KINEMATICS AND AUTOMATION IN AN ASTRONOMICAL OBSERVATORY MANAGED BY THE OMEGA LAB SUITE

The recent restyling of the programs labelled OMEGA LAB, has improved their potentialities enabling a complete and better structured control of the astronomical Observatory

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FIG. 1: *A remote and robotic example of astronomical Observatory, completely managed by OMEGA LAB program suite*

Abstract

Each equipment or physical compound necessary to either observe the sky or take astronomic images, is characterized by simple and complex kinematic mechanisms, that provide movements of translation and rotation conveniently matched.

The connection of hardware compounds to a computing machine, allows a total control of the single elements and the systems made up by them.

In June 2014, OMEGA LAB released the version 6 of Ricerca, the noted automation and remote control program adopted by noble astronomical observatories.

It is an important restyling, not only as a façade, that concerns many instruments, diversified routines and the modules connected to the basic program.

This report substantiates the improvements and the integrations made by the Italian factory to a suite which is able to satisfy the needs of the most significant astronomers and also professionals.

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In June 2014, S. Massaro, by OMEGA LAB, released the definitive version of Ricerca 6, which presents upgradings, revisions and enhancements to all connected modules.
The control of the functions is practically total and is not limited to support the needs of astroimagers, researchers but, more generally, of everyone who is interested in observing and studying the sky with the aid of a software.
The whole package of applications and hardware, see *Observatory Control System*, manages in an independent and parallel mode all the elementary phases and every sequences necessary to make run a whole astronomical Observatory, fig. 1.
Not only the group for the acquisition of images, like the telescope, the focuser, the filterholder wheel, photon detection devices and more, to be followed, piloted, controlled and possibly corrected, but the whole structure and all the interactions that it presents with the inside and the outside parts.
The suite, suitably set, configured and prepared, distributes in an optimised way the commands and, in function of the feedback received from the physical drives, allows functional parallelisms. In other words, at the same time, it manages and overlaps more phases in order to raise the overall performance of the observational system.
This new release provides an extended compatibility with the *MaxIm DL CCD 6* (**www.cyanogen.com**) program, which has also been recently released, and is prepared to take full benefit of the new ASCOM 6.1 (**http://ascom-standards.org/**) libraries.
The map that has also been revised and updated in its panels and commands, relies on the complete *Smithsonian Astrophysical Observatory Star Catalogue*. This important integration makes available, not only with the scope of display characteristics, but also of calculation, comparison and measurement, about 270,000 stars, fig. 2.
Depending on the adopted configurations, on the type of communication and on the nature of the control, the OMEGA LAB group of applications, can be considered as performer, as controller, and/or both of them. In other words, a specific software element offers directly

