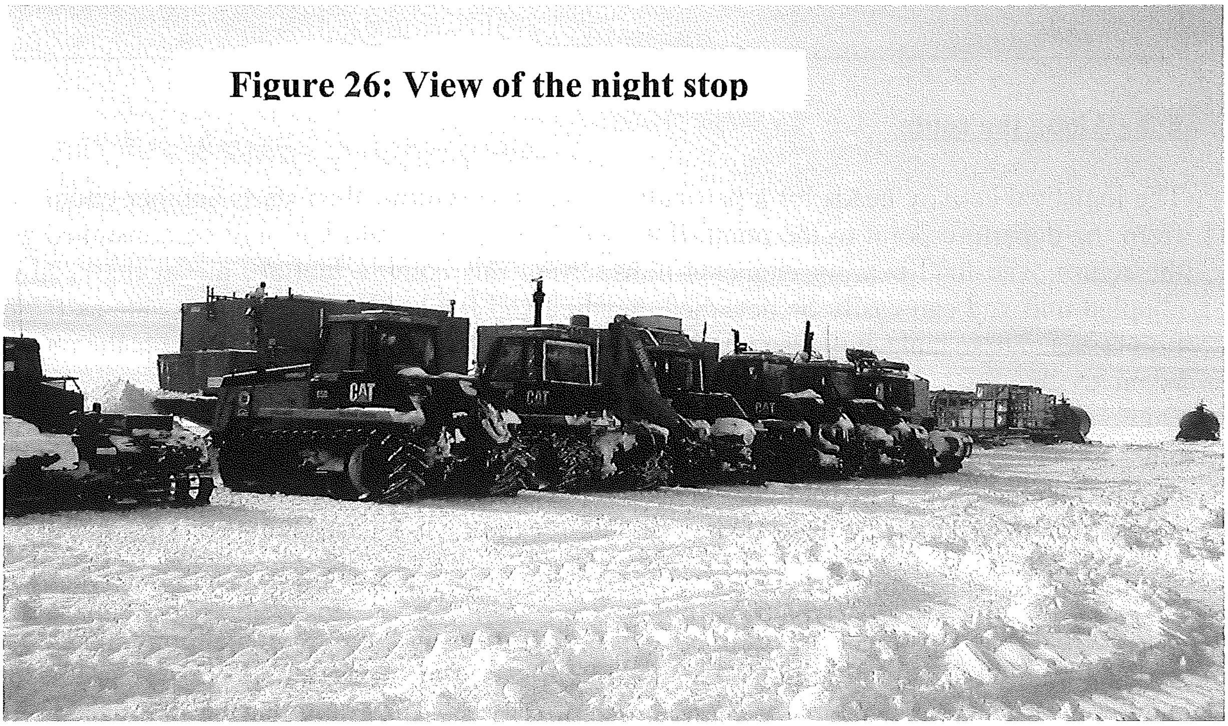


Figure 26: View of the night stop

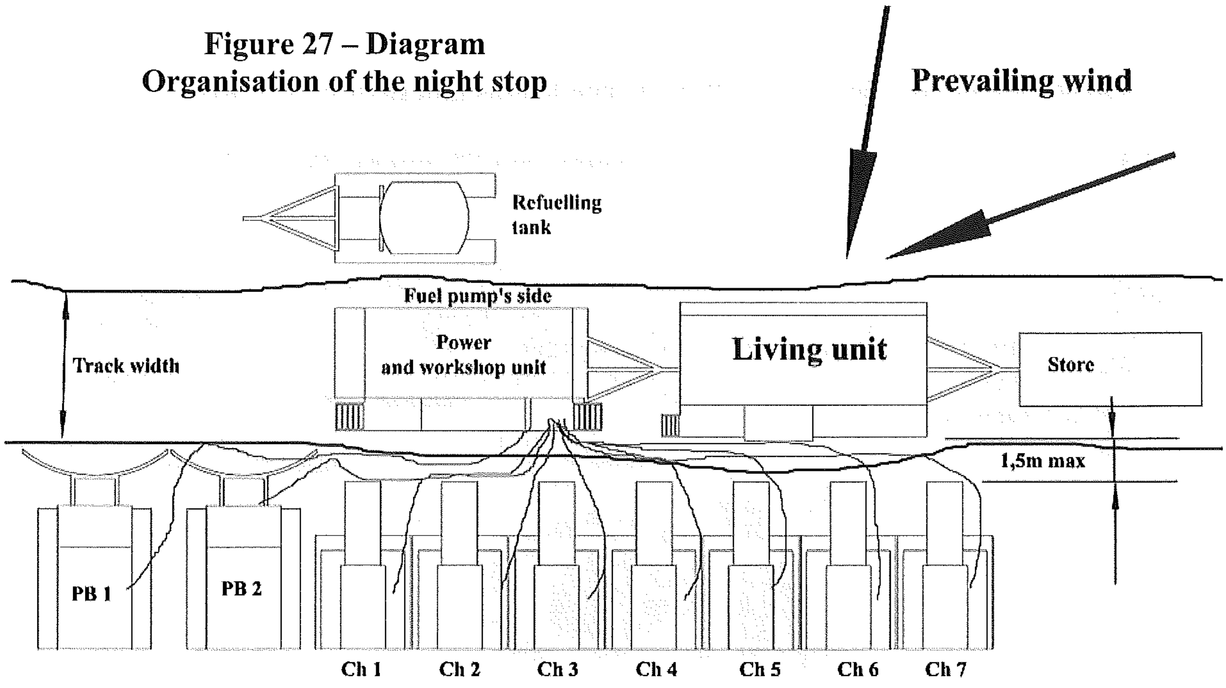
The evening stop **(Figures 26 and 27)** is organised for the arrival of the last train at 20H30. The loads are stationed on the route. The tractor hitched to the fuel tank in use positions it alongside the refuelling pump. The drivers uncouple their machines and drive them to the parking area, to the right of the caravans.

The parking area is always sheltered from the prevailing wind by the caravans and the placement of their openings, emergency exits, electric power points for heating etc… have been designed in terms of the route to be taken on the ascent (or loaded traverse to the delivery site).

The caravans are placed so that the dominant wind is contained at an angle between 10H00 and 11H00, to the left. This arrangement and the distances to be observed between the various items of equipment in order to limit the effects of a snow storm have been the subject of a climatic wind test.

In the evening, each technician takes up a new work role – the doctor prepares the meal, two mechanics check the Caterpillar tractors, another the Kassbohrer graders, two others check the complex of cargo, decks and sleds, two technicians supervise refuelling of tanks. In general this latter task is given to the radio operator who is then freed sooner than his colleagues to see to the radio traffic. The evening meal takes place at 22H00 unless delayed by an incident or repairs. At 23H00, personnel who are not engaged in the cleaning roster have about an hour to themselves to send messages, have a shower etc.. Bedtime is at about midnight.

Figure 27 – Diagram
Organisation of the night stop



F – TECHNICAL ASSESMENT

F.1 - The Concordia Vehicle Pool

The pool of vehicles dedicated to the Concordia intra continental transport system currently comprises:

- 7 Challenger 65x tractors
- 3 Kassbohrer PB 330 snow graders
- 14 x 12m3tank sleds for storage and transport of fuel
- 1 living caravan
- 1 'power supply' / workshop / ablutions caravan
- 1 'stores' caravan
- 1 temperature controlled container / additional caravan
- 1 x 20' cold store container
- 3 multipurpose cargo trailers 12 m long and 25 ton capacity
- 5 multipurpose cargo sleds 6 m long and of 12 T capacity termed deck sleds
- 7 specialised sleds for transport of 20' containers
- 1 – a maximum of 3 x 26m3 fuel tanks for transport of site fuel

A standard traverse currently comprises 6 to 7 Challenger tractors, 2 PB 330 snow graders, the 3 caravans, one to two temperature controlled containers, with 20 to 25 units of cargo, or 25 to 30 units including the living caravans.

F.2 - Modification of vehicles to antarctic conditions and to desired function

F.2.1- CAT Challenger 65x, main winterisation modifications (Figure 28)

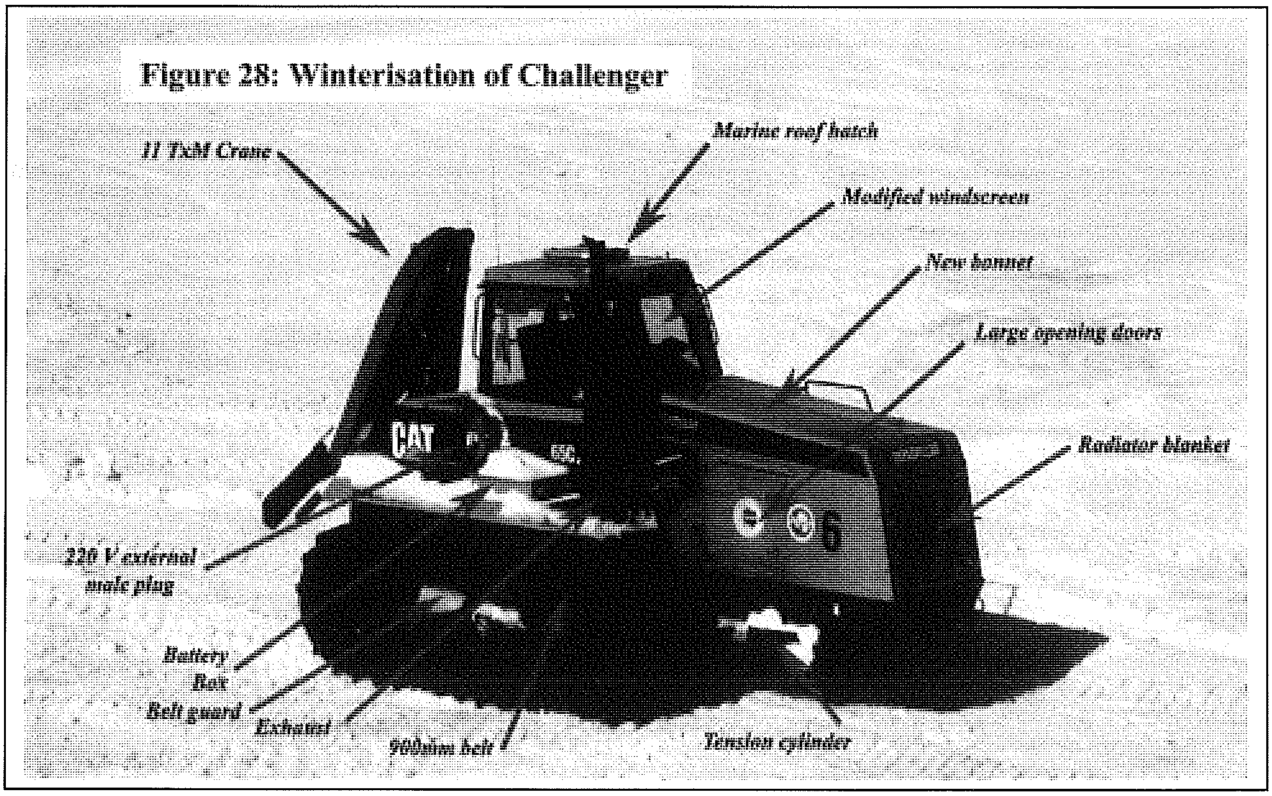


Figure 28: Winterisation of Challenger

Engine compartment:

- Installation of a fuel priming pump, a water separator and a fuel line heater in fuel system,
- Addition of a man hole on the fuel tank, a water collector at the bottom and a drain pipe.
- Installation of a 12/24 v alternator and a 50 MT starter motor
- Installation of Fleetguard heaters in all oil compartments, a tank type heater to cooling system and a silicon heating blanket stuck on the original oil sump,
- Installation of a 220V electric circuit to feed the engine heating elements when the convoy is stopped, with external connector and protection switchboard
- Installation of an additional oil sump to increase oil capacity and hence intervals between oil changes.
- Installation of one catalytic filter on the exhaust. This device works in association with a fuel additive containing cerium oxide. This additive reduces the carbon deposits in the cylinders, lowers the exhaust gas temperature and reduces the particles rejected in the atmosphere.

Cabin

- Installation of a marine type roof escape hatch with adjustable hinge, including external handle and lock facility ;
- Manufacture and installation of a double glazed front windscreen (original curved unit is replaced by 3 smaller flat units fitted in an adapted frame);
- Installation of heating air pipes around front windscreens
- Replacement of the glass rear windscreen by a thick, clear plastic screen (it is too large to allow the installation of a double glazed glass panel)
- Installation of a new locker and silicon seals on the cabin door
- Installation of a pyrometer to monitor the exhaust gas temperature and electronic tachometer on the right hand side of the cabin
- Removal of all levers not used in instrument panels and of their mechanisms (except on the vehicle fitted with the plough)
- Installation of a bench type driver seat. The bench is mounted on a KAB seat base
- Installation of 2 road truck type rearview mirrors, mounted on the external handle of the side of the cabin
- Installation of supports for external GPS and VHF antennas;
- Installation of aVHF transceiver, marine channel, per machine
- Installation of a radio player for cassettes and mp3 cds
- Removal of the external traffic and indicator lights

Frame, body, belts and bogies

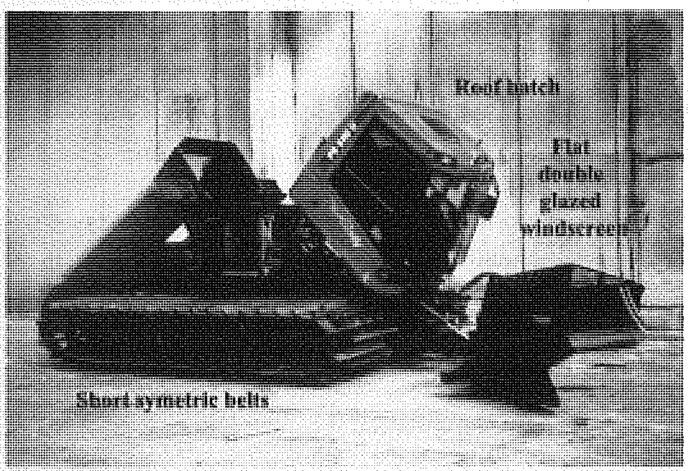
- Manufacture and installation of a new bonnet assembly to improve engine compartment sealing and complete insulation. The bonnet assembly has large openings and lift off doors for easy maintenance;
- Manufacture and installation of a heavy duty roll up blanket for the coolant radiator air intake;
- Manufacture and installation of a sealed sump cover with relocated dipsticks and filters and transmission guard group;
- Manufacture and installation of a heavy duty battery box - with 2 x 210 AH Optima gel batteries and connected to an external 24 V starting/charging plug
- Insulation of the Hydraulic tank;
- Manufacture and installation of ice scraper and belt covers to protect the drive wheels from the snow

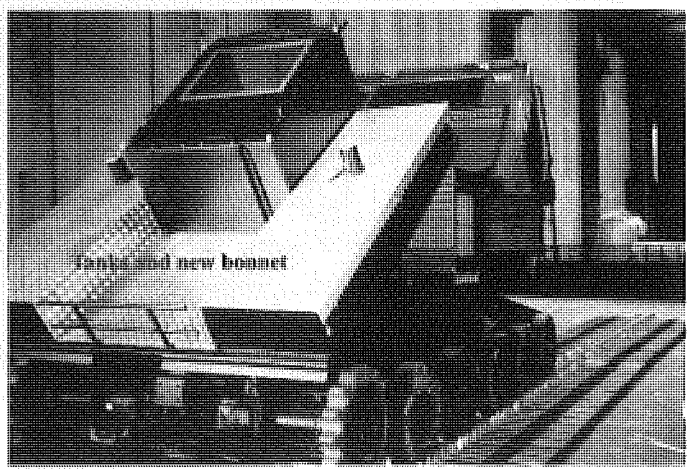
- Installation of silicone seals in drive and idler wheels;
- Installation of metallic hubs on wheels;
- Extension of the tracks grousers by vulcanisation of an additional strip;
- Installation of silicone seals in belt tension cylinders.
- Replacement of air suspension on bogies with rigid elastomer blocks;
- Blockage of movement on the bogies' balance arm so as to keep the track flat or concave

It should be noted that the mixed track tension system combining springs and compressed nitrogen, is not always satisfactory as in low temperatures the cylinder loses nitrogen despite fitting of silicon seals. The alternative solution we are currently considering is to improve cylinder tension using a supplementary air shock absorber.

F.2.2 – Kassbohrer PB 330s (Figure 29)

Figure 29 – PB 330 / View of winterisation





Cabin

- Installation of a roof escape hatch, including external handle and lock facility
- Installation of a road truck type rearview mirror.
- Installation of a hand operated accelerator
- Installation of supports for external GPS antennae
- Manufacture and installation of a double glazed front windscreen (original curved unit is replaced by 2 flat units fitted in an adapted frame);
- Installation of a VHF transceiver, marine channel, per machine
- Installation on one of the Kassbohrer machines, of traverse navigation equipment

Engine compartment

- Modification of the engine air intake and exhaust system to include snow separator,
- Installation of Fleetguard heaters in all oil compartments, a tank type heater to cooling system and a silicon heating blanket stuck on the original oil sump,
- Installation of a fuel circuit made of Caterpillar elements (with fuel priming pump, water separator ...),
- Installation of a 220V electric circuit to feed the engine heating elements when the convoy is stopped, with external connector and protection switchboard
- Installation of one catalytic filter on the exhaust. This device works in association with a fuel additive containing cerium oxide. This additive reduces the carbon deposits in the cylinders, lowers the exhaust gas temperature and reduces the particles rejected in the atmosphere.

Frame, body, belts and Boggies

- Improvement of the engine compartment sealing and insulation. The bonnet assembly has large openings and lift off doors for easy maintenance;
- Manufacture and installation of a sealed sump cover;
- Manufacture and installation of a removable metallic cover for the coolant radiator air intake;
- Replacement of the original batteries by 2 heavy duty 210 AH Optima gel batteries and connected to an external 24 V starting/charging plug
- Insulation of the Hydraulic tank
- Installation of 2 x 300 l fuel tanks, 1 x 50 l buffer tank with a water collector at the bottom and a drain pipe and tap.
- Installation of rubber filled tyres
- Replacement of standard blade hoses by silicone hoses
- Manufacture and installation of 2 narrower (1400mm wide), symetrical tracks
- Removal of snow cutter's suspension and installation of towing hook

F.2.3 - Additional equipment used on the group of tractors in the convoy

- Installation of 3 hydraulic cranes of 11 tm capacity at the back of 3 Challenger tractors;
- Fitting of a 20 ton Hyster winch on one Challenger;
- Installation on one Challenger tractor of a 40 kVA / 50 Hz / 3 x 400 V electric generator driven by the equipment socket, as a backup for the caravan's generator;
- Installation on 2 others Challenger tractors of 2 x 20 kVA / 50 Hz / 3 x 400 V' electric generator driven by the equipment socket, to power the projectors
- Installation on one Kassbohrer of a 12 kVA / 50 Hz / 3 x 400 V electric generator driven by a hydrostatic engine;
- Installation on 2 Challenger tractors equipped with a generator of 4x2 kW 380V projector lights;
- Installation on 1 Challenger tractor equipped with a generator of 6x2 kW 380V projector lights;
- Installation of a special plough on the equipment arms of one Challenger tractor;
- Installation on two Challenger tractors of two radars;
- Installation of two HF radio transceivers on two Challenger tractors.

F.3 – Note about the transport of the fuel used by the traverse

The dedicated system installed for transport of fuel is working well. On the other hand, if the need should arise for new tank sleds of the 12m3 class or if we were to start the whole operation from scratch, it would be preferable to choose the model shown in **Figure 30.** This sled, 14m3 in volume, uses the parts and the kinetic principles of the cargo sled. For a slightly greater cost (four skis, 14 instead of 12 m3) it would allow the fleet of sleds in use to be reduced to just one family of models.

Figure 30 - Diagram
14m3 tank on chained base sled

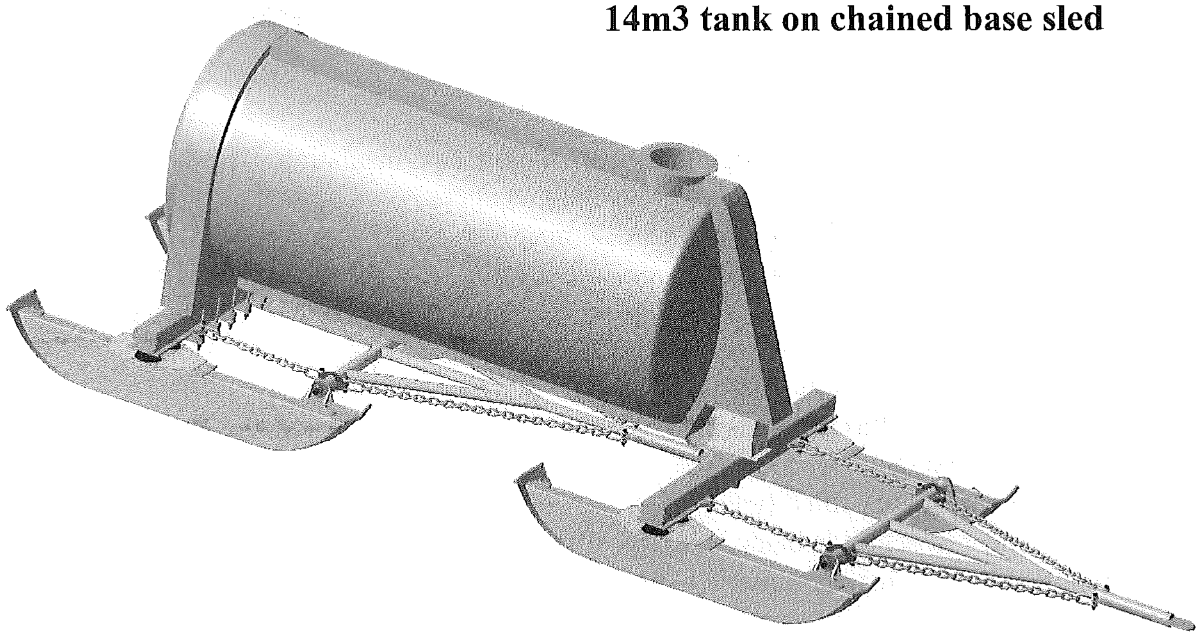


FIGURE 7

CONCORDIA TRAVERSES
SUMMARY (March 2004) of CARGO LOADS TRANSPORTED

Season	Traverse N°	Date pre transfer	Depart CPH	Arrive DC	Depart DC	Return CPH	Gross Weight (T)	Payload ex- CPH (T)	Payload delivered at DC	Fuel used (M3 / T)	Duration (days)	Net cargo flow (t/day)	Efficiency Payload / Gross
1996-97	04		16-01-97	29-01-97	31-01-97	10-02-97	420	187 T	125 T	75/60	27.0	4.63	0.30
1997-98	05		16-11-97	02-12-97	04-12-97	13-12-97	374	160 T	099 T	74/59	27.1	3.65	0.26
	06		20-12-97	02-01-98	03-01-98	12-01-98	384	165 T	115 T	63/50	24.5	4.70	0.30
	07		16-01-98	26-01-98	28-01-98	06-02-98	392	173 T	123 T	62/49	20.8	5.92	0.31
1998-99	08	17-11-98	20-11-98	03-12-98	05-12-98	13-12-98	377	164 T	109 T	68/55	23.4	4.65	0.29
	09	19-12-98	21-12-98	04-01-99	06-01-99	14-01-99	439	188 T	129 T	74/59	24.1	5.35	0.29
	10	17-01-99	18-01-99	29-01-99	31-01-99	09-02-99	428	194 T	129 T	81/65	21.6	5.97	0.30
1999-00	11	16-11-99	19-11-99	02-12-99	04-12-99	12-12-99	421	186 T	119 T	84/67	23.3	5.10	0.28
	12	17-12-99	19-12-99	28-12-99	02-01-00	11-01-00	486	223 T	157 T	83/66	23.0	6.83	0.32
	13	15-01-00	16-01-00	26-01-00	28-01-00	06-02-00	473	208 T	131 T	96/77	21.2	6.18	0.28
2000-01	14	17-11-00	20-11-00	04-12-00	06-12-00	14-12-00	428	197 T	121 T	95/76	25.5	4.74	0.28
	15	19-12-00	20-12-00	30-12-00	02-01-01	11-01-01	513	239 T	162 T	93/77	22.5	7.20	0.31
	16	16-01-01	18-01-01	27-01-00	29-01-01	06-02-01	513	235 T	165 T	86/69	19.8	8.33	0.32
2001-02	17	17-11-01	20-11-01	04-12-01	06-12-01	14-12-01	520	240 T	160 T	100/80	24.5	6.50	0.31
	18	19-12-01	21-12-01	01-01-02	03-01-02	12-01-02	496	240 T	167 T	91/73	22	7.60	0.34
	19	17-01-02	19-01-02	29-01-02	31-01-02	08-02-02	443	204 T	137 T	85/68	19.8	6.90	0.31
2002-03	20	17-11-02	18-11-02	02-12-02	05-12-02	13-12-02	495	245 T	159 T	108/86	25.5	7.00	0.32
	21	18-12-02	20-12-02	31-12-02	02-01-03	10-01-03	497	236 T	166 T	88/70	22	7.50	0.33
	22	14-01-03	17-01-03	27-01-03	30-01-03	07-02-03	496	237 T	162 T	93/75	21	7.70	0.33
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	132 T	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	139 T	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	127 T	[redacted]	[redacted]	[redacted]	[redacted]

F.5 - Costs and Performance

Performance:

25 return cargo traverses have now been completed. The traverses reported here are purely logistic. The average duration of a return traverse to Dome C, including a 2 day stop on the site, is of 19 to 25 days (9 to 13 days for outward journey, 8 to 10 days the return).

The fuel consumption of a Challenger tractor is very dependant on ground surface quality. It will vary, loaded and on the ascent, from 5.5 L to 8 L / KM and on the return, towing only empty sleds and trailers, from 3.5 to 4.5 L / KM. The Kassbohrer consumes on average 5 L / KM.

The mass delivered to the site is usually less for the first traverse of the season as, even though it uses the preceding season's track, it encounters more fresh snow and then improves the route for the two following convoys. It is more pertinent therefore to speak of the load delivered for the season than the load per traverse. The 26 convoys up to last year delivered 3300 T to Dome C.

The Challenger tractor connected as two trains in a line produces a traction effort of 70 KN. The two machines together produce a traction effort of 140 KN and can tow a mass of 110 T divided into 8 to 9 units of cargo. In relation to **Figures 01 and 25,** running two in tandem most of the time allows an increase of one load, going from 8 to 9. The maximum speed attained in this configuration is about 8 KM/H with Challenger using gear 4.

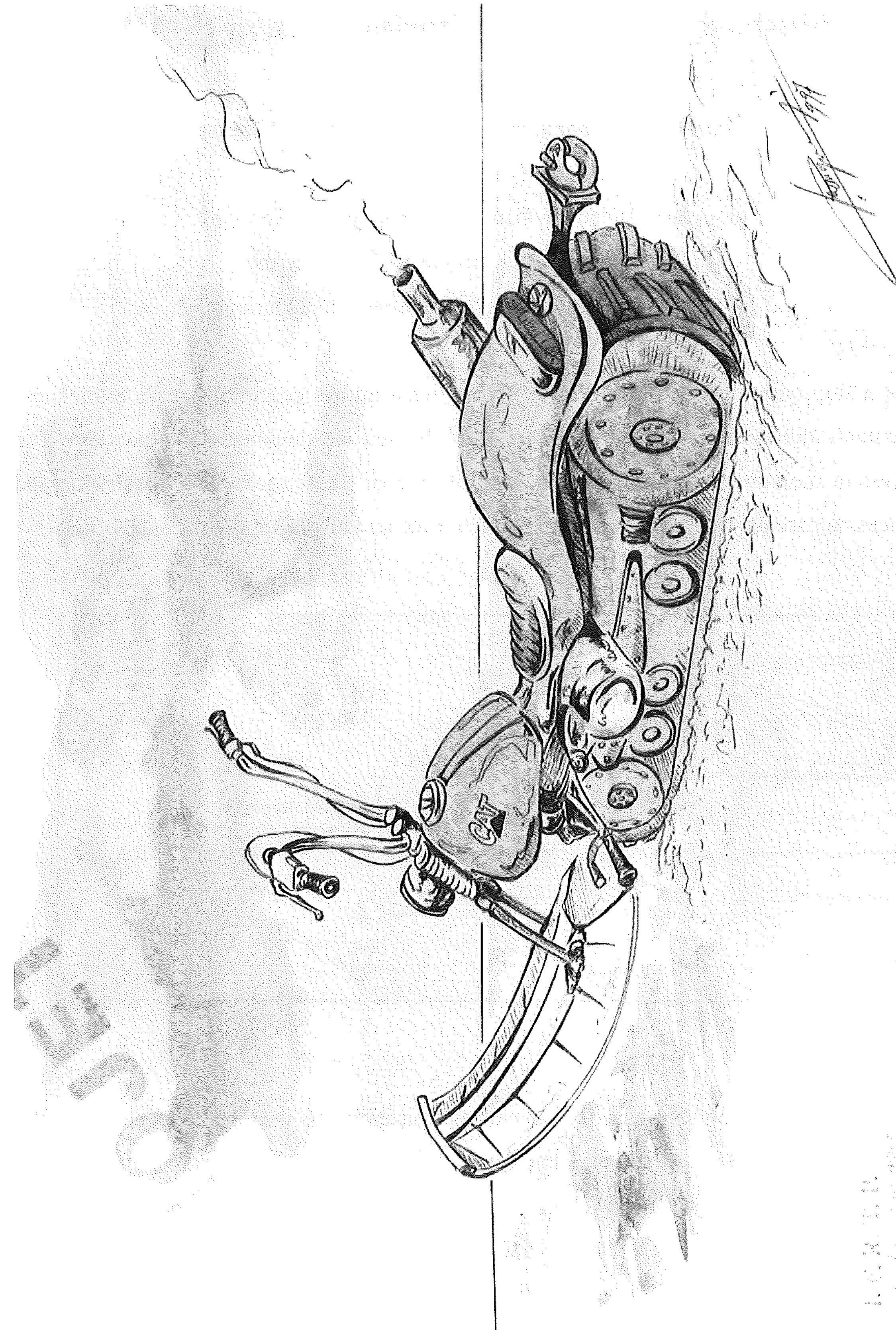
Cost:

The analysis of the transport system costs includes the costs of equipment in use and development costs. Development costs include equipment discarded or replaced as trials have gone on and the costs of modifications progressively made to all existing equipment. The costs are based on an average rate of 1.1 US dollar (USD) for 1 Euro.

Consolidated costs:

Cost of traverse equipment:	4.2 MUS$
Development cost:	1.7 MUS$
Cost of Cape Prudhomme coastal installations:	2 MUS$
Cost of Dome C unloading installations:	O.5 MUS$

The cost of Cape Prudhomme includes salary costs for installation which are based on French salary scales. The operational cost of each season is not included as about half of it is made up of salary costs which may vary too much from one organisation to another. The same is the case for amortisation costs. In our transport system the overall cost per kilogram delivered to Dome C is approximately 3 US$ per kg.



