



# Open Robotic Observatory Control System OpenROCS v2.0

Proyecto Final de Carrera  
Ingeniería Técnica en Informática de Sistemas

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Universitat Politècnica de Catalunya (UPC)

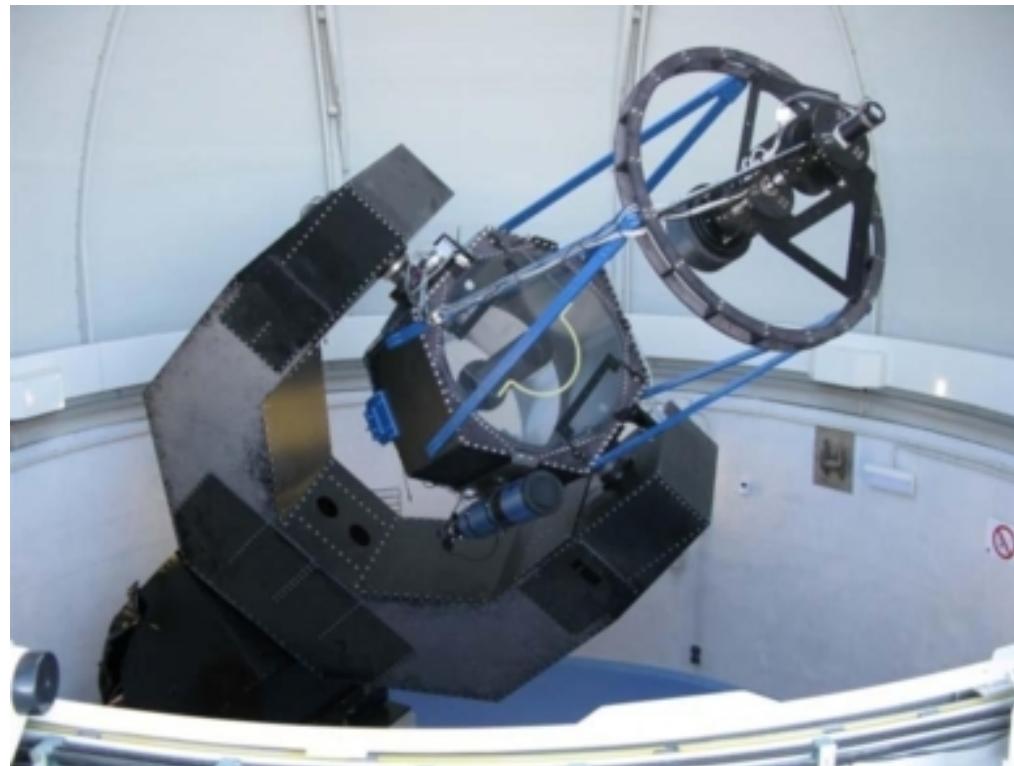
Mayo de 2015

# OpenROCS: Índice

- Objetivos
- Introducción
- Sistema robótico
- Diseño global
- Requisitos
- Alternativas
- Diseño
- Tareas previas
- Implementación
- Resultados
- Planificación y costes
- Conclusiones

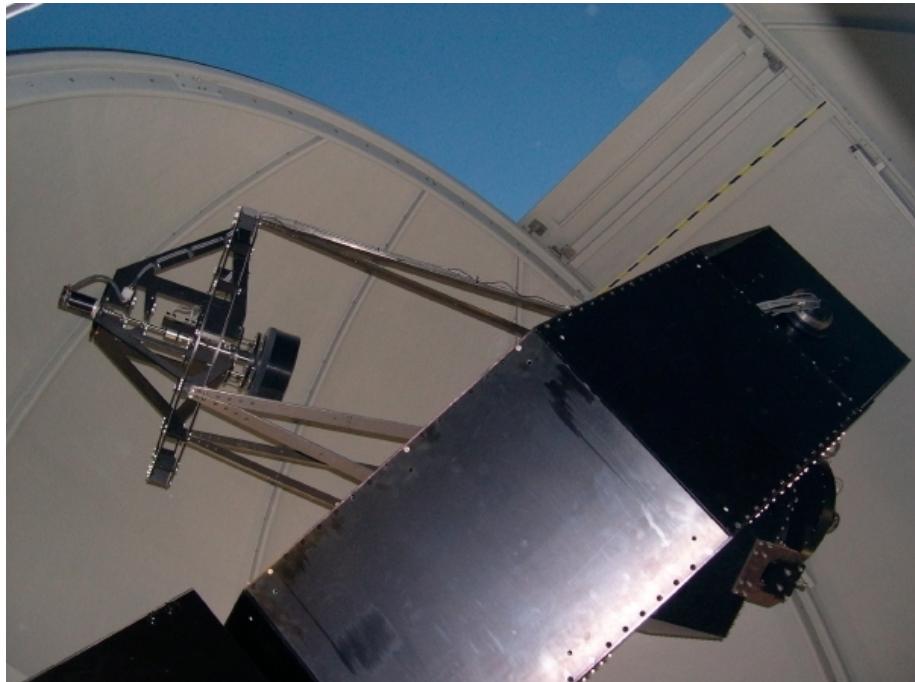
# OpenROCS: Objetivos

El objetivo de este PFC es dar una solución a las necesidades de control robótico del Telescopio Joan Oró (TJO).



# OpenROCS: Introducción

El TJO es un telescopio de 80cm fabricado por OMI



- Cúpula automática de 6m aprox. de diámetro
- Cámara de adquisición de imágenes (MEIA)

# OpenROCS: Introducción

## El Observatori Astronòmic del Montsec (OAdM)



- A 1570m. de altura en la sierra del Montsec.
- Denominación de “Reserva Starlight”

# OpenROCS: Introducción



Telescopio Joan Oró



Telescopio Fabra-  
ROA-Montsec



Cámara all-sky del  
IEEC



Unidad XO del STScI



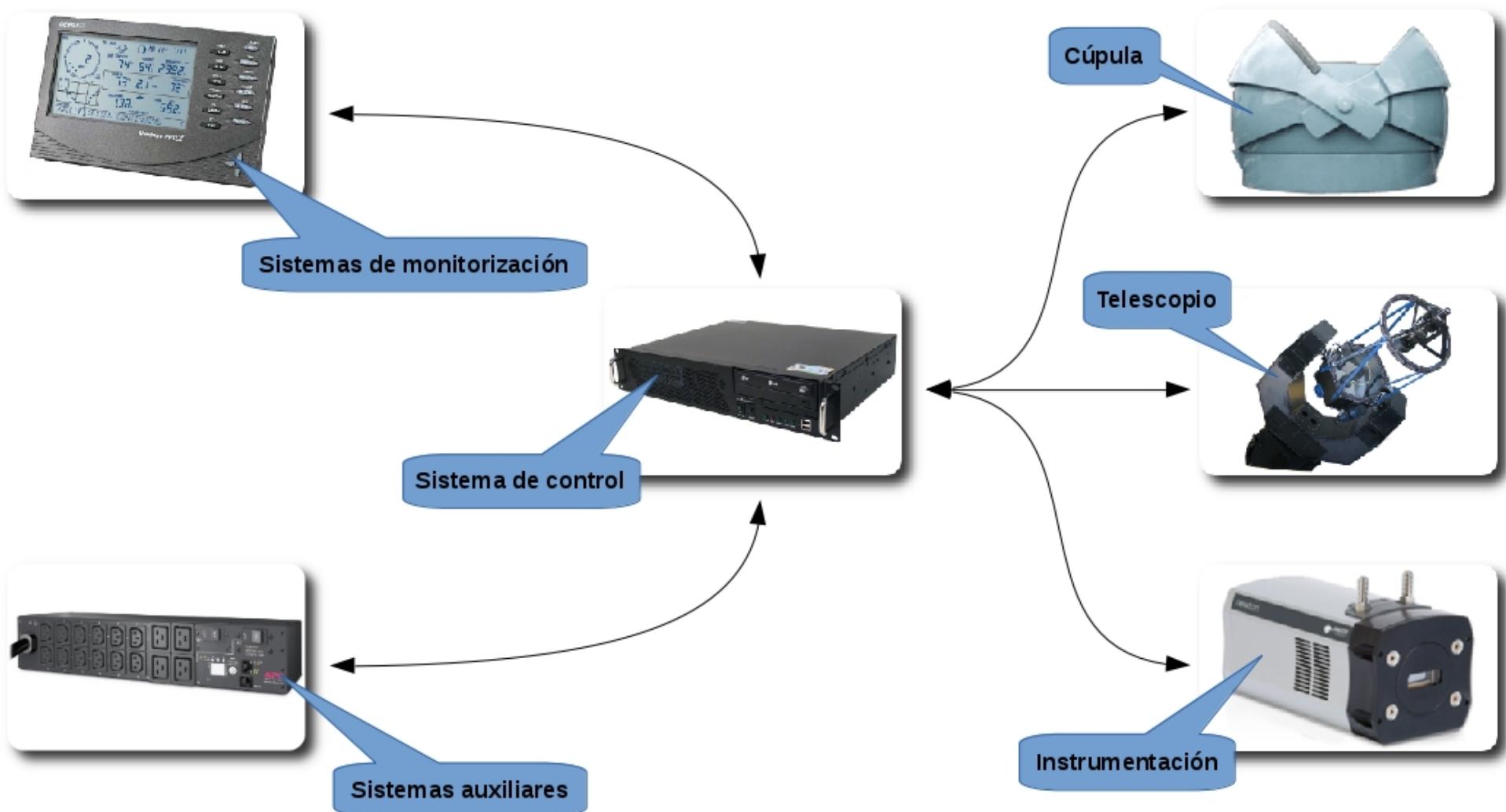
Estación meteorológica  
del SMC



Estación XVPCA

# OpenROCS: Sistema robótico

## Elementos del sistema robótico:



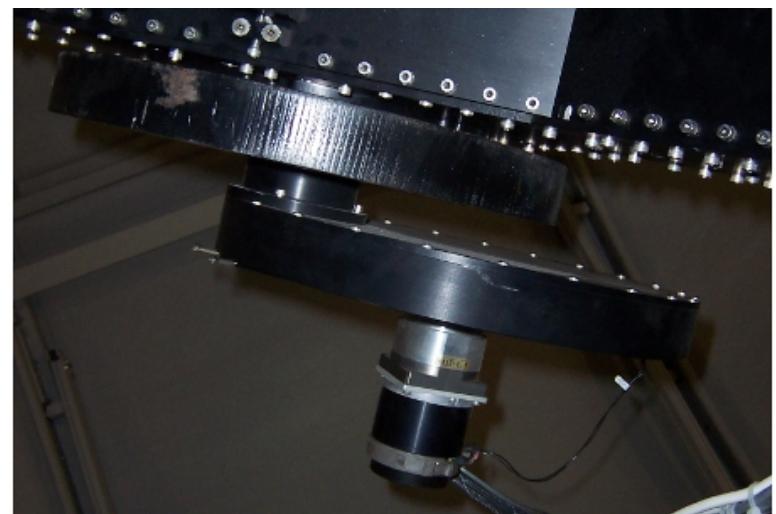
# OpenROCS: Telescopio y cúpula



- Control por AVS y CSIMC
- Comunicación RS-232
- Software de control TALON

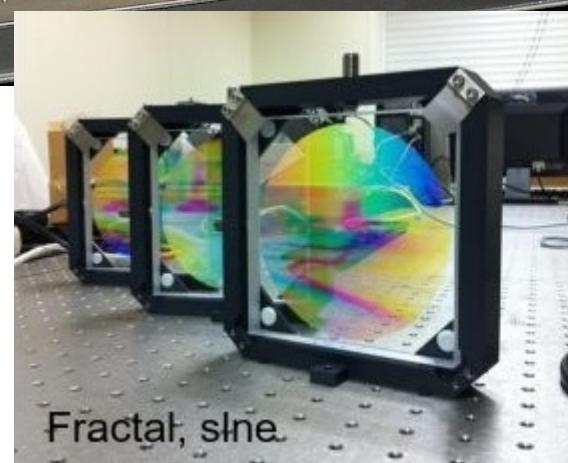
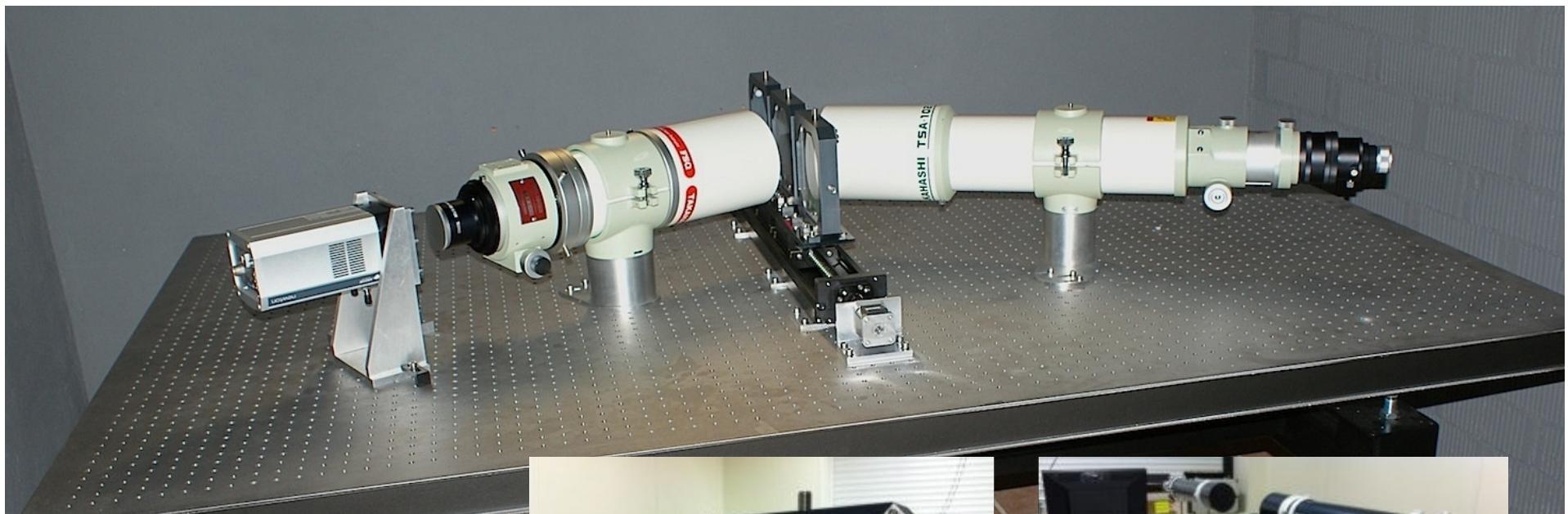
# OpenROCS: Instrumentación

MEIA (instrumento principal)

