EST NEWS 14

THE EUROPEAN SOLAR TELESCOPE NEWSLETTER

JUNE 2024

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COORDINATOR'S CORNER

EST continues making progress. The EST Foundation is already a consolidated entity after having accomplished all the required legal steps. Most relevant is that a new institution joined the Foundation: the University of Graz has become a new member and is duly represented at the Board. With it, the Foundation already comprises ten institutions from eight European countries. Efforts continue to make the consortium larger with the help of the communities that are not yet represented.

A major step for the project is expected to be achieved soon with the appointment of the Director and Administrator. Both positions were announced at the beginning of the year and the processes are in the last stages for the decision.

This issue also includes a summary of the present status of some EST subsystems. An update of the Pier Optical Path (POP) is reported. The POP is the optical subsystem that transfers the light from the F2 focal plane generated at the exit of the telescope to the F3 focal planes in the observing rooms where the instruments are to be located. This subsystem was already described in the last issue of the Newsletter. Here, important updates in its design are described. The Polarimetric Calibration and Alignment Assembly, which hosts all elements required to confirm and ensure the proper performance of the telescope and instruments, is also summarised. Finally, the EST Control System, responsible for the real-time coordination and synchronisation of the operation of the telescope and instruments is also described.

The Newsletter is complemented with various communication and outreach activities in different countries and with the usual section of newcomers to the project.

M. Collados, EST Foundation Board President

THE UNIVERSITY OF GRAZ JOINS THE EST FOUNDATION

The University of Graz has officially become a member of the EST Foundation. With this addition, the entity now comprises 10 European institutions from 8 countries.

Main building of the University of Graz. Austria. Credit: Michael Kopp in Pixabay.

The EST project concluded the year 2023 with an important news: the EST Canarian Foundation is now expanded with the inclusion of the University of Graz, representing Austria. The University of Graz, one of the largest institutions in the country, becomes the tenth European institution to join the Foundation as a full-fledged member for the next two years. The decision was formalised during the meeting of the Foundation's Board of Trustees on 19 December 2023.

Dr. Philippe Bourdin is the liaison person chosen by the University of Graz to represent the institution on the Board of Trustees. This board serves as the main governing body of the EST Foundation and is responsible for representing and exercising all the powers necessary to achieve the Foundation's aims. Bourdin currently works as a group leader in the field of Computational Solar Physics at the Institute of Physics of the University of Graz.

Dr. Philippe Bourdin. Credit: UniGraz

This development not only signifies the addition of a new country to the EST Foundation, but also indicates the growth of the consortium, which will facilitate the fulfillment of the objectives set to achieve the construction of the largest solar telescope in Europe.

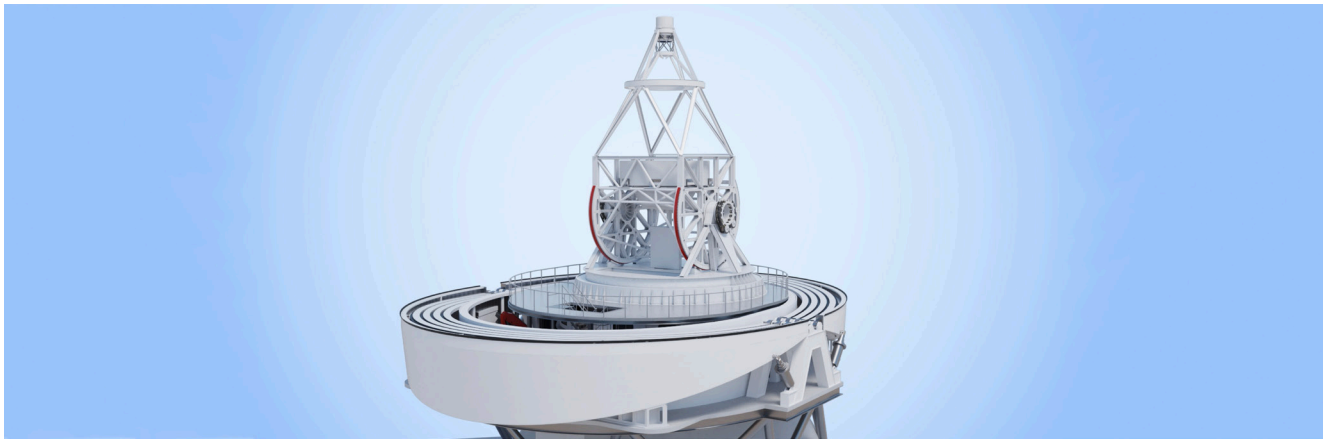
The updated list of members of the EST Foundation, arranged in alphabetical order by countries, is as follows:

- University of Graz (Austria)
- Astronomický Ústav AV ČR, V. V. I. (Czech Republic)
- Institut für Sonnenphysik, KIS (Germany)
- Max Planck Institute for Solar System Research (Germany)

- Astronomický ústav Slovenskej Akadémie vied (Slovakia)
- Agencia Estatal Consejo Superior de Investigaciones Científicas and Instituto de Astrofísica de Andalucía (Spain)
- Instituto de Astrofísica de Canarias (Spain)
- Stockholms Universitet (Sweden)
- Università della Svizzera italiana - Istituto Ricerche Solari Aldo e Cele Daccò (Switzerland)
- University of Sheffield (UK), for the UK Universities Consortium.

