Centro de Estudios de Física del Cosmos de Aragón

REQUIREMENTS FOR THE WIDE FIELD FOCAL PLANE IMAGER FOR THE 80cm TELESCOPE OF THE OBSERVATORIO ASTROFÍSICO DE JAVALAMBRE

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1. APPLICABLE DOCUMENTS

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2. REFERENCE DOCUMENTS

	Doc title	Doc Number
RD1	Centro De Estudios De Física Del Cosmos De Aragón, The Project. M. Moles, 2008.	
RD2	Memoria Descriptiva	
RD3	OAJ T80 Optical Design Report	OAJ-TRE-AMO-3000-004-i5
RD4	Informe Sísmico	

3. LIST OF ACRONYMS AND ABBREVIATIONS

CEFCA	Centro de Estudios de Física del Cosmos de Aragón
CSB	Control and Service Building
T80Im	Wide Field Focal Plane Imager for the T80, including cooling system, vacuum pumps, detector and its electronics, control software, entrance window and mechanical flange to attach it to the Telescope.
EW	Instrument Entrance Window
FoV	Field of View
GdA	Government of Aragón
OAJ	Observatorio Astrofisico de Javalambre
J-PLUS	Javalambre Photometric Local Universe Survey
MPMNT	The MPMNT is the night-time per year that the system is not available for operation due to planned (preventive) maintenance tasks.
T80	OAJ 80cm aperture telescope
RON	CCD read-out noise

TBC: "To Be Confirmed" by the CEFCA during Contract negotiations or at an agreed date during Contract duration.

TBD: "To Be Defined" and agreed between the CEFCA and the Contractor at the time of Contract signature or at an agreed date during Contract duration.

4. DEFINITIONS

T250	The 250cm aperture OAJ telescope
T80	The 80cm aperture OAJ telescope
T80Im Support Flange	The mechanical flange to attach the T80Im to the T80 telescope.
Critical Damage	Refers to any damage that can cause a structure collapse or a risk to produce it, or a decrease in the serviceability during the life cycle, that is, a damage that reach the survival limit assumed in the design of the T80Im. Additionally, critical damage will be any damage that prevents any instrument subsystem from working within specification or that constitutes a system failure.
Cryostat	Refers to the main body of the T80Im. It includes the entrance window, the detector and its electronics, and the elements to cool the system and to achieve and maintain the required vacuum.
Enclosure Building (EB)	The building enclosing the telescope. It includes the Enclosure Base and the Dome and some auxiliary installations
Dome	Enclosure rotating part.
Enclosure Control System (ECS)	The system that controls the Enclosure hardware, itself controlled by the Telescope Control System.
Failure	A *Failure* is defined as an event causing complete loss of observing capability which cannot be recovered by corrective maintenance (including fault identification) in less than 3 hours.
Observatory Control System (OCS)	The system that controls the Observatory, including the telescopes, instruments and monitors.
Telescope Control System (TCS)	The system that controls the Telescope, including the ECS.
Temperature of Reference	The temperature of reference for all the dimensions and tolerances, unless otherwise specified, shall be 8° C.
Contractor	Refers to the Company entrusted with the design and build of the Telescope and the EB

5. INTRODUCTION

The definition, construction, operation and scientific exploitation of the OAJ [*RD1, RD2*] will be the responsibility of the CEFCA. The basic profile of the CEFCA project has been defined in its statutes, approved in July 2008. The contract to build the OAJ was signed on March 22nd, 2010. The T80 will be installed by mid 2011.

The OAJ 80cm telescope (T80) will have a plate scale of 55.56"/mm and a f/# = 4.5 [*RD3*]. The FoV is 1.7° (diameter) with full performance, corresponding to 110mm, and 2° (diameter) with a reduced performance, corresponding to 130mm. The distance from the T80 instrument mounting flange to the Focal Plane is 160 mm.

The goal for the first year of operation is twofold. First it is intended to do the calibration tasks for the survey that will be done with the T250. We also plan to carry out a systematic study of galaxies in the Local Universe. Both objectives can be accomplished with a multi-band, photometric all-sky survey, about 8,000 square degrees, using broad-, intermediate- and narrow-band filters. The survey, called the *Javalambre Photometric Local Universe Survey* (J-PLUS), can be completed in about 2-3 years and will reach r~23 at the 3σ level.

The instrument specified below is intended for surveys with T80, starting with the planned J-PLUS. The specified chip covers a large fraction of the FoV with a pixel scale of ~0.5"/pixel, which is considered as an optimum solution.

5.1. Functional Description

The Wide Field Focal Plane Imager for the T80 telescope has the following main components, starting at the instrument flange of the telescope:

- Instrument Support Flange.
- Cryostat, containing:
  - Entrance window.
  - Science detector.
  - Detector controllers.
  - Cooling system.
  - Vacuum system.
- Amplifiers and Control Electronics.
- Control Software.

