

What is GLORIA?



Emer O Boyle (UCD)



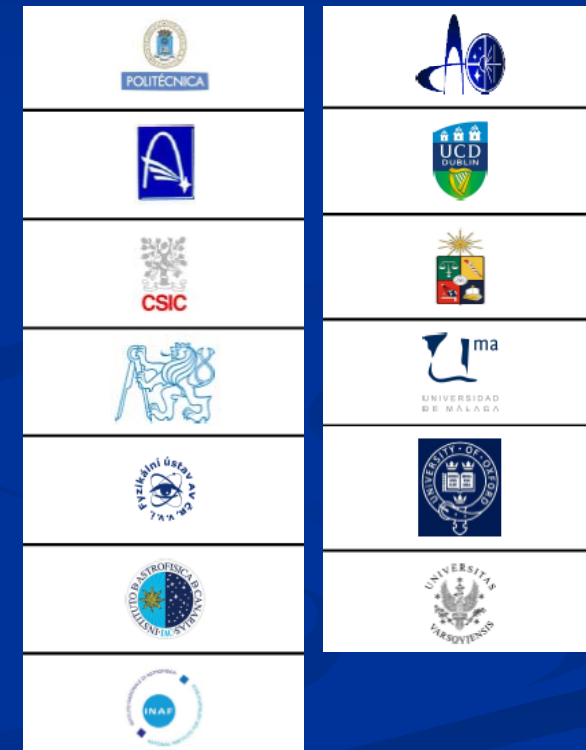
Prof. Dr. Alberto J. Castro-Tirado
GLORIA Project Scientist and Deputy Coordinator
(IAA-CSIC)

GLORIA Community Open Day, Bologna, 15 Maggio 2014



On behalf of the GLORIA collaboration

A. J. Castro-Tirado, F. M. Sánchez-Moreno, D. Azócar, G. Beskin, E. O' Boyle, J. Cabello, R. Cedazo, L. Cuesta, R. Cuniffe, J. A. Díaz-Andreu, E. González, A. González-Rodríguez, J. Gorosabel, L. Hanlon, R. Hudec, F. Ibáñez, P. Janeček, M. Jelínek, S. Karpov, P. Kubánek, O. Lara-Gil, C. Linttot, M. C. López-Casado, M. Malaespina, L. Manckiewicz, E. Maureira, J. Maza, V. F. Muñoz-Fernández, L. Nicastro, E. Palazzi, P. Páta, C. Pérez del Pulgar, M. A. Pío, M. Prouza, F. Serena, M. Serra-Ricart, R. Simpson, U. Serrano, P. Sprimont, J. Strobl, J. C. Tello, M. Topinka, S. Vítek, F. A. Zarnecki



44 people, **14** institutions, **8** countries

Outline

1. Robotic Astronomical Observatories

2. RAOs: a brief history

3. The GLORIA Project

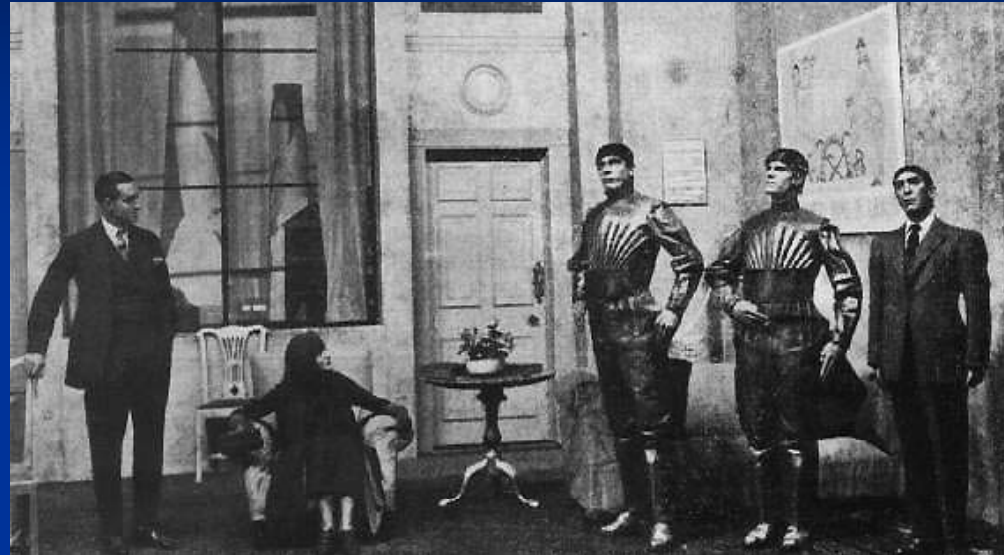
4. Conclusions

1. Robotic Astronomical Observatories (I)

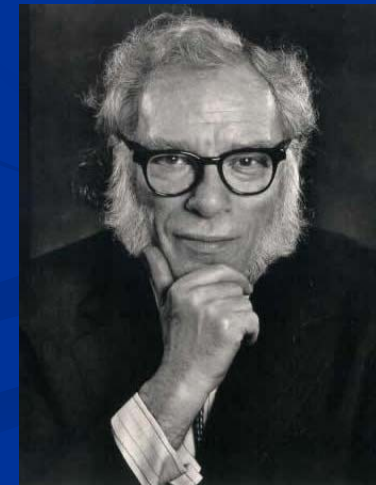


Who coined
the word
“robot” ?

The word **robot** was coined in 1921 by the Czech writer Karel Čapek (1890-1938) in his play “Rossum’s Universal Robots” (R.U.R.) in which three robots were despited. The new word was suggested by his brother Josef Čapek (cubist painter).



Isaac Asimov (1920-1992) coined in 1941 the word **Robotics** in his play “Liar!”: as the branch of the science and technology related to “robots”: design, manufacturing and applications.



1. Robotic Astronomical Observatories (II)

(RAOs from now on). Some definitions...

Robot

A mechanical system which executes repetitive tasks with good accuracy with human assistance. Example: Industrial robotic arm.

Teleoperated Robot

A mechanical system which executes a given task with good accuracy and that can be modified with human assistance. Example: Submarine research robots.