SELECTION OF DIRECTOR AND ADMINISTRATOR OF THE EST FOUNDATION

At the beginning of January, the terms and conditions for filling the positions of Director and Administration of the EST Canarian Foundation were announced.



Rendering of the European Solar Telescope structure. Credit: IDOM.

The EST Foundation is a private non-profit organisation comprising ten research institutions and universities from eight European countries. It was created to support the EST project through scientific research and engineering, as well as to increase societal benefits and business competitiveness by generating technological knowledge, to collaborate with public research organisations, and to support education and training. Its main mission is to complete the design of the European Solar Telescope and to facilitate its construction and operation, fulfilling the objectives described in the Foundation's statutes.

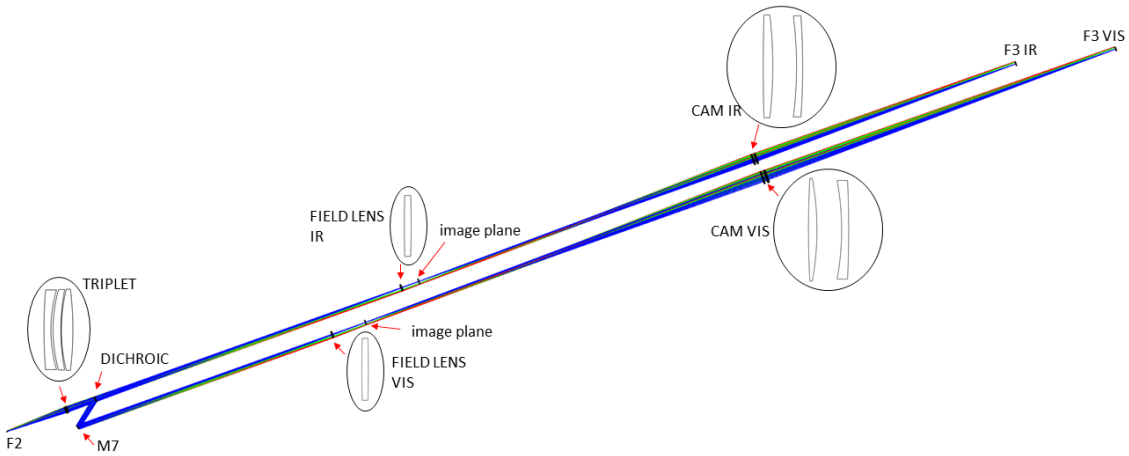
The Director, who shall be an active astrophysicist of recognised international prestige with proven experience in the leadership of international projects and demonstrated skills in leading high-impact research teams, will be responsible for the global management of the Foundation's action plan. The successful candidate should focus on the definition of the EST European Research Infrastructure Consortium (ERIC) and the consolidation of the plan to make the construction of EST a reality. S/he shall also be responsible for executing the agreements of the Board of Trustees and for managing and overseeing the Foundation organisation. Additionally, the Director may be assigned additional duties by the Board of Trustees or the Executive Committee as necessary to achieve the Foundation's objectives.

On the other hand, the Administrator, who shall have a wide experience in the field of management of international projects or centres, will be responsible for effectively managing, coordinating, and overseeing all of the Foundation's administrative activities, including human resources, finances, procurement, and legal issues. Additionally, s/he shall assist the Director in the tasks assigned by the Board of Trustees, aiming to achieve the Foundation's objectives.

At the time of writing, the selection process is still ongoing for the two positions, although a final decision is expected soon following the interview phase with the candidates. At this stage, special emphasis is being placed on assesing their experience in projects of a similar nature, their professional background and their vision of the EST project and how to move forward towards the creation of the EST ERIC.

EST PIER OPTICAL PATH DESIGN UPDATE

An overview of the latest modifications implemented in the EST Pier Optical Path design is given.



Optical elements of the EST Pier Optical Path, transferring the light from the Gregorian focus F2 to the science focus F3.

The Pier Optical Path (POP) is the lens system which transfers the secondary focal plane (F2) of the telescope to the science focus (F3) in the Coudé rooms, where the light will be distributed to the different science instruments.