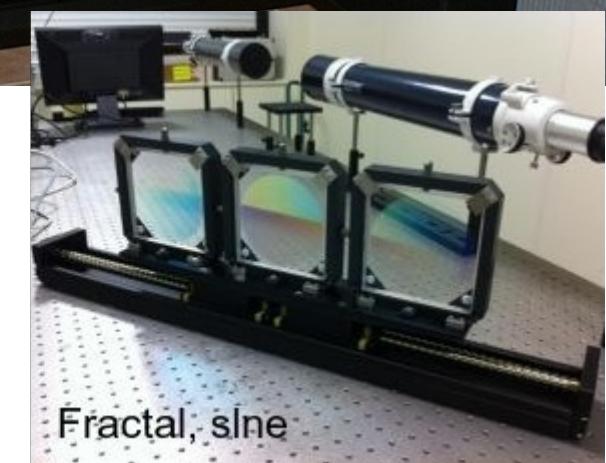


# OpenROCS: Instrumentación

ARES (Espectrógrafo alimentado por fibra)



Fractal, sline



Fractal, sline

# OpenROCS: Monitorización



# OpenROCS: Sistemas auxiliares



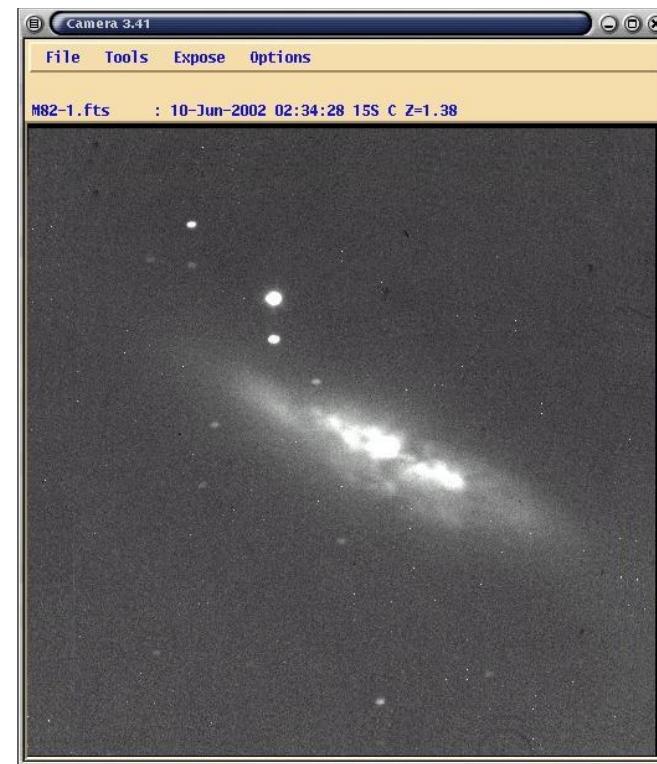
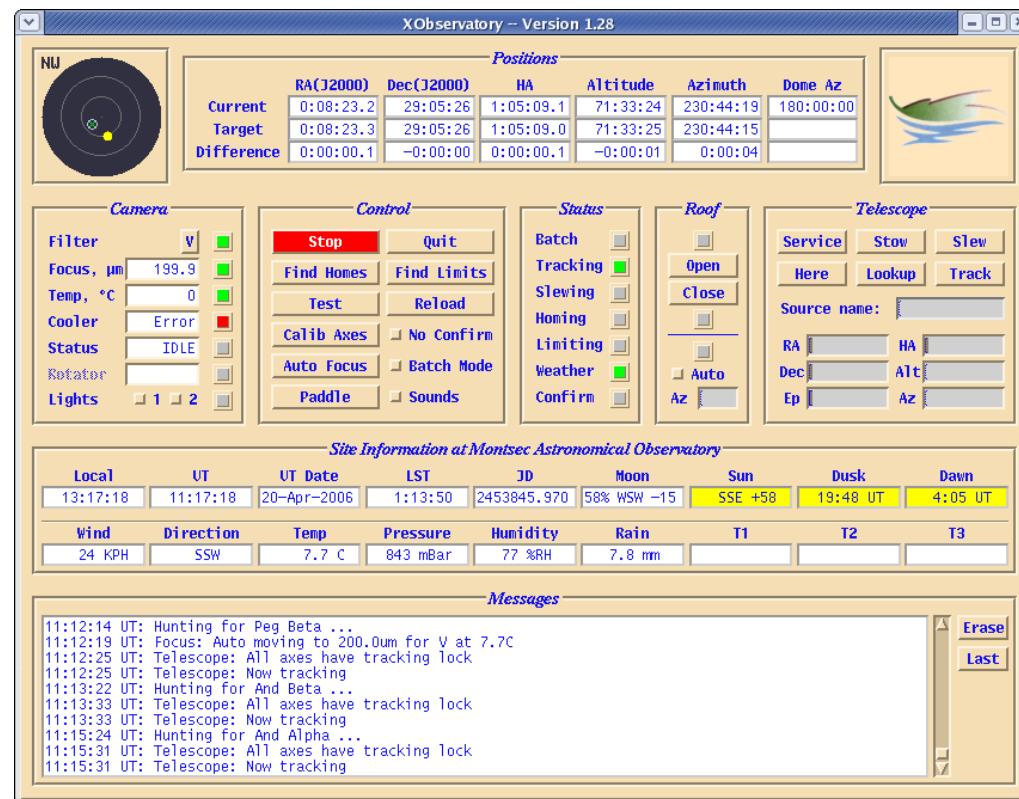
# OpenROCS: Sistema de control

Se empezó a desarrollar un software de control llamado OpenROCS v1.0 que realizaba las siguientes tareas:

- Monitorizar la estación meteorológica
- Monitorizar el sensor de lluvia
- Iniciar el software TALON

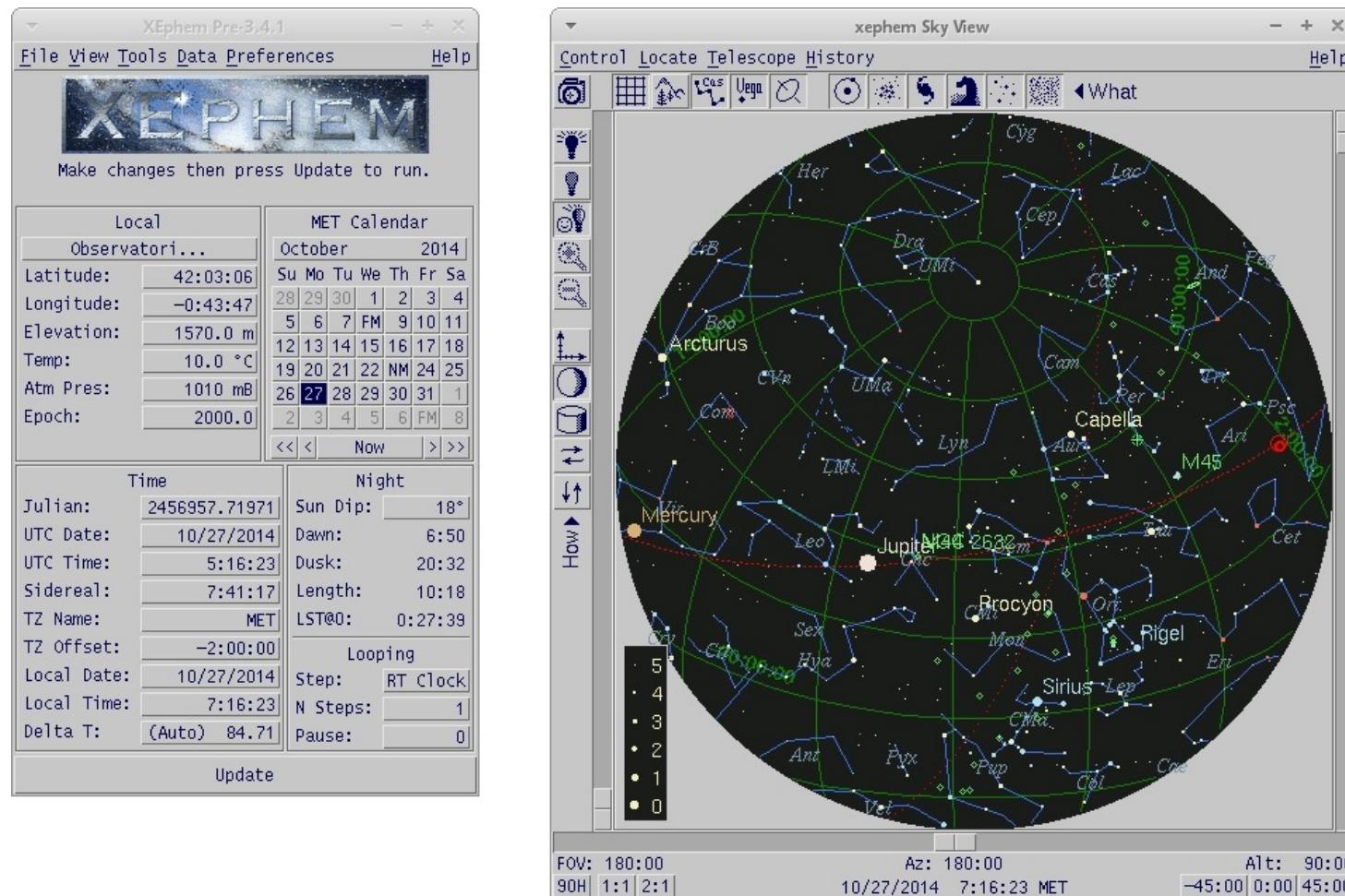
# OpenROCS: Sistema de control

El software de control proporcionado por el fabricante fue TALON

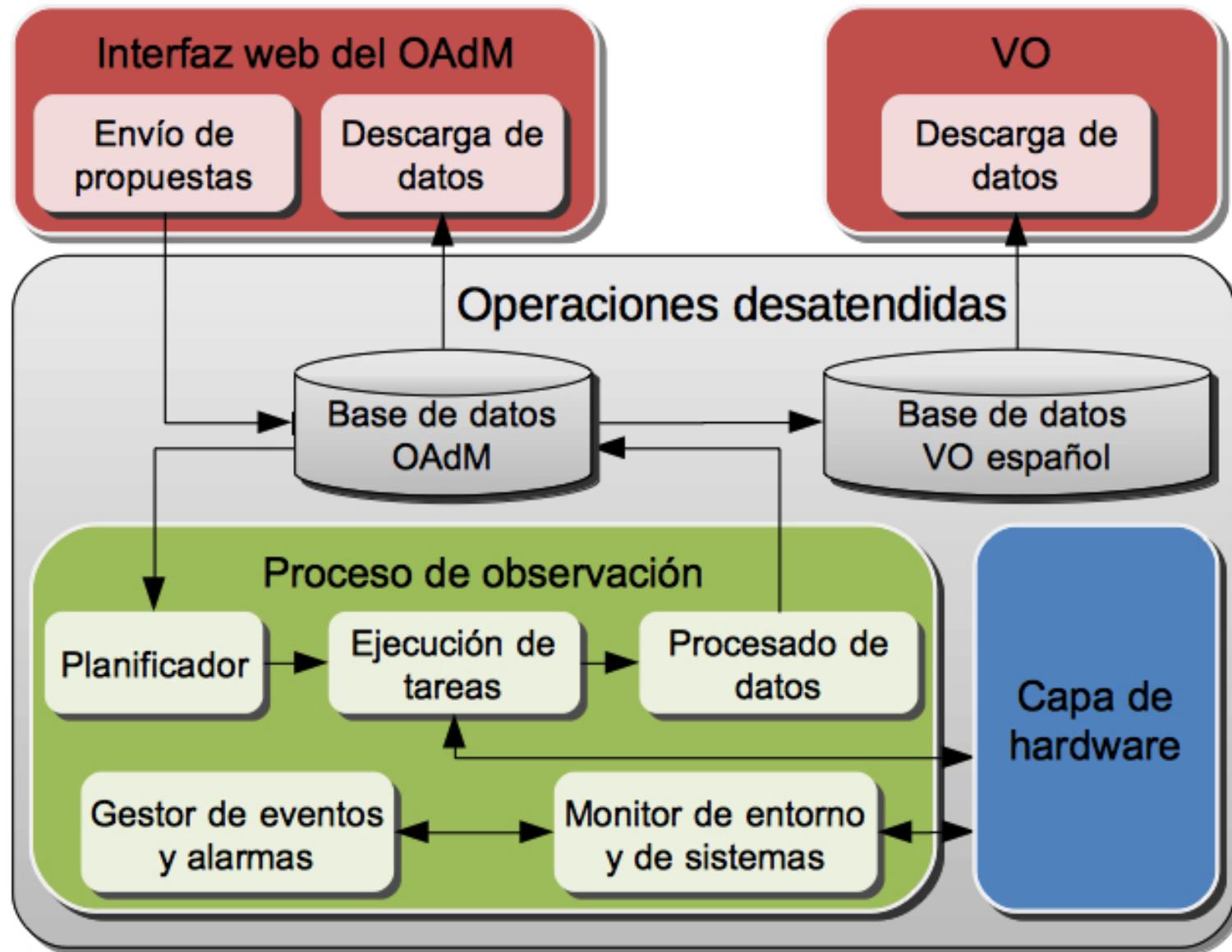


# OpenROCS: Sistema de control

# Interfaz XEphem



# OpenROCS: Funcionamiento



# OpenROCS: Web OAdM

## Página Web

Contactar

Català Castellano English

**IEEC**  
Institut d'Estudis Espacials de Catalunya

**OAdM**  
Parc Astronòmic Montsec  
Observatori Astronòmic del Montsec

Inicio OAdM TJO Observar Entorno Prensa Imágenes

**MUR PROPOSALS**  
SUBMISSION TOOL

May -2015

Mo	Tu	We	Th	Fr	Sa	Su
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

**Prensa**

11/02/2015 | Últimas noticias | Entrevista a Ignasi Ribas, director del OAdM e investigador del IEEC  
El pasado 10 de febrero, el programa de TV3 Quèquécom entrevistó al doctor Ignasi Ribas, director del Observatorio Astronómico...

24/10/2014 | Resultados científicos | Confirmación espektroscópica de la candidata a novia PNIV J00423972+420117  
Más información (en inglés) aquí.

25/09/2014 | Resultados científicos | Espectroscopía y fotometría de las novas M3IN 2014-09a y M3IN 2014-09b  
Más información (en inglés) aquí.

17/09/2014 | Resultados científicos | SN 2013df, una supernova Ibb de doble pico de un progenitor compacto y una envoltura extendida de H  
Más información (en inglés) aquí.

10/07/2014 | Resultados científicos | Nueva candidata a novia en el óptico en el disco de M31  
Más información (en inglés) aquí.

