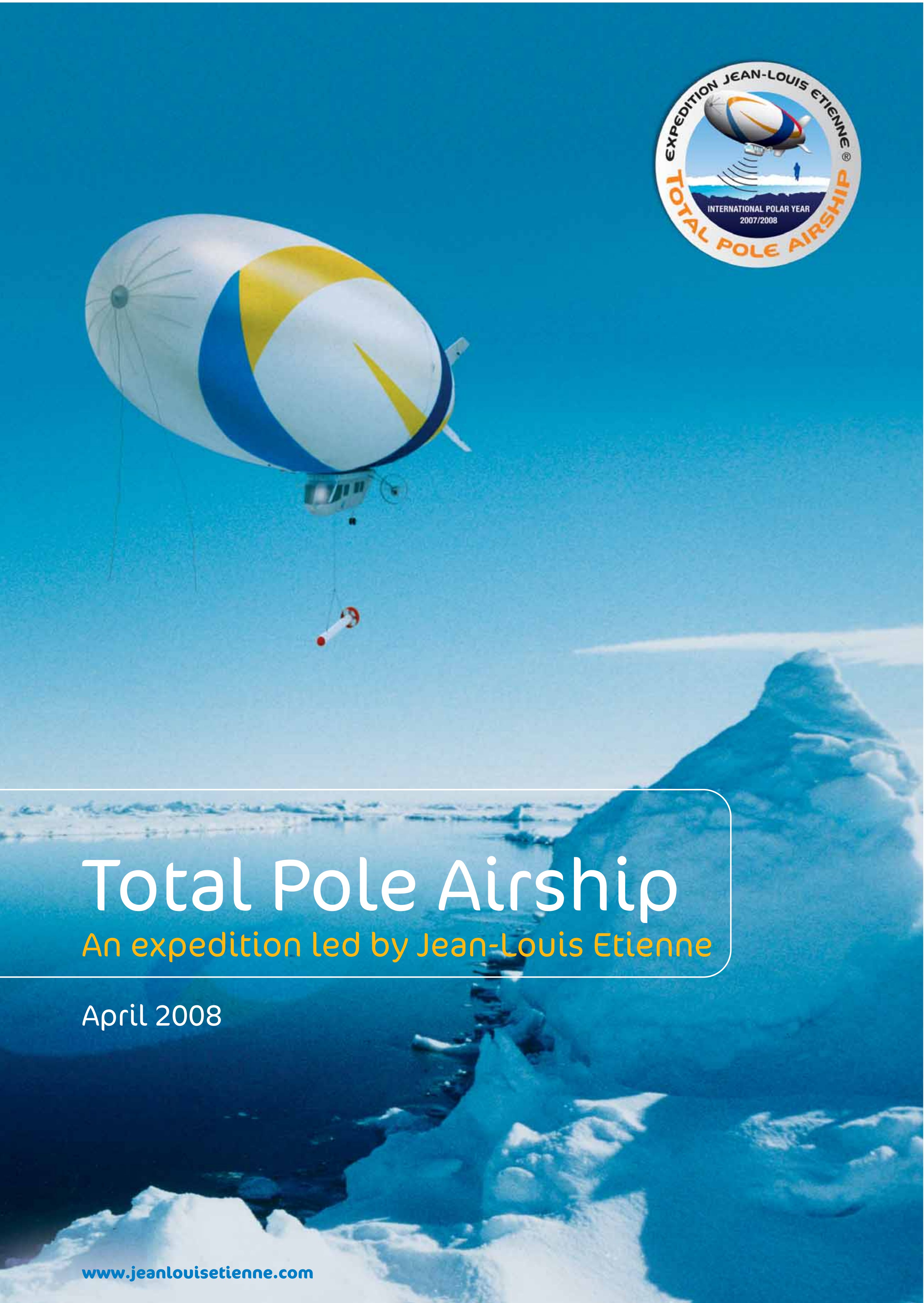