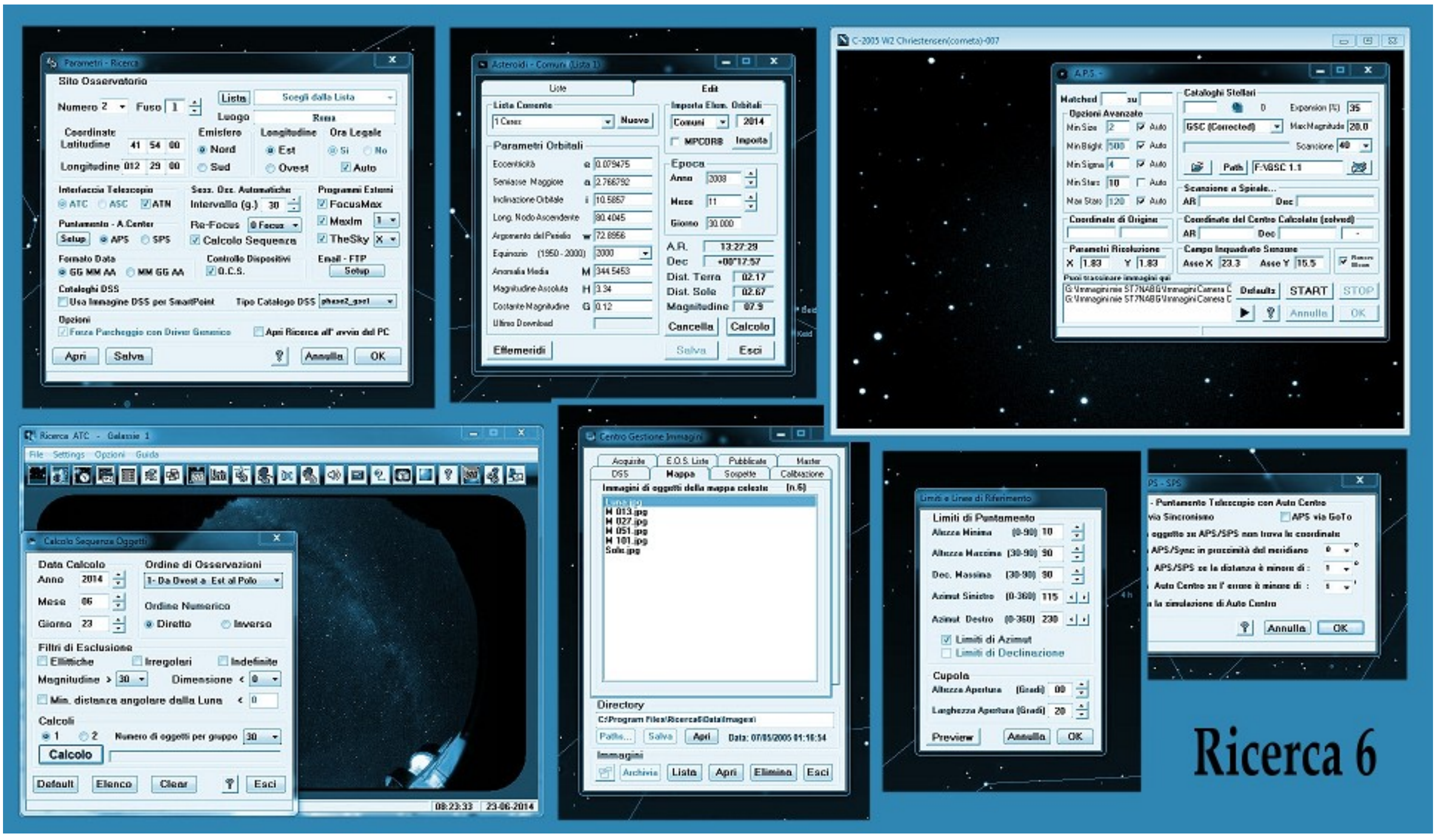

FIG. 2: *Screenshots captured during a test with latest Ricerca program release.*