Intelligent Robot

A mechanical system which executes a task with good accuracy and is able to adapt itself to changes during the task execution without any kind of human assistance. Example: Rovers devoted to planetary research.

1. Robotic Astronomical Observatories (III)

...applied to Astronomy [as *agreed on the Málaga 2009 Workshop*]

Automated scheduled telescope (Robot)

A mechanical system which executes repetitive predefined tasks with good accuracy with human assistance. Telescope which performs observation without the astronomer actually moving the mount by hand.

Remotely operated (remote) telescope Robot

A mechanical system which executes a given task with good accuracy and that can be modified with human assistance.

Autonomous Robot (observatory)

A mechanical system which executes a task with good accuracy and is able to adapt itself to changes during the task execution without any kind of human assistance. Weather control. Must not kill a human !.

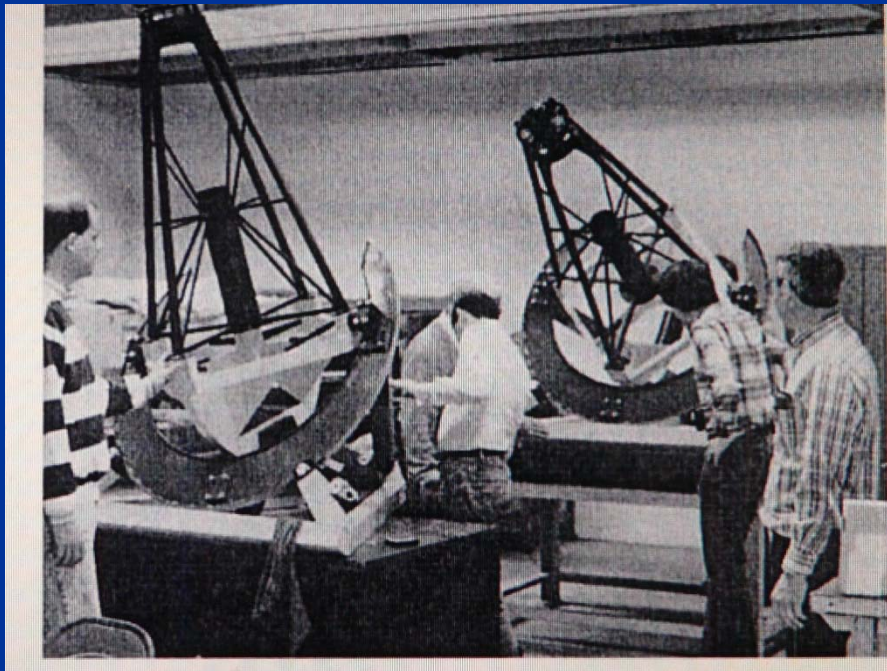
2. RAOs: A brief history (I)

First attempts to robotize telescopes were first developed by astronomers after electromechanical interfaces to computers became common at observatories. Computer control is the most powerful technique for research today. But computer systems are inherently low voltage and are very susceptible to electrical noise. Thus putting electromechanical devices under computer control can be particularly challenging. Early examples were expensive, had limited capabilities, and included a large number of unique subsystems, both in hardware and software. This contributed to a lack of progress in the development of robotic telescopes early in their history.



2. RAOs: A brief history (II)

The first **automated** telescopes were able to start on a pre-programmed sequence of photometric measurements if the sky was clear. This was the case of the Automated Telescope Photoelectric (APT) service, a computer driven system in Mt. Hopkins (AZ, USA) which knew when the Sun set and checked for rain, snow, etc.

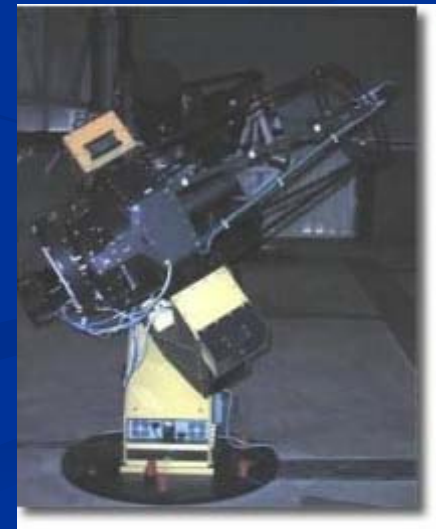


In an ideal world, the computer will report the astronomer on the next morning how beautiful the night was. But we know that us do not leave a telescope unattended for the whole night ...

2. RAOs: A brief history (III)

The Bradford Robotic Telescope (UK) was operating in the web since 1993. It's located in England, where the weather isn't optimal, but it accepts requests from anyone (Baruch's talk).

The Perugia University Automated Imaging Telescope (0.4m) in Italy and the University of Iowa Robotic Telescope Facility (0.37m diameter Rigel telescope at Winer Observatory in AZ) joined later (1994). The former was devoted to Blazar and CV monitoring. The second one was devoted to education, is operated primarily by undergraduates, many of whom are involved in independent research projects.



2. RAOs: A brief history (IV)

By the end of the 90's the number of automated telescopes increased with many of the devoted to gamma-ray burst (GRB) follow-up:

GROSCE (1993), LOTIS (1997) and ROTSE (1998): wide-field lens systems (USA)

BOOTES (1998) , 0.2m telescope + wide-field system (Spain)

BART (2000) , 0.2m telescope + wide-field system (Czech Rep)

TAROT (France), RAPTOR (USA), REM (Italy), MASTER (Russia) joined in the early 2000's.

And we should not forget all development by amateur astronomers since 1998.

All these achievements implied a change in the technology (See the book *Unusual telescopes*, by Peter L. Manly). For instance, for wide-field system, fast mount and dew control is most essential. For telescopes, open tube design is desirable: lighter and better stabilization of the temperature (but this requires a large central baffle to prevent straylight), etc.

