DLR magazine
German Aerospace Center (DLR) · No. 163 · December 2019

METROPOLITAN TRANSFORMER

THE URBAN MODULAR VEHICLE

More topics:

- GO WTH THE FLOE
- NIGHT FLIGHT AT THE END OF THE WORLD

GO WITH THE FLOE

An international research team is drifting across the northern Arctic Ocean, frozen in the sea ice, on a mission to improve our understanding of the Arctic and climate change.

By Philipp Burtscheidt

A vast white expanse, the endless night of the Arctic winter, a distant outpost of humanity, cut off from civilisation – almost as remote as the International Space Station. On 20 September 2019, the Polarstern was waved off from Tromsø harbour in northern Norway. The German research icebreaker, which belongs to the Alfred Wegener Institute (AWI), embarked on its journey to the Arctic Ocean, where it would become frozen in the sea ice for one year. The largest Arctic research expedition of all time has been given the name 'Multidisciplinary drifting Observatory for the Study of Arctic Climate' – or MOSAiC.

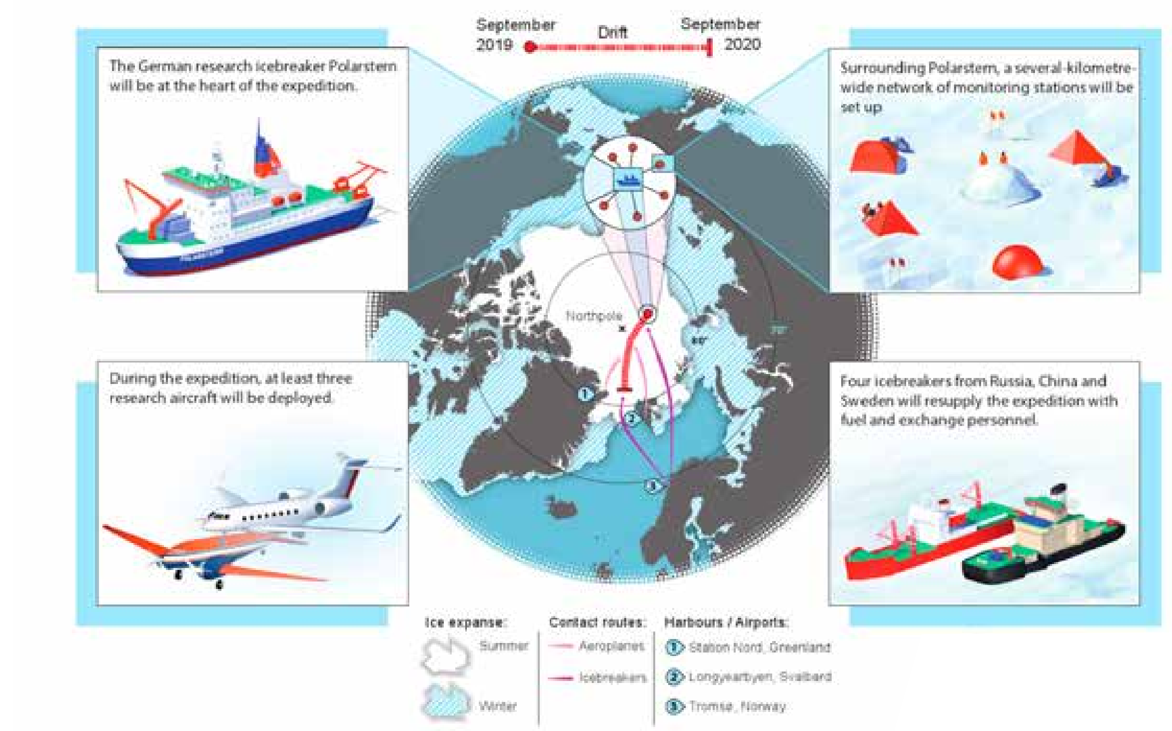
The crew reached their destination in October. Shortly after, they identified a suitable ice floe for drifting and moored to it. As the Arctic winter set in and temperatures dropped, the sea ice thickened and the Polarstern froze fast. It has since been drifting across the Arctic Ocean, carried along by the forces of nature alone. This will be the first mission to conduct extensive and highly accurate measurements and experiments in the Arctic over four seasons. For more than two months, the Polarstern will be less than 200 kilometres from the geographic North Pole. MOSAiC will focus on climate and environmental research. The researchers are hoping to obtain fundamental data and insights into climate change. A better understanding of the physical and chemical interactions of ice, snow, atmosphere and ocean in the Arctic will enable the development of more accurate climate models. Over the course of the mission, the research vessel will travel approximately 2500 kilometres.