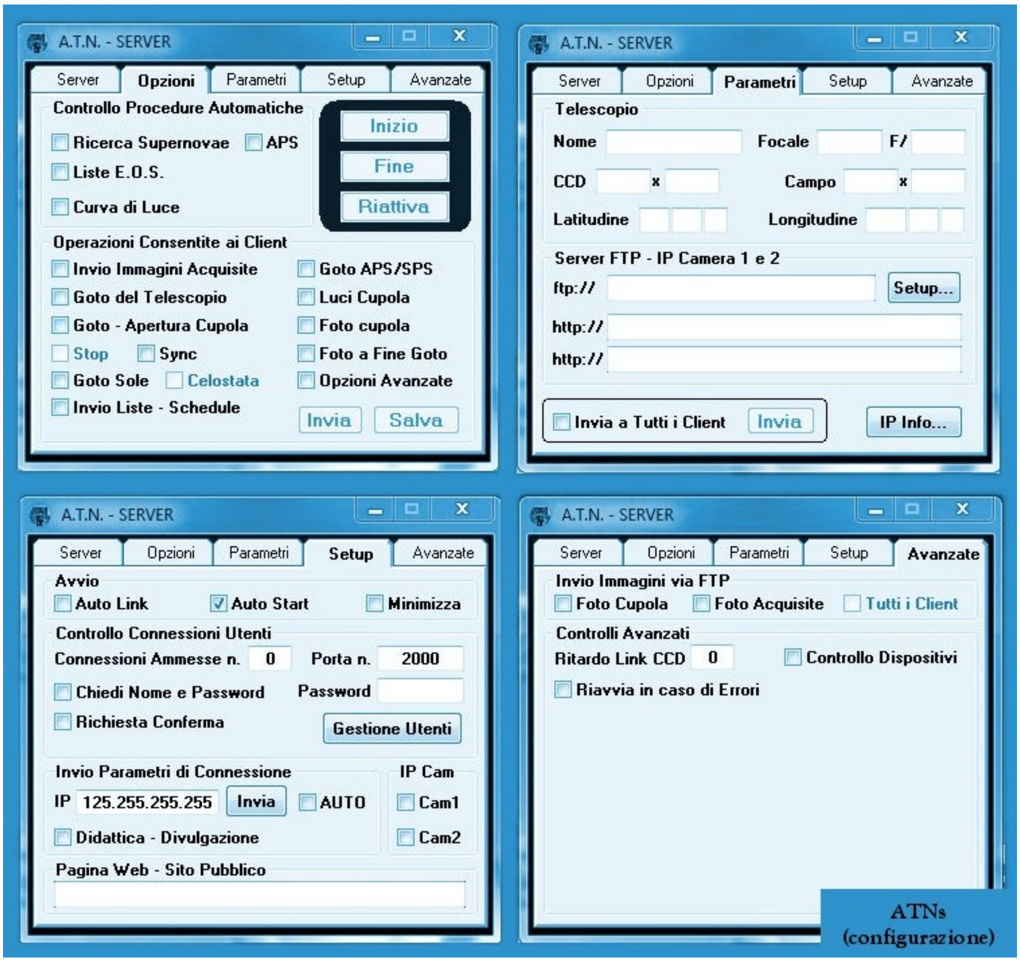

FIG. 3: *Configuration and control panels of Automatic Telescope Network server.*

commands to the astronomical equipment, monitors the correct development, totally or partially, of the phases connected to the images acquisition procedure, controls the work of the components, applications, external tools or routines, distributes direct commands or those provided by a third party and manages, in direct and/or indirect mode, the totality of the inputs and feedback related to the integrality of instruments and accessories.

The above mentioned roles, depending on the case and on the condition, are carried out in single, dual or multiple mode.

This operational versatility proves to be successful in the various managing architectures: from the simple mobile Observatory to the professional Observatory characterized by permanent instrumental parking, from the essential setup to the complete one, from the direct connection to the multiple connection, from the structure that hosts only a single instrument to that with two or more telescopes.

We had the opportunity to point out in articles published on previous issues of the Astronomia Nova webzine, that the whole control of hardware technologies located inside the observational complex, as well as many of its external elements, for instance, the surveillance webcam, the meteorological stations, the local lighting and roof system, should involve in the architectural chain of the whole, some modules named, respectively, O.C.S. - Observatory Control System and A.T.N. - Automatic Telescope Network client, fig. 3.

These two elements, together with the Automatic Telescope Network server, integrated to Ricerca, determine a real remotization and robotization of the astronomical Observatory. The recent releases allow the control of two O.C.S. devices, located inside the same dome; the hardware are mutually connected through the auxiliary port labelled “Relay 3”, in order to ensure the necessary communication and synchronization, for the correct functioning and to prevent unintentional operations or the establishment of dangerous situations.

This option of double interface manages, safely, two complete acquisition instruments located inside the same dome system: the shared channel “Relay 3” controls the signals coming from actuators, detectors and instrumentations, in input and output, to put in sequence the parking of both instruments with the closure of the shutter or, more generally, of the Observatory “roof”.

Fig. 4: *Observatory Control System box and relative software component.*

The closing of the electrical circuit that feeds the engines of the dome, at the end of the observing session, takes place only when both telescopes are correctly parked and, in case of weather alert or Internet connection failure/breakdown, the condition of standby is reached according to a quite precise sequence, that provides the parking of both instruments and the closing of the dome system.

The initial configuration of the O.C.S. modules is automatic when the proprietary software is used, whereas it must be set as ASCOM “OCS Dome” component/driver, if you consider external programs.

The Observatory Control System box determines a characterized multilink connection, i.e., from more “connection bridges” between user and each single mechanical component, intended as telescope, CCD camera, focuser, weather station, filterholder wheel, etc., fig. 4.