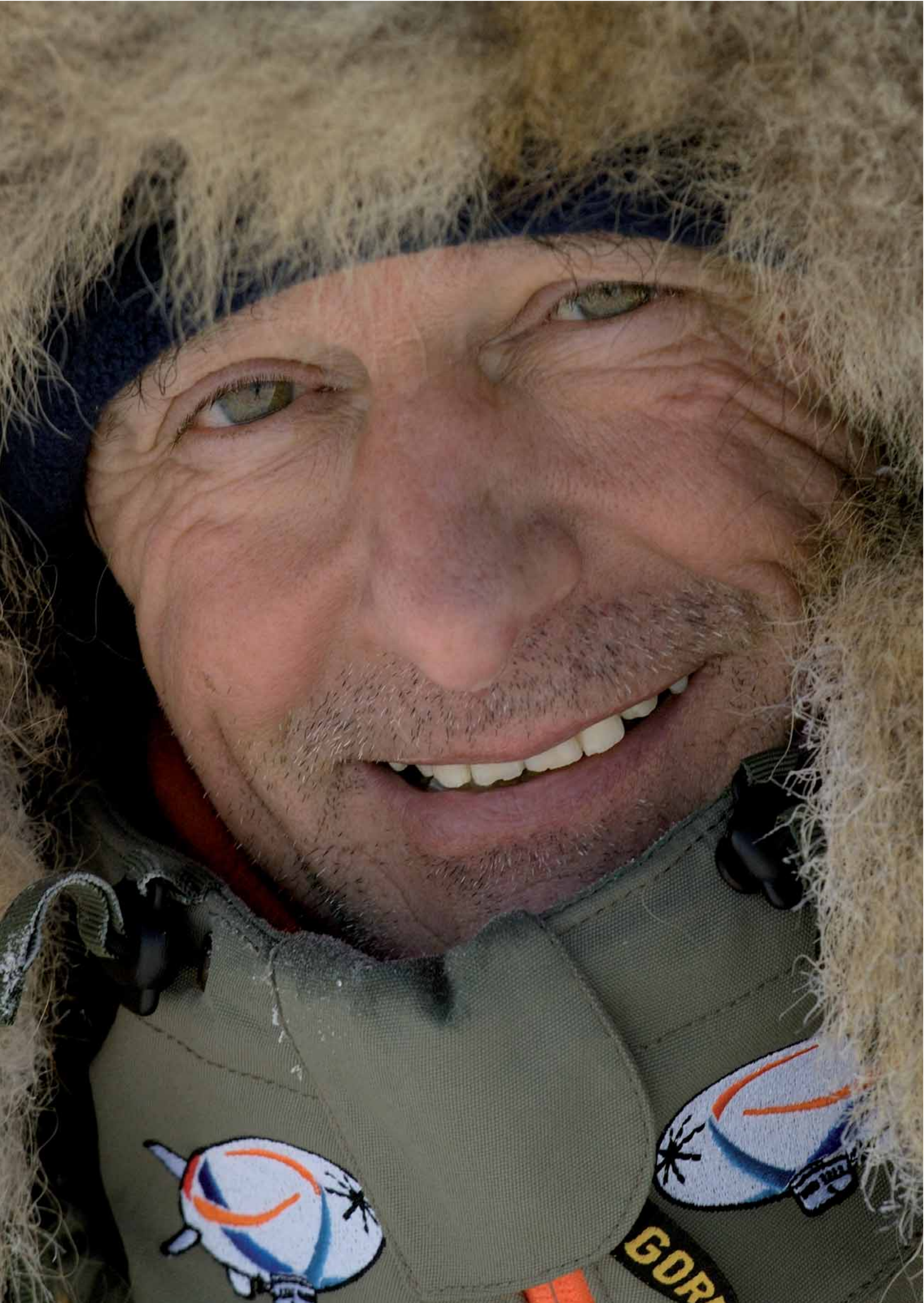


