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FROM EARLY COMMUNICATIONS SATELLITES TO SWARM INTELLIGENCE

EARTH FROM SPACE: Tandem satellite mission on course for success

REPORTING LIVE: It takes two to tango

STORY: A way around the volcanic ash cloud

IT TAKES TWO TO TANGO

Field campaign in Heligoland investigates the transfer of large amounts of data at sea

By Manuela Braun

Sea spray rises over the pier and foams over the dark stone. The 'Hermann Marwede' is still safe and protected at the pier. But behind the quays, it is a different story – waves are towering three metres high all around Heligoland. The wind is reaching speeds of more than 50 kilometres per hour, or force 7 on the Beaufort scale; in other words, 'near gale'. Some gusts are even reaching wind force 8, battering the water, other boats and the colourful wooden houses that line Heligoland's harbour. "It's not pretty," says Thomas Müller unimpressed, as he looks out, sitting on the captain's chair on the ship's bridge. "Oh well," he continues, as he shrugs his shoulders. There have been times when the rescue vessel has had to battle its way through eight-metre-tall waves.

The man from the German Maritime Search and Rescue Service has clearly experienced worse. Researchers from the DLR Institute of Communications and Navigation, on the other hand, have not. That said, this is exactly what they had been hoping for, and they would not want it any other way. "We want to find out what impact such circumstances have on signal propagation," says Project Manager Ronald Raulefs, explaining the aim of their investigation. He was, however, in his office at the DLR Institute of Communications and Navigation in Oberpfaffenhofen at the time. Everything was in its place, on terra firma, nothing flying around in all directions, and his laptop did not need to be fixed down to the desk. Soon, however, everyone would feel every movement caused by the sea. The 'Hermann Marwede' has a draught of 2.8 metres and, despite its 46-metre length, does not have a large displacement. When someone is in distress at sea, this ship has to be able to arrive at the scene quickly – it cannot plough through the waves.

Radio communication between rescue vessel and icebreaker

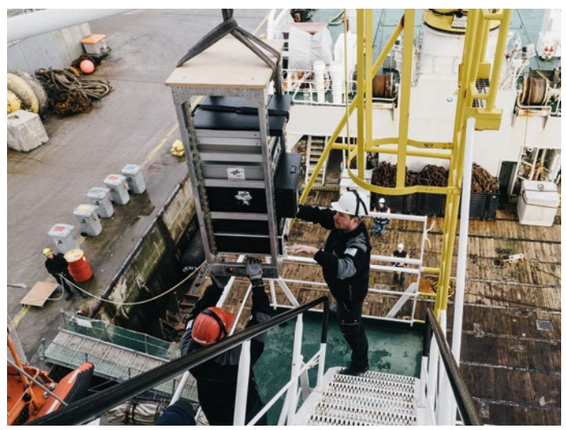
While the 'Hermann Marwede' was still in dock, DLR researchers attached the additional antennas needed for their experiment; they continuously transmitted a signal during the experimental voyages and determined the exact location of the vessel using GPS. One day before going out on the high seas, Thomas Jost, Paul Unterhuber, Wei Wang, Michael Walter and Siwei Zhang installed and secured the equipment on the ship. Of course, the equipment cannot go flying across the bridge in the event of high waves! The rescue vessel is now a swaying, floating broadcasting station at sea. The receiving station is also on its way to the North Sea: the 'Neuwerk', a ship operated by the Cuxhaven Waterways and Shipping Administration, is the counterpart of the 'Hermann Marwede' for this mission. Normally, the 80-metre vessel can be found in the North Sea performing coast guard duties and acting as an emergency tug, or in the Baltic Sea as an icebreaker. This time, however, captain Dietmar Seidel will be steering his ship through the waves in the name of science.

Before the ‘tango’ begins at sea: Thomas Müller steers the rescue boat ‘Hermann Marwede’ through the harbour of Heligoland. In the background, the Coast Guard’s ‘Neuwerk’ is still at the pier.

