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Italian technologies for E-ELT: overview of the T-REX project

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Abstract. The T-REX (**T**elescope to **R**each the **EX**treme) project is one of the 6 *progetti premiali* led and organised by the Italian National Institute for Astrophysics (INAF) that have been approved and financially supported by the Italian Ministry of Education, University and Research (MIUR). T-REX was conceived to promote research, technology and formation activities in a coordinated way, and develop new frontier technologies useful for the national and international science communities. In particular, T-REX is aimed at maximizing the participation of Italian astrophysicists and industries to the realization of the largest telescope in the world: the E-ELT (European Extremely Large Telescope). In this paper we provide general information on the reference framework for the *progetti premiali*, and describe the key features of the T-REX project and its organisation.

Key words. Telescopes – Instrumentation – Astronomical Technology

1. Introduction

The E-ELT is the most challenging project of the European Southern Observatory (ESO). With a primary mirror of 39 m of diameter, it will be the largest optical/near-infrared telescope in the world and will gather much more light than the largest optical telescopes existing today. E-ELT will be able to correct for the atmospheric distortions with fully adaptive and diffraction-limited optics, providing images sharper than those acquired with the Hubble Space Telescope and than those expected from the James Webb Space Telescope. E-ELT will vastly advance astrophysical knowledge by enabling detailed studies of planets around other stars, star forming regions, resolved stellar populations in distant galaxies, super-massive black holes, the first galaxies in the Universe, and the dark components of the Universe.

E-ELT (http://www.eso.org/public/teles-instr/e-elt.html) will be one of the projects with larger European investment in this decade. It has highest priority in the European Strategy Forum on Research Infrastructures (ESFRI), and has also been ranked as one of the two clear top priorities for future ground-based astronomical infrastructures in the 2010-2025 ASTRONET European strategic planning.

The participation to this project is strategic at the highest level for science, industry and international policy. The size features of E-ELT and its expected performances require original and innovative approaches in the field of opto-mechanics, metrology, engineering and construction. It is thus mandatory to consolidate the position of INAF, Italian universities and companies in the project and develop technologies, expertise and capabilities to face and win such ambitious challenge.

In order to maximize the participation of Italian astrophysicists and industries to the realization of this European endeavur, INAF applied with the project T-REX to the first and second MIUR's call for the highly competitive national programs funded by the Ministry and called *progetti premiali* (reward programs), open to all the Italian research organizations (ASI, CNR, INAF, INFN, etc.). T-REX has been selected and financed in both calls.

T-REX was planned to promote research, technology and formation activities in a coordinated way, with the aim of developing new frontier technologies useful for the entire national and international science communities.

In the following, we briefly summarise the institutional background and the INAF achievements in the *progetti premiali* contests, and then describe the main structure and approach of T-REX.

2. The Italian *progetti premiali*

Following the 2009 law n. 213 and the National Research Plan issued by MIUR in 2011, every year the Ministry retains at least 7% of the budget of all its research organisations (ASI, CNR, INAF, INFN, etc.) and is supposed to redistribute that money to national projects presented by the organisations, and selected on a competitive, peer review basis. The guidelines issued by MIUR in these calls are for projects more technology than science oriented, with explicit collaboration with italian industries, universities and other types of organisations. This kind of national projects are dubbed *progetti premiali*, and are allowed financial support significantly higher that any other type of MIUR grants, but only for one year. To obtain further years of support one needs to re-apply. The selection is made by a MIUR committee made of experts in all fields of research (i.e. one astrophysicist, at most).

Competition is very high: The average success rate is quite lower that 10%, and the majority of the organisations don't succeed in getting their fraction of budget back. INAF instead has performed extremely well, so far.

At the end of 2011 MIUR issued the first call for *progetti premiali*, with deadline in early January 2012. INAF presented 4 such applications and got 3 approved (T-REX on E-ELT, one on LBT, and one on VLT). The total allocation to INAF was 10.6 Meuro, about twice as much as 7% of its budget (the latter being around 80 Meuro/year). The fund allocation was approved in June 2012, and actually assigned at the end of 2012.

The second MIUR call was issued on December 19^{th} 2012, with deadline early February 2013. INAF presented 8 applications and got 5 approved (on E-ELT, LBT, CTA, ALMA and on exoplanetary science - WOW) for a total of 15.9 Meuro (almost three times our 7%). Funds arrived in May 2014.

In 2013 MIUR decided to skip the call for the *progetti premiali*, and allocate the 7% funds on the basis of the results of the national evaluation of the research institutions called ANVUR-VQR. The allocation to INAF was 13.7 Meuro, approved in March 2014, once again higher than 7% of its budget. INAF has used these funds to support research in general (e.g. INAF PhD grants, INAF national projects PRINs, fundamental research within the institutes) and pay our share in e.g. LBT and E-ELT.

In 2014 MIUR decided to devote 30% of the 7% budget to a new call for *premiali*, and allocate the remaining 70% on the basis of the ANVUR-VQR results. As of July 2015, no call or guidelines[1] were issued by MIUR, either for the 2014 or the 2015 7% funds. These, however, have been indeed subtracted to the organisations budgets each year.

3. T-REX

T-REX aims at coordinating and facilitating the Italian contribution to the E-ELT construction in the fields where Italian technologists and scientists perform better: mirrors and instruments. The project scheme, based on the

[1] The 2014 call was eventually issued by MIUR on August 5^{th} 2015 with deadline September 4^{th}.

synergy between different fields and expertise, provides the basis for the creation and formation of new experts and professional profiles of extremely high specialisation.

