

## LEARNING FROM THE BAE JUAN CARLOS I: LESSONS FOR AN ANTARCTIC ARCHITECTURE OF 21<sup>ST</sup> CENTURY

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**Keywords:** *Antarctic architecture; research bases; building management*

### Abstract

Since the end of the last century, Antarctica has been revealing its great global importance for the scientific study of such relevant phenomena as climate change. In fact, there are currently more than 50 research bases, and there is a marked trend focusing on architectural design and the use of new technologies, all in a particular context marked by an extreme climate and the zero environmental impact required by the Antarctic Treaty. Among them is the Spanish Antarctic Base (BAE), managed by the Unidad de Tecnología Marina - CSIC. This study aims to contribute to its knowledge since, despite its tight initial budget and having reached half of its expected life, its interesting design (reminiscent of certain utopian proposals) and the use of specific technological and constructive solutions have turned it into a space not only useful for research but for the very definition of an Antarctic Architecture (see Fig. 1).

The objectives and hypothesis are to analyse the BAE in order to conclude that it is possible to define a preliminary methodology for the design and construction of future bases and for the Antarctic Architecture of XXI<sup>th</sup> Century.

It consisted of an analysis of the key parameters of its design and construction, supported by a 3D drawing of module A of the BAE (see Fig. 6). The following key parameters have been chosen for the analysis:

1. SITE: It is located on a firm sloping towards the sea, not affecting the lichens of the surrounding areas.

2. PROGRAM and FORM: It is a temporary use base, inhabited only during the austral summer. It is made up of 10 scattered modules, each one of them owns a different function. The main building houses the bedroom modules (B1 and B2) and the habitability module (A) where the offices, kitchen, dining room and pantries are located. Each module has two floors, with the main uses located on the upper floor and the services and facilities on the ground floor. These three modules are arranged forming a "Y" joined by a core (N) with a hexagonal plant. The science module (C) is located away from the others to avoid risks in case of fire propagation. It is made up of two floors where the laboratories and services are arranged. The rest of the modules have a single floor and a specific function (see Fig. 2).

3. RELATIONS BETWEEN SPACES: Table from Figure 2 shows the areas and percentages of occupation per use. It should be remarked the importance of working areas corresponds to the largest surface areas. It is also relevant that the index of occupants per square meter of space dedicated to the rest and leisure areas is 16.9 m<sup>2</sup> per person. The spaces related to these functions are collected in a single set of three modules (A, B1 and B2). However, the work areas and facilities are located independently, separated from each other. All spaces are communicated through a path that facilitates the movement of people and machinery between the modules (see Fig. 2 and 3).

4. CONSTRUCTION: It was carried out in the stages indicated below, and always during the Austral summer seasons:

1. Transport of material to the beach in small boats.
2. Land grading and foundation construction.
3. Construction of spatial structure, columns and beams.
4. Cladding.
5. Facilities installation.
6. Decoration and furniture.

5. CONSTRUCTIVE ELEMENTS: The following part of the building have been considered as key elements:

- FOUNDATION: Isolated footings made up of precast concrete slabs, stacked in situ using prestressed bars and filling material.

- STRUCTURE: Spatial bar structure made of galvanized steel against corrosion, raised above the ground by means of metal supports anchored to the foundations. Above it there is a simple structure of galvanized steel beams and pillars.

- CLADDING: Made of sandwich panels with double metal skin with core made of thermal insulation (polyurethane foam inside). The outer sheet also has a thin layer of protective coating based on polyester reinforced with fiberglass and a red gel coat finishing layer. It is remarked that due to the strong UV radiation, low temperatures and thermal contractions, the sealant between panels has turned out to be a very important

component of adequate durability. Finally, double-glazed windows with an air gap filled with argon, and solar coating were placed (see Fig. 5).

- FACILITIES: The most relevant are summarized below:

- Fire protection: Extinguishing system by an antifreeze solution of water solution, fire-resistant doors, and a detection system.
- Energy production / air conditioning: Cogeneration system. The heat from the three Diesel generators that produce the energy is used to heat the water and heat the indoor spaces. It also has 24 solar panels and 3 wind turbines that produce energy and are stored in 24 batteries, allowing the continued work of the research teams.
- Variable production of drinking water and water treatment: During part of the Austral summer, the nearby stream brings melt water. There is a stream water treatment plant and a reverse osmosis treatment plant to purify sea water.
- DHW production: It is provided thanks to the cogeneration system; starting from the tank, from there it is pumped to the different modules through thermally insulated external pipes.
- Waste disposal: The base has an incinerator and a compactor for the treatment of waste and a selection and segregation system. The waste is stored until it is removed from the mainland.