The team of the ‘Hermann Marwede’ discusses the different formations for its work with the ‘Neuwerk’ during the measurement campaign

The DLR researchers have considered many possible scenarios for their investigations this Wednesday. But both boats should, whenever possible, travel parallel to one another, cross over in front of each other, and also send and receive signals despite the great distance between them. To date, no one has ever investigated how hulls, rough seas or even turbine rotors in wind farms affect broadband signal propagation. Radio, the conventional communication method between boats, only transmits one thing – voice. The transfer of more data is not possible in the maritime industry at the moment, unless costly means of communication, such as satellites, are used.

New knowledge about transmission channels acquired under realistic conditions at sea could enable boats like the ‘Hermann Marwede’ and the ‘Neuwerk’ to, in future, send medical instructions via video even before medical personal have arrived at the scene. Ships could even send traffic information to each other in the form of radar images. This field campaign conducted by the DLR Institute of Communications and Navigation will contribute to a project being run by the DLR Maritime Safety Research Department, which aims to develop a model that shows how signals change when external influences are at play during transmission. The industry would then be able to adapt transmitting and receiving systems accordingly at a later date.



An unusual terrain for DLR’s measurement technology: it is lifted to the bridge of the ‘Neuwerk’ with a crane.

From trough to trough

On board the ‘Hermann Marwede’, Thomas Müller is browsing through the researchers’ specifications. He traces the routes they would like to take with his finger and discusses these with Third Officer Norbert Sarnow. “We would be better off following a north-south direction so that we don’t roll too much,” the captain of the ‘Neuwerk’ can be heard from the control panel’s black telephone handset. The first formation to be sailed by both boats has been decided – the ‘Hermann Marwede’ will sail in the quiet waters between Heligoland and its offshore island, and the ‘Neuwerk’ will sail around the island. In so doing, the island will shadow the radio signal. “Then, we will perform the first routine,” Captain Dietmar Seidel says over the radio.

This, however, would not be the reason why the DLR researchers got an upset stomach. It was the second manoeuvre, when the ‘Hermann Marwede’ left the quieter waters and sailed around the cliffs. Lange Anna, a 48-metre tall rock in the northwest of Heligoland, and a symbol of the island, quickly disappeared from everyone’s sight. “Everyone back inside the bridge now,” calls Ulrich Wenzel, the paramedic. The rescue vessel bounces through the waves like a stubborn bull, dropping into the troughs and then shooting back up towards the sky. It goes without saying that the only people on board who look completely at ease in this situation are the members of the rescue crew, who have had plenty of experiences like this.

The wipers are fighting in vain against the masses of water. The ‘Neuwerk’ is just a small, blurry dot on the horizon. We receive a message over the phone – the rough ride is not only getting to the scientists, but

The ‘Hermann Marwede’ is a mobile broadcasting station battling the rough seas

also to one of the new members of the crew. DLR’s measuring equipment, on the other hand, is operating correctly on both ships. A frequency of five gigahertz is being used to send data. Later, back in the comfort of the laboratory, the first look at the measurements shows that everything worked out the way the scientists had planned, and there is sufficient data for several doctoral theses.

Round two in the North Sea

Shortly before 13:00, the first run is complete. The ‘Neuwerk’ sails into harbour so that the researchers can climb up the ship’s mast to a height of 26 metres and change one of the antennas. Rather than using one antenna, the second run aims to capture more signal reflections from various directions by using an array of 32 antenna elements.

Germany’s bright lighthouse is the site for the signal transmission between ship and shore. High above Heligoland, the DLR scientists install their antennas.

The ‘Hermann Marwede’ is on standby in quieter waters between the islands. A welcomed break from the rise and fall of the waves offers a necessary recovery period so that everyone can prepare for the shaky environment at sea once again. Then the programme starts – this time involving a turbulent journey off of Heligoland with the ‘Neuwerk’, which is pushing its way through the waves just 50 metres away.