The present document describes the specifications for this instrument.

6. AIM OF THE CONTRACT

The aim of this contract is the fabrication and procurement of the Wide Field Focal Plane Imager for the T80 telescope, T80Im hereafter, whose requirements, cost and schedule are presented here.

7. OVERALL REQUIREMENTS

T80Im includes the instrument support flange, the entrance window, the vacuum and cooling systems, the science detector with the corresponding electronics and the control system. The necessary interfaces will be defined during the design phase.

7.1. Functional and Operational Requirements

7.1.1. Wavelength Range

T80Im shall observe in the wavelength range 330-1000 nm and shall be optimized for the wavelength range 360-885 nm.

7.1.2. FoV

T80Im will not produce any additional vignetting of the telescope FoV [*RD3*].

7.1.3. Physical Requirement

The Wide Field Focal Plane Imager for the T80 telescope shall be compliant with the mechanical specifications and conditions to be installed at the Cassegrain focus of the T80. The following T80Im physical requirements should be used as a guideline, final requirements will be defined during the design phase.

7.1.3.1. Allocated Volume

T80Im shall fit inside the allocated volume defined by a cylinder of 600 mm (diameter) x 408 mm (height).

7.1.3.2. Allocated Weight

T80Im weight shall not be greater than 30 kg.

7.1.3.3. Center of Gravity

Its center of gravity position will be defined during the design phase.

7.1.4. Mechanical Interface

7.1.4.1. Instrument Support Flange

The T80Im shall be coupled to the T80 through the instrument support flange. The T80 shall provide the right attachment surface to the instrument support flange.

7.1.4.2. Mechanical Stability

The instrument support flange of the T80Im shall ensure its mechanical stability so the flexures will be compatible with the image quality and pointing accuracy of the telescope at any position within the range of operation of the telescope, i.e., down to 70° of zenith distance.

7.1.5. Cable Wrap

The T80 telescope will have a cable wrap on the DEC axis side.

7.1.5.1. Cross Section

The T80 cable wrap will have a cross section of 50x50 mm^2. T80Im shall use approximately 25% of the available cable wrap cross section.

7.1.5.2. Bend Radius

The minimum bend radius inside the instrument cable wrap shall be 100mm.

7.2. Operational Requirements

7.2.1. Environmental Requirements

T80Im shall be designed to operate and survive in the general conditions of the OAJ. In particular, it shall operate in the conditions given in the table below.

The instrument requirements shall be fulfilled under the Nominal conditions. The instrument shall be able to operate up to the Limit of operation conditions but the instrument specification need not be fulfilled to this level. Under Survival conditions the instrument is assumed not to be in operation.

		Nominal conditions	Limit of operation	Survival limit
Temperature		-15°C to +10°C	-20°C to +20°C	-25°C to +25°C
Thermal variation (at night) in 15 minutes		0°C to 0.9°C	N/A	N/A
Thermal variation (at night) in 1 hour		0°C to 1.8°C	N/A	N/A
Thermal variation (at night) in 2 hours		0°C to 2.4°C	N/A	N/A
Relative humidity		2% to 90%	95% (or condensation)	0% to 100% with condensation
Wind	Nominal	Up to 18 m/s	24 m/s (averaged over 15 min)	N/A
	Gust peak speed	N/A	30 m/s	N/A

7.2.2. Earthquake survival

The instrument shall be able to survive earthquakes (both while mounted on the telescope and when stored in the storage place) with the characteristics defined in the *Informe Sísmico [RD4]*, without suffering critical damage.

7.2.3. Low reflectivity Guideline

All the units and components of the T80Im should be finished so that they have a very low reflectivity in the operation wavelength range, in order to minimize the amount of scattered light incident on the scientific detector. However, the outside part of the instrument should have a reflectivity such as to avoid undesirable thermal gradients at its interfaces.

7.2.4. Thermal Requirements

7.2.4.1. Thermal Inertia

The T80Im should be made of materials and/or structures with low thermal inertia.

7.2.4.2. Heat Dissipation

The design of the T80Im and its components should minimize the amount of heat dissipation to the telescope chamber.

7.2.4.3. Isolation and Refrigeration

The T80Im shall be isolated or refrigerated to dissipate (in heat) less than 100 W (TBC) into the telescope chamber. The heat excess (over 100 W) shall be removed by using flow-regulated glycolate water provided by the OAJ at the focal Station.

7.2.5. Temperature Requirements

The temperature of the external surfaces of the enclosures of active heat sources located close to the optical light path, or potentially creating convective thermal flow into it, should differ negligibly from the ambient temperature.

