The OAdM robotic observatory

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on behalf of the OAdM team

Workshop on Robotic Autonomous Observatories

Málaga, May 18th 2009

Project overview

Institutions involved

- ⇒ IEEC (CSIC, UB, UPC)
- ⇒ Consorci Montsec, FJO

Project description

- ⇒ 0.8 m diameter telescope (OMI)
- ⇒ CCD camera FLI: 2k x 2k Marconi chip, Back illuminated chip, FOV: 12.4 x 12.4 arcmin^2
- ⇒ Photometric Filters: Johnson - Cousins (UBVRI)
- ⇒ Operation: high confidence-level robotic operation

Timeline

- ⇒ Testing period (astronomers present)
  - o MILESTONE1: Supervised Robotic Operation ➔ Period: May to July
  - o MILESTONE2: Unattended Robotic Operation ➔ Period: August to December
- ⇒ Routine operations: Unattended Robotic Operation ➔ Starting: January 2010

OAdM-TJO Robotic Observatory

Poor initial installation

➔ extensive efforts to reach working condition

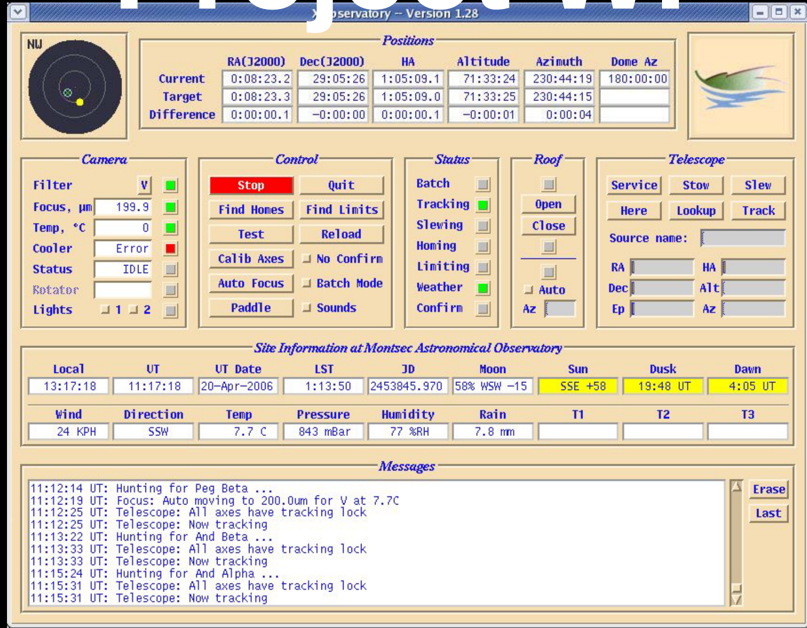
Number of aspects improved and new features added

➔ achievement of a reliable, secure and efficient robotic control

Main features

- ⇒ Designed and developed to achieve a high reliability operation
- ⇒ Control based on a distributed task scheme, using several computers: hardware operation, environment status check, general operation control, data management, image processing, data backup
- ⇒ Single Points of Failure and Redundancies, two critical subsystems: redundant control of dome shutter closing and environment monitor
- ⇒ Real time environment monitoring and HW reliability dealt with the appropriate equipment

Project WP



WP 1000: Dome

- ⇒ Baader Planetarium Dome (∅ 6.15 m)
- ⇒ Redundant control of shutter closing

WP 2000: Telescope

- ⇒ Equatorial fork mount
- ⇒ Cassegrain focus
- ⇒ Electronics setup for basic axis movement control (RA, DEC, FW, mirror covers, Dome) based on a network of four standalone boards

WP 2100: Telescope control SW (TALON)