Traverse motor bike by Pascal Le Mauguen
Artictical project

A ship-based Sea Ice Monitoring System (SIMS)

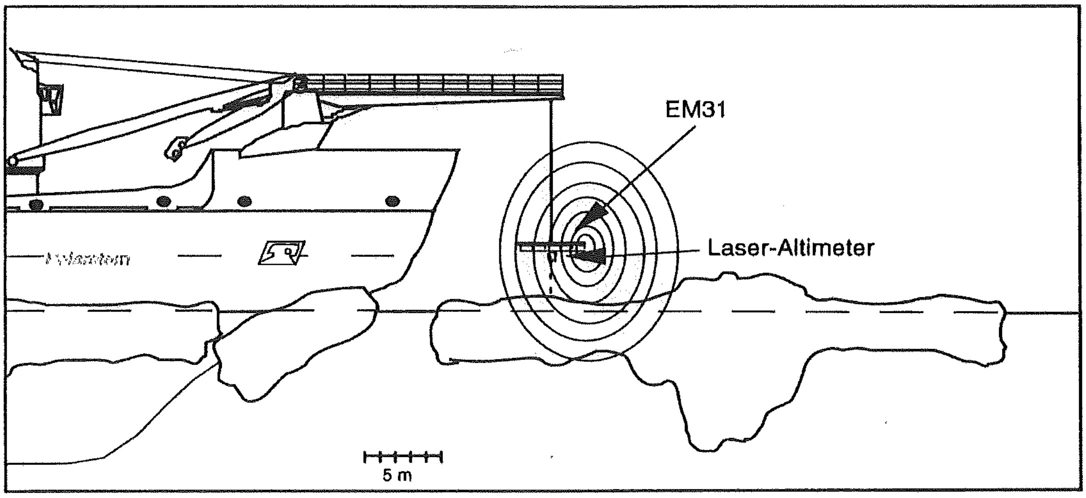
Christian Haas[1], Eberhard Wagner[2] and Marcel Kruse[3]

(1) Alfred-Wegener-Institute, Bremerhaven, Germany

(2) Reederei Laeisz, Bremerhaven, Germany

(3) denkmanufaktur GmbH, Grossenkneten, Germany

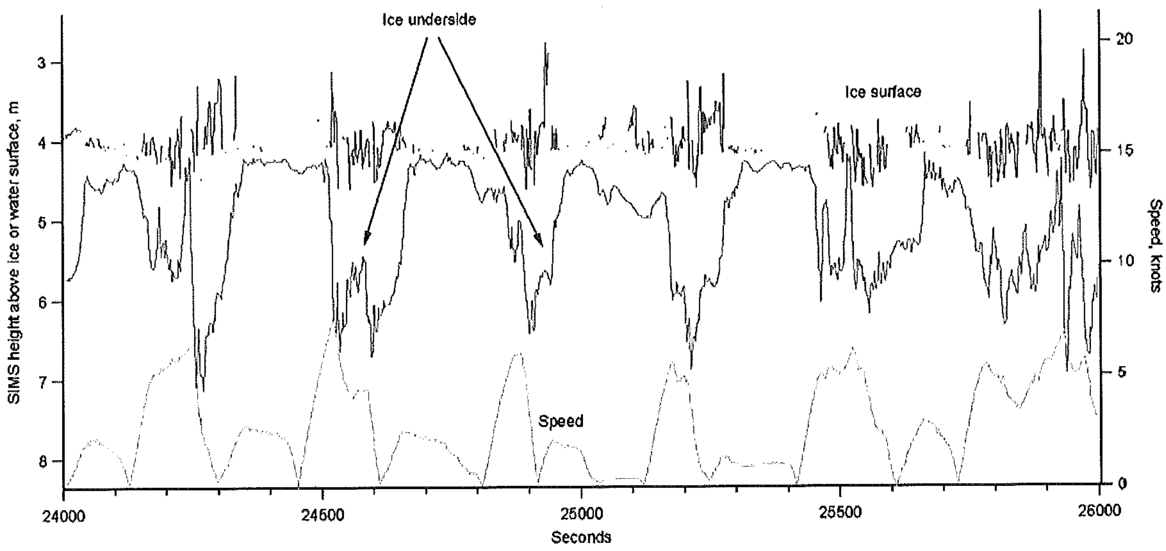
SIMS is a ship-based Sea Ice Monitoring System wich allows continious sea ice thickness measurements during a cruise. The measuring of the sea ice thickness is contactless. The SIMS system measures the surface and the bottomside of the sea ice. Data acquisition and data processing are performed automatically in real time and displayed on the ships bridge.

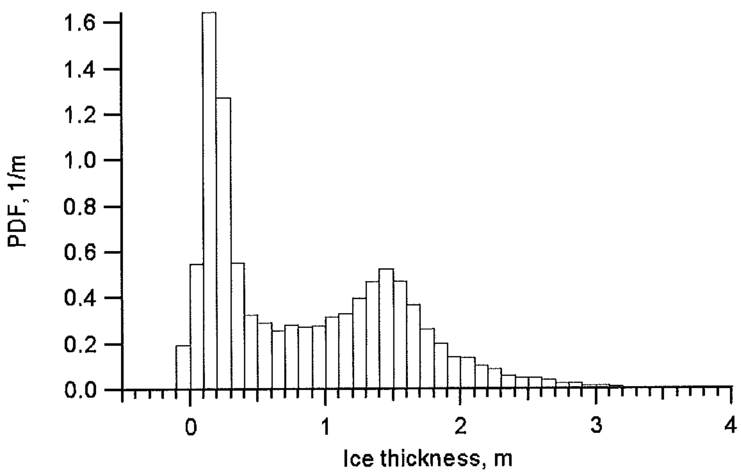


Method

Electromagnetic induction ship-based ice thickness measurements have been developed at the Alfred-Wegener-Institute over the past ten years. A Geonics EM-31 instrument is used for conductivity measurements. This yields the SIMS height above the ice bottom. With a downward looking laser altimeter the SIMS height above the ice surface is measured. Ice thickness results from substraction of both distance measurements.

Reederei F. Laeisz developed an automatic launching system for SIMS on the bow crane of the German research icebraker RV Polarstern. Additional electronics for data processing and transmission to the ships information system has been developed by denkmanufaktur GmbH.





Fields of application

- Determining regional sea ice thickness distributions for sea ice physical scientific research and climate change studies.
- Design and optimation of ice breaking capabilities of new ships, by means of determining relationships between ships speed, fuel consumtion and ice thickness.
- Route planning and validation.

Summary and Conclusion

SIMS provides accurate and high resulution ice thickness and surface roughness (pressure ridges) information along the ships track. Accuracy over level ice is +/- 10 cm, less over ridges. The data has been validated by means of comparisons with numerous drill-hole data.

A proposal of garage for snow vehicle by combination of ice shell, water well and wind turbine

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(2) Hokkaido Tokai University, Asahikawa, Hokkaido, Japan

1. Introduction

A small camp at the merge of the continent is necessary as the starting point of inland traverse if the main station is located at small island apart from the continent like Syowa Station. The S16 point is such a small camp for Japanese Antarctic Research Expedition, that is about 15km from Syowa Station. Snow vehicles and sledges are deposited on the snow surface at the camp for whole the year. The efforts of digging up and maintenance of those vehicles and sledges under strong wind are enormous. Therefore, a simple garage would be useful for preventing the growth of snow drift develops surround snow vehicles and for decreasing the maintenance efforts under heavy wind.
Ice shell (Ice dome) is a structure made of only snow and ice. The construction technique, the theoretical and experimental studies have been carried out by Kokawa et al. (1), (2), (3). In the Antarctic, Ishizawa tried to make a 10-m span ice dome at Asuka Station (4). The biggest problem is to make water under the condition of low temperature. On the other hand, katabatic wind prevails in coast area, and the wind speed and direction are constant through the year except for blizzard. The characteristics of the wind are ideal for wind turbine. The heat produced by wind turbine would make a water well under snow surface. The compaction processing speed of snow is rapid near coast area because the snow temperature is higher than that in inland area. The snow changes to ice within the depth of10 m at S16 point. Therefore, the water well could be made at a shallow depth easily.
We propose the above mentioned garage made of snow and ice. The garage is not necessary to be removed even if the deformation develops. The technique is advantageous to the

transportation of construction materials and heat production by sustainable energy is good for Antarctic environment.

2. Construction of ice dome in the Antarctic

An ice dome was attempt to construct in order to study the construction technique and to examine the creep of the ceiling at Asuka Station in 1991. The construction works consist of: (1) mounting the anchors with ropes into snow at the positions surveyed previously as shown in Fig. 1 (2) inflating a membrane bag made of polyestel fibers with polyvinyl chloride coating by a portable air blower (3) spraying water and blowing snow on the bag (Fig.2). (4) removing the bag and ropes. A 10-m span membrane bag was inflated by a portable air blower with 55 m^3/min. The blower was operated continuously while the spraying continued. The milled snow was blown onto the membrane at intervals by a rotary snow plow. The spraying was stopped when the thickness of the ice dome reached about 10 cm. The membrane bag and ropes were removed from the inside of the dome and were taken out through a door attached to the lateral face of the ice dome.

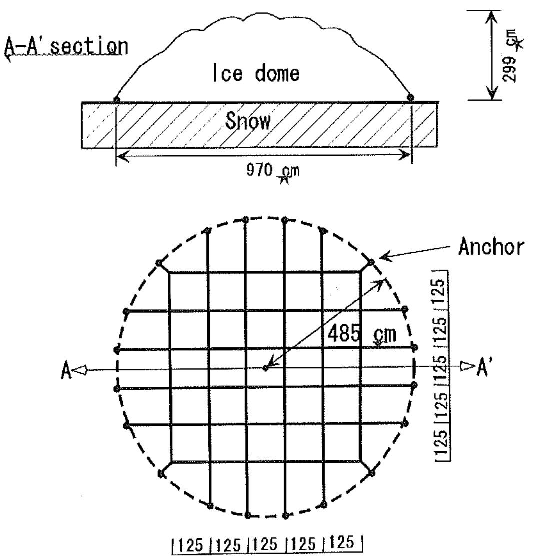

Fig.1 Layout of the ropes and anchors

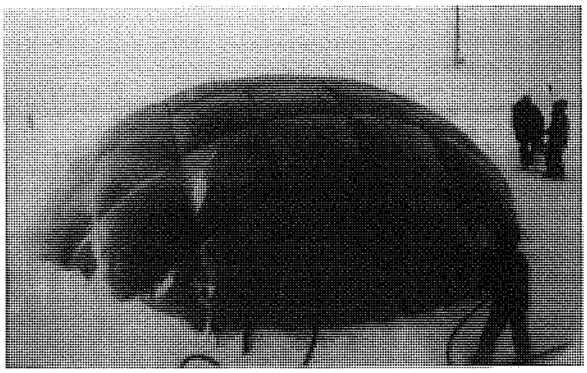

Fig.2 Spraying onto the membrane bag

We consumed about 13-tons water in making the ice dome with about 7-cm thickness. The deformation of the ceiling of the ice dome grew with time due to creep of ice. The deformation reached 52mm for 99 days from September 13 to December 21 1991 as shown in

Fig. 3. It is estimated that the shrinkage would be 20cm in a year if we use the obtained value.

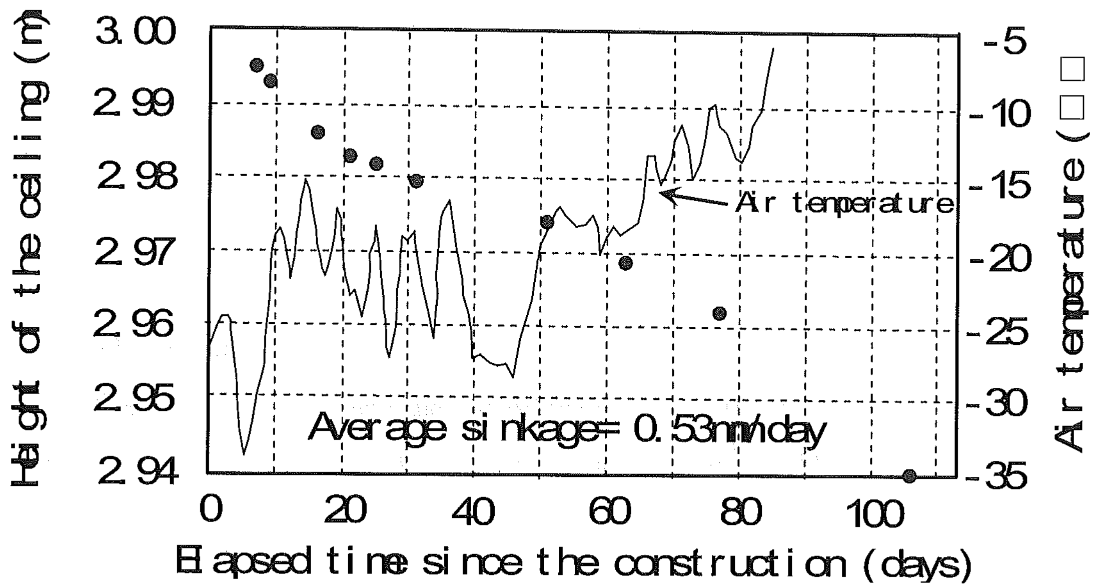

Fig. 3 Deformation of the ceiling of ice dome

The ice dome was effectively used as workshop, storehouse and doorway of the station. A door was attached to the wall at the right angle to the prevailing wind direction. The door was very available because snow drift was not attached to it. The thickness of the ice dome rapidly decreased due to sublimation in summer time.

3. Water well

Schmitt and Rodriguez (5) were the first to build a melt pocket water well in ice. Such water wells have been used in Greenland and Antarctica. The heat for melting ice and preventing the water freeze is usually gained from the wasted hot water of engine which supplies electricity to camp's facilities.

3.1 Heat loss from water well

Now, we suppose that there is a spherical shell filled with water with radius r at the depth d from the snow surface. It is assumed that the heat of water loses by steady heat conduction. The heat loss is calculated by a formula as shown in Fig.4. In the formula, λ denotes the heat transfer coefficients of ice, θ_1 and θ_2 are temperatures of water and ice respectively. Table shows the result of the calculation when we change the radius of the water ball.

Radius of water ball (m)	Volume (m^3)	Ice temperature (deg. C)	Depth (m)	Heat loss (W)
1.8	13.7	-15	10	880
2	18.8	-15	10	988

Table 1 Heat loss from water well

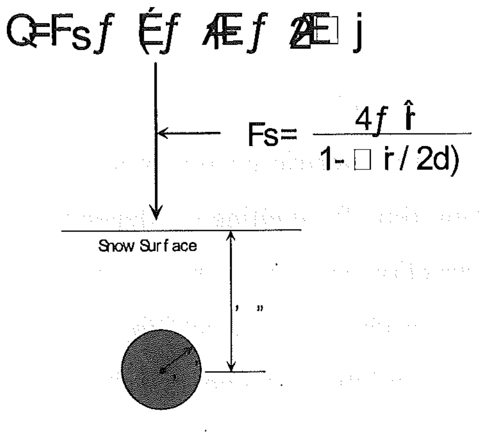

Fig.4 heat loss from water well

As we consumed about 13 tons of water for the 10-m ice dome at Asuka Station, a water ball with 2 m in radius is enough for 10-m ice dome construction, and we found that the estimated heat loss is about 1 kW.

3.2 Quantity of heat for making water

The quantity of heat for melting ice ball with r in radius is calculated with the following formula.

$$Q=4/3\ \pi r^3 \rho\ (\ Cp\ (0-\theta) +333.6) \quad [kJ]$$

Where, ρ is density of ice, Cp is specific heat of ice, and θ is temperature of ice.

$$Cp=2.117-0.0078\theta \quad [kJ/kg\ deg.C]$$

Table 2 shows the quantity of heat for melting ice (-15 deg. C), and the required time when we use an electric hater of 5 kW, and assuming the heat loss as 1 kW.

Radius of ice ball (m)	Density of ice (kg/m3)	Water weight (kg)	Required heat (kWh)	Heating time (day)
2	800	15,072	1538.2	16.02
2.1	800	17,448	1780.7	18.55

Table 2 Quantity of heat for melting ice

4. Wind turbine

The coast area of the Antarctic is advantageous for wind turbine because katabatic wind blows at all times of the year. The electric energy produced by wind turbine is all used to submersible heater. The heating time for melting ice depends on the capacity of wind turbine and wind condition at construction site. Now we assume that a 10-kW wind turbine is installed at Asuka Station. The production of electricity is calculated using figures of power versus wind speed curve (Fig. 5) and the frequency distribution curve of wind speed at the site (Fig. 6).

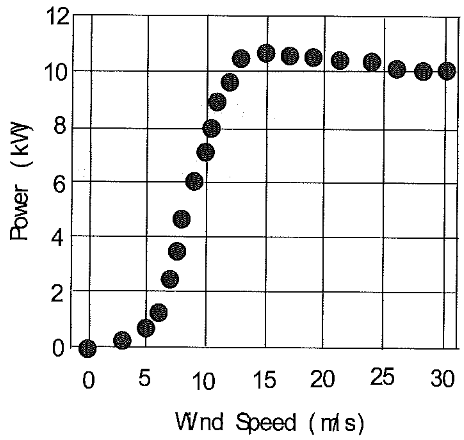

Fig.5 Power versus wind speed of a wind turbine

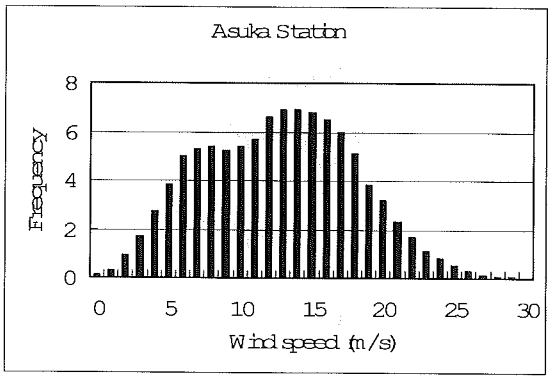

Fig.6 frequency of wind speed at Asuka

The production of electricity at Asuka Station is 171 kWh/day (6). That value means that 15-tons water can be obtained by heating for the period of about 9 days at Asuka Station. An image of the construction system is shown in Fig. 7.

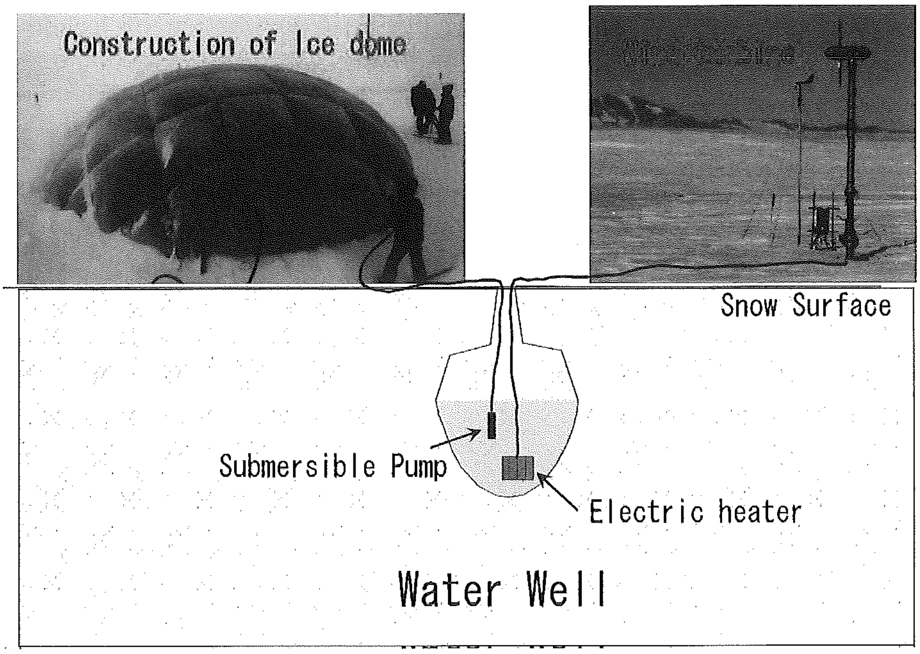

Fig 7 Construction system of ice dome

5. Maintenance of ice dome

The thickness of ice dome decreases gradually by sublimation caused by solar radiation. In order to protect the phenomenon, the ice dome should be filled with snow. The ceiling of ice dome also deforms by creep of snow and ice, then we have to cut the ceiling sometimes.

6. Conclusion

A feasibility study on the construction of ice dome was carried out for the Antarctic use. The wind turbine takes the electricity to the heater suspended in a water well. The completed ice dome should be filled with snow to prevent from sublimation by solar radiation. The ice dome is useful for garage or storage at small camp in katabatic wind zone. The system is environmentally good for the Antarctic.

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Redevelopment of the Progress Station

Valery Klokov[1] and Igor Krawchuk[2]

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Following the Russian Government decision, the Russian Antarctic Expedition (RAE) commences a long term program to centralise most facilities for our terrestrial transport support at Progress Station. RAE plans to use new support facilities at Progress to support oversnow traverses to the Vostok Station. At the same time Progress will be developed as main entry point for the RAE's air operations.

The Environmental Impact Assessments (EIAs) of the proposed construction and associated activities in Antarctica has been prepared, distribute and approved in accordance with the requirements of its national legislation and Antarctic Treaty obligations.

New facilities consist of Living and Operations Quarters (LOQ), Powerhouse and Workshop (PWS), Ancillary Facilities (AF) including fresh water supply, wastewater treatment plant and fuel storage systems and Compacted Snow Runway for heavy lift wheeled aircraft (CSR). The project will be run through a two stages. In first stage PWS, CSR and partly AF will be constructed during 2004-2008.

The first construction team and construction materials have been delivered to the Progress Station and in January 2004. The construction team will stay over the winter 2004 at Progress and aim to construct a foundation of the PWS and fuel storage systems.

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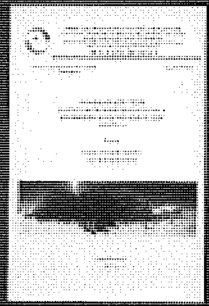
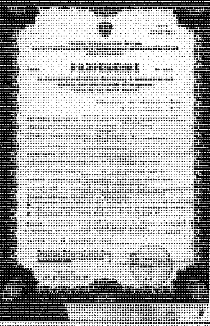
Igor Kravchuk – Lenaeroproekt

REDEVELOPMENT OF THE PROGRESS STATION



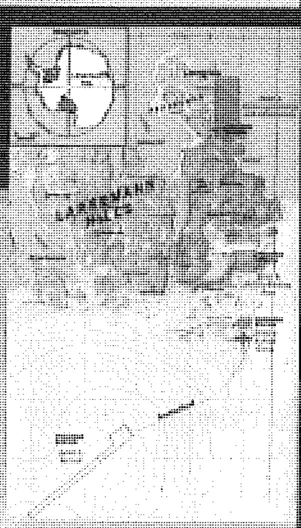


Progress Station was established in 1986 in the Larsemann Hills (69°30' S 76°20' E), Prydz Bay coast, East Antarctic. In accordance with the Russian Government decision, the Russian Antarctic Expedition (RAE) commences a long term re-development program started in 2003. The aim of the re-development program is to centralize facilities for RAE's terrestrial transport support at Progress Station. On the project completion RAE plans to move whole transport facilities from Mirny Station to Progress station to undertake inland traverses to Vostok Station. At the same time a main airfield to support the RAE's air operations should be developed at Progress Station.

The Environmental Impact Assessments (EIAs) of the proposed construction and associated activities in Antarctica have been prepared, distributed and approved in accordance with the requirements of the national legislation and Antarctic Treaty obligations. In accordance with national official procedure the Permit for the activity in Antarctica has been issued by the Russian Government.

After the Progress Station re-development will consist of the three parts that occupied three separated spots in the Mirror Peninsula and on the icesheet southward. These parts are shown on the sketch map of the area:

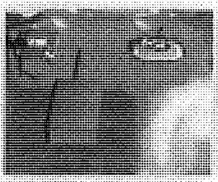
Progress Station " Zone A" located on the sea site,
Progress Station " Zone B" located inland close to the icesheet border,
Progress Station " Zone C" located on the icesheet southward of the Hills

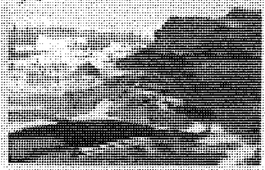


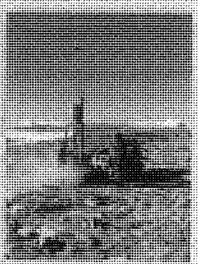
PROGRESS STATION "ZONE A"

New facilities are under construction in the ZONE A and include:
- Living and Operations Quarters (LOQ),
- Powerhouse and Workshop (PWS),
- Ancillary Facilities (AF),
- Fuel Farm (FM)
- Helicopter Pad (HP)

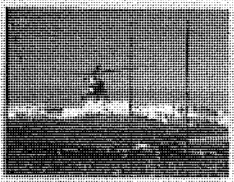
The project will be run through a two stages. In first stage PWS, AF, FM and HP will be constructed during 2004-2005.

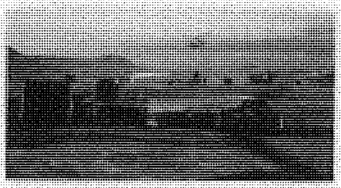


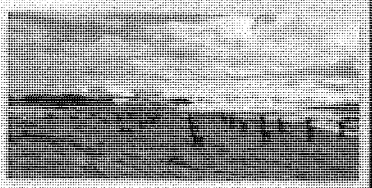




The first consignment of bulky construction materials have been delivered to the Progress Station and in December 2003. During the 2003-2004 summer season the RAE's construction team has made a foundation of the Powerhouse and Workshop (PWS) and Helicopter Pad (HP).

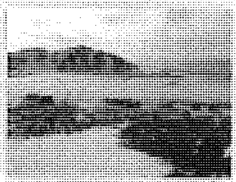


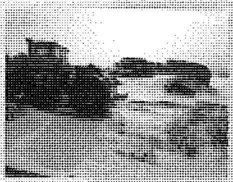




PROGRESS STATION "ZONE B"

In the "Zone B" that located close to the icesheet border RAE will arrange Vehicle Parking Area. This spot will be used as a start point for inland traverses and also as a transition zone for heavy runway plants

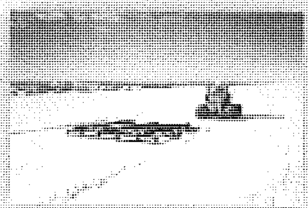




PROGRESS STATION "ZONE C"

Runway site is located on a snow plato in 2 km southward of ultimate rock outcrops of the Larsemann Hills. There are no upwind mountains or any other obstacles on both take-off and landing paths in the area. The runway parametrers are as following.

Geodetic Coordinate of counterpoint		Bearing	Altitude	Length	Width	Runway type
Latitude	Longitude	degree	(m) a.s.l.	(m)	(m)	
69° 24'	76°19'	40°33' / 220° 33'	252	2580	60	compacted snow



A field camp for runway construction and maintenance is to be established on ultimate rock outcrops of the Larsemann Hills . The field camp cosist of three small units: accommodation hut, powerhouse combined with workshop, radio/nav aids block. The runway will be capable to receive such heavy wheeled aircraft as Ilyushin 76 and all types of skied aircraft.

The new traverse route from Atka Bay to SANAE IV

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(2) Department of Environmental Affairs and Tourism, Directorate Antarctica and Islands, Cape Town, South Africa

Abstract

The feasibility of a new traverse route between the South African base SANAE IV (71°40' S, 2°51' W, 860 m a.s.l.) and Atka bay, near the German base Neumayer (70°39'S, 08°15'W), is investigated. The planning of the new traverse is based on the analysis of satellite data and a local survey. SAR data of the European remote sensing satellites ERS-1 and -2 are used for an interferometric analysis of the ice motion in order to detect critical zones of crevasse formation. Out of three proposed routes two were selected for a local survey, which was conducted in the summer season 2003/2004 from air by helicopter and, for the final route, by a field party. Field observations confirmed good travelling conditions on the 280 km long route, which connects the two research stations mostly on grounded ice.

Introduction

The South African Antarctic base SANAE IV (71°40' S, 2°51' W, 860 m a.s.l.), located in the Ahlmanryggen mountains, is presently supplied via a traverse route starting at the ice shelf front of Fimbul Ice Shelf (Fimbulisen) about 170 km to the north (Fig. 1). However, the loading and unloading of the ship at this location is a difficult task because of the high ice shelf front. Therefore, a more suitable location is urgently needed. The nearest landing site with favorable conditions is Atka ice port at the front of the Ekström Ice Shelf (Ekströmisen) near the German Neumayer station (70°39'S, 08°15'W). Here we investigate the feasibility of a new traverse route between Atka Bay and SANAE IV.

The finding of new and safe traverse routes for the supply of remote polar research stations is a challenge which needs careful planning to avoid risk for life and material. Besides extreme climatic conditions the main obstacle for ground operations in Antarctica is the existence of crevasses in regions of active ice dynamics such as grounding and shear zones at the margins of ice streams. Large crevasses can be readily identified in satellite images or in the field. However, this is not the case for snow bridged crevasses, often invisible even in high resolution satellite images or photographs, or in the field.

SAR interferometry offers the possibility to map surface strain rates, where other techniques like feature tracking fail because of lack of contrast. As surface strain rates are related to the occurrence of crevasses (Vaughan, 1993), regions of potential risk can be mapped. A short description of SAR interferometry is presented in the text, but can be found in more detail for applications in glaciology e.g. in Joughin and others (1996, 1998) or Massonet and Feigl (1998).

Our planning of a new traverse route is based on the interferometric analysis of data of the ERS-1 Ice Phase (1994), the ERS-1/2 Tandem mission between 1995 and 1996, and a local survey.

Methods and database

We used C-Band SAR (Synthetic Aperture Radar) data acquired by the European Remote Sensing satellites ERS-1 and ERS-2 to derive the ice deformation and topography (Fig. 1, Table 1). Data were obtained in SLC (Single Look Complex) format and the interferometric processing was performed using a commercial software package. The pixel spacing of the SLC product is 4.0 m in flight direction (azimuth) and 7.9 m in radar look direction (slant range), which calculates at 23.4° incidence angle to about 20 m in ground range. SAR interferometry exploits the phase difference of the reflected radar wave between two satellite overpasses. The phase difference is a result of surface height (h) and surface displacement in radar range. The sensitivity for topography is proportional to the distance between the two satellite positions B (the effective perpendicular baseline) and is approximately given by

$$\phi_{topo} \approx \frac{4\pi B h_a}{\lambda r \sin\theta} \qquad (1)$$

In (1), θ is the mean incidence angle of the two sensors, r the mean range distance between sensor and target, and λ the radar wavelength. The altitude of ambiguity h_a is the elevation difference which corresponds to a phase shift ϕ_{topo} of 2π (one fringe). The phase shift δ due to relative horizontal and vertical motion is given by

$$\delta_{y2\pi} = \frac{\lambda}{2\sin\theta}, \delta_{z2\pi} = \frac{\lambda}{2\cos\theta} \qquad (2), (3)$$

For ERS-SAR (C-Band, λ=5.66 cm), a δ of 2π corresponds in the scene center (θ = 23.4°) to a horizontal displacement of 7.24 cm or a vertical displacement of 3.07 cm. The high sensitivity for vertical displacement can be readily used to map the grounding lines at high horizontal resolution (Rabus and Lang, 2002), as interferograms show a close sequence of fringes in tidal flexure zones.