Total Pole Airship

An expedition led by Jean-Louis Etienne

April 2008

www.jeanlouisetienne.com



Foreword

The purpose of my next expedition, “Total Pole Airship”, is to measure the thickness of the pack ice while crossing the whole Arctic Ocean.

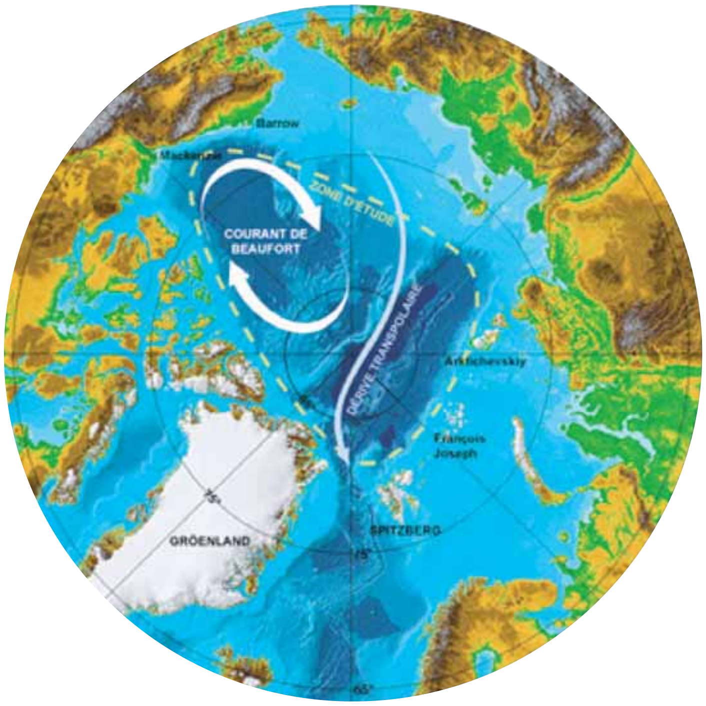
The frozen expanse that is home to the polar bear both influences our climate and is impacted by climate change; today the polar ice is seriously threatened by global warming.

Taking up the flame passed on by early polar explorers, we will explore the pack ice in an airship, the ideal vehicle to carry our special measuring apparatus and to cover the vast area we wish to survey.

From our polar odyssey we will bring data on the thickness of the sea ice during International Polar Year 2007-2008, data that will later serve as a benchmark for monitoring the impact of our way of life on the climate of our planet.

The Arctic Ocean and the sea ice

> Influencing climate and impacted by its changes



The two major currents affecting the ice pack

The ice pack: huge, chaotic, constantly renewed

The polar ice pack is a thin sheet of sea ice on average only 2 or 3 metres thick floating on water nearly 5,000 metres deep. Constantly driven by the wind and marine currents, the sea ice drifts between 4 and 5 km per day. This moving mass of ice is subject to titanic forces that fracture the pack into huge plates, leaving channels of open water that freeze over again. Elsewhere, the plates collide and ride up over each other forming pressure ridges, a jumbled mass of ice chunks several metres high and stretching for kilometres. On the underside of the ice, this same compression forms blades of extending down as deep as 30 metres. Each year some of the sea ice melts, only to freeze over again and become thicker in winter. Some ice also drifts towards the North Atlantic. But for several decades now, the balance between old ice melting and new ice forming has been negative.

The sea ice is shrinking rapidly and getting thinner

The sea ice has shrunk by 8% in each of the last three decades. Observations on site show that the summer melt is starting earlier and the winter freeze-over is occurring later. And there are more and more large areas of permanently open water; in summer 2005, oceanographic vessels got as far as latitude 87°N before they were halted by ice. By September 2007, the ice pack had shrunk more than ever before.
The Arctic is affected by global warming more than any other region of the world, because the fact that the area covered by sea ice is shrinking means that there is a larger area of water to absorb solar radiation, become warmer and speed up the melting of the adjacent sea ice.
At the centre of the Arctic Ocean, data recorded between 1993-1997 showed that the average ice thickness had decreased by 40% compared to 1958-1976.
Furthermore, there has been a change in the nature and composition of the ice pack: it now includes less multi-year ice and more seasonal ice, which is not as thick and is more sensitive to global warming.

At the forefront of climate change

While the average world temperature has risen by only 0.6°C over the past century, temperatures in Alaska and northern Canada have risen by 4°C in just the last 60 years. In 2005, the south-east coast of Greenland recorded a temperature of 24°C and all the fjords were free of sea ice for the first time ever. The cause of the rapid and extensive sea ice regression is clearly global warming. Oceanographers have now discovered that unusually warm and saline currents coming up from the Atlantic are swirling under the polar ice pack all across the Arctic Basin. If no serious action is undertaken to curb global warming, there will be no more sea ice left in the Arctic Ocean by the summer of 2060. The ice pack will form again during the winter, because the nights are so glacial, but the fact that there will no longer be a cold pole in summer will cause major climate changes in the Northern Hemisphere.

> Clear evidence of global warming

The reduction in the surface area of sea ice is clearly visible in satellite imagery and is being closely monitored.
However, monitoring the thickness of the ice pack is a much more complex undertaking because of the jagged profile of the ice sheet and because of the wide variations between seasonal ice and multi-annual ice.
The ERS and Envisat satellites are now providing data on the surface, the deformations, the variations in thickness and the drift of the sea ice. And in March 2009, the European Space Agency is due to launch CryoSat 2, a satellite designed to study the cryosphere and which will be able to measure the thickness of the sea ice.
But none of these measurements can be regarded as reliable without "ground truthing", or confirmation via field observations. This is the purpose of Total Pole Airship, which will endeavour to obtain reference measurements across the whole of the Arctic Ocean.