As darkness begins to fall, the ships enter the quiet harbour. Next to the ‘Neuwerk’, which is like a floating multi-storey building among the quays, the ‘Hermann Marwede’ looks rather small. As if the high-speed winds were not enough, it starts to rain. Battery-operated lamps are used to light up the small carts that the researchers will use to transport their receivers from the quay to the lighthouse on the rocky island. In addition to measuring ship-to-ship communication, ship-to-shore communication must also be measured to determine how it is influenced and changed by environmental factors. A metal basket filled with measuring equipment is slowly lowered from the top of the ship on a crane. If nothing else, it saves having to transport it from deck to deck via narrow staircases. The next day, things look different from the 35-metre high lighthouse.

Measuring under the beacon

There are 160 steps to the top of the tower, and eight storeys to climb before you reach the platform beneath Germany’s brightest lighthouse. Bread, meat and cheese await the team on the windowsills of the top storey. The food, which was provided on board the day before, yet left untouched due to the rough seas, is now being served to the field campaign team on land. Someone even remembered to bring coffee with them to the lighthouse. The team will work from the lighthouse all day, during which time the ‘Hermann Marwede’ will transmit as it sails the chosen routes. “That was the awkward part,” says Michael Walter, looking somewhat unimpressed as he taps against the metal frame in which the receiver, recorder and screen have been installed.

One floor up, the wind is whistling over the exterior platform of the lighthouse. Christian Gentner and Markus Ulmschneider are measuring the exact location of the DLR antenna. Once the scientists know exactly where the transmitter and receiver are, the transmission channel between the two can be analysed precisely. Back in the harbour, the ‘Hermann Marwede’ is still at the pier. Those who proved themselves to be seaworthy the day before, or who think they can withstand several more hours out at sea, make their way there to climb on board. Today’s trip will be a journey to a wind farm located some 25 kilometres away.

The researchers want to find out how some components of the transmitted signals will be reflected off the rotor blades, and how they then get scattered around the ship.

Off to the wind farm

The decision to embark on the journey was made in the morning by Thomas Müller, the Captain of the ‘Hermann Marwede’. “We’ll see what the weather is like,” he had said the night before, sat in the mess of the ‘Hermann Marwede’. Higher waves and stronger winds had been forecast. “If the wind is too strong, we are not going anywhere.” The waves are predicted to reach heights of 3.5 metres in the morning and go down to three metres by the afternoon – but it is still not raining. However, the Captain of the ‘Hermann Marwede’ decided that everything was all right, so the field campaign gets a thumbs-up.

Wei Wang gives the OK over the phone to Ronald Raulefs, who is on board the ‘Hermann Marwede’. “We are here and ready to go.” The antennas are firmly attached to the grid located on the exterior deck of Heligoland’s lighthouse, the atomic clocks in the transmitter and receiver have been synchronised exactly with one another, and the North Sea is playing its part, providing the necessary waves for the investigation. The first readings appear on the screen of the receiver, standing out from the vast amount of noise. The ‘Hermann Marwede’ transmits, and the lighthouse receives. Measurements will be performed well into the afternoon and will be finished after the return trip to the wind farm has been completed.

Data for the laboratory

The prospect of obtaining more measurements the next day is not looking good – storms are expected and the ‘Hermann Marwede’ has to remain on standby in the harbour in case of an emergency. The equipment in the lighthouse must, however, be dismantled, and carried back down all eight flights of stairs. It is not until Saturday that the scientists will receive data at sea level from the harbour, when the rescue vessel sails to the horizon from Heligoland. Raulefs is, nevertheless, more than satisfied. The team will return to the Institute in Oberpfaffenhofen with a vast amount of data. “And in the meantime, spending a full day on land is truly great.”

The orientation and position of the antenna must be accurately determined so that the data acquired can be analysed in the home laboratory

About DLR

DLR, the German Aerospace Center, is Germany's national research centre for aeronautics and space. Its extensive research and development work in aeronautics, space, energy, transport and security is integrated into national and international cooperative ventures. In addition to its own research, as Germany's space agency, DLR has been given responsibility by the federal government for the planning and implementation of the German space programme. DLR is also the umbrella organisation for the nation's largest project management agency.

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Cover image
The 30-metre antenna at DLR Weilheim. Researchers at the DLR Institute of Communications and Navigation have received and analysed navigation signals using the antenna.

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