Large baselines are preferred for the analysis of topography. To obtain a digital elevation model (DEM) of moving targets like ice streams, differential interferometry has to be applied, assuming that surface displacement is constant in time. This requires at least two coherent interferograms from the same satellite frame and track, which are rarely available. Furthermore, after ERS-1 was switched off in 1999, no systems for the acquisition of suitable 1-day interferograms are available because of too long repeat passes. For example, the 35 day repeat pass of Envisat normally leads to complete decorrelation over snow and ice. ERS satellite data used for this study are listed in Table 1. For these data precise orbit information is available (Hanssen, 2001). In areas where the surface height could not be derived from differential SAR interferometry an external elevation model was used for the analysis. Available DEMs of the area are based on the Antarctic Digital Database (Liu, 1999) or on satellite altimetry (Bamber, 1997).

In order to resolve the 2π ambiguity in the relative phase image (interferogram) to obtain the absolute phase, a minimum cost flow unwrapping algorithm was applied (Wegmüller and others, 2002). The absolute phase was then converted to velocity assuming pure horizontal motion.

Results of analysis and route proposal

The ice motion in ground range for several ascending satellite passes is shown in Fig. 2. On grounded ice between Halvfarryggen and SANAE IV three ice streams are clearly visible. The largest one is Schytt Glacier, where ice velocities amount to about 300m/a at the narrow central part northwest of SANAE IV. Shear zones and areas with large strain rates were localized in order to detect critical areas with a high potential for crevasse formation. High resolution ERS and Radarsat SAR images were used to make a more detailed planning of those critical areas. The outcome is a proposal for the three routes A, B and C (Fig. 2). The direct way on the ice shelf from Ekströmisen to Schytt Glacier was excluded because of heavily rifted zones on Jelbartisen, which are well visible on optical and radar satellite images. Starting at Atka ice port, two routes follow a previously established and safe traverse route to Halvfarryggen, where the seismological array "Watzmann" (70°55.52 S, 7°23.58 W), part of the German geophysical laboratory at Neumayer station, is installed. Route A crosses the ice cap Halvfarryggen and continues to Schytt Glacier on Jelbartisen. Critical regions are the grounding zone east of Halvfarryggen and of Schytt Glacier. Ascending Schytt Glacier it meets route B at 500 m a.s.l.

The intention of route B is to keep the achieved terrain height at the ridge of Halvfarryggen and to follow roughly the contour line on grounded ice to Schytt Glacier. Critical zones of this route are a shear zone of an icestream immediately southeast of Halvfarryggen (B3) and the crossing of the shear zone at the margin of Schytt Glacier (B1).

Route C crosses the grounding line in the south east of Ekströmisen and climbs along the central flow line of an outlet glacier to the saddle point between Halvfarryggen and Ritscherflya, where it joins route B.

Field survey

From the three proposed routes, all approximately 300 km long, route B and C were selected for airborne and ground based surveys, which were conducted by SANAP (South African National Antarctic Program) during the field season 2003/04. A reconnaissance flight was carried out by helicopter starting at SANAE IV. Because crevasses and pressure ridges were observed in the area southwest of Halvfarryggen in the area C1 (Fig. 2), route C was abandoned and it was decided to concentrate on route B. Because no areas of obvious concern were observed along the entire route, experienced field operators started the ground survey of route B using snow mobiles. The route between Neumayer station and Watzmann is known, which minimises risks in the grounding zone. On the ice ridge near Watzmann, a temporary repeater station (RS) and a temporary fuel depot were installed (71°10.67 S, 6°50.19W).

On 12th January 2004, the field operators F. Hoffmann and R. Lewis (SANAP) started from SANAE IV, following the planned route to RS in a zigzag course in order to guarantee a safe channel of at least 400m width.

After a 24 hour stay at RS due to storm and low visibility the traverse continued to Neumayer station. Fields of crevasses were observed along the traverse in zone B1 near Robert's Kollen and in zone B3 downstream the proposed route on the orographically right margin of the ice stream (Fig. 2). However, the field party was never concerned that the route is too close to observed crevasses.

The ground survey was concluded using two heavy vehicles (Caterpillar Challengers), one pulling a caboose and the other a 25.000 liter fuel tank. Starting at SANAE IV, they arrived after an uninterrupted 25 hours journey at Neumayer station. After a short stay they headed back and arrived 22 hours later at SANAE IV.

The new route is plotted on a MODIS image in Fig. 4, and waypoints are listed in Table 2. At Schytt Glacier, the route follows closely the proposed one through zone B1. After this it was decided to leave the 500m contour line and to head in a straight line towards zone B3, where the route joins again the proposed one, in order to circumnavigate the critical zone. Surface conditions were mostly excellent for travelling, especially in the dry snow zone above 400 m a.s.l. Rough surface conditions were only found at the ascent between the grounding line of Ekströmisen and RS.

Conclusion

Utilizing SAR interferometry as a technique to identify potential safe routes turned out to be an exciting and novel exercise. Field party observations and surveys verified the usefulness of this technique. The result is the establishment of a safe heavy vehicle route between Atka Bay and SANAE IV - jointly established by SANAP and AWI. This will allow the relocation of discharging and back loading operations for the SANAP supply ship S.A. Agulhas from Penguin Bay (near E-Base) to Atka Bay. There, a new summer camp will be established by SANAP.

Although the new route is about 100 km longer than the previous traverse, long term benefits are expected. Firstly, the high risk operation of building a ramp at the ice shelf edge near E-Base is no longer necessary. Secondly, the need of heavy and expensive helicopters for offloading purposes is significantly reduced. Thirdly, SANAE IV and Neumayer station are now linked via a traverse route, which will increase the overall safety of operations. In particular, the stations can reach each other for rescue operations, especially during the period when ships and helicopters are not available.

Coming along with new high resolution altimeter data, such as from Icesat's GLAS (Geoscience Laser Altimeter System) or ESA's Cryosat, to be launched in March 2005, a better interferometric analysis of archived ERS data will be possible. In addition, measurements of surface height and flow velocity along the traverse will even improve our results.

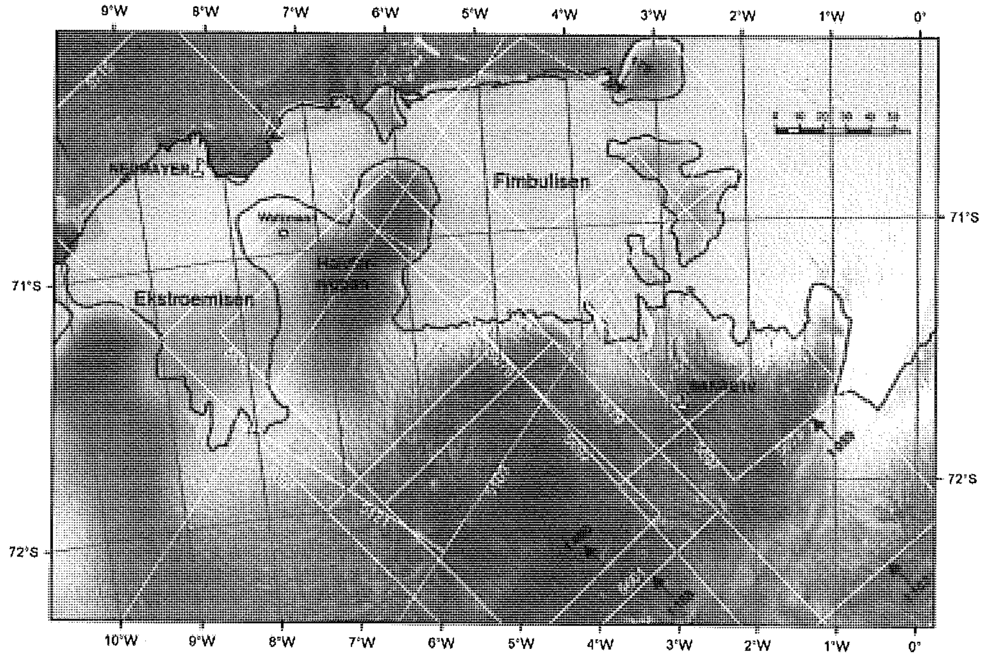

Fig.1: Radarsat-1 image mosaic (1997) of Dronning Maud Land between 10°W and 0°, showing ERS SAR image frames used for this study (full/dashed lines: ascending/descending pass). Black lines show the grounding line (boundary between floating and grounded ice) and the ice shelf edge.

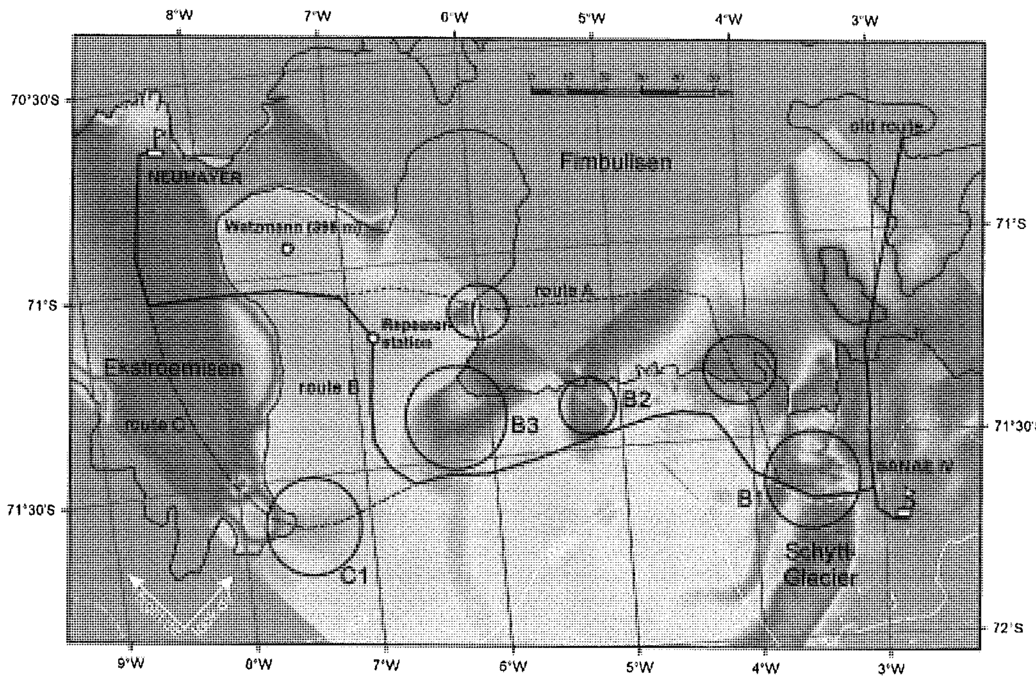

Fig.2: Ice motion in radar look direction (ground range) for the area between Neumayer station and SANAE IV, derived from ERS-1/2 SAR interferograms. The topographic phase is substracted. On grounded ice, dark grey values indicate large ice motion, whereas areas with low or no ice motion are light grey. Circles show potential risk zones along the proposed routes A, B, and C.

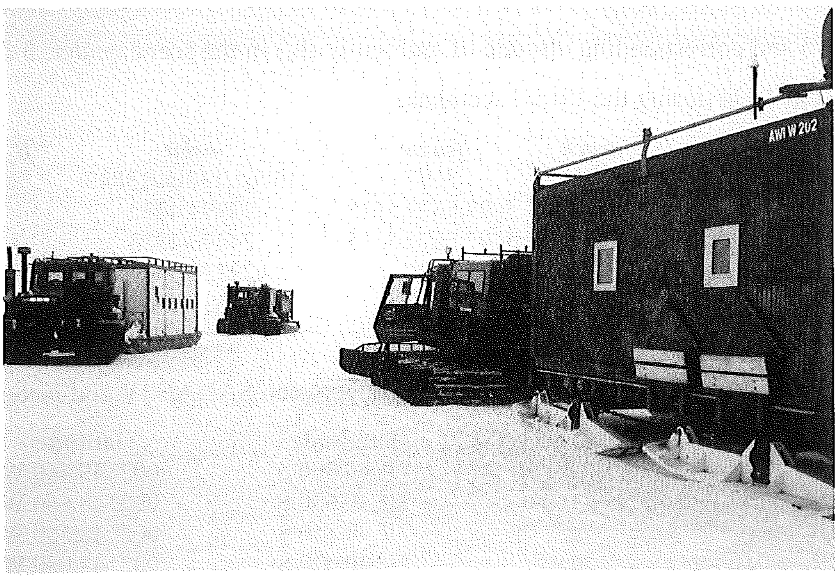

Fig. 3: Two heavy vehicles of SANAP ground survey (left hand side) meeting a German traverse vehicle (right hand side) near Neumayer base.

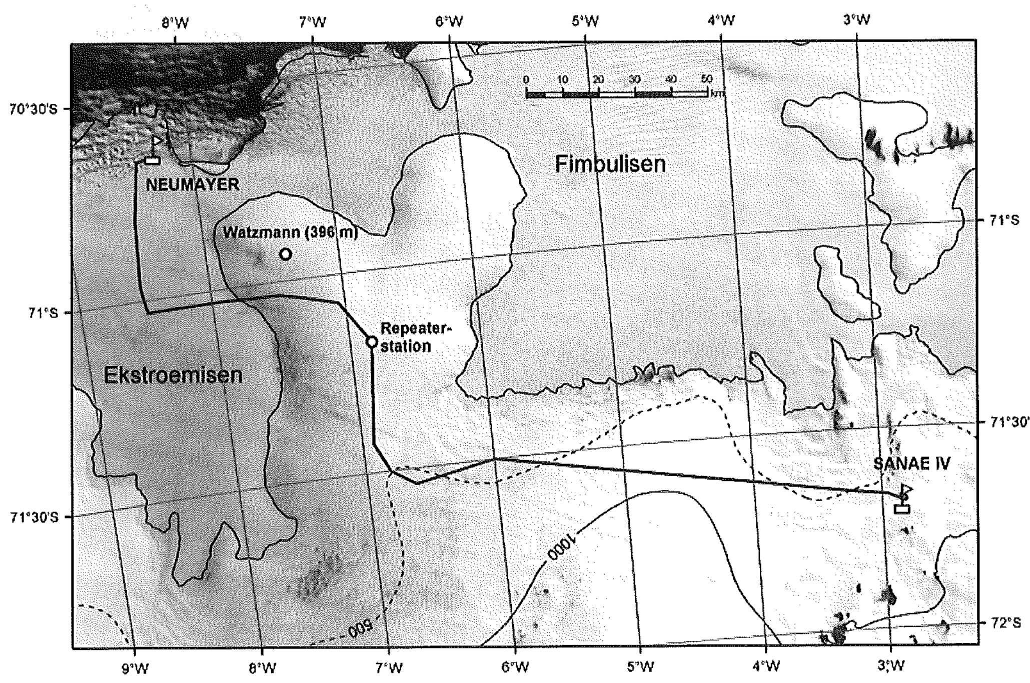

Fig.4: MODIS image (1st January 2004) showing the new traverse route between SANAE IV and Atka bay.

Table 1: ERS SAR data (ERS-1: E1, ERS-2: E2) used in the interferometric analysis, perpendicular baseline (B_|_) and corresponding altitude of ambiguity (h_a) in the scene center. 3-day repeat pass data were acquired in 1994 during the ERS-1 ice phase.

Sat.	*date*	*track*	*frame*	*orbit*	*B_⊥ (m)*	*h_a (m)*
E1	4/7/10 Mar. 1994	2	5697	13761/13804/13847	50/30	185/309
E1/E2	16/17 Feb. 1996	460	5697,5679,5715	23995/4322	-137	-68
E1/E2	22/23 Mar. 1996	460	5697,5679,5715	24496/4823	17	545
E1/E2	15/16 Oct. 1995	188	5697	22220/2547	-113	-82
E1/E2	13/14 Nov. 1995	102	5697	22635/2962	87	107

Table 2: Waypoints of the new traverse between SANAE IV and Neumayer.

comment	**longitude**	**latitude**
SANAE IV BASE	71° 40.300 S	002° 49.460 W
Existing SANAP route	71° 40.630 S	002° 48.660 W
	71° 40.850 S	002° 48.550 W
	71° 40.970 S	002° 49.080 W
	71° 40.990 S	002° 49.740 W
	71° 39.930 S	002° 57.280 W
New traverse route	71° 39.265 S	003° 14.939 W
	71° 30.000 S	006° 00.000 W
	71° 32.390 S	006° 37.320 W
	71° 30.115 S	006° 48.450 W
	71° 25.805 S	006° 55.040 W
	71° 10.669 S	006° 50.192 W
	71° 04.252 S	007° 03.186 W
Existing German route	71° 02.804 S	007° 19.307 W
	71° 02.075 S	007° 29.474 W
	71° 01.976 S	007° 40.197 W
	71° 01.828 S	007° 54.776 W
	71° 01.867 S	008° 10.594 W
	71° 01.898 S	008° 29.870 W
	70° 58.069 S	008° 31.463 W
	70° 48.195 S	008° 29.387 W
	70° 39.501 S	008° 25.000 W
Neumayer station	70° 38.923 S	008° 16.157 W

Acknowledgements

The ERS data were made available by ESA through the VECTRA project. TERRA-MODIS data were made available by the Earth Observing System Data Gateway (EDG) at the Goddard Space Flight Center (GSFC) Earth Sciences (GES) Distributed Active Archive Center (DAAC).

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Cruise Planning with Matlab®

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Abstract

During cruises with a multi-purpose research vessel like the German research icebreaker "Polarstern" a variety of tasks related to research projects and logistic requirements have to be coordinated. Multi-disciplinary programmes necessitate applying a series of different instruments at one single station. Scientific findings, weather or sea ice require modifications of the schedule which may impact on the longer term planning. Therefore, fast oversight and documentation is needed. A new software tool, written in Matlab®, is now available to make cruise planning easier, faster, and more comfortable. The software is called PERPLEX, which stands for "Program for Expedition Route, Planning and Execution". PERPLEX contains routines to set up the cruise track with waypoints and stations which can be rearranged in any desired order. Stations can be inserted or modified and ship speed between waypoints may be prescribed. PERPLEX will automatically update the cruise schedule. PERPLEX provides menus to edit the cruise schedule and merge the calculated schedule with the real date and time. At any stage the cruise plan is shown in a list box and plotted on a map.

Introduction

During a research cruise logistic and scientific tasks of different disciplines have to be carried out. The sequence of the operations is determined in the cruise schedule. It is a list of locations, which can be ports, waypoints along the cruise track, and scientific stations, together with the estimated date and time of arrival at each location. On board, work has to be organised for the ship's crew and the scientific personal. Therefore date and time of the planned operations has to be estimated as precise as possible. However, the cruise schedule must allow a significant amount of flexibility because weather, and especially for cruise operating in polar regions, the sea ice conditions may cause delays or faster progress. In addition, the scientific program must be kept as flexible as possible. For these reasons, changes in the cruise plan, which result in an update of the calculated times, must be performed quickly. For a first estimate of the cruise schedule, dates and times are calculated based on standard ship speed between the stations and the time needed for the scientific activities. The station time depends on the type of instrument, e.g. for a mooring recovery a standard period of 12 hours is appointed. The required time for instruments which are lowered with a winch is calculated from the lowering speed and the profile depth.

Preparing the cruise schedule consists of a number of sub-tasks which all need different sources of input data. A chart is needed to setup the course and select the locations for the scientific stations. Also the water depth has to be taken from the chart, e.g. to choose the station spacing to be closer along the continental slope or wider in smooth deep basins. As already mentioned the water depth is also needed to calculate the time needed for a profile with a lowered instrument. The track is calculated by connecting the selected station locations. Distances between the locations have to be calculated and a realistic ship speed according to the probable sea ice condition must be given for sections along the route.

At present cruise planning is done by each chief scientist according to his/her own recipe using the help of computers on very different levels. But there is a lack of a planning tool which provides a clearly structured concept and requires uniform formats for the input data. Even with the use of standard spread sheet calculation software a number of manual procedures remains to do, e.g. to include external data from different sources. A tool is needed that is able to do an immediate update of the cruise schedule if modifications are needed. The real ship speed may be much slower than the speed used in the preliminary calculation due to extreme sea ice conditions but also a change of time required for a one station affects the following part of the cruise schedule. Thus frequent updates of the cruise plan are necessary to keep the work within the given ship time.

Software which fulfils the very specific requirements which cannot easily be done with a standard software package facilitates cruise planning significantly. Thus a new software tool was developed with Matlab® (MathWorks, 2002). The cruise planning and execution software is integrated in an easy to operate graphical user interface. This was realized with Matlab's GUIDE (Graphical User Interface DEveloper). Cruise planning on the basis of charts is realized with Matlab too using the Mapping Tool Box. This tool box provides also the functions for the nautical calculations. On the basis of Matlab software can be kept up-to-date, e.g. with the use of the Database Tool Box (MathWorks, 2000) when it should be of interest to include on-line data.

Data which were generally needed for cruise planning are stored in files in standard format. One file contains the names of ports and their geographical coordinates. When planning a cruise the user can chose the port from a name list and its location will be plotted in the map. A file exists with a list of instruments and their specific data which were needed to calculate the time e.g. to measure the temperature and salt profile with a CTD-Sonde (Conductivity, Temperature, Depth). The water depth is taken from the worldwide bathymetric and elevation data set ETOPO5 (NGDC).

The cruise planning begins in its first phase with some fixed conditions, e.g. departure and arrival ports with date and time. Later more details can be added when the scientific program is further elaborated. Therefore the program package consists of individual modules to generate the final cruise plan step by step.

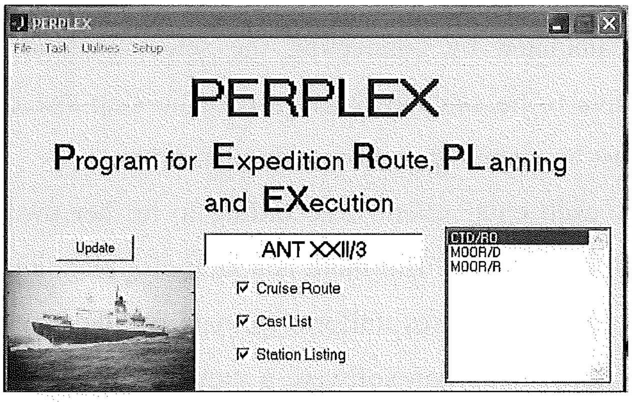

Fig. 1: Main menu with access to individual modules for planning a scientific cruise.

The first module "Cruise Route" is used to setup the rough cruise track. This module provides the information of the time which remains for the scientific station work after considering all time needed for steaming from station to station. A further module is used to enter the station plan. This module is used separately for each instrument, e.g. one station list for the CTD, a second for box corers, a third for mooring recovery and so on. This method allows to enter stations independently form the requirements of another discipline, because some disciplines may have distinct demands concerning the locations. Other disciplines for example may like to have stations at given latitude along the main route with a fixed station spacing. Finally a program module combines the cruise track and all stations lists for the different disciplines. Due to the independent input of the station lists it may happen that stations of different instruments A and B may be located closely together. In such a case the program combines instrument A as cast 1 and instrument B as cast 2 at the location of instrument A or B depending on the priority which can be set for A or B. This module also includes a procedure to sort all scientific stations, waypoints, and ports starting from the departure port resulting in the final cruise schedule, which is used to go at sea and carry out the cruise.

Using PERPLEX at sea

Since it is not possible to describe the full program package with all modules in detail, some examples are given to demonstrate the use of PERPLEX at sea. PERPLEX was already used to prepare the coming Antarctic cruise ANT XXII/3 with the German research vessel "Polarstern". The preliminary cruise schedule contains the date and time and the number of stations based on the data which have been entered in the cruise header. Therefore the cruise header (see Figure 2) must be corrected after start of the cruise.

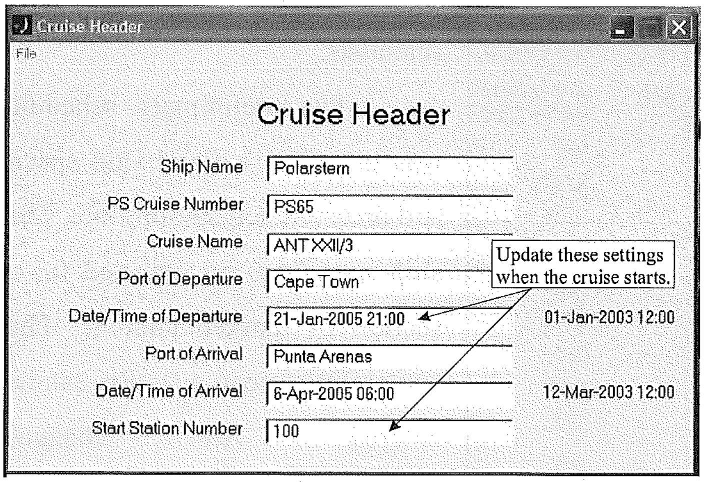

Fig. 2: The cruise header contains the general cruise information.

As soon as the module for the cruise execution "EXecution" is opened it reads the new header and updates the cruise schedule automatically. Figure 3 shows the layout of the graphical user interface (GUI) for "EXecution". The GUI contains information about the cruise and provides a number of buttons for the operation.

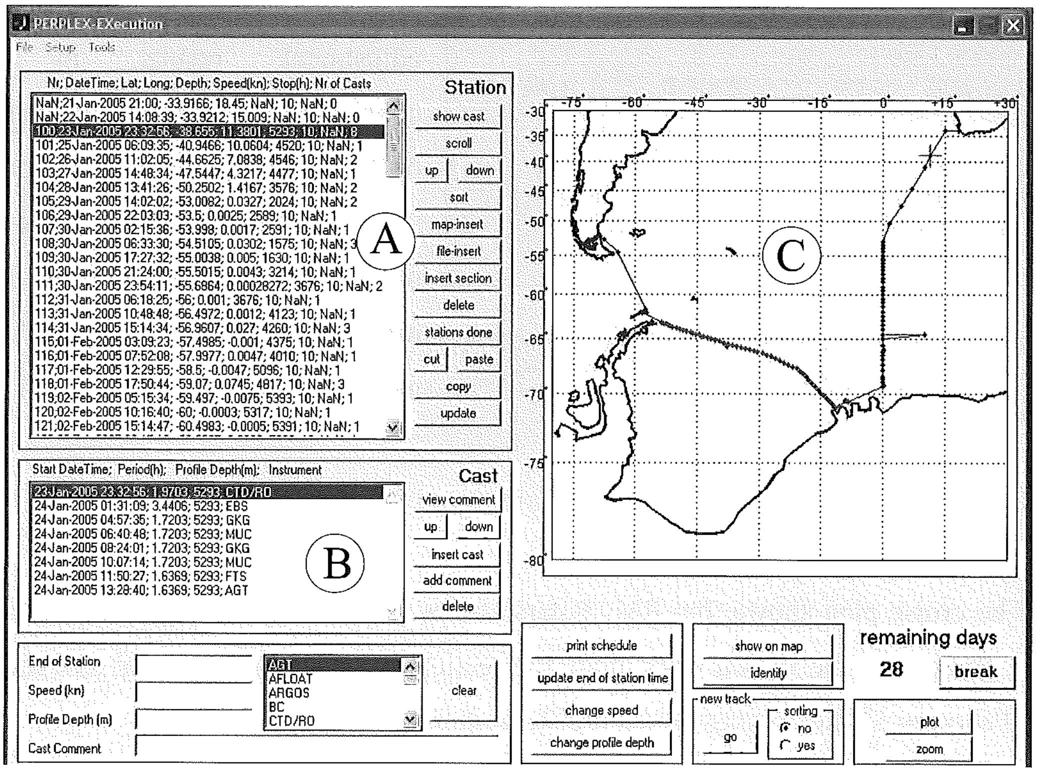

Fig. 3: The GUI for the cruise execution. "A" indicates the list box with all ports, waypoints, and stations. "B" indicates the list box with detailed information, e.g. the instruments which are planned to be used. "C" is the cruise plot with coast lines. The cross indicates the station marked in "A".

In Figure 3 "A" indicates the list box with all ports, waypoints, and stations. Station numbering, date, and time are based on the current header, see Figure 2. "B" indicates the list box with detailed information, e.g. the instruments which are planned to be used. "C" is the cruise plot with coast lines. The cross indicates the station marked in "A". At the current status there are 28 days remaining for station work to arrive Punta Arenas in time. The "print schedule" button creates a printable output list of all stations marked in the list box "A" as information of the short term schedule for the crew and scientists.

The preliminary schedule was based on a fixed ship speed and an estimated station time. The ship speed can be adjusted for a section of marked stations. The actual time to end a station can be entered. All changes automatically start the update procedure for the complete cruise schedule. Thus a continuous adjustment results in a continuously improved estimate of the cruise schedule. In a future version of PERPLEX it is planned to use the direct input from the navigation system to reduce the manual update.

07-Jul-2004 13:32:08

Station Schedule
Polarstern ANT XXII/3
Cape Town (21-Jan-2005) - Punta Arenas (06-Apr-2005)

Station Nr. Cast Nr.	Latitude Date	Longitude Time	Bottom Depth Instrument	Distance to Profile Dept
PS65/100	**38° 39.3' S**	**11° 22.81' E**	**5293**	**150**
Cast 1	23-Jan-2005	23:32	CTD/RO	5293
Cast 2	24-Jan-2005	01:31	EBS	5293
Cast 3	24-Jan-2005	04:57	GKG	5293
Cast 4	24-Jan-2005	06:40	MUC	5293
Cast 5	24-Jan-2005	08:24	GKG	5293
Cast 6	24-Jan-2005	10:07	MUC	5293
Cast 7	24-Jan-2005	11:50	FTS	5293
Cast 8	24-Jan-2005	13:28	AGT	5293
PS65/101	**40° 56.8' S**	**10° 3.62' E**	**4520**	**259**
Cast 1	25-Jan-2005	06:09	MOOR/D	4520
	Auslegung PIES-3			
PS65/102	**44° 39.75' S**	**7° 5.03' E**	**4546**	**208**
Cast 1	26-Jan-2005	11:02	MOOR/R	4546
	Aufnahme PIES-1			
Cast 2	26-Jan-2005	15:02	MOOR/D	4546
	Auslegung PIES-1-2			
PS65/103	**47° 32.68' S**	**4° 19.3' E**	**4477**	**199**
Cast 1	27-Jan-2005	14:48	MOOR/D	4477
	Auslegung PIES-4			

Fig. 4: Output of the short term schedule for the crew and scientists being created with from the "print schedule" button (see Fig. 3).

Two scenarios will be given to demonstrate the flexibility of this module.

Scenario 1: The cruise plan shows that RV "Polarstern" will arrive at Neumayer Station on February 13th. But during the station work along the section to the south the arrival date must be shifted on February 6th due to unexpected logistic requirements.