**Datos estaciones**

Date	2015-05-21 09:09:02
Temperature	3.5°
Humidity	62%
Rain detector	NOT RAINING
Electrostatic	0.8 kV/m
Wind speed	8.0 m/s
Wind dir.	45.0°
Pressure	846.7 mb

Saber más |

2015-05-21 09:09:05

2015-05-21 09:00:05

Developed with RhinOS

## Meteorología

Contactar

Català Castellano English

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**OAdM**  
Parc Astronòmic Montsec  
Observatori Astronòmic del Montsec

Inicio OAdM TJO Observar Entorno Prensa Imágenes

**Datos estaciones (2015-05-21 09:11:02)**

Humidity	Rain detector	Electrostatic	Wind speed
61%	NOT RAINING	0.8 kV/m	8.0 m/s
Temperature	Pressure	Solar rad.	Wind dir.
3.5°C	846.7 mb	252.1 W/m <sup>2</sup>	28.0°

Last 24h data

Last 24h | Last 48h | Last week | Last month | Last year | Last 2 years | [charts](#)

**TEMPERATURE (°C)**

**HUMIDITY (%)**

Entorno

- Datos estaciones
- Cámaras web en directo

# OpenROCS: MUR

## Propuestas

Contactar      Català Castellano English



**OAdM**  
Parc Astronòmic Montsec  
Observatori Astronòmic del Montsec

[Inicio](#) [OAdM](#) [TJO](#) [Observar](#) [Entorno](#) [Prensa](#) [Imágenes](#)

[IEEC MUR PROPOSALS](#)

### Proposals

On this page you will find the running and completed proposals

ID	PI	Title	Priority	Time	Due date
p109	Marciak	Reducing observational bias in...	8	100 h.	2016-05-06
p101	Trigo-Rodríguez	OAdM Photometric and Spectrosc...	7.5	100 h.	2016-04-13
p107	Herrero	Study of exoplanetary systems ...	8	100 h.	2016-03-24
p103	Perger	Confirmation of two transiting...	85	29.7 h.	2016-02-19
p97	Santana-Ros	Rotational and shape propertie...	7	30 h.	2015-10-31
p95	TARIS	Optical monitoring of extragal...	7.5	65 h.	2015-10-07
p93	Vilardell	First astrometric measurements...	8	7 h.	2015-10-07
p91	Burgaz	Photometric follow-up of Gaia...	9	100 h.	2015-09-12
p89	Morales-Garoffolo	Study of nearby and rare trans...	85	74 h.	2015-07-15
p85	Triaud	Photometric monitoring of a la...	7	16 h.	2015-07-02

[All proposals](#) [Active](#) [Completed](#)

**Observar**

- Proposals
- MUR
- Calendar
- Archive
- MUR help
  - Proposal submission
  - Data retrieval
  - Database policy
- Exposure time calculator

[More](#)

IEEC - Institut d'Estudis Espacials de Catalunya      Developed with RhinOS

Contactar      Català Castellano English



**OAdM**  
Parc Astronòmic Montsec  
Observatori Astronòmic del Montsec

[Inicio](#) [OAdM](#) [TJO](#) [Observar](#) [Entorno](#) [Prensa](#) [Imágenes](#)

[IEEC MUR PROPOSALS](#)

### Calendario

Here, you can see the observed proposals per night.

January												February												March												April											
Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su																				
1	2	3	4	5			3	4	5	6	7	8	9	3	4	5	6	7	8	9	1	2	3	4	5	6																					
6	7	8	9	10	11	12	10	11	12	13	14	15	16	10	11	12	13	14	15	16	14	15	16	17	18	19																					
13	14	15	16	17	18	19	17	18	19	20	21	22	23	17	18	19	20	21	22	23	21	22	23	24	25	26																					
20	21	22	23	24	25	26	27	28	29	30	31			24	25	26	27	28	29	30	28	29	30																								
27	28	29	30	31			24	25	26	27	28			24	25	26	27	28	29	30	28	29	30																								

**Observar**

- Proposals
- MUR
- Calendar
- Archive
- MUR help
  - Proposal submission
  - Data retrieval
  - Database policy
- Exposure time calculator

May												June												July												August											
Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su																				
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6																					
8	9	10	11	12	13	14	9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16																					
15	16	17	18	19	20	21	18	19	20	21	22	23	24	21	22	23	24	25	26	27	18	19	20	21	22	23																					
22	23	24	25	26	27	28	23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30																					
29	30						27	28	29	30	31			24	25	26	27	28	29	30	29	30	31																								

September												October												November												December											
Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su																				
1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6																					
8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13																					
15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20																					
22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27																					
29	30						27	28	29	30	31			24	25	26	27	28	29	30	29	30	31																								

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# OpenROCS: MUR

## Archivo

The screenshot shows the 'Archive' section of the OpenROCS interface. At the top, there are links for 'Contactar', 'Català', 'Castellano', and 'English'. Below this is the IEEC logo and the OAdM logo. A navigation bar includes 'Inicio', 'OAdM', 'TJO', 'Observar', 'Entorno', 'Prensa', and 'Imagenes'. A 'IEEC MUR PROPOSALS' button is also present. The main content area has a heading 'Archive' and a sub-section 'Observar'. It displays a table of proposals with columns for 'Id', 'PI', 'Title', and 'Last observed days'. The table lists several entries, such as p101 (Trigo-Rodríguez), p95 (TARIS), p91 (Burgaz), etc. A 'More' button is at the bottom right of the table.

## Acceso usuarios

The screenshot shows the 'MUR' section of the OpenROCS interface. At the top, there are links for 'Contactar', 'Català', 'Castellano', and 'English'. Below this is the IEEC logo and the OAdM logo. A navigation bar includes 'Inicio', 'OAdM', 'TJO', 'Observar', 'Entorno', 'Prensa', and 'Imagenes'. A 'IEEC MUR PROPOSALS' button is also present. The main content area has a heading 'MUR' and a sub-section 'Observar'. It displays a login form with fields for 'Username\*' and 'Password\*', and buttons for 'Login', 'Register', and 'Reminder'. To the left of the form, there is a welcome message: 'Welcome to the Management for Users in ROCS (MUR) application. Use this web tool to add and manage your scientific proposals.' A sidebar on the right lists various links: 'Proposals', 'MUR', 'Calendar', 'Archive', 'MUR help' (with sub-links for 'Proposal submission', 'Data retrieval', 'Database policy'), and 'Exposure time calculator'.

# OpenROCS: MUR

## Panel principal

The screenshot shows the main interface of the OpenROCS MUR application. At the top, there is a header with the IEEC logo, the text "Institut d'Estudis Espacials de Catalunya", and the OAdM logo. Below the header, there is a navigation bar with links for "Inicio", "OAdM", "TJO", "Observar", "Entorno", "Prensa", and "Imagenes". On the right side of the header, there are language links: "Català", "Castellano", and "English". The main content area is titled "MUR" and displays a list of proposals. Each proposal entry includes the ID, title, phase (Phase 1, Phase 2, Phase 3), due date (e.g., 2016-03-24), and status (e.g., View, Edit, View, Closed). To the right of the proposal list, there is a sidebar titled "Observar" with links for "Proposals", "MUR", "Calendar", "Archive", "MUR help" (with sub-links for "Proposal submission", "Data retrieval", and "Database policy"), and "Exposure time calculator". At the bottom of the page, there is a footer with the text "IEEC - Institut d'Estudis Espacials de Catalunya" and "Developed with RhinOS".

## Fase 1

The screenshot shows the "MUR Phase 1" observation form. At the top, there is a header with the IEEC logo, the text "Institut d'Estudis Espacials de Catalunya", and the OAdM logo. Below the header, there is a navigation bar with links for "Home", "OAdM", "TJO", "Observing", "Environment", "Media", and "Images". On the right side of the header, there are language links: "Català", "Castellano", and "English". The main content area is titled "MUR Phase 1" and displays a proposal for "p107: Study of exoplanetary systems via transit timing variations Multisite photometric". The form includes fields for "Id" (p107), "Title" (Herrero, Enrique (CSIC, Consejo Superior de Investigaciones Científicas)), "Abstract" (a detailed description of the proposal), and "Collaborators" (a list of names and institutions). A note at the bottom states: "During its four years of photometric observations the Kepler space telescope has detected thousands of exoplanet candidates. One of Kepler's most intriguing tools has been the confirmation and characterization of multiple-planet systems via TTVs. However, the current TTV detection limit is around 100 days, which is too long to detect TTVs on such long time scales that the existing Kepler observations are not sufficiently long enough to confirm and characterize them. Therefore, here we propose to use the 0.8m Telescopi Joan Oró (TJO) to follow-up on the Kepler network of measured telescopes over the next years and use KOINet to follow-up on the confirmed systems to confirm and characterize them. Here we propose to use the 0.8m Telescopi Joan Oró (TJO) to fulfill KOINet's scientific goals." At the bottom of the page, there is a footer with the text "IEEC - Institut d'Estudis Espacials de Catalunya" and "Developed with RhinOS".

# OpenROCS: MUR

## Fase 2

**MUR Phase 2**

Use this form to modify the observation details

Observers should provide all the requested information to validate and process the observation request. Please visit the [Help pages](#) for further information.

<b>Id</b>	p65
<b>PI</b>	Herrero, Enrique (CSIC, Consejo Superior de Investigaciones Científicas)
<b>Title</b>	Characterization of the atmosphere of HAT-P-12b

Step 1 Step 2 Step 3 Step 4

**Observing**

- Proposals
- MUR
- Calendar
- Archive
- MURhelp
  - Proposal submission
  - Data retrieval
  - Database policy
- Exposure time calculator

**Target:**

Source name: HAT-P-12  
 Coordinate format: Equatorial  
 Coordinate value: 1357.337 0.0 +4329.373  
 0.0 2000.0

**Observing constraint:**

Sky brightness: Bright  
 Seeing: Medium  
 Cloud cover: Photometric  
 Solar elevation: Night Time  
 Moon distance: 0  
 Airmass (min): 1  
 Airmass (max): 2  
 Hour angle (min): 0  
 Hour angle (max): 24  
 Window:  
 • Start (ID): 2454419.1052 | End (ID): 2454419.2857 | Period: 3.2130598

**Instrument configuration:**

Instrument: MEIA  
 Target type: Science  
 Follow type: Object  
 Other pattern: 1x1  
 Other (RA): 0  
 Other (Dec): 0  
 Defocus: Disabled  
 Exposures: 1  
 Exposure time: 120  
 Adapt time: Enabled  
 Binning: 1x1  
 Subframe: 2048  
 Filter: I

75x t1o1l  
 &  
 5x t2o1l

Required max time: 04:00:40  
 Required min time: 02:48:40

Enabled

Sequence 2 (Enabled)  
 Sequence 3 (Enabled)  
 Sequence 4 (Enabled)

## Fase 3

Contact

Català Castellano English

**IEEC** Institut d'Estudis Espacials de Catalunya

OAdM Parc Astronòmic del Montsec Observatori Astronòmic del Montsec

Home OAdM TJO Observing Environment Media Images

**MUR PROPOSALS**

**MUR Phase 3**

On this page you will find the result of the observations made in its proposal

<b>Id</b>	p71
<b>PI</b>	Herrero, Enrique (CSIC, Consejo Superior de Investigaciones Científicas)
<b>Title</b>	Study of exoplanetary systems via transit timing variations Multi-site photometric

**Observing**

- Proposals
- MUR
- Calendar
- Archive
- MURhelp
  - Proposal submission
  - Data retrieval
  - Database policy
- Exposure time calculator

**File**      **Date**      **Size**

2015012targz	12/03/2015	524.07 Mbytes
20141018targz	18/10/2014	366.42 Mbytes
20141017targz	17/10/2014	276.27 Mbytes
20140930targz	30/09/2014	125.23 Mbytes
20140926targz	26/09/2014	415.06 Mbytes
20140913targz	13/09/2014	239.55 Mbytes
20140909targz	09/09/2014	416.86 Mbytes
20140906targz	06/09/2014	222.86 Mbytes
20140903targz	03/09/2014	184.32 Mbytes

More

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# OpenROCS: Requisitos

Es necesario un sistema que realice las siguientes **tareas**:

- Monitorizar las variables de entorno
- Tomar decisiones
- Comunicarse con los diferentes dispositivos
- Intercambiar información con otros equipos

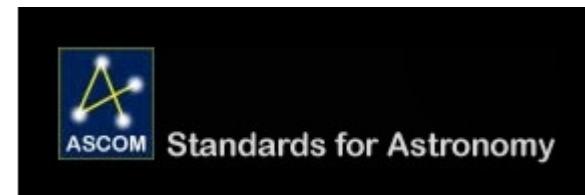
Pero además, debe cumplir las siguientes **restricciones**:

- Debe permitir evolutivos de forma fácil, rápida y fiable.
- Debe ser flexible para adaptarse a cambios de hardware.
- Debe ser automático para ejecutarse de forma desatendida.
- Mecanismos para comunicarse con otros programas existentes.