After an in-depth internal analysis and some conversations with manufacturers of deformable mirrors and optical glasses, it became evident over the last months that some modifications needed to be implemented in the POP optical design.

Firstly, some issues were detected with the manufacturability of the lenses using the selected materials. This is due to the fact that the capabilities of optical glass manufacturers are limited when working with large apertures, as is the case with EST. Secondly, a technological gap was identified in the manufacturing of deformable mirrors with a pitch size between 2.5 and 5 microns. As a consequence, M7, the deformable mirror located inside the POP, had to adopt a diametre above 250 mm or below 125 mm in order to have the same number of actuators as the adaptive secondary mirror M2.

With the new information available, along with the rest of requirements, the design of the EST POP was updated. The first decision made was to reduce the size of the intermediate pupil from 200 to 125 mm to solve the M7 size problem. A pupil above 250 mm in diametre would have implied an aperture of the triplet lenses larger than the manufacturing limits for most optical glasses, making it impossible to use a combination of materials that would provide adequate chromatic correction.

This decision necessitated a change in the design concept to maintain certain parameters such as telecentrism and an F/50 beam at the output. The collimator-camera concept had to be discarded in favour of an optical relay which produces an extra intermediate image and pupil plane inside the POP. This approach allowed the required parameters and mechanical envelopes to be maintained, at the cost of having an extra optical surface in the form of a field lens, which is made of a highly transmissive material across the entire spectrum, such as CaF_2.

The beam generated by the triplet was designed to be as slow as possible (F/75) to minimise the image degradation caused by the dichroic that divides the beam into the visible (VIS) and infrared (IR) branches of the POP. In this regard, the tilt introduced in the dichroic was also minimised by positioning it at 19º, identical to M7, which also enables offloading the weight of the tilt onto the correction of the deformable mirror.

Regarding the selection of materials for the POP lenses, their availability and manufacturability have already been confirmed with the manufacturers. The new combination of optical glasses enables achieving superior chromatic correction compared to the previous design. For each sub-branch beam in the Coudé rooms —blue, visible, red, and infrared— the maximum resulting chromatic shift is below 7 mm, 2 mm, 8 mm, and 4 mm, respectively. These values are much smaller than the defined 30 mm requirement, allowing the instruments to have a simpler refocusing mechanism.

All this is achieved with a POP design composed entirely of spherical elements with an optical quality well within the diffraction limit.

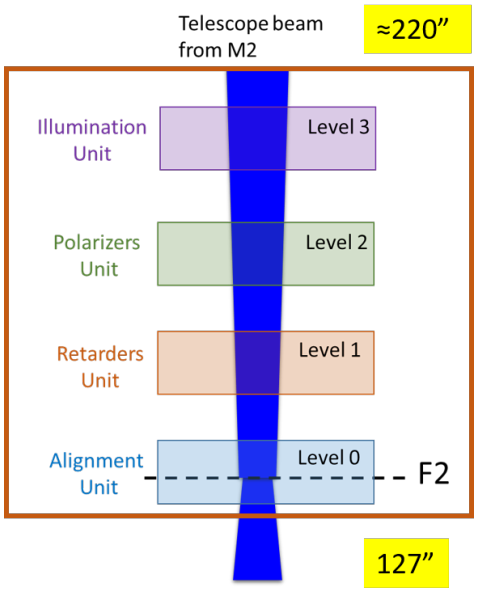
EST POLARIMETRIC CALIBRATION AND ALIGNMENT ASSEMBLY

EST is fitted with a Polarimetric Calibration and Alignment unit which is described below.

One of the primary objectives of EST is to measure magnetic fields in the solar atmosphere accurately, from the deepest photosphere to the upper chromosphere. This ambitious goal aims to uncover the thermal, dynamic, and magnetic properties of the solar plasma at high spatial and temporal resolution, as required to understand the magnetic and dynamic coupling of the various atmospheric layers.

Solar magnetic fields can be inferred from measurements of the polarisation state of the light in selected spectral lines formed at different heights in the atmosphere. Recognising the enormous importance of polarisation measurements for reaching the science goals of EST, the azimuth and elevation axes of the telescope were deliberately decentred from the optical axis during the design. This intentional offset allows for the optical path to be folded asymmetrically, resulting in a polarimetrically compensated layout that produces minimal instrumental polarisation. Indeed, the telescope Mueller matrix remains nearly independent of both the elevation and azimuth angles, as well as wavelength, which significantly reduces the time spent on telescope calibrations.