The software provides the information from which station "Polarstern" must steam with direct course towards Neumayer Station to be there in time for the supply. The remaining stations of the section can be placed in reversed order behind "Neumayer". (Mark the remaining stations in the list box (Fig. 3 "A") and press "cut". Highlight "Neumayer" and press "paste", again mark the group of remaining stations and press "sort").

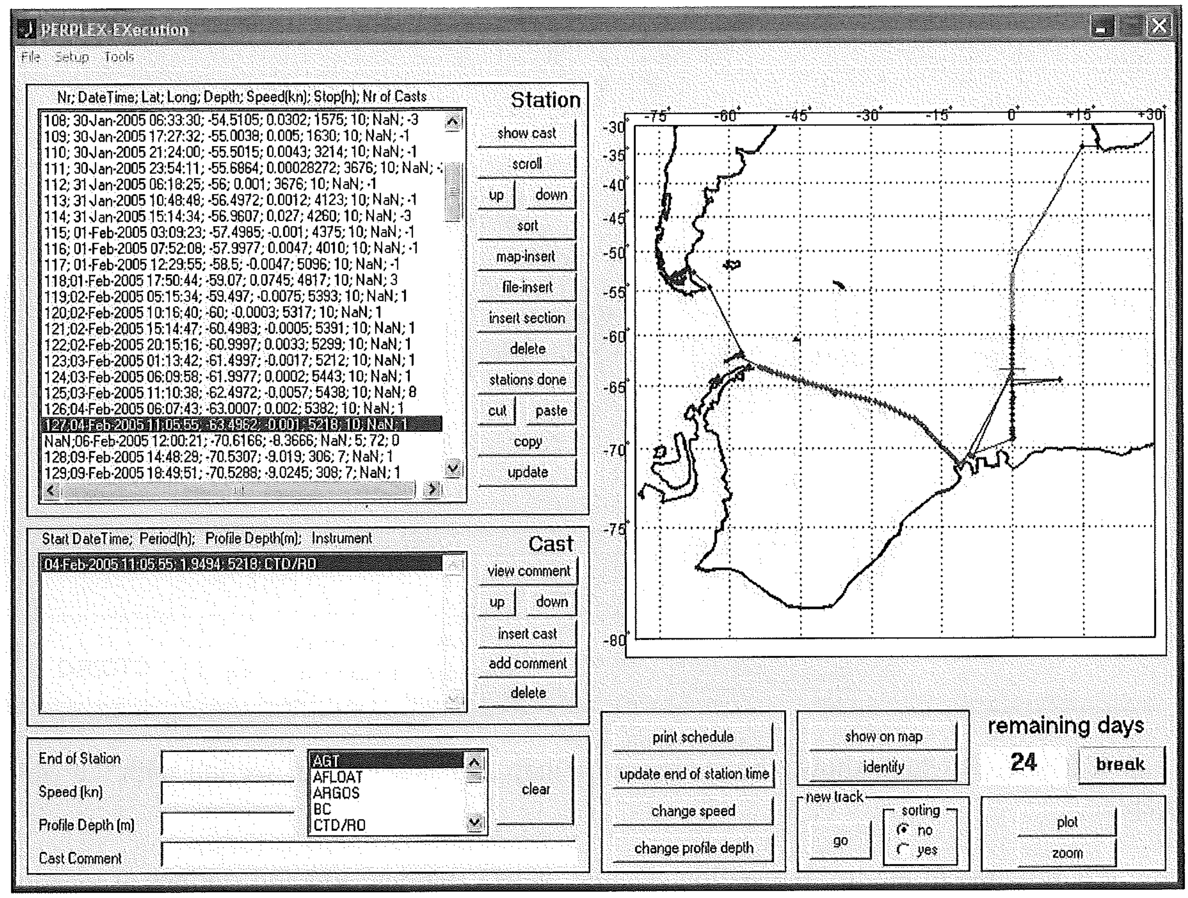

Fig. 5: The modified cruise plan to arrive Neumayer Station on February 6th instead of the 13th (see Fig. 3). The cross indicates the station 127 where "Polarstern" will take its direct course towards Neumayer Station.

The cruise schedule will be updated after each operation. Figure 5 shows the resulting cruise route. The cross indicates the station 127 where "Polarstern" will take its direct course towards Neumayer Station. Comparing the modified with the original cruise schedule (see Figure 3) it can be seen that the modification takes additional four days.

Scenario 2: Unexpected heavy sea ice conditions caused a delay and it becomes necessary to save time by increasing the station spacing to reduce the station time at the section end to arrive in Punta Arenas in time.

Deleting every second station at end of the section is the easiest way to save station time. But a better way is to reduce station regarding to the topography. A part of a section can be copied to a clipboard. Then, these data are transferred into a sub-routine (see Figure 6) which shows the stations in a map and as a vertical section with the water depth.

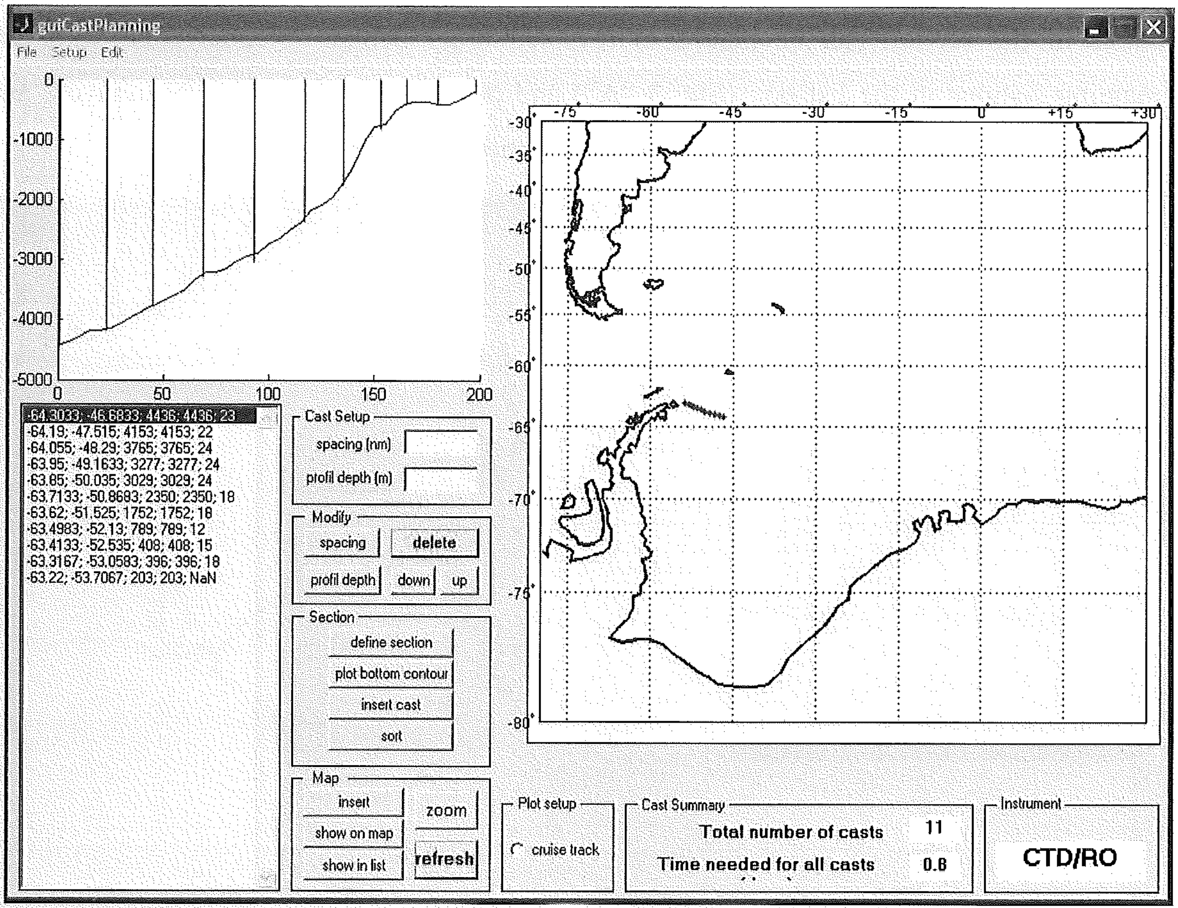

Fig. 6: The GUI which shows the stations in a map and as a vertical section with the water depth.

Now it is possible to modify the station spacing, delete stations, and add stations at locations in respect to the topography. The new group of stations can be used to replace the initial stations.

Summary

With PERPLEX cruise planning and execution can be performed easy and quickly. Therefore different versions of a cruise route can be created and compared to be optimized. The final cruise plan can be modified at any time during the cruise. PERPLEX was used in practise to prepare the cruise plan for two cruises with RV "Polarstern" in the Arctic and Antarctic. The software was tested taking possible scenarios into account which may happen during the cruise execution. After having the experiences from the practical cruise executions it is planned to put a link to the ships navigation system.

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Scientific rationale for a spaceborne P-band ice-sounder

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Future Programmes on Earth Observation

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1. Introduction

Currently, remote sensing of the Earth from space is generally limited to a thin superficial layer, while many issues related to climate, Earth resources or risk monitoring require information over greater depths. Radars operating at low frequencies offer, under certain circumstances, the possibility of imaging through ice layers down to the bed(rock), which could be over 4 km depth. Several campaigns over Antarctica using Ground Penetrating Radars (GPR) and airborne radars have clearly demonstrated these capabilities. However, to model global ice sheet dynamics and mass balance (accumulation of snow and losses through melt and iceberg calving) over longer periods (100 to a few 100'000 years), it is mandatory to have a complete coverage of the Antarctic ice sheet with observations of homogeneous quality, which can be best accomplished using a spaceborne platform.

Efforts are being undertaken within ESA to assess the applicability and maturity of a space-borne ice sounder operating at P-band (432 - 438 MHz) as a future satellite mission in the Earth Explorer Programme. This paper will describe the main science questions, which such a satellite mission could help answering to. Also, the problems and limitations of a P-band ice sounder will be discussed. The science questions asked by the climate and glaciological communities broadly fall under the following topic areas:

1) Better estimates of ice sheet thickness and geometry are needed for assessment of different glaciological contributions to the total ice discharge to the ocean. The resulting mass balance drives a major part of the sea level variations. Further, retrievals of internal horizons and isochrones can be used to assess historical variation in ice sheet snow accumulation, and thus can be correlated to the historical variation in sea level.

2) The understanding of the connection between Earth's paleo-climate and past evolution of the Antarctic ice-sheet: Using ice-core dating and coupled climate/ice-dynamical modeling, the past evolution of the ice-sheet is analysed. In such analyses, large climate events are identified and their effects on the ice-sheet evolution are examined. There is also the un-answered question of the origin of the Antarctic ice-cap in the history of the Earth and its reversibility. The study of the past evolution also provides some degree of validation to the ice-dynamical model.

3) Understanding the present evolution of the ice-sheet as a function of the past and present climate forcing: The Antarctic ice-sheet is in a transient state due to the Holocene warm wave event, some 11000 years ago. Thus, the understanding of the present evolution can only be gained through the use of the ice-dynamical model driven by the climate forcing from the past to the present time. The ice-dynamical model is validated by using wide variety of observations available today, and in the near future by those from the proposed satellite mission.

4) Predicting the future evolution of the ice-sheet: A prediction of the future evolution of the Antarctic ice-sheet requires a thorough understanding of its dynamics under past, present and future climate forcing due to its very slow response time. The key tool to be used for this prediction is the ice-dynamical model, validated through the observations of the paleo-climate and present day evolution of the Antarctic ice-sheet.

2. Ice Sounder Mission Objectives

Globally, the Ice Sounder mission goal is to provide reliable ice sheet soundings down to the bed to gain a better understanding of the mentioned science questions. Summarizing, the mission objectives are to:

- Improve the knowledge of the bedrock topography and ice thickness on whole Antarctica;
- Provide information on the internal stratification by studying internal layering echoes. As these internal layers are isochrones, their curvatures depend upon the 3D velocity field that depends itself upon the viscosity field;
- Provide information on basal roughness, condition and existence of sub-glacier 'lakes';
- Improve the ice-sheet thermo-mechanical models through the infusion of Ice Sounder data into these models;

- Enhance the understanding of the role of Antarctica in the global climate.

To (partially) meet these mission objectives, the observational requirements would need to be obtained from the required information. Logically, where obtainable, global mission requirements would be deduced from these observational requirements, in the end leading to a set of preliminary instrument characteristics. In the following, for areas where the mission could help answering to, observational requirements on the information need will be discussed.

Bed(rock) topography

An overall knowledge of the bed topography in Antarctica is needed to derive

(1) Ice sheet thickness, and

(2) Information on the mass balance (model).

Especially in the peripheral part of Antarctica, this would be more useful for the mass balance. Bed topography is an essential information need. As current models using a grid size of 20x20 km will evolve in the near future possibly towards a 10x10 km, knowledge of the bed topography on a similar scale will most likely suffice.

Internal layers / isochrones

Here, 2 issues need to be distinguished, i.e. the need to follow the isochrones over a stretched distance and secondly the knowledge of the depth to study the temporal and spatial variation of the accumulation rate over large areas of the ice sheet. Also, as the slopes of layers explain freezing and refreezing events (e.g. at Lake Vostok), this could in the end lead to a requirement of the detection of isochronal layers for both depth and slope. As it has been shown in a recent paper by Kanagaratnam et.al.[1], experiments over Greenland have shown that the detection of layers is merely driven by the available bandwidth of the system, thus the resolution and the radar sensitivity.

Basal roughness

Assessment of roughness parameters is linked to the derivation of ice flow (including direction thereof). The exact scale of roughness, which has an influence on the ice flow, is still under investigation. For example, do kilometer-scale 'mountains' influence ice flow or is bigger-scale relief necessary?

Detection of meltwater (basal condition) or sub-glacier lakes

This information is needed to explain local difference in ice sheet velocity or other discontinuities. A likely problem may be the difficulty in detecting this contrast at depth where significant signal attenuation could have taken place.

Temperature field

This quantity is an important parameter of the thermo-mechanical properties of the ice (e.g. viscosity, ice-morphology and the transport of thermal energy with the ice flow). An estimation of the temperature field can be made indirectly with the use of the surface temperature (external input, either in-situ or satellite data), the ice sheet thickness and the geothermal flux model. The other method is to somehow invert the resulting attenuation in the ice sheet and inducing some values for the ice characteristics. At this stage, it is difficult to assess the merit for this method due to the many unknowns involved (roughness parameters, radiometric accuracy, ionosphere, etc.). Although the temperature field is an important parameter, it may not be a directly observable quantity with a P-band ice sounder.

Ice-shelf observation

Presence of marine ice controls for a great part the possibility of the grounded ice to flow off the continent (ice sheet dynamics). Knowledge would be needed on the thickness and topography of the marine ice in order to determine, for example, whether at a certain location the ice sheet is in equilibrium or if it is evolving.

3. Implementation & Feasibility

In order to make a first step to assess the overall feasibility for this mission, an Instrument Design Activity study named *"P-Sounder: P-Band Sounder Instrument Design for Antarctica"* [2] was carried out within the ESA Concurrent Design Facility (CDF) in 2003. A propagation model was developed [2] in order to calculate the radar cross-section as well as the attenuation presented by the Antarctic ice sheet. This model provides for each reflection mechanism, i.e. reflections due to changes in density, conductivity (e.g., due to changes in acidity with depth) and crystal orientation, the radar cross sections as a function of depth. Reflectivity caused by the interface of the ice sheet with the bedrock is also calculated as a function of depth.

For each likely contrast change (i.e. air-ice, ice-layer, ice-bedrock), the model calculates the radar cross sections at all depths, including the attenuation for the overlaying ice sheet. No specific profile is returned, but can obviously be reconstructed with the output of the model.

In addition, reflectivity at the air-surface interface for different incidence angles is calculated. Strong surface echoes from off-nadir angles can potentially mask the wanted signal, i.e. the (potential) weak internal echo from depth at nadir, when these arrive at the same time at the instrument.

Empirical formulas as well as theoretical scattering models have been applied in this model. In case of roughness, both large-scale and small-scale roughness parameters have been included in the model. For the large scale, a 1 m rms height for a correlation length of 10 m has been used, and for the small scale 2 cm rms height for a correlation length of 20 cm has been used. These values have been taken into account for all interfaces and are believed to be worst case for the parts of the continent where no large topographic features, such as mountains, are present.

The performance of this model has been assessed by means of several tests intended to observe the impact that individual factors (such as temperature, surface roughness or chemical properties of ice) have on the final value of the radar backscatter coefficient. The objective of this set of tests was to confirm if the behaviour of the model in response to a change in the input conditions is coherent to what is expected in theory. Also, the accuracy of the model has been compared with true ground penetrating radar data at 60 and 179 MHz measured along 1150 km long traverse in Antarctica [3]. These measurements reveal the nature of the dominant reflection mechanisms at different depths.

The average tendency with depth of the GPR data by Fujita et al. [3] (at both 60 MHz and 179 MHz) is shown in Figure 1. In the simulation for 60 MHz, real data appear somehow to follow the trend of simulated density–based echoes during the upper one hundred meters. The offset between both curves, is probably due to the empirical formula used in the model to calculate density as a function of depth. This empirical law calculates density variation with depth for snow and firn in the Dome C area, while in the region where the GPR campaign was carried out, it is frequent to find exposed ice on top of cold ice glaciers. The density is higher than that of firn or snow, and consequently the dielectric contrast is therefore bigger and so is the reflection coefficient. However, despite of this offset, the estimated attenuation for both frequencies seems to be quite realistic. From depths around 350 m and on, the tendency of GPR data seem to be perfectly matched by the estimation of conductivity-based reflections. Although this matching could be an artefact, according to Fujita [3,4], at frequencies about 60 MHz this can be the dominant reflection mechanism. The behaviour of the GPR data could be also explained by the simulated crystal orientation fabrics reflections, if an offset between both sets of data is considered; as in the case of simulated density-based reflections. This offset could be overcome by better tuning the value of anisotropy (the parameter D_a) that is used in the model.

According to what Fujita published in his article [3], it is indeed permittivity changes (either density based or crystal orientation fabrics based) which are the dominant reflection mechanisms at depths above 700 m. In contrast, changes in conductivity can be one of the dominant causes only when frequencies below about 60 MHz are used. Focusing on the results for 179MHz, a closer behaviour to the estimation for crystal orientation fabrics appears, which has also been observed by other workers [4].

In summary, the model compares quite well with actual field measurements. Although more refinements have been identified necessary for this model, its behaviour appears nevertheless coherent with respect to observations found in the literature. Obviously, the model only calculates the likely backscatter coefficient from a certain depth (for different reflection mechanisms) and its output does not actually represent a true echo sounding profile. However, from these results it can be concluded that both attenuation and the range of received power are in close agreement with actual GPR data.

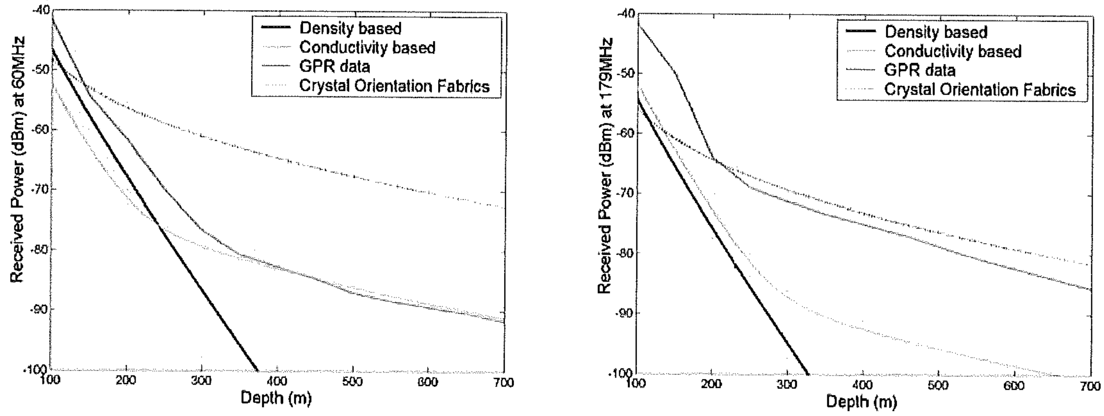

Figure 1: Comparison of averaged GPR data with simulations at 60 MHz (left) and 179 MHz (right)

Ice Sounder Characteristics

The sounding is performed with a horizontal sampling of 1 km × 1 km, followed by a 10 km × 10 km averaging for most of the intended applications. The anticipated mission characteristics (a central frequency of 435 MHz with a transmitted pulse bandwidth of 6 MHz) will result in a range resolution of 14 m in ice and a maximum penetration depth of up to 4 km. The ice-imaging mode does not require stringent radiometric accuracy and stability as the main objective is to detect and map contrasts between layers. The synthetic aperture processing in along track to achieve 1 km resolution requires pulse-to-pulse phase coherency over the signal integration period which is limited by the ionospheric stability (≤ 0.5 s). The challenge of the development is to enable large, deployable antennas to be embarked on a small satellite for achieving a high sensitivity.

Due to the low reflectivity and the losses introduced by the ice, subsurface echoes are much weaker than those coming from the air-ice surface boundary. Especially in the first few hundred meters, the wanted signals from nadir direction can be obscured by the ambiguous surface signal from off-nadir directions. One obvious solution to this problem can be to employ a well-focused antenna beam to suppress the surface echoes from off-nadir direction. Unfortunately in the case of a spaceborne ice sounder, this would require a very large antenna due to the long distance to the target and the low operating frequency. Another way of addressing these surface ambiguities, is to attempt to cancel these echoes using a processing scheme for clutter cancellation. In along-track direction, this will most-likely be accomplished with unfocused synthetic aperture processing, while in across-track a range ambiguity cancellation technique would need to be applied in order to detect the subsurface and bed(rock) echoes.

The philosophy of the clutter cancellation techniques proposed here consists in dedicating separate channel(s) to receive only the unwanted signal (surface clutter). The accurate detection of the unwanted signal enables the subtraction later, during the ground processing, of the surface clutter component from the raw data (subsurface echoes + surface clutter).

Receiving the surface clutter means to perform an effective discrimination between signals arriving from nadir (useful signal) and signals arriving from off-nadir (clutter).

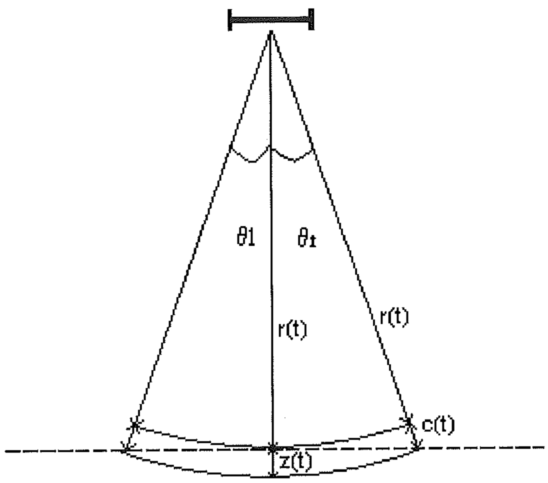

Figure 2: Geometry of spaceborne radio echo sounding showing left and right ambiguities

The unwanted surface clutter arrives from off-nadir directions, whose propagation paths up to the surface cause the same time-delay as the propagation path to a subsurface interface at nadir (see Figure 2).

The detection of the unwanted signals usually relies on the use of antenna radiation patterns in reception that have a null in bore-sight (i.e. nadir). By using such patterns, the receiver will detect signals coming from every direction but nadir. A subtraction afterwards will provide with the desired echoes without interferences. An amplitude correction of the unwanted signal received in the additional channel has to be done prior to the subtraction. By means of this correction, the unwanted signal from the additional channel reaches the same level of power as the clutter component of the raw signal detected in the main channel. Having equal levels of power in both channels, the subtraction is complete and the cancellation of the clutter is optimum.

Ideally, this scheme showed to have excellent performance [5]. However, non-ideal situations, such as a sloping surface or a tilted (or deformed) antenna will have an effect on the surface ambiguities cancellation and this has been investigated further. A trade-off between mission complexity and performance regarding this cancellation technique has resulted in the use of the following 3-channel configuration using a multiple receiver array technique:

-Channel 1: receives with the nominal receiving pattern (in principle the same as the one in transmission);

-Channel 2: receives with the main lobe shifted to the left;

-Channel 3: receives with the main lobe shifted to the right.

With this scheme, the de-pointing can be detected and its magnitude, angle α, can be estimated, which is accomplished by retrieving the received power at the first range gate in the several channels and then calculating the ratio between them (see Figure 3).

One proposed way of obtaining these three patterns using the same antenna in reception by means of digital beam forming, is to divide the antenna in three sub panels and place three receivers so that each one detects the signal coming from a different sub panel, as shown in Figure 4. Then, by making the DFT of the signals detected at the three receivers, three orthogonal beams are synthesized. Nevertheless, other techniques may be applied to generate the three patterns.

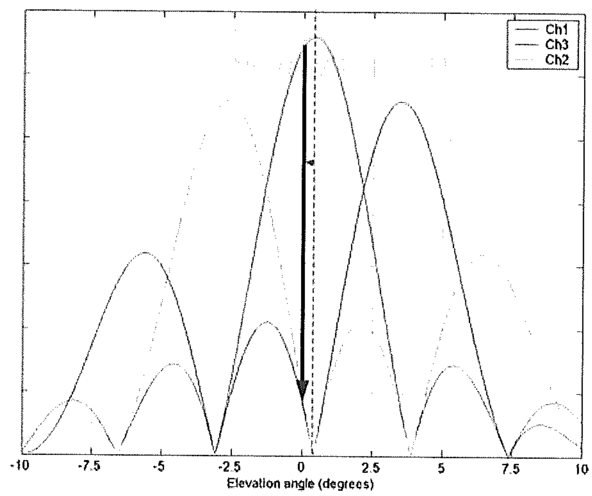

Figure 3: Radiation patterns for Ch1, Ch2 and Ch3

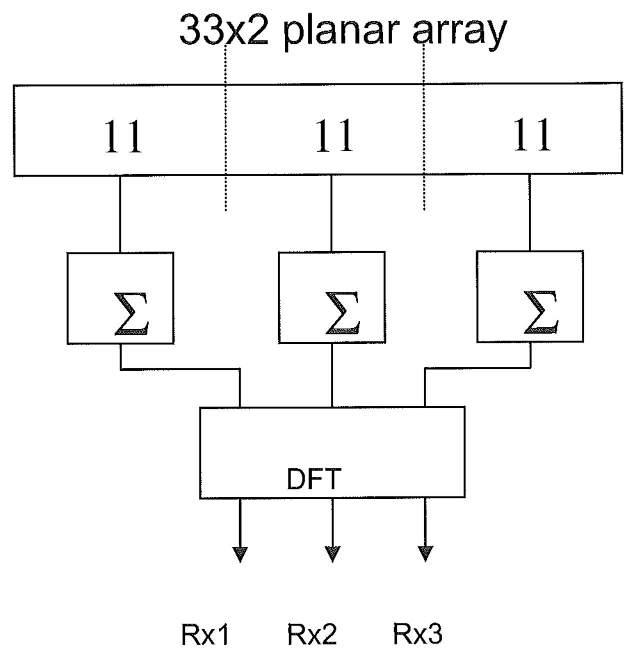

Figure 4: Digital synthesis of the radiation patterns in the 3-channel configuration

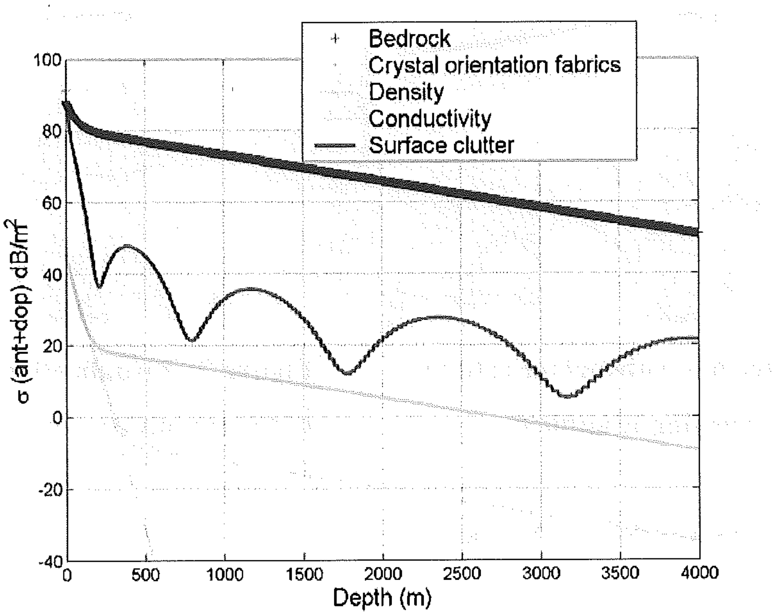

Figure 5: Surface and subsurface returns when no clutter processing is applied

The first set of simulations was intended to observe the strength of off-nadir echoes against internal echoes when no clutter cancellation processing is applied. As depicted in Figure 5, without any processing, the bedrock can be observed at all depths (with the used temperature profile) while the different layers will be hidden below the clutter.

In Figure 6, the multiple phase-center antenna with 3 receiving channels is used and the clutter rejection is performed in the ground processing. In this simulation a linear deformation of the antenna (with a deviation of ±λ/20 at each end of the antenna), which is analogous to a continuous slope in the ice sheet or bed(rock), has been included so as to show the performance under non-ideal conditions. Without any deviation (or when a zero slope is present), the clutter- cancellation scheme shows excellent performance.One can observe that the processing now enables the detection of the internal layers (at least crystal orientation fabrics), while, as shown in Figure 7, the distortion of the useful signals due to the processing is very limited. The improvement with respect to no clutter processing (Figure 5) is quite significant, even for this simulation where quite rough surfaces have been used that may not be typical all over the continent.

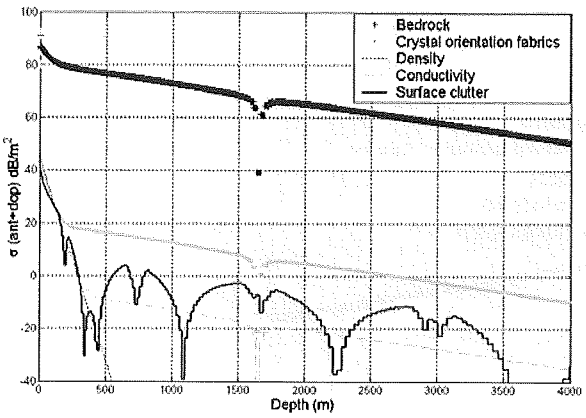

Figure 6: Surface and subsurface returns when clutter processing is applied

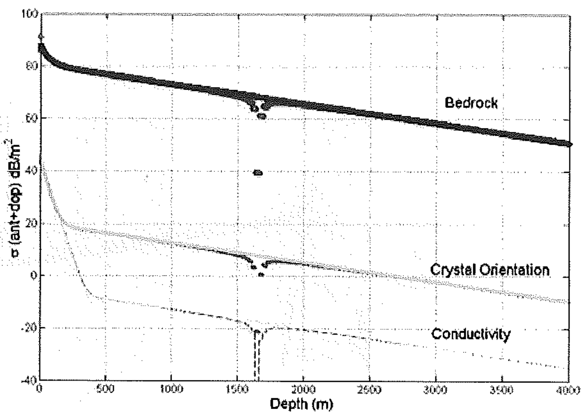

Figure 7: Visualization of the distortion of the signals due to processing

4. Conclusions and Future Work

A novel spaceborne mission concept is currently under study: a spaceborne ice sounder operating at 432 – 438 MHz. The paper addressed science questions to which the mission could help providing answers, as well as the aspects where more research is needed. In order to prove feasibility for such a mission, the most pressing issues to be further investigated are the electromagnetic characterisation of the ice sheet at P-band and the detection of subsurface echoes that may be obscured by the surface clutter.