# OpenROCS: Alternativas

## Estudio de mercado

Remote Telescope System - 2nd version



[Talon - Observatory Control Software](#): Project Web Hosting - Open Source Software  
**Talon - Observatory Control Software**



**The Orococos Project**  
*Smarter control in robotics & automation!*

 ROS

# OpenROCS: Diseño

Es un programa para:

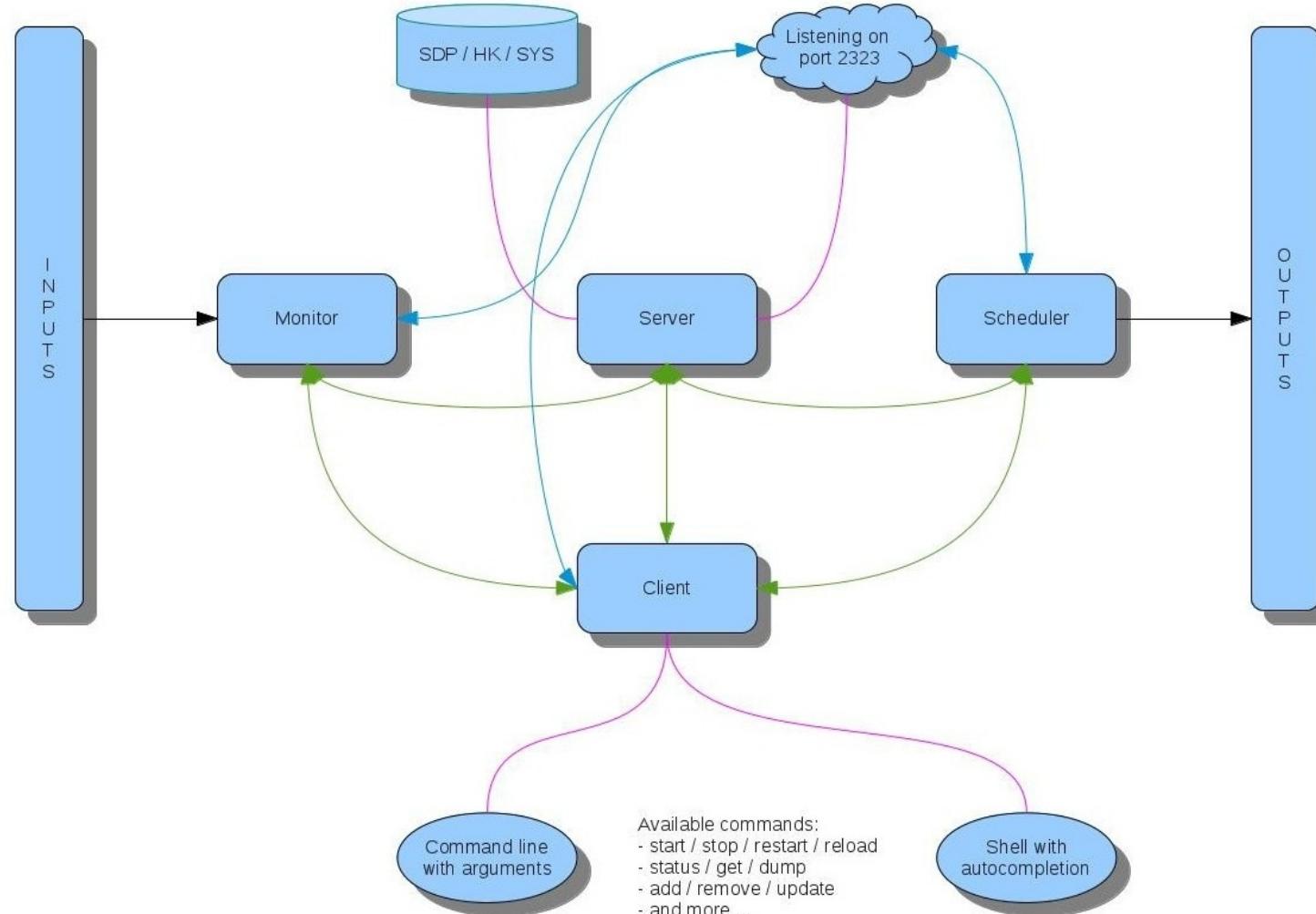
- Leer entradas
  - Estaciones meteorológicas, controladores de motor, ...
- Actuar sobre las salidas:
  - Interruptores electrónicos, controladores de motor, ...

Objetivos tecnológicos:

- Usar archivos XML para la configuración: fácil y estructurado
- Disponer de herramientas como:
  - Un cliente de línea de comandos para interaccionar con el software
  - Ficheros de registro personalizados especificados por el usuario

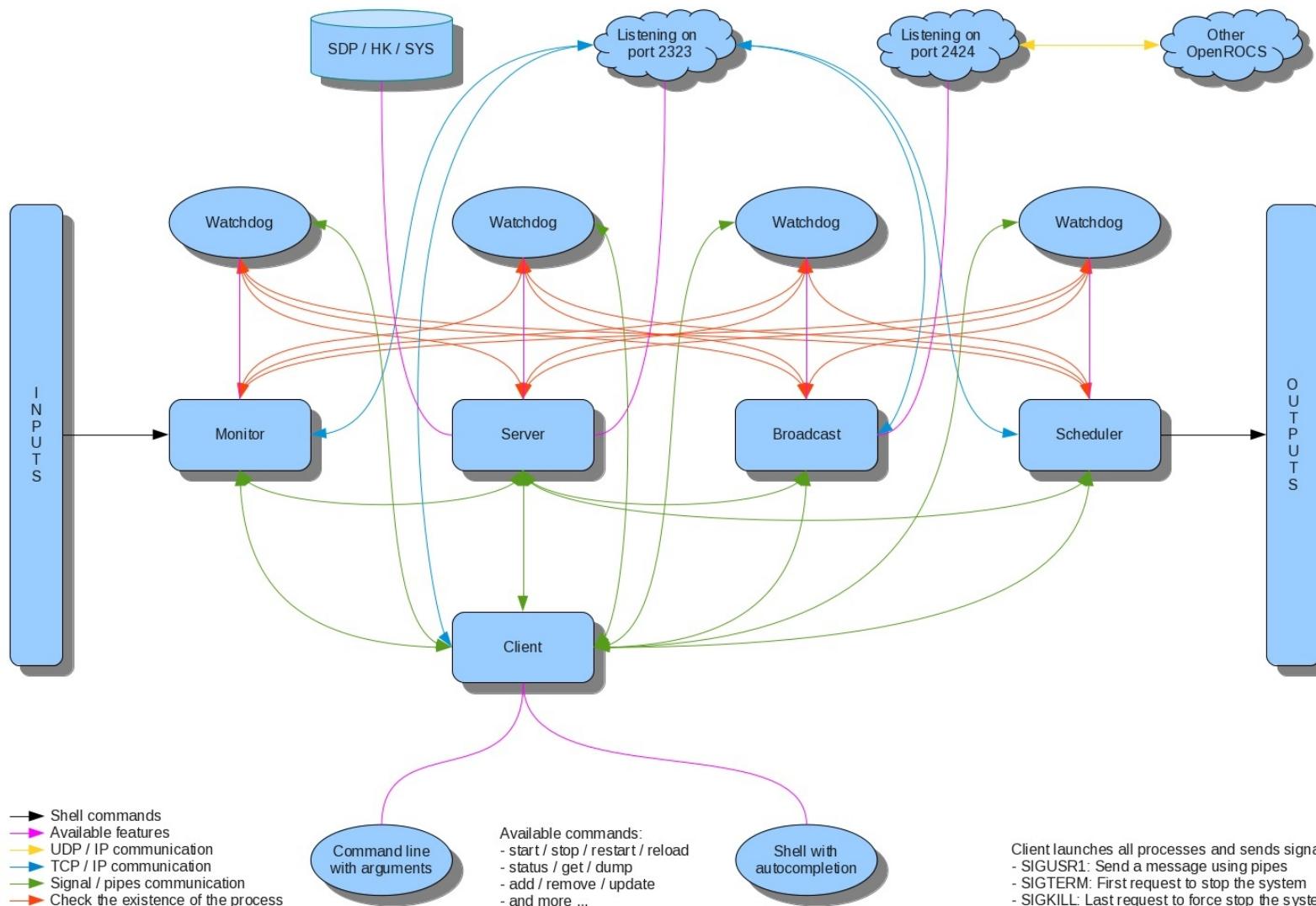
# OpenROCS: Diagrama básico

OpenROCS v2.0 Block Diagram



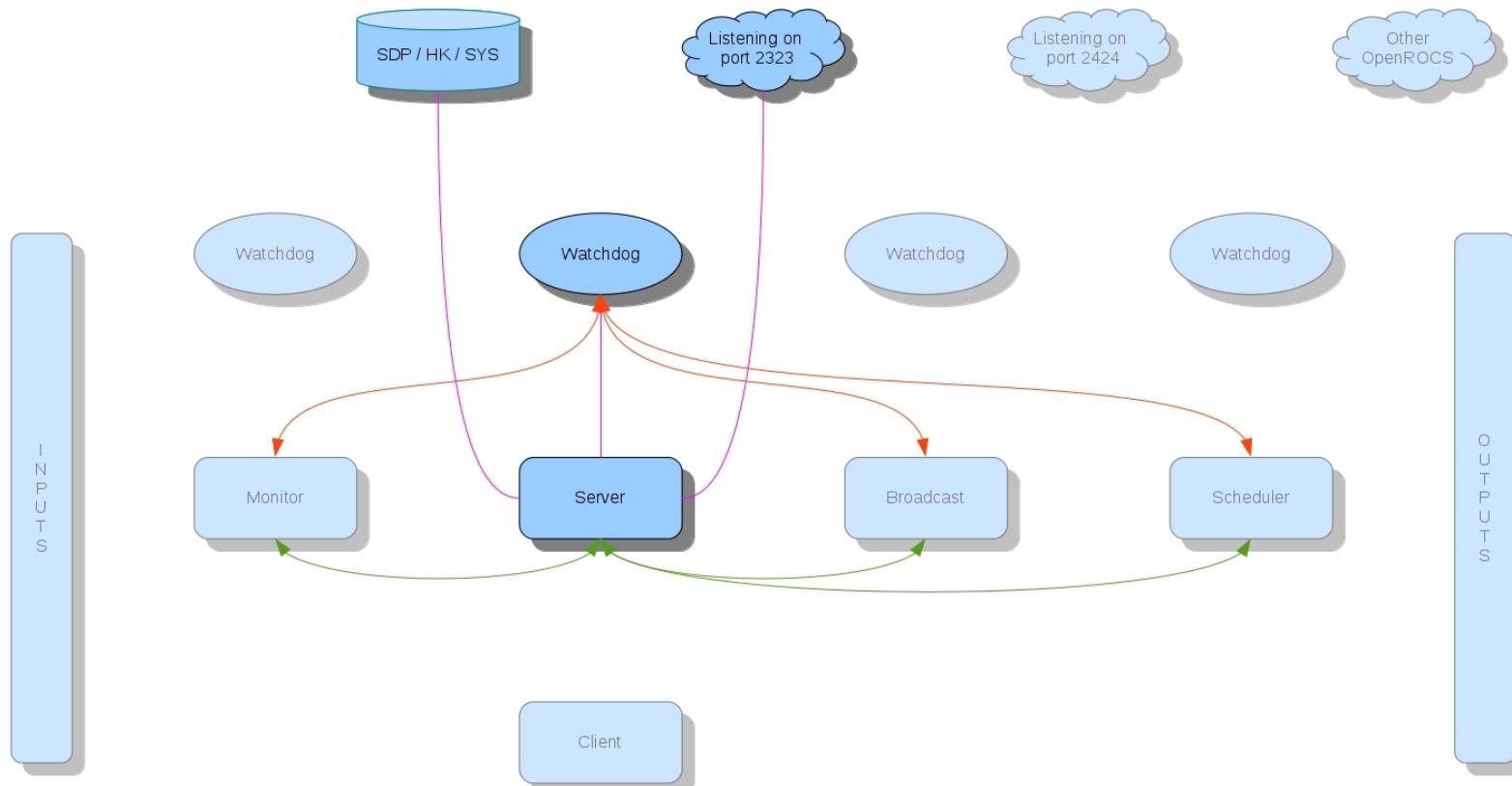
# OpenROCS: Diagrama completo

OpenROCS v2.0 Block Diagram



# OpenROCS: El servidor

OpenROCS v2.0 Block Diagram



- Shell commands
- Available features
- UDP / IP communication
- TCP / IP communication
- Signal / pipes communication
- Check the existence of the process

Command line  
with arguments

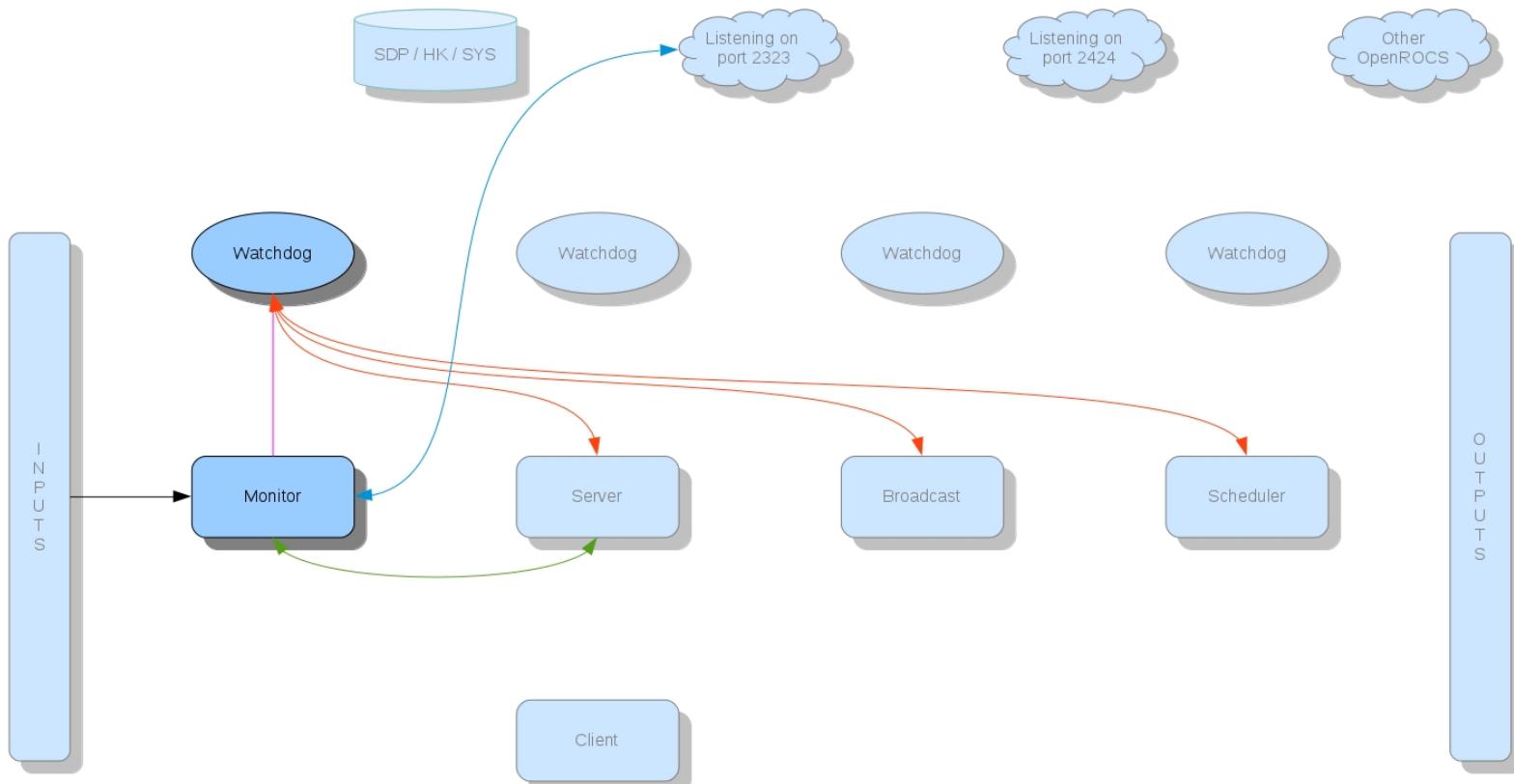
Available commands:  
- start / stop / restart / reload  
- status / get / dump  
- add / remove / update  
- and more ...

