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Procedures To Desing The Robotic Astronomical Observatories

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Abstract

Robotic Astronomical Observatories (RAO) are constantly evolving. Optical observations of astronomy advanced very rapidly during the twentieth century, to become data captures and images that cover almost the entire range of the electromagnetic spectrum. This evolution that has always been linked to astrophysical research continues to advance and can now cover other celestial objects of a very diverse nature, such as artificial satellites and space debris. In addition to Astrophysics, the RAO are called to carry out work of detection and tracking of extraterrestrial objects created by the human being. These new objectives of the ROA are carried out with exclusive models and specific designs such as those shown in this work. To achieve this purpose, RAOs need a well-organized and precise design, in which all the factors that make up the project are optimized: Objectives, Engineering, Technical Equipment, Facilities, Training, Operations and Maintenance.

Keywords: Artificial satellites, Astrophysics, ProAm, Robotic Astronomical Observatory.

1 Introduction

During the twentieth century, the Robotic Astronomical Observatories (RAO) have evolved along with telescopes and sensors of different formats **[2].** These advances have made it possible to capture images and obtain data in different ranges of the electromagnetic spectrum. The Earth's atmosphere has considerably limited these advances, but thanks to telescopes and sensors that have been sent into outer space, outside our atmosphere, atmospheric impermeability has been saved in different regions of the electromagnetic spectrum.
In the telescopes and sensors that operate in space, important advances have been incorporated in the remote control and robotization of this equipment. Operating at great distances and without the possibility of accessing the instruments, for repair and maintenance, has allowed the development of the hardware and software necessary to optimize the performance of these space instruments **[1, 13].**
In the telescopes and sensors that operate in space, important advances have been incorporated in the remote control and robotization of this equipment **[7].** Operating at great distances and without the possibility of accessing the instruments, for repair and maintenance, has allowed the development of the hardware and software necessary to optimize the performance of these space instruments **[8],**
To optimize the performance of ground equipment, a new generation of ROA is being developed. The new ROA are models of specific Observatories that are designed and built for each project **[17, 21].** They can be unique and very different from each other. Although the procedures are necessarily similar, they are broadly flexible and adaptable to the objective and purpose of the project. New ROA models can be configured following an intuitive and standard procedure.

2 Analysis

The author of this work proposes a design model of ROA, based on his experience in the construction, design and manufacture of astronomical observatories from 2010 to the present day. The procedure that is presented, tries to include all the factors that are relevant to optimize the operation of the ROA and the equipment it houses **[10, 21].** In this model, three phases are established that must be followed in order (from top to bottom and from left to right).

PHASE 1: It is intended to start the ROA project, from the definition of the project by its promoters. In this beginning of the project, three sections A, B and C.
A are differentiated. The objectives pursued are defined (detection and tracking of artificial satellites, study of celestial bodies, space debris ...), then indicate the type of activity that is intended to be developed in these facilities (scientific research, security, training,) and, finally, indicate how the observatory is intended to operate. For example, manual, remotely or autonomously.
These initial premises are intimately related, so that, by defining the first, it conditions its second and so on. In this way, the initial project is determined and defined, which, in turn, determines the next need.
B. The initial project demands the scientific and technical instrumentation, necessary to develop its objectives. This section clearly exposes the required optical instrumentation, its mounts and motion

systems, video or photography cameras, spectrographs, filters and other auxiliary elements of measurement, optics or image capture. It is also very important to detail the control systems of these devices, such as PCs and the necessary hardware.
As a technical complement to scientific instrumentation, the incorporation of devices that allow the correct use of scientific instruments should also be considered. This should include the type of roof necessary for the ROA, such as the dome (shell, with shuttle, polyhedral ...), roll-off roof (flat, vaulted, folding ...), gable roof, remote or robotic control systems and a possible weather station.
In the following section C, the specific information of B is necessary, in addition to that extracted from the ROA project itself. The set of actions that must be developed are of special relevance for the proper functioning of the ROA and that is why they are considered as a Critical Zone (the problems not resolved during this phase are very difficult to solve). It will be essential to know the needs of the observatory regarding its location. According to the objectives of the ROA, the necessary height, absence of wind, relative humidity, orientation, location (geographical area) and quality of sky necessary must be taken into account, with respect to seeing and light or environmental pollution [12, 16]. . This previous information will serve as a first filter to decide the location of the observatory. In this way you can make a first pre-selection of the best places available. The second filter, which will be the final one, is provided by the meticulous study of meteorology and sky quality, or Site-Testing, in the pre-selected places [5,14, 15].. The outcome of these two studies will determine the best location of the ROA.
In this first phase, the questions of What do you want to do?, What is needed? and Where would be the best place to do it?

PHASE 2: In the next phase, the Construction and Facilities of the Observatory are addressed in sections D and E.
In section D, you must proceed with the drafting of the technical engineering project of the ROA, which will depend on its objective and final claims. Once all the necessary actions to build the ROA have been contemplated, the corresponding works for its construction must begin.
Then, in section E, a situation of extreme importance appears (many "common" problems in observatories occur at this stage), which has been called Critical Zone II [18, 20]. . In this phase it is necessary to have the intervention of the scientific managers of the project, as well as the collaboration and willingness of the technical managers of the construction. It is essential to coordinate the actions carried out to place, guide and properly level the scientific and technical instrumentation. Good coordination will ensure its good commissioning. If these actions are optimized in this phase, future problems, damages and repairs will be avoided.
In this second phase, you can answer how will it be done? and How will it be proceeded / installed, so that it works correctly?