To determine the polarisation state of the incident light, however, it is essential to have a precise characterisation of the optical system. For this reason, just after the axis-symmetric mirrors M1 and M2, close to the instrumental polarisation-free secondary focus F2, space is reserved for the Polarimetric Calibration and Alignment (PCA) assembly. This positioning allows to calibrate the maximum number of elements of the optical train, and is especially advantageous for large apertures,



Components of the Polarimetric Calibration and Alignment Assembly of EST.

given the size of the beam. The PCA assembly is a sophisticated sub-system spanning four distinct levels which can be slid in and out of the beam, each playing a crucial role in ensuring the accuracy of solar observations.

Level 0, situated right at the Gregorian focus F2, serves as the initial stage of the PCA assembly. It comprises optical elements that will be used for the telescope assembly, integration and verification, as well for standard verifications during operations, with the field stop serving as the main component. This element is cooled and allows a 127 arcsec diagonal beam to pass through during regular observations. Alignment tools with pinholes and grids are foreseen to be housed also at Level 0.

The optical elements used for the telescope polarimetric calibration are located at Level 1 (retarders) and Level 2 (linear polarisers). Together, they generate known polarisation states of the light that is fed into the system, facilitating the determination of the polarisation properties of the optical train after the secondary focus F2.

Level 3 houses an illumination unit, which accommodates a broad spectrum illumination source and its re-imaging system. This system projects a beam onto the F2 focal plane, simulating the telescope's beam. The illumination unit will aid in alignment and calibration tasks when the dome is closed. The possibility of accommodating at Level 3 calibration elements for both the deformable mirror of the POP visible arm and the adaptive secondary mirror being explored.

The EST PCA assembly is more than just a calibration system: it is a gateway to unlocking the secrets of the Sun. Thanks to its calibration procedures and innovative design, EST promises to revolutionise our understanding of the solar atmosphere, providing unprecedented insight into the dynamic interaction of magnetic fields and plasma.

EST CONTROL SYSTEM

EST will integrate a large number of complex elements that must be orchestrated to meet its scientific requirements. This is the task of the EST Control System presented here.

The EST Control System (ECS) manages the main elements of the telescope and the instruments (see Figure 1). It is based on the control system used at the 10-m Gran Telescopio Canarias (GTC), one of the largest nighttime telescopes that has been operational for years. Together with the future New Robotic Telescope (NRT), all three telescope teams are collaborating to create a powerful basis for the control system.

The ECS is designed as a distributed system, constituted by a set of independent nodes, interconnected by the ECS network. Each of these nodes has its own physical resources and implements specific functionalities as an integrated component of the system, contributing to the global functionality of the telescope.

In order to coordinate and synchronise the operation of the telescope, the ECS offers a set of common services shared by all components of the system, as well as a set of services to operate the telescope.

The ECS follows the Inversion of Control design, where the operation services manage, coordinate and synchronise the components required to perform the operations carried out by the telescope. Figure 2 shows a diagram of the Inversion of Control design.

To integrate the various independent components into the system, the ECS architecture offers a set of frameworks that every component incorporates to follow the operation rules specified by the ECS. These include specifications to access user interfaces, services, device management, and control and data flow.

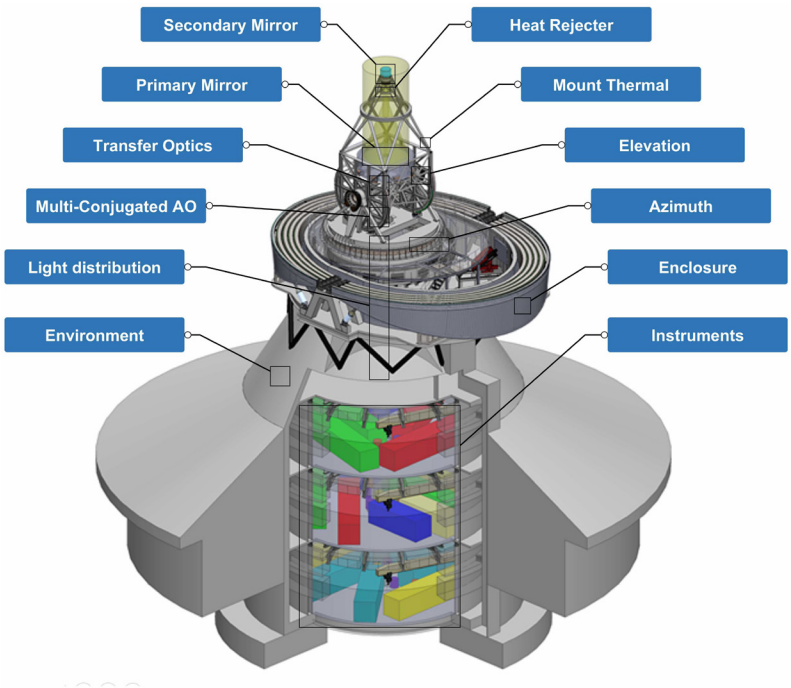


Figure 1. Main telescope elements to be managed by the EST Control System.