More in detail, the aims of our *progetto premiale* were: Define the technical specifications of the E-ELT instruments based on the science cases of highest priority; strengthen the position and role of INAF and Italian Universities in the international consortia created for the realisation of the E-ELT instruments; support the executive design phase of the E-ELT instrumentation, strengthening facilities and laboratories; promote integration processes between research institutes, universities and industry; innovate the international cooperation processes through new scientific and industrial dynamics, strengthening the involvement of Italian companies in the design and construction of instrumentation for the E-ELT; promote the formation of young researchers to be employed in the design and construction of instrumentation for the E-ELT via training by highly qualified personnel; develop new technologies to ensure the feasibility of the E-ELT instruments; ensure the maintenance/enhancement of scientific and industrial know-how; promote the transfer of technology from the field of astronomical instrumentation to other fields such as renewable energy, medical technologies, information technology and communication.

Our *progetto premiale* gathered more than 100 participants, distributed over 10 INAF Institutes (the Observatories of Arcetri, Bologna, Brera, Capodimonte, Catania, Padova, Roma, Trieste, and the institutes IASF-Bo and IASF-Mi), the Universities of Bologna, Firenze, Insubria, Padova (in Italy) and Glyndwr (in UK). The Companies Astrel, Criotec, Forestal s.r.l, Hyperteach s.r.l. Media Lario Technology, Microgate, Pecchioli Research, Selex Galileo and Tomelleri s.r.l. also collaborated to the project.

T-REX was organised in 6 Operating Units (OUs), one in charge of the general management of the whole project (OU1, coordinator M. Tosi), and each of the others devoted to a specific part of E-ELT: OU2 ELT-MIRRORS (G. Pareschi), OU3 ELT-CAM (E. Diolaiti), OU4 ELT-HIRES (E. Oliva), OU5 ELT-MOS (B. Garilli), OU6 ELT-PCS (R. Gratton) .

Members of OU1 were M. Tosi (project Principal Investigator), F. Zerbi (Head of the Ground Based Programmes Unit of the INAF Science Directorate), R. Ragazzoni (member of the ESO Project Science Team and leader of the Italian Adaptive Optics Laboratory), A. Marconi and B. Marano (former members of ESO's STC and Council, respectively, and representative of the Italian Universities, in charge of the T-REX education program), and the coordinators of the OUs. The OU coordinators were in charge of the activities of their OU, of their financial and FTE requests, and were responsible for the allocated resources.

The project was funded the first year with 3.9 Meuros, and the second year with 2.7 Meuros. The OU1 kick-off meeting for T-REX-1 was held on September 28th 2012 and that for T-REX-2 on May 28th 2014 (see Fig.1). At these meetings we agreed on the final fund allocation to each work package, based on the original request, on the actual budget approved by MIUR and on the highest priorities indicated by the OU coordinators.

T-REX was managed in tight connection with the INAF Science Directorate, discussing with them all the major issues and needs and deciding together how to distribute the allocated funds to the various work packages. In agreement with the Science Directorate we chose to provide more support to the OUs with higher chances of Italian success and give higher priority to the activities related to the E-ELT first light. On this ground, we allocated a larger fraction of the budget to the OU2-MIRRORS and the OU3-CAM units. Considerable funds have been assigned also to OU4-HIRES to strengthen the Italian role in the HIRES Consortium. Smaller amounts were allocated to OU5-MOS and OU6-PCS. We allocated about one third of the budget to FTEs and mobility. Further information on T-REX can be found at the website http://www.bo.astro.it/premiale.elt/Premiale.
We payed special attention to educating and training a new generation of scientists and technologists to help them become significant contributors to the construction and then to

Fig. 1. Picture taken in Merate at the kick-off meeting of T-REX, May 28th 2014. From left to right: Livia Origlia, Emiliano Diolaiti, Tino Oliva, Monica Tosi, T-Rex, Roberto Ragazzoni, Bianca Garilli, Raffaele Gratton, Giovanni Pareschi, Filippo Zerbi, and Alessandro Marconi.

the exploitation of E-ELT. For this reason one of the tasks of T-REX was to support PhD courses and grants in the Universities collaborating with the project (see Alessandro Marconi's paper in this volume), as well as to finance postdoctoral positions in all the OUs.

On January 14th 2013, a meeting opened to the whole national astronomy community was held in Bologna to describe the activities of T-REX-1 and plan the application for T-REX-2.

The meeting hosted by the Sexten Center for Astrophysics (Sexten, Bozen, Italy) from July 19th through July 23rd 2015 was conceived as the final meeting of the project, where all its activities and achievements would be presented to the public. Approaches and results of all the work packages are described in detail by Coordinators and members of the OUs in their contributions to this volume.

Here I simply wish to conclude recalling a few major goals reached during the course of T-REX:

- The ESO – ADS-Microgate contract for M4 is in place;
- The ESO – INAF contract for Maory has been approved by the ESO Finance Committee and Council;
- The HIRES consortium has a solid configuration and A. Marconi as PI.

These goals have been achieved only thanks to the quality of those proposals and to the outstanding performances of their leaders and collaborators, but I like to think that T-REX has been of some help in the selection process, by providing the background financial and political support.

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