# Quick resolution of ambiguities required!

***RTK positioning of ships using Leica GPS500***

***Above: Bridge and lock buildings caused GPS shadows. However, this did not prove a hindrance to the Leica GPS500. Below: Reference station and computer base. Right: Even with all the various ships and different mountings involved, it took less than 5 minutes to fit the two Leica GPS sensors and radio transmission equipment to the bow and stern.***

Could the turbines in a new hydro-electricity generating station cause ships to drift within their shipping lanes? Following the construction of a new hydro-electricity generating station on the bend in the River Danube at the lower Bavarian town of Bad Abbach (Germany), it was feared that the operating turbines might have just such an effect. The turbine inlet zone opens out directly into the shipping lane just before a lock, which requires ships to pass this position only at reduced speed. Model tests carried out in advance of the construction did not detect any effect. It was essential that the results of the model tests were verified in practice by measuring the courses of a representative sample of passing ships. Therefore, the Geodetic Institute at the Technical University of Munich was commissioned to determine and analyse the tracks of the ships in position and height to an accuracy of ±5 cm in real time.

**Working in real time, mobile, flexible and reliable**
The demands on the measurement system were challenging. In order to keep the number of monitored ship passages as few as possible, and hence minimise the associated time and costs, the system was required to be able to produce initial analyses from the real time measurements immediately on site. Furthermore, the installed system had to be unaffected by the weather and able to determine the position of the bow and the stern simultaneously at a frequency of 1 Hz. As the monitoring was to be carried out on ordinary ships belonging to any Danube ship company, it was necessary to have sensors that would be mobile, and above all, flexible and quick to attach. The length of the test course was approximately 800 m, with good visibility and free of shadows – that is, except for the lock buildings at the start and a bridge at the end. In spite of these GPS shadows would it still be possible to use real time kinematic differential GPS here?

It had to be shown in advance that re-initialisation of the ambiguities in the on-the-fly process due to the loss of signal when ships passed under the bridge would only take a

***GPS 530 at full speed***

***GPS rover at the stern***

***Mobile backpack solution***

maximum of one minute. Any longer and it might not be possible to determine any drift accurately because the speed of the ship would have taken it too far into the test course. One test with the Leica GPS System 530 soon cleared things up: both rovers were mounted on the roof of a VW bus and several journeys were made along an industrial road beside the Danube at simulated ship's speed. At high and low speeds and with different satellite constellations, the ambiguities at both frequencies were able to be resolved within the specified time period.

**A measurement concept using Leica components**

During Summer 2000, a total of three SR 530 GPS receivers were used for the monitored journeys. The reference station was in the middle of the test course on an embankment over a shadow-free hectometre stone of known coordinates. The two rovers were each used with a backpack system with a plumbing pole and an AT 502 GPS antenna as well as a Leica TCPS26 radio data modem. The modem transmited the determined 3-D positions to a base station on the bank in the test bus, which housed a computer. The received data in NMEA format was recorded on a laptop, saved and then analysed immediately after the ship had passed with the Geodetic Institute's shiPos software and LISCAD Plus from Leica Geosystems.

**GPS surveying on board ...**

The river navigation authority's officer informed the captains of the passing freighters about the monitoring exercise over the radio just before they reached the test course and asked them for permission to attach the GPS rover antennas. As boarding the ships was only possible whilst they were in the locks at Kehlheim and Bad Abbach and any disruption to shipping movements on the river was to be avoided, in most cases the time available for attaching the GPS sensors was only 5 minutes. The GPS plumbing poles were attached in suitable positions at the bow and stern with the help of cable ties and referenced to the ship's side with a measuring tape. After the receiver was switched on, the ambiguities resolved and a test of the transmission back to the computer, the measurement of the monitored journey could begin. A total of six monitored journeys were undertaken per day. The resolution of ambiguities after the bridge was generally completed within 45 seconds and always provided reliable results.

**Quick results!**

The NMEA data records received on the bank were analysed immediately after each monitored journey. In addition to the height and speed plots, the main interest was the course of the ship. The trajectory was superimposed on the digital navigation charts and the plan of the power station by the LISCAD Plus graphical software. This plot could be manipulated to provide the required information and printed in colour to any scale – all on site.

Our measurement concept proved itself successful. In spite of the shadows, the GPS-System 500 from Leica Geosystems worked very reliably and provided the required accuracy and measurement frequency. The data radio transmission solution was also impressive. None of the monitored journeys was subject to an equipment failure. A big advantage was the quasi-real time analysis. The results were available on site a very short time after every monitored journey. This meant that the number of monitored journeys could be kept to a minimum.

***Jens Czaja***

***GPS rover with TCPS26 modem***

***GPS rover at the bow***