7.2.6. Packaging, Handling, Storage and Transportation Requirements

The equipment supplied under the resulting contract shall be cleaned and prepared in the workshop prior to shipping. The design of the items and packages shall prevent them from being damaged under the conditions at the OAJ site.

7.3. Reliability Requirements

7.3.1. Instrument Lifetime

The T80Im shall be designed for a minimum lifetime of 10 years of operation, comprising an average 12 hours of observation and 12 hours of stand-by per day.

7.3.2. Overall Reliability

As a general rule, a high reliability shall be enforced in the design and manufacturing process by appropriate methodology and review.

7.3.2.1. Non-Scheduled Down Time

The T80Im shall be designed and manufactured in order to ensure that the non-scheduled down time does not exceed 2% of the observing time.

7.3.2.2. Mean Time Between Failures

T80Im shall be designed for a Mean Time Between Failures of 1 year at least.

7.4. Maintenance and Support Requirements

7.4.1. T80Im Components

CEFCA will operate the T80Im and perform the on-site maintenance. The components of the instrument should be standard, commercial and well proven and should be selected in such a way as to facilitate their maintenance.

7.4.2. Maintenance Tasks

Maintenance tasks shall be as simple as possible. The T80Im shall follow a modular design, which will allow easy exchange and maintenance of its modules.

7.4.3. MPMNT

The instrument shall have an MPMNT of 3 hours per year as maximum.

7.4.4. Components Access

It shall be possible to dismount the instrument and access its components in a straightforward manner in order to facilitate maintenance. Any component that it foreseeable may require to be exchanged during the night should have easy and simple access.

7.4.5. Spare Parts

T80Im shall be delivered together with a list of the spare parts that are foreseen for the minimum lifetime of 10 years of operation.

8. TECHNICAL REQUIREMENTS AND FUNCTIONALITY

The requirements for the different components of T80Im are given here below.

8.1. Instrument Support Flange

The Instrument Support Flange shall be coupled to the T80 so that the telescope and the T80Im stay aligned without noticeable distortion or flexures. The Instrument Support Flange shall include some elements to minimize the entrance of undesirable light inside the cryostat.

8.2. Cryostat

The Cryostat should allow easy operation and maintenance of the detectors. The maintenance operation shall be assumed to be done during day-time.

8.2.1. Temperature Control

The cooling system and cryostat shall guarantee that there are no significant temperature gradients across the detector. The cryostat must guarantee that, once

reached, the required conditions of temperature and vacuum will be stable within the required precision for 1 week at least.

8.2.2. Vacuum Control

The cryostat shall incorporate all the mechanical elements and connectors necessary to produce and maintain the vacuum level and the required working temperature of the detector, and all the probes to monitor and control those conditions.

8.2.3. Additional Requirements

- i) Cooling time from ambient should be < 12 hours with a goal of 4 hours.
- ii) Warming time to ambient should be < 4 hours
- iii) Temperature gradients (while cooling or warming up) should not to exceed 2K/min (TBC).

8.3. Entrance Window

The Entrance Window (EW) is the last optical element of the T80 and it will be provided by CEFCA. However, the window integration is part of this contract. The EW shall be made of Suprasil (n=1.458) and shall have a plano-concave shape. The EW shall have the following requirements.

8.3.1. Free Diameter

The EW shall have a free diameter of at least 130.68 mm, and it will not introduce any additional vignetting of the telescope FoV.

8.3.2. Radius of Curvature

Under vacuum conditions, the EW shall be concave with a radius of 1150 mm ± 3μm. The second surface shall be flat.

8.3.3. Reflections, Ghost Images and Background Radiation

Reflections, ghost images and background radiation will contribute to less than RON per pixel.

8.3.4. Thickness

The EW thickness at its center shall be 10 mm ± 10μm.

8.3.5. AR Coating

The EW shall have anti-reflective coating to achieve transmission over 98% in the whole working spectral range, from 330 nm to 1000 nm.

8.3.6. EW-Focal Plane Distance

The distance from the inner surface of the EW to the focal plane shall be 8 mm ± 100 μm.

8.3.7. Parallelism between the EW and the focal plane

Departure in the parallelism between the EW and the nominal focal plane shall be within 20 μm.

8.3.8. Decentering

The EW decentering tolerance shall be 50 μm.

8.4. Detector

8.4.1. Detector Format

The detector will be a science grade large format CCD, larger than 9000x9000 pixels with a pixel size of 10μm at most, with 16 amplifiers and reading ports. The chip will be *thinned, backside illuminated* and *blue enhanced.* It shall have a QE higher than 70% between 350 and 800nm, with a peak of ~95%, and higher than 40% in the spectral range 330 to 900nm. The detector choice shall be agreed by CEFCA. The detector, its testing, characterization, acceptance and installation are part of this contract. The acceptance of the detector shall be agreed by CEFCA.