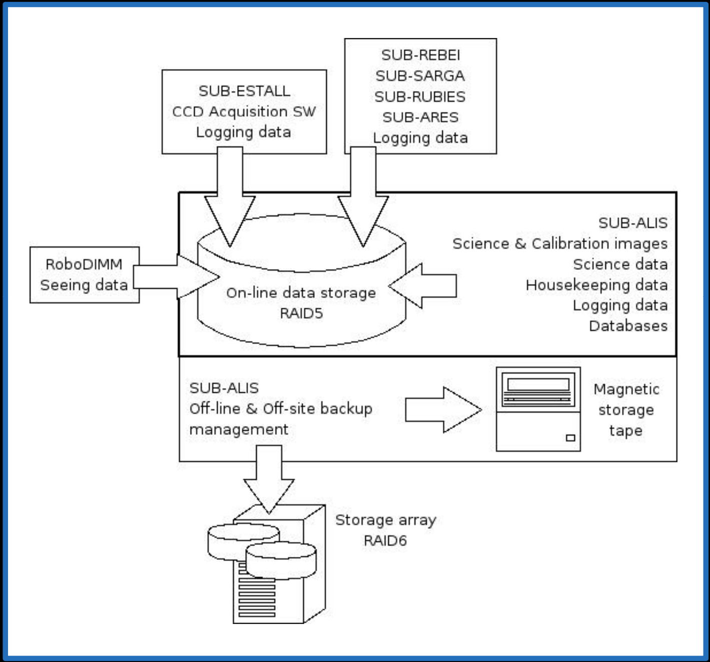
- o SW under GNU license
- o Based on daemon system and fifo internal communication programming and low level machine code for telescope electronics
- o Automatic control of basic HW involved with the observation sequence
- o New features developed: dome control, mirror covers, integration into observatory general control, etc.

WP 3000: Housekeeping

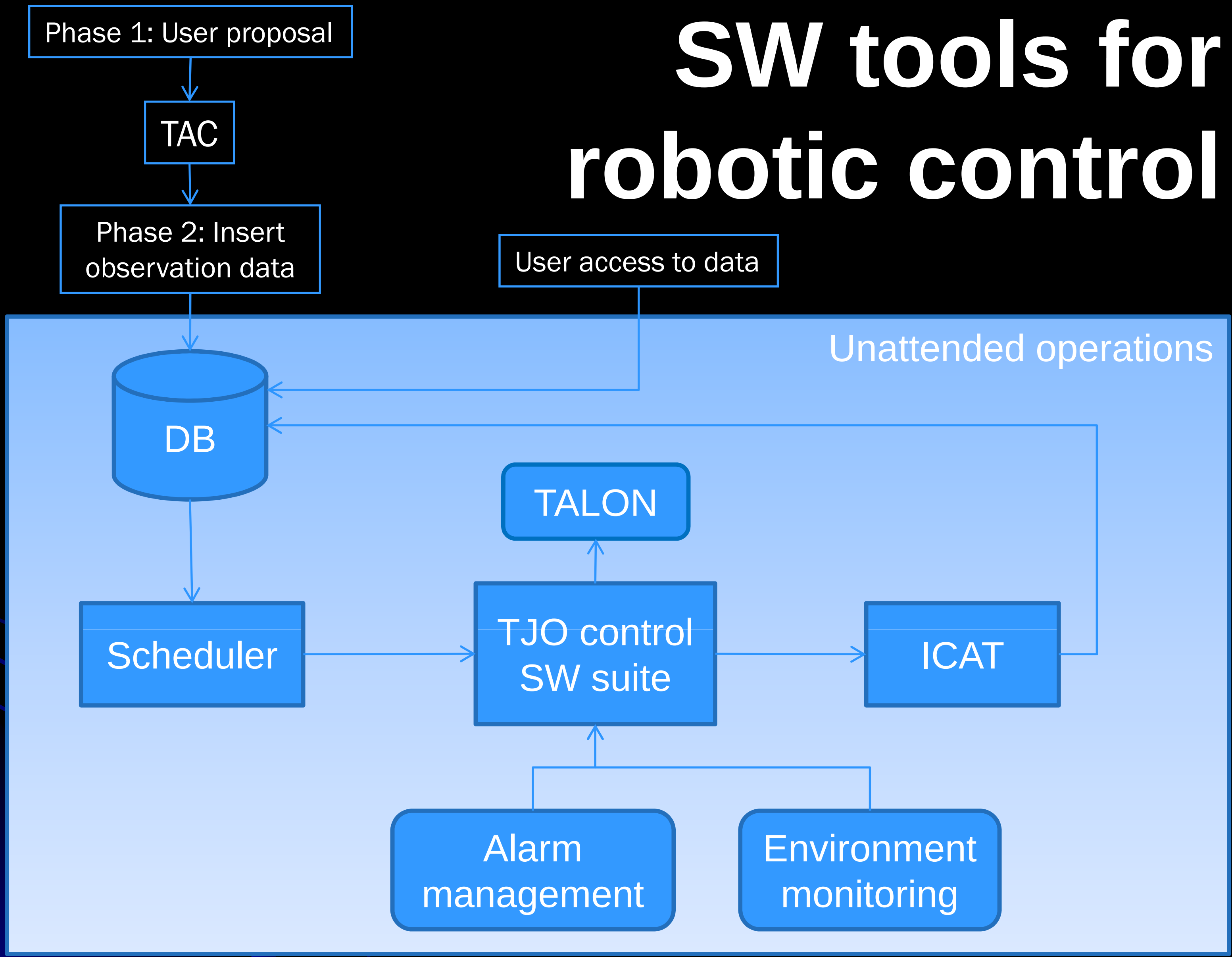
- ⇒ Set of sensors to monitor all the environment variables
- ⇒ Mainly based on commercial devices
- ⇒ Tools to manage the data and the generated alarms
- ⇒ Power management and protections against induced current and perturbation of the communication signal: UPS, SW controlled switches, electric insulation components, fiber optics cables