The critical aspects to consider for the design of a base are:

1. OCCUPATION: Temporary or permanent. The logistic cost and maintenance of a permanent base is much higher than in a temporary one, that is why there is a general tendency to design temporary bases. Permanent bases are more restrictive because they must accommodate staff and meet their needs during the severe Antarctic Winter weather. Given these restrictions, it is more advisable to design focusing on permanence, even if it turns out to function as a temporary base.
2. LOCATION AND SITE LAYOUT: Defined by the scientific research program together with resources and ease of transport, terrain, climate and accessibility, which will define its location. Compact or dispersed settlement of the base and its complementary or temporary facilities.
3. ZONING: Classification of interior spaces into four categories of zones or uses: rest, leisure (especially important because of isolation and harsh working conditions), work and facilities. The sleeping areas include the sleeping rooms and their services. The leisure areas are the social spaces such as the dining room or recreational areas, among others. As for the working areas, these refer to the laboratories and offices where research is carried out. Finally, the areas for installations will provide shelter for the equipment necessary for the base operation.

4. CONSTRUCTION PLANNING: It is necessary to organize previously its transport and assembly, which requires the construction of full-scale prototypes, in order to avoid logistical and constructive problems later on, as well as the need to provide accommodation for the personnel required for the construction.

5. CONSTRUCTION SYSTEMS AND INSTALLATIONS: Prescription of prefabricated materials and construction systems, not necessarily innovative, but favorably assessed in terms of their fitness for the intended use, e.g. (DIT, DITplus, DITEX) of their demonstrable durability in an extreme climate (low temperatures and strong radiation).

Care in the design and construction of foundations, structure, envelope and installations, as an example an elevated pillar layout, which will be necessary to limit the accumulation of snow due to wind. In order to avoid burying the base or blocking access.

Complex thermal, DHW, fire protection installations, capable of responding durably, reliably and effectively in case of emergencies.

6. FUTURE LINES OF RESEARCH: Antarctica is not an earthquake-free zone. Consequently, this new seismic factor will have to be studied and analysed in order to understand the risks and, therefore, the strategies to be followed in terms of the location and design of future base structures.

The scientific research bases in Antarctica were designed for a certain estimated useful life and based on technical solutions available in the market. In the case of the BAE, this would be 20 years, of which almost a decade has elapsed. That is why there are opportunities for the development of new lines of research in the field of construction in the building itself, for example by incorporating super-insulating materials, ultra-resistant sealants, interior coatings with antibacterial properties among others.