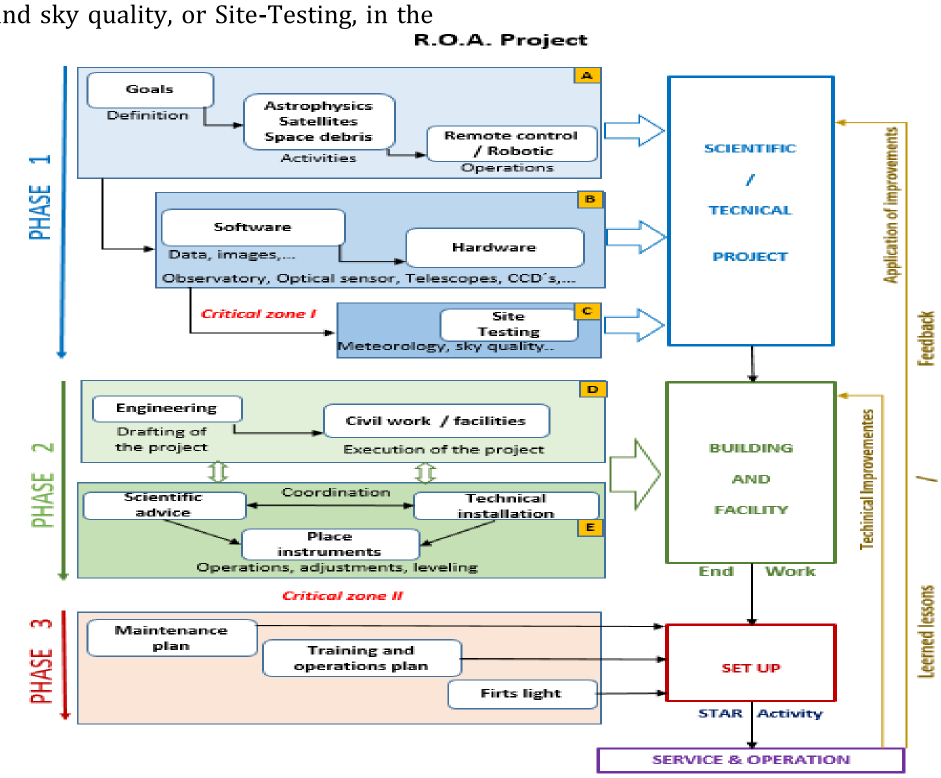

Figure 1 Scheme of procedures for the design, construction and installation of the new Robotic Astronomical Observatories (ROA).

PHASE 3: In this last phase, aspects that are usually forgotten or simply not raised are highlighted. Two fundamental concepts are included for the operation of the ROA: A detailed maintenance plan, so that the observatory can operate normally and not suffer breakdowns or major stops, and on the other hand, a training and commissioning plan, which guarantees and trains the necessary personnel for its operation. The first light of an optical sensor, is from the astronomical point of view, the most faithful indication that an observatory is operational and functioning correctly.

Finally, the commissioning and operation of these facilities is incorporated as the final objective of the whole process, but in astronomical observatories, this step has been considered very important, since, from the first moment, relevant information can be obtained on how the objectives proposed at the beginning of the project are being met **[6].** By analyzing these results, new lessons will be learned and a very important feebback will be obtained. This will contribute to implement improvements and new projects for the future.

3 Results

By applying these procedures in the design and construction of the new ROAs, solutions to different problems have been sought. New projects seek alternatives and meet new demands **[11, 19].**Having a network of robotic observatories has been possible with the new ProAm models. Obtaining an observatory in which up to 10 telescopes can be housed has also been possible with the development of a hosting for telescopes. Below are the results

3.1 Hosting

Having a large space to house telescopes means considerable savings in facilities and automation. In this case, a separate room has been included, where the control systems and PCs are located. This makes it possible to control more than ten telescopes from one place.

Figure 2. Image of AstroCamp hosting with an open roll-off roof (right). The roof on the left is closed.

The models shown in the images were built for the company AstroCamp in its facilities in Nerpio (Spain) at more than 1,600 m above sea level. This ROA has two independent automated Roll-Off roofs. They can be controlled remotely. In the right area of the image, there is a room (entrance) to house the control systems. This room is independent of the whole observatory.

Figure 3 Image of the southern slope of AstroCamp hosting in Nerpio (Spain).

The Observatory is 40m long (East - West) and 5m wide (North - South). It has two independent ceilings, which are joined half of the wall facing south. This arrangement offers the possibility that when the roof is opened, it has attached to it a part of the South wall. In this way it offers a wide view of the South to all the telescopes it houses and the region of the ecliptic is totally free every night.

3.2 ProAm Observatory.

ROA's ProAm models have been developed with the aim of achieving a small, inexpensive observatory that can accommodate small telescopes **[9].**The purpose of the ProAm models has been to offer a solution for small-scale research projects and to offer a solution for projects that need to have an ROA network.

Figure 4. Image of the robotic observatory ProAm 2.5.www.esparterocs.com

The network of BOOTES Observatories and the network GLORIA **[3, 4].** , has served as a reference to find an alternative of small robotic observatories that can accommodate telescopes up to 0.8 m in diameter.

4. Conclusions

A standard system for the design and construction of ROA has been established. Site testing, suitable placement, technical construction considerations and the use of new materials adapted to the new projects and their needs are all essential tools to achieve a quality astronomical observatory.
Three models of ROA have been presented. They are all based on very similar construction materials, with designs adapted to new projects and a new robotic control system which has been tested and proved to be reliable and versatile. The new designs of roll-off roofs with vaults and retractable gable systems provide a very wide field of view, with significantly optimize these facilities.
The results show that it possible to construct new observatories which have better materials and can be specifically adapted for any research project. The models presented in this work not only show notable improvements in methods and materials, but also present a new concept of more versatile, economical and efficient observatories. The three observatories are currently operative and Performing the functions which they were designed for at 100%.

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