Report on Refurbishment and Modernization of the German Antarctic Receiving Station GARS O’Higgins

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**Information Paper submitted by Germany**

Summary

The renovation and modernization of the German Antarctic Receiving Station GARS O’Higgins at the Antarctic Peninsula was planned and funded by the German Aerospace Center DLR and was kicked off in the year 2017. The overall aim of this project is to sustain the station in overall layout and purpose as is, but to achieve up to date infrastructure and technological equipment and to reduce the environmental footprint of ongoing station operations.

From 2018 to 2020, the technical proposal for the refurbishment and modernization of GARS O’Higgins has been developed by a German engineering company, supported by a Chilean service company. During that time, the tendering process was started as well.

In 2020, DLR submitted the Initial Environmental Study (IES) to the German Environment Agency (Umweltbundesamt - UBA) as the National Competent Authority (NCA). Based on the IES, UBA conducted the Initial Environmental Evaluation (IEE) during the same year. The evaluation states that the planned activities give cause to suspect only minor and transitory impact on the Antarctic environment. The approval to conduct the refurbishment and modernization was given with conditions to ensure that the requirements of the Act Implementing the Protocol on Environmental Protection to the Antarctic Treaty are met. End of 2020, the on-site work was started in the Antarctic.

The project is slightly delayed through the pandemic for several reason, but is nevertheless progressing well. Major goals are achieved and it is planned to finalize the work by the end of 2023.

In the following the station background, activities in detail, status of the project and measures for reducing the environmental impact are described.

Background

The German Antarctic Receiving Station GARS O’Higgins at the Antarctic Peninsula is a multi-purpose facility for Earth observation and geodesy since more than 30 years. It serves as a satellite ground station for payload data downlink and telecommanding of Earth observation satellites as well as a geodetic observatory for determination of global reference frames, continental drift, Earth rotation parameters and radio astrometry. Both applications use the same 9 m diameter radio antenna. The German Antarctic Receiving Station is owned and primarily operated by the German Aerospace Center DLR. DLR is the national aeronautics and space research centre of the Federal Republic of Germany.

The German Antarctic Receiving Station GARS O’Higgins is located in direct neighbourhood to the Antarctic Base of the Chilean Army General Bernardo O’Higgins, on the island Isabel Riquelme at the northern tip of the Antarctic Peninsula (63.32°S, 57.90°W). It is jointly utilized by the German Aerospace Center (DLR) and the Federal Agency of Cartography and Geodesy (BKG). The station operation is organized in cooperation with the Chilean Antarctic Institute (INACH).

A manifold support in overall station operations and logistics is obtained under Chilean responsibility by the Chilean army (Ejercito de Chile). The carriage of freight and passengers from Punta Arenas via King George Island to O’Higgins is realized by the Chilean air force (FACh) and the Chilean naval forces (Armada de Chile), the Brazilian Antarctic Program

(PROANTAR) and the Brazilian air force (FAB). The operations and maintenance of the station infrastructure is supported by a private Chilean service company (Servimet).

Research

GARS O’Higgins was constructed in 1989-1991 and was planned to act as satellite ground station for the, at this time, upcoming European Remote Sensing satellites ERS-1 and ERS-2, and as the first station on the Antarctic continent supporting very long baseline interferometry (VLBI) measurements. In the past the station was continuously upgraded to keep pace with technological progress. For example, it was complemented by additional measurement systems like GNSS (Global Navigation Satellite System) receivers, a PRARE (Precise Range And Rangerate Equipment) system, or tide gauges. Additionally, also the satellite data receiving chain was upgraded by more sensitive and more reliable demodulators and further equipment. 20 years of reception of radar data from the ERS-1 and ERS-2 satellites generated a unique data set of remote sensing data over the Antarctic Peninsula and the surrounding area. This data set was and is still used in various research fields. Today it plays an important role as a satellite ground station supporting mainly Earth observation missions, and as fundamental geodetic point in Antarctica for the realization of global reference frames and monitoring crustal motions. The geodetic VLBI experiments are usually performed once or twice a month, while the IGS reference stations (GNSS receivers) and the meteorological station yield continuous time series. From 1991 to 2010, the operation on site was mainly done campaign-wise during the Antarctic summer. However, with the launch of the German TanDEM-X satellite in 2010 and the close formation flight of the two German satellites TerraSAR-X and TanDEM-X a year-round station operation was necessary. This was especially important for generating a digital elevation model of the land surface of the whole Earth. This digital elevation model achieved unprecedented accuracy and uniqueness as a global data set. The TerraSAR-X data are continuing the data set established with ERS-1 and ERS-2 and furthermore the digital elevation model also comprises Antarctica and is currently being updated (second version) especially for the Antarctic coastal zones.

