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March 2002



Racing with the Sun

Technology Transfer Programme





Introduction

Space is often associated with advanced, highly performant technology. The association with cars is less obvious. Yet over the years European space technologies have directly contributed to the better and safer cars that we drive today. Brakes, airbags, batteries and shock absorbers are all examples of how space research is now present in our daily lives, with better products and services on Earth.

"Space and environment" is also a common association. Just think of weather forecasting, and the monitoring of the ozone hole. Yet the environment is crucial to the mission of a satellite for another reason: energy. Without solar energy, most satellites would not function. The importance of energy production, storage and use has spurred enormous advances in space research and technology related to solar cells, batteries and other technologies, where Europe has become a world leader.

Every year, the Technology Transfer Programme assesses hundreds of space technologies, some of which are further adapted for use on Earth. Energy is a key area where the know-how developed for space projects can greatly improve our lives and our environment. Besides the automotive industry, the Technology Transfer Programme is also working on other projects related to housing, work in harsh environments and the monitoring of pollution.

I am proud to present here the "Nuna" car, a wonderful example showing that European space technologies can be world leaders, and benefit the environment and the quality of our lives.

I hope you will share the enthusiasm of a European victory, and the excitement of our young team.

Dr. Pierre Brisson

Head of the Technology Transfer and
Promotion Office



ESA research into the environment and solar energy

The European Space Agency (ESA) provides the vision for Europe's future activities in space and the benefits that we on Earth can derive from space research. It also develops the strategies needed to fulfil this vision through collaborative projects in space science and technologies.

ESA is making an important contribution to climate research, with the Meteosat and ERS missions and the latest European Environmental Satellite, Envisat. On 1 March 2002, an Ariane-5 rocket launched Envisat, the largest and most advanced Earth observation satellite ever built. Envisat will deliver images and data that will help us to better understand and more effectively protect the Earth. One of the instruments on-board this satellite is Sciamachy, designed to study the thinning of the stratospheric ozone layer over Antarctica.

Space-based solar racing

In addition to conducting environmental research, ESA is also contributing significantly to technical developments in the area of solar energy. Among other things, these technical developments consist of improvements in the way solar energy is captured and stored. The development of solar cells, batteries, and devices optimising the process by which sunlight is converted to electricity to power spacecraft is in full swing at ESA. Solar energy users on Earth also benefit from these developments.

The Sun as an energy source

The Sun came into being 4.5 billion years ago and is 150 million km from Earth. It is an average small star, much like many others in the Universe. Inside the Sun, the heat is extreme: the temperature of the Sun's core is 15 million degrees Celsius. The pressure in the Sun's core is a hundred billion times greater than the Earth's atmospheric pressure. It is this extreme pressure, among other factors, that allows atomic nuclei in the Sun to fuse, generating heat. Every second, the Sun uses 700 million metric tons of hydrogen protons for this nuclear fusion. A small portion (0.7%) of all of the energy released consists of light. Every square centimetre of the Sun's surface gives off as much light as a 6000 watt lightbulb.





Space-based solar racing

ESA's research activities in the areas of the environment and solar energy led to its participation in the Alpha Centauri Project. This project combined the knowledge and efforts of two Dutch universities, the space industry, the Dutch energy provider Nuon and ESA to produce 'Nuna', a solar-powered vehicle that participated in the 2001 World Solar Challenge.

The Alpha Centauri Project

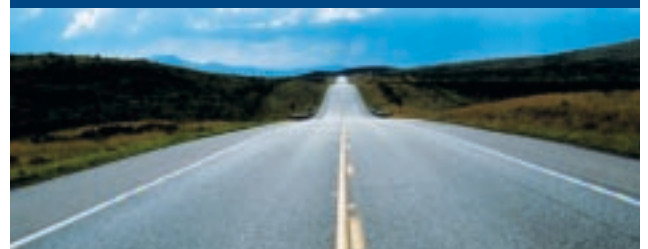
In April 2000, a team of students from the Delft University of Technology and the University of Amsterdam kicked off the Alpha Centauri Project. The goal of this project was to build a solar-powered car and enter it in the World Solar Challenge 2001. Alpha Centauri is our nearest galaxy and this name was chosen for the project to emphasise that just like this galaxy, switching to sustainable energy is within reach. In the early stages of the project, ESA was approached to support the team with equipment, funds and expertise. Wubbo Ockels, a former ESA astronaut and a professor at the Delft University of Technology, also decided to contribute to the project with technical and strategic advice.