WP 4000: Data storage and backup

- ⇒ Data storage policy design and system implementation:
  - o Maximum data rate ➔ 8 GB per day
  - o On-site data storage: magnetic storage tapes (200 GB) and a Redundant Arrays of Independent Disks (RAID) 5 (276GB)
  - o On-site management of the data repository:
    - ▪ On-line backup
    - ▪ Daily Off-line backup: copies on a magnetic tape
  - o Off-site data storage: massive storage using an LVM over a RAID6 that provides double redundancy (2TB)
- ⇒ Automatic compression scheme:
  - o Design and implementation using GNU license SW
  - o RICE algorithm (NASA's HEARSARC CFITSIO library)

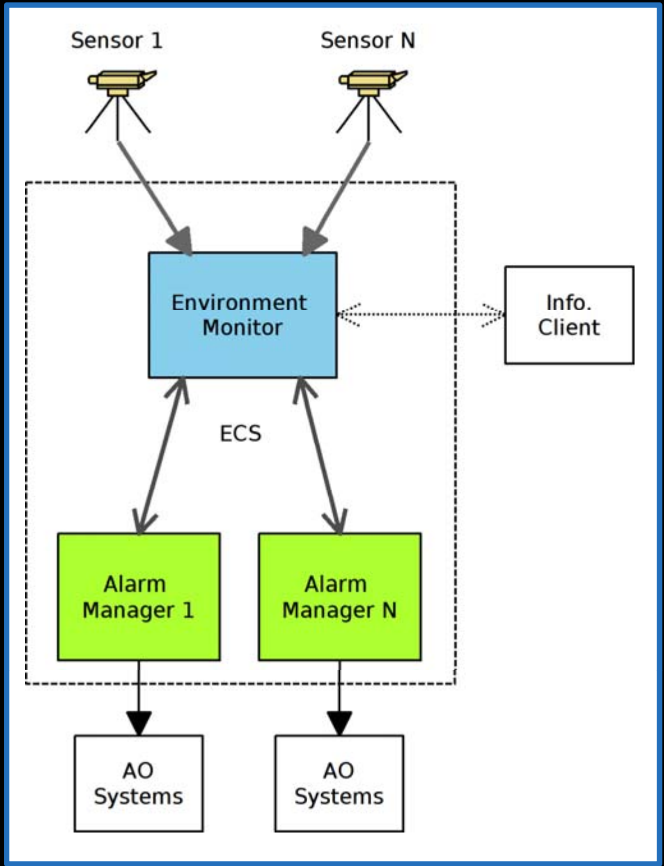


SW tools for robotic control



WP 5000: Systems control

⇒ WP 5100: Environment Monitoring
⇒ WP 5200: Alarm managers
⇒ WP 5300: Interfaces



WP 5100: Environment Monitoring

⇒ Set of tools to monitor the environmental conditions and to manage and generate alarms according to these conditions
⇒ Main features:
- Constant monitoring of the environmental conditions
- Alarm generation and management
- Designed to be used for several observatories at the same site

