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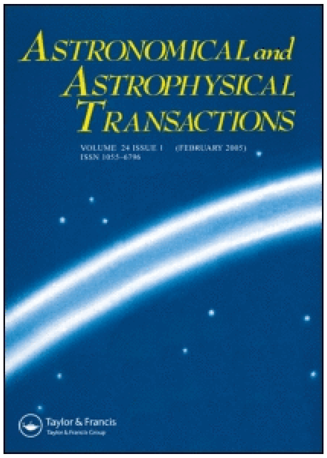

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ITALIAN ROBOTIC ANTARCTIC INFRARED TELESCOPE (IRAIT)

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The Antarctic continent offers ideal atmospheric conditions to carry out observations at infrared wavelengths > 5 μm, a task which is other wise possible only from space with rare and short-lived infrared satellites. In this paper we report the main characteristics of the Italian Robotic Infrared Telescope (IRAIT) which will be installed on the Antarctic Plateau. The telescope will be a $f/20$ Cassegrain with a 0.8-m parabolic primary mirror and an oscillating secondary mirror. It will be equipped with an IR-camera based on a Si:As or Si:Sb arrav of 128 × 128 pixels operating in the spectral range 8–27 μm (Si:As) or 8–40 μm (Si:Sb).

KEY WORDS IR-astronomy, antarctic observatory, IR-telescopes, project IRAIT

1 INTRODUCTION

A key technological achievement of recent years has been the development of bidimensional low-noise infrared arrays which allow one to observe in the mid-infrared range with a high degree of sensitivity. These devices underline the problem of finding high-quality sites for observations, to exploit their possibilities.

In fact, due to the absorption caused by the water vapour present in the atmosphere, mid-infrared astronomy is possible only at few sites on the Earth. The Antarctic Plateau (~ 3000 m above the mean level of the sea) has cold and dry climatic conditions. Site testing campaigns were set up by our group during the years 1993 and 1994, in the summer time, at the Italian base at Terranova Bay and on the Antarctic Plateau (Valenziano, 1995). The data collected about the sky noise and the atmosphere transparency in the mid-infrared, confirmed that the Antarctic continent is an ideal place to carry out high-quality low sky background observations. Among the first scientific goals that can be achieved are long-term monitoring of variable sources without day light interruptions (for all the objects which are always above the horizon in the winter time); continued surveys of selected sky fields at 10 and 20 μm: physical studies of dusty environments in the Galaxy; studies of the very old and very young populations in nearby galaxies. However, the atmospheric conditions are such that probably new atmospheric windows will be discovered in the spectral region between 20 and 40 μm: the most recent technology offers the possibilty of exploting them through Si:As and, especially, Si:Sb detectors.

The advantages offered by the Antarctic continent are particularly stimulating, but many difficulties must be overcome. In fact, the environmental conditions are such that astronomical observations are possible only in a robotic, remotely controlled way.

In 1992–1993 we proposed a project to develop a robotic telescope-IR Camera able to operate at Dome Concordia on the Antarctic Plateau. The project was approved and supported by the Italian National Plan for Research in Antarctica (PNRA): hence we started with project studies of the telescope and of the camera and we are now in a position to start the construction phase.

The telescope and its control system is the responsibility of the team of the University of Perugia which has already developed a prototype robotic telescope (Tosti *et al.*, 1996). The general design, optics, cryogenics, mechanics, and integration of the IR-Camera are the responsibility of the Istituto di Asfrofisica Spaziale (IAS). The fast electronics needed to read the array and the hardware/software control system will be developed at the Torino Astronomical Observatory (OAT). The institutes involved in the camera project have already jointly developed the first European mid-IR camera (TIRCAM), now operated at the Italian Infrared telescope TIRGO (Persi *et al.*, 1994; Busso *et al.*, 1996).

Here we present an overview of the project. The telescope is described in Section 2. The IR-Camera is illustrated in Section 3. The general features of the telescope control system are reported in Section 4. Conclusions follow in Section 5.