## List of Illustrations

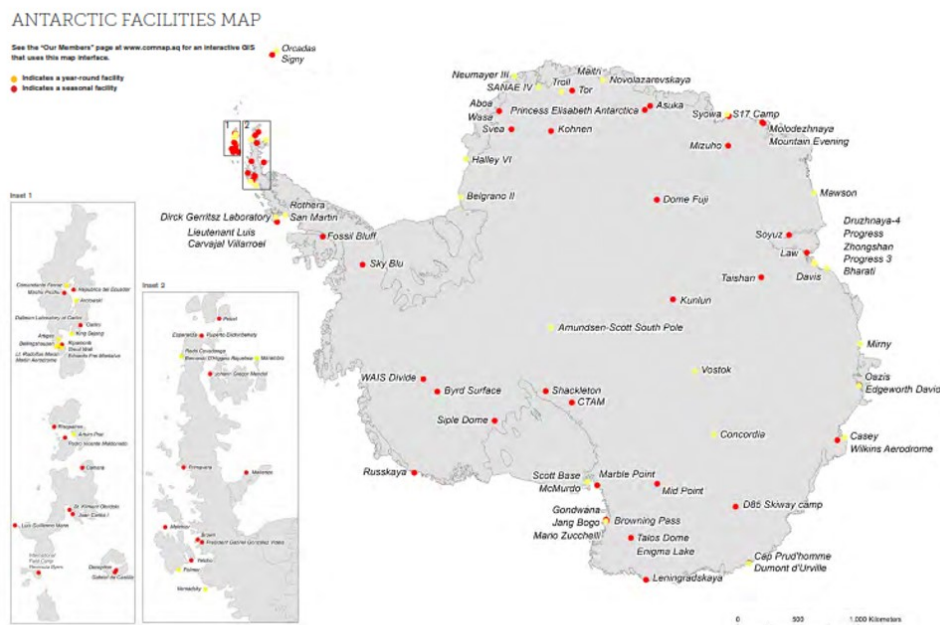
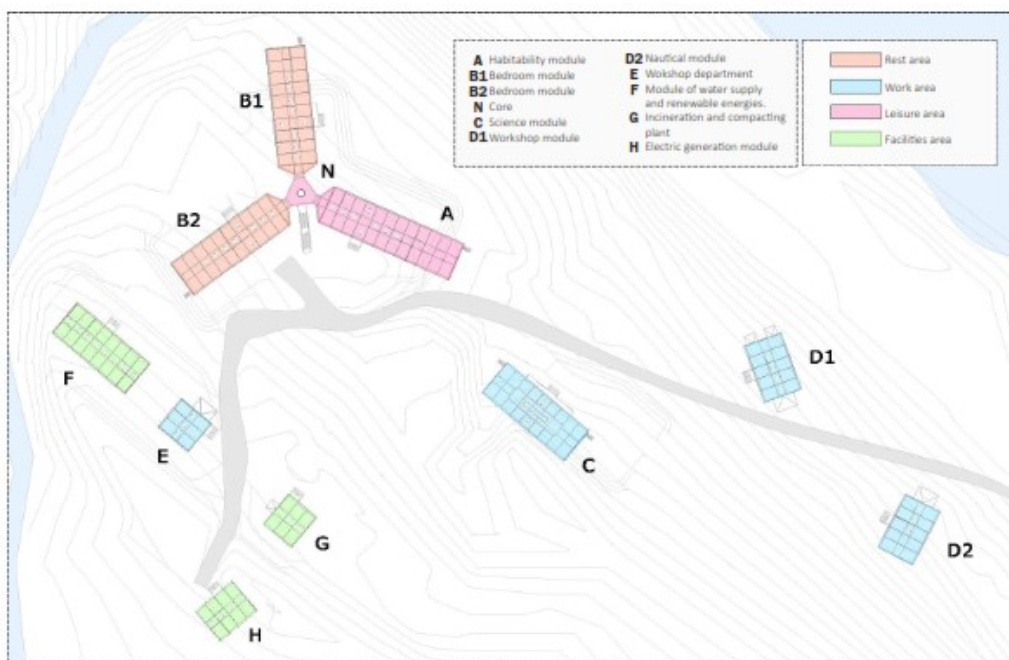
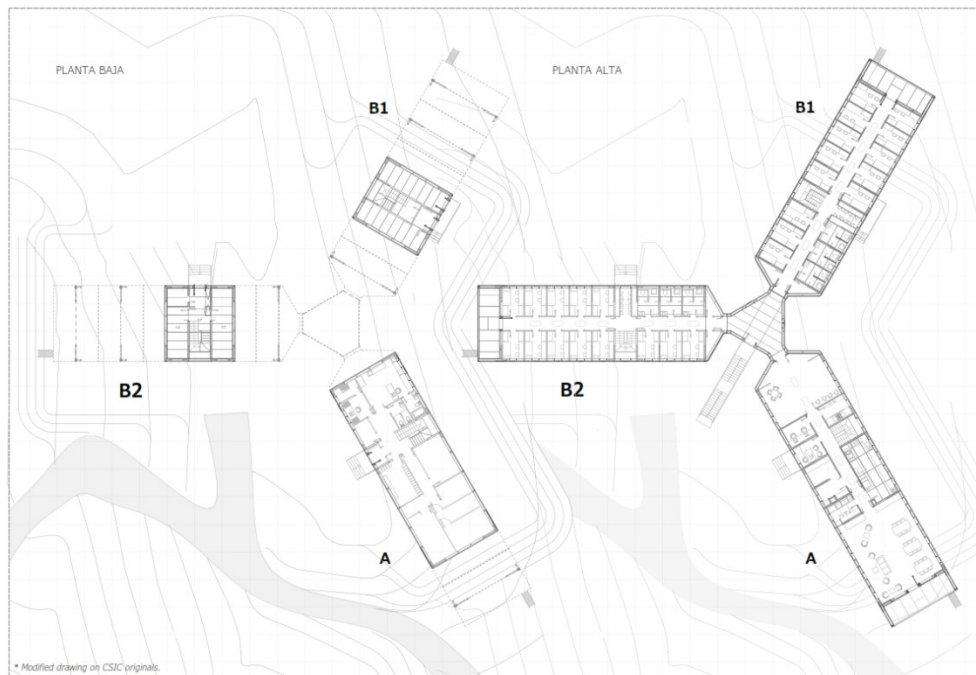