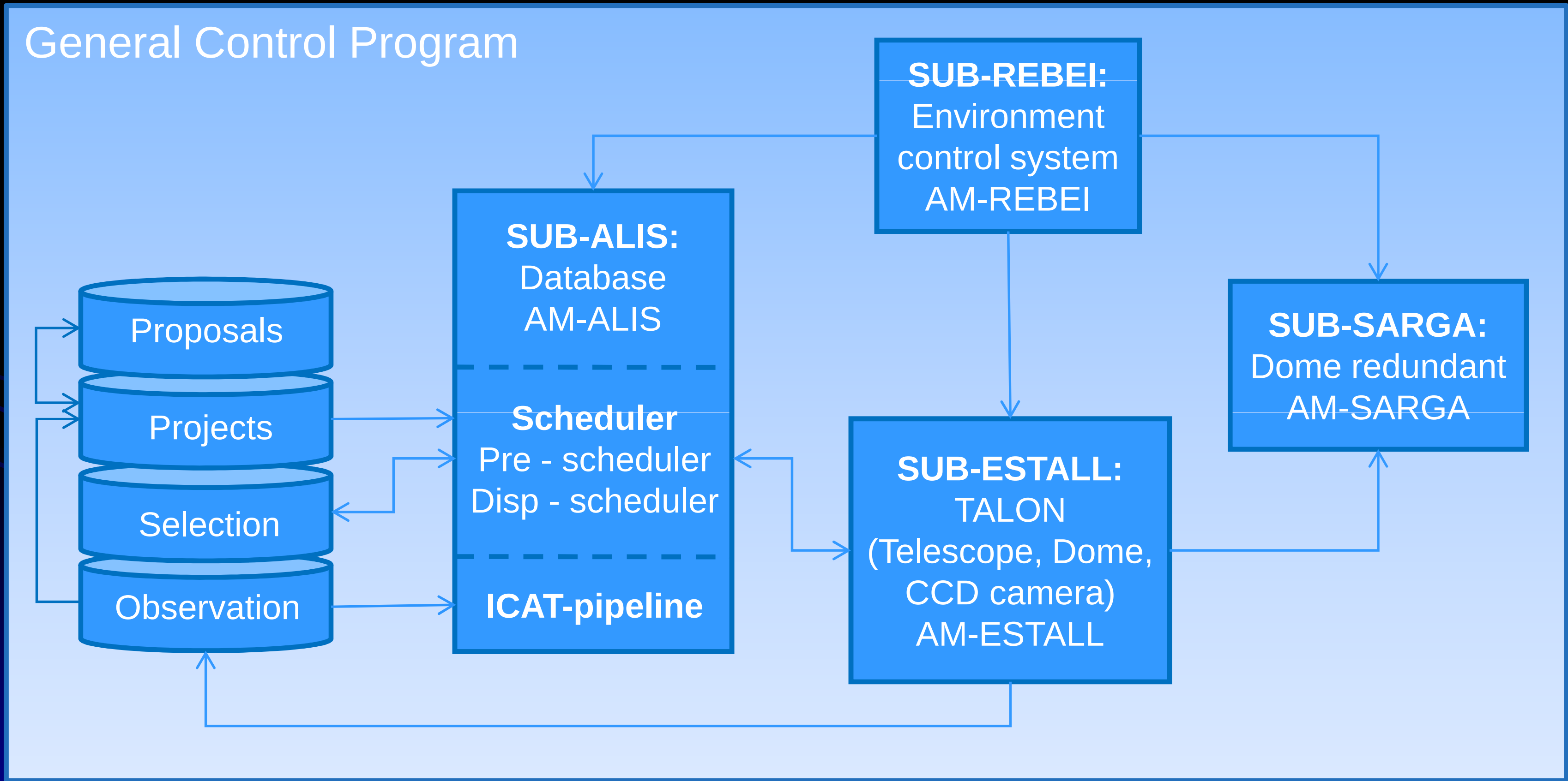
WP 5300: Interfaces

⇒ Software interfaces (SW – SW and HW – SW)
⇒ Proposal and data management

WP 5200: Alarm managers

- ⇒ Distribution of alarm managers, each one running on different computers and with routines subject just to a unique subsystem
- ⇒ Server-client architecture, where the AM server informs AM clients at other subsystems about the alarms