2001 World Solar Challenge (1)

Come, See...

Australia is a continent of Sun, pioneers, and endless roads with only the occasional gas station - the perfect ingredients for solar-powered automobile experimentation. The first World Solar Challenge race for solar-powered vehicles was held in 1987.

What started out as a hobby contest has since become a world-famous phenomenon and an opportunity to develop new technology in the field of sustainable energy. The World Solar Challenge is held every two years. Starting in Darwin, the race takes a convoy of solar-powered vehicles a distance of some 3010 km to Adelaide. Since the race uses public roads, every driver must have a valid driver's licence and the cars must meet all technical safety requirements that apply to normal automobiles. The 2001 race was the first time a Dutch team had participated in the World Solar Challenge, with the Alpha Centauri Team entering their 'Nuna' car.



Racing Cars without Fuel

A solar car is basically an electric vehicle that carries its own generator. Solar panels on top of the car generate electrical power. The solar panels convert light energy into electricity, and a battery pack stores this energy.

The Alpha Centauri solar car, 'Nuna', was built to compete in and win the World Solar Challenge 2001. The vehicle was therefore designed to sustain the highest speed possible. To obtain a fast solar racer, special effort went into developing maximum electrical efficiency, minimum rolling resistance and best aerodynamic performance.

The 'Nuna' car is designed for an average speed of 100 km/h, with a theoretical maximum of 160 km/h and its most important component is therefore its solar generator. The technology spin-off from the space industry was therefore a critical factor in the car's race-winning performance. For the longer term

ESA Technological Support to the Project

Nuna's aerodynamically optimised outer shell is built from space-age plastics to keep it light and strong. Its main body is made from carbon fibre, reinforced with kevlar, a material once used only in satellites, but now used extensively for bullet-proof vests. Nuna also carried Maximum Power Point Trackers, small devices that guarantee optimal balance between power from the battery and from the solar cells, even under unfavourable conditions like shade and overcast skies. Many satellites carry these devices, e.g. ESA's Rosetta mission to comet Wirtanen.

Two small strips of solar cells on the Nuna were originally part of the Hubble Space Telescope. They were donated to the Alpha Centauri Team as a lucky mascot and were intended to power the car's communication equipment.



Space-based solar racing

this type of project, supported by the Universities, the ESA Technology Transfer Programme, space-technology industries, and sponsors, creates opportunities for the eventual production of environmentally friendly vehicles for us all.





Technical data

Performance

Speed on 1000 W: 80 km/h
 Speed on 1700 W: 100 km/h
 Maximum speed on solar power only: 108 km/h
 Theoretical t/s: 160 km/h

Aerodynamics

The car's drag coefficient is 0.1, compared to 0.30 for most cars

Dimensions

Vehicle weight: 250 kg
 Length: 5000 mm
 Width: 1800 mm
 Height: 970 mm
 Wheelbase: 2200 mm
 Track: 1500 mm

Motor

Inwheel Biel School of Engineering custom DC brushless motor
 Weight: 12 kg
 Voltage: 168 V
 Efficiency: 97% regeneration

Tyres

Michelin 14 inch, pressure: 8 bar.
 These tyres have a very low rolling resistance.

Solar panels

For best results in the World Solar Challenge race, the car needed optimum energy production. The project, therefore, obtained the finest solar cells currently available: the Triple Junction Gallium Arsenide Solar Cell, created for aerospace applications. The performance of the cells is relatively independent of temperature fluctuations. The panels into which the solar cells are integrated were manufactured to fit into the aerodynamically shaped body of the solar racer. In space, the efficiency of these cells is around 25%. On Earth, their efficiency is even higher.

Battery

Like the motor, batteries are a heavy component of the car. For this car, 46 Li ion cells were used in order to keep the weight as low as possible. The battery pack weighs about 35 kg. Conventional lead acid batteries would be 5 times heavier!

Body

The Nuna's body is made of carbon and kevlar reinforced with a foam core.

Solar cells

Mix of double and triple junction GaAs solar cells.
 Efficiency: >24% @ AM 1.5
 Interconnection, encapsulation, and integration on the solar panel by Gochermann Solar Technology.
 Total area: 8.4 m²
 Active area: 7.8 m²
 Voltage: 100 V



2001 World Solar Challenge (2)

...And win!