2. RAOs: A brief history (V)

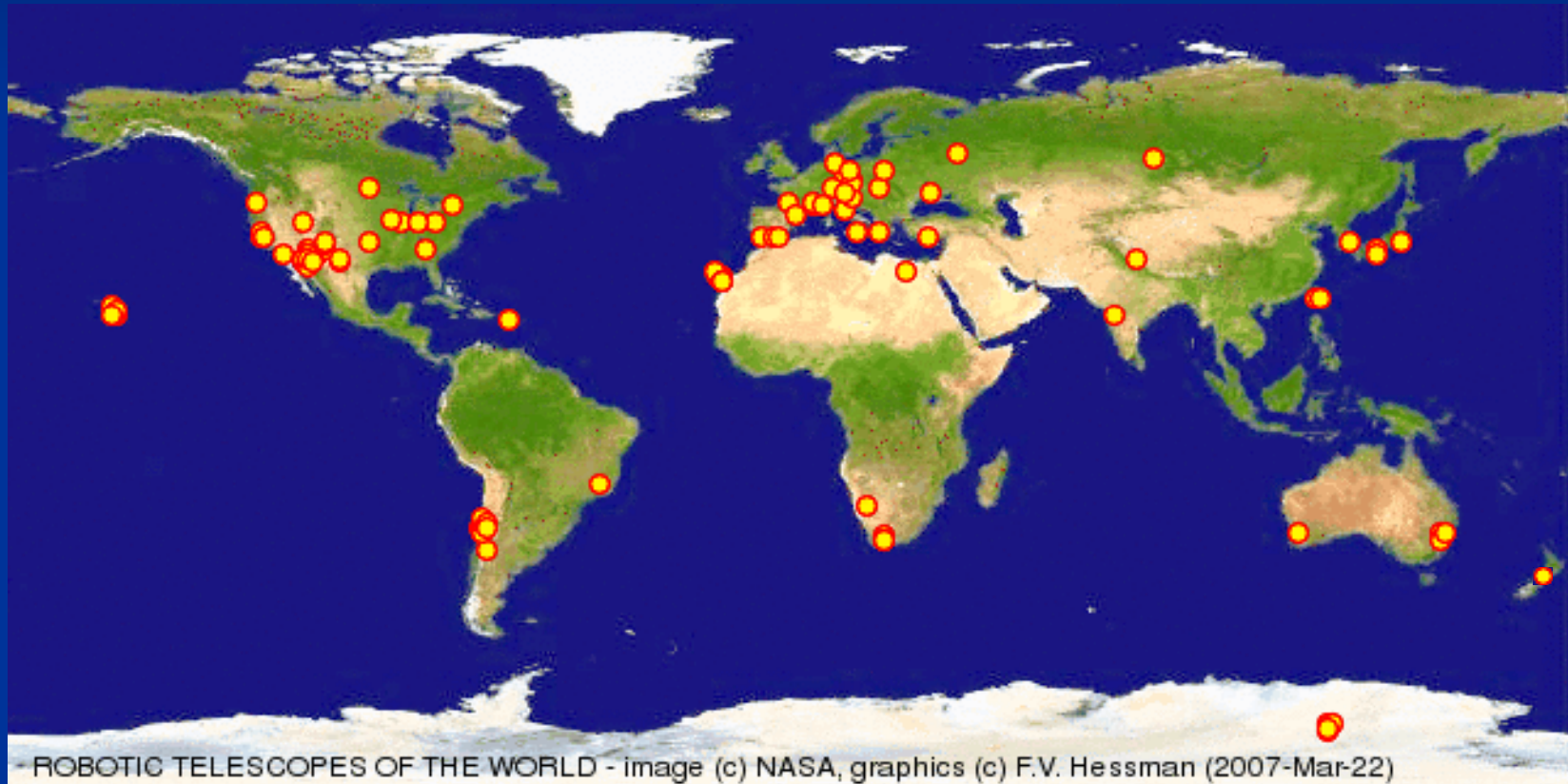
The first **robots** were the telescopes with an absolute positioning control and guiding systems, and the automatic weather stations, introduced in astronomical observatories.

The first **robotic astronomical observatories** are those ones which are able to integrate and coordinate the different automatic subsystems at the observatory (telescope, dome, weather stations). But they require human assistance (teleoperation) for the taking of decisions regarding a given task and/or its supervision.

The **intelligent robotic astronomical observatories** are the following step, where human assistance in the taking of decisions is replaced by an artificial intelligent system. They are being developed nowadays.

3. RAOs: A brief history (VI)

RAOs worldwide: around 100 so far



3. RAOs: a brief history (VII)

RAOs in Europe: around 35



3. RAOs: a brief history (VIII)

Scientific Use (aprox. statistical based on provided info by F. Hessman)

Description	Number of Ref.'s	Percentage
Gamma a-Ray Bursts	29	22.3%
Service observations	21	16.2%
Photometric monitoring	14	10.8%
Education	15	11.5%
All-sky surveys	12	9.2%
Exoplanet searches	10	7.7%
Supernovae search	9	6.9%
Asteroids	7	5.4%
Spectroscopy	4	3.1%
Astrometry	4	3.1%
AGN, Quasars	3	2.3%
(Micro-)Lensing	1	0.8%
Other uses	8	6.2%

3. RAOs: a brief history (IX)

Range of apertures (included expected instruments by 2010)

aperture $\leq$ 0.25m	77	45.3%
0.25 < aperture $\leq$ 0.50m	37	21.8%
0.50 < aperture $\leq$ 0.75m	14	8.2%
0.75 < aperture $\leq$ 1.00m	17	10.0%
1.00 < aperture $\leq$ 1.25m	7	4.1%
aperture > 1.25m	18	10.6%

3. RAOs: a brief history (X)

Observatory Managers

AUDELA: Developed by A. Klotz et al. (Toulouse), starting in 1995. Open source. Linux/Windows.

ASCOM: Designed in 1998, by B. Denny (USA), as a standard interface for astronomical observatories based on model of object components (under MS), which he dubbed “the Astronomy Common Object Model”. Widespread among amateur astronomers, but also use among professional astronomers. Windows. Used in SNs y MPs searches.

RTS2: “The Robotic Telescope System version 2”, developed by P. Kubánek, (Ondrejov/Granada) and started in 2000. Open source code. Linux (command line and graphical interface). Used in GRBs follow-ups. **rts2.org**

INDI: “The Instrument Neutral Distributed Interface” (INDI) started in 2003. When comparing with the standard ASCOM (MS), INDI is an independent protocol platform developed by E. C. Downey (USA). Open source code but not widely spread due to the lack of upper layer interface.