General control diagram



WP 5200: Alarm managers

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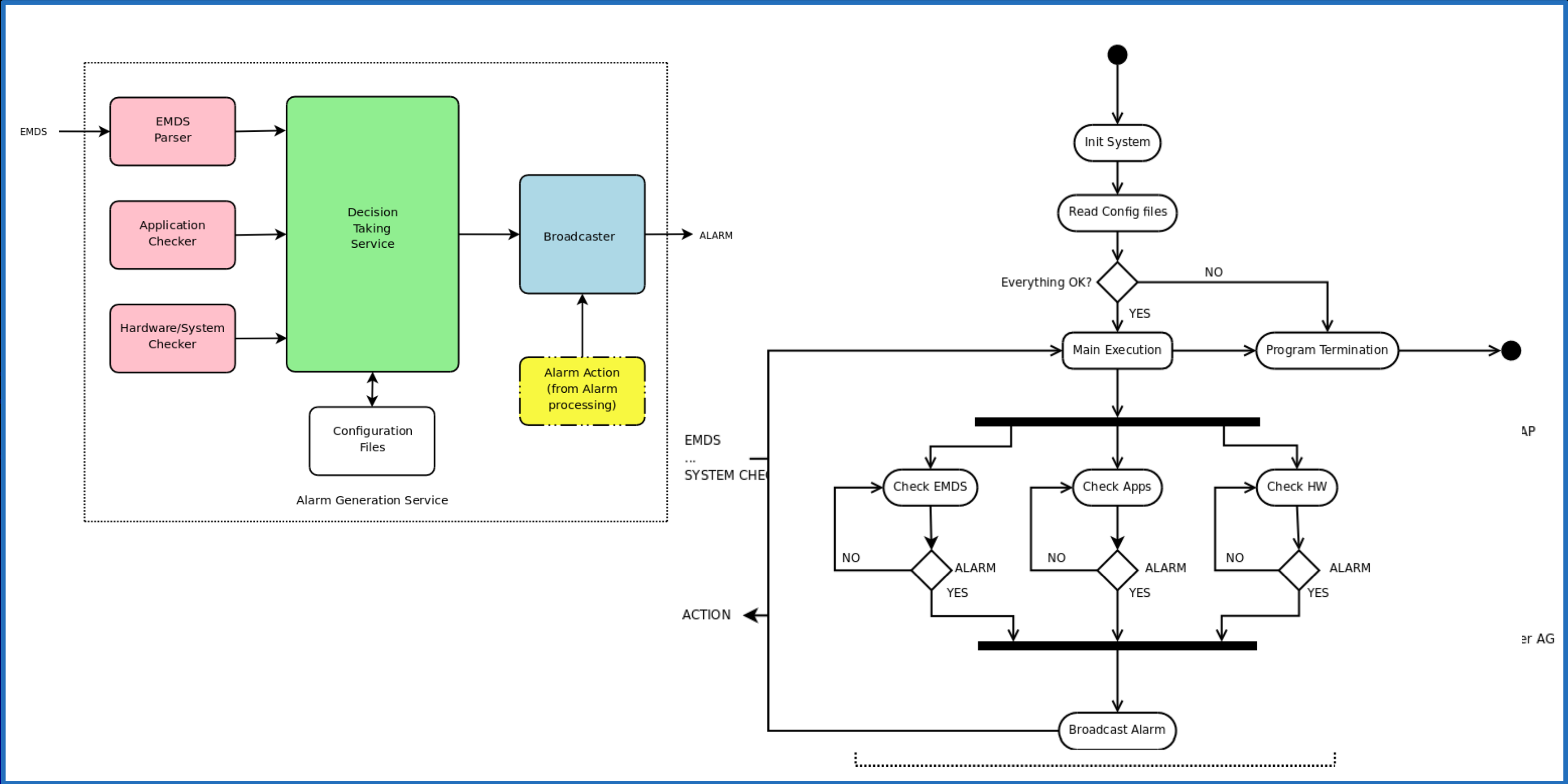
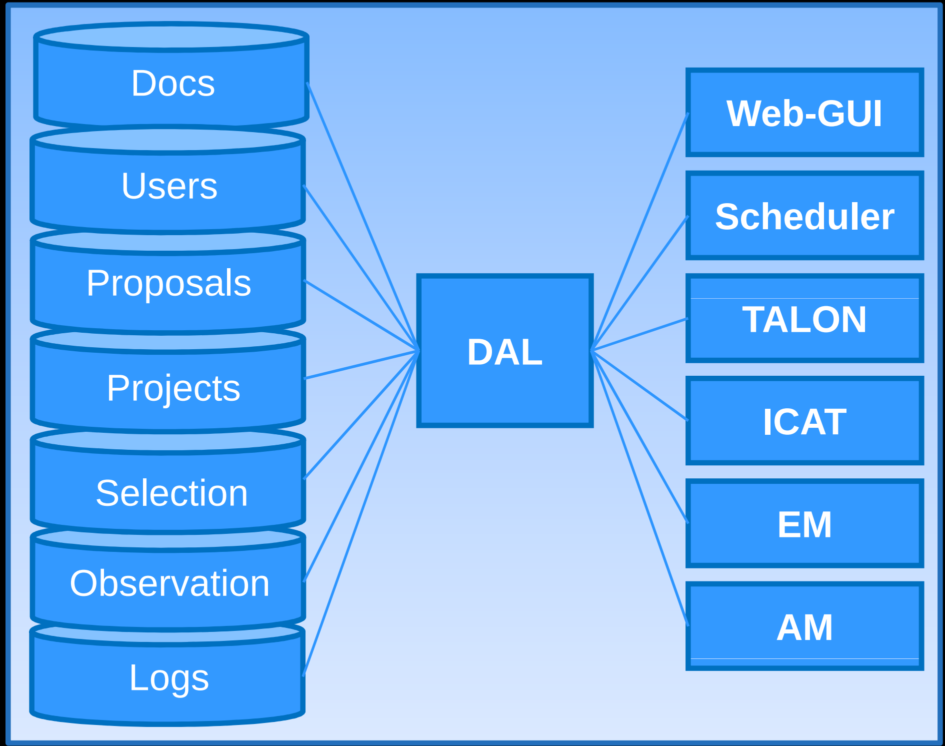