The management of digital and analog signals, like switching on a lamp, the feeding of a CCD camera, the translation of a sliding roof or the rotation of a dome, clicking on a button located in the command window, appears rather complete and further optimized with the release of the recent updates and the last versions of the software integrated in the suite.

A local client establishes a contact with a server located in the Observatory and, based on the settings and the priority and privileged configurations, performs actions that result in status changes in one or more “entities”, operates on primary power sources, on converters, controllers, actuators, control devices in order to operate a machine which gives effect to necessary mechanisms to obtain functional automation.

Control over powered devices, operating or on standby, is wide-ranging and structured in a way that prevents accidental errors related to the opening and closing of the electrical circuitry. In other words, we can define the above mentioned management methodology, not only as secure but also as partially intelligent: computers and software recognize the status of a specific system and/or of one or more instrumental precinct, put the equipment involved in a logical sequence featuring a specific stage of the acquisition process and preclude the possibility of direct intervention on switching devices that determine the in/out, on/off status of the components in question.

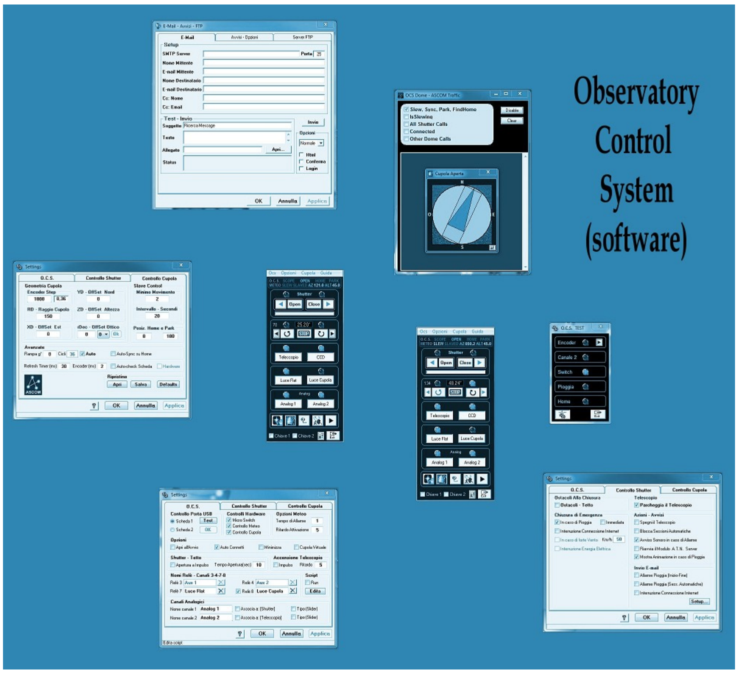

Fig. 5: *Exploded views of Windows that can be loaded by O.C.S. software menu items*