Exploring the epicentre of climate change

Teams of scientists from 19 countries and over 70 institutions are participating in the MOSAiC project, under the leadership of the AWI, the Helmholtz Centre for Polar and Marine Research. The researchers will carry out numerous experiments above, on, in and under the polar ice with the aim of cracking the 'Arctic puzzle'. They want to find out how the atmosphere, sea ice, ocean, ecosystem and biogeochemical processes interact with one another. Like the pieces of a mosaic, when viewed together, the results of the different MOSAiC research projects should provide an accurate picture of the Arctic system as a whole.

The Arctic reacts much more strongly to climate change than regions at lower latitudes, and it has an enormous impact on the global climate. The atmosphere here is warming faster than anywhere else. The 'eternal ice' is becoming ever thinner as the years go by. The increasing reduction in the ice surface is constantly changing the face of the Arctic and its ecosystems. In August 2008, the Arctic's Northeast and Northwest passages were both simultaneously free of ice for the very first time. What was once eternal is threatening to become temporary as time goes by.

PIECES OF THE MOSAIC EXPEDITION



An expedition of extremes

MOSAiC is a mammoth undertaking – both scientifically and logistically. Four icebreakers from China, Russia and Sweden will supply the Polarstern with fuel and provisions over the course of its mission. The crew will be rotated at regular intervals, with a total of 600 international experts working on site throughout the mission – from researchers, to the ship crew, and through to polar bear guards. Three research aircraft will require a landing strip of their own on the ice. A network of diverse research stations will be set up around the Polarstern, with the vessel as the base station. The various measuring stations will investigate the Arctic ecosystem as comprehensively as possible.

A single expedition day costs 200,000 euro, with the budget for the entire expedition amounting to 140 million euro. Some 50 percent is financed by Germany, mainly with funds from the Federal Ministry of Education and Research. The remaining amount is borne by international partners.

The Alfred Wegener Institute's research icebreaker Polarstern made its maiden voyage in 1982 and has travelled over 1.7 million nautical miles since. Today, it remains the most modern and versatile polar research vessel in the world.

AWI sea ice physicists work on the sea ice amidst bracing winds and ever-growing snow drifts

THE MOSAIC TEAM RESEARCH AREAS AT A GLANCE

ATMOSPHERE
Only a thin layer of ice separates the atmosphere from the Arctic Ocean. At an outdoor temperature of down to minus 45 degrees Celsius, the water, at a temperature of 1.5 degrees, acts like a heater. Cracks are increasingly appearing in the ice, allowing heat to escape into the atmosphere and forming clouds. MOSAiC atmospheric researchers are now investigating the properties of these clouds and their effect on global temperature.

SEA ICE
Climate change has significantly altered the Arctic Ocean. The sea ice has become thinner and more mobile. MOSAiC provides scientists with an opportunity to observe and measure how sea ice and snow cover change over the seasons. The Sea Ice Team is examining the thickness of the ice, its composition, the snow cover and the amount of light that penetrates into the ocean under different conditions.

OCEAN
For the very first time, the MOSAiC mission is giving oceanographers the opportunity to investigate temperatures and currents at different depths of the Arctic Ocean over the course of an entire year. The scientists are concentrating on circulation in the upper levels of the gigantic ocean currents that carry vast quantities of water into and out of the Arctic. The temperature here affects the ice cover, and thus the atmosphere.