As a satellite ground station GARS O’Higgins is part of the global ground station network of the DLR’s German Remote Sensing Data Center (DFD) with ground station location in the Arctic, Antarctic and of course Germany.

For space geodesy and astrometry, the radio telescope GARS O’Higgins significantly improves the coverage on the southern hemisphere and plays an essential role within the global Very Long Baseline Interferometry (VLBI) network. In particular, the determination of the Earth Orientation Parameters (EOP) and the coverage of the International Celestial Reference Frame (ICRF) are benefitting from the location at high southern latitude. Further, the resolution of VLBI images of active galactic nuclei (AGN), cosmic radio sources defining the ICRF, drastically improves when O’Higgins is included in the network. The various geodetic instrumentations and the long-term time series at GARS O’Higgins allow a reliable determination of crustal motions.

The outstanding location on the Antarctic continent makes GARS O’Higgins also in future attractive for polar orbiting satellite missions and an essential station for the global VLBI network.

Rationale for Refurbishment and Modernization

The station was built from 1988 onward and was set into operations in the year 1991. The station has always been continuously maintained. Station components where improved and especially the technical station equipment was renewed as necessary.

Nevertheless, parts of the technical equipment are used from the very beginning on and are thus more than 30 years old. Those parts (e.g. the diesel engines for generating power) are no longer state of the art and need either to be completely replaced (e.g. fuel storage, diesel generators, inverse osmosis) or basically refurbished (e.g. container modules). Furthermore, the station construction in the original building phase followed design principles and safety regulations of time of station set up. Especially the safety regulations, including measures for environmental protection, are changed and much more comprehensive now and necessary adoptions have to be performed. Therefore, a package of measures was decided, without significantly changing the station layout as such.

Overview of Refurbishment and Modernization Measures

The station consists of three main facilities: the research station composed of a set of containers housing technical equipment for operating the satellite station and the radio telescope providing living and sleeping accommodation, the supply station comprising infrastructure for power generation, water supply, sewage plant and workshop etc. and the antenna system as such. The main measures for refurbishment concentrate on two aspects.

1. Technological/technical modernization of the antenna system. The antenna system is very well maintained and provides the reception of satellite data with a very high reliability (> 99 %). The basics of the antenna control, antenna gears and motors, cabling etc. needs an upgrade to state of the art technology.
2. Infrastructure: diesel generators, UPS, fuel storage, inverse osmosis, electrical installation and other technical details have to be renewed. But there is also improvement in structural fire protection necessary in order to achieve the current safety regulation in fire protection. In addition, a decrease of the environmental impact and the reduction of human footprint shall be achieved.

The built-up area of the station buildings as such will not be significantly changed. The first of the named facilities (a set of containers housing technical equipment for operating the satellite station providing living and sleeping accommodation) will nearly be not affected at all, only two server room containers are added. The second named facility (the station infrastructure part with power generation, water supply, sewage plant, etc.) needs modifications of the internal floor plan, renewal of the foundations, replacement of the majority of the containers building this structure and renewal of the exterior cladding of the building, but the building location stays the same and the built-up area will be increased only slightly at the southwestern building corner. Finally, the antenna system, being a special construction is anyway only affected in the technical parts and the whole foundation, steel structure and mechanical construction will not be touched.