WP 6000: Database

⇒ Structured using the relational model and implemented using GNU license SW

⇒ DAL interface



WP 7000: Scheduler

⇒ Pre – scheduler: selection of objects according to their possibility of observation from those projects approved

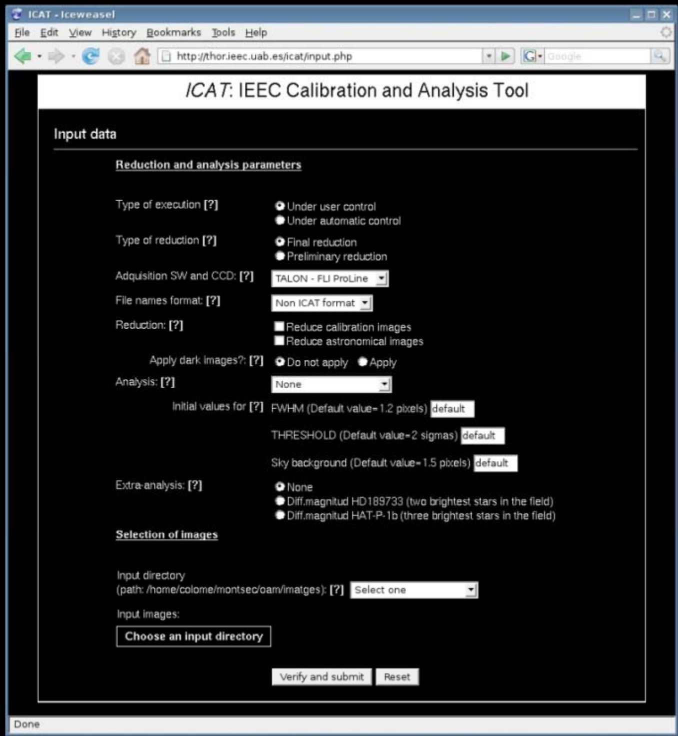
⇒ Dispatch – scheduler:

- Executed any time a target observation is over and a new one must be scheduled
- Done in real time according to current environment conditions and the set of priorities
- It calculates the figure-of-merit of each object and the object with the highest merit value is schedule

$$m(t) = \sum_i \alpha_i \cdot f_i(t)$$

WP 8000: Data processing –
The IEEC Calibration and Analysis Tool (ICAT)