ACP: Commercial and developed for DC-3 dreams in 2000-13 by R. Denny (USA).

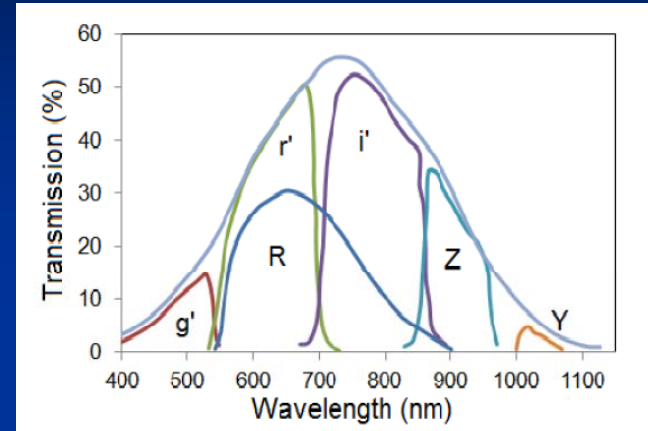
3. RAOs: a brief history (XI)

One of such systems using rts2 is **BOOTES** (Burst Observer and Optical Transient Exploring System)

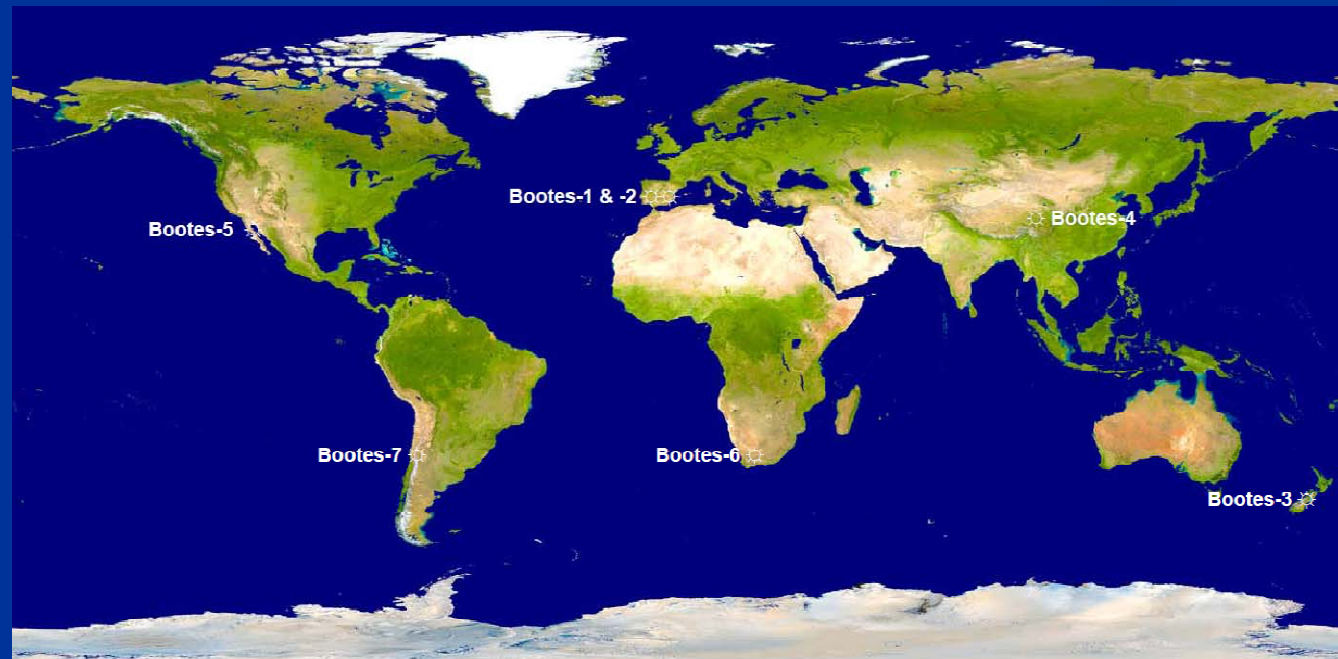
Identical Ø 0,6m telescopes spaced worldwide

Identical filterset (u')g'r'i'ZY

Identical EMCCD cameras



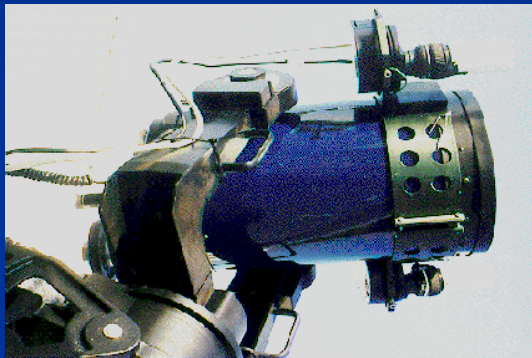
bootes.iaa.es



The BOOTES Network (I)

BOOTES-1 (INTA/CSIC/ASU/CVUT) in El Arenosillo (Huelva).

Jun 1998: 0,3m Ø *Robotic* telescope and wide-field cameras.



1998

Database of images down to $I = 13$ since 1998. The BOOTES-1 site in ESAt is becoming a reference place for wide-field Astronomy.



2000



2009: **Spanish Patrol Meteor Network** -
collaboration with UHU



2013: **Pi-of-the-Sky North** - collaboration
with UWAR (Poland)

The BOOTES Network (II)

BOOTES-2 (INTA/CSIC/UMA/ASU) in Algarrobo-Costa (Málaga)

Nov 2001: 0,3m Ø *Robotic Telescope* and wide-field cameras

Jun 2008: 0,6m Ø *Robotic Telescope* (TELMA) with $v = 100 \text{ g/s}$ and $a = 10 \text{ g/s}^2$ in imaging mode (g'r'i'ZY filters) and limiting magnitude $r' = 20$

Nov 2011: COLORES imaging spectrograph



The BOOTES Network (III)

BOOTES-3 (CSIC/UoA) in Blenheim (Nueva Zelanda)

Feb 2009: 0.6m Ø *Robotic telescope* (YA),
twin of BOOTES-2 (TELMA), in imaging
mode (g'r'i'ZY filters)



3. The GLORIA Project

Is it possible to obtain observing time at the BOOTES-1, -2 and -3 telescopes for anybody unrelated to the BOOTES collaboration?