The expedition

> Measuring sea ice thickness

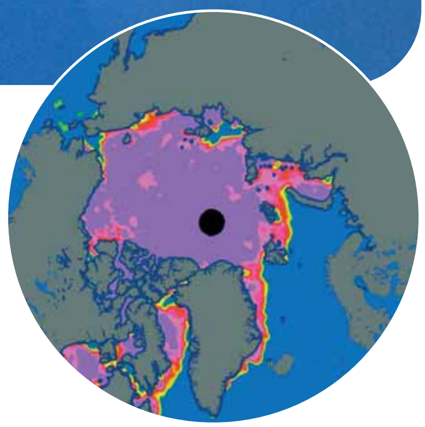
The expedition will use an electro-magnetic device called the EM-Bird developed by engineers at Germany's Alfred Wegener Institute for Polar and Marine Research (AWI). The EM-Bird is designed to be towed along 15-20 metres above the sea ice taking continuous measurement of the ice thickness. The apparatus will be hung underneath a dirigible; the flight characteristics and range of an airship make it ideally suited to this type of mission.

Ice measurements will be processed by Christian Haas of the AWI and made available to a number of research programmes on sea ice and climate (AWI, Damoclès, Mercator Océan, Météo France). This will be reference data, acquired during International Polar Year.

> Selecting survey zones

Every year, the oceanic zone that includes the immense continental plateau ranging along the coasts of Siberia and Canada freezes over with a layer of seasonal, or annual ice that melts during the summer. By the end of the northern summer, the only ice cover remaining is in the Central Basin and the Beaufort Sea, and this is mainly made up of multi-year ice.

The expedition will explore the zones covered by an accumulation of multi-year ice, i.e. the zones that maintain the Northern Hemisphere's climate balance. Ice thickness will be measured in April 2008, at the end of the winter when the ice sheet is most solid and passable.



Sea ice on 1 June 2007

Sea ice in late August 2007 (mainly multi-year ice)

The airship

> Ideal for the purpose

A dirigible, or airship, has the long range needed to cover a large area of the Arctic Ocean. In addition, an airship can fly at the right speed and altitude to deploy the EM-Bird apparatus.

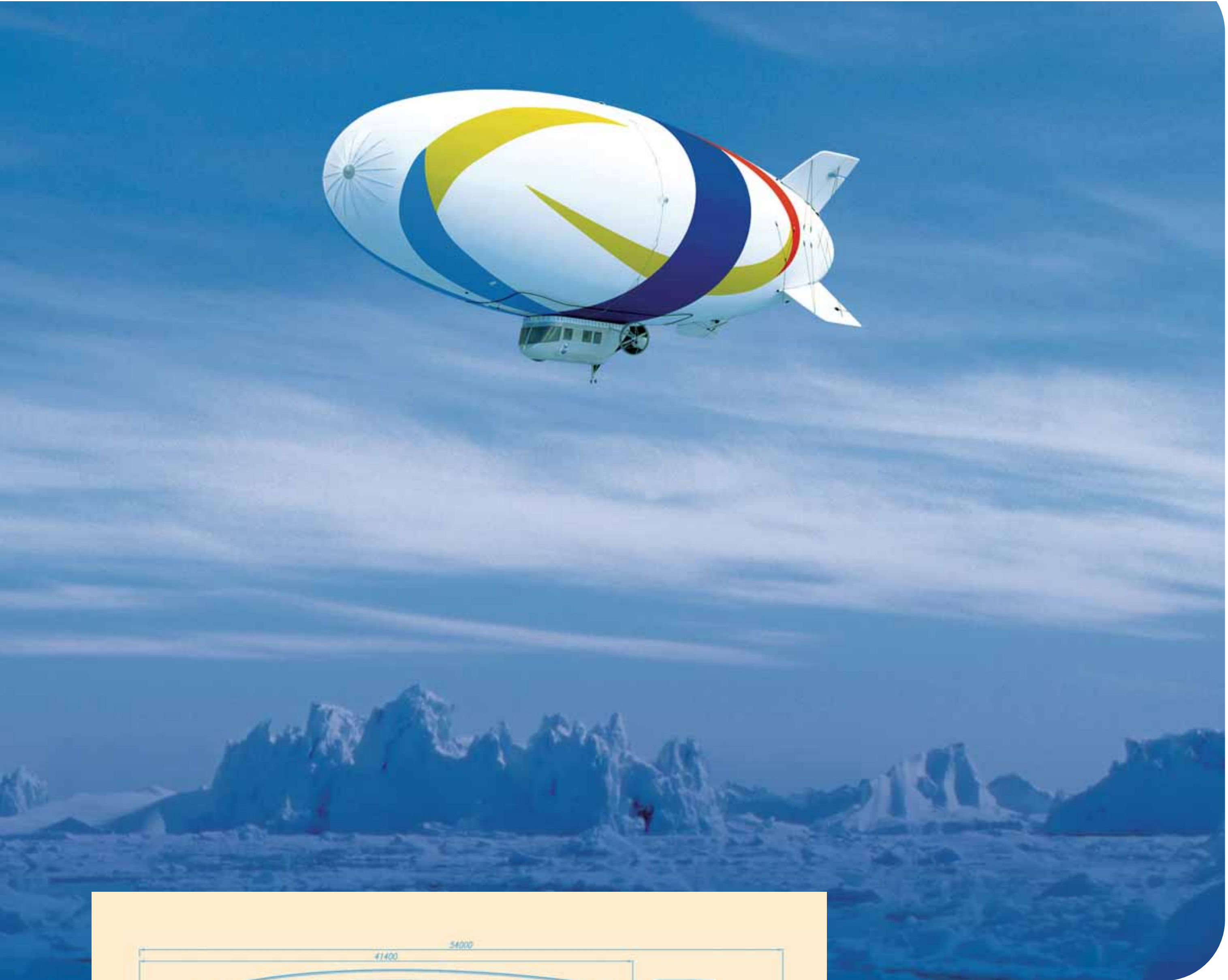
The expedition organisers opted for the Russian AU30 airship built by RosAeroSystems. The AU30 is 54 metres long, 14 metres wide and 17 metres high and its 5,500-cu.m envelope is filled with inert and non-inflammable helium.