2 THE TELESCOPE

In order to minimize the telescope emissivity, the optical system has been optimized tacking into account the size of the IR array. The secondary mirror is used as the entrance pupil so that the edge and the mount of the primary mirror are not visible from the focal plane.

The optical characteristics of the telescope are listed in Table 1. The hole of the primary mirror is larger than necessary so that it will be possible to test the telescope with secondary mirrors of different focal ratio. This may be important to investigate the feasibility of a direct matching between telescope and camera. In fact to obtain a pixel-matching obeying Nyquist's theorem, it is impossible to use the IR-Camera over the spectral range between 8 and 40 μm without an ad hoc cold demagnification optical system is front of the detector.

The telescope will have a rigid alt-azimuth mounting. We have adopted this solution because the main support axes are always vertical and horizontal and the

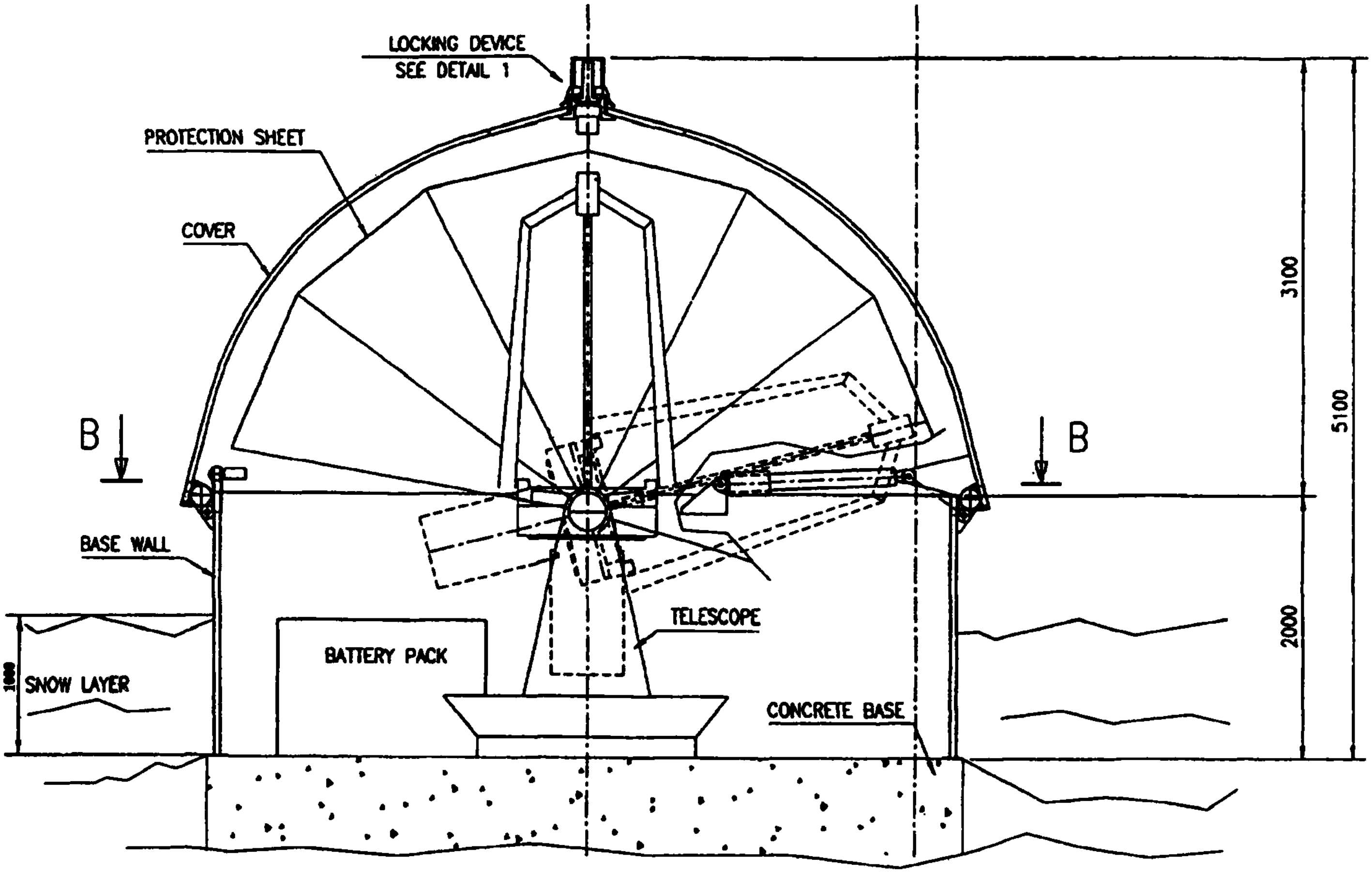

Figure 1 Global view of the IRAIT for its installation at Terranova Bay (Antarctica).

Table 1.

Characteristic	*Value*
Effective primary dia.	800 mm
Free primary dia.	750 mm
Primary focal length	2400 mm
Telescope focal length	16000 mm
Mirror separation	1983 mm
Linear obscuration ratio	0.18
Unvignetted field of view	10 arcmin.
Back focal length	800 mm

stresses on the axes hardly vary with the direction in which the telescope is pointing. Besides, we will test the telescope in Italy and at Terranova Bay, so an alt-azimuth mounting is more practical. The global view of the telescope and dome for the tests at Terranova Bay is given in Figure 1.

3 THE INFRARED CAMERA

The camera is designed to operate with the new Rockwell high-flux Si:As or Si:Sb 128 x 128 pixel Focal Plane Arrays (FPA) for ground-based observations. The pixel size is 70 μm. These detectors can operate with high quantum efficiency in the range 8—27 μm (Si:As) or 8–40 μm (Si:Sb). In the first phase the sensor will be operated using the He-cooled dewar and the acquisition electronics of the TIRCAM (TIRgo InfraRed CAMera) camera (Persi *et al.*, 1994) developed by the OAT and IAS groups in recent years. In the final configuration the cooling will be assured by a close-circuit cryogenic system working at a temperature of about 13 K.