Figure 1: Antarctic map. (Source: COMNAP Catalogue)

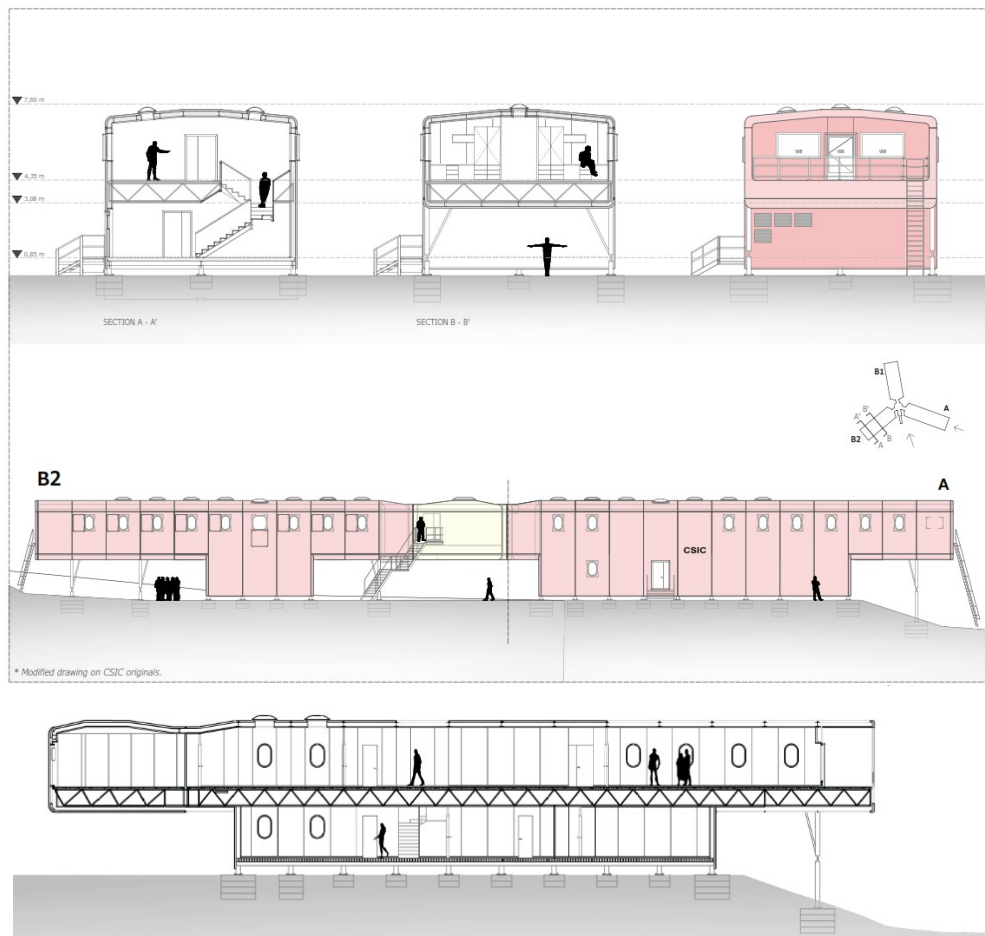


AREAS	Surface area (m <sup>2</sup> )	Percentage (%)
Rest area	423	24
Work area	550	32
Leisure area	421	24
Facilities area	356	20
Total	1750	100