A more sophisticated forward electromagnetic propagation model is currently being developed whereby more detailed information on Antarctica will be used, such as accurate temperature profiles, better description of Antarctica's bed and its ice sheet layers. In order to prove feasibility for this mission, this EM model is seen as the first step in developing a detailed 3D simulation of the imaging process from space and could be validated with data from an area already sounded by aircrafts. Also, effects of the ionosphere should be taken into account (mainly Faraday rotation).

The estimation of the angle of de-pointing is based on the calculation of a ratio between gain patterns. The de-pointing of the antenna causes a shifting of those patterns but its shape remains invariant. However, if higher order deformations (quadratic, cubic) are present, the shape of these patterns is affected and, thus, the ratio between them. Higher order deformations will therefore affect the estimation of the angle of de-pointing and its influence has not been analysed. This has a direct relationship with the detection feasibility when significant topography is present and is an issue for further investigation.

Overall, the mission may not be able to retrieve data all over the Antarctic continent either due to the inability of detecting contrasts at depth (e.g., due to high temperature of the local ice sheet), due to the presence of large topographical features like mountain areas for which the data may not be interpretable, or due to the surface ambiguities. The largest question that currently remains is the quantification of what improvement such a mission could bring in our understanding of Antarctica in itself and its role in the global climate…

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Eis.bear – A new way of building in Antarctica

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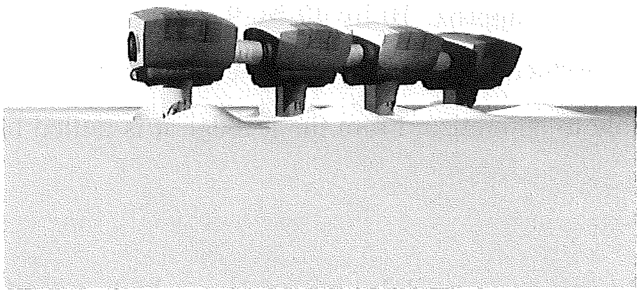

Fig. 1: Eis.bear Polarstation in Antarctica

Within our master thesis in architecture at the University of Stuttgart we started to look for a new concept in building ice stations.

Beeing introduced to the subject by the Alfred Wegener Institute in Bremerhaven and with the support of the Departement for Light Structures of Professor Sobek we were looking for a construction that was more and better adapted to the fascinating but hostile environment of Antartica than any solutions we got to know so far. During our research we found two major topics that we considered most important to be solved. Following the antarctic treaty and our firm conviction we wanted to guarantee a deconstruction without any leftovers. According to our decision to build above the antarctic surface the second main problem was how to cope with the massive snowdrift at neumayer. Every year the ground is covered by a new layer of snow thicker than one meter even without any obstacles on the surface. In order not to be „burried" by these forces of nature we realized that that the only escape was to use them.

Our station consists of a number of independent but connectable capsules. Each capsule is founded on a column made of ice growing relatively to the rising groundlevel. Like a donut on a finger the capsule is stuck on the column. The modules are formed aerodynamically in order to gather the snow from the strong winds without producing much windresistance. The accumulated snow is kept above the column and once a month used to grow the column. The growth is achieved by using the stations weight to compress the snow to ice until the new top of the column is strong enough to support the station. Then, like a climbing formwork, the station is slowly raised in order to keep the same distance to the rising ground. The distance between ground and capsule is kept at 5 meters to protect the station and its inhabitants from the heaviest turbulences directly above the ground.

The modules with a size of approx. 10 by 17 by 9 meters are built of glas and carbonfibre compounds in order to reduce weight. This way the capsule can be prefabricated in germany and shipped as a whole to antarctica. From the iceedge it is pulled like a sledge by snowcats to its destination.

By the division of the station in modules we achieve a high redundancy. During winter the deserted modules can be shut down and used as back-up. Modules can serve an infinite numbre of purposes: accommodation; science, research and laboratories; hotels; summerstations or expeditionquaters.

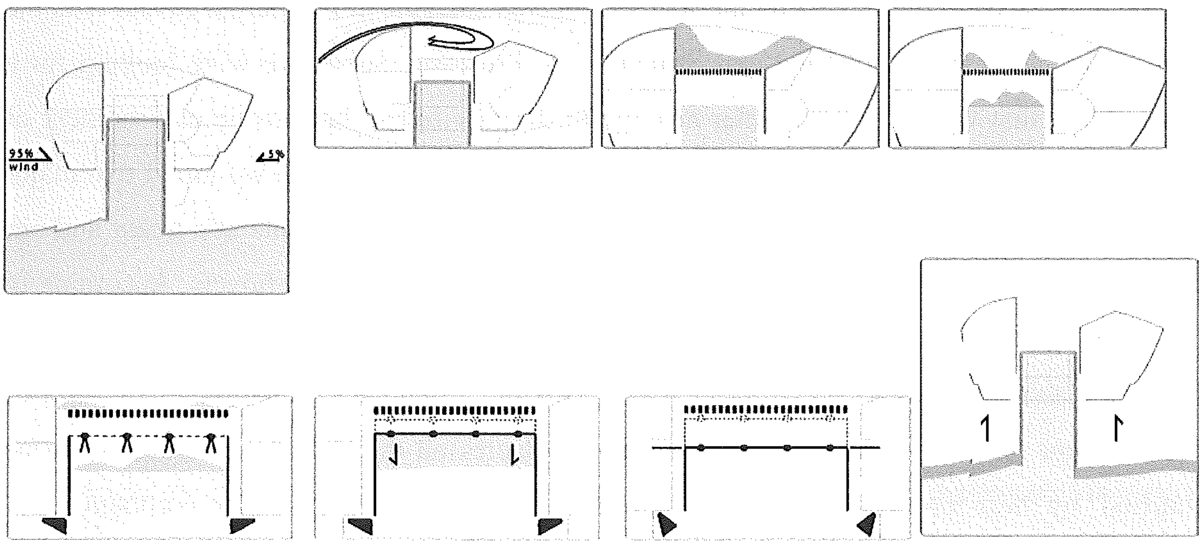

Fig.2: Principle of Eis.bear

Overview on Hydrogen and Fuel Cells as Energy Technologies

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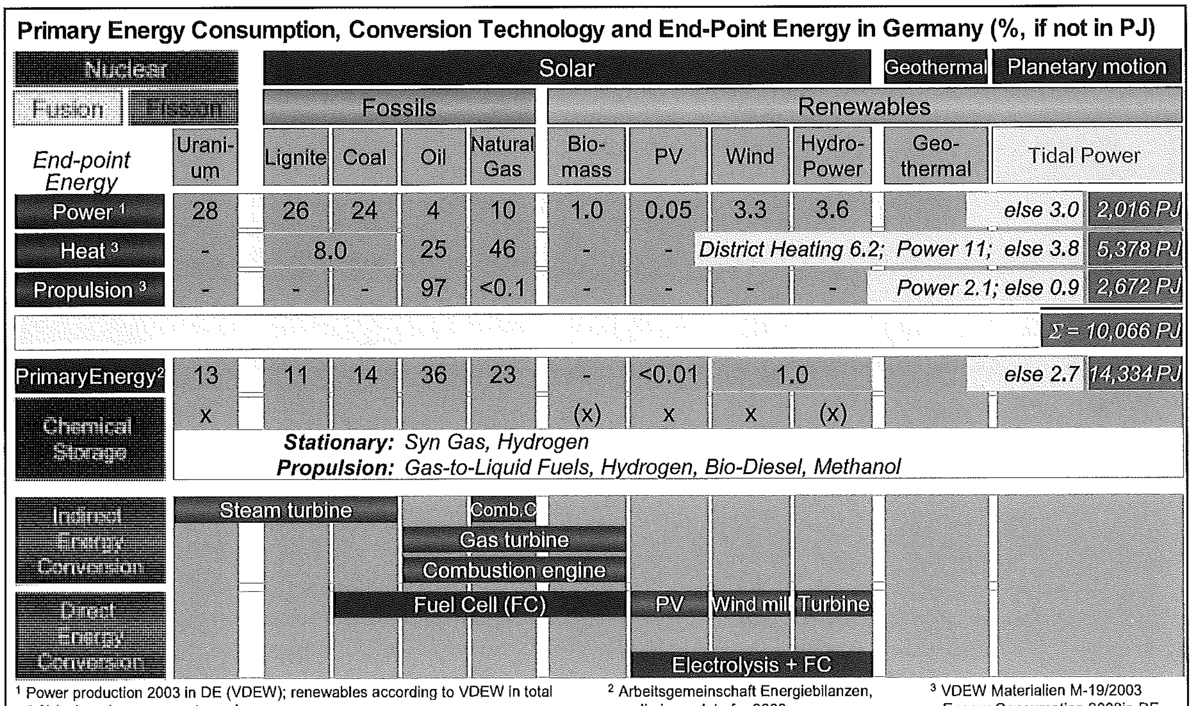
Introduction:

Novel energy technologies are crucial for the future. Beyond global warming energy security and – particularly in Germany – substitution of nuclear power production are notable drivers for research and deployment. Wind power has a remarkable potential – particularly if off-shore wind power is considered. A general overview of power shares for the different technologies is here presented.

For the time being hydrogen and fuel cells are addressed worldwide in research as major contributors for a better future. Based on scientific and technological facts status, merits, potential prospects and inherent limits are discussed.



[1] Power production 2003 in DE (VDEW); renewables according to VDEW in total 8 % incl. garbage, www.strom.de

[2] Arbeitsgemeinschaft Energiebilanzen, preliminary data for 2003

[3] VDEW Materialien M-19/2003 Energy Consumption 2002in DE

External Cost Figures for Electricity Production

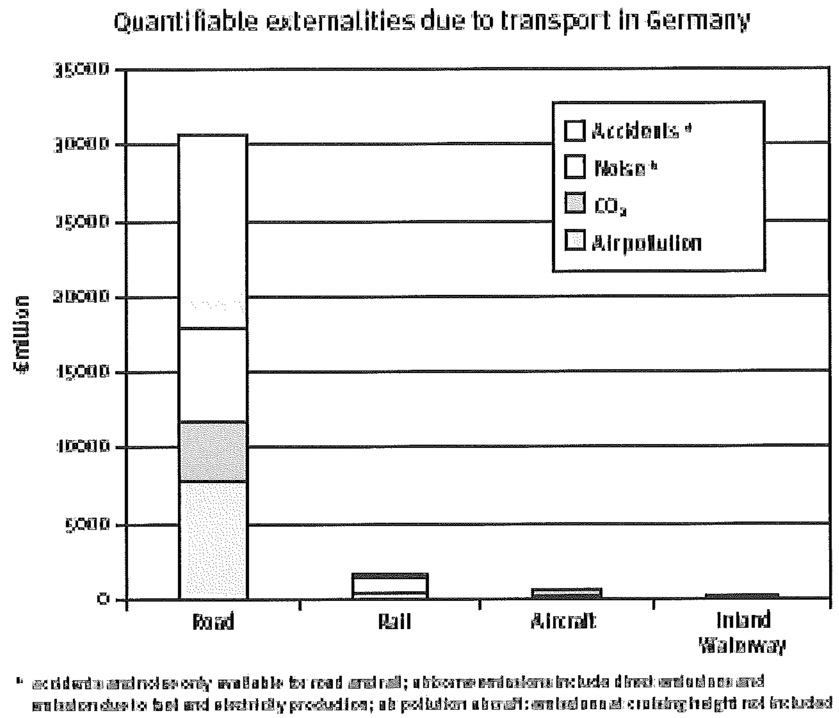
External cost figures for electricity production in the EU for existing technologies[1] *(in € cent per kWh*)*									
Country	Coal & Lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
AT				1-3		2-3	0.1		
BE	4-15			1-2	0.5				
DE	3-6		5-8	1-2	0.2	3		0.6	0.05
DK	4-7			2-3		1			0.1
ES	5-8			1-2		3-5**			0.2
FI	2-4	2-5				1			
FR	7-10		8-11	2-4	0.3	1	1		
GR	5-8		3-5	1		0-0.8	1		0.25
IE	6-8	3-4							
IT			3-6	2-3			0.3		
NL	3-4			1-2	0.7	0.5			
NO				1-2		0.2	0.2		0-0.25
PT	4-7			1-2		1-2	0.03		
SE	2-4					0.3	0-0.7		
UK	4-7		3-5	1-2	0.25	1			0.15

* *sub-total of quantifiable externalities (such as global warming, public health, occupational health, material damage)*
** *biomass co-fired with lignites*

Breakdown of External Costs to their Contributions

Quantified marginal external costs of electricity production in Germany[2] *(in € cent per kWh)*							
	Coal	Lignite	Gas	Nuclear	PV	Wind	Hydro
Damage costs							
Noise	0	0	0	0	0	0.005	0
Health	0.73	0.99	0.34	0.17	0.45	0.072	0.051
Material	0.015	0.020	0.007	0.002	0.012	0.002	0.001
Crops	0	0	0	0.0008	0	0.0007	0.0002
Total	0.75	1.01	0.35	0.17	0.46	0.08	0.05
Avoidance costs							
Ecosystems	0.20	0.78	0.04	0.05	0.04	0.04	0.03
Global Warming	1.60	2.00	0.73	0.03	0.33	0.04	0.03

Externalities due to Transport in Germany



Energy Consumption and Ratio of Reserves/Resources to Production

	Annual global consumption (1999)	Ratio of global re-serves to production (1999)	Estimated ratio of global resources to production
Oil	145 EJ 25 bn bbl	44 yrs 1100 bn barrel	about 260 yrs incl. shale/sand oil
Natural gas	88 EJ	73 yrs 170 Tm^3 6452 EJ	about 190 yrs incl. coal-bed gas
Coal	92 EJ 4.4 Gt	220 yrs 1000 Gt	about 1,000 yrs about 4550 Gt
Methane hydrates	n.a.	n.a.	about 10,000 yrs of total worldwide energy consumption
CO_2-free energy (renewables, nuclear)	about 65 EJ	unlimited for renewables, some hundred years for nuclear	
Total	390 EJ		

Some pivotal Questions

Will we run out of primary energy soon?
Contrary to public perception: probably not, see table above

Do we face energy shortages on political or economic grounds?
Probably yes: conventional oil will increasingly be concentrated in the realm of OPEC

➔ Potential answers are:
- ➔ Gas-to-liquid fuels
- ➔ Higher degree of renewables in transportation (bio-to liquid fuels)
- ➔ Hydrogen in transportation as a secondary energy carrier with high primary energy flexibility

Does global warming exist and is global warming anthropogenic and urgent?
Highly likely yes. Widely, though not completely, accepted in world politics

➔ Energy savings
➔ High energy efficiency in end-use technologies

➔ The broadest set of CO_2- free energy technologies is direly needed
- ➔ Renewables
- ➔ Nuclear (fission and fusion)
- ➔ Fossils with carbon sequestration
  - ➔ Centralized CO_2-sequestration
  - ➔ Centralized hydrogen production for decentralized usage

Some more pivotal Questions

Will fossils be needed in the time to come?
As >80% of our energy is fossil currently it will take time to switch over to non-fossil energy

What can the the perspective of carbon sequestration be on the time line?
Carbon sequestration is a means to be investigated for mid-term use

➔ Means to separating CO_2 not yet technically proven
➔ Storage potential for sequestering CO_2 is probably limited and unequally distributed over the globe
➔ Carbon sequestration does not prevent the atmosphere from being savaged on their oxygen content

Are there further aspects to be considered?
Definitely yes: economics, local emissions, societal acceptance, see below

About the Merits and Misperceptions on Hydrogen

➡ Secondary energy carrier (no notable natural resources world wide)
→ Hydrogen needs to be made of a primary energy source
→ Hydrogen is at best as CO_2 lean as the primary energy source it is made of

➡ Basic reaction hydrogen is used in: $H_2 + \frac{1}{2} O_2 \leftrightarrows H_2O \; -\Delta H$
→ Energy (Enthalpy) is set free if hydrogen gets oxidized
→ Energy input is needed for hydrogen production
→ Water is not a fuel in any case! (even if some industrial ads suggest it)
→ Water is the matter hydrogen can be made of <u>but under power consumption</u>

➡ Hydrogen cannot solve the energy problem, it may contribute to storage, distribution and allows for application of novel energy technologies like fuel cells
→ E.g. hydrogen based storage of wind energy surplus
→ E.g. early and easy introduction of fuel cells for transportation
→ E.g. prevention of local emissions

What is the chance hydrogen may offer – if introduced properly?

- **<u>Hydrogen may serve as an energy hub</u> like electricity does today**

→ Production out of a variety of primary energies offers great flexibility:

- natural gas; nuclear, hydropower, wind; solar; coal; renewables

→ Broad range of application: transportation, portable and stationary

→ Contributes to achieving Kyoto targets through

- carbon leanness

- application of efficient energy converters (fuel cells)

→ Apt for local zero emission technologies

→ Advantage over electrical power due to enhanced storage capabilities

→ Utilization in fuel cells and combustion engines

→ Primary use in vehicles, great market potential in portables, stationary use to be validated

→ Easy and early access to hydrogen is a prerequisite for the proliferation of fuel cells

The hydrogen economy can serve for different objectives.
Success requires defining the objectives carefully!

• **If an energy problem is addressed: Long energy chains must be avoided**
Each energy conversion step has an efficiency below 100%, some steps are below 50%
Long energy chains reduce efficiency substantially
100% Power → Hydrogen via electrolysis 80% → liquefaction 70% → fuel cell 50% ➔ in total 28%

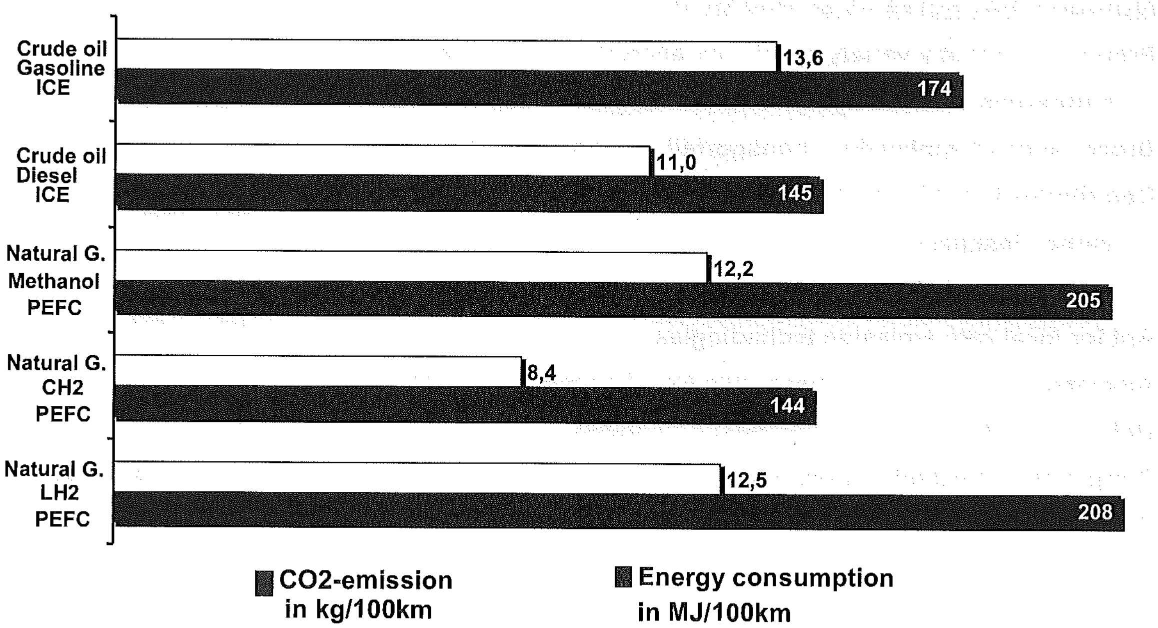
• **If a CO_2 problem is addressed: Energy consumption may deliberately increase**
Depending on fuel supply carbon sequestration needs to be introduced
Nuclear power represents a viable option
Renewables will contribute to specific CO_2-reduction but cost will limit the use

• **If local emissions are addressed: Energy input and CO_2 output may grow deliberately**
Importance will increase as worldwide cities tend to grow; effect underestimated in Germany

• **If energy security is addressed: Energy input and CO_2 output may grow deliberately**
Conventional oil resources will concentrate in the Middle East in the years to come

• **If industrial policy is addressed:**
Hydrogen powered portable fuel cells will increase energy consumption
Since portables will proliferate anyway fuel cells and hydrogen will contribute
to environmental benign even in this case

Energy consumption and CO_2-emissions for selected energy chains in comparison for vehicle



Boundary Conditions to be Considered when Introducing Hydrogen as an Energy Carrier

- **Energy needs to be kept affordable: Infrastructure and distribution cost will be high**

Subsidies can be granted for market introduction only
Tax needs to be considered if environmental relevance is intended
(e.g. bio-diesel is not cheaper than diesel but about threefold as expensive if tax is considered)
For the time being, only hydropower as an alternative primary energy source is cost competitive
Hydrogen infrastructure / distribution may exacerbate the cost issue

- **Internalization of external costs: Ecologically right, requires careful economic usage**

Societal life cycle costs need to be regarded
External cost is not a burden to liquidity – if internalized a new burden to the economy is placed by making these cost relevant to liquidity

- **Regional individualities need to be regarded properly**

e.g. the situation of Iceland is specific as renewable energy is abundant there
e.g. Spain is more suitable for solar energy than Germany
e.g. areal states like Poland may be assigned for biomass production

Obstacles to hydrogen can be overcome efficiently only after defining goals
This entails a semi-quantitative definition of the political targets

Can Hydrogen and Fuel Cells Solve the Energy Challenge?

As energy is needed in enormous quantities it is not supposed to be covered by one technology.

As Energy is already produced by a variety of technologies it is not supposed to be converted by one dominating technology in future.

In transportation hydrogen can contribute to solving the energy challenge we face, yet it will not solve it.

No single technology can be supposed today to solving the energy challenges described. A proper mix of all environmental technologies will be needed.

Requirements for Fuel Cells in Different Applications

	stationary	transportation propulsion	transportation auxiliary power	portable
total life time	> 10 years	approx. 10 years	approx. 10 years	1...5 years
required power production time	40 000...80 000 hrs	5000 hrs	5000 hrs	1000...5000 hrs
thermal cycles	≥100	≥5000	> 10 000	depending on application
$\eta_{el,system}$	> 50%	> 40%	30...40%	> 20%
unit size	100...1000 kW decentralized power 1...50 kW residential power	50...70 kW automobiles 500...5 000 kW trams...trains 5...500 kW boats 1000...20 000 kW ships	5...10 kW automobiles, trucks, boats 50...200 kW airplanes 100...1000 kW ships	0.1...5 kW
specific target	limited through materials' cost	1 kg/kW	10 kg/kW automobiles << 5 kg/kW airplanes	limited through portability
specific target cost	1500 US$/kW	30...50 US$/kW automobiles	100...200 US$/kW automobiles	<5000 US$/kW
Allowable degradation rate*	0.13...0.25 %/1000 hrs	≤2 %/1000 hrs	≤2 %/1000 hrs	2...10 %/1000 hrs

* corresponding to 10% of degradation over life time

What is Technically the Weakest Link of a Hydrogen Economy?

Production	Storage	Distribution	Utilization
Reforming Electrolysis	Pressurized Liquefied Metal hydrides Alkali boron hydrides	Pipelines (pressurized only) Trucks On-site reforming On-site electrolysis	Fuel cells Gas turbines Reciprocating engines

Owing to low energy densities in storage distribution is to be seen as the weakest link
High pressure storage is to be developed
Liquefaction of hydrogen is not a mass market option
R&D for highly efficient fuel cells (η >70%) is need

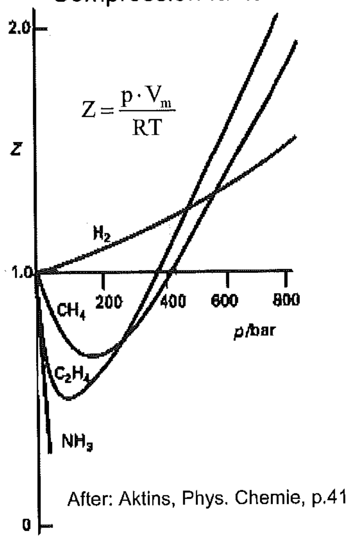
The paramount advantage of fuel cells is the high efficiency of small units

Fuel Cell Technology / Overview

operating temperature	fuel cell type: acronym	fuel cell type: name	ionic conduction: ion	ionic conduction: medium in which the ion moves	ionic conduction: common electrolytes
1000°C – 750°C	SOFC	Solid Oxide FC	O^{2-}	oxygen sublattice of ceramics	Y_2O_3-doped ZrO_2
650°C	MCFC	Molten Carbonate FC	CO_3^{2-}	molten salt (fixed in porous $LiAlO_2$)	$Li_{0,5}(Na,K)_{0,5}CO_3$
220°C – 160°C	PAFC	Phosphoric Acid FC	H^+	conc. H_3PO_4 (fixed in porous SiC)	conc. H_3PO_4
120°C – 60°C	PEFC	Polymer Electrolyte FC (PEM, PEMFC)	H^+	diluted acid (nano-porous polymer)	sulfonated polymer

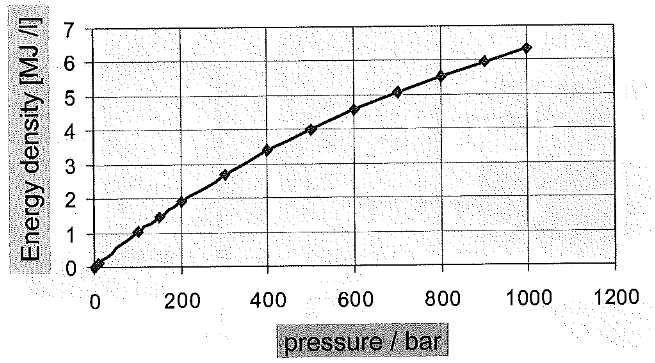
High Pressure Compression of Hydrogen

Compression factor Z



After: Aktins, Phys. Chemie, p.41

Energy density of hydrogen under pressure



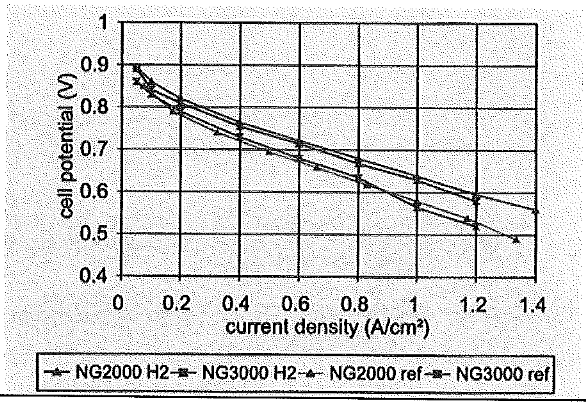
- The energy needed for compression inflates with increasing pressure
- The energy needed to distribute hydrogen decreases with increasing energy density
- Therefore, an optimum will exist.
- 700 bar storage is currently favored with regard to technical achievability, cost and energy efficiency
- The energy efficiency of the 700 bar compression step is high at about 90% compared to liquefaction reaching at best 65-70%

High Efficiency Fuel Cells are Needed to Compete with Advancing Conventional Technologies

$\eta_Z = \eta_{th} \cdot \eta_E = \frac{E_Z}{E_H^0}$ Cell efficiency

Objectives taken from the program

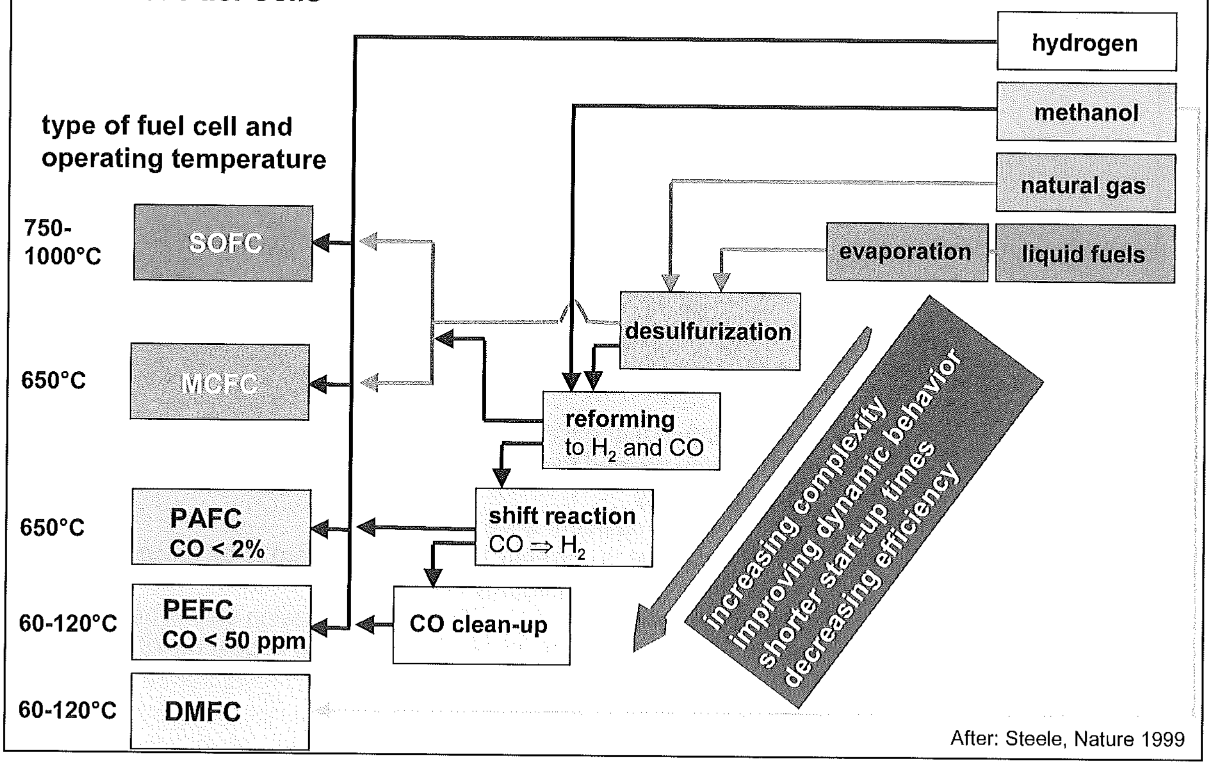
- **Power density 600mW/cm²**
- **Hydrogen / air**
- **Power option: 600 mV @ 1000 mA => η= 48 %**
- **Efficiency option: 800 mV @ 750 mA => η= 64 %**



NG 2000: 292 cm² cell area
NG 3000: 596 cm² cell area

Reformate: 40% H_2; 40% N_2; 20% CO_2
λ = 1,67

Fuels for Fuel Cells



After: Steele, Nature 1999

Steps to Achieve a Roadmap for a Hydrogen Economy

1. Political priorities are to be defined in detail (semi-quantitatively)
2. Technological pathways based on (1) need to be designed
3. Competitive non-hydrogen solutions are to be compared with the hydrogen pathways
4. If and where hydrogen is the choice

   Long-standing implementation-plans will be crucial

   Decisive deployment strategy is of utmost importance
5. Long-standing R&D will be crucial
6. Openness to various production methods for hydrogen is essential

Issues to be considered

1. Regional individualities
2. Chicken & egg problem of market introduction
3. Research for highly efficient energy converters
4. Long energy chains are to be prevented

Hydrogen as an issue needs to be kept at a low emotional level with great proficiency in order to prevent a deadlock or a similar fate to that of nuclear energy

Waste Management and Environmental Monitoring at the Italian Station "Mario Zucchelli" at Terra Nova Bay, Ross Sea, Antarctica

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Introduction

Located on the coast of Terra Nova Bay, on a North oriented peninsula (Northern Foothills, Victoria Land, in the Ross Sea), Mario Zucchelli Station has been designed as the permanent Italian Scientific Base in Antarctica. Until now, it was decided to implement only summer activities, but the station could however be, in the future, used during the winter period with minor modifications. Terra Nova Station is a pretty large station where major and diversified scientific programmes supported by a complex logistic are carried out. Waste Management and Environmental Monitoring plans have a very important role on the Environmental features protection. Numerous factor can be signs or symptoms of change not directly related to the environmental feature, but that potentially may impact the environmental features, such as human activity outputs (e.g. emission, fuel spills o waste management). Article 3 of the Protocol, which came into force in 1998, set out environmental principles for all activities and makes specific reference to monitoring requirements as well as waste disposal and waste management.