The camera will be equipped with a demagnification optical system that will be designed to obtain the best compromise between spatial resolution and optimal sampling of the source images: during the test phase the camera will be optimized to observe at 10 μm.

In the first phase we plan to use the Si:As array, so here we outline the methods by which we will achieve our goal, divided according to the various sub systems of the camera/telescope unit needed to operate such an array.

Front-End Electronics

The front-end electronics is the first circuit for signal handling before passing the 16 video signals coming from the detector to the acquistion system for A/D conversion and for further digital processing.

In the particular case where the Si:As detector will be used, we need a 16-channel pre-amplifier with a band width up to 4 MHz. In addition, it is foreseen that a circuit section for biasing the detector and for buffering the control signals for the readout procedure will be needed. In order to ensure remote monitoring on the correct detector's biasing, we plan to adopt a multiplexing technique for the video signals and the bias voltages on the output lines feeding the A/D converter.

Acquisition and Control System

The system consists of a small rack housing some processing units based on transputer processors and on digital signal processors (DSPs), connected on a custom bus in such a way to perform a small transputer network. The control signals (digital clocks for detector scanning and triggers for the conversion unit) are supplied by a sequencer based on a DSP. Data transfer is guaranteed at 10 Mbits up to 1 km distance. A different link with the same electrical characteristics is devoted to command handling between remote host and sequencer. A processing unit, based on one or more transputer processors, is foreseen for all the needs of digital processing (e. g. co-adding) on data collected by the A/D unit, as required by the different integrating modes that an infrared observation may need. Four 4-channel 12 bit 2 MHz A/D converter units are required for parallel analoge-digital conversion on the 16 video channels: each unit has a transputer processor controlling four A/D channels, storing data on to a 8 Mbyte DRAM onboard and handling communication on the transputer network.