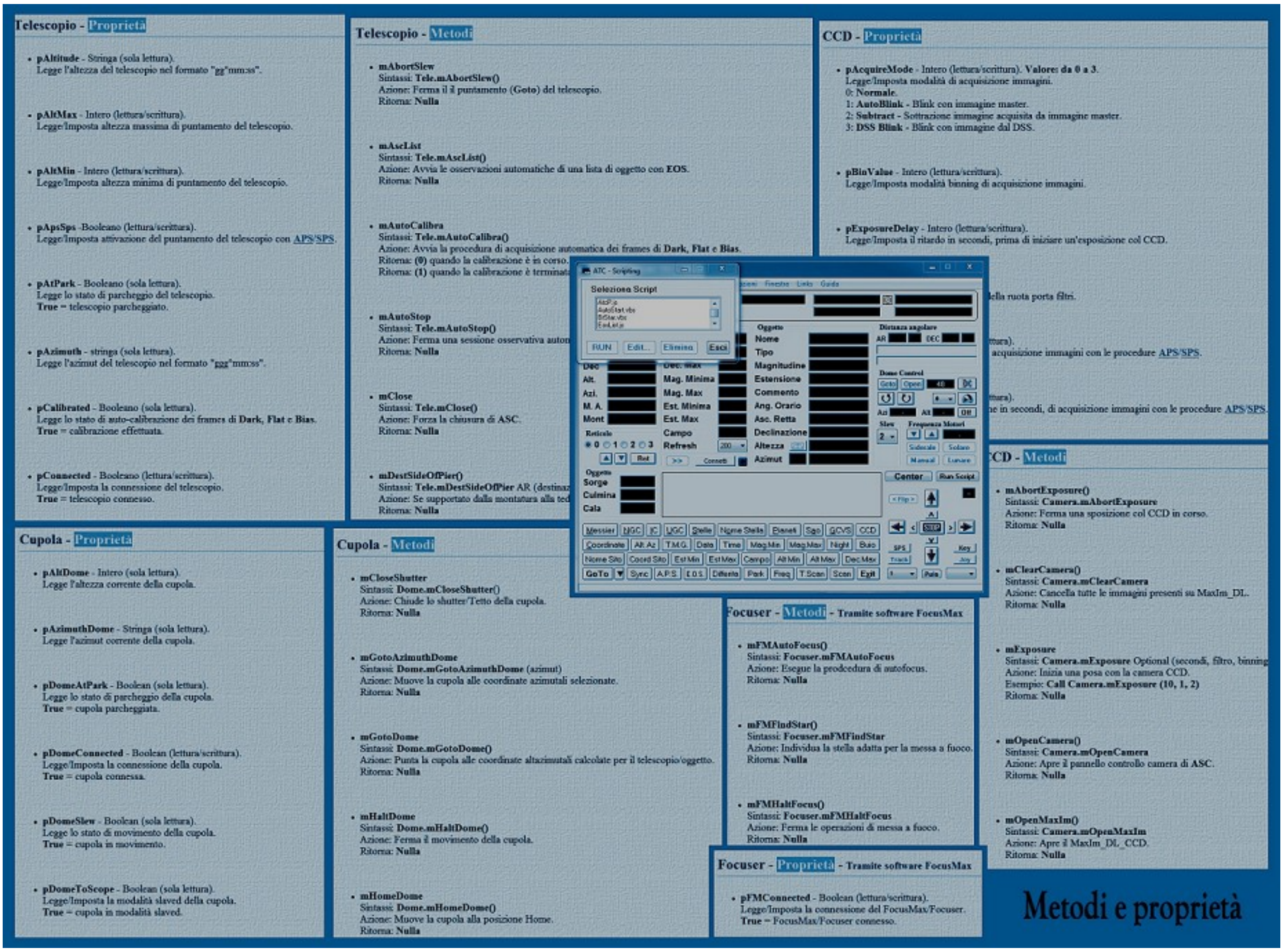

FIG. 6: *Methods and properties become available for the dome system, the telescope, the CCD camera and the focuser.*

The "Observatory Control System" hardware and software elaborate and manage the instrumental setup with a switch ignition system or a button. For the latter, there is a timed pulse that keeps the circuit in closed condition for a predetermined number of seconds; the electromagnet relays, which include the power supply wires of the telescope, are kept excited for the time necessary to the performing of the procedures and the internal controls of the mount.

The electrical impulses that control the movements of the dome, shutter and the roof system in general are given for *n* number of seconds or are regulated by microswitches, position switches or other positional sensors that can play positional feedback function and that are sensitive to axial, transversal, frontal, sagittal, radial displacements, etc., fig. 5.

Complete and automatic initialization of the whole observation structure, beyond through start inputs of the autonomous procedure at the scheduled time, takes place through a script named "AutoStart.vbs" integrated in the OMEGA LAB suite starting with version 6 of Ricerca.

Customized scripts are editable with a text editor and feasible in VB, .vbs extension, and Java, .js extension.

Methods and properties become available for the closing system, the telescope, the CCD camera and the focuser. , fig. 6.

A determined alphanumeric sequence can be activated ("Run" command), by entering it with the literally *drag and drop* method, into the specific window labelled "Scripting".

Practically it is sufficient to click with the mouse on the selected script, drag and drop it in the "association" window.