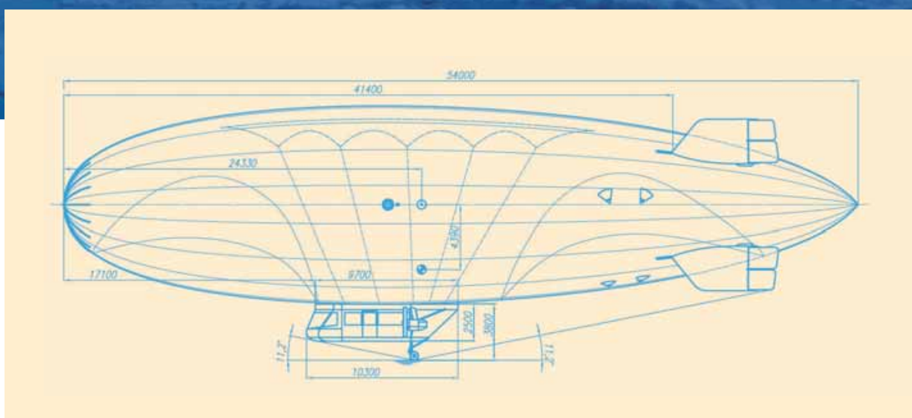
The aircraft has a design payload of about 1,200 Kg. In order to carry enough fuel to cover a larger survey zone, the expedition will minimise the rest of the payload and carry only 4 people: the crew (pilot and co-pilot), a scientist and one other person (scientist, cameraman or journalist).

> Helium

The Sun's atmosphere contains large quantities of helium (hence its name, Helios) but helium only occurs as a trace gas in the Earth's atmosphere. However, helium can also be found in fossil form in pockets of natural gas occurring in a number of petroleum deposits in some regions of the US, Algeria and Poland. This helium can be extracted by drilling well deep into the subsurface.

Helium is an extremely light gas (with a density of only 0.14) and it is therefore very volatile. Helium is colourless, odourless, non-inflammable and completely inert. It is used to fill airships (dirigibles) and balloons.