In the following are reported principles and general obligations regarding waste management and environmental monitoring adopted to the Mario Zucchelli Station at Terra Nova Bay.

Table 1 Waste Separation and Disposal System

Waste characteristics	**Type of wastes**	**Disposal metodology**
Burnables materials	Paper products; food scraps; untreated wood; rubbish bags; medical waste.	All burnable wastes are burnt in the BTN Station high temperature

		incinerator. Ashes are drummed and returned to Italy.
Recyclable material	Plastic products;glass and cans	All wastes designated as recyclable are returned by ship to Italy for disposal.
Non-recyclable material	Electrical batteries; empty fuel drums; exhausted, oils; exhausted engine filters; expired drugs or sharps (syringe needles, blades and empty syringes); solid and liquid chemical wastes; radioactive wastes.	Non-recyclable wastes and radioactive wastes are returned by ship to Italy.
Domestic Liquids		Sewage and domestic liquid wastes are processed in BTN Station physical-chemical treatment plant. The residues are drummed and retrograded to Italy for disposal. All solid wastes and, to the maximum extent practicable, all liquid wastes generated in field camps, are returned to BTN Station to be integrated into the Station waste management plan.

Current waste disposal practices of the Italian Antarctic Programme in partial fulfilment of Annex III to the Madrid Protocol are follow:
Waste Separation (Burnable material, Recyclable and non Recyclable material); Waste Disposal (Disposal of Recyclable and non Recyclable waste, Disposal of domestic liquids). Specific waste disposal procedure are utilised inside or outside the station or in respect to laboratory wastes or in the case of field activities. A number of containers is located in a dedicated zone for waste management, to be returned in Italy. Burnable wastes are stored in cages near the incinerator and incinerated several times a week.

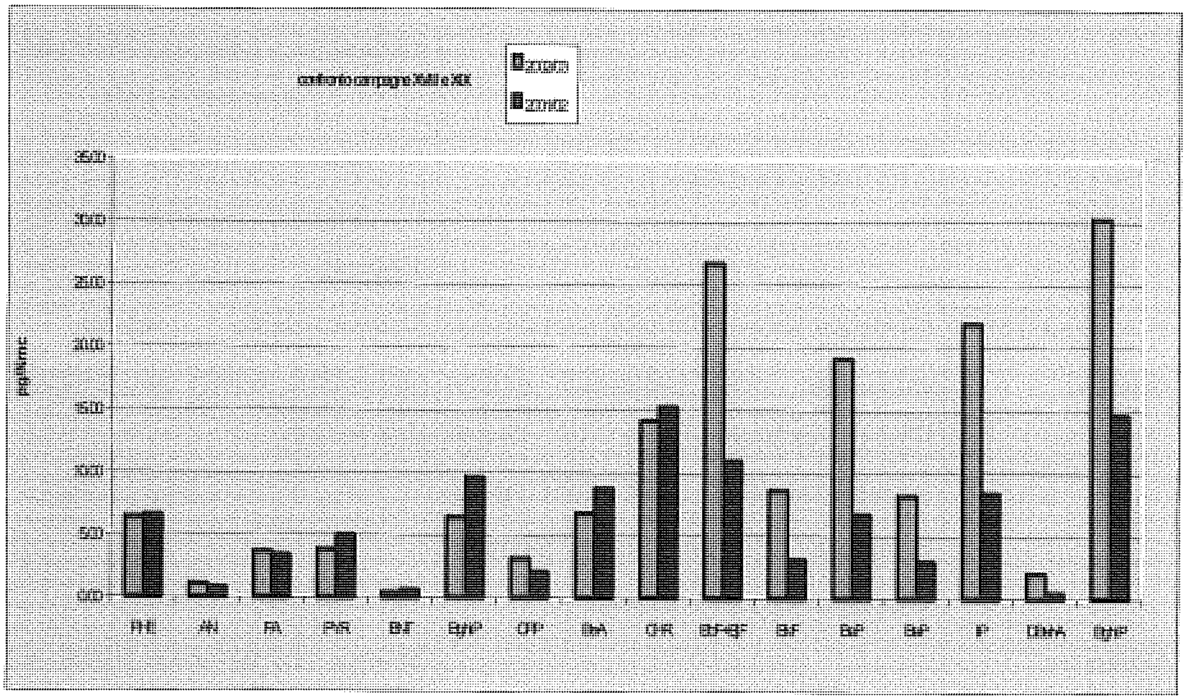

Fig. 1 Concentration levels of PAHs in the atmospheric particulate matter, expressed as pg/mc.

PHE: phenanthrene, AN: anthracene, FA: fluoranthene, PYR: pirene, BNT: benzonaftotiophene, CCP: ciclopenta(cd)pirene, BaA: benzo(a)anthracene, CHR: chrisene, B(b+j+k)F: benzo(b)-(j)-(k)-fluoranthene, BeP: benzo(e)pirene, BaP:

Table 2 Type and weight of the wastes produced at Mario Zucchelli Station during the last five Antarctic campaingns

Wastes	**XV (99/00)**	**XVI (00/01)**	**XVII (01/02)**	**XVIII (02/03)**	**XIX (03/04)**
Ashes from incinerator	1160 kg	1032 kg	580 kg	600 kg	480 kg
Mud from purifying plan	1090 kg	840 kg	990 kg	1560 kg	990 kg
Motor and hydraulic oil-soaked filters	90 kg	100 kg	80 kg	15kg	60 kg
Rags to recover motor oil and fuel	260 kg	300 kg	160 kg	360 kg	180 kg

Dark glass	660 kg		1360 kg	1520 kg	1760 kg
Light glass	320 kg		1360 kg	570kg	170 kg
Jet cherosene soaked mould				920 kg	990 kg
Exhausted motor oil		1120 kg	3300 kg	1190 kg	1530 kg
Waste cooking oil				300 kg	300 kg
Compresed plastic wastes	7000 kg	3500 kg	14000 kg	3500kg	4500 kg
Exhausted lead batteries	1300 kg	835 kg	1660 kg	660 kg	480 kg
Exhausted stylus and button batteries	13 kg	38 kg	9 kg	8 kg	13 kg
Exhausted photocopier toner	4,5 kg	14 kg	1,5 kg	15 kg	3,5 kg
Sickroom wastes	18 kg		4,5 kg	5,5 kg	1,5 kg
Foam AAAF-type from extinguisher				760 kg	
Motor oil- soaked mould			940 kg		
Electric cables	340 kg				

Table 3 Analysed Parameters matrices and metodology utilized in the environmental monitoring program at the Scientific Base in Antarctica

Analysed Parameters	Matrices	Methodology
DO, COD, BOD_5, Al, $NH_4/NO_3/NO_2$, PO_4 , Surfactants, Faecal Coliforms	Waste water and, for some parameters, sea water in the proximity of treatment plant	Standard Control Analyses
PAHs	Atmospheric particulate, sediments, biota	Accelerate Solvent Extraction, extract fractionation and purification, GC/MS analysis

Heavy Metals	Atmospheric particulate, sediments, sea water, snow, biota	Acid digestion (or APDC/$CHCl_3$ extraction for liquid samples), ICP/MS analysis

As an example of the monitoring activity, in fig 1 the comparison between the average levels ofthe PAH determined during 2001/2002 and 2002/2003 expedition are reported. PAH are toxic and persistent pollutants which are formed mainly during incomplete combustion of organic matter. The potential sources of PAH at Terra Nova Bay are: power plant, waste incinerator,vehicles,helicopters, spillage of fuels, etc.

PAH are continuously monitored in the atmospheric around the base and a few sample of sediments are analysed too. Four high volume samplers are placed at about 200 meters from the central point of the base. Atmospheric particulate (<10 micrometers diameter) is sampled on quartz fibre filters. The samplers operate continuously and the filter are changed every 72 hours. The filters are stored at –20° C, and carried to Italy for the analysis. PAH analysis is performed by ASE extraction silica gel clean up and GC_MS determination.

Conclusions

The monitoring program for the Italian Scientific Base in Antarctica, started at the end of '80s, has been continuously optimised and implemented, according to the "Monitoring of Environmental Impacts from Science and Operations in Antarctica" (SCAR, 1996) and "Standard Techniques for Monitoring in Antarctica" (Council of Managers of National Antarctic Programs, 2000) . A significant data base of the results obtained in the analyses of samples from different environmental compartments (air, water, sediments, biota) is now available. The analyses of these data permit, as a general consideration, to evidence the absence of any significant contamination. The waste management and disposal has been a priority since the construction of the base. The strategic aim of the waste management is to minimise to the maximum extent possible the environmental impacts due to the wastes generated by Italian scientific and logistic activities in Antarctica. After many years of activities, the balance is definitely towards a continuation of the activity, with the same attention to the Antarctic environment, which has been a characteristic of the Italian Program in the past.

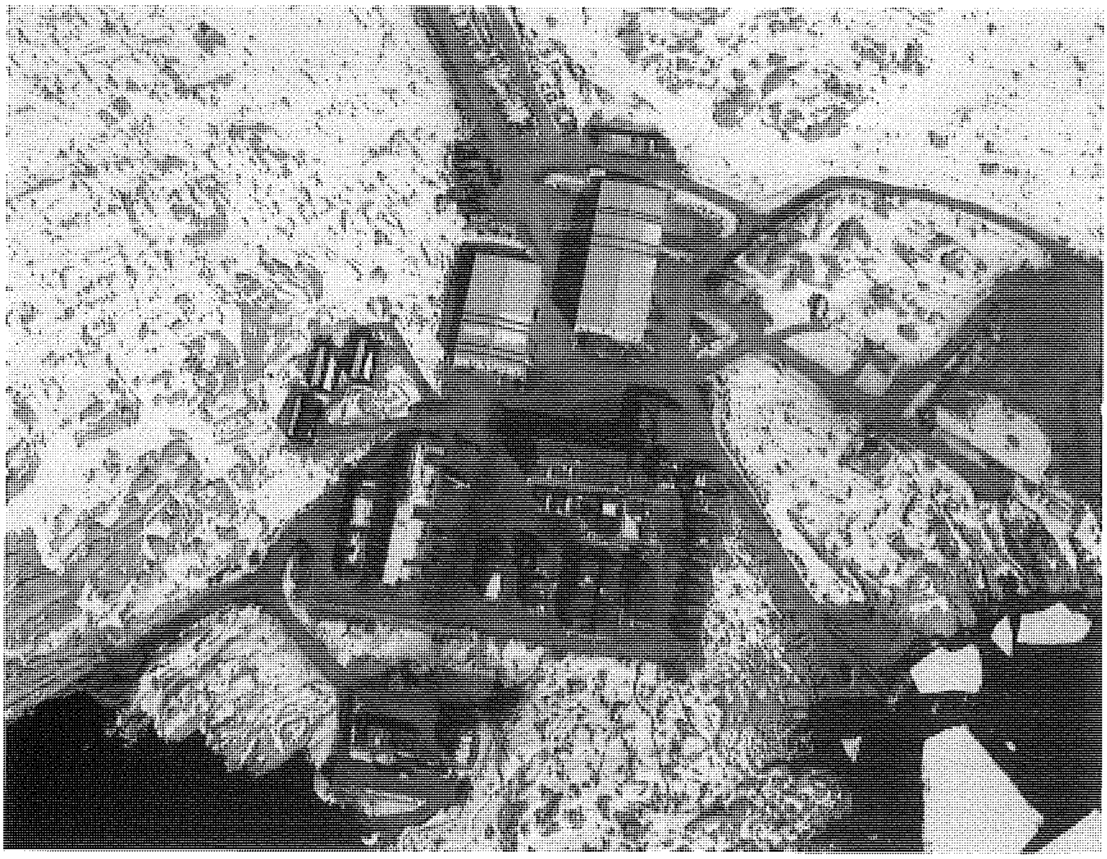

Fig. 2 Mario Zucchelli Station view

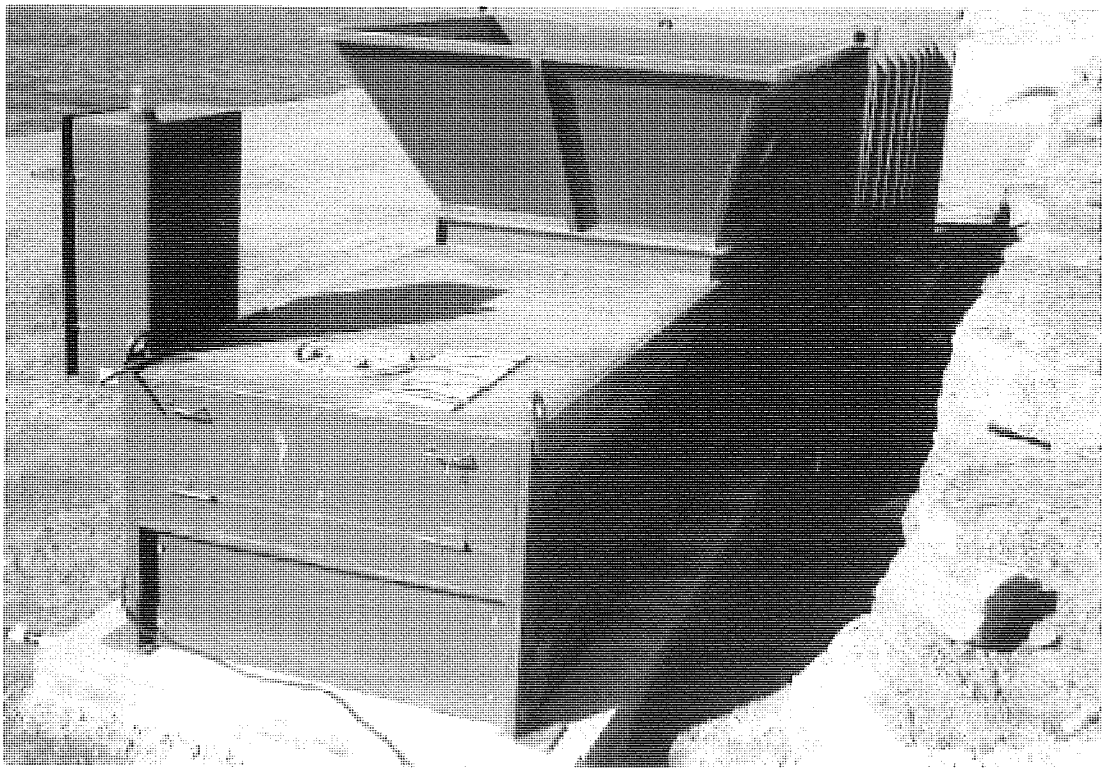

Fig. 3: Plastic Compacting Machin

Sensor technologies and networks for polar research aircraft

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Abstract

Airborne operation is a crucial element of polar research activities. Scientific observations from the fields of geophysics, meteorology, air chemistry and oceanography can be realized by means of airborne sensor systems over large and remote areas and up to high altitudes. However the reliable operation of such sensors and their related data acquisition system in environmental conditions of the Arctic and Antarctica demand for specialized technologies and strategies.

The multi-role data acquisition system MEDUSA was developed for the operation surveillance of maritime pollutions, namely oil-spills, in the two German pollution control aircraft of Type Do228. It combines 6 sensors (SLAR, IR, UV, MWR, LFS, FLIR) in one environment and includes telemetry links, geo-correction and data fusion. Recently the German polar research aircraft POLAR 2 and 4 (Type Do228) were equipped with a newly developed sensor network MEDUSA-P, combining existing and new sensors from different disciplines within one architecture. On the basis of specific scientific configurations for geophysics and air-chemistry and the experiences gained in flight, the problems, approaches, solutions and features of this network approach will be presented and discussed. Finally an outlook of upcoming developments will be given.

Introduction

The requirements for a data acquisition system are basically set up the sensors connected, the platform, the environmental conditions and the mission profile. Different approaches can be selected for the sensor connecting, for example a central data acquisition, a transputer network or like in this case, a network approach utilizing standard protocols and architectures. The first application of this sensor network and therefore its original purpose was the mission management and data acquisition within maritime surveillance aircraft. Chapter 2 will describe this oil-pollution detection system, its sensors and the network solution installed. When the demand for a flexible network for polar research aircraft came up, it was our approach to apply this sensor network in a modified configuration. The system and sensor description of this system, called MEDUSA-P, is the contents of chapter 3. Finally a summary and outlook is given.

Airborne pollution control

Marine pollution by oil-spills or harmful chemicals is still one of the major environmental problems to be faced. Besides the accidental releases of pollutants the main source is assumed from the controlled release by ship traffic and oil production platforms. Although the MARPOL convention (see http://www.imo.org) allows in certain open sea areas the discharge of 30 l of oil per nautical mile, the German responsibility area is announced to be a complete discharge free area. Nevertheless illegal discharge of oil still represents a significant threat, like for example the North Sea is polluted each year with approximately 300,000 tons of mineral and bunker oil from ships. Since accidents or violations of regulations can never be completely excluded, precautions and instruments are needed to detect and combat maritime pollutions and a crucial element of this framework is airborne surveillance. Like no other system, airborne pollution control is capable a) to detect possible oil-slicks by radar sensors, b) to verify, quantify and qualify reported pollutions by different near range sensors, c) to secure evidence against polluters and d) to coordinate clean-up operation of ships. Many nations have established such kind of airborne surveillance and also dense networks of international co-operations, since oil-spills are not restricted to national borders. One example is the Bonn agreement of 1983, establishing a trans-border observation between the North-Sea adjacent states (see http://www.bonnagreement.org/).

The platform

Regular routine airborne surveillance flights began in Germany in 1986 with two Dornier Do-28 aircraft, operated by the German Navy over the North and Baltic Sea on behalf of the German Ministry of Transport, Building and Housing. Flights are carried out on a irregular base on several different routes and with a total amount of up to 1600 hours on mission per year (two to three flights per day). Meanwhile both Do-28 have been replaced by modern Do-228 aircraft one of them equipped with the highly flexible MEDUSA sensor network while the other aircraft is still operated under a more rigid sensor architecture that will be replaced in 2005. The typical instrumentation flown on board of an aircraft is shown in Figure 1.

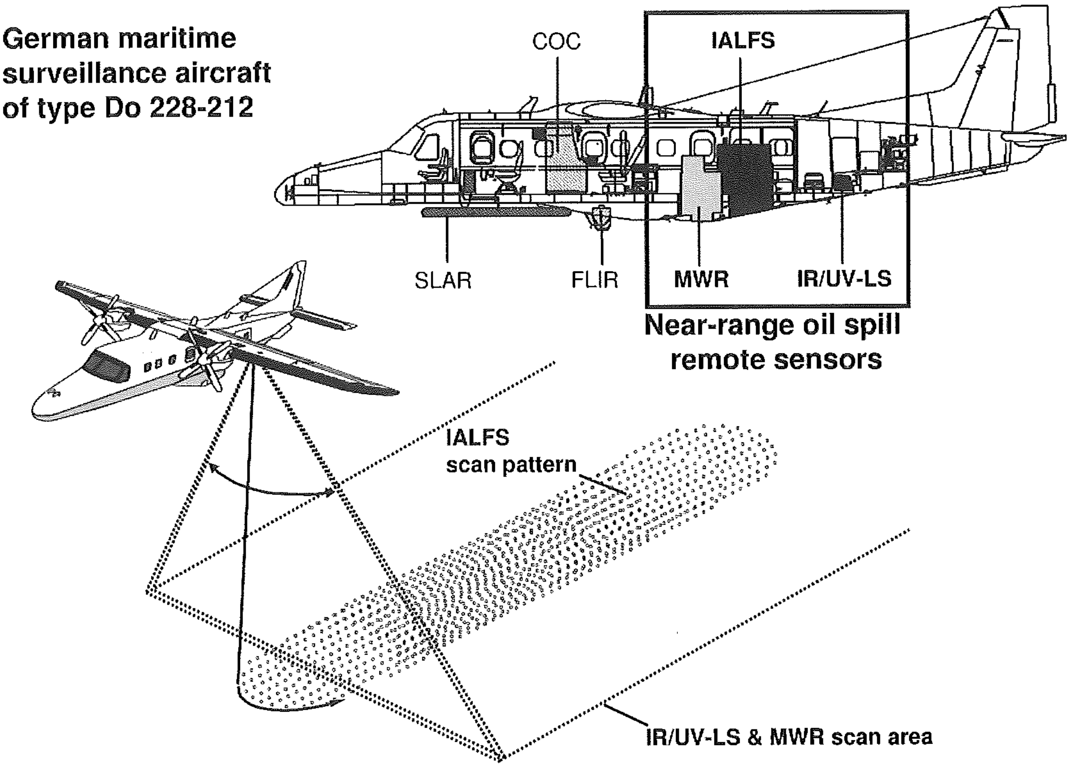


Figure 1: Near-range remote sensors of the German maritime surveillance aircraft and their spatial coverage. Also shown are the SLAR as a far-range sensor, the Central Operating Console (COC) and the forward-looking infrared imaging system (FLIR) for ship identification.

The sensors onboard

During the last two decades airborne remote sensors have evolved into common instruments for the operational surveillance of oil pollutions (Goodman, 1994, Zielinski, 2003). Today's mostly used sensor arrangements include a SLAR (side looking airborne radar) and an IR/UV (infrared/ultraviolet) detector (see Figure 2). To give an example: Among the 8 contracting parties of the Bonn agreement, contributing 14 aircraft in total, all platforms are equipped with a SLAR and all but one are using IR/UV sensors for the near-range investigation.

In addition to the above described standard there are more sophisticated sensors like the laser fluorosensor (LFS) or the microwave radiometer (MWR) that allow an advanced analysis of oil spills concerning the remote identification of oil species and the quantification of film thickness. The two German maritime surveillance aircrafts are examples of operationally used pollution control systems incorporating the above mentioned wide range of remote sensors. Other nations operate comparable systems or are at the step of defining new airborne systems, incorporating these advanced sensors for the second generation of maritime surveillance aircraft.

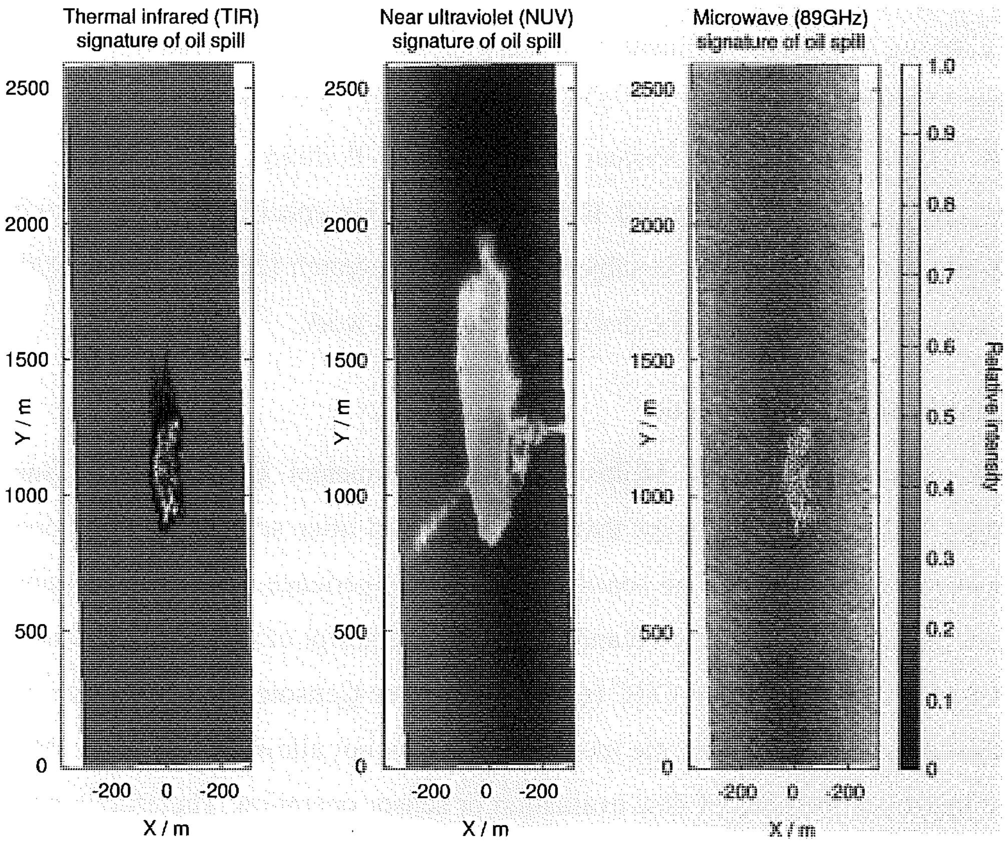


Figure 2: From left to right: Thermal infrared, near ultraviolet and passive microwave (89GHz) signatures of an oil spill (all data rectified, source: Robbe and Zielinski, in press).

Since thermal imagers, also known as Forward Looking Infrared (FLIR) devices, became commercially available, they are increasingly installed into smaller and mid-size aircraft. In September 2003 a Star SAFIRE thermal imaging system with a newly developed covert action laser illuminator (CALI) started operation as part of the second German surveillance aircraft, enabling the operator to read the ships name in the absence of daylight or investigate areas of specific interest. This thermal imaging capability brings an important step towards night operation and polluter identification. It is also a sensor with a wide range of application, like SAR or border patrol, making it a perfect device for multi-role aircraft, often only equipped with basic maritime surveillance sensors.

Routine oil pollution monitoring with advanced remote sensing equipment requires a complex network and communication structure to be operated by a single operator. The combination of different data sources towards higher level products is crucial in two ways: First, the operator is struck by the amount of data to evaluate and needs guidelines, alarm triggers and synergetic overviews. Second, the combination of different sensors drastically increases the probability of qualitative and quantitative predictions of the substances observed. Both aspects, combined with the entering of GIS environments in the operator's console, will lead the way to the third generation of airborne maritime surveillance systems. As a contribution to the EU project DISMAR (Data Integration System for Marine Pollution and Water Quality , http://www.nersc.no/Projects/dismar/) the analysis of this specific application with neural networks and dynamic attractors is subject to ongoing research (Zielinski et al., 2001; Robbe and Zielinski, 2004) and will not be discussed within this work.

The mission management system

MEDUSA as an acronym for Multispectral Environmental Data Unit for Surveillance Applications is based on a concept that was developed after several years of operation of remote sensing instrumentation on board aircraft. The experience from many missions lead to the demand to improve the restricted and non flexible concept of operating all sensors from a single main work station named COC (Central Operator Console). User interface and sensor data evaluation is located within the main work station not allowing the sensor developer to introduce improved methods of data evaluation or sensor operation. Therefore a new concept was developed with the demand to install all sensor specific features within a sensor related computer, aiming at:

- Improved operation and data registration
- Improved data evaluation and analysis
- Presentation of evaluated data
- Documentation of sensor data for prosecution
- Improvement of maintenance and repair capabilities.

The solution to such demands was the introduction of a standard network concept where each sensor is connected to the fiber optic network as standalone, completely autarkic client (Figure 5). This fiber optic network is connected through a fast Ethernet switch with the central work station within the central operator console. Standardized network infrastructure and improved protocols including NFS allow the integration and operation of sensors from the central operator station in a much more progressive way. It also improves the adaptation and integration of new sensors in such a way that generally spoken only 28VDC and a fiber optic connection is needed. All necessary information about the sensor is located within the sensor computer and protocols for sensor operation, data registration and visualization on the operator's monitor have been developed. Data are stored in a general data base in the COC as well as redundantly in the sensor computer itself.

Since 1997 MEDUSA is in full operation within the German Pollution Surveillance. It provides a common interface for the operators and a valuable tool for documentation and prosecution of marine oil-spills. As research and technology is evolving, continuous improvements were established over the years and further updates are planned. However the basic architecture and philosophy of the sensor network is unchanged and provides the backbone of the system performance.

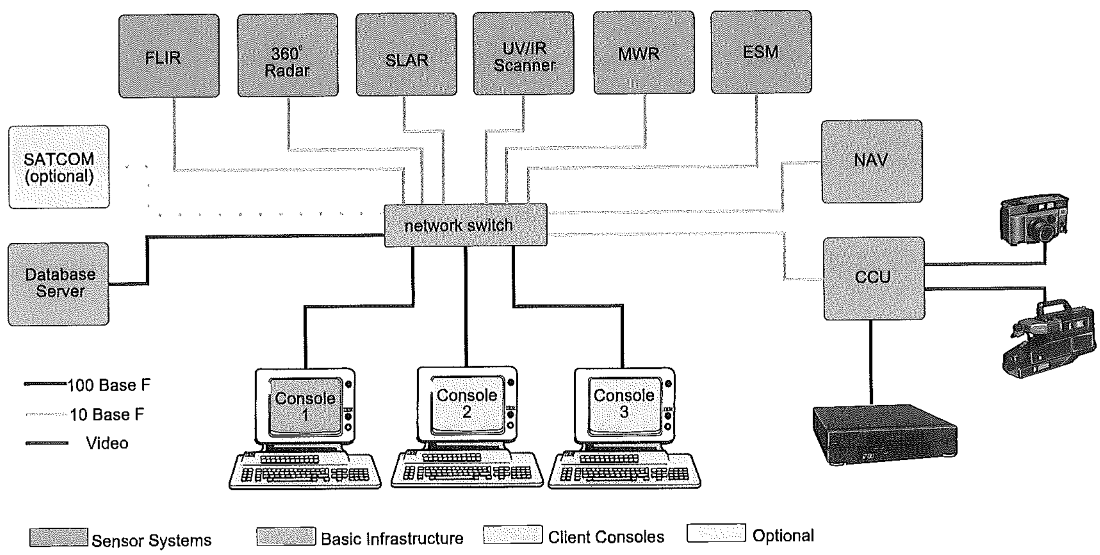


Figure 3: Basic structure of the remote sensing network MEDUSA.