Diagrama, Dibujo de ingeniería

Descripción generada automáticamente

Figure 1a: Layout of the station GARS O’Higgin.s

Diagrama

Descripción generada automáticamente

Figure 1b: Design of the modernized supply station including position of the new double-shell stainless steel tank containers - 3D view.

**Initial Environmental Study & Evaluation / Environmental Impact Mitigation Measures**

For the approval of the refurbishment and modernization project, DLR was preparing an Initial Environmental Study (IES). The IES would be available from DLR, but is available in German language only. The IES covers the following topics:

* Overview and context.
* A description of the station itself, as well as the environment, including all protected assets.
* The necessary renovation/modernization activities that will be carried out at the station, including the objective, location, and schedule.
* An analysis potential environmental impacts and proposes mitigation measures to minimize them.
* And finally the conclusions and summary of environmental impacts.

In 2020, DLR submitted the IES to the UBA as the NCA, for approval of the project. As the project was expected to have minor or transitory environmental impact UBA had to obtain a statement from the national Committee of independent scientific experts. The Federal Agency for Nature Conservation (BfN) as the consent authority with regard to the protection of flora and fauna was also involved in the approval process. Based on the IES and opinions from the Committee and the BfN, UBA conducted the IEE and concluded, that the planned activities give cause to suspect *not* more than minor and transitory impact on the Antarctic environment. However, the approval to conduct the refurbishment and modernization was given with conditions to ensure that the requirements of the Act Implementing the Protocol on Environmental Protection to the Antarctic Treaty are met. End of 2020, the on-site work was started in the Antarctic.

An important IES consideration is gentoo penguins breeding in the immediate vicinity of the station buildings and associated mitigation measures to reduce impacts on the size of the local gentoo penguin breeding population. These mitigation measures are included as conditions in the approval according to the AUG and Annex II of the Protocol.

Mapa

Descripción generada automáticamente

Figure 2: Gentoo penguin breeding sites (stars), out of bounds crane access through breeding areas west of the supply station (red dashed arrow with X), and proposed penguin fence (lime green dashed).

In order to avoid affecting the potential breeding areas of gentoo penguins west of the supply station, a conscious decision was made to implement crane access to the supply station exclusively from the roadway east of the station and not to use access through the potential breeding areas west of the station (see Figure 2, red dashed arrow with X).

This avoidance of crane access from the west complicates construction logistics, but avoids impacting the penguins' ancestral breeding grounds.

Part of the IES proposed mitigation measures was also the construction of a penguin protection fence at a distance of about 5 m from the construction site to the west of the supply station and research station, to deter penguins from breeding within the construction area or too close the noisy core zone of the works (see Figure 2, indicated lime green dashed). The construction of a penguin protection fence was also part of the conditions in the permit.

The penguin protections fence consists from

* the metal posts with eyelets (100 mm distance), embedded in the ground/rock in a storm-proof manner,
* the ropes stretched through the eyelets and
* the "chicken wire" (small animal fence, galvanized metal wire, 6-corner mesh, mesh size 25 mm) attached to the ropes.

Imagen que contiene exterior, cerca, alambre, campo

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Figure 3: Penguin protection fence - northern part, zoom, view towards west (photo January 25, 2021).

During the austral summers of 2020/2021 and 2021/2022, the penguin protection fence worked extremely well - also especially with the very curious, exploratory juvenile penguins (see Figure 3 and Figure 4). The combination of taut, thicker ropes and "chicken wire" proved particularly effective here. Additionally, the ropes ensure good visibility of the fence for the penguins (better than without ropes).

Un campo de nieve

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Figure 4: Penguin protection fence - northern part, looking northwest (photo November 18, 2020).