> DESCRIPTION

Type: blimp
Gas used: Helium

> DIMENSIONS OF THE ENVELOPE

Total volume: 5,065 m³ (with all sections filled)
Volume of each envelope section: up to 1,250 m³
Maximum diameter: 13.5 m
Length: 54.0 m
Maximum height: 17.5 m

> WEIGHT

Maximum takeoff weight: 4,950 kg (without helium or air in the envelope)
Weight when empty: 3,500 kg
Maximum apparent weight on takeoff: 500 kg
Payload: up to 1,500 kg (1,200 preferred for the expedition)

> SPEED

Minimum speed: 0 kph
Cruising speed: 50-80 kph
Maximum speed: 105 kph
Maximum climb/descent rate: 8 m/sec

> FLYING TIME

At 50 kph: 24 h
At 80 kph: 10 h
At maximum speed: 5 h

> RANGE

Maximum range at 50 kph (no wind): 1,200 km

> ALTITUDE

Normal flying altitude: 100-1,500 m
Maximum flying altitude: 2,500 m

> MOTOR

Type: LOM-M332C
Number of motors: 2
Power of each motor: 168 hp

> CREW

Aircrew: 2
Passengers: 6
Ground crew: 6-8

> TEMPERATURE

Min. operating temperature: -40°C

> DIMENSIONS OF THE GONDOLA

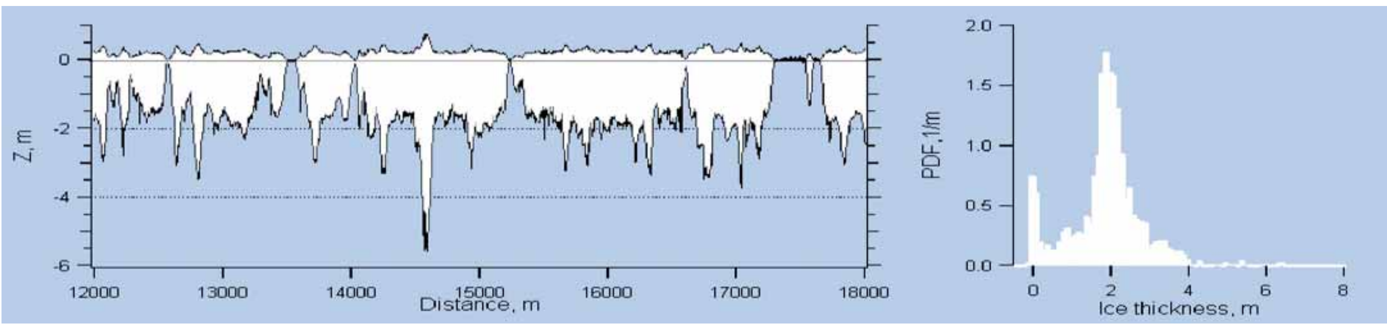
Overall length: 10.3 m
Length inside cabin: 4.6 m
Overall height: 2.5 m
Height inside cabin: 1.9 m
Max. width 2.35 m