For the user interface framework, the engineering team is considering to adopt the latest front-end web-based technologies and tools to dynamically build the graphical user interfaces. One tool that the ECS will incorporate is PO-RIS, from the CosmoBots team. It will be used to create the scientific panels of the individual instruments by means of graphical design modelling. An alternative solution being considered for the ECS is to unify the front-end elements that the components will employ to interact with the users. The goal is to build and load them dynamically at execution time using different device supports. Figure 3 shows the flow followed by the user-interface framework employing the proposed design tools.

The ECS design must address several specific challenges. On one hand, EST is expected to generate a substantial amount of data during the

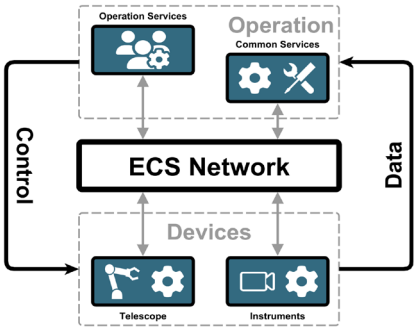


Figure 2. EST operation flow.

observations. On the other hand, EST will operate multiple sophisticated instruments simultaneously. The ECS needs to have the capability to handle an estimated amount of 30 PB (that is, 30 million GB) per day in the most challenging case when all the instruments observe for hours under excellent seeing conditions.

Although it is still under discussion,

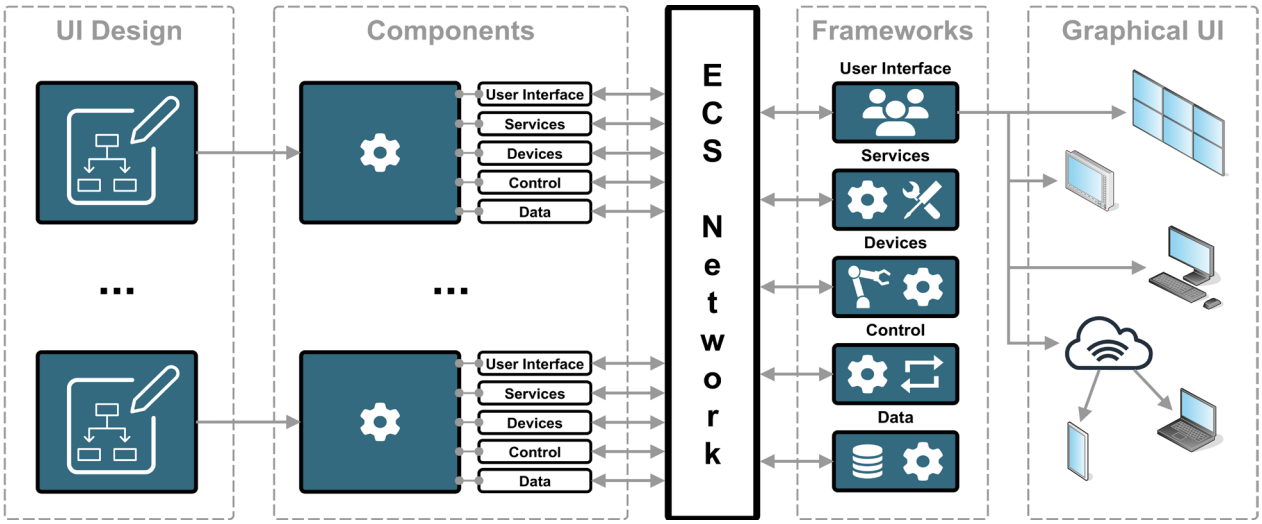


Figure 3. ECS user interface framework tools.

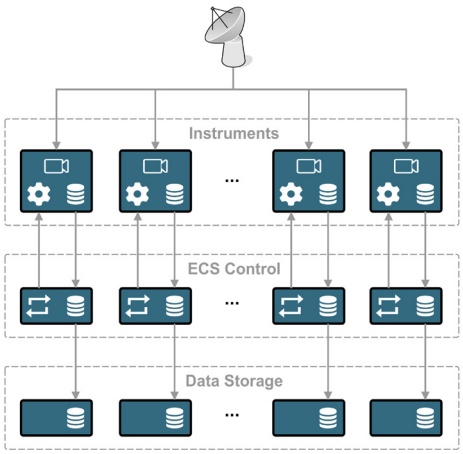


Figure 4. ECS data handling concept.