On 21 November 2001, the Alpha Centauri Team won the 2001 World Solar Challenge at their first attempt. Their winning time of 32 hours and 39 minutes is a new world record. The team completed the race in four days, another feat that no team had ever accomplished.

Other records: the team's average speed was 91 km/h; top speed was over 100 km/h. The fourth day of the race saw a new record for distance covered in a day: 830 km. The 1999 Australian winner, 'Aurora', came in second and needed a fifth day to complete the final stretch of the race.

For more information about the Alpha Centauri team and the World Solar Challenge, visit:
<http://wsc.org.au>.)
 and
<http://www.alpha-centauri.nl>

Carbon and kevlar

In addition to engineering and software developments, aerospace research has also contributed to the development and application of new synthetics, such as carbon fibre and kevlar. The application of carbon fibre allows for very strong and shockproof designs. It may be used, for example, in the construction of earthquake-proof buildings. Carbon fibre is also used in automotive brakes.





ESA Technology Transfer Programme (TTP):

Space Technology on Earth

Space-based solar racing

Over the years, European space industries have gained considerable expertise in launching, controlling and communicating with satellites. During these years of technological space development, many valuable new technologies, products and procedures have been developed. This expertise is not only put to use in space applications: space industry inventions and innovations also improve our daily lives on Earth. Groundbreaking European space technologies are made available to non-space industry for development and licensing through technology transfer. The ESA Technology Transfer Programme has already achieved over a hundred such transfers.

The ESA Technology Transfer Programme is implemented by a network of technology brokers across Europe and Canada, whose job it is to identify space technologies with potential for non-space applications. They must also detect the non-space technology needs: where can space-technology respond to demands from Earth?

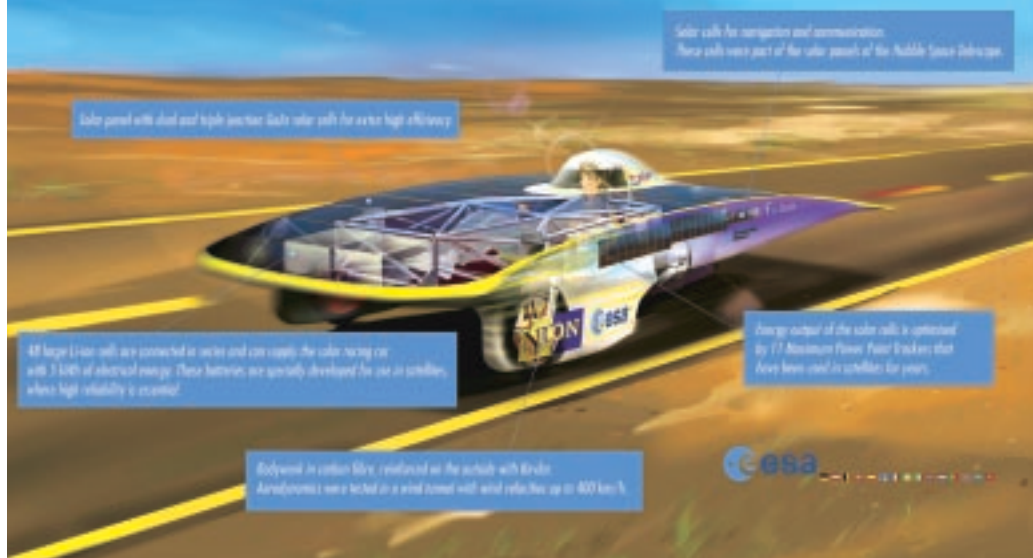
The programme co-operates with various European Commission networks, like the Innovation Relay Centres. All ESA Member States participate in the Programme with a fixed contribution based on their GNP. In addition, some contribute special funding for specific activities. The cost of the Programme is just € 0.01 for every European taxpayer but the payback is substantial (see above right).

Payback from the Technology Transfer Programme

Since 1991, technology transfer has generated more than € 20 million in revenues for European space companies and € 150 million for the non-space industries involved. More than 27,500 jobs and 12 new companies have been created, with a total of 25 expected by 2003.



SPACE TECHNOLOGY USED IN DUTCH SOLAR CAR 'NUNA'



To find out more...

<http://www.esa.int/technology>
<http://www.t4techonline.com>

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or the ESA-supported technology market places: <http://www.technology-forum.com>
and <http://www.t4techonline.com>

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