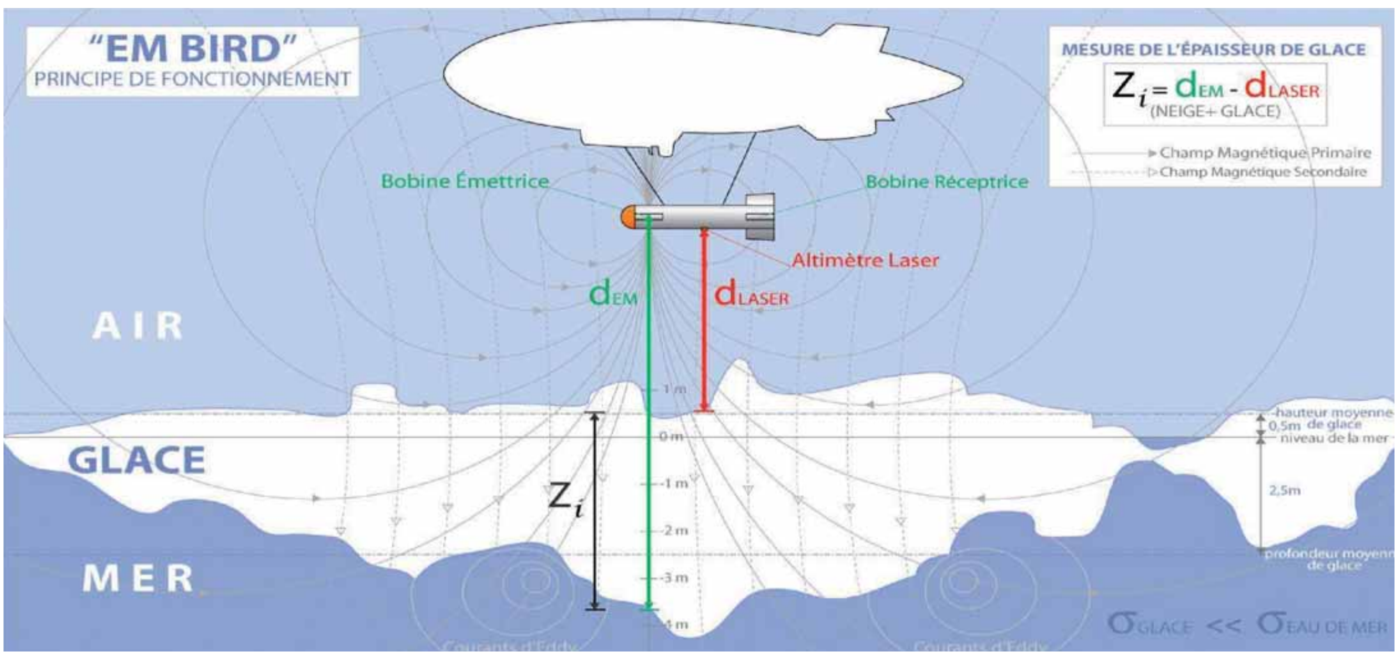
The EM-Bird measuring apparatus

German researchers at the Alfred Wegener Institute (AWI) have developed a measuring apparatus called the EM-Bird that generates a continuous profile of the thickness of the sea ice.

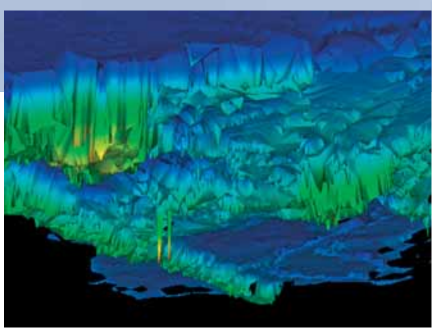
The instrument, which is 3.4 metres long and weighs 120 kg, is designed to be towed 15-20 metres above the ice at a speed of 30 knots.

A laser altimeter records the height of the upper surface of the ice pack. The distance from the under-surface of the ice is measured using low-frequency electro-magnetic induction (hence the name electro-magnetic bird). The difference between the two distances gives the thickness of the ice directly under the airship.





Results of the measurement campaign, April 2007



Topography of the underside of the sea ice as recorded by the ROV (left) and surface topography of the same section of sea ice carried out by France's National Geographic Institute (IGN).

> Calibration of the EM-Bird

On 19 April 2007, the Total Pole Airship team took its first ice-thickness measurements along a 350-km route from the North Pole towards the coast of Canada (86°50' N – 58° W). The ice along the track was mainly two-year-old ice. The measurements recorded by Christian Haas of the AWI gave an average ice thickness of 2.35 metres, i.e. 30-70% less than the ice measured in the same zone in 2001.

For the first time, scientists were able to compare the sea-ice thickness given by the EM-Bird with the data recorded in the same zone by the wire-guided robot submersible (ROV) and by topographical data from a survey using laser technology. This data enabled the team to calibrate (or "ground-truth) very precisely the data provided by the EM-Bird (particularly the measurements taken vertically overhead of pressure ridges) and so ensure the accuracy of the measurements that will be taken during the expedition due to begin in April 2008.

Jean-Louis Étienne

Doctor and explorer - Born 9 December 1946 in southern France

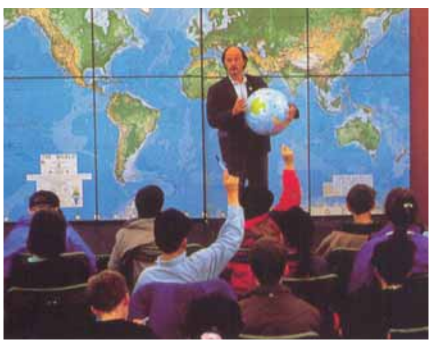
Doctor of medicine, Member, French government Polar Environment Committee
Officer of the Legion of Honour, Member, French Academy of Technologies, Gold Medal, French Geographical Society

Over the past 30 years, Jean-Louis Etienne has taken part in numerous expeditions to the Himalayas, Greenland and Patagonia as well as the polar zones in both the Northern and Southern Hemispheres. In 1986, he became the first man to reach the Pole overland solo, pulling a dog sled himself for the entire 63-day journey. From July 1989 to March 1990, he was co-leader, alongside the American Will Steger, of the International TransAntarctica Expedition, in company with a Russian, a Chinese, a Japanese and a Briton. The aim of the expedition was to promote the Antarctic Treaty and ensure that the continent around the South Pole remains a zone of science and peace. The 6,300-km expedition was the longest Antarctic crossing ever achieved using dog sleds.