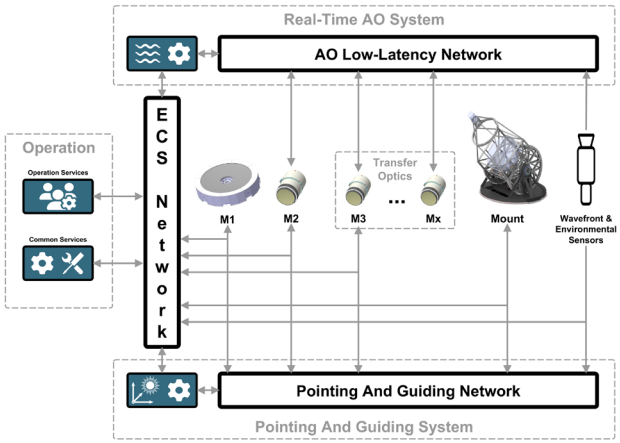


Figure 5. ECS concept for the telescope optical elements.

the current design foresees parallel and distributed data processing, as illustrated in Figure 4. Instead of retrieving the data generated by the instruments and then processing them in a centralised system, the instruments are expected to reduce and store the raw and calibrated data locally, until the ECS handles and stores the entire datasets.

Furthermore, EST will be equipped with state-of-the-art optics technology, including a 4.2-metre active primary mirror with around 100 actuators, a 0.8-metre adaptive secondary mirror with around 2000 actuators, and a multi-conjugated adaptive optics (MCAO) system. The adaptive optics (AO) system is a high-performance, low-latency system expected to operate in real time to correct the perturbations generated by the atmosphere. To achieve this, the AO system has to read real time information from several components, process it, perform the calculations, and act on the different mirrors through thousands of actuators to deform their surface. It must also verify that the calculations and compensations are correct. The entire process has to be performed in, at most, one millisecond. To meet this requirement, the AO system will have a dedicated real-time system to control the required components and deliver the highest image quality to the instruments during observations.

The ECS will manage these components along with the rest of the observatory's elements. Figure 5 shows the current design of the integration of the optics elements with the subsystems that use them and the other systems.

Considering all these aspects, the use of the latest developments in testing, integration, deployment, and front-end technologies is being evaluated in this design phase of the control system. All these elements are being developed and tested in the EST labs to create a control system that will be efficient and up to the needs of the telescope and its instruments.

COMMUNICATION AND OUTREACH ACTIVITIES

In 2024, the members of the EST consortium have continued to promote the project through their institutions and various outreach and communication activities. Efforts to disseminate the details and vision of the project remain ongoing.

Interview with Marianna Korsos on the local channel Kanizsa TV.

On 17 January, Robertus Erdélyi (University of Sheffield) visited the National Astronomical Observatory of China in Beijing and made a presentation there. One of the main topics of the talk was the European Solar Telescope.

In May, three educational talks on solar physics were given in Hungary, during which the most relevant aspects and curiosities of EST were discussed. Two of them, delivered by Erdélyi, took place at the Nagykanizsai Bethlen Secondary School and at Nagykanizsa Pannon University. On the other hand, Marianna Korsos (University of Sheffield and University of Catania) addressed a group of young aspiring scientists about the importance of solar physics and EST at La Kiskanizsai Primary School in Hungary. Korsos was also interviewed by Kanizsa TV, a local TV channel in Hungary serving the city of Nagykanizsa and its surroundings.

At the same time, in Budapest, Balazs Asztalos from the University of Eötvös and Szabolcs Soos from the Hungarian Solar Physics Foundation were running an open solar telescope demonstration with students at the University of Eötvös, taking the opportunity to explain the scientific objectives of EST.

In the same vein, on 24 March, a small

Open solar telescope demonstration. University of Eötvös, Budapest (Hungary).

Peter Gömöry presenting EST at the 'Vivat Scientia!' event in Lučenec (Slovakia).

Slovakian town called Lučenec hosted an event organised every month by the Slovak Academy of Sciences (SAS) under the name 'Vivat Scientia!'. During this activity, Peter Gömöry, director of the Astronomical Institute of the SAS and vice-president of the EST Foundation Board of Trustees, presented some details of the EST project to the public.

This was not the only occasion on which Gömöry had the opportunity to talk about the European Solar Telescope in the first half of 2024. On 17 April, he presented the project to representatives of the Ministry of Education, Research, Development and Youth and the Ministry of Investment, Regional Development and Informatisation of the Slovak Republic. This meeting took place at the headquarters of the Slovak Academy of Sciences in Bratislava.

The Slovak Academy of Science also published updated information about the EST Foundation on its website. The publication places special emphasis on the advantages of the country's membership in the EST Foundation for the Slovak scientific community, which will have a voice in key decisions related to the project. It also mentions the medium and long-term objectives of the foundation and the importance

Peter Gömöry addressing representatives from the Slovak Government in Bratislava.

of the project's inclusion in the European Strategy Forum on Research Infrastructures (ESFRI) for its continuity.