Remote Host

A 486/100 MHz PC will be used as the control host. The PC has to be equipped with a transputer interface to match the standard communication links used for the acquisition system; hence the transputer-bus AT/XT interface has to be provided with the same optical decoupler that the sequencer adopts in the acquisition system.

4 THE TELESCOPE CONTROL SYSTEM

The control system of IRAIT will be developed in collaboration with the Telescience group who are responsible for the development of a centralized and coordinated management of all the scientific experiments supported by the PNRA. The general hardware functional blocks diagram of the system is given in Figure 2. A workstation and a PC (the IR-camera remote host, not shown in Figure 2) and three VME systems will provide the intelligence necessary to perform the unattended observing process.

Here we give a list of only the most important functions that will be implemented in the control system software, which has been designed in order to operate IRAIT both from Italy and from Antarctica.

From Italy it will be possible to prepare, modify and upgrade the scheduling; utilize the data obtained by the IR-camera; control the progress of the schedule;

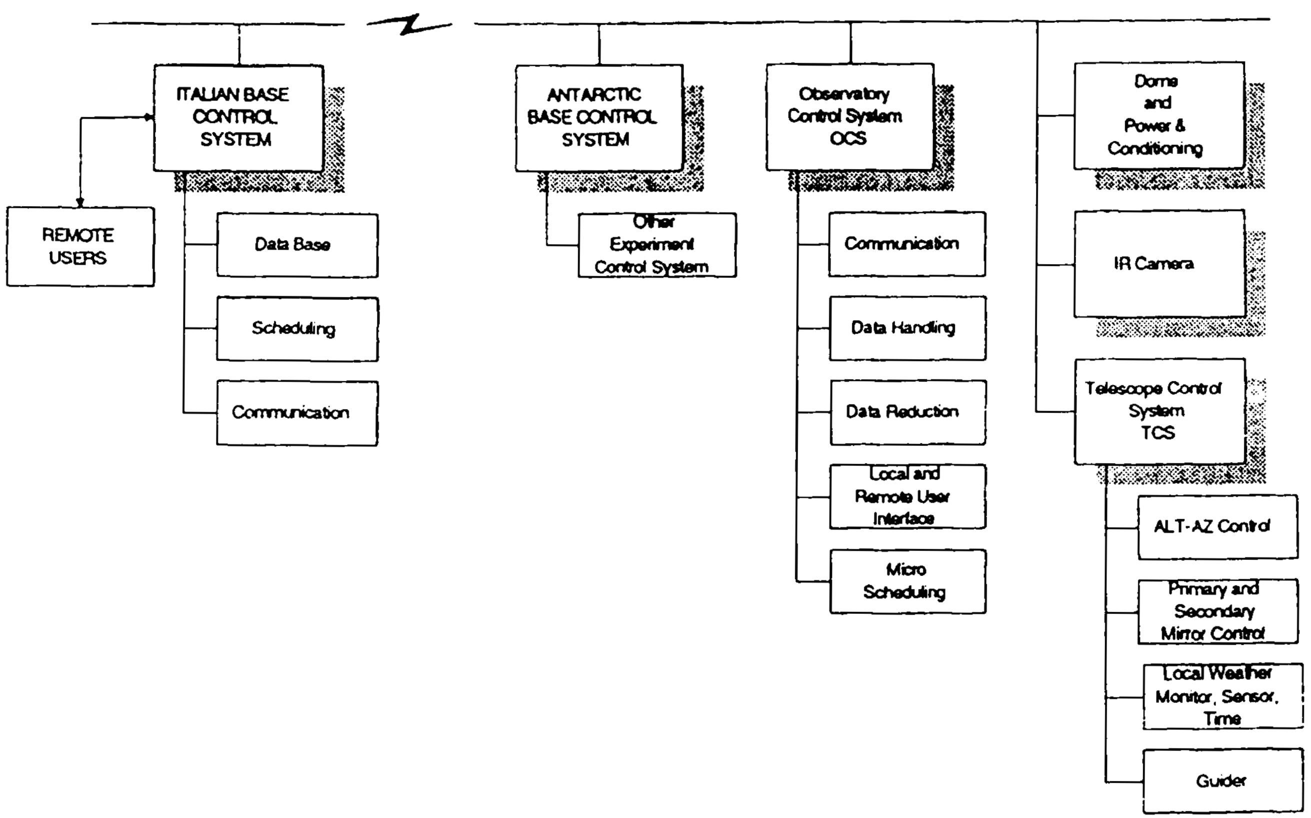

Figure 2 Functional block diagram of the IRAIT control system. The grey areas indicate the subsystems for which software analysis is still in progress.