- ⇒ Automatic management and treatment of FITS images according to database input information
- ⇒ High accuracy photometric and astrometric data extraction
- ⇒ Real time execution
- ⇒ Automatic or user-controlled (web interface)
- ⇒ Use of four packages:
  - o **NOAO-IRAF**
  - o **DAOPHOT**
  - o **SExtractor**
  - o **CFITSIO**
- ⇒ Based on Perl scripting and executed together with UNIX shell and NOAO-IRAF scripts
- ⇒ Designed to be easily adapted to be used at other observatories



Commissioning Tests

D.Fernández et al. (poster): “Site Quality at the OAdM and Commissioning of the TJO”

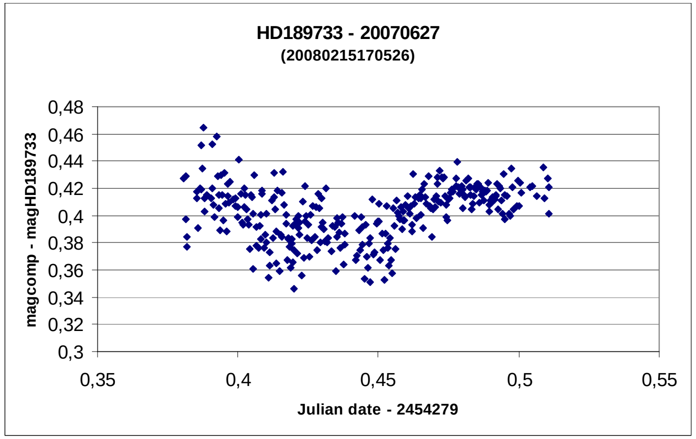
Transiting exoplanets

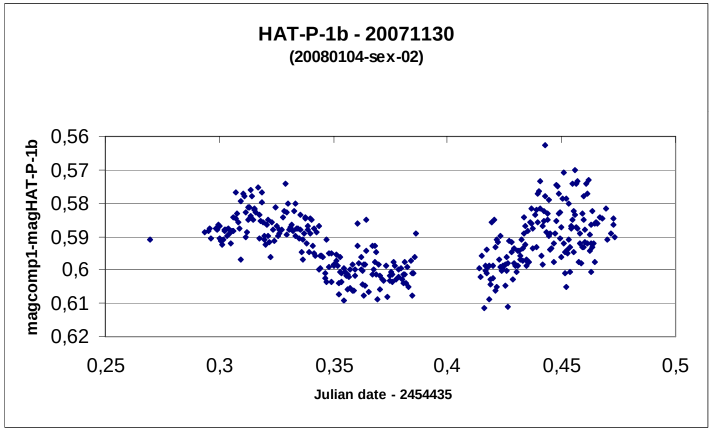
HD189733b, source data:

- ⇒ Apparent Mag. V (star): 7.5
- ⇒ Planetary transit depth: 0.025 mag
- ⇒ Transit duration: 2h

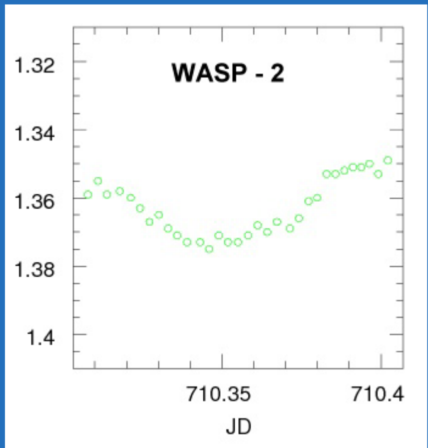
HAT-P-1b, source data:

- ⇒ Apparent Mag. V (star): 10.4
- ⇒ Planetary transit depth: 0.015 mag
- ⇒ Transit signal period: 4.46529d





WASP-2



Conclusions

ROBOTIC TELESCOPE

- ⇒ 2 years to complete the system to achieve high confidence-level robotic operation
- ⇒ We have acquired experience and knowledge

LESSONS LEARNED

- ⇒ 2 SPF: dome shutter closing and housekeeping (environment monitoring)
- ⇒ Redundancies for these critical elements are mandatory
- ⇒ New critical SW applications developed (EM, AM, ICAT, Sched, etc.)
- ⇒ HW elements to ensure the system reliability and stability (power supply, electric insulation, etc.)

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