Meanwhile, the EST website continues to be updated. Renewed technical information has been uploaded on the EST Control System and local seeing simulations, including figures and diagrams created exclusively to illustrate these aspects of the telescope.

EST Consortium Gallery

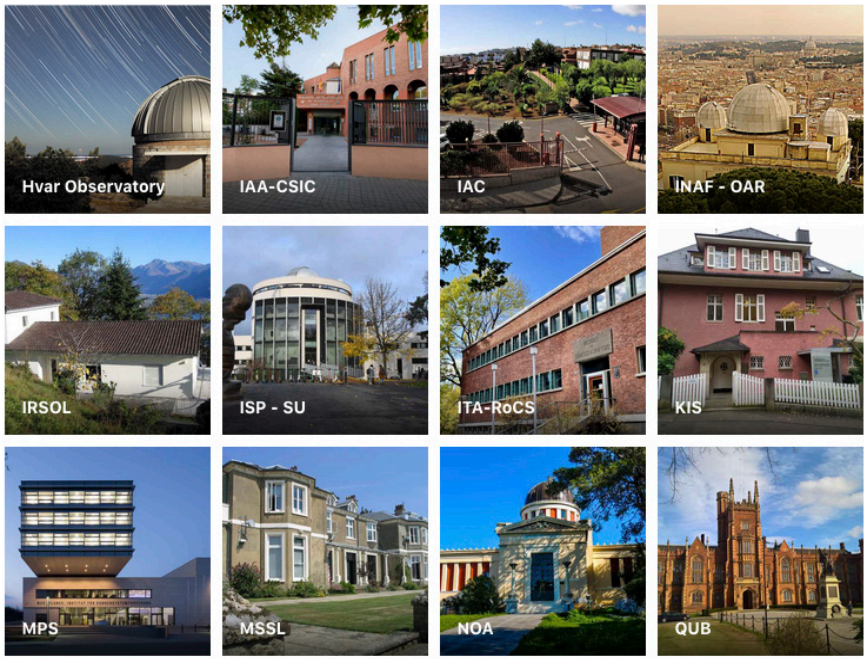
Without the support and collaboration of the European institutions involved in the EST consortium, the progress towards the construction of the European Solar Telescope would not be as tangible as it is today.

To recognise these efforts, a gallery of images has been created and published on the EST website, showcasing the twenty-three research centres committed to this scientific project.

A total of 16 European countries are represented in the gallery through photographs provided by the EST

consortium members, featuring their main buildings, headquarters, and various other facilities. Accompanying the most representative images, which will be periodically updated to keep the gallery fresh and current, valuable information and interesting facts about each institution are provided: foundation date, location, lines of research, human resources, and other curiosities. Additionally, links to the official websites of each institution are included for those who wish to learn more.

All images in the EST Consortium Gallery can be freely downloaded under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 international licence. As long as the authors and their institutions are properly credited, these images may be used for personal and institutional projects.



Example of EST Consortium Gallery entries on the EST website.

Drone recordings of solar telescopes

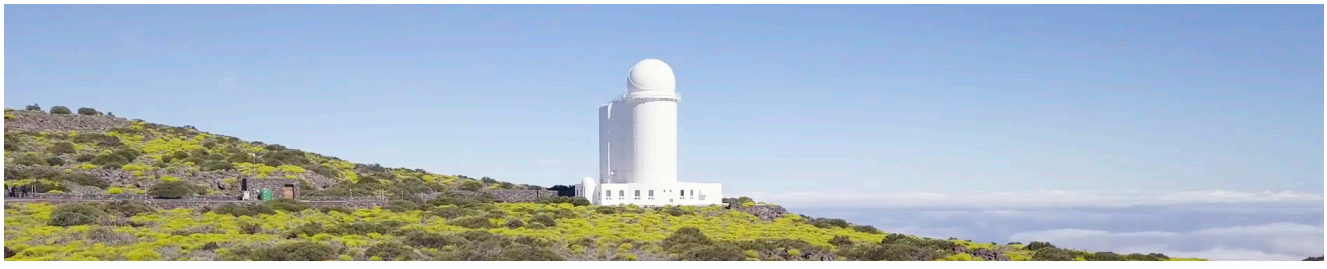
During the recording of the EST documentary 'Reaching for the Sun' between May and June 2018, the film crew used professional cinema cameras and drones.

These technical resources were employed to capture aerial shots of solar telescopes at Teide Observatory (Tenerife, Spain), the Einstein Tower (Potsdam, Germany), the Pic-du-Midi Observatory (Bagnères de Bigorre, France), and the future site of EST at Roque de los Muchachos Observatory (La Palma, Spain).