The answer is YES, thanks to ...

FP7-INFRASTRUCTURES-2011-2 (Call 9)

INFRA-2011-1.2.1: e-Science environments

**Global Robotic Telescopes Intelligent Array For
Citizen Science**



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Consejo Superior Investigaciones Científicas

3. The GLORIA Project (II)

GLORIA Partners

	UPM Universidad Politécnica de Madrid SPAIN
	ASU-CAS Astronomical Institute, Academy of Sciences of the Czech Republic CZECH REPUBLIC
	CSIC Consejo Superior de Investigaciones Científicas SPAIN
	CTU Czech Technical University in Prague CZECH REPUBLIC
	FZU-CAS Institute of Physics of the Academy of Sciences of the Czech Republic CZECH REPUBLIC
	IAC Instituto de Astrofísica de Canarias SPAIN
	INAF Istituto Nazionale di Astrofisica ITALY
	SAO Special Astrophysical Observatory of Russian Academy of Sciences RUSSIA
	UCD University College Dublin IRELAND
	UCH University of Chile CHILE
	UMA University of Malaga SPAIN
	UOX University of Oxford UNITED KINGDOM
	UWAR Uniwersytet Warszawski POLAND

GLORIA is funded by
the European
Commission under the
7th Framework
Programme



GLORIA is a collaborative web 2.0 based on a robotic telescopes network including *many* telescopes with open access and focused towards the public outreach of Astronomy and Citizen Science.



3. The GLORIA Project (IV)

Pillar I: the GLORIA goals

Goal 1: ...establishing synergies amongst the different “astronomical” communities



3. The GLORIA Project (V)

Pillar I: the GLORIA goals

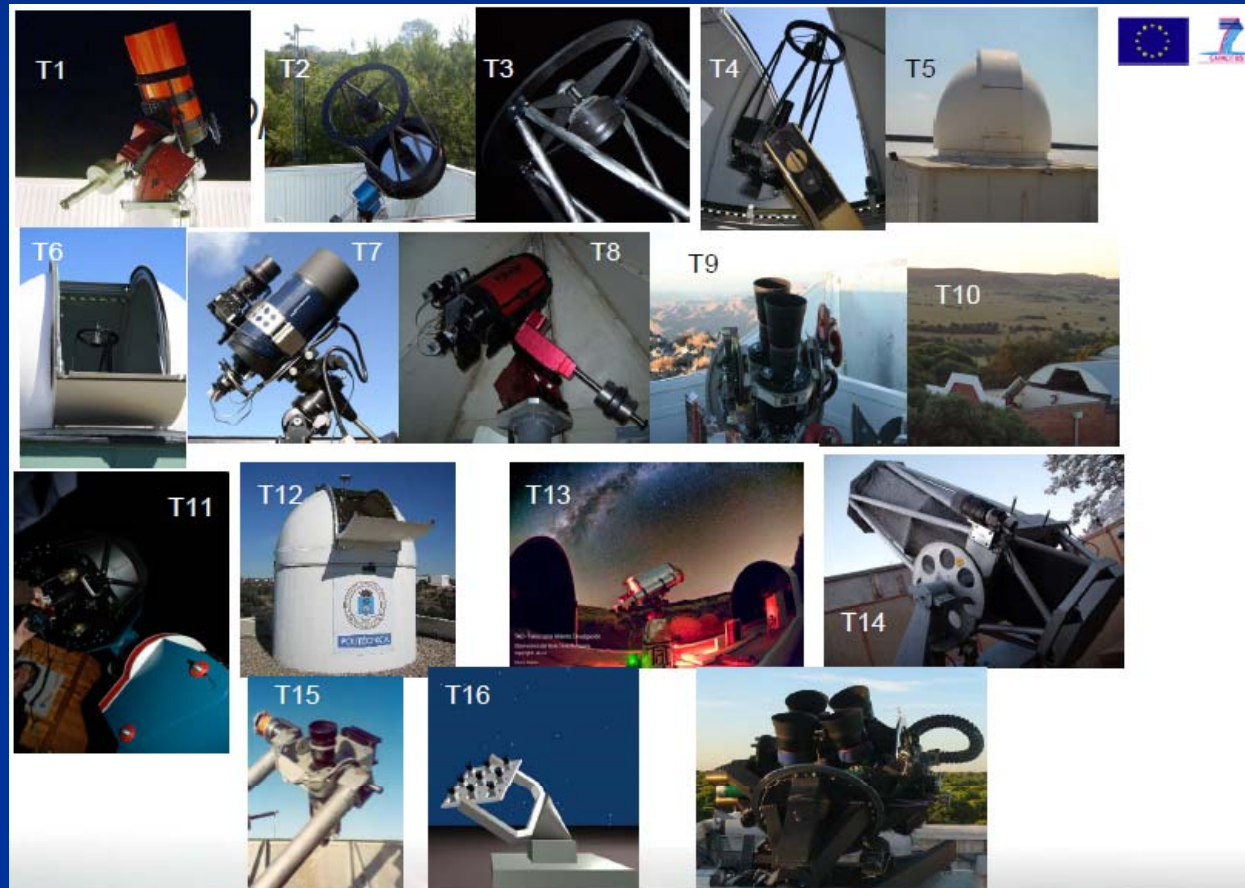
Goal. 1: ...and making use of the GLORIA telescopes. Which ones? (I)

Name	Location	Aperture size (m)
BOOTES-1	Andalucia, Spain	0.3
BOOTES-2/TELMA	Andalucia, Spain	0.6
BOOTES-3/Yock-Allen	New Zealand	0.6
CAB-EVA1	Avila, Spain	0.5
CAB-CAHA	Almeria, Spain	0.5
BART	Czech Republic	0.254 & 0.1
FRAM	Argentina	0.3
Pi of the Sky I	Chile	0.07
Pi of the Sky 2	Huelva, Spain	0.07
Watcher	South Africa	0.4
C. Tololo	Chile	0.5
OM	Madrid, Spain	0.25
TAD	Tenerife, Spain	0.26
D50	Czech Republic	0.5
FAVOR	Russia	0.15

