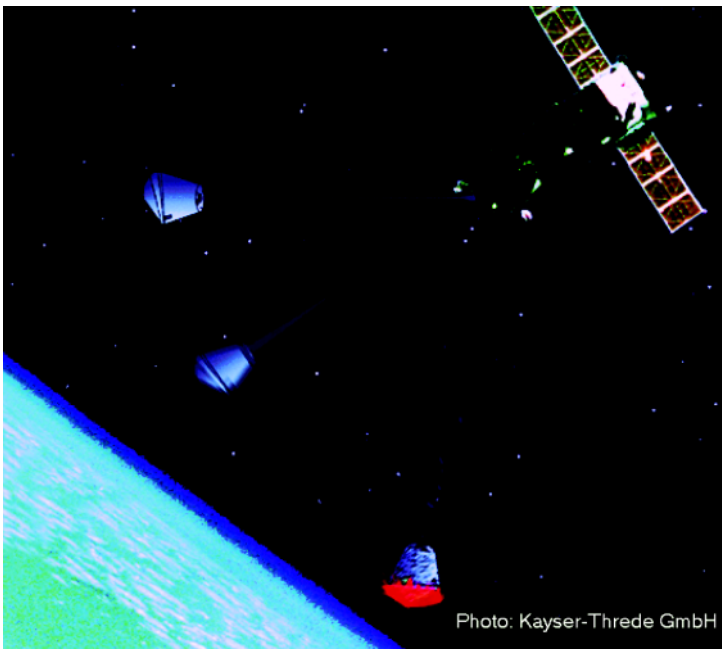
Freight Traffic in Outer Space

CUSTOMERS

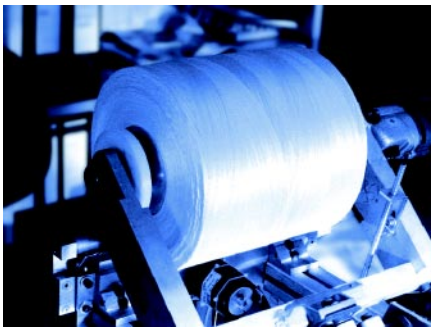
- **University of Applied Science in Remagen, Germany, does research for ESA**
- **Freight transportation cheaper than by Space Shuttle**
- **No space junk**
- **Quick experimental setup with dSPACE ACE Kit**

The International Space Station (ISS) is creating an ever-increasing need for freight transportation between space and Earth. Measurement systems, samples collected in experiments, and other items all need to be brought back to Earth. So the hunt for a cheaper alternative to the fuel-hungry Space Shuttle is on. The European Space Agency (ESA) commissioned a team of companies and university research departments to investigate a simple solution. What they have come up with is so simple, it almost seems impossible: Loads are to be lowered down from space on a thread!



The capsule on its way to Earth.

Obviously, for a job like this you need a very special thread. The material chosen is called Dyneema. It's a polyethylene compound that tolerates extreme forces. The light-weight thread has a diameter of 0.6 mm. Up to now it has been used for purposes such as fishing lines, bulletproof vests and suits for motorcyclists.



The spool with the thread: length 35 km, diameter 0.6 mm, weight 7 kg, diameter of the spool 250 mm.

In the space application, the idea is to let a capsule down from the ISS for a distance of about 35-40 km and then to cut the thread at the ISS. Because the capsule has a special braking procedure, it is brought into an elliptical orbit. It reenters the atmosphere at a height of about one hundred kilometers, without the expensive usage of fuel or engines. During the reentry the thread burns up.

Only if the capsule maintains the calculated reentry angle can it perform a soft landing in a defined drop zone, supported by braking parachutes. Afterwards it can be located by the Global Positioning System (GPS). The highly intensive ultraviolet radiation in the upper layers of the atmosphere dissolves possible remains of the thread into polymers, so there is no risk to other satellites.