Airborne Polar Research

In-situ and remote sensing of atmospheric, oceanographic and geophysical parameters can be a realized by means of airborne platforms. Especially the high spatial and temporal resolution of the collected data is enabling a dedicated research on local and regional phenomena and provides the link between ground and satellite based measurements.

The platform

The Alfred-Wegener-Institute for Polar and Marine Research (AWI) owns two research aircraft of Type Dornier 228-101 for scientific and logistic applications during Arctic and

Antarctic surveys (Nixdorf et al. 1999). Since May 2001 OPTIMARE Sensorsysteme AG, located at the regional airport of Bremerhaven, is responsible for the scientific equipment onboard both aircraft. The main task of this contract is the maintenance and integration of existing and new sensors together with the operation on polar expeditions. Additionally a new data acquisition system based on the sensor network from chapter 2 was developed and integrated. This network, called MEDUSA-P has undergone several changes from the original oil-spill detection system with respect to the harsh environmental conditions and the rapidly changing configurations of scientific expeditions, in contrary to the operational systems often remaining unmodified for several years.

Figure 4: Integration of scientific equipment onboard the two polar aircraft of the AWI within the hangar of OPTIMARE Sensorsysteme AG at the regional airport of Bremerhaven, Germany.

Missions of polar aircraft are subject to extreme environmental conditions. Operational temperatures can drop to -40°C and flight altitudes of up to 24.000 ft (approx. 7300 m) may be required from a non-pressurized cabin. The later fact for example requires pressure cases for hard-discs or the application of solid-state discs. Take-off and landing on ice landing strips with skies is also very demanding for aircraft, crew and equipment on board. All systems have to be tested and documented according to airworthiness regulations and a retraceability of all parts is to guarantee. The development of airborne equipment for scientific missions in polar regions presents a challenge for engineers, technicians and scientists. Procedures and components developed for such extreme environments can however be used under less demanding circumstances and thus represent an effective gain in expertise in the design and operation of rugged systems.

Scientific missions and instrumentation

The basic scientific instrumentation of both aircraft consists of meteorological sensors for the gathering of temperature, humidity and wind-related information. Additionally primary navigational data available within the flight management system (GPS, INS, GNS-X) will be recorded. For the scientific mission one or two phase-resolving GPS receiver are separately available which also form the basis of the common timing information within the aircraft. Aircraft missions range from meteorological to geophysical or oceanographic questions to be addressed. Therefore a vast number of sensors, all with their individual protocols, data formats and behavior have to be included into the central data acquisition or at a minimum, brought to the same time frame and mission concept. As an example the sensor configurations during two different surveys are shown:

Geophysics:

- ice thickness radar
- airborne gravitymeter
- aeromagnetometer
- laser altimeter und laser scanner
- video camera

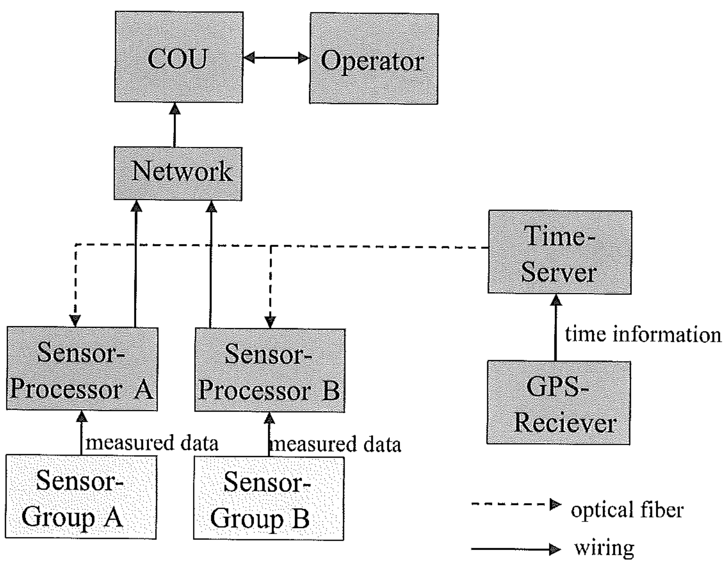
Meteorology and air chemistry:

- turbulence probe within meteopod
- radiation sensors pyranometer and pyrgeometer
- PMS-particle probes
- laser altimeter
- several hygrometer and humidity detectors
- spectral photometer and tracegas detectors
- color-line-scanner and IR-scanner

The data acquisition system

The acquisition and synchronization off all measured data within the aircraft, being it from AWI sensors or from other expedition participants, as well as the supply of all required data and power is the task of the data acquisition system. The integrated sensors are grouped by aspects of application and location within the aircraft. Following the MEDUSA philosophy of autarkical sensors each of these groups is supplied with an individual sensor-processor. This unit is a rugged computer hardware which measures, digitalizes and temporally stores the data of the sensors.

The data rate of sensors within these applications is 20 or 100 Hz. Especially the analysis of turbulent structures or geophysical surveys demands for an exact synchronization of different sensors which has to be met by the data acquisition system. Therefore central time information generated by the time server (which is connected to a GPS if available) is distributed throughout the aircraft via optical fibers or serial data connections. This central time-stamp is directly transferred to the data acquisition hardware, for example a specially designed PCB with fast AD converters and an FPGA for the first processing. This acquisition hardware is part of the sensor processor which now transfers the coupled data-time-information via network protocols to the central operating unit (COU). Here the information is stored in a database and in parallel transferred to a graphical user interface (GUI) for the operator. In contrary to the comfortable GUI of the oil-pollution system, the polar application demands for a reduced and more static graphical design which enables an online-control of the data flows and the status of the system. Due to the redundant data storage on the sensor processor and the COU database a high reliability is achieved.



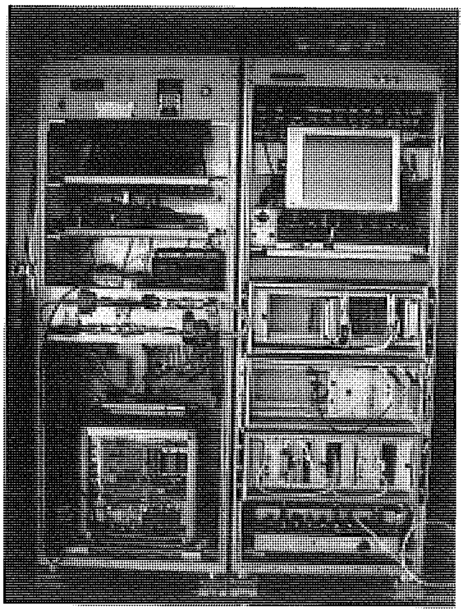


Figure 5: Left side: Diagram of the sensor network MEDUSA-P. Right side: Mission rack of the National Institute of Polar Research, Tokyo, Japan and mission rack of the data acquisition (no covers installed) within Polar 4.

Summary

MEDUSA-P is the advancement of the network concept MEDUSA, which has proven its capabilities during longtime operational application in maritime surveillance and pollution control over North and Baltic Sea. The environmental conditions in polar regions and the mission specific requirements set up the need for engineering changes like pressurized hard-discs or a reduced operator GUI. A very exact synchronization was achieved by introducing a central time server, a separate time-stamp distribution and a coupling of data and time information at the very earliest stage of data acquisition. Up to now the system has been applied on six surveys in the disciplines of meteorology, air chemistry and geophysics. The network architecture and the philosophy of autarkical sensor groups, which is the core of MEDUSA, make it flexible to new sensors and will bring more applications during the upcoming years.

The next developments within the MEDUSA-P system will be the inclusion of observer places with laptops, very high altitude components (up to 150000 ft) and the inclusion of larger displays and upcoming sensors. New features of the MEDUSA system for maritime surveillance are an AIS transponder, new DDL and communication links and more advanced fusion and analysis software options onboard.

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Abstracts only

Performance evaluation of surface traverse vehicles

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The US Antarctic Program is pursuing development of surface-based traverse capabilities for the delivery of inland camp and station supplies, and for establishing new scientific research opportunities. As part of this development, a two-month proof-of-concept traverse took place during the 2003-2004 austral summer. This traverse was based out of McMurdo and covered nearly 1500 km on the Ross Ice Shelf. A number of variables were evaluated in the course of the traverse, including equipment types. Four prime mover examples, and three types of towed units were represented.

Just prior to launch of the proof-of-concept traverse, and at times while in the field, quantitative vehicle performance tests were completed. Data were obtained for the tractors relative to drawbar-pull (tractive power) in straight ahead, fixed-radius, and diminishing-radius turns. For the trailers and sledges, towing resistance was measured at various speeds, and with the trailer's running gear placed within and outside of the tractor's ruts. Tests were performed in several different snow conditions.

Results clearly show advantages for certain arrangements of prime mover and towed unit under the limited range of conditions tested. For example, twice as many sledges can be towed in soft snow when their ski path follows outside (wider than) the tractor's tracks. Also, it can be shown clearly that an articulated tractor maintains both its maximum drawbar-pull and its complete steering response, while traditional (non-articulated) tractors suffer serious loss of steering ability, under heavy load when making low-radius turns. Further, we show that towing resistance for sledges is dependent on travel speed (lower resistance at faster speeds), but tracked trailers display a single value regardless of speed.

To generalize the results of field testing, and to avoid making measurements for every combination of equipment on the proof-of-concept traverse, we developed a calculator. Using the quantitative data generated with this set of vehicles, a spreadsheet-based traverse calculator was constructed to allow any combination (quantity and type) of prime mover, towed unit, and payload to be evaluated for net mobility. The calculator provides output for

go/no-go, mobility reserve, and load placement (center-of-gravity). This tool is very simple to use, with a checklist entry of the configuration to be considered and keyboard entry of towed unit payloads. This first generation of the calculator has assisted us in the initial arrangement of proof-of-concept equipment, and continues to allow the evaluation of "what-if" scenarios.

The development of an integrated communications system

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The British Antarctic Survey (BAS) has used the dial-up INMARSAT satellite communications system since the 1980s for voice and data traffic between Antarctica and the UK. This system has been reliable but has bandwidth limitations and traffic costs are relatively high.

The availability of funding to purchase capital equipment has lead to the installation of VSAT satellite communications to enable a continuous connection from the UK to Antarctic bases and ships. The initial cost of installing large ground stations has been offset by reduced ongoing communication channel charges. The introduction of a voice over IP telephone system will enable a seamless
telephone system between BAS Cambridge and Antarctica.

The scope of this paper is to introduce the capabilities of the VSAT and VoIP systems, the improvements in communication functionality and the potential for cost savings. The project procedures and difficulties encountered will also be outlined.

Proposing an international collaboration on lightweight autonomous vehicles to conduct scientific traverses and surveys over Antarctica and the surrounding sea ice

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Planetary exploration relies on rover-based operations, and space agencies have long had programs to develop vehicles with scientific and operational autonomy to conduct in-situ scientific data gathering. Planetary rover designs vary widely, but some are clearly of use in Earth science, and the inflatable rover design is, in particular, an excellent candidate for long-range solar-powered (or wind-powered) autonomous transects of ice sheets, sea ice or other remote areas. Today there are a number of instruments available with suitable mass and power requirements for this kind of deployment. The use of these systems presents the opportunity to reduce logistics costs, improve safety, introduce less pollution into the environment, and accomplish challenging science.

According to an international workshop held in Washington DC in 2001, Earth science surveys that are particularly appropriate for autonomous survey are those:

1. With Difficult or Hazardous Routes. Science traverses across sea ice are challenging because of open-water areas, and across ice sheets because of crevasses; lightweight floating rovers can handle these well.
2. Utilizing Measurements Not Compatible with Presence of Humans or Combustion Engines. One aspect of the traditional traverse is the generation of pollutants by both the humans and the combustion engines involved.
3. In Polar Night. Numerous processes are thought to occur primarily during the dark of polar winter, but current sampling is restricted to few year-round stations.
4. With Extremely Remote and/or Inhospitable Routes. Some sea ice areas and parts of East Antarctica (and other sites) are so remote that airborne support is logistically difficult, but they are accessible to rovers.
5. Having Routes Involving Simple Instrumentation. Quick acquisition of simple data sets may be crucial to comparing data sets or to calibration/validation of a satellite data set; a field traverse can take years.
6. Deploying Instrumentation Requiring Slow Traverse Speed. Certain geophysical observables, e.g. magnetometer and gravimeter data, are best taken at the surface at very low speed.
7. Which are Augments of Manned Scientific Traverses. Manned traverses are increasingly capable in scientific breadth, but they are inherently one-dimensional; a rover can work to widen the coverage.
8. With Detailed and Tedious Routes. Mapping routes such as "mowing the lawn" for detailed information in a region are notoriously difficult for operator-controlled systems.

An approach to the development off scientific rovers for Antarctic science has become apparent in the ongoing discussions for IPY4: An international collaboration involving the nations with Antarctic programs, scientists who need the kinds of surveys that suit autonomous rovers, engineers interested in the development of aspects of the systems to be deployed, and planetary mission developers who need demonstration opportunities for systems and concepts for future space exploration. We note that the smaller Antarctic national programs can take part at whatever level is appropriate. A program of this sort, advanced through international scientific and operational organizations, can enhance Antarctic science, reduce logistical cost and impact, and improve international bonds of collaboration.

2002 CECS/NASA/ARMADA airborne exploration of the Amundsen Sea Glaciers and the Antarctic Peninsula

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In November and December of 2002 airborne surveys were carried out in Antarctica, as part of a collaborative project between Centro de Estudios Científicos (CECS), National Aeronautics and Space Administration (NASA) and the Armada de Chile (Chilean Navy). Four flights were performed to the Amundsen Sea glaciers and two flights to the Antarctic Peninsula, onboard an Orion P-3A aircraft provided by the Chilean Navy, based from Punta Arenas. The flights were performed within a 17-day period, each lasting 10-12 hours and providing a total of 18 hours of data collection. The survey of the Amundsen Sea region, 1520 nautical miles from Punta Arenas, posed the largest logistic challenge, allowing only 2 hours of survey time in situ. Survey time increased to 5 hours in the Antarctic Peninsula region, located closer to Punta Arenas. Sensors included the CARDS 150 MHz ice penetrating radar of the University of Kansas, the ATM-2 scanning laser altimeter of NASA/Wallops Flight Facility and digital cameras of both NASA and CECS. The sensors allowed the acquisition of high-resolution ice thickness data and surface topography elevation, geolocated with an accuracy of a few decimeters.

We present here two new maps at 1:1,000,000 scale, one of the Amundsen Sea Region and one of the Antarctic Peninsula, with colour-coded flight tracks to show ice thickness and also ice thinning rates. Ice thickness results show deep troughs over most of the Amundsen Sea glaciers and in some glaciers of the Antarctic Peninsula as well, in many cases several hundred meters deeper than previously existing data. In the Amundsen Sea sector, laser altimetry data were used to detect ice shelf extent based on hydrostatic equilibrium, yielding several km of retreat of grounding lines since the early to mid 1990s; glacier thinning larger than 50 m since 1994 over grounded ice; and considerable thinning over ice shelves that restrain glacier flow. If this trend continues, significant increases in ice discharge from this sector of West Antarctica are predicted.

AAD air transport project

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The Australian Antarctic Division is in the process of introducing new aircraft to support its operations in Antarctica. Two ski equipped C212-400 aircraft will commence operations in the 2004/05 season. The aircraft will be used to move personnel and equipment between stations and field locations and to conduct airborne research. An ice runway is being constructed near Casey station to support the deployment and redeployment of the aircraft from Hobart.

The AAD will provide a presentation (with photos and posters) on the progress of the project.

Air operations in the Italian Antarctic program

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The Italian Antarctic Program (PNRA) entrusts most of its activity to the air operation.

Methods: PNRA operates in any of the three classes of the air activity, as identified by COMNAP:

- intercontinental fixed wing;
- intracontinental fixed wing;

- rotary.

At the first class belongs the 4-engine, wheeled cargo aircraft (Hercules) used for the air bridge between Terra Nova Bay and New Zealand. At the second class belong the 2-engine ski-equipped aircrafts (Twin Otter) used to connect the Concordia Base, on the plateau, with Terra Nova Bay. At the third class belong the helicopters (Squirrel) used, mainly, to perform the scientific activities and in this class the PNRA is, by far, the main operator in Antarctica in terms of flight time. It is evident how important is for the PNRA to utilize all the available tools to improve the safety and the reliability of the air operation.

The paper describes the effort made in the recent years by the PNRA to pursue the target. The sectors where we acted can be identified as follows:

- communications (satellite systems, tracking system);
- meteo forecast (increasing on data and accuracy);
- instrumental navigation (installations of nav-aids and introduction of procedures);
- operations;
- facilities (refuelling points on the plateau, operations room.

The Italian Antarctic Expeditions has found the air transport safe and efficient and will go on along the same lines in the next future, improving them according to the needs, available technologies, costs, and promoting international co-operation.

The development of an airborne polarimetric radar

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The British Antarctic Survey (BAS) routinely operates an ice-sounding radar to measure ice thickness, internal structure and basal conditions of the Antarctic ice sheet. The need to replace life expired equipment and the desire by the science community to study the material structure of internal layers and the ice sheet base, lead to the development of a polarimetric radar.

Using novel sampling techniques and real time digital processing implemented in field programmable gate arrays (FPGA), the radar is designed to penetrate the continental ice sheet (4 Kms). By transmitting orthogonally generated radar waves and employing a very fast data acquisition system, a very capable radar has been developed.

The radar is to be trialed in Greenland during the 2004 summer before being deployed in Antarctica during the 2004/05 austral summer.
The presentation will describe the capabilities of the equipment and process associated with fitting the radar to a BAS Twin Otter aircraft.

A wideband radar depth sounder for measuring the thickness of glacial ice

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Sea level rise is an important indicator of global climate change. Sea level has been increasing at about 2mm/year over the past century and may continue to do so. The continuing rise in sea level will have a devastating impact on humanity as the vast majority of people on this planet live in coastal regions. The polar ice sheets, which account for 80% of earth's fresh water supply is a major source of sea level rise. A key to quantifying their contribution is an accurate determination of the mass balance of these ice sheets. Ice thickness is an important parameter required to estimate the mass balance of the ice sheet and to study ice dynamics. Depth sounding radars designed at RSL/KU have been successful in measuring the ice thickness for the past 10 years.
We recently developed a Wideband Coherent Radar Depth Sounder System to obtain better delineation of the internal layers and information about the bedrock properties. The radar operates over a frequency range of 50-200MHz with resolution of less than 1m. A high speed Arbitrary Waveform Generator is used to generate a chirp from 50-200MHz over very small pulse width to obtain large unambiguous range and maximum number of integrations. Two gain channels are incorporated into the receiver to obtain very high dynamic range. The low gain channel is used to map the shallow internal layers and the high gain channel provides ice sheet thickness and bedrock properties up to a depth of 4500m. A high-speed data acquisition system is used to digitize and perform necessary real time processing on the data before transferring it to the storage device. The radar and data-acquisition systems have been significantly miniaturized using the latest RF technology and will be housed in a compact-PCI chassis. Laboratory tests show that the radar system has the required sensitivity to map a 4500 m thick ice.

We will be testing this system during the Summer 2004 field experiment at Summit, Greenland. This presentation will include system design considerations, system laboratory test results and data collected over Summit test site.

Containerised air-breathing PEM fuel cell power plant for mobile and stationery applications even under "unusual environmental conditions"

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A modular and flexible adaptable fuel cell power plant is integrated into a 20 ft. standard container consisting of:

- a number of 40 kW hydrogen-operated fuel cell modules (number is adapted to the required power output of the plant)
- the fuel cell auxiliary systems (cooling-system, heating, control and monitoring system, etc.)
- electrical system (inverter, transformer, etc.) for adapting the produced electrical energy to the local conditions

The hydrogen source can be chosen depending on what is best for the individual situation.

In 2003 Siemens Marine Solutions was awarded a contract by HFCS GmbH for design, construction and manufacturing of a containerised air-breathing PEM fuel cell power plant for maritime applications which is now in realization stage and is accompanied by the German classification society Germanischer Lloyd.

Following this basic idea, other application concepts for mobile and stationary use working even under extreme climate conditions are conceivable.

This type of containerised PEM fuel cell plant then can be used as one module of a stationary energy supply system for research stations located in the Antarctic.

The presentation will elaborate the subjects

- air breathing PEM fuel cell technology
- structure and layout of the plant concept
- functions and mode of operation
- interfaces

In individual power generation systems hydrogen can favourably be stored in metal hydrids. In order to keep the auxiliary power for the compression of hydrogen low the characteristics of metal hydrids, e.g. pressure plateau and temperature profile, can particularly be adapted to the special Antarctic operating conditions. A short presentation about the principle technology of hydrogen storage in metal hydrids, state of the art and development potentials, from HFCS will complete this presentation about an innovative approach to a part of a demanding energy supply concept

International collaboration on air operations to and within Dronning Maud Land (DROMLAN)

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For a long time it has been of great interest to establish a flight route between South-Africa and Dronning Maud Land (DML). Several nations have stations in DML with both all-year and seasonal activities and this could be the basis for a wider international collaboration. The Nordic countries, Finland, Norway and Sweden started their logistic collaboration in the end of the 1980's and it would be natural to develope this existing collaboration.

Already in the 1990's Norway contacted the other nations with facilities in DML to discuss the possibilities of an evaluation of flight operations in DML using the commercial operator Adventure Network International (ANI). After some delays en evaluation flight with 20 people from 8 countries was carried out in 2000. The group included several specialists within different fields.

The flight evaluation report concluded that the work with an international air network should continue. During the COMNAP/SCALOP meeting in China in July, 2002 it was agreed to establish an organisation, DROMLAN, and the undersigned was elected project director.

Since then flights have been carried out regularly. The co-ordination has taken place between the nations ahead of the flights and afterwards experiences and lessons learned have been summarised. Work has also been conducted between the seasons and in Brest, 2003 a final "Terms of Reference" was signed by nine nations (two nations remain) and work is ongoing in order to finalise a "Project Document" in 2004.

A very important contribution so far has been the use of the Russian station Novo and their infrastructure. A considerable effort has also been performed at Troll where a new blue-ice air strip is under construction. The air strip will probably be ready for the 2005-2006 season.
The work with finding suitable aircrafts for both intercontinental flights and feeder services in DML is also ongoing.
The South-Africa based company ALCI has also been an important contributor with central contracts for flights. IL 76 has been used for intercontinental flights.
Work is continuously ongoing in order to improve infrastructure and services to all national operators in the area.

The scientific data acquisition system PODAS on board of RV Polarstern

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A new concept for data acquisition, distribution and archiving (PODAS) was implemented for scientific data on RV Polarstern during its 'midlife conversion'. It is based on a new fibre optics network that spans all laboratories, ship functions rooms and living rooms. A real time database management system is the core component that manages all nautical, technical and scientific data. These data are distributed online on the local area network (LAN) based on the TCP/IP protocol. Data could be either used directly by scientific measuring equipment or via 30 so-called 'Info-Terminals' that are situated in all laboratories and function rooms. Data can be selected and extracted through a web interface on board for use on personal computers. All PODAS data are archived, brought to land and published on the Internet at the Alfred Wegener Institute, Bremerhaven [http://podas.awi-bremerhaven.de]. A special feature is integrated electronic station book for all scientific activities on board. All relevant facts of scientific work are documented in that system whereby the real time environmental data are directly received from PODAS. Hence, the station book contains the first meta data for scientific data measured on board. The PODAS system is based the data acquisition system DAVIS-Ship and was developed in close co-operation between the computing centre of the Alfred Wegener Institute and the medium sized company WERUM, Lueneburg, Germany. The system has evolved into a kind of standard for data acquisition on German research vessels. Small-scaled versions of this systems will be used for ROVs and AUVs. It is planed to publish data from all German RVs on the Internet by national data centres.

Operational sea ice concentration from satellite microwave sensors for ship routing

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Detailed up-to-date information about the sea ice coverage is crucial for ship routing in the polar regions. The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) aboard NASA's Aqua Satellite provides daily global sea ice information almost independent of the weather conditions. The ARTIST Sea Ice (ASI) algorithm takes advantage of the high spatial resolution (5 km) of the AMSR-E 89 GHz channels as well as of the low weather sensitivity of the lower frequency channels. Moreover, the ASI results are nearly insensitive to snow layering which is a major error source for the widely-used NASA-TEAM sea ice retrieval algorithm. The AMSR-E data are available within less than 24 hours which is sufficient for various operational applications. The practicability and usefulness has been demonstrated successfully with an automated internet sea ice service.

Enabling technology - wing-in-ground-effect vehicles

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Background : A wing-in-ground-effect vehicle makes use of the fact that an aerofoil generates more lift and less drag when flown close to the ground. Such vehicles range in size from small, single person units to very large, bulk transport ones. Most operate from water and are seen as fuel-efficient load carriers with speeds approaching that of aircraft. These craft usually fly at heights of between 0.5 and 3 m above the surface at speeds between 100 and 200 km/hr. For further details see www.flightship.net or www.se-technology.com/wig.
Use in Antarctica
A wing-in-ground-effect (WIG) vehicle could be used in Antarctica for rapid survey of large areas, much like an aircraft but with much lower capital and operating costs.

Advantages compared to aircraft
- Classified as boats, therefore:
- Lower capital cost
- Lower operating cost
- Lower training cost
- Higher payload vs engine size
- Low operating height advantageous for some geophysical techniques
- Safer - low height, automatic landing in event of engine failure

General advantages
- Established technology - not new development
- Less take-off power required compared to operation on water
- Skims over sastrugi better than hovercraft
- Faster than any other ground transport over snow

Proposal: I propose that BAS assembles and leads a consortium of Antarctic operators (through COMNAP) to evaluate wing-in-ground-effect vehicles for use in Antarctica. A trials programme could be initiated using existing commercially-available craft with minor modification.

Science and tourism in Antarctica—Is it compatible?

Landau D.
IAATO-International Association of Antarctica Tour Operators

For the last 35 years Science and tourism have co-existed in Antarctica. IAATO member companies provide logistic and scientific support to national Antarctic programs and Antarctic organizations. With approximately 200 departures annually to the Antarctic, tour vessels represent a platform of opportunity for researchers and science programs. Tour vessels provide a cost-effective transportation links from Argentina, Chile, Falkland Islands, New Zealand and Australia Antarctic with regular departures from November to March each season.

Tourist landings take place in adjacent areas where research sites exist for scientists. How can we further the cooperation between the science and tourist community? What measures can we take to assure that a site where scientific work is being done isn't affected by tourist presence? How can tourists work as ambassadors and encourage governments and private institutions to fund needed scientific work in Antarctica? Several ideas will be explored to further the cooperation of science and tourism in the Antarctic.

Concordia water treatment and recycling systems

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The new Concordia scientific station, located on Dome C, will soon come into operation. From its conception Concordia, constructed by the French and the Italian Polar Institutes, has incorporated methods for reducing the environmental impact of the new station on the site. All waste generated is shipped out, thermal co-generation has been optimized, generators are equipped with particle filters and catalysts. All water consumed is recycled for washing needs.

The study and the development of these water treatment systems have been placed under the leadership of the European Space Agency, which also has an interest for its own needs. All wastewater streams, including grey water from washing, and black water consisting of organic waste (food scraps from the kitchen and refectory) and excrements, are collected by two respective networks under vacuum and transferred to two treatment systems. Grey water undergoes a 4-step treatment process - ultrafiltration, nanofiltration and two stages of reverse osmosis; black water is treated by an anaerobic fermentation unit.

In order to minimize waste production, the sludge from the grey water unit is re-treated by the black water system and the water produced from the black water system is taken up by the grey water treatment unit. The final waste, the sludge issuing from the black water fermenteur, is frozen and shipped back to the coast to be dried and incinerated.

Mawson hydrogen demonstration project

Magill P.

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In May 2003 the Australian Federal Minister for the Environment and Heritage announced an AUD0.5 million grant to the Australian Antarctic Division to demonstrate the use of hydrogen as an energy storage medium in our Antarctic operations. When the hydrogen is generated by excess wind energy and used in fuel cells to generate electrical and heating power in periods of low winds, the potential exists to operate permanent Antarctic stations free of fossil fuels, generating zero greenhouse gas emissions. In addition, hydrogen can be generated and stored at stations with large wind resources and used as the primary source of energy at remote, smaller field stations, reducing intercontinental transport costs and greenhouse gas emissions. This presentation describes the proposed project to use the grant money to set-up a small scale hydrogen generation, storage and fuel cell generation system linked to the newly completed wind farm at Mawson station. The project aims to demonstrate the feasibility and safety of hydrogen and to collect data for modelling of a full-scale system for Mawson.

One year's operational results of the Mawson wind farm

Magill P.
Australian Antarctic Division, Kingston, Australia

This poster provides an overview of the project that has installed two 300 kW wind turbines at Mawson station, and presents operational results including turbine performance, power system performance, fuel savings achieved, and describes issues which have arisen during the first year of operation. Future directions for the project are described.

Meteorological airborne survey instrumentation

Massucci M.
British Antarctic Survey, Cambridge, UK

The British Antarctic Survey (BAS) uses De Havilland Twin Otters to transport personnel and equipment between Antarctic bases and field sites in the northwest region of the Antarctic Peninsula. This presentation describes the use of a Twin Otter configured to monitor atmospheric and meteorological conditions.
In climatic terms, Antarctica is an unique environment giving rise to cloud properties, atmosphere-ice interactions, boundary layer structures and synoptic and mesoscale weather

systems. These features are poorly studied and as a consequence poorly represented in climate models. BAS has embarked on a project called MASIN (meteorological airborne survey instrumentation) to greatly extend the range of atmospheric research that can be undertaken in Antarctica. A twin otter is being fitted with a range of instruments to cover cloud physics, turbulence, radiation and meteorological measurements.

Details of the instruments being fitted, the aircraft installation and system performance are presented.

PLUDIX: a new instrument for ice phase precipitations observation

Natali S. (1), Folegani M. (1), Vitale V. (2) and Prodi F. (2)

(1) Nubila S.a.s, Via Zago 2, Bologna, Italy, (2) ISAC - CNR. Area della Ricerca di Bologna, Bologna, Italy

Ice phase precipitation is, amongst hydrometeor reaching the Earth surface, the most difficult to be measures, even though it plays a very important role especially at high latitudes. Moreover Ice phase precipitation is obviously an important term (the input) in the ice mass balance of Polar Regions. Presently, ice mass balance estimations are performed by means of satellite observations over the whole polar areas with seasonal/annual frequency and locally by means of simple measurement methods such as snow boards and warmed tipping bucket for the observation of equivalent melt water. These systems suffer of many problems, from the intrinsic limitation of being an indirect measurement (as it is for the greatest part of the measuring systems, except optical devices), to the lack of comparative measurements. These problems, together with the low temporal resolution, do not allow the observation of any feature related to the dynamic of the precipitation process. Near real time measurement could help in the validation/improvement of current numerical models to test their modellization of precipitation processes. PLUDIX is a bistatic X-band low-power continuous wave radar that has been designed to evaluate Doppler shift of falling particles, which are supposed to randomly cross the radar volume. It is commonly used as disdrometer for liquid-phase hydrometeor detection and measurement, but it has also proven to be able to effectively detect ice phase precipitation. In addition of disdrometric capabilities, it is also a good present Weather Sensor (PWS) due to its low integration time (up to 10 s).