BIOGEOCHEMISTRY
A constant exchange of gases between the atmosphere, ice and sea water takes place in the Arctic. These include carbon dioxide, nitrogen oxides, methane and other trace gases – all of which have an impact on the climate. Both the freezing and melting of ice as well as microorganisms and algae influence their interactions. These processes are not sufficiently understood. As part of MOSAiC, researchers are examining the dynamics of gases and other chemical compounds.

ECOSYSTEM
Despite the harsh environmental conditions, a myriad of animals and plants live on and in the sea ice, in the Arctic Ocean and on the seabed. Biologists will take samples and conduct an array of experiments during the MOSAiC mission. They are hoping to gain a better insight into the species that live in this region, their habitats, the way in which they interact, and their response to the changing seasons and environmental influences.

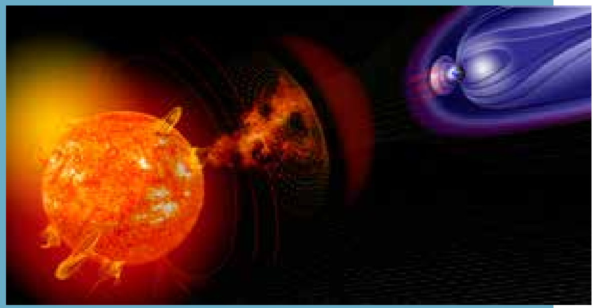
Up-to-date news, straight from the Arctic, are published regularly on the MOSAiC Twitter and Instagram feeds under the hashtags #MOSAiCexpedition, #Arctic and #icedrift. More information about the expedition is available at:

- www.mosaic-expedition.org
- follow.mosaic-expedition.org

© Alfred Wegener Institute

Polar lights make the interaction of the solar wind and the atmosphere visible. Although a beautiful sight, they can disrupt satellite navigation.

© NASA



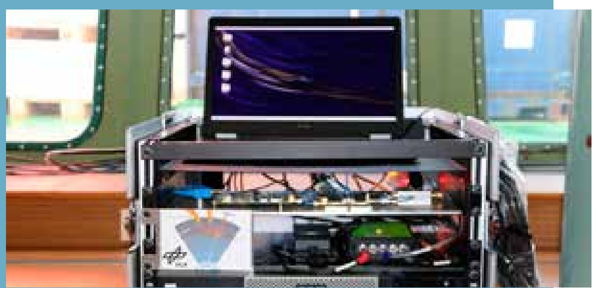
Solar activity affects Earth's atmosphere. The effect is particularly noticeable in the polar regions.

© DLR

Simon Plass and satellite navigation expert in the DLR MOSAiC team, Friederike Fohlmeister, mount the receiving antenna on the sounding deck. They were responsible for water- and cold-proofing the installation.

© DLR

During his free hour and from the Fjellheisen mountain station, DLR project leader Simon Plass collects ship signals, known as AIS (Automatic Identification System) signals, from the waters off Tromsø.



DLR's scintillation recorder – the heart of the measuring on board the Polarstern.

YOU'VE GOT MAIL … FROM THE ICE

Satellite signals are particularly susceptible to interference at the poles. The DLR Institute of Communications and Navigation is investigating a robust positioning system.

Several teams of DLR experts support the MOSAiC mission. The German Remote Sensing Data Center (DFD) is providing sea ice maps for the Polarstern. DLR's Maritime Safety and Security Lab in Bremen is developing new methods for differentiating between different types of ice using samples collected over the course of the mission. The DLR Institute of Communications and Navigation is conducting research into improved positioning in areas close to the poles. To this end, a team of researchers installed a receiving station for satellite navigation signals on board the icebreaker. For the first time, this mission will establish an extensive base for these signals close to a pole. As the facility is self-sufficient, it requires no on-board presence from the DLR team.

