

SAM SYSTEM DESIGN NOTE

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SAM observing tool: IDL version

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1 Introduction

Observing tool (OT) for SAM is a software to prepare and execute observations. It helps in organization of target lists, definition of guide stars, and planning of work with respect to target visibility and LCH closure windows.

Here we describe a stand-alone tool programmed in IDL which partly covers these needs.

2 Data structures

The initial list of targets is prepared as a text file, e.g. `mytarget.txt`, in free format, where each line contains the target name, equatorial coordinates, and possibly other data. The restrictions are: (i) target names without spaces, (ii) target names must be unique, and (iii) coordinates for J2000 equinox only. Note that the coordinates are separated by spaces, not by colons. Example:

```
# Targets for SAM engineering Dec 2-3, 2012 with further additions
Lindsay1    00 03 53.22 -73 28 16.66    2000 GC SMC
GB_001      00 20 16.4  -05 31 26      2000 Schirmer 2x2,300-600ss,VRI
```

The IDL program `gettarg.pro` imports such text list into the IDL structure `targ` with the following elements:

```
el={name:'',type:0,progid:'ENG',radeg:dblarr(5),dedeg:dblarr(5),mag:fltarr(5), $
filt:strarr(5), cmt1:'',cmt2:'',pri:1.}
```

Lines beginning with `#` and `*` are interpreted as comments and ignored. The coordinates of up to 5 stars (in degrees) are kept for each target, with the element 0 referring to the target itself and the other 4 elements to guiding or pointing stars. Magnitudes and filters are added for each star when available. Another fields of the structure are two comments (preferably no longer than 80 characters each), type of target (integer number), priority (floating number), and program identifier. The IDL structure `targ` is saved in the `targ.idl` and represents the target database. The intention is to keep common database of all SAM targets, although nothing prevents several separate databases. *I recommend to save backup copies of `targ.idl`, in case this binary file gets corrupted or over-written.*

To add new targets to the existing list, prepare the text file with names and coordinates and issue the command

```
IDL>gettarg, 'mytagrets.txt', /append
```

If the target with the same name already exists, it will not be appended (so, no harm in repeating existing targets in `mytargets.txt`). Presently there is no way to *remove* targets, unless doing this by hand in IDL (assign a special name and select targets that do not have this name).

Another data structure is *run* – a selection of targets to be observed in a particular SAM run of one or several nights. Runs are defined by text files containing the names of selected targets, one per line, e.g. `201301.run`. The names must be *exact* matches to the target database. We assume that all run targets will be observed with LGS, so the LCH PRM files will be produced for all targets of the run. Objects to be observed without laser (e.g. photometric standards) need not be included in these target lists.

3 Preparation of the run

3.1 IDL programs

The IDL programs `*.pro` are collected in some working directory. To launch the tool, start IDL from this directory, compile files by `IDL> @make`, then start the GUI by the command `IDL> xtarg`. The working directory must contain the `targ.idl` database created previously, the run files, and the PAM files (when available, in the `PAM/` sub-directory). Optionally, specify the observing run and/or the non-standard target database on the command line: `IDL> xtarg, run='201301.run', savename='mytarg.idl'`.

3.2 Main GUI (`xtarg`)

The main GUI is depicted in Fig. 1, with a brief explanation of its functions. Targets are selected from the drop-down menu or by the Prev/Next arrow buttons. For each target, we can select its type (star, cluster, nebula, etc.) from the drop-down menu (star by default), enter the priority number (default 1), select/deselect for the current run.

The run can be specified on entry by `IDL> xtarg, run='201301.run'` or loaded by pressing the **Load-run** button (only files with the `.run` extension will be shown in the dialog window). Alternatively, you can enter the new run name in the field (press carriage return after the name!), select targets, and save the run at any moment. When you enter the new run, the existing selections are not reset (so, you can assign a new name to the old run).

By default, all targets are displayed. If you want to see only the selected targets, press the toggle button **Show All/Show run**. The drop-down menu is modified accordingly and the first target is displayed. Note that the selections do not affect the list of displayed targets until you press this button again (the de-selected target remains visible).

The button **ALL** in the top-right corner selects all targets. This is convenient if the database contains only the targets to be observed.

