

The Birds, which twitter with the ISS Project ICARUS

On Thursday, 16.08.2018 09:59 MEZ, the two resident Russian cosmonauts Sergei Valeriyevich Prokopyev and Oleg Germanovich Artemyev installed the ICARUS antenna on the International Space Station (ISS). This was the highlight of their extravehicular activity (EVA), which tasked them to carry out work on the exterior of the Russian Zvezda module for several hours. The two cosmonauts were supported during their work by the German astronaut Alexander Gerst, who monitored the activity from inside the station. The antenna's installation marks the completion of the "International Cooperation for Animal Research Using the Space" system (ICARUS) provided by the Max Planck Institute for Ornithology (MPIO) in cooperation with the Russian space agency (Roscosmos) and the German Aerospace Center (DLR). ICARUS will allow worldwide tracking and monitoring of all kinds of animal migration paths and will be tested and brought into service over the coming days and weeks. [1]



Cosmonauts Prokopyev and Germanovich having mounted the ICARUS antenna. © RSC Energia

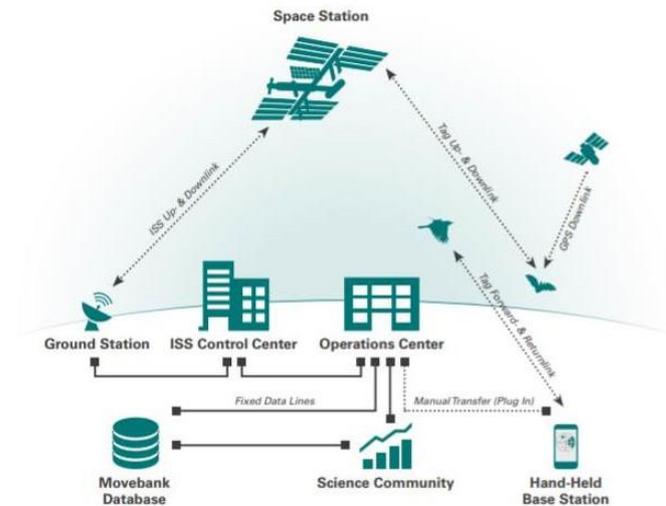
The aim of the project is to better capture movements of animals on Earth. The selected groups of animals are equipped with thumbnail sized, five gram micro-transmitters/receivers ("tags") which are tracked with the help of the ISS. The scientists hope to find out about movement patterns of migratory birds, which could contribute to the conservation of species by solving unknown facts about their driving forces.

In addition, in the future ICARUS might even serve as an early warning system for natural disasters such as earthquakes and volcanic eruptions by detecting and deciphering any unusual behavior of animals. [2]

The technology on board the ISS consists of the ICARUS antenna and a dedicated computer unit, previously installed in the Zvezda module. On the ground, small radio transmitters known as "tags" are highly sophisticated, miniaturized super-computers: these thumbnail-sized devices weigh just five grams and can be attached to small animals, such as songbirds, without influencing their behavior. The tags gather data on acceleration, ambient temperature and orientation relative to the Earth's magnetic field. They also record the animal's route with the help of satellite navigation data. In addition it can calculate and predict upcoming transmission contact times with the ISS for data transfers. All of this takes place in an economical low-energy mode, activating the tag to full power mode only during actual data transmission periods. [3]

Communications Concept

As soon as a tag-transmitter is in the reception area of the ISS, it receives a data stream from the ISS and transmits its own position as well as the sensor data stored since the last contact with the ISS (A). The ICARUS on-board system on the ISS stores the data and transmits it during the next ISS downlink contact to an ISS ground station. The raw data is forwarded via the ISS Control Center to the ICARUS Operations Center where it is processed and subsequently stored in the "Movebank" scientific database (B). The scientists evaluate the data and, if necessary, send a command via the operations center to an individual tag-transmitter to change its configuration. The corresponding command is forwarded and stored on the ICARUS on-board system (A). If the tag-transmitter sends data to the ISS the next time it is detected, the stored command is transmitted to this tag-transmitter (C). [3]



ICARUS Communications Concept

Legend Ground Segment:[4]

- ▶ **(A) ISS Space Station** with ICARUS onboard computer
- ▶ **Ground Station:** ISS Ground Stations in Russia
- ▶ **ISS Control Center:** ZUP at Moscow
- ▶ **Operations Center (OC):** MPIO in Radolfzell
- ▶ **(B) Movebank Database :** Located at OC in Radolfzell
- ▶ **Science Community** at internationally decentralized locations
- ▶ **Hand Held Base Station:** Hand held tag-Receiver for local use
- ▶ **(C) Tag Transceiver:** Attached to the animal(s)

Technical Realization

ICARUS uses CDMA (Code Division Multiple Access) communication technology to send small amounts of data from the ground to low-earth orbit decoding processing units (400-800 km orbit altitude) with low energy consumption. Thus, ICARUS implements an IoT (Internet of Things) communication principle via satellite. These tag-transmitters have among other features a GPS receiver to determine the position of the animal. In addition, the researchers are also able to query the data by means of a mobile device communicating directly with the animal's receiver-transmitter unit on site. One of the challenges was to minimize the amount of data that should be sent to the ISS. [3] The tag-transmitters calculate the time at which the ISS will be passing overhead and then are activated to "full life" to send the recorded data to the space station, receive new orbital data from the ISS. They also can be reprogrammed if necessary. In the process, the antenna on the ISS can receive the data of whole flocks – that is, from several hundred birds at the same time.

The tag-transceivers were developed by the German companies Rohde & Schwarz INRADIO GmbH in Dresden and I-GOS GmbH in Immenstaad. The ICARUS antenna and the on-board computer were designed and built by SpaceTech GmbH (Immenstaad) with support from the Russian industrial partner RSC "Energia" (Korolev). [1]

"The ICARUS project is a successful example of the excellent Russian-German collaboration on the scientific use of the ISS," emphasises Johannes Wepler, project manager at the DLR Space Administration. The two sides have now been collaborating on the project's implementation for over five years. "We're proud to have been able to incorporate Russian experience with the operation and construction of experiments on the ISS into ICARUS. At the same time, we're giving our scientists the opportunity to establish themselves as world leaders in this area of research," says Vasilij Savinkov, project leader at Roscosmos. "It's also exciting to consider possible future applications of the ICARUS technology, such as tracking freight containers to make their transport more reliable or locating chipped pets."

ICARUS is a collaboration between the Max-Planck-Gesellschaft, the Russian State Corporation for Space Activities ("Roscosmos") and the DLR Space Administration, which is supporting the project with funding from the Federal Ministry for Economic Affairs and Energy (BMWi). [1], thus using resources in addition to the ESA-Columbus-ISS utilization agreements.

References

- [1] <https://www.mpg.de/12200065/ICARUS-project-spacewal33k>
- [2] Wikipedia: <https://de.wikipedia.org/wiki/ICARUS-Initiative>
- [3] MPIO: https://www.tiersensoren.mpg.de/38126/ICARUS_Flyer.pdf
- [4] Private communications with MPIO