Shell with  
autocomplete

Client launches all processes and sends signals:  
- SIGUSR1: Send a message using pipes  
- SIGTERM: First request to stop the system  
- SIGKILL: Last request to force stop the system

# OpenROCS: El monitor

OpenROCS v2.0 Block Diagram



- Shell commands
- ↔ Available features
- UDP / IP communication
- TCP / IP communication
- Signal / pipes communication
- Check the existence of the process

Command line  
with arguments

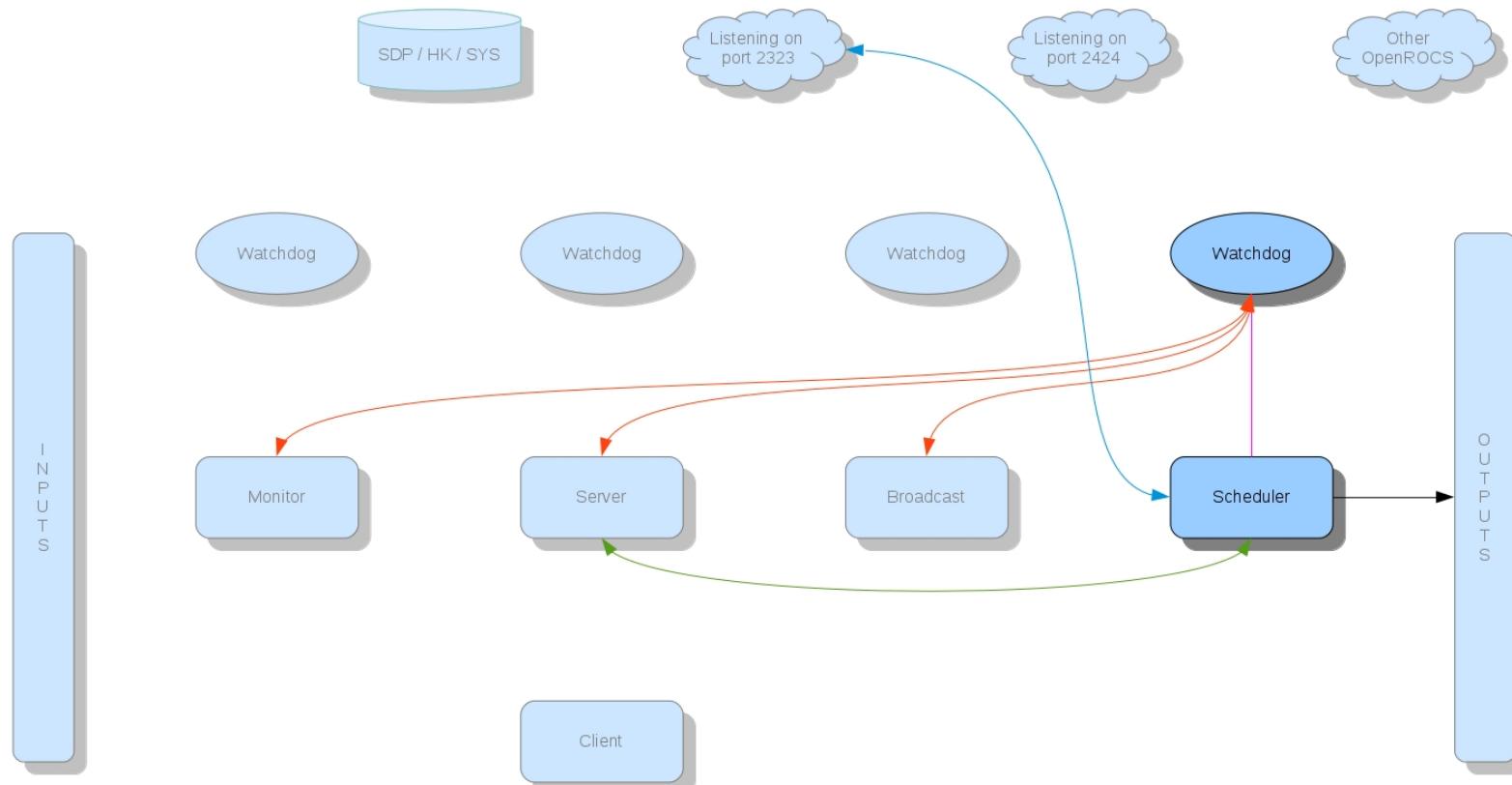
Available commands:  
- start / stop / restart / reload  
- status / get / dump  
- add / remove / update  
- and more ...

Shell with  
autocomplete

Client launches all processes and sends signals:  
- SIGUSR1: Send a message using pipes  
- SIGTERM: First request to stop the system  
- SIGKILL: Last request to force stop the system

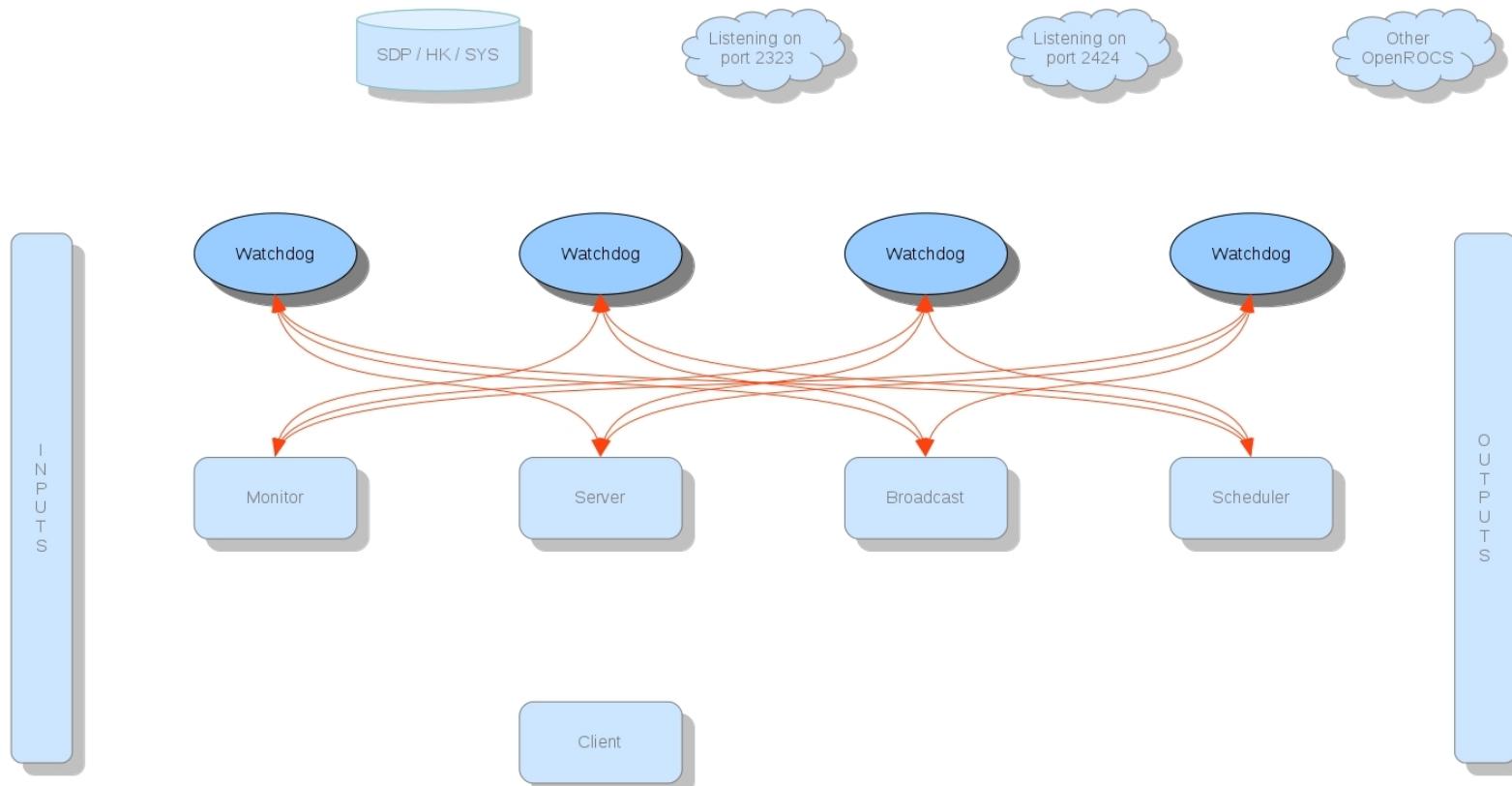
# OpenROCS: El scheduler

OpenROCS v2.0 Block Diagram



# OpenROCS: El watchdog

OpenROCS v2.0 Block Diagram



- Shell commands
- Available features
- UDP / IP communication
- TCP / IP communication
- Signal / pipes communication
- Check the existence of the process

Command line  
with arguments

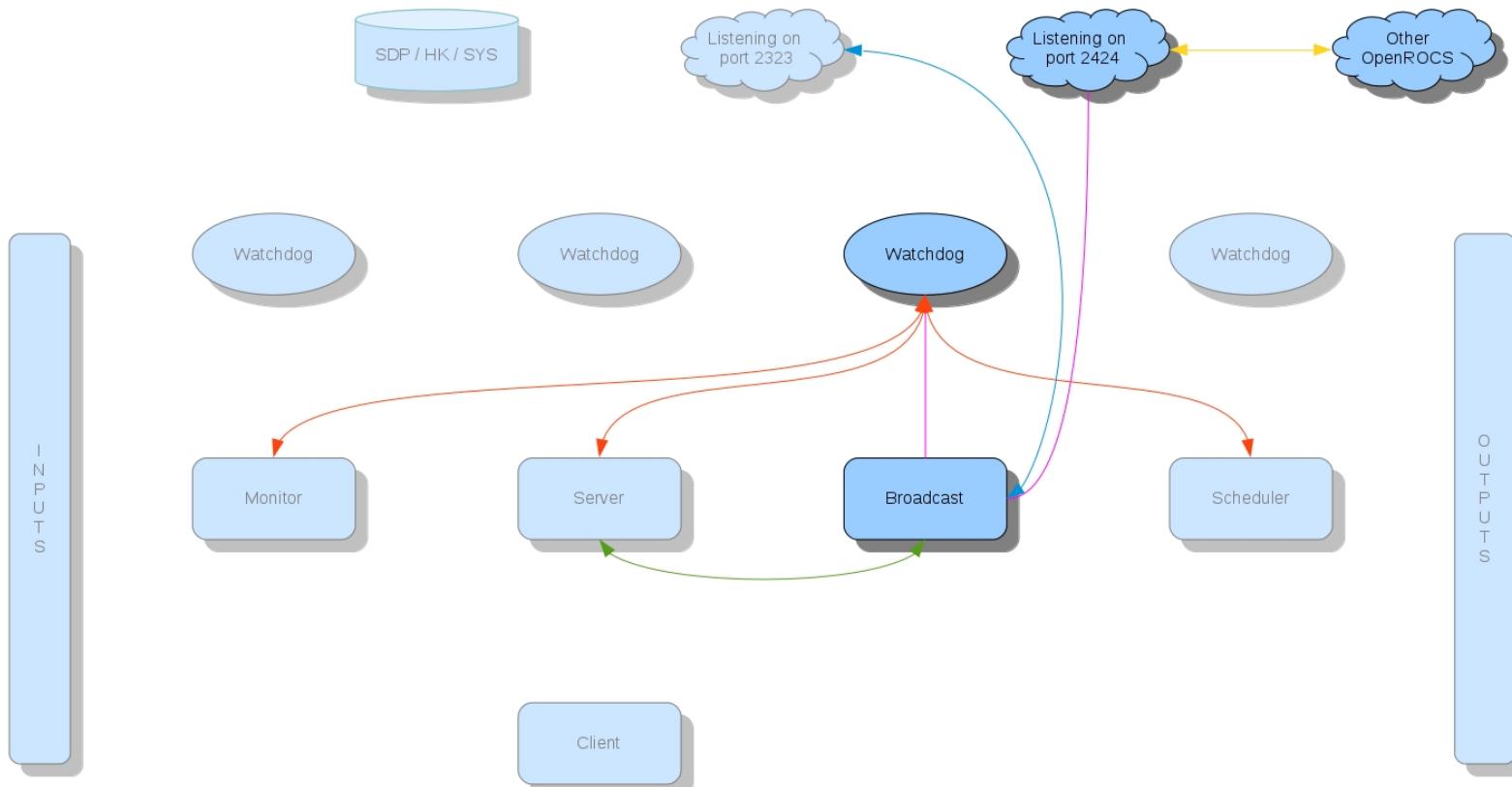
Available commands:  
- start / stop / restart / reload  
- status / get / dump  
- add / remove / update  
- and more ...

Shell with  
autocomplete

Client launches all processes and sends signals:  
- SIGUSR1: Send a message using pipes  
- SIGTERM: First request to stop the system  
- SIGKILL: Last request to force stop the system

# OpenROCS: EI broadcast

OpenROCS v2.0 Block Diagram



- Shell commands
- Available features
- UDP / IP communication
- TCP / IP communication
- Signal / pipes communication
- Check the existence of the process

Command line  
with arguments

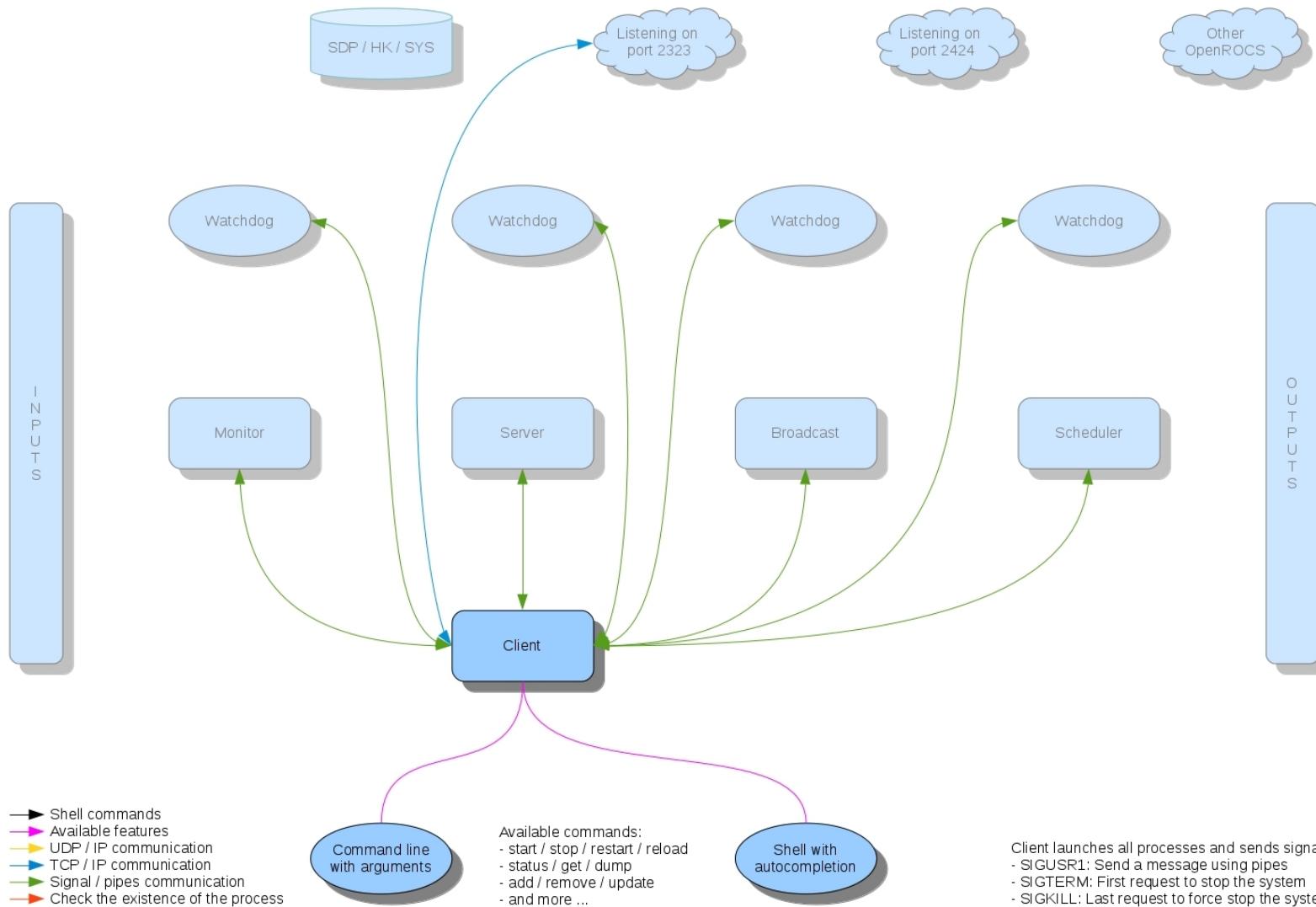
Available commands:  
- start / stop / restart / reload  
- status / get / dump  
- add / remove / update  
- and more ...