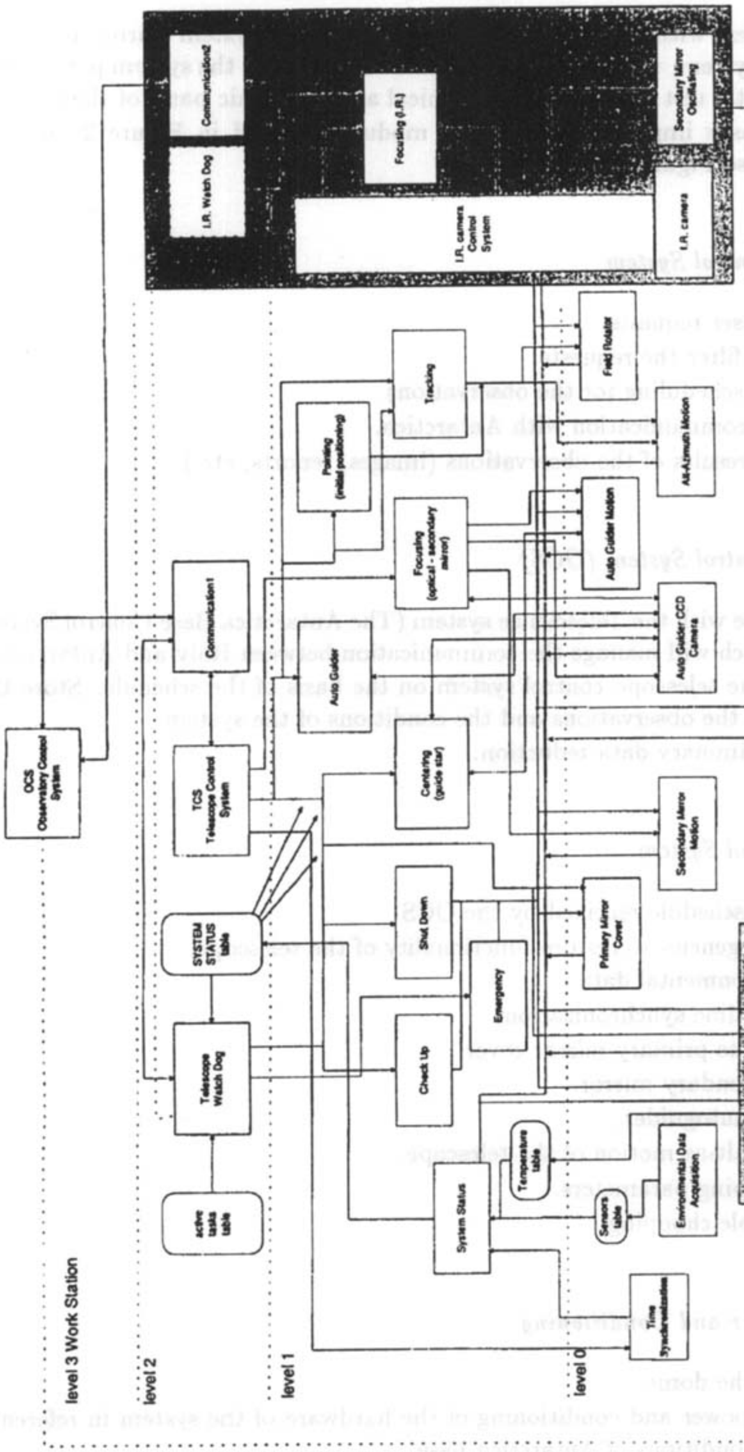

Figure 3 The software architecture of the IRAIT control system.

monitor the system with full access to all the tasks; recover system alarms; interrupt and reboot the system; upgrade the system software; backup the system parameters and scientific data; test the optical, mechanical and electronic parts of the system.

The main tasks implemented by each module reported in Figure 2, are the following (see also Figure 3).

Italian Base Control System

Collect the user requests.
Analyse and filter the requests.
Produce the scheduling for the observations.
Manage the communication with Antarctica.
Manage the results of the observations (images, reports, etc.).

Observatory Control System (OCS)

Communicate with the Telescience system (The Antarctica Base Control System in Figure 2) which will manage the communication between Italy and Antarctica.

Command the telescope control system on the basis of the schedule. Store the data concerning the observations and the conditions of the system.

Perform preliminary data reduction.

Telescope Control System

Arrange the schedule received by the OCS.
Control emergencies to restore functionality of the telescope.
Collect environmental data.
Perform the time synchronization.
Open/close the primary mirror cover.
Move the secondary mirror.
Manage the autoguider.
Manage the alt-az motion of the telescope.
Set the chopping parameters.
Enable/disable chopping.

Dome and Power and Conditioning

Open/close the dome.

Control the power and conditioning of the hardware of the system in reference to the climatic conditions of Antarctica base.

5 CONCLUSIONS

In order to obtain robotic observations in the mid-IR it is very important to know, in real time, the environmental data to evaluate the conditions under which each measurement is taken. To collect these data IRAIT will be equipped with some auxiliary devices.

A weather monitoring system (temperature, pressure, wind velocity and direction, humidity, snow, clouds).