3.3 Catalog tool (`xcat`)

The button **2MASS** invokes the catalog tool `xcat.pro`, which opens its own GUI (Fig. 2). Although it is a separate program, it works only with `xtarg` and communicates with it through the common block `xtarg`. The tool loads coordinates and magnitudes of stars from the 2MASS Point Source Catalog in the 5-arcmin square field centered on the target. It uses the `queryvizier.pro` IDL utility. The query

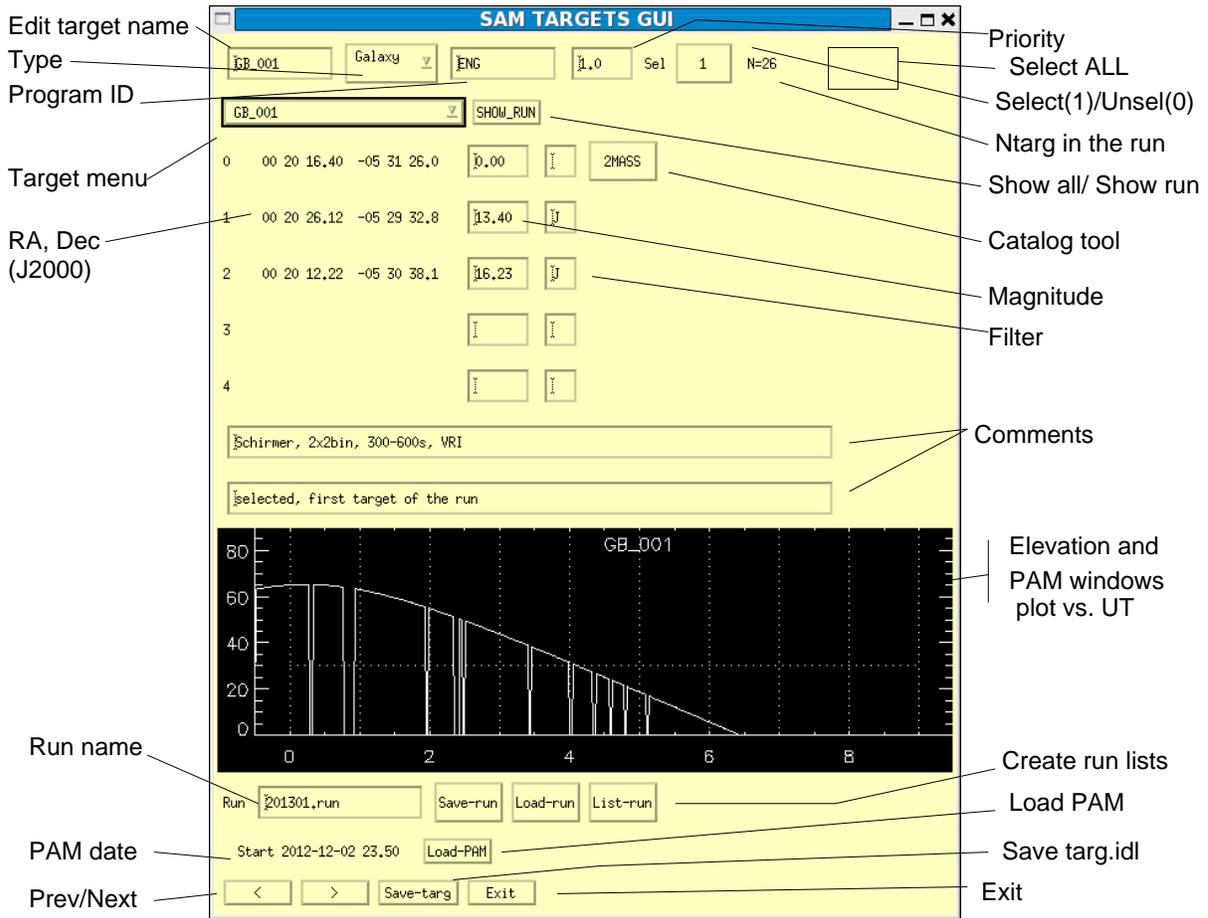


Figure 1: GUI of xtarg.pro.

result is available in the IDL structure `info`. Stars are plotted as squares, with square size related to the J -magnitude. By pressing the button `USNO`, we query also the USNO B1 catalog (those stars are displayed by the plus signs of fixed size).

When we left-click in the field, the information on the nearest star is displayed. If USNO is queried, the information from its nearest USNO source is also shown on the next line. The distance between these USNO and 2MASS stars is calculated.

We estimate R -magnitudes of stars from their J and K magnitudes by assuming that all stars have spectral type G2 ($J - K = 0.36$, $R - J = 0.57$) and redder stars are extinguished ($E_{R-J}/E_{J-K} = 2.1$). The formula is therefore

$$R - J \approx 0.57 + (J - K - 0.36) * 2.1, \quad (1)$$

where the last (extinction) term is restricted to be non-negative. Comparison of these estimates, designated as R_j , with the R_2 magnitudes from USNO, shows that the algorithm gives acceptable results (errors $< 0.2^m$) for most stars which are not too red, $J - K < 0.8$.