Philipp Burtscheidt spoke to Simon Plass, DLR's MOSAiC project manager in Tromsø, Norway, about the research conducted by DLR on the Polarstern. Plass and his team installed the facility just days before the icebreaker set sail on 20 September 2019.

Why is DLR involved in the MOSAiC mission, an expedition focusing on polar climate research?

: Broadly speaking, the MOSAiC expedition has the overarching goal of better understanding the Arctic system as a whole. In addition to measurements and experiments on the Arctic Ocean, the ice and the lower atmospheric layers, research questions also include phenomena in the upper layers of the atmosphere.

The solar wind exerts a particularly strong effect within the ionosphere in the regions around the North and South Poles, most famously manifested in the Aurora Borealis and Aurora Australis. These polar lights make the interaction between the Sun and Earth visible to the naked eye, but they can also interfere with satellite signals. When it comes to navigation signals, this can lead to incorrect positioning data being picked up by the receivers. Improving safety in polar regions is another of MOSAiC's aims.

Are you measuring atmospheric interference?

: This interference is a natural phenomenon known as scintillation, which takes place in the ionosphere. The effects are stronger in the polar regions, where the Earth's magnetic field is weaker than at mid-latitudes. Here, the energetic particles of the solar wind can penetrate into the atmosphere more easily. Our devices do not measure disturbances in the ionosphere itself, but rather the satellite signals. With our monitoring equipment, we can detect changes in the signals caused by scintillations. In the event of a disturbance in the atmosphere, the device records the raw signals from the Galileo, GPS and GLONASS systems until the scintillation is over. We need the raw data from the satellites to recognise patterns and develop more robust navigation receivers.

Before MOSAiC, the necessary data from polar regions were not yet available in sufficient quantities. We hope that the scintillations that occur during this year in the Arctic are enough to yield a wealth of data for analysis upon the return of the Polarstern.

What happens if you detect a distinctive pattern in the disrupted satellite signals?

: Together with the DLR Institute for Solar-Terrestrial Physics, we will evaluate the collected data and develop algorithms to devise countermeasures for addressing atmospheric interference on the receiver side. Modern standard navigation receivers do not 'notice' whether they are receiving a disrupted signal; they simply analyse every signal and calculate a position. If the signal is disrupted, the receiver issues incorrect position information or no position whatsoever. These errors can be considerable during a scintillation. In the event of adverse conditions at the poles, it is particularly important to know exactly where you are. This is especially critical in the case of rescue missions, as safety must be ensured during maritime operations. In future, navigation receivers will be 'smarter' in this regard, or more resilient. They will be able to compensate for signal interference and display reliable and precise positions, even in polar regions. Looking ahead, within two to three years we will have tangible results and will have developed algorithms capable of coping with scintillations. But we are still a long way from the finished product.

Simon Plass

is an electrical engineer and works at the DLR Institute of Communications and Navigation in Oberpfaffenhofen. In addition to managing the Department of Institute Project Management and Institute Administration, he coordinates the Institute's maritime activities. In 2015 he was invited to join one of the Task Forces of the Arctic Council as an expert. The previous year, he was appointed to the DLR Scientific-Technical Advisory Council, an advisory body for the DLR Executive Board. He has chaired the Council since 2019.

Plass' work now covers a fascinating spectrum of research, project management, departmental management, execution of measuring campaigns and implementation of the technology transfer of the results into industry – at the interface of research, industry, government and diplomacy. Plass is 42 years old and the father of two children.

© DLR

What could go wrong on the long journey?

: Our on-board technology consists of an external unit – the antenna on the top deck – and the core system inside the Polarstern. The computing unit receives, processes and stores the incoming raw signals. The devices have to work self-sufficiently, as no one from our team will be on board.