The recent release version 6.00.1 at the time of the article drafting, provides a new command located at the right end of the upper task bar (keys/buttons) of Ricerca panel, to launch and/or directly edit the scripts, without accessing the windows of the ATC, Advanced Telescope Control, or ASC, Advanced Scope Control modules.

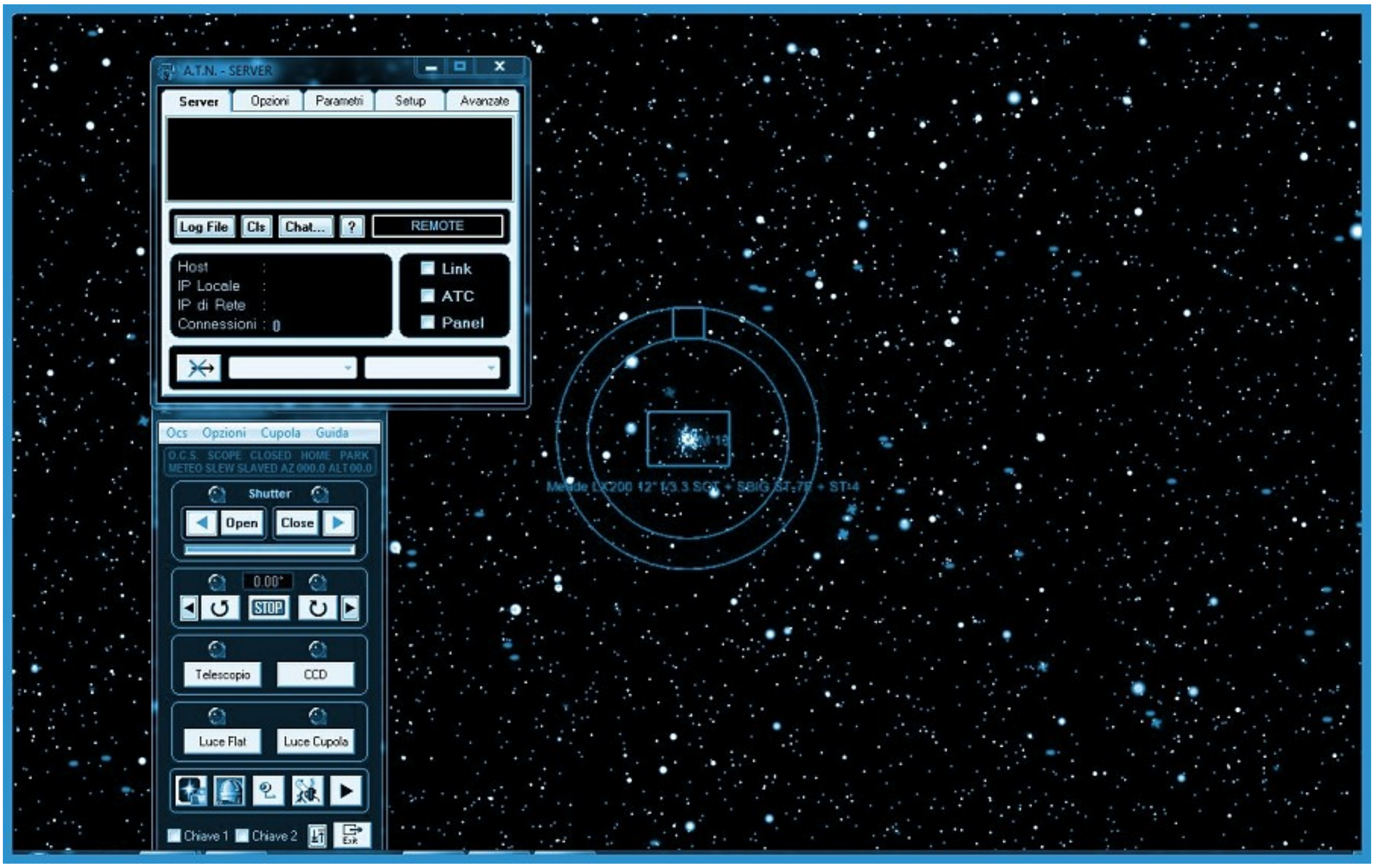

FIG. 7: *The Automatic Telescope Network client module has been transformed into an ActiveX, ASCOM component and now it can be matched to every planetary software.*

The log file, generated and recorded by the Observatory Control System, in the new program versions is permanent and all the geometrical parameters that distinguish the dome are saved and uploaded in a separate file.