A radiometer to measure the water-vapour content of the atmosphere.

A bolometer on the telescope beam to obtain sky-noise and transparency data.

A device to measure the telescope emissivity.

Moreover, other indispensable devices that will be integrated into the IRAIT system will be:

A dome to protect the telescope.

A GPS receiver for time synchronization.

A conditioning system to protect all the computers and electronic systems.

All the devices will be careful tested in Italy before their integration in Antarctica. The project will be completed through the the following steps.

Development of a alt-azimuthal telescope using technologies that are compatible with the habitat of Antarctica (range of temperature from −80°C to −20°C).

Development of the control system of the telescope.

Development of the control system of the observatory.

Development of the infrared camera and its control system.

Installation of the telescope at Montone (near Perugia) where an observatory is under construction to test the telescope, the control system and the Telescience remote supervision system.

Simulation and testing of the remote control system.

Delivery and installation of the system at Terranova Bay.

Integration of the system and final tests.

Installation of the telescope at Dome Concorde on the Antarctic Plateau in early 2000.

Using the Si:As detector, the expected limiting magnitude of the telescope-IR camera system at $\lambda = 9.8\ \mu\text{m}$ ($\Delta\lambda = 0.95\ \mu\text{m}$) is 6.4 if the integration time is of 5 min.

The telescope-mid-IR camera combination we are developing will be used to investigate, with a high spatial resolution power, a quite large number of fundamental issues of modern astrophysics. In particular, our primary scientific goals will be to study the energy distribution of young stars in dark clouds; the asymptotic giant branch stars; the dust distribution in planetary nebulae; the infrared energy distribution of the active galactic nuclei.

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