An indefatigable environmentalist, Jean-Louis Etienne has always worked to raise public awareness of the polar regions and their influence on life on Earth, particularly via our climate. Between 1990 and 1996, he led a number of scientific and educational expeditions aboard the sailing ship "Antarctica", travelling to the Antarctic Peninsula, Patagonia, South Georgia, the volcano Mt Erebus and Spitzbergen, where an expedition wintered. His most recent polar expedition was the Ice Pack Mission in the spring of 2002. Jean-Louis Etienne drifted for three months on the polar sea ice living in his "Polar Observer" capsule and making observations for a research programme on climate change.

From December 2004 to April 2005, Jean-Louis Etienne took a break from polar climes, leading a team of 40 researchers from France's Museum of Natural History, the Institute for Research on Development (IRD), the graduate science school (EPHE) and the national scientific Research Centre (CNRS) to France's Clipperton atoll in the Pacific to carry out a biodiversity inventory and a study of the marine environment.

> Science and Education



Jean-Louis Etienne has led numerous scientific expeditions, always closely linked to educational programmes on earth sciences and natural sciences, in conjunction with France's Ministry of Education, the National Centre for Educational Documentation, the Paris Science Centre (Cité des Sciences et de l'Industrie), Oceanopolis, Nausicaa, etc.

> Educational programme "Climate change and the energy future"

Both the polar adventure itself and the airship have excellent communication potential and will form the basis of an educational project on the theme of "Climate change and the energy future" to be organised in conjunction with France's Ministry for Research, Ministry for Education and the Paris Science Centre. The project has the support of UNESCO as part of the UN Decade of Education for Sustainable Development.

Ongoing information can be accessed via **www.jeanlouisetienne.com**

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Learning more about the mechanisms involved in climate change and the action required to slow the process and reduce future consequences is one of the key challenges of the 21st century.

There is an urgent need for such action, and yet we still lack much of the information we need to ensure that our action is effective. As a major world energy player, Total is concerned by the climate change issue in many ways. Going beyond our initiatives to reduce the environmental impact of our operations and our products, Total has chosen to take an active part in the public debate on climate change and to partner efforts to gather the data that will help us gain a better understanding of this phenomenon.

Obtaining new data thanks to innovative measurement technologies can certainly advance scientific knowledge in this area and Total is pleased to support the new expedition to the North Pole, to be led by Jean-Louis Etienne. This first field campaign to measure the thickness and extent of the polar sea ice should provide information that will be vital to further research on the ice pack and climate change, to be undertaken as part of International Polar Year 2007-2008.

Christophe de Margerie
Chief Executive Officer, Total

Expedition Jean-Louis Etienne®
Total Pole Airship
International Polar Year 2007/2008

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The Pole Airship expedition has the support of the Ministry of Research in conjunction with the Ministry of Education.

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Under the patronage of UNESCO

Expedition timetable

2007

> Autumn-winter 2007

Training flights in France

The airship will remain in France until the expedition's departure for the North Pole, scheduled for mid-March 2008. This period will be used for crew training and for testing the scientific equipment. The pilots will receive the theoretical and practical training necessary to be authorised to fly the airship.

2008

> March 2008

From Paris to Northern Europe

The airship will fly across Belgium, the Netherlands, Germany, Denmark, Sweden and Norway. Its destination will be Tromso at the northern tip of Europe.

The planned route across the Arctic Ocean, with transects.

Crossing the Barents Sea

The flight from Tromso to Spitzbergen will be one of the most delicate stages of the expedition. This 1,000-km leg over water strewn with ice will have to be flown non-stop, which will require favourable winds.

> April-May 2008

Across the Arctic Ocean: Spitzbergen – North Pole – Alaska

Spitzbergen was the historic departure point for the airship expeditions led by Amundsen ("Norge") in 1926 and Nobile ("Italia") in 1928.
The expedition will begin taking measurements as soon as the airship leaves Spitzbergen, with the EM-Bird slung under the airship. The craft will fly from Spitzbergen to the depot at 85°N and on to Russia's Station Barneo (where a number of radial surveys will be carried out), then to the Magnetic North Pole north of Canada. Further radial surveys will be carried out over the Beaufort Sea, and the airship will then come out of the survey zone via Prudhoe Bay, Alaska.

> May-June 2008

The return voyage

The method of return of the airship will depend on the experience gained during the expedition and the technical capabilities of the craft. The airship will either be dismantled in Alaska and shipped home in containers or flown back to France.

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