# RTS2 - Remote Telescope System, 2$^{nd}$ version

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**Abstract.** BART is a small remote controlled robotic CCD telescope, devoted to rapid observation of prompt gamma ray burst transients. During its operation since early 2001, it had three prompt observations with world-competitive response time. The constraints to object magnitude were estimated and published in GCN circulars. Telescope is located in Astronomical Institute of the Czech Academy of Sciences in Ondřejov. This poster describes its new control system, named RTS2, which is in service since February 2003.

## INTRODUCTION

RTS2 is designed as a networked system for driving of robotic telescopes. It is composed of several device servers, central server and various observational clients cooperating over a TCP network. For the communication, there is a private protocol, ensuring speed and reliability. It is intended to be independent on used astronomical HW, with access points for controlling of different types of mounts, domes and CCDs. Observation entries, requests and results are kept in database. Positions of GRBs are received from the Internet, and observed either in prompt mode, or added to list of observation targets, depending on weather and other conditions influencing the observation. The idle time, when there is not any request for GRB observations, spends the telescope monitoring various active galaxies. The database lookup entry point is accessible at `http://lascaux.asu.cas.cz/bartdb`.

New system has been recently implemented also for cooperating Spanish-Czech BOOTES experiment. It is installed and performs well on stations BOOTES-1 and BOOTES-2 in southern Spain.

The system may be used on most Linux distributions. The vast majority of the code is written in C programming language and uses PostgreSQL database. The whole RTS2 package is available on request to download, with complete source code included.

The code is covered by GNU license, which enables anybody to modify it, if certain conditions are being held. RTS2 web page is at `http://lascaux.asu.cas.cz/rts2`.

## SYSTEM DESCRIPTION

The system consists of three kinds of programs:

**central server**

**server/client programs** for accessing and controlling devices like cameras, telescope or weather controller paired with dome/roof controller

**client programs** to control an observation - currently there is scheduler client for regular observations, gamma ray burst client for prompt observations of GRB optical transients, console based monitoring client, stream based monitoring client and focus client for camera focusing

Central server holds list of all connected devices and clients. Every new device registers to central server in order to be accessible to clients, and every client connects and authorises itself to central server in order to be able to access devices. Access to devices is priority-based - only client with the highest priority can access state-changing functions of a device - such as mount moving or exposing and readout of camera.

We are able to control whole family of SBIG parallel port based CCD cameras. We work on USB based SBIG, Apogee and FLIcam CCDs. We are able to control LX200 family of telescopes by Meade, and we have an alpha level driver for the Paramount.

Implementing a driver-layer of nearly any device daemon should be relatively easy thanks to a well-elaborated design of the upper layers.

## DATABASE STRUCTURE

The basic structure of database can be seen on Figure 1. The main tables are TARGETS, OBSERVATIONS and IMAGES.

Possible targets are kept in TARGETS table. Each target entry has a type, used by scheduler when selecting a target. Each target can have an expanding table of constraints (or properties) defining when and how it will be observed. Such properties involve a minimal desired number of images per night, minimal period between observations etc.

OBSERVATIONS table form a relation between TARGETS and IMAGES. It may be thought as a log of all light images performed by telescope. In IMAGES table are stored only images which have correct astrometry computed by the real-time processing software.

## IMAGE ANALYSIS

Observed images can be processed with any image analysis software, which is able to run on UNIX based operating system. Currently we use modified Opera package, which was developed at Madrid. It writes sky coordinates in standard World Coordinate System (WCS) header to processed images. Coordinates of processed images are being sent to the telescope driver. This process constitutes a feedbackl for fine positioning.