3. The GLORIA Project (VI)

Pillar I: the GLORIA goals

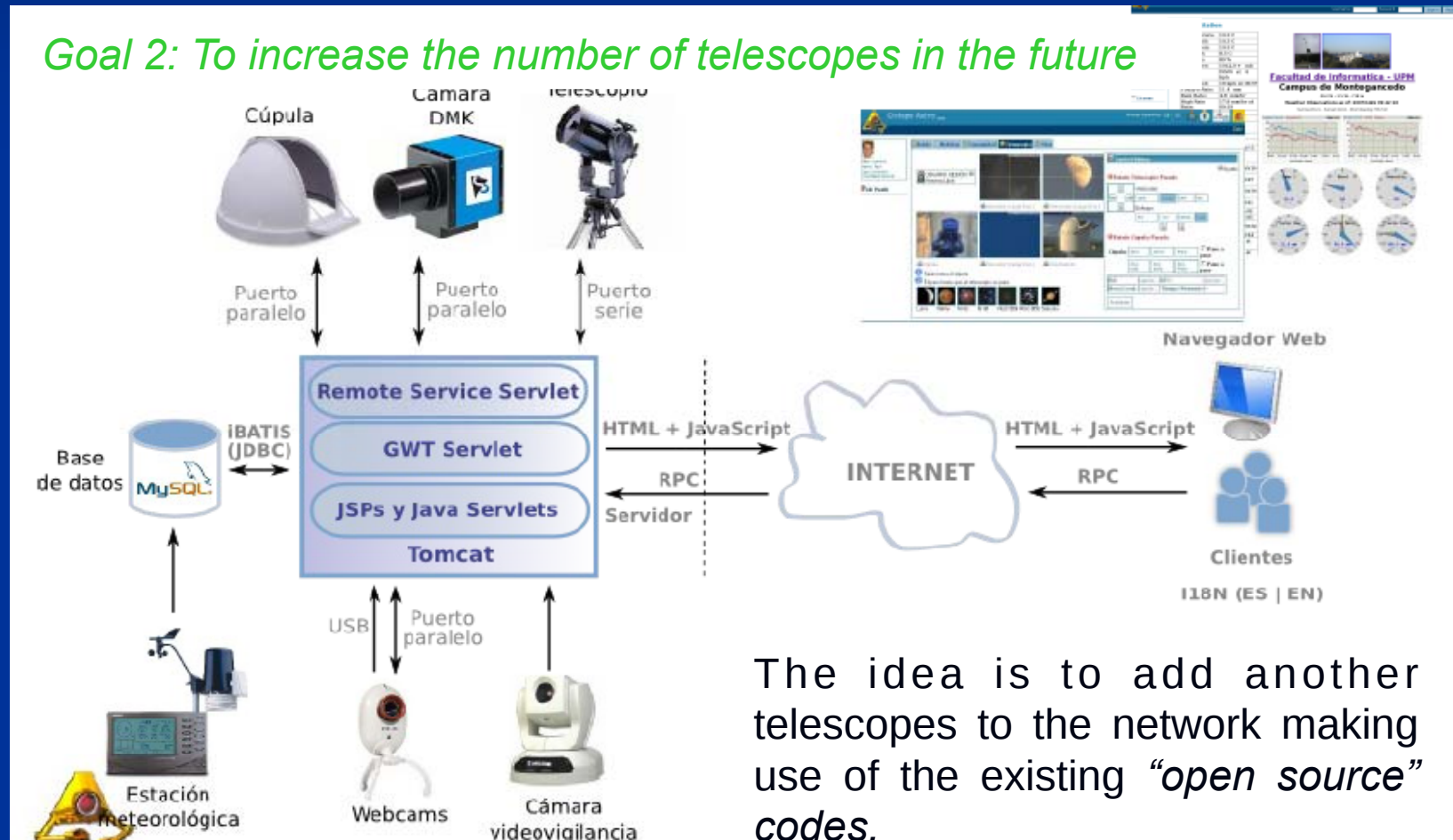
Goal 1: ... and making use of the GLORIA telescopes. Which ones? (II)



3. The GLORIA Project (VII)

Pillar I: the GLORIA goals

Goal 2: To increase the number of telescopes in the future



3. The GLORIA Project (VIII)

Pillar I: the GLORIA goals

Goal 3: To research in “citizen Science”, allowing users at every level to participate at each level by means of experiments.

“On-line” Experiments (Interactive)

Solar Activity (in real time)

Night observation (in real time)

“Off-line” Experiments

Personal Space (**personal-space.eu**)

Solar Activity (using archival data)

Estrellas Variables (using archival data)

Batch observations (under previous requests)

3. The GLORIA Project (IX)

Pillar II. Infraestructure for e-Science

Comunity of Citizens able to perform scientific activities around GLORIA

Meritocratic methodology: the Karma policy

Collaborative tools to share astronomical information (e.g. the SADIRA database)

Pillar III. Free Software and SW Architecture

Open standards and methodology for interactive (“on-line”) experiments and experiments based on queue observations or making use of archive data products (i.e. “off-line” experiments). sourceforge.net

Public access to astronomical data.

3. The GLORIA Project (X)

Pillar IV. To attract new users

Educational Public Activities.

*UCD, November 2013 - Emer O Boyle and Lorraine Hanlon
at the 'Spark at the Ark'*



*CSIC, December 2013, Observing the Sun with GLORIA
in Parque de las Ciencias in Granada*



*IAC, December 2013 - children around the GLORIA planetarium in Tenerife,
Canary Islands, more than 9000 visitors*



University of Chile – Astrobus (5400 school children, January & March 2014)



3. The GLORIA Project (XI)

Pillar IV. To attract new users (2)

Life broadcast of astronomical events for the general public also focused to schools.