The correct connection and the normal functioning of channels and the piloted hardware are checked in automatic mode with the launching of a specific instrumental test.

The O.C.S. box is adjustable and adaptable to any kind of hardware; the in/out channels, if necessary, can be differently configured from that which has been provided by the factory that built them. These changes should be supplied with some caution by qualified technicians, because besides excluding the product warranty, they could generate serious damages to the connected equipment and devices.

The astronomical Observatories, particularly those remotely controlled through Internet, should be equipped with an uninterruptible power supply dimensioned to ensure the closing operations of an observation session in case of electrical black out. The uninterruptible power supply should, at least, be connected to the primary importance devices for the safety of the equipment, instruments and accessories located inside the Observatory. In case of sudden interruption of the electricity supply, it is important, in fact, not only to complete the integration on a subject, but rather park the telescope and close the roofing system. In this way it is also necessary to bypass the Observatory Control System box, as well as the computer, the mount and the dome engines.

With Ricerca 6 and relative modules, regular or complex kinematics, that involves mechanical and technological devices during the pointing and centering functions, are supplied by algorithms, tools and very high-performing routines that find their greatest efficiency in the Go To, in the calibration and in the automatic learning from fits images.

The software obtains the celestial coordinates either of an object or a point directly from a digital frame or digitizes it in Flexible Image Transport System format.