8.4.2. Detector Controllers

T80Im will include the control electronics for reading the detector. It will be designed and built to allow the user to select different working modes including the requirement to modify the read-out time, the binning factor or defining regions of interest. The selection will be done through low-level routines and through the control software from a PC. Priority will be giving to minimizing the RoN for a given read-time in a range that will allow for full frame read-outs in less than 20s.

8.5. Cooling system

8.5.1. Operating Temperature

The sensor will be cryo-cooled to a nominal operating temperature between minus 100ºC and minus 110ºC. The cooling system will be selected to fulfill the requirements with the minimum level of vibration (compatible with the required image quality at the focal plane), but avoiding, if possible, gas lines and the use of oil.

8.5.2. Maintenance Operations Frequency

The cooling system shall be chosen such that the detectors remain cold enough, without any maintenance operation, for at least one week.

8.6. Vacuum system

A Vacuum unit appropriate to fulfill the requirements of the cryostat will be identified and supplied.

8.6.1. Evacuation Time

The vacuum system shall evacuate the detector in about 1-2 hours.

8.6.2.Operation Pressure

The vacuum system shall reach a low pressure to avoid pumping of the residual gas, mainly water adsorbed on the walls, by the cold CCD. The system shall attain 10^{-6} mb before the crycoolers are switched on.

8.6.3.Additional Requirements

The vacuum system shall be as much as possible oil and vibration free.

8.7. Image Acquisition Electronics and Control Software

8.7.1. Communication with the TCS

The general control of the T80Im shall be able to communicate with the TCS and OCS.

8.7.2. Image Acquisition

The image acquisition will be done from a PC. The images will be in FITS format. The headers of the images will include all the relevant information on the state of the

instrument, the regions of interest of each readout port (overscan or prescan, image data), the exposure time, the filter used, the reading mode, binning, gain, saturation and RON, the kind of image (science, flat, acquisition, bias, dark,...), together with the position of the telescope and dome, the time of the start and end of the exposure, the average air mass, and the general conditions of the telescope when the image was taken.

8.7.3. Control Software

The control software of the T80Im will include an SDK that can be installed and run in the common operative systems like Linux. It shall be able to communicate with the Telescope and Observatory Control Systems to make the whole system accessible by remote control.

8.7.4. Control Software Documentation

It will be documented to allow the operation by staff of the Observatory. Training will be given by the contractor to the staff of the OAJ.

8.7.5. Control Software Source Code

The source and compilation modes of the control software will be considered a deliverable, as part of the T80Im.

9. ELECTROMAGNETIC COMPATIBILITY

The T80Im electronic control and image acquisition systems shall be able to work without interference when other devices such as the filter unit or the telescope are operating.

10. WORKING AND VERIFICATION PLAN

The total term of T80Im manufacturing process is 12 months, with the partial deadlines identified in the following phases:

- ***Phase 1. Design of the T80Im.*** During this phase the contractor shall produce a detailed design of the instrument and its components and subsystems, including the detector choice, to fulfill the requirements. The detailed design and the detector selection shall be agreed and approved by CEFCA. This phase shall not take more than 1 month.

- ***Phase 2: Characterization and Acceptance of the scientific detector:*** The contractor shall procure, characterize and accept a scientific detector that fulfills the requirements. The acceptance of the detector shall be agreed by CEFCA. This phase shall be finished within 6 months after the detailed design has been approved by CEFCA.

- ***Phase 3: Building, Assembling and verification.*** The contractor shall manufacture the different parts of the instrument. The T80Im shall be assembled at the contractor's premises where the T80Im will be tested for functionality and verification. People from CEFCA will be invited to participate in the testing in order for CEFCA to certify the fulfillment of the requirements. This will constitute the Preliminary Acceptance of the T80Im. The building, assembling and verification of the T80Im shall be finished within 3 months after the detector acceptance.

- ***Phase 4: Packing and shipping to CEFCA.*** After the Preliminary Acceptance the T80Im will be disassembled, packed and shipped to the CEFCA, in Teruel. The T80Im should arrive CEFCA in no more than 1 month after the Preliminary Acceptance.

- ***Phase 5: Verification at the Telescope.*** Once T80Im arrives in Teruel, CEFCA shall make all tests to verify the integrity and functionality of the T80Im. Then CEFCA will install T80Im at the T80 for the final verification tests on the sky. The whole process shall not take more than 1 month. This process will be terminated with the Final Acceptance certificate.

11. COST

The maximum cost of the present contract shall be of US$ 354.000 (~245.322 €) including taxes, this corresponds to US$ 300.000 (~207.900 €) plus US$ 54.000 (~37.422 €) of taxes (18 % IVA).

Zaragoza, a 11 de 5 de 2011

El VICEPRESIDENTE DEL PATRONATO

Fdo: Javier Velasco Rodríguez