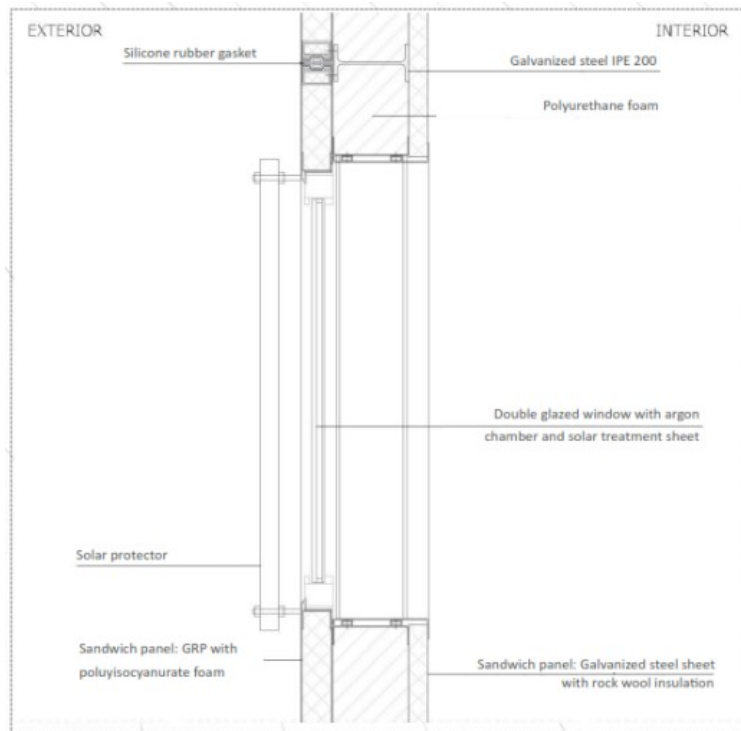
Figure 2 and Table 1: Base program. (Source: own elaboration)



**Figure 3:** Habitability area plan. (Source: own elaboration)

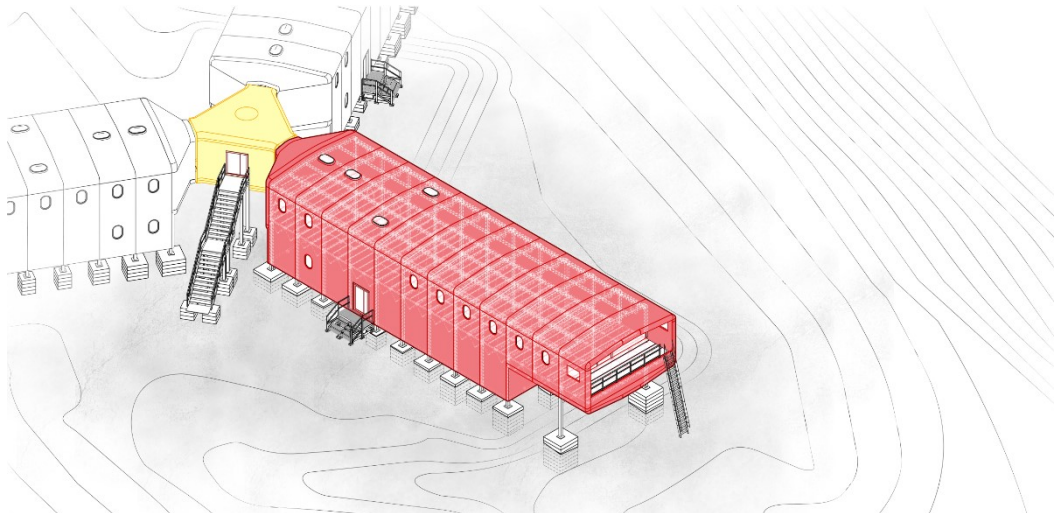


**Figure 4:** Habitability area. Elevation and sections. (Source: own elaboration)



LAYER	THICKNESS (mm)	CONDUCTIVITY $\Lambda$ (w/ M·k)	THERMAL RESISTANCE (m <sup>2</sup> ·K/W)	MATERIAL
J	3	0,4	0,0	Glass Reinforced Polyester
K	80	0,025	3,2	Polyisocyanurate foam
J	2	0,4	0,0	Glass Reinforced Polyester
L	205	0,028	7,3	Polyurethane foam
O	2	0,4	0,0	Polyester lacquer
M	50	0,037	1,4	Rock wool insulation
O	2	0,4	0,0	Polyester lacquer
TOTAL			11,9	
TRANSMITTANCE (W/ m <sup>2</sup> K)			0,08	

Figure 5 and Table 2: Cladding components. (Source: own elaboration)



**Figure 6:** Isometric perspective Juan Carlos I base. (Source: own elaboration)

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