Shell with  
autocomplete

Client launches all processes and sends signals:  
- SIGUSR1: Send a message using pipes  
- SIGTERM: First request to stop the system  
- SIGKILL: Last request to force stop the system

# OpenROCS: El cliente

OpenROCS v2.0 Block Diagram



# OpenROCS: Interfaces

Tuberías y señales.

- Comunicación entre procesos

UDP/IP

- Comunicación entre broadcasts

TCP/IP

- Comunicación con el servidor

Shell command

- Interacción con programas externos

# OpenROCS: Comandos shell

La shell es importante:

- OpenROCS no incluyen código para acceder a dispositivos.
- Cada tarea debe poder ejecutarse desde la línea de comandos.
- Feedback usando el stdout o stderr.
- Permite reciclar una gran cantidad de programas existentes
- Independencia del lenguaje de programación

# OpenROCS: Configuración

## El fichero config.xml

- Servidor (IP, puerto, nombre, stacks)
- Broadcast (enabled, puerto, discovery, sync)
- Debug (permite obtener trazas internas)
- Shell (define comportamiento del cliente)
- Timeouts / Pollings / Retries
- ini\_set / putenv (variables de PHP)

# OpenROCS: Configuración

## Ejemplo de fichero variables.xml

```
<variables>

    <IP>
        <SERVER>192.168.0.10</SERVER>
        <SENSORS>192.168.0.11</SENSORS>
        <TELESCOPE>192.168.0.12</TELESCOPE>
        <DOME>192.168.0.13</DOME>
        <CAMERA>192.168.0.14</CAMERA>
        <POWER>192.168.0.15</POWER>
    </IP>

    <INTERVAL>10</INTERVAL>

    <PDU>
        <OID>.1.3.6.1.4.1.318.1.1.12.3.3.1.1.4</OID>
        <ON>1</ON>
        <OFF>2</OFF>
    </PDU>
</variables>
```

# OpenROCS: Configuración

## Ejemplo de fichero monitor.xml

```
<monitor>

    <name>mymonitor1</name>

    <task>

        <interval>10</interval>
        **** Process nodes ****
    </task>

    <task>

        <frequency>10</frequency>
        **** Process nodes ****
    </task>

</monitor>

<monitor>
    **** Task nodes ****
</monitor>
```

# OpenROCS: Configuración

## Ejemplo de fichero scheduler.xml

```
<scheduler>
    <name>myscheduler1</name>
    <hash>
        <variable>myvariable1</variable>
        <variable>myvariable2</variable>
        <variable>myvariable3</variable>
    </hash>
    **** Process nodes ****
</scheduler>
<scheduler>
    **** scheduler nodes ****
</scheduler>
```

# OpenROCS: Configuración

## Lenguaje de configuración de OpenROCS

- <action>
- <shell>, <timeout>, <ontimeout>
- <php>
- <choose>, <when>, <eval>, <fromiter>, <everyiter>, <untiliter>, <fromsec>, <everysec>, <untilsec>, <otherwise>
- <send>
- <log>

# OpenROCS: Tareas previas

Sistema de control del telescopio y cúpula

- TALON: talon\_fifo y talon\_alias

Sistemas de meteorología

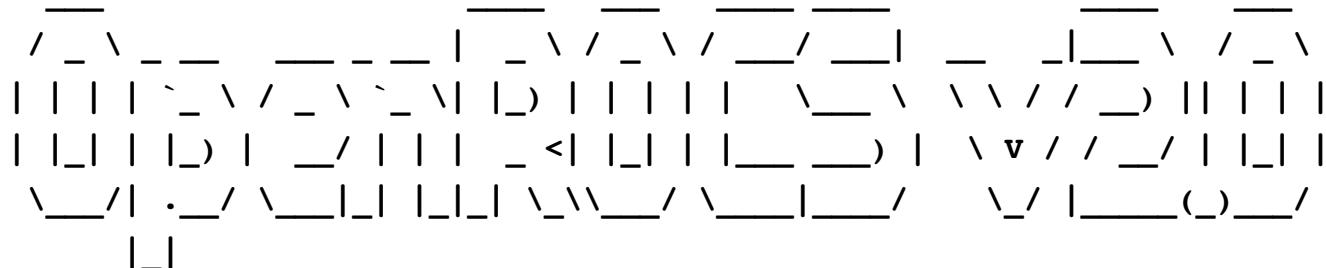
- Previstorm: previstorm.c
- EM-Davis: davis.c
- EM-SMC: PBCdIComm, emsmc.php y EMSMC.xml
- EM-TFRM: vaisala.php
- Sensor de lluvia: raindetect.c
- Sensor de nubes: cloudsensor.c

# OpenROCS: Lenguaje PHP

OpenROCS esta escrito en PHP:

- Similar a Python o Perl
- Sintaxis muy parecida al lenguaje C
- pcntl\_fork y pcntl\_signal
- register\_tick\_function y unregister\_tick\_function
- socket\_create, socket\_bind, socket\_listen, socket\_select y socket\_accept
- register\_shutdown\_function
- set\_error\_handler y set\_exception\_handler

# OpenROCS: GPL-3.0



**OpenROCS: Open Robotic Observatory Control System**

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**More information in <http://www.ieec.cat> or [ieec@ieec.cat](mailto:ieec@ieec.cat)**

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GNU General Public License for more details.**

**You should have received a copy of the GNU General Public License  
along with this program. If not, see <<http://www.gnu.org/licenses/>>.**

# OpenROCS: Resultados

Actualmente, el TJO dispone de un sistema de control que ha aportado mejoras en varios aspectos:

- Estabilidad
- Recuperación ante errores
- Escalabilidad
- Adaptabilidad
  - TJO
  - SuperWASP Qatar Telescope

# OpenROCS: Resultados

Algunas imágenes obtenidas con el TJO:



M82 y SN2014J  
Galaxia M82 con la supernova SN2014J indicada con líneas amarillas



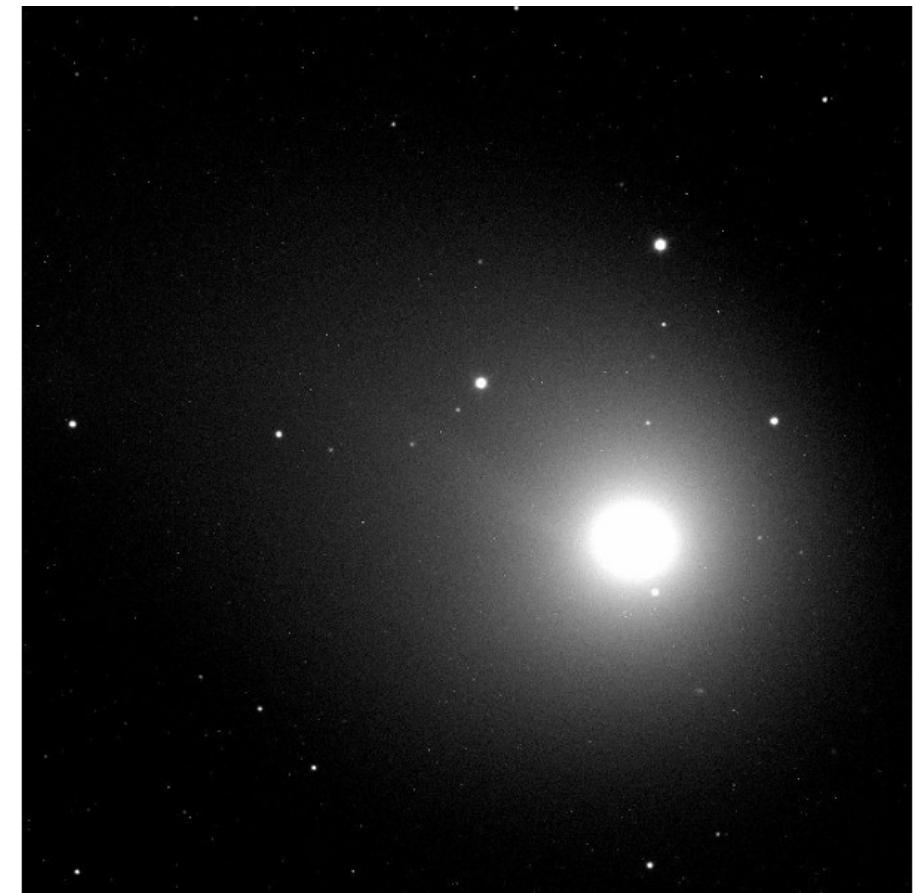
Arp316  
Galaxias en interacción

# OpenROCS: Resultados

Algunas imágenes obtenidas con el TJO:



M1  
Nebulosa del Cangrejo



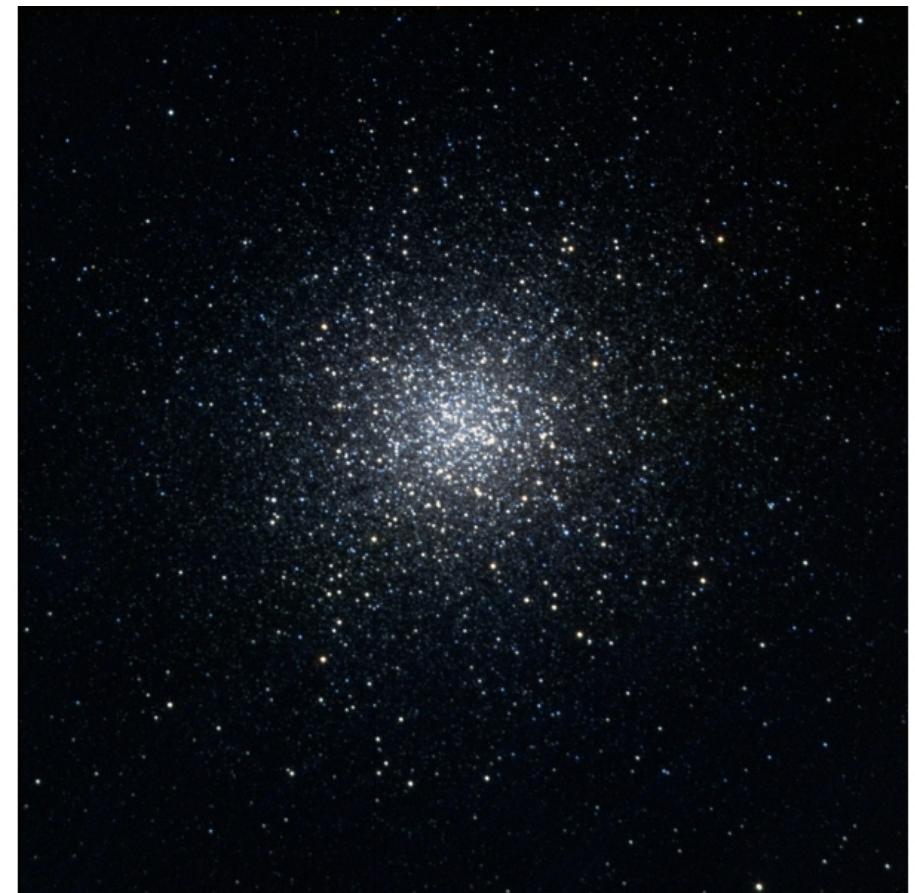
Cometa Lulin C/2007 N3  
Coma del cometa Lulin

# OpenROCS: Resultados

Algunas imágenes obtenidas con el TJO:



NGC7331  
Galaxia espiral, en la constelación de Pegasus.