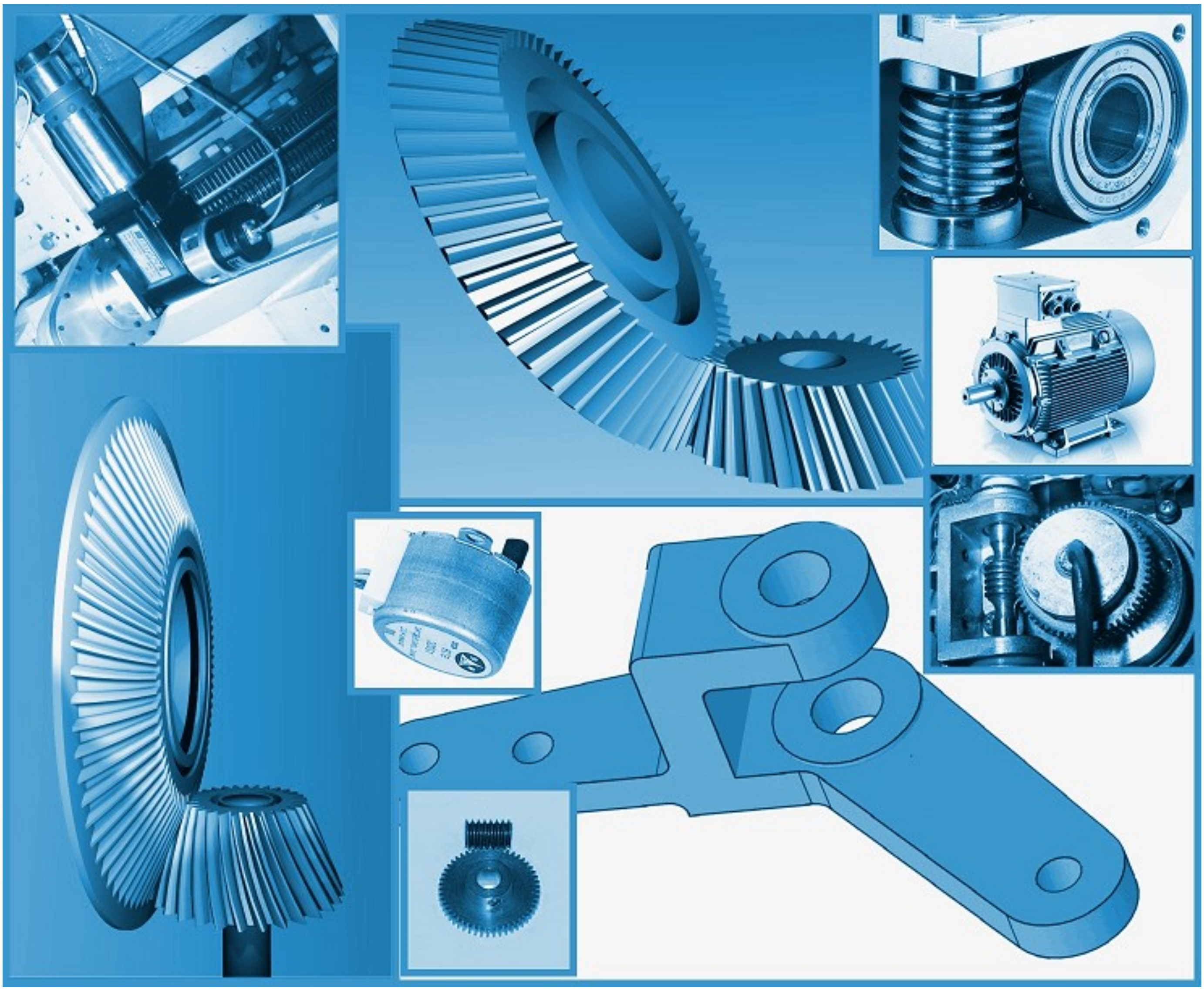

FIG. 8: *A plurality of elements, like: engines, axles, mechanical gears, levers, racks, gear wheels or worm screws are coordinated, mechanically, according to a precise architecture that organize them in inserted collections, in a context of cause and effect.*

In this scientific saving standard, defined for the first time more than 30 years ago, an ample space is given in the panels and in the modules dedicated to the management, processing, viewing and analyzing of Ricerca 6 images and of ATC images.

The Automatic Telescope Network client module was transformed into ActiveX, ASCOM component. This integrated extension, in addition to adding new potential and providing greater opportunities for future developments, allows an extended control to all external planetaries, like TheSky, Stellarium, Cartes du Ciel, etc., fig. 7. Ordinary communications and feedback exchanges between remote clients and servers were expanded with the inclusion of new commands, more actions and the extension of the control as an administrator. These include, for example, the command for management of the operational equipment status, displaying of the log file, system alerts, analysis of weather alert device, the relationship, in real time, on the position of the mount and on the progress of the main elementary stages.

The recent performed innovations and extensions allow now to all clients connected to the computer placed in the Observatory, via ATNc, to have a panoramic view, in real time, on the tools and accessories used in a particular area of research. A plurality of items such as engines, axles, gears, levers, racks, gear wheels or worm screws, are mechanically coordinated, according to a precise architecture that organizes them in collections placed in a context of cause and effect (energizing an electromagnet > circuit closure, closure of a circuit > an axis rotation, rotation of an axis > component translation, component translation > change of the status of a gauge, change of the status of a gauge > generation of a signal, etc.) , fig. 8.

Mirco Villi (on the left) and Mario Bombardini (at the centre), on July 15, 2014, have discovered the 2014 BY supernova, in the UGC 9267 galaxy, from the "G.B. Lacchini" Amateur Astronomers Group Observatory, in Faenza. For a number of years, they have been using the Ricerca suite at the Observatory, also during the hunting of supernovae.

The set of elementary movements that combine themselves and create a variety of mechanical kinematics in an astronomical Observatory served by personal computers, is controlled by applications that in any way originate the causes for the existence of the effects.

The relationship between cause and effect is monitored by detectors that transmit the information to a software, which suitably elaborates returning commands to the actuators.

Each movement can be considered as a dynamic phenomenon, in all respects, manipulated by programs that, in practice, recognize its causes, determine the effects and identify the connection, or connections, among them.

The OMEGA LAB suite generates single phenomena, associates them suitably and creates the necessary kinematics and automation to establish that particular connection among instruments and the sky able to restore scientific information to the entire global community of researchers and scholars.

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Author of a technical manual, with a foreword by Margherita Hack, mainly designed to the automation and remote controlling of astronomical observatories, and of several technical articles published by Italian scientific and cultural magazines.

Tester of software and application modules developed for the automatic control of astronomical instruments.