Spool Winding is Crucial

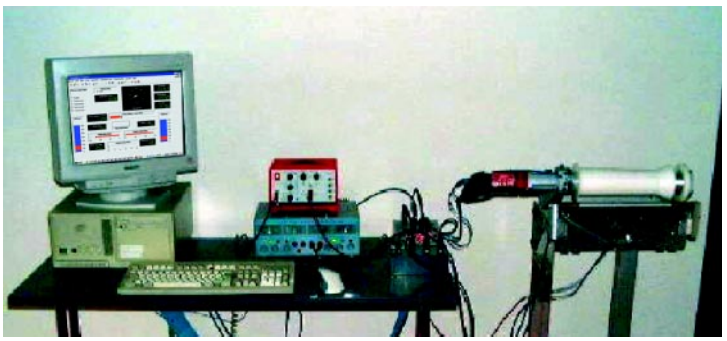
The method looks easy, but is in fact extremely challenging. At the department of electrical engineering at the University of Applied Science in Remagen, Germany, we are investigating the problem of precise layer winding on the spool, which is particularly

crucial. To solve this problem, we can benefit from the experience of the textile industry, where the challenge of winding up a sewing thread on a spool has been a subject of research. The results of that work are several standard techniques (cone, kingspool, etc.) for winding a thread onto a spool with completely even spacing. The layering styles differ mainly in the packing density of the thread.

But for the space application, the boundary conditions are more difficult. The thread must not tangle, either during acceleration and vibrations when the rocket is launched, or while being unwound in zero gravity, because if it did, the capsule with the load would be lost. To meet these requirements, the packing density of the thread must be very high. We have developed an experimental setup to reach the necessary precision of layer winding on the spool.

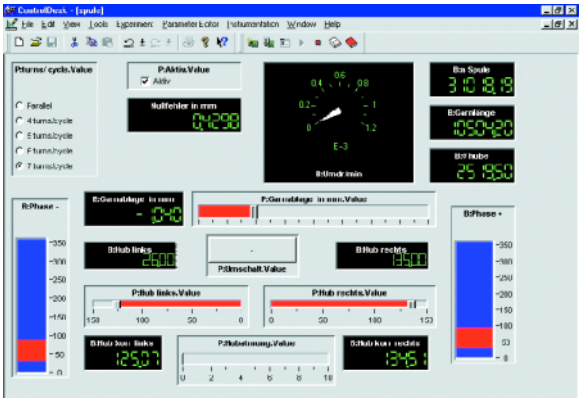
Experimental Setup

The experimental setup to reach the necessary precise layer winding on the spool consists of several modules:



Experimental setup of the spool winder.

- The device for winding up the spool, realized by a commercial standard drilling machine.
- The drive for precise thread positioning on the spool.
- The module to measure the length of the thread.
- A system to modify the forces acting on the thread.



ControlDesk layout to perform spool winding.

Key parameters like the strain on the thread caused by tractive forces and the winding velocity are controlled (at a sampling time of 0.4 ms) by dSPACE Prototyper, based on an ACE Kit university package. Because dSPACE Prototyper is so easy to handle, it was possible to set the experiment up within only three months. The algorithms were programmed graphically in Simulink. After the Simulink blocks were downloaded to the hardware, no corrections were necessary to perform a successful experiment.

First Launch into Orbit

A Russian Proton rocket will carry the first spools into orbit, and a test satellite will be let down by thread.

In this first test run the satellite will carry only a few measurement instruments. If the spool stands the test run, future transportation of loads in outer space will be more environment-friendly and cheaper than by Space Shuttle.

Following that, it would also be possible to transport humans by this method. However, in that case additional life support systems would have to be installed.

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Software on "Solutions for Control" Release 3.2

dSPACE software runs under Windows 95/98/Me/2000 and NT 4.0.

- RTI 4.1
- ControlDesk 2.1
- MLIB/MTRACE 4.3
- RealMotion 1.1 (Windows NT only)

For more detailed information, please refer to *www.dspace.de*.