To assess the impact of the construction work and the efficiency of the mitigation measures on breeding success, the annual counting of the penguin nests using the same method and period as before the construction work started, has been imposed as further important condition by UBA. Count data from February 2020 and February 2021 were merged and compared - for the entire Peninsula Schmidt and especially for the GARS sector. The following statements can be made:

On the entire Peninsula Schmidt, the number of occupied nests increased slightly by 3 nests from 795 (2020) to 798 (2021).

In the GARS sector, the number of occupied nests decreased slightly by 3 nests from 281 (2020) to 278 (2021). However, if we consider that one particular area could not be used for breeding in the southern summer of 2020/21 due to exceptionally large amounts of snow - regardless of the construction measure - and consider this in the comparison, then the remaining breeding sites actually show an increase of 13 nests.

For the southern summer of 2020/21, it can be concluded that the previous modernization measures at the GARS O'Higgins station had no significant impact on the size of the local breeding population of the gentoo penguins. The fluctuations are within the usual range.

Modernization activities carried out and planned progress

*Logistics*

In November 2020, the supply vessel LSDH 91 "Sargento Aldea" of the Chilean Navy transported a total of 12 container units consisting of container modules and container attachments from Talcahuano to O'Higgins in Antarctica. A further 4 container modules were transported from Punta Arenas to O'Higgins by the Chilean Navy's supply vessel AP-41 "Aquiles" in April 2021.

In November 2021 and March 2022, the AP-41 "Aquiles" transported a total of 16 container units consisting of container modules and container attachments as well as transport containers from Punta Arenas to O'Higgins.

Thus, a substantial part of the container modules, container attachments and transport containers required for the refurbishment and modernization of the GARS O’Higgins station are already in Antarctica.

*Refurbishment and modernization of the supply station and complement to research station*

The following activities have been completed or are in the process of implementation to date:

* Achieving station level consolidation by lifting the containers of the north side by 762 mm.
* Preparation of the foundations. A load-bearing substructure of galvanized HEB 200 double-T steel beams was installed under the lifted containers of the north side.
* Temporary wall was built up to the east of the old generators and the old containers were removed by crane from the compound of the previous supply station.
* Temporary replacement of UPS, inverse osmosis and further removal of old containers.
* Temporary relocation of the two old diesel generators and the new emergency backup generator.

Imagen que contiene exterior, transporte, agua, barco

Descripción generada automáticamente

Figure 5: Conversion of the old supply station with use of the Liebherr LTM1040-2.1 mobile crane within the old supply station.

* Extension of research station by two server room containers.
* Extension of the fuel storage by 2 additional double-shell stainless-steel tank containers, each with a capacity of 24,000 liters, which are also approved for the transport of diesel.
* Emptying of the old single-shell tanks by transferring the fuel (Antarctic diesel) into the total of 5 double-shell stainless steel tank containers of the fuel storage.
* Removal of the old, single-walled tanks (3 container units).
* Positioning of two new double-shell stainless-steel tank containers, also approved for the transport of diesel, each with a capacity of 24,000 liters on the new double-T steel beam foundations of the new supply station to be built.

Un barco de fondo

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Figure 6: Positioning of a new double-shell stainless steel tank container with a capacity of 24,000 liters, also approved for the transport of diesel, on the new double-T steel beam foundations prepared for the new supply station.

*Planning for upcoming season and Antarctic summer season 2023/2024*

* Conducting of technical antenna modernization.
* Finalizing the new structure of the supply station.
* Establishing of new cladding of the supply station (2023/2024 season).

Important Remark

It is emphasized that the whole logistics relies on the Antarctic operations of Chile (mainly) and especially the Chilean navy. Support was also given by Brazil (PROANTAR) and to a small portion also on Uruguayan operations. The German Aerospace Center DLR appreciates this support of the named nations very much and likes to emphasize, that without this support it would rarely be possible to perform a successful station modernization.