The hardware is vulnerable, particularly the antenna and the cable in the exterior. They will be directly exposed to temperatures of up to minus 45 degrees Celsius, ice, salt and storms with high waves. The cable attached to the antenna could give in or fray during a storm. The hardware inside the vessel is firmly tied down and the temperature is constant. That said, the ship's vibrations could cause the plug connections or solder joints to come loose. Surfaces could become rusty. During big swells, one of the crew could grab out to try to keep their balance and snap the mooring. Of course, these are all worst-case scenarios, but they could happen. We could also encounter errors with our software, as we programmed it ourselves. Although it was thoroughly tested for three months in Germany, you never know.

You are not on board. How can you tell if there is a problem?

: We have written a software routine that regularly checks all of the components. All of the data are stored locally on our hard drives, as well as on the Polarstern's on-board server. Our system automatically sends us a weekly email with the status of the device. Are data being received? Is the power supply working? In the event of a problem, we can contact the Polarstern. However, the data volume is very low: we can only send 50 kilobytes per week from the Polarstern. Basic communication is possible, but it goes without saying that we cannot have a livestream or issue detailed instructions over the telephone on how to rectify errors. Communication coverage is simply very poor in the Arctic Circle.

How do you intend to respond to problems?

: We have given a lot of thought to how we can react from a distance. It is very difficult. That is why the system must be maintained by all those on board, and the whole crew has to be able to repair it, should the need arise. We have provided a detailed manual for addressing software or hardware failures, and attached spare cables for all of the installed cables next to the assemblies.

How did DLR become involved with the Polarstern?

: As often happens in life, it was a matter of chance and being in the right place at the right time. As part of my work on the Arctic Council, I became the communications engineering expert for the German delegation of the Federal Foreign Office in 2015. In 2016, we presented Germany's Arctic research work at the Arctic Circle Assembly, which is held every year in Reykjavik. Representatives from the AWI also attended. Among them was Markus Rex, the MOSAiC expedition coordinator. We really hit it off. The following year, we met again at a network event for the Helmholtz Association of German Research Centres. On that occasion, I told him "I heard that you are working on the amazing MOSAiC project. Is there any chance that we could participate?" As we did not intend to put any members of staff on the vessel and our system is small, can run self-sufficiently, and can be operated at an on-board voltage of 230 Volts, he did not see a problem, and replied, "Yes, of course!"

For DLR, MOSAiC goes far beyond scientific research. What else has driven you?

: MOSAiC is a wonderful example of the interface between research, policy, industry and diplomacy. For instance, government representatives must be able to understand what we are doing, and appreciate why it is necessary. DLR can make a significant contribution towards climate research and environmental monitoring in this regard, by providing the expertise, tools and data required – not just for Germany, but worldwide.

The Arctic Council is all about diplomacy at an international level. It addresses cross-border cooperation. Given the geography of the Arctic, it is vitally important to think in a 'pan-Arctic' manner by working out comprehensive solutions across the sovereign territories of the neighbouring states. This is far from easy at times. Ensuring smooth operation across these interfaces is one of my tasks at DLR. I support these different areas and maintain contact with all parties. This allows for close and direct exchange, and is a fantastic part of my work. Every interface has an aspect of its own, and its own requirements. Of course, that is very diverse and a lot of fun.

How did it feel to install the technology in Tromsø and then disembark?

: I left the Polarstern happy yet somewhat exhausted. We worked intensively for several days. I came away from Tromsø having had a marvellous experience and took lots of wonderful memories home with me.

I envy the crew for this unique opportunity to be part of such an expedition, especially given that they will be conducting measurements and taking samples on site. That said, during that time they will be completely isolated in a highly inhospitable environment – almost like being on the International Space Station. Although in the Arctic you are much more likely to come face-to-face with a polar bear than you are with aliens during a spacewalk!

Philipp Burtscheidt is an editor at DLR's Media Relations department.

Cover image

Urban vehicles should bring people and goods from A to B safely, comfortably and in an environment-friendly manner. In the Urban Modular Vehicle, DLR combines various vehicle types on a single platform. The 'Peoplemover' variant can be used as a shuttle to supplement the local public transport system and saves individual parking spaces.

DLR
Deutsches Zentrum
für Luft- und Raumfahrt
German Aerospace Center