Some of these drone sequences were incorporated into the documentary, showcasing European solar research facilities from a unique perspective and enhancing the film's aesthetic. However, many minutes of footage were not used in 'Reaching for the Sun'. Therefore, the EST Communication Office decided to repurpose this material to create new audiovisual pieces.

To do this, more than five hours of recorded material were reviewed, with colour correction and homogenisation of the frame rates. From there, the new videos were edited, allowing audiences to appreciate the fresh perspective these recordings provide on leading solar physics facilities in Europe and around the world. These videos can be accessed on the EST website.

Drone's eye view of Observatorio del Teide.



Drone's eye view of the THEMIS telescope at Observatorio del Teide.

EST NEWCOMERS

HARIDIAN RAYA DOMÍNGUEZ

SECRETARY

Haridian is studying a university degree in tourism business administration and management. She also has a professional certificate in management and finance.

She has worked as administrative staff in several companies.

Haridian joined the EST Project Office in October 2023.

ALVARO PÉREZ-GARCÍA

OPTICAL ENGINEER

Álvaro holds a BSc in Optics and an MSc in Optical and Imaging Technologies from the Complutense University of Madrid. He has accumulated valuable experience in the field. Starting as a space optics intern at INTA, he ventured into optical applications for aerospace technology before transitioning into the private sector where he served as an Optical Design Engineer for night vision devices. From there, he went on to work at IAC, where his role as an Optical Engineer has involved his participation in several projects. Álvaro is part of the EST team and currently works on the telescope and transfer optics.

ANTONIO ZAMORA JIMÉNEZ

MECHANICAL ENGINEER

Antonio holds a bachelor's degree in Industrial Technology Engineering and a Master's degree in Industrial Engineering from Technical University of Cartagena. Interested in calculus and finite element analysis, he also holds a Master's degree in Numerical Simulation with majoring in dynamics and thermal analyses. His professional background is mainly as Mechanical Engineer at the IAC, working on cryogenics and developing instrumentation for microwave astronomy for almost the last four years. He recently joined the EST team as Mechanical Engineer for performing thermal and structural finite element analyses and design.

JAVIER SÁNCHEZ BARRANQUERO

TIS/FBI OPTICAL ENGINEER

Javier holds a degree in Physics from the University of Granada and a MSc in Optical and Imaging Technologies from the Complutense University of Madrid. He conducted his Master's thesis research on the design of ultra-compact telephoto lenses for astronomical applications in the Solar Physics Group at Instituto de Astrofísica de Andalucía (IAA-CSIC). He has experience in R&D within the private sector, specifically focusing on computer vision and hyperspectral imaging. Javier joined the EST team at IAA-CSIC in March 2024, to work as an optical engineer for the Tunable Imaging Spectrometers (TIS/FBI).

EVENTS

EST INVITED TALKS

A list of EST invited talks and presentations in national and international meetings is available on the EST website at http://est-east.eu/est-invited-talks

EST PRELIMINARY DESIGN, STATUS AND FUTURE STEPS
Mary Barreto, in EAS 2024 Symposium 15, Padova (Italy), 5 July 2024

EUROPEAN SOLAR TELESCOPE: MORE STEPS FORWARD
M. Collados, in VIII Spanish Meeting of Solar and Heliospheric Physics, Granada (Spain), 13 July 2023

STATUS AND PERSPECTIVES OF THE EUROPEAN SOLAR TELESCOPE
Manuel Collados, in SOLARNET Sun in Science and Society, Mestre (Italy), 13 September 2023

THE EUROPEAN SOLAR TELESCOPE: SCIENCE AND INSTRUMENTS
Rolf Schlichenmaier, in The Many Scales of the Magnetic Sun, Potsdam (Germany), 9 May 2023

UPCOMING EVENTS

EAS 2024. SYMPOSIUM 15: HIGH RESOLUTION SOLAR OBSERVATIONS
Padova (Italy), 1-5 July 2024

IAU SYMPOSIUM 390: A MULTI-POINT VIEW OF THE SUN
Cape Town (South Africa), 6-8 August 2024

45TH COSPAR SCIENTIFIC ASSEMBLY
Busan (South Korea), 13-21 July 2024

17TH EUROPEAN SOLAR PHYSICS MEETING
Torino (Italy), 9-13 September 2024

XVI SCIENTIFIC MEETING OF THE SPANISH ASTRONOMICAL SOCIETY
Granada (Spain), 15-19 July 2024

BIG SCIENCE BUSSINESS FORUM 2024
Trieste (Italy), 20-24 January 2025

HINODE-17/IRIS-15/SPHERE MEETING
Bozeman (USA), 23-27 July 2024

EUROPEAN SPACE WEATHER WEEK 2024
Coimbra (Portugal), 4-8 November 2024

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