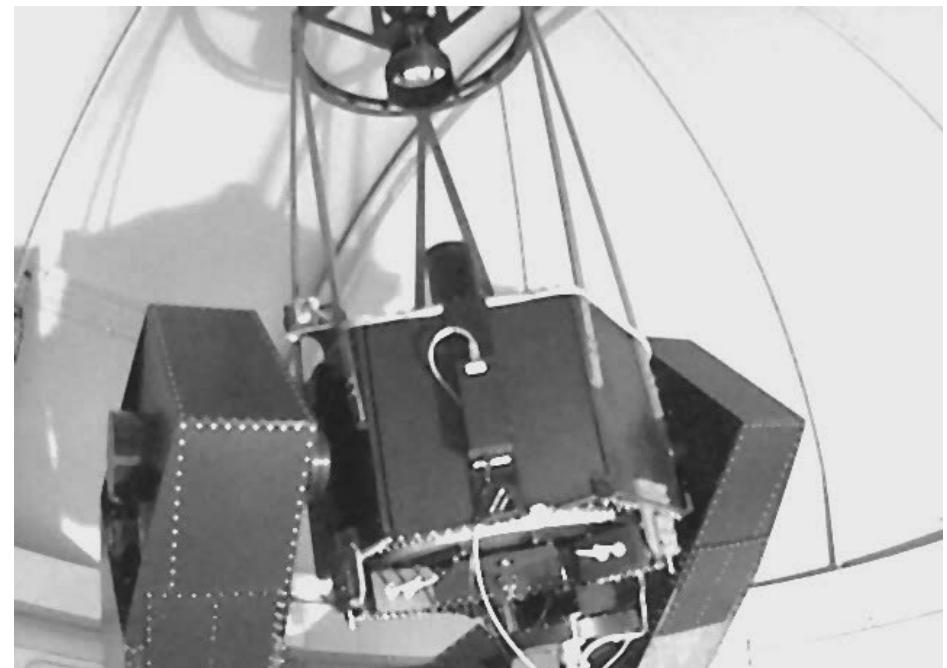
M13  
Gran cúmulo globular de Hércules

# OpenROCS: Resultados

Cámara exterior



Cámara interior

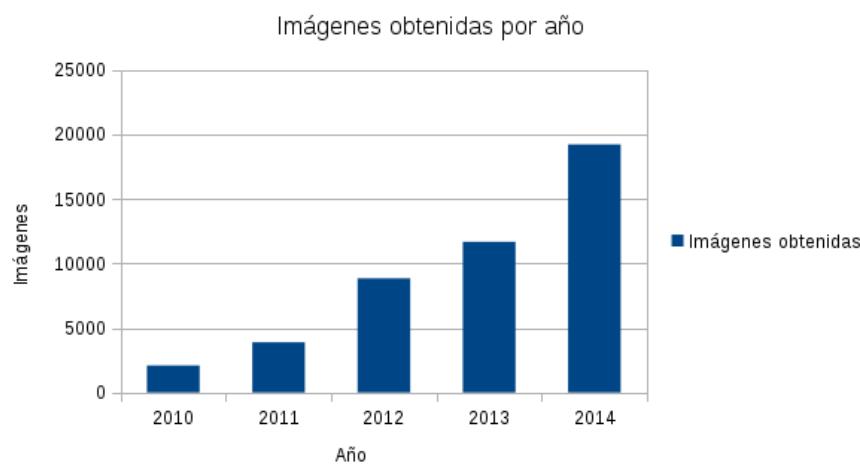
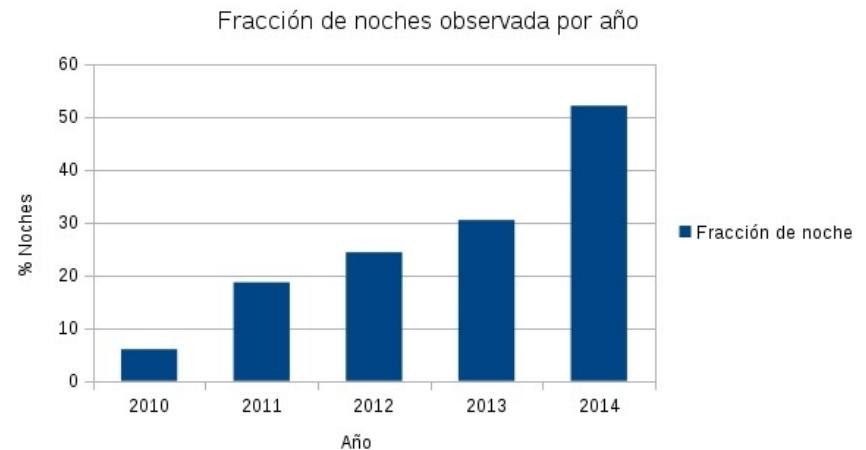
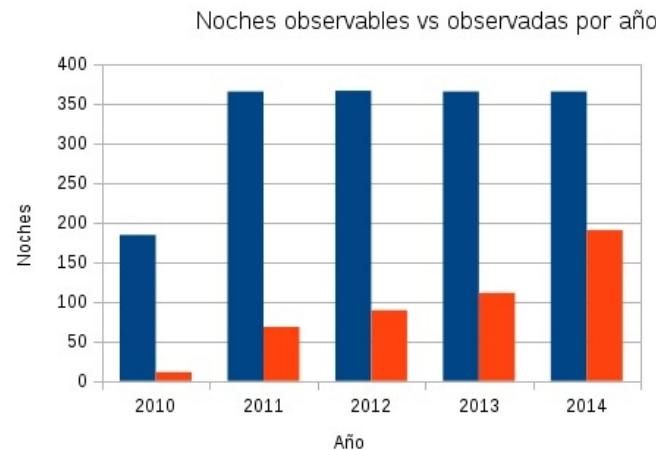


# OpenROCS: Resultados

Primeras observaciones científicas



# OpenROCS: Resultados



# OpenROCS: Resultados

Desde el IEEC-CSIC, se ha solicitado un acta de depósito notarial para OpenROCS

- Número de Protocolo: 1392/2012
- Fecha de depósito: 16 de noviembre de 2012

Este deposito notarial:

- Aporta un aumento de protección de la propiedad intelectual
- Facilita la transferencia con la industria

# OpenROCS: Resultados

**Spectroscopic confirmation and additional photometry of the M31 nova candidate PNV J00423972+4120117** (2014-10-24)

*G. Sala, P. Rodriguez-Gil, M. Henze, et al.*

Astronomer's Telegram, #6616

**Spectroscopy and photometry of the novae M31N 2014-09a and M31N 2014-09b** (2014-09-25)

*E. A. Barsukova, S. Fabrika, A. F. Valeev, et al.*

Astronomer's Telegram, #6498

**SN 2013df, a double-peaked I Ib supernova from a compact progenitor and an extended H envelope** (2014-09-17)

*A. Morales-Garoffolo, N. Elias-Rosa, S. Benetti, et al.*

Monthly Notices of the Royal Astronomical Society, Volume 445, Issue 2, p.1647-1662

**New optical nova candidate in the M 31 disk** (2014-07-10)

*M. Henze, G. Sala, J. Jose, et al.*

Astronomer's Telegram, #6305

**Optical and near-infrared observations of SN 2011dh - The first 100 days** (2013-05-08)

*M. Ergon, J. Sollerman, M. Fraser, et al.*

Astronomy & Astrophysics, Volume 562, id.A17, 35 pp.

**The 2011 October Draconids outburst. I. Orbital elements, meteoroid fluxes and 21P/Giacobini-Zinner delivered mass to Earth** (2013-04-29)

*J. M. Trigo-Rodríguez, J. M. Madiedo, I. P. Williams, et al.*

Monthly Notices of the Royal Astronomical Society, Volume 433, Issue 1, p.560-570

# OpenROCS: Resultados

## Observing with the Telescopi Joan Oró

2013, may

Vilardell, F., Colomé, J., Sanz, J., Gil, P., Ribas, I.

Highlights of Spanish Astrophysics VII, pp. 958-958

## OpenROCS: a software tool to control robotic observatories

2012-09-30

J. Colomé, J. Sanz, F. Vilardell, I. Ribas, P. Gil

Proceedings SPIE, Amsterdam (2012)

## The Open Robotic Observatory Control System (OpenROCS)

2012

Colomé, J., Ribas, I., Sanz, J., Vilardell, F.

CSIC-IEEC, RPT, ICE\_OpenROCS\_RPT-001

Poster 8461-89  
Session Software and  
Cyberinfrastructure for  
Astronomy II

### OpenROCS: a software tool to control robotic observatories

Pep Colomé (colome@ieec.cat), Josep Sanz, Francesc Vilardell, Ignasi Ribas, Pere Gil  
Institut de Ciències de l'Espai (IEEC-CSIC), Barcelona

**Abstract.** We present the Open Robotic Observatory Control System (OpenROCS), an open source software platform developed for the robotic control of telescopes. It acts as a software infrastructure that executes all the necessary processes to implement responses to the system events that appear in the routine and non-routine operations associated to data-flow and housekeeping control. The OpenROCS software design and implementation provides a high flexibility to be adapted to different observatory configurations and event-action specifications. It is based on an abstract model that is independent of the specific hardware or software and highly configurable. The system components are defined in simple modules to achieve this goal. We give a detailed description of the version 2.0 of the software, based on a modular architecture developed in PHP and XML, configuration files, and using standard communication protocols to interface with applications for hardware monitoring and control, environment monitoring, scheduling of tasks, image processing and data quality control. We provide two examples of how it is used as the core element of the control system in two robotic observatories: the Joan Oró Telescope at the Montsec Astronomical Observatory (Catalonia, Spain) and the SuperWASP Qatas Telescope at the Roque de los Muchachos Observatory (Canary Islands, Spain).

**Robotic Operation**

- ❑ Fully autonomous facilities
- ❑ Control modes for the execution of science observations and calibration mode
- ❑ Operation modes for the operation of different instruments
- ❑ Scheduler for task prioritization
  - Poster : 8464-89 Session 8
- ❑ Nominal Workflow with fully unattended processes
  - Task scheduling, Task execution & Data Processing

**Control System**

- ❑ Central application in the telescope control layer
  - Housekeeping layer: Applications devoted to the environment monitoring and system health monitoring and control
  - End-to-end data flow: Software processes for task management, task scheduling, and processing of the acquired data. It also includes software and/or firmware processes for hardware control in the execution of tasks.
- ❑ Control architecture
  - Connect the suite of applications involved in the housekeeping and the end-to-end data flow control
  - Adapt to the workflow of the observation processes

**OpenROCS Modular Design**

- ❑ Server module: Handles requests from the other services using TCP/IP communication.
- ❑ Broadcast service: Synchronization of multiple instances of OpenROCS in different computers.
- ❑ Monitor service: Execution of periodic tasks to perform a continuous evaluation of the system and determine its state.
- ❑ Scheduler service: Execution of actions when preconfigured variables reach certain thresholds or to control the entire telescope workflow, implementing the data flow events.
- ❑ Client module: Provides a direct control of the service status (start/stop/restart/reload).

**OpenROCS Configuration**

- ❑ Programming language: PHP & XML files for configuration.
- ❑ Interfaces: Signals and pipe, TCP/IP sockets, UDP/IP sockets, shell commands (SNMP, TALON wrappers).
- ❑ Process names: Specification of commands, evaluations and flow control for each of the different subsystems.
- ❑ Configuration: Based on XML standard syntax. XML files define the system configuration, the variables, the data structures, and the event-action pairs that define the behavior of the system.
- ❑ Wrapper libraries: TALON, SNMP protocol, INDI available in next version.
- ❑ License: GPL-3.0 → <http://sourceforge.net/projects/openrocs>

**OpenROCS at TJO and SQT Robotic Telescopes**

- ❑ TJO\*: Multi-purpose telescope located at the Montsec Astronomical Observatory (MAM). Spitzer telescope with a 0.8-m telescope and two instruments for photometric and spectroscopic data collection. <http://www.ieec.edu>
- ❑ SQT 1-m robotic telescope equipped with a two-arm instrument and housed in a clam-shell dome. It is devoted to exoplanet characterization and follow-up of transient objects. It observes the detection of transients discovered from the real-time reduction of SuperWASP data.
- ❑ OpenROCS configuration: Similar configuration in both telescopes. Easy configuration thanks to its flexibility and modularity.

\*Brewer, J. E. F., Hodges, D. G., Michell, J., and Tallon, C. J. "Robotic telescopes and the public." *AN*, v.235, 467-481, DOI: 10.1111/j.1365-2729.2004.01004.x (2004)

[1] Brewster, J. E. F., Hodges, D. G., Michell, J., and Tallon, C. J., "Robotic telescopes and the public," Proc. SPIE 5448, these proceedings (2003).

[2] Clear Sky Institute, "Observatory Control and Astronomical Analysis System. Reference manual for OCAS version 2.0," Technical report (2005).

**System states and event handling**  
OpenROCS determines the current state and changes the necessary actions triggered by the events produced by the housekeeping or the data flow control.

**Customizable**  
OpenROCS is highly customizable, each command can be executed in an automatic manner for all the subsystems

# OpenROCS: Resultados

## SuperWASP Qatar Telescope (SQT)

- Ubicado en el Roque de los Muchachos Observatory (Isla de La Palma, España)
- Telescopio del fabricante OMI de 1m de diámetro
- Proporcionará fotometría de alta precisión de exoplanetas en tránsito

# OpenROCS: Resultados



# OpenROCS: Resultados

Main RAW Wiki Users Logout

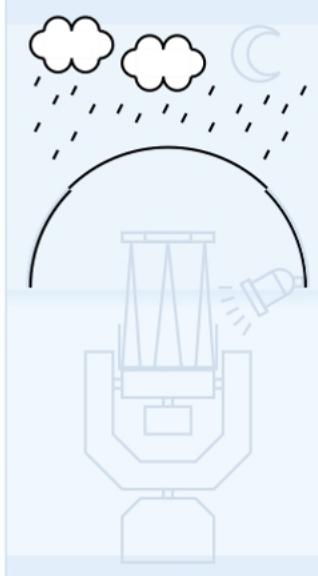
### OpenROCS status

SYS				
	ACTION	ALARM	GOAL	STATUS
USER	CALIB	NONE	OFF	
TCS	NONE	NONE	OFF	OFF
METEO		NONE		BAD_OUT
ICS	MONITOR	NONE	OFF	OFF
DOME	NONE	NONE	DARK_CLOSED	DARK_CLOSED

SDP METEO
SDP TCS
SDP ICS
HK METEO
HK DOME
HK TCS
HK ICS
HK USER

### Global status



### Internal Camera



Blue Camera

### External Camera



Red Camera

### OpenROCS log file

```

1 2014-01-20 16:44:18.0350: Information: Setting SYS_DOME_STATUS=DARK_CLOSED
2 2014-01-20 16:44:16.2700: Information: Setting SYS_DOME_ACTION=POWER_LIGHT_OFF
3 2014-01-20 16:44:15.5040: Information: Setting SYS_DOME_GOAL=DARK_CLOSED
4 2014-01-20 16:44:13.6851: Information: Setting SYS_USER_GOAL=OFF
5 2014-01-20 16:43:39.7532: Information: Setting SYS_TCS_ALARM=None
6 2014-01-20 16:43:31.6590: Information: Setting SYS_ICC_ALARM=None
7 2014-01-20 16:43:24.7302: Information: Setting SYS_TCS_GOAL=OFF
8 2014-01-20 16:43:24.3854: Minor error: Setting SYS_TCS_ALARM=MINOR_ERROR
9 2014-01-20 16:43:23.9984: Information: Setting SYS_DOME_ACTION=SHUTTER_CLOSE
10 2014-01-20 16:43:23.7957: Information: Setting SYS_TCS_STATUS=OFF
11 2014-01-20 16:43:20.3064: Information: Setting SYS_DOME_ALARM=None
12 2014-01-20 16:43:20.2365: Information: Setting SYS_ICC_GOAL=OFF
13 2014-01-20 16:43:19.8128: Minor error: Setting SYS_ICC_ALARM=MINOR_ERROR
14 2014-01-20 16:43:19.4331: Information: Setting SYS_DOME_STATUS=BRIGHT_CLOSED
15 2014-01-20 16:43:19.2240: Information: Setting SYS_ICC_STATUS=OFF
16 2014-01-20 16:43:16.8774: Information: Setting SYS_DOME_ACTION=SHUTTER_CLOSE