Solar Eclipses:
Australia (13 Nov 2012) y Kenia (3 Nov 2013).

Lunar Eclipse (15 Apr 2014)

Venus transit (6 Jun 2012):
Noruega, Japan & Australia.

Northern Lights
(2012, 2013, 2014)



(In collaboration with Shelios (IAC) expeditions)

3. The GLORIA Project (XII)

Pillar IV. To attract new users (3)

Participating in worldwide observational campaigns.

Comet ISON in late 2013

News from comet ISON

Posted on 22/11/2013 by English Editor

Comet C2012/S1 ISON: the brightest comet in the XXI century (so far) followed by GLORIA.



Comet ISON at dawn on November 21st (5:20 UT). The image was taken from the Teide Observatory (Instituto de Astrofísica de Canarias) with a digital camera (Canon 50-Mk, 65mm lens) and an exposure time of about 5 seconds. The brightest object in the image is the planet Mercury while at the bottom center, just above the sea of clouds, the peaks of the Gran Canaria Island are visible. Credits: J.C. Casado, IAC ES.

Supernova SN2014J/M82 in early 2014

SN2014J – supernova in M82



Image of M82 and SN 2014J obtained with the DSO telescope on January 23th, 2014.

The nearest type Ia supernova in 400 years has been found in the Messier 82 (M82) galaxy. First spotted on 21 January 2014, it is relatively close to Earth, about 11.4 million light years away! This supernova is called SN2014J (the 'J' is a supernova discovered so far during 2014), and is a rare kind. 'Type Ia' supernovae (SNIa) are believed to be caused by exploding white dwarf stars. These SNIa explode with very predictable brightnesses, making them ideal 'standard candles' to measure distances to galaxies accurately.

Now that it has reached maximum brightness around Jan 31 (with a magnitude in the R band of about 10), GLORIA will keep monitoring the SN2014J light-curve (along with other supernovae) for the next few months as part of the regular program conducted by some of the GLORIA partners. Indeed, many astronomical observatories worldwide (including space-borne facilities) will point to this unique target regularly over the coming weeks.



3. The GLORIA Project (XIII)

Project website: gloria-project.eu



3. The GLORIA project (XIV)

users website: users.gloria-project.eu

The screenshot shows the GLORIA USERS website interface. At the top, there is a navigation bar with the GLORIA USERS logo, a user profile section for 'angela.gonzalez' with a 'Logout' button, and a language selection menu showing flags for the UK, Spain, Italy, France, and others. The main content area is divided into several sections:

- Solar experiment:** Features an image of the Sun and text: 'Explore the Sun and its spots. Take images to contribute to measurement of solar activity.'
- Night experiment:** Features an image of a starry night sky and text: 'Watch the night sky. Planets, stars, galaxies and asteroids await.'
- Personal space:** Features a 'personal SPACE' logo and text: 'Choose an important event in your life and see the sky that was directly overhead at that exact moment.'
- Solar activity:** Features an image of sunspots and text: 'Analyse sunspots on your Android and contribute to the measurement of solar activity.'
- Variable stars:** Features an image of a star field and text: 'Hunt for variable stars in the data from wide field sky observations.'
- Our telescopes:** Features a map of Europe and Africa with several location pins indicating telescope sites. The map includes a legend for 'Map', 'Sat', and 'Ter' views, and a copyright notice for '©2014 Google'.

A 'A bigger map' link is visible at the bottom right of the map section.

3. The GLORIA Project (XV)

users website: users.gloria-project.eu

The screenshot displays the 'GLORIA USERS' website. The top navigation bar includes the logo, a user welcome message 'Welcome, angela.gonzalez' with a 'Logout' button, and a row of flags. Below this is a menu with 'Home', 'Experiments', 'Images', 'Profile', and 'Issues'. The main content area is titled 'Make a reservation' and explains the booking process. It then presents two main steps: '1. Select an experiment' and '2. Select a telescope'. Under the first step, there are two options: 'Solar experiment' (with a thumbnail of the sun) and 'Night experiment' (with a thumbnail of a starry night sky). Under the second step, there are four telescope options: 'BART' (with a thumbnail of a telescope), 'BOOTES-1A' (with a thumbnail of a telescope), 'BOOTES-1B' (with a thumbnail of a telescope), and 'BOOTES-2' (with a thumbnail of a telescope). The 'Night experiment' and 'BOOTES-2' options are highlighted with orange borders.

GLORIA USERS

Welcome, angela.gonzalez Logout

Home Experiments Images Profile Issues

Make a reservation

In order use a telescope's observing time you must make a booking. Then, when the time comes, you will have the telescope all to yourself. Each telescope owner sets the availability of their telescope. We then allocate intervals of 15 minutes during the available times.

1. Select an experiment



Solar experiment
Explore the Sun and its spots



Night experiment
Watch the night sky

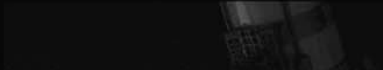
2. Select a telescope



BART
Ondrejov, Czech Republic (AUAV)



BOOTES-1A
Andalucia, Spain (CSIC)