A three-months measuring campaign was conducted at BTN from November 2002 to February 2003, and results are here presented. During this campaign, PLUDIX has proven be able to measure and characterize Antarctic precipitations in terms of precipitation amount and ice crystals terminal velocity; PLUDIX has also proven to maintain its performances in severe environmental conditions; only mounting problems were identified due to wind-induced oscillations of the structure.

Scientific missions by means of a Autonomous Underwater Robot

Papalia B.
ENEA, Roma, Italy

The SARA project started in 1994, gaining a sponsorship by the PNRA, the Italian Programme for Antarctic Research. Within the Italian Antarctic Program, the subject "Technological Research" is explicitly mentioned and funded; however, technological developments are strictly linked with scientific and functional goals related to the Antarctic environment; funding authorities (the Government) recommend to forecast industrial spin-off in terms of application and growing of know-how.

The overall scope for the robot SARA is the substitution of researchers in long and repetitive missions, and the accomplishment of "impossible" tasks, such as the observation of water-ice interface in undisturbed conditions, or the operation in wintertime. In particular the last mission represents a reference goal, in view of which the main requirements are dimensioned; effective operation of SARA under the ice pack for a 8-10 months period will follow several experiments in domestic waters and also in the neighbourhood of Terra Nova Bay, but in friendly conditions and with human assistance.

The identified typical missions include:

- Hydrology (conductibility, temperature, depth, current profile)
- Chemical oceanography (oxygen, turbidity, pH, etc.)
- Biological oceanography (chlorophyll, nutrients, etc.)
- Geological oceanography (sea bottom morphology)
- Under ice survey (topography of the submerged part of the ice).

According to the above missions, the following main specifications have been identified:

- maximum depth: 1000m
- cruise velocity: 2 m/s
- maximum range: 250 Km
- maximum mission duration: 20 hours

- hovering capability

A Underwater robot is a quite complex machine, where a number of technological problems have to be solved, in order to reach the functional goals, and to ensure a high level of reliability and safety of the vehicle.

A short overview of main concerns and solutions will be shown, related to the following topics:

- general architecture
- structural problems
- navigation strategy
- control system
- service and scientific sensors

SARA started running since half 2002, and was in Antarctica in the summer 2002-2003; some discussion on first experiences, as well as on planned scientific missions, will take place.

Clean up and remediation of the Thala Valley waste site

Paterson C.

Australian Antarctic Division, Kingston, Australia

The Australian Antarctic Division has begun the first remediation of a contaminated waste site at an Australian Station, at Casey in East Antarctica.

A number of novel managerial and technical approaches were developed to deal with the challenges of the Casey site, most notably the on-site water treatment and management methods to limit contaminant dispersal, and the complimentary three tiered environmental monitoring approach.

This poster will discuss the project, the logistics involved, and document progress achieved over the 2003/04 summer season.

Meteorological aids supporting the decisional operational process at Terra Nova Bay

Pellegrini A. and Coppola P.F.

(1) PNRA, Rome, Italy, (2) Italian Air Force Weather Service

In the recent past the meteorological branch of the Italian Meteorological Antarctic Project has considerably grown particularly with respect to the weather support to operational planning and more generally to decisional process. The weather risk management, which reveals to be a key factor in all the operations being conducted in the Antarctic Continent, is a loop process articulated in a set of chained phases in which the weather risk is identified, analyzed, subdued to planning, monitored and controlled. In all such phases specific technologies and techniques are being utilized to exploit the weather operational aspect; among these the Automatic Weather Station network must be mentioned which meets the requirement of synoptical, climatological and operational meteorology in terms of observations availability. Besides numerical weather products derived from global and meso-scale models are being used to cover medium, short and very short range of forecasts, while now-casting is being accomplished by a redundant system of satellite imagery receiver. In this paper such technological systems are investigated and the techniques through which weather information is extracted, processed and made available to decision makers.

Development of a penguin activity logging gateway

Preston M.

British Antarctic Survey, Cambridge, UK

BAS biologists studying the movements of Macaroni penguins have, in the past, used radio transmitters on the birds to determine if a bird is out at sea or in it's colony. This is expensive, intrusive and unreliable and can be deployed on only a limited number of birds.

To overcome these limitations a 'gateway' system has been developed. The gateway is constructed between the colony and the sea. Birds travelling between the two must pass through it. The gateway uses radio-frequency identification technology (RFID) to read the industry standard animal tags implanted in the birds. The system records the tag number, the time and the direction of travel of the bird. Time at sea and time in the colony can therefore be deduced.

Mains power is not available at the site so the system was designed to have low power consumption and is powered by a combination of solar panels and wind generators feeding rechargeable lead-acid batteries.

Open automatic weather station platform

Reeve J. (1) and Boucher C. (2)
(1) Australian Antarctic Division, Glenorchy, Australia, (2) Barking Spider Pty Ltd., Australia

Antarctic Automatic Weather Stations (AWS) gather invaluable near surface weather data for a variety of research applications, such as:
- interpretation of ice-core paleoclimate data;
- validation and downscaling of global weather models;
- a range of glaciology studies; and
- support for operational weather forecasting.

These AWS are deployed in hostile environments and are typically required to operate without maintenance for periods up to ten years (or until buried by snow). In some sites these AWS might encounter:
- temperatures below -80°C;
- wind speeds in excess of 150 knots; and
- periods of up to 5 months without any sunshine.

The Australian Antarctic Division, in a joint development with Barking Spider Pty Ltd, has developed a new generation of AWS in light of the lessons learnt from the Australian Antarctic Division's deployment of AWS in Eastern Antarctica over the last 20 years.
This AWS design provides a generic data collection and transmission platform, as well as an open sensor interface allowing third party development and rapid integration of new sensors. The platform supports a range of data storage and transmission formats and methods (e.g. ARGOS, UHF) with easy reprogramming of sensor sampling schedules and output message formats. A unique folding mast design allows for deployment using small aircraft (such as an Aerospatiale AS.350B - 4-6 seat utility helicopter).
In addition, custom temperature (air and sub-surface) and wind speed sensors have been developed, with the individually calibrated temperature sensors attaining an accuracy of ± 0.02°C (for gradient studies) and the wind speed sensor remaining operational below -60° C.
The poster will present the functionality of the station, discuss design issues and consider future development. It will in particular address the philosophy guiding the development, including:
- building on long term experience to provide reliability and accuracy; while

- re-thinking the design in view of the latest technologies to provide a more flexible and more efficient platform; and
- building the AWS on a standard, open and flexible data collection and transmission platform that will enable the gathering of high-quality data.

New Zealand experiences in site clean up - the value of monitoring

Roper-Gee R., Gilbert N. and Tangaere J.
Antarctica New Zealand, Christchurch, New Zealand

Annex III of the Protocol on Environmental Protection to the Antarctic Treaty states that that "waste disposal sites on land and abandoned work sites of Antarctic activities shall be cleaned up by the generator of such wastes and the user of such sites", except where removal of structures or wastes would result in greater adverse environmental impact.
In accordance with these obligations, New Zealand has completed successful clean up activities at two major sites of activity - Vanda Station (1968-1995) and Cape Roberts (1995-2000). Vanda Station was established before current environmental requirements were in place, while the Cape Roberts Project was able to be planned with regard for minimum impact and post-activity remediation. Monitoring played a key role in both cases, continuing at both sites until 2002.
Lake Vanda was the site of a small New Zealand station occupied from 1968 to 1995, when it was removed due to concerns over rising lake levels. The site was contaminated by fuel, greywater and human waste. The key concern was that the lake, highly valued for science, would be contaminated. Buildings, equipment and a large amount of contaminated soil and rocks were removed. From 1994/1995 until 2001/2002, water and algae samples were taken at least annually from Vanda Bay (immediately adjacent to the station site) and a control site to monitor for changes in the lake water near the station site been undertaken. Analysis by NIWA (the National Institute for Water and Atmospheric Research) included nutrients, chlorophyll, algal species composition and heavy metals. The data collected over the seven years provided a good understanding of natural variations in the lake, and detected no evidence of contamination in Vanda Bay. On this basis, annual lake sampling was ceased and it is expected that in the event that lake water inundates the old station site, particularly "Greywater Gully" (the main liquid waste disposal area), sampling and analysis will be able to quickly ascertain whether contamination is occurring.

A large international drilling project was staged from Cape Roberts between 1995 and 2000. Good baseline information about the site was collected before the project began and a strict environmental management programme, including auditing and monitoring, was built in through the Comprehensive Environmental Evaluation process. Because of the strong preventative measures, very few spills occurred during the project. Those that did occur were well reported. Monitoring including visual assessment of terrestrial disturbance, total petroleum hydrocarbon analysis of soil and water, and skua censuses was conducted during the project's operation and for two years following its completion (at which time storage containers and equipment were removed from the site). Almost no signs of the project's presence remain, including no detectable hydrocarbons in soils or surface water. Some novel remediation was undertaken - soil compacted by vehicles and storage was loosened by raking. After a winter these areas were impossible to identify.

At both sites, environmental monitoring was able to verify the effectiveness of clean up efforts, and the information collected provides a useful baseline for evaluating future impacts caused either by environmental changes (such as a rise in Lake Vanda's level) or by further human activity.

A more realistic model for solar loading in polar regions

Rose M.
British Antarctic Survey, Cambridge, UK

Solar loading models are used to predict the amount of power available to photovoltaic solar panels and the amount of heating imposed of building surfaces (usefully in the case of Trombe walls). Typically, models ignore several effects that are important in polar regions such as surface albedo. This poster describes a model written to provide more realistic results in polar regions, although it is applicable at any latitude.

Low power modular technology for use on the Antarctic Plateau

Rose M.
British Antarctic Survey, Cambridge, UK

BAS has successfully operated a network of eleven environmentally powered magnetometers on the Antarctic Plateau for three years. The modular design has been reused in IR radiometers, automatic weather stations, and in a remote SODAR.

The key feature of the system's design is the minimal logistical requirement for deployment and maintenance.

The merits and implications of the low power approach, and benefits of a modular design will be discussed.

The power system will be explained, and examples of the implementation presented.

Tracking the Antarctic scientist in field work with NOAA/ARGOS transmitters

Setzer A.

CPTEC/INPE, Sao Jose dos Campos, SP, Brazil

Scientific and technical people involved in field wok in Antarctica occasionally face extreme weather conditions and emergency support needs or evacuation. Cellular phone networks are not available, and probably won't for a long time in the region. Geostationary satellite communications require the user to use notebooks and to point antennas, usually not compatible with straining physical situations and nasty winds; additionally, such devices operate only at latitudes below 65 degrees south without mountains in the satellite sightline. Commercial satellite phones depend on internal batteries with short life of about one day and delicate operation beyond the reach of a person in a blizzard sporting clogged snow goggles and freezing hands inside thick and wet gloves or mittens. For 10 years field crews of the Brazilian Antarctic Program has been using specially designed transmitters with real-time reception at its Ferraz Station and Navy support ship. The technology is based on the ARGOS system on-board NOAA (National Oceanic and Atmospheric Administration) satellites commonly use to collect weather data from automatic weather stations and to track wildlife; it is also similar to the emergency beacons in airplanes and ships around the world. The units weight about 01 kg and the internal batteries last up to 4 months of continuous use. Uplink is UHF, and the downlink used is the VHF one and not the standard 1.7 GHz what makes the reception much simpler and cheaper. 244 predefined messages can be chosen by the people in the field, ranging from normal mission status to emergency requests. An alarm will sound at the Ferraz station and at the ship when the field crews send specific or distress messages. Geographical location of the transmitters is obtained with about 01 km accuracy. Many critical human situations were avoided thanks to the transmitters. The paper summarizes the technical aspects of the system and the field experience acquired so far

The clean-up and removal of abandoned British bases and waste dumps in Antarctica

Shears J.R.

British Antarctic Survey (BAS), Cambridge, UK

The UK is undertaking a major five-year programme to remove abandoned British stations and waste dumps from Antarctica, in accordance with the Environmental Protocol to the Antarctic Treaty (1998). The £2 million clean-up programme is a major step forward in UK efforts to protect the Antarctic environment.

By mid-2004, the British Antarctic Survey (BAS), working in partnership with British construction company - AWG Construction Services, will have removed redundant facilities at Signy Research Station, the waste dump at Fossil Bluff summer field station, and the abandoned British bases along the Antarctic Peninsula. The clean-up of these bases, some of which date back to the mid 1940s and are spread over a wide geographical area, represents a significant logistical challenge for the UK.

The first phase of the clean-up was at Signy Research Station, South Orkney Islands, during the 2001/02 season. A project team of ten environmental staff from BAS and AWG emptied and dismantled the old bulk fuel tank, and demolished two large disused buildings and smaller facilities. A special filtration system reclaimed 20,000 litres of waste fuel that was subsequently used in the station's diesel generators. The BAS vessel RRS Ernest Shackleton took out a total of 800 cubic metres of wastes from Signy Island for recycling or safe disposal either in the Falkland Islands or UK.

The second phase of the clean-up was the excavation and removal of the old waste dump at Fossil Bluff, Alexander Island, Antarctic Peninsula, during 2002/03 season. Fossil Bluff is one of the most remote bases in Antarctica, and can only be reached by small, ski-equipped aircraft during the austral summer. Removal of the dump was a technical and logistical challenge because the project team of six BAS and AWG environmental staff had to set up their own temporary field camp at Fossil Bluff, most of the wastes were trapped in solid ice and difficult to break out, and the complex logistics required to move personnel, cargo and wastes by air between Fossil Bluff and Rothera Research Station. The entire dump was removed - a total of 50 tonnes of wastes and general rubbish, including over 300 empty fuel

drums. The wastes were flown to Rothera and then shipped to the Falkland Islands or UK for recycling or safe disposal. The success of this project led to BAS being awarded the international 'Green Apple' Gold environmental award for 2003.

The BAS are now planning to complete the clean-up programme during the 2003/04 season with the removal of the three remaining abandoned British bases (Danco Island, Prospect Point and Detaille Island) along the Antarctic Peninsula, and to carry out a clean-up at Whalers Bay, Deception Island.

Morbidity and health survey of wintering members in Japanese - Antarctic research expedition - life styles also do harm as severe Antarctic climate

Shimoeda N. (1,2), Ohno G. (1,3), Otani S. (1,4), Nakao M. (5), Morimoto T. (5), Ohno H. (6)

(1) Japanese Antarctic Research Expedition, (2) Kashima Rosai Hospital, (3) Tokatu Hospital, (4) Tottori University, (5) Kobe Women's Junior College, (6) Kyorin University

The Japanese Antarctic Research Expedition (JARE) started in 1956. Syowa Station is the mother station of JARE at 69°00'S and 39°35'E in East Antarctica. An epidemiological survey of the wintering team of JARE was carried out based on the annual reports of JARE over the period 1956-2001. The total number of personnel was 1230. We examined the proportion of personnel who had contracted disease with healthy personnel as reported by the medical department at Syowa as well as a health survey by biochemical analyses.

The total number of cases of disease at Syowa Station was 4836. The highest percentage was found in the surgical/orthopaedic domain at 45%, followed by internal medicine at 23% and dentistry at 13%. Other diseases in dermatology, ophthalmology, and so on, extended over almost all domains. The internal medical cases included hyperuricacidemia, gout, liver dysfunction and alcohol related disorder. Also these diseases has been tending upward. Only one death of JARE from a blizzard was recorded, though the majour fatal disease in Antarctica is heart attack. The lifestyle diseases might threat the health of the wintering person as well as the severe Antarctic climate.

In the health survey by JARE 40, there were no great changes in serum levels of albumin and total cholesterol. In particular, serum calcium did not decrease during the polar night period. Serum levels of triglyceride and gamma-glutamyl transpeptidase increased significantly, compared to initial levels, during the wintering period . In another one by JARE43, the liver dysfunction was detected in 45% of wintering personnel, Hyperlipidemia 38%, hyperglycemia 30%, hyperuricacidemia 23% and hypertension 23%. In the same survey, the body weight became 104% and body fat mass 121% increased compared to initial levels, during the wintering period.

In analysis of nuturitional supply for JARE39 personnel wintering-over, protein and fat intake were higher and carbohydrate was less than the recommended daily amounts for Japanese. The average daily food energy consumption of one personnel was 2021 Kcal. This intake was nearly equal with the standard of normal Japanese citizens and far less than 3500kcal which decided as the desirable value in Antarctica in 1959.

Today, Antarctic life styles also might do harm as severe Antarctic climates do. Looking over the wintering over life style including food is necessary for the health during winter period without evacuation nor rescue and also would bring the cost effect.

The Bonner laboratory reconstruction

Taylor D.
British Antarctic Survey, Cambridge, UK

The replacement Bonner Laboratory at Rothera Station has been completed only two years after the original was destroyed by fire.

At the same time as designs for the replacement were being prepared, the fire was investigated and the debris and waste removed. The new laboratory incorporates a high level of fire protection, including passive elements such as timber treated with fire-retardant products, and active elements such as a sprinkler system. Scientific equipment has been updated, providing an excellent research facility for BAS and visiting scientists for the next twenty years. A small team attended site this year to complete snagging work and fully commission the laboratory in time for an official opening ceremony.

The scope of this paper is to describe the investigation process, the waste removal project, and the subsequent reconstruction, including costs.

Halley VI

Tuplin K.
British Antarctic Survey, Cambridge, UK

The purpose of the poster or possible oral presentation will be to announce the initiation of the Halley VI project, a state-of-the-art scientific research station to be constructed by the British Antarctic Survey (BAS) on the Brunt Ice Shelf.

BAS has had a continuous scientific presence on the Brunt Ice Shelf for the last fifty-years undertaking atmospheric research. To maintain that presence BAS has had to construct a replacement research station virtually once a decade since 1956 as each previous station has become obsolete. Halley V, the current station, has been a huge success outstripping all its predecessors in longevity and functionality. However, it has become a victim of its own success, being transported on the ice shelf closer and closer to the ice front with the increasing probability of the shelf calving, and the station itself floating off in to the Weddell Sea.

Previous incarnations of the Halley stations have taken many forms, each design improving on the previous. The design concepts and structures have ranged from subsurface to surface to above-surface layouts. BAS are keen to move the design concepts forward with the next generation of ice station, Halley VI.

Halley VI will embrace innovative thought, new design concepts and new technologies. It is the project vision to provide a state-of-the-art facility that supports front ranking science with front ranking infrastructure.

It is the project aim to strike a balance between engineering finesse and architectural flair. BAS will therefore be starting an international design competition run by an independent professional body with the expectation of attracting forward thinking, innovative architects, engineers and material technologists with the experience of the application of their designs in extreme conditions.

In pursuance of the Halley VI vision and to drive forward infrastructure technologies in the Antarctic, BAS are keen to collaborate with other international polar institutes to provide a knowledge pool of well tested reliable technologies used in new innovative ways in the Antarctic context.

India's geoscientific achivements and future programs in Antarctica

Verma S.K., Singh B., Malaimani E.C., Tiwari V.M., Prem Kishore L. and Rao M.B.S.V.

National Geophysical Research Institute, Hyderabad, AP, India

During the last 23 years Indian scientists have made significant achievements in various disciplines of Physical, Oceanographic, Atmospheric, Biological, and Earth Sciences. In the area of Earth Sciences, geological mapping of Schirmacher Oasis (SO), and large area of Wohlthat Mountains (WM), Gruber Massif, and Petermann Range has been completed. Rock samples from various locations are studied to obtain valuable geochemical, paleomagnetic, and geochronological information. During the initial years of Indian Antarctic Expeditions (IAE's), long magnetic traverses were taken on the ice shelf along with seismic surveys at select locations to unravel the structure of the shelf and the underlying seawater and sediments. These studies complemented the marine geophysical traverses taken during the first IAE. In the SO, Radiometric, Electromagnetic, gravity and magnetic surveys have been conducted during a number of expeditions to assess the structure and mineral potential of the region. The region between SO and various nunataks in the south has been also covered by gravity measurements. A major geophysical achievement under India's Antarctic research program is the helicopter bome magnetic survey conducted between the SO and the WM during the 7th IAE. Employing a compact TANS 71 Doppler navigation system, a sensor bird, and a lightweight aeromagnetic data acquisition system, about 10,000 sq km of area was surveyed within a short span of a fortnight. Modeling of the aeromagnetic data thus collected provided information on the first order variations in the glacial thickness between SO and WM. Significant clues on the subglacial topography, geology and structure were also obtained. In the next phase of geophysical studies, emphasis was laid on GPS and broadband seismic measurements. Permanent GPS tracking station and seismological observatory were established at Maitri during the 16th IAE. It is heartening to note that these facilities have been running continuously without any problem and have contributed significantly towards a better understanding of seismotectonic and geodynamic processes between India and Antarctica.

Future geophysical investigations under IAE program should include magnetotelluric and heat flow measurements in SO and WM regions. These studies, in combination with seismological results, will provide useful information on the crustal and lithospheric structure below the Enderby Land. This could be complemented by a few long (> 500 km) geophysical transects comprising gravity, magnetic, GPS, radio echo sounding (RES) surveys, and seismic investigations at some suitable locations. In recent years, DGPS and RES have emerged as effective tools for geophysical investigations in icy terrains. Thus these two surveys should be included among the routine geophysical investigations in future IAE's. For ice mass variation studies in Antarctica, a combination of microgravity and DGPS surveys can provide valuable information. The study will also reveal the behavior of glacial isostatic adjustment and viscoelastic deformations in the region. Valuable supplementary inputs to this study are obtainable from satellite imagery and radio echo (and of late laser) sounding experiments.

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IP telephony in Antarctica

Yates P.

Australian Antarctic Division, Kingston, Australia

The Australian Antarctic Division is in the process of implementing IP Telephony in support of its operations at all major sites. The roll-out has been completed at the Kingston Head office and now is being introduced to each of Australia's Antarctic Stations. The voice links over satellite are currently being converted to IP Voice, and the initial roll-out of IP telephones at the stations has commenced.

The paper will give an overview of the project, cover lessons learned as well as discussing problem solving techniques that have been used. The paper will also include comment on the use of Wireless LANs and IP phone links to communicate with visiting ships, and between stations and field camps e.g. Mawson Station to the Bechervaise Island Penguin study site.

Heard Island communications and power supply

Yates P.

Australian Antarctic Division, Kingston, Australia

During the summer of 03/04, the AAD operated a summer field camp at Heard Island. The ambitious scientific program required the regular transmission of animal tracking information, location maps and dive records between the Island, the RSV Aurora Australis and head office. This poster provides an overview of the communications facilities implemented to achieve this, and also will include information on the solar/wind power systems developed to provide power at the field sites.

Proposed replacement for Davis Living Quarters

Young A.
Australian Antarctic Division, Kingston, Australia

This poster provides an overview of the project that is looking at replacing the existing Davis Living Quarters building. This building is over 20 years old and comprises a conventional steel frame, clad with insulating panels. The replacement building will be constructed from composite materials and will allow very rapid construction times in Antarctica compared with conventional building designs.

Annexes

Polar Aircraft Display

For the first time in the history of SCALOP Symposia polar research aircraft were displayed at the conference at two airports (Bremerhaven and Bremen) from 26 to 29 July 2004.
This new element of the exhibition provided practical contacts between aircraft operators, commercial companies for scientific instrumentation and the scientific user community attending the COMNAP/SCAR meetings. All participants could directly get some practical insight into the potential of intercontinental and intra-continental aircraft operations for research and logistics in the Antarctic. The polar aircraft display was highly recognised by the conference participants.

Bremerhaven Regional Airport (Luneort):
The first display of polar research aircraft was organized at the regional airport of Bremerhaven. This airfield is the home base of the two AWI aircraft of type Dornier Do228-101 and also the main service point for the polar helicopters used onboard RV Polarstern. Daily bus shuttle services and guided tours were arranged by the DLR and OPTIMARE Sensorsysteme AG, the two contractors of AWI responsible for airborne operation and scientific mission equipment.
Over 150 visitors took the opportunity not only to see the two Do228 and their mission equipment but also the new CASA 212 aircraft of the Australian Antarctic Division, operated by Skytraders. Additional poster displays of the BAS Twin-Otters, the Basler BT-75 and many other airborne platforms illustrated the important role of airborne operation in polar regions from the perspective of logistics and science.

Bremen Airport:
The second display took place at the airport Bremen on 28 and 29 July 2004. One LC 130 Hercules aircraft of the 109th Airlift Wing, Stratton Air National Guard Base, US visited the airport Bremen to meet conference participants. Wing Commander Colonel Max H Dellapia and his crew landed the famous Herc at the airport runway on 28 July 2004.
Since many years these outstanding type of aircraft were operated in the Antarctic and Greenland. The record of successful polar missions is legendary. The Hercs belong to the

most efficient tools for polar air operations. About 60 conference participants made use of the possibility to see this well-known aircraft during the 1.5 days stay.

CASA 212 at Bremerhaven Airport

AWI-Polar aircraft, Dornier 228 at Bremerhaven airport, Optimare Sensorsysteme AG

Instrumentation show at Optimare Sensorsysteme AG, Bremerhaven

U. S. Air Force, LC 130 aircraft at Bremen airport

Crew and visitors at Bremen airport

Industrial Exhibition
on Antarctic Research and Operations

The industrial exhibition on Antarctic research and operations held in parallel to SCAR XXVIII and COMNAP XVI meetings provided an unique forum to establish direct links between world leading scientists, operators working in the harsh Antarctic environment and technology providers.

The Senator for Economics of the government of Bremen opened the Industrial Exhibition on 26 July 2004, and it was closed on 28 July 2004. The exhibition was organised under the topic "Engineering and Technology meet Antarctic Science and Operations".

Polar research as a multi-disciplinary approach involves almost all fields of technical developments for transportation, navigation and scientific instrumentation. Altogether 45 commercial companies as well as national and international research agencies and institutions from 11 countries offered their latest and proven techniques, instrumentation, applications from space technology, support services such as shipping companies and aircraft operators, scientific equipment, clothing, food etc. to the SCAR and COMNAP community.

List of exhibiting companies and institutions

Name	Street	Post code	Town	Country
AANDERAA Instruments AS	Nestunbrekken 97	N5221	Nestun	Norway
ALCI (PTY) Ltd.	97 Keerom Street	8001	Cape Town,	South Africa
ATLAS Hydrographic GmbH	Kurfürstenallee 130	28211	Bremen	Germany
AWG Construction Services Ltd	Shand House, Matlock	DE4 3AF	Derbyshire	United Kingdom
AWI Alfred-Wegener-Institut für Polar- und Meeresforschung	Postfach 12 01 61	27515	Bremerhaven	Germany
Basler Turbo Conversion, LLC	255 West 35th Street	54902	Oshkosh	Wisconsin, USA

Berco Production AB	Plastvägen 3	93142	Skelleftea	Sweden
Blackwell Publishing	9600 Garsington RD	OX4 2DQ	Oxford,	United Kingdom
denkmanufaktur gmbh	Vor der Reihe 1	26197	Großenkneten	Germany
DLR - Deutsches Zentrum für Luft- und Raumfahrt Oberpfaffenhofen	Münchner Straße 20	82234	Weßling	Germany
European Space Agency	PO-BOX 299	2200 AG	Noordwijk	The Netherlands
Fielax Gesellschaft für wissenschaftliche Datenverarbeitung	Schifferstraße 10-14	27568	Bremerhaven	Germany
FOGTEC Fire Protection	Hermann-Maul-Str. 4	21073	Hamburg	Germany
France Telecom - Mobile Satellite Communications GmbH	Hochstadenring 50	53119	Bonn	Germany
GS Elektromedizinische Geräte GmbH	Hauswiesenstr. 26	86916	Kaufering	Germany
HATLAPA - Uetersener Maschinenfabrik GmbH & Co. KG	Tornescher Weg 5-7	25436	Uetersen	Germany
HELI TRANSAIR GmbH	Hans-Fleissner-Str. 1	63329	Egelsbach	Germany
J.H.K. Anlagenbau und Service GmbH & Co. KG	Labradorstr. 5	27572	Bremerhaven	Germany
K.U.M. - Umwelt- und Meerestechnik Kiel GmbH	Wischhofstr. 1-3	24148	Kiel	Germany
Kässbohrer Geländefahrzeug AG	Kässbohrerstr. 11	88471	Laupheim	Germany
Kenn Borek Air Ltd	290 McTavish Road NE	T3A5S2	Calgary AB	Canada
Lehmann & Michels GmbH & Co. KG	Marlowring 4	22525	Hamburg	Germany

Lehmann Maschinenbau GmbH	Jocketa-Bahnhoftstraße 34	08543	Pöhl	Germany
Lloyd Werft Bremerhaven GmbH	Brückenstr. 25	27568	Bremerhaven	Germany
MBT Meerestechnisches Büro Turla GmbH	Wischhofstr. 1-3, Geb. 11	24148	Kiel	Germany
Missing Link Versandbuchhandlung	Westerstraße 114-116	28199	Bremen	Germany
MWB Motorenwerke Bremerhaven AG	Barkhausenstraße 60	27568	Bremerhaven	Germany
Nautilus Marine Service GmbH	Blumenthalstrasse 15	28209	Bremen	Germany
NIWA National Institute of Water & Atmospheric Research Ltd	PO Box 14-901	Kilbirnie	Wellington	New Zealand
Optimare Sensorsysteme AG	Am Luneort 15 a	27572	Bremerhaven	Germany
Peter Frisch GmbH	Isar-Ring 11	80805	München	Germany
Reederei F. Laeisz (Bremerhaven) GmbH	Barkhausenstraße 37	27568	Bremerhaven	Germany
Rieber Shipping AS	Solheimsgt. 13, P.O.Box 1114 Sentrum	N-5809	Bergen	Norway
Rochem - UF-systeme GmbH	Seegelkenkehre 4	21107	Hamburg	Germany
Siemens AG (Marine Solutions) c/o PUBLICIS Relationship GmbH	Lindenplatz 2	20099	Hamburg	Germany
SIMRAD GmbH & Co. KG	Hellgrundweg 109	22525	Hamburg	Germany
Tasmanian Polar Network Inc.	GPO BOX 824	7001	Hobart	Australia
Tempex GmbH Schutzausrüstungen	Plouquetstr. 11	89522	Heidenheim	Germany

Thermo Electron (Bremen) GmbH	Barkhausenstr. 2	28197	Bremen	Germany
Top Housing AB	PO BOX 16010	20025	Malmö	Sweden
Uwe Kloska GmbH	Pillauer Str. 15	28217	Bremen	Germany
Weatherhaven	5700 Marine Way	V5J 5C8	Vancouver	Canada
WERUM Software & Systems AG	Wulf-Werum-Straße 3	21337	Lüneburg	Germany