```

# OpenROCS: Resultados

Main    RAW    Wiki    Users    Logout

**OpenROCS log file**

```

1 2014-01-20 16:44:18.0350: Information: Setting SYS_DOME_STATUS=DARK_CLOSED
2 2014-01-20 16:44:16.2700: Information: Setting SYS_DOME_ACTION=POWER_LIGHT_OFF
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10 2014-01-20 16:43:23.7957: Information: Setting SYS_TCS_STATUS=OFF
11 2014-01-20 16:43:20.3064: Information: Setting SYS_DOME_ALARM=None
12 2014-01-20 16:43:20.2365: Information: Setting SYS_ICS_GOAL=OFF
13 2014-01-20 16:43:19.8128: Minor error: Setting SYS_ICS_ALARM=MINOR_ERROR
14 2014-01-20 16:43:19.4331: Information: Setting SYS_DOME_STATUS=BRIGHT_CLOSED
15 2014-01-20 16:43:19.2240: Information: Setting SYS_ICS_STATUS=OFF
16 2014-01-20 16:43:16.8774: Information: Setting SYS_DOME_ACTION=SHUTTER_CLOSE
17 2014-01-20 16:43:15.2427: Information: Setting SYS_DOME_ACTION=POWER_LIGHT_ON
18 2014-01-20 16:43:14.3957: Information: Setting SYS_DOME_GOAL=BRIGHT_CLOSED
19 2014-01-20 16:43:13.7723: Minor error: Setting SYS_DOME_ALARM=MINOR_ERROR
20 2014-01-20 16:43:13.1851: Information: Setting SYS_DOME_STATUS=DARK_UNKNOWN
21 2014-01-20 16:43:12.2550: Major error: Setting SYS_USER_GOAL=UNKNOWN
22 2014-01-20 16:43:11.0859: Information: OpenROCS started
23 2014-01-20 16:43:10.7719: Information: Setting SYS_METEO_ALARM=None
24 2014-01-20 16:43:10.2286: Information: Setting SYS_METEO_STATUS=BAD_OUT
25 2014-01-20 16:42:31.4748: Debug snapshot: 0 0
26 2014-01-20 16:41:56.4118: Debug snapshot: 0 0
27 2014-01-20 16:41:21.4194: Debug snapshot: 0 0
28 2014-01-20 16:40:46.3450: Debug snapshot: 0 0

```

**Secure shell client**

login:

**OpenROCS SYS stack**

```

1 USER_GOAL=OFF
2 USER_ALARM=None
3 USER_ACTION=OFF
4 TCS_STATUS=OFF
5 TCS_GOAL=OFF
6 TCS_ALARM=None
7 TCS_ACTION=MONITOR
8 METEO_STATUS=BAD_OUT
9 METEO_ALARM=None
10 ICS_STATUS=OFF
11 ICS_GOAL=OFF
12 ICS_ALARM=None
13 ICS_ACTION=MONITOR
14 DOME_STATUS=DARK_CLOSED
15 DOME_GOAL=DARK_CLOSED
16 DOME_ALARM=None
17 DOME_ACTION=None

```

**OpenROCS HK stack**

```

1 USER_TCS_GOAL=OFF
2 USER_ICS_GOAL=OFF
3 USER_DOME_GOAL=DARK_CLOSED
4 TCS_WID_STATUS=STOPPED
5 TCS_WID_GOAL=STOPPED
6 TCS_WID_FORMER=STOPPED
7 TCS_WID_ALARM=None
8 TCS_TELESCOPED_STATUS=STOPPED
9 TCS_TELESCOPED_GOAL=STOPPED
10 TCS_TELESCOPED_FORMER=STOPPED
11 TCS_TELESCOPED_ALARM=None
12 TCS_POWER_MIXED_STATUS=OFF
13 TCS_POWER_MIXED_GOAL=OFF
14 TCS_POWER_MIXED_FORMER=OFF
15 TCS_POWER_MIXED_ALARM=None
16 TCS_POWER_COVER_STATUS=OFF
17 TCS_POWER_COVER_GOAL=OFF
18 TCS_POWER_COVER_FORMER=OFF
19 TCS_POWER_COVER_ALARM=None
20 TCS_POWER_80V_STATUS=OFF
21 TCS_POWER_80V_GOAL=OFF
22 TCS_POWER_80V_FORMER=OFF
23 TCS_POWER_80V_ALARM=None
24 TCS_POWER_12V_STATUS=OFF
25 TCS_POWER_12V_GOAL=OFF
26 TCS_POWER_12V_FORMER=OFF
27 TCS_POWER_12V_ALARM=None
28 TCS_FOCUS_STATUS=OFF

```

**OpenROCS SDP stack**

```

1 TCS_RA_CURRENT
2 TCS_FOCUS_CURRENT
3 TCS_DEC_CURRENT
4 TCS_CSIMCD_PORT=7623
5 TCS_AZ_TARGET
6 TCS_AZ_CURRENT
7 TCS_ALT_TARGET
8 TCS_ALT_CURRENT
9 METEO_SWASP_TIME_CURRENT=2456678.87500
10 METEO_SWASP_OUTDOOR_WIND_SPEED_CURRENT=30
11 METEO_SWASP_OUTDOOR_WIND_DIR_CURRENT=327
12 METEO_SWASP_OUTDOOR_TEMP_CURRENT=-3.20
13 METEO_SWASP_OUTDOOR_RAIN_CURRENT=RAIN
14 METEO_SWASP_OUTDOOR_PRESSURE_CURRENT=773.5
15 METEO_SWASP_OUTDOOR_HUMIDITY_CURRENT=96
16 METEO_SWASP_OUTDOOR_CLOUDS_CURRENT=-41.5
17 METEO_SWASP_INDOOR_TEMP_CURRENT=-10.4
18 METEO_SWASP_INDOOR_HUMIDITY_CURRENT=57
19 METEO_NTP_CURRENT=1.477
20 ICS_RED_TEMP_CURRENT
21 ICS_RED_IMAGE_USE=off
22 ICS_RED_IMAGE_PLAN=1
23 ICS_RED_IMAGE_NEXT
24 ICS_RED_IMAGE_NAME
25 ICS_RED_IMAGE_INDEX
26 ICS_RED_IMAGE_EXPOSURES
27 ICS_RED_IMAGE_CURRENT
28 ICS_FOCUS_TARGET

```

# OpenROCS: OAdM+TJO

## Inversión en la construcción y equipamiento

Descripción	%
Obra civil (año 2003, fase A)	18 %
Obra civil (año 2007)	22 %
Telescopio OMI 80cm en configuración Ritchey-Chrétien	45 %
Instrumentación (MEIA/ARES/Equipos informáticos)	15 %
<b>Total</b>	<b>100 %</b>

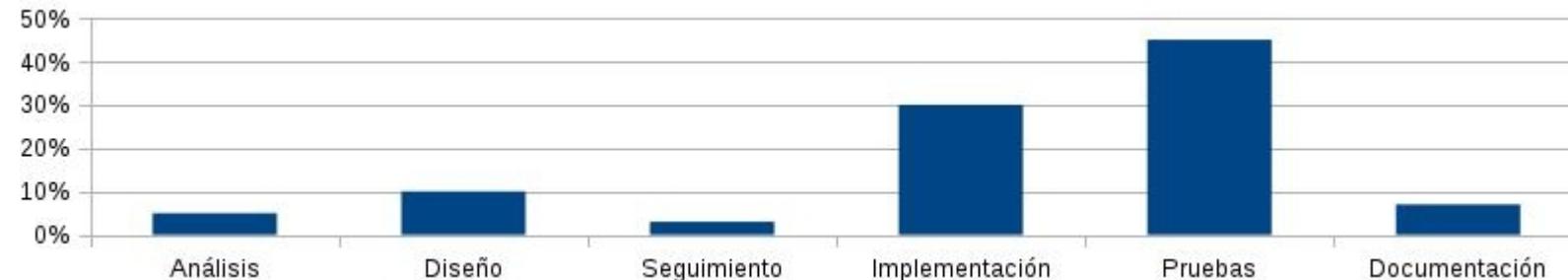
- Supuso un coste inversión de **1.328.000,00€**

Descripción	Precio	%
Inversión	1.328.000,00€	60 %
Mantenimiento del OAdM en el periodo 2004-2013	887.000,00€	40 %
<b>Total</b>	<b>2.215.000,00€</b>	<b>100 %</b>

- Supuso un coste total de **2.215.000,00€**

# OpenROCS: Planificación

## Distribución de la dedicación por tareas



## Diagrama de Gantt con la planificación

Tarea	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
Análisis	■								■											
Diseño	■	■							■	■	■									
Seguimiento	■								■	■	■					■				
Implementación																				
Pruebas																				
Documentación																				

## Diagrama de Gantt con la ejecución real

Tarea	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190
Análisis	■								■											
Diseño	■	■							■	■	■									
Seguimiento	■								■	■	■					■				
Implementación																				
Pruebas																				
Documentación																				

# OpenROCS: Costes

## Coste de ejecución de este proyecto

Tarea	%	Días	Horas	Personas	Precio hora	Total
Análisis	5 %	10	75h	1	30,00€/h	2.250,00€
Diseño	10 %	20	150h	1	30,00€/h	4.500,00€
Seguimiento	3 %	6	45h	1	30,00€/h	1.350,00€
Implementación	30 %	60	450h	1	30,00€/h	13.500,00€
Pruebas	45 %	90	675h	2	30,00€/h	40.500,00€
Documentación	7 %	14	105h	1	30,00€/h	3.150,00€
<b>Total</b>	<b>100 %</b>	<b>200</b>	<b>1500h</b>			<b>65.250,00€</b>

- **4.91%** respecto a la inversión del OAdM y TJO.
- **7,36%** respecto a la partida destinada al mantenimiento.
- **2.95%** respecto al total de todo el proyecto.

# OpenROCS: Conclusiones

Actualmente, estamos controlando 2 telescopios:

- TJO en el Observatorio Astronómico del Montsec (OAdM).
- SQT en el Observatorio del Roque de los Muchachos en La Palma.

Hemos planteado de hacer mejoras para:

- Mejorar la especificación del lenguaje de configuración (XML) para simplificarlo.
- Buscar reemplazos para el interprete de PHP que proporcionen mejoras de rendimiento
- Añadir un algoritmo de Inteligencia artificial para tomar decisiones de forma automática mediante el uso del algoritmo STRIPS

# OpenROCS: Conclusiones

Online Strips Demonstrator r10

Defined actions

```

1 <root>
2   <actions>
3     <action>
4       <name>power_on</name>
5       <require>power=off</require>
6       <provide>power=on</provide>
7       <weight>1</weight>
8     </action>
9     <action>
10      <name>power_off</name>
11      <require>power=on</require>
12      <provide>power=off</provide>
13      <weight>1</weight>
14    </action>
15    <action>
16      <name>telescope_on</name>
17      <require>telescope=off, power=on</require>
18      <provide>telescope=on</provide>

```

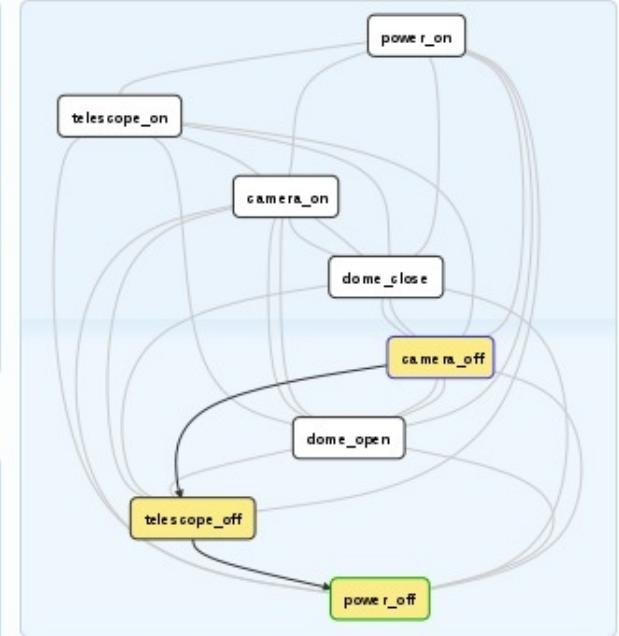
Defined status

```

1 <root>
2   <status>
3     <name>start</name>
4     <vars>power=on, telescope=on, camera=on</vars>
5   </status>
6   <status>
7     <name>stop</name>
8     <vars>power=off, telescope=off, camera=off</vars>
9   </status>
10  <status>
11    <name>science</name>
12    <vars>power=on, telescope=on, camera=on</vars>
13  </status>
14 </root>

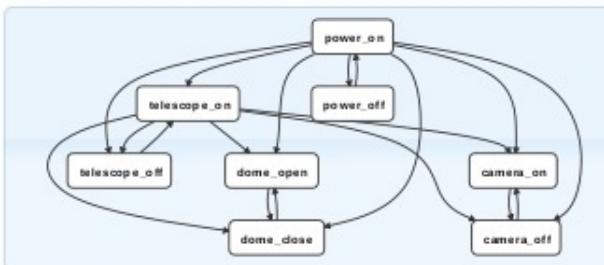
```

Full paths graph

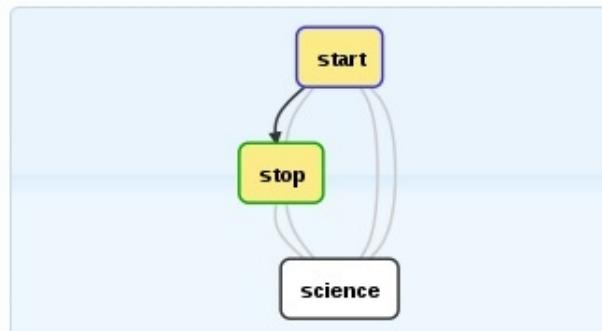


Show original plot

Validate the XML file



Validate the XML file



	From:	To:
Power:	On	Off
Telescope:	On	Off
Dome:	Close	Close
Camera:	On	Off

	From:	To:
Status:	Start	Stop

Compute path using status

Compute path using actions

# OpenROCS: Agradecimientos



**Generalitat  
de Catalunya**



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Fondo Europeo  
de Desarrollo Regional

**IEEC**<sup>R</sup>  
INSTITUT D'ESTUDIS  
ESPAZIALS  
DE CATALUNYA



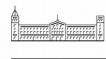
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