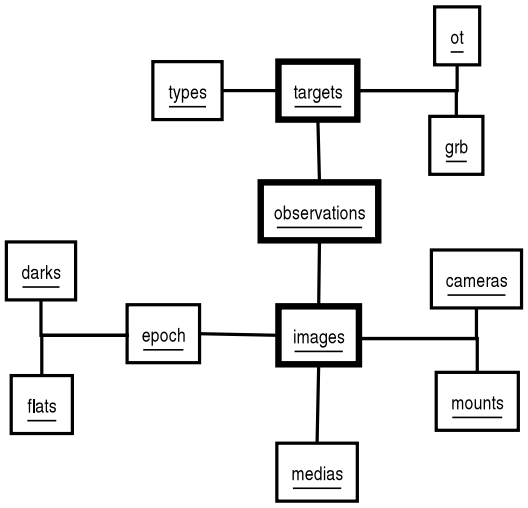


**FIGURE 1.** Database structure overview

## SYSTEM OPERATION

Main scheduler takes care of obtaining pictures for flat-fields during dusk and dawn. It also obtains dark-frames at predefined time interval.

Primary GRB receiving is done through dedicated client. It's connected through socket to GCN server in NASA-GSFC. If it gets GRB event, which is currently visible, it asks central server for priority, moves mount and when the telescope is aimed at obtained coordinats, it asks for camera exposures. Pictures from cameras are downloaded during readout through network to computer running GRB client. There they are stored, get WCS, and kept in database.

In case that socket connection fails, backup system uses reliable e-mail receiving. GRB event is then observed from main scheduler. Main scheduler also takes care of observing GRB error boxes, which were bellow horizon when they occurred, or which were received when system didn't operate due to bad weather conditions.

## SYSTEM STABILITY

RTS2 is observing in Ondřejov for half a year. Majority of errors in program code have been tracked down. System is running there in semi-automatic mode, with staff available to check it 24 hours a day. The restriction is given by the lack of automatic roof control, thus the need of person to watch the weather nightly. This will change after complete roof automatization in beginning of 2004.

In Spain, at BOOTES-2, RTS2 have been implemented recently, without any trouble in a few days, it performs well until the moment of this writing. It works there in fully automatic mode, without human intervention in place, controllable only through the Internet.

The RTS2 is based on experience gained from RTS1, which had been running on BART for two years.

## CURRENT RESULTS

Between $15^{th}$ and $18^{th}$ August 2003, RTS2 responded to following GCN triggers:

| Telescope | GCN # | RTS-2 # | Delay | first image | Notices |
|---|---|---|---|---|---|
| BART | 2805 | 5740 | 1d 10:15 | 08-16 20:06:47 | (1) |
| BOOTES-2 | 2805 | 67 | 09:18:26 | 08-15 19:10:05 | (1) |
| BART | 2808 | 5741 | 00:10:07 | 00:36:34 | (2) |
| BOOTES-2 | 2808 | | | | (3) |
| BART | 2809 | 5742 | 17:53:37 | 20:28:49 | (2)(4) |
| BOOTES-2 | 2809 | | | | (3) |
| BART | 2812 | 5743 | | | no observation, bad weather |
| BOOTES-2 | 2812 | 78 | 00:00:21 | 23:16:49 | (5) |

**(1)** Daytime GCN, burst localisation observed from scheduler during night.
**(2)** Due to problems with rights on log file, GRB client wasn't running, all observations were from scheduler. That's reason for such long delay.
**(3)** GRB client crashed at 2003-08-16 around 16:30 UT, leaving no traces. Code review will follow.
**(4)** GRB was bellow horizon at receiving time.
**(5)** GRB was on horizon, images are sometimes disrupted with trees.

Exact timing of GRB-2812 processing on BOOTES-2

| Time (UT) | Event |
|---|---|
| 23:16:01 | Burst detected on HETE |
| 23:16:11 | GCN without localisation |
| 23:16:21 | First GCN with localisation |
| 23:16:22 | Beginning of observation |
| 23:16:22 | GRB client asks for priority and gets it |
| 23:16:22 | GRB client starts moving telescope from 01:36:58, +15:49:12 |
| 23:16:22 | scheduler request for common observation is ignored |
| 23:16:48 | Mount reach its position |
| 23:16:49 | Start of first 30 sec exposure |
| 23:19:xx | First image with on-line astrometry |

Limiting magnitude on NF was about 13 at the beginning of observation. No new object was found.

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