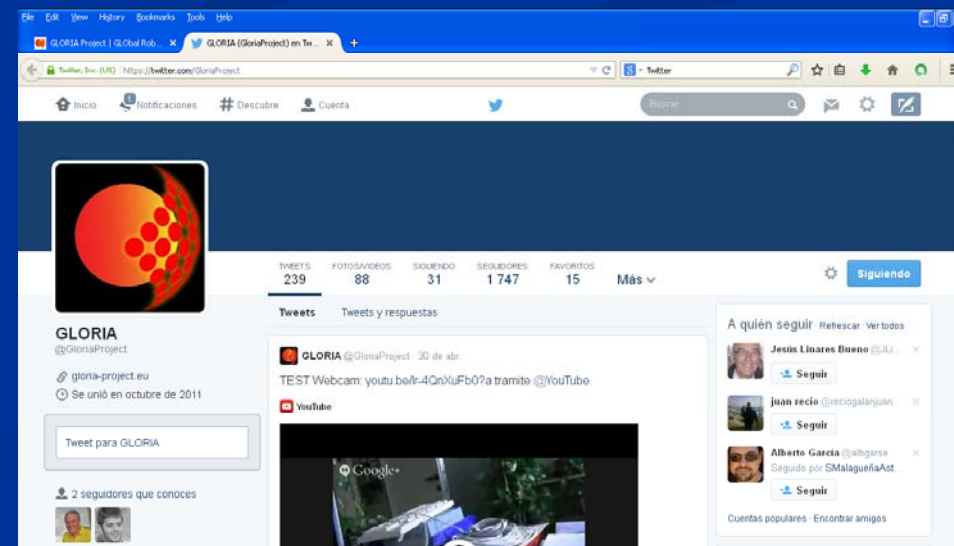
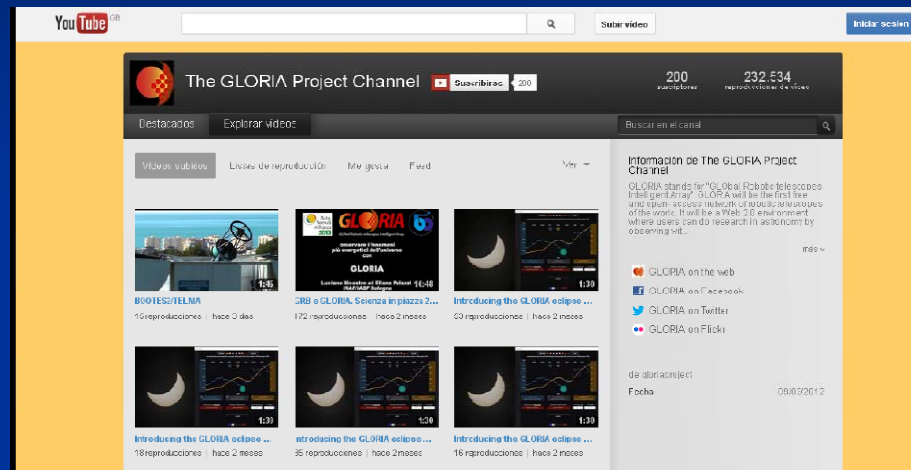
BOOTES-1B
Andalucia, Spain



BOOTES-2
Andalucia, Spain

3. The GLORIA Project (XVI)

GLORIA in the social networks



Conclusions

The application of Robotic to Astronomical Observatories (and network of Astronomical observatories, such as **BOOTES**, bootes.iaa.es), started to opening a new field of research in the last two decades.

GLORIA (gloria-project.eu) is a project funded by the FP7 European Union programme, and started in 2011. Its main goal is to make available a fraction of the onbserveing time for 17 telescopes, thru a meritocratic system. Real-time (“On-line”) experiments as well and programmed experiments (making use of archive data products, “Off-line” experiments) are also available.

As BOOTES Project Scientist and Deputy Coordinator, on behalf of the GLORIA Collaboration (44 people, 14 institutions, 9 countries) I encourage you to make use of GLORIA as of today! In the near future you will be able to join your telescope to GLORIA, to design your own experiment, and much more... Stay tuned!

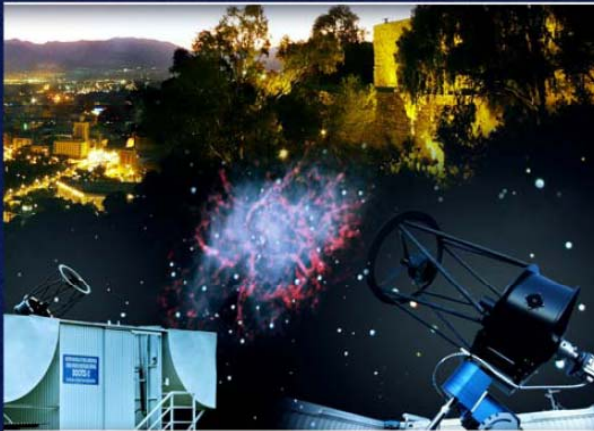
IV Workshop on Robotic Astronomical Observatories

Málaga (Oct 2015)

astrorob.iaa.es

ROBOTIC ASTRONOMY 2009

*Alberto J. Castro-Tirado,
Josh Bloom,
Lorraine Hanlon
and Taro Kotani
(Editors)*



IAA-CSIC
UMA

Third Workshop on Robotic Autonomous Observatories

Torremolinos, Málaga, Spain, 7th - 11th October 2013

<http://astrorob.iaa.es>

e-mail: astrorob@iaa.es

Main Topics

Existing robotic observatories worldwide
New hardware and software developments
Real-time analysis pipelines
Archiving the data and quality control
Telescope and observatory control systems
Transient detection and classification
Protocols for robotic telescope networks
Scientific results obtained by means of robotic observatories
Public outreach and Citizen Science
Global networks
Educational applications
Future strategies

LOC

María Eva Alcoholido-Felström (LOC secretary)
Alfonso García-Cerezo, Victor Muñoz (chair)
Juan Cabello, Carmen López Casado,
Carlos Pérez del Pulgar (UMA, Spain)
Ronan Conniffe, Javier Gorosabel, Martin Jelinek,
Oscar Lara Gil, Rubén Sánchez Ramírez,
Juan Carlos Tello (IAA-CSIC, Spain)
Luis Cuesta (CAB/INTA-CSIC, Spain)
Marilyo Pérez-Ramírez (U. Jaén, Spain)

Photographs by Alberto J. Castro-Tirado. Design by Irina Guziy

SOC

Alberto J. Castro-Tirado (IAA-CSIC, Granada, Spain; chair)
Sergiy Guziy (Nikolayev National Univ., Ukraine)
Lorraine Hanlon (UCD, Dublin, Ireland)
René Hudec (ASU-AIC Ondřejov, Czech Republic)
Alain Klotz (CESR, Toulouse, France)
Vladimir Lipunov (Moscow State University, Russia)
Lech Mankiewicz (GFT, Warszawa, Poland)
Shashi B. Pandey (ARIES, Nainital, India)
Francisco Manuel Sánchez-Moreno (UPM Madrid, Spain)
Klaus Strassmeier (Astrophysical Institute Potsdam, Germany)
James Wren (LANL, USA)