By pressing the button `Get`, we transfer the coordinates and R_j magnitudes of the currently pointed star to the `targ` structure which contains place for up to 4 stars. Guide stars from 1 to 4 are selected in the drop-box menu `GS` (the `GS` number is incremented automatically after each `Get`). Previous coordinates of this star (if present in `targ`) are lost. The `Del` button sets zero coordinates

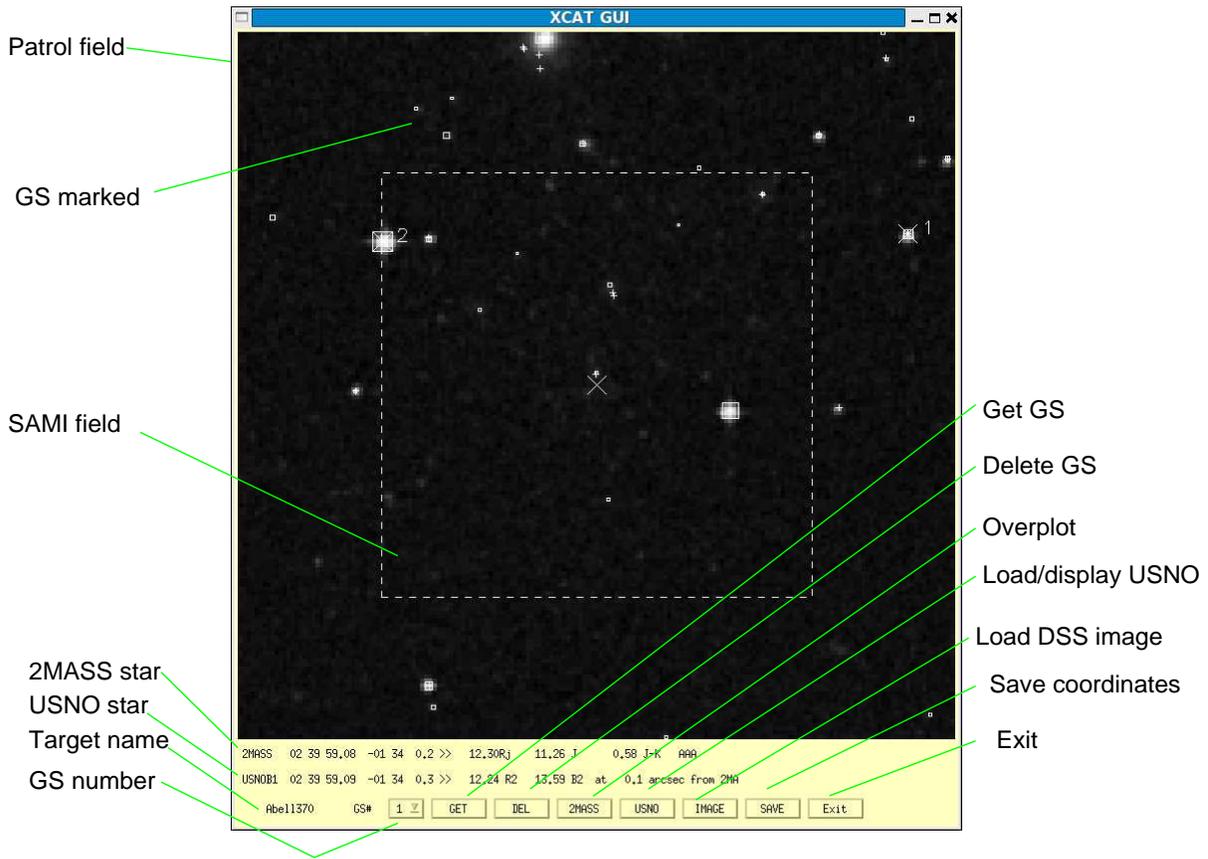


Figure 2: The GUI of `xcat.pro`.

and magnitudes for the selected GS. The GSs are marked by large X crosses in the display.

The button `Save` creates the file `name.info` which saves the results of 2MASS (and possibly USNO) queries in the IDL binary file for each target `name`. When the `xcat` is called, it checks the existence of such saved information (in the current directory) before querying Vizier, to avoid repeated queries.

The button `IMAGE` loads the sky image from the DSS server (it uses `querydss.pro`) and displays it in the same window. The symbols plotted previously are lost. However, the button `2MASS` overplots these symbols again, on-top of the image. The image is helpful for field identification or for distinguishing stars from galaxies (some USNO objects are galaxies, not suitable for tip-tilt guiding).

3.4 Target lists

The button `List-run` creates three text files for the current run. The first, `run.coo`, is intended for the SOAR operator for slewing to targets. All target names are preceded by sequential numbers in square brackets (for ease of communication with the operator). The GS coordinates are listed as well with target names appended by -a, -b, etc. The coordinates are colon-separated. Here is an example:

```
[1]GB_001           00:20:16.40  -05:31:26.0   2000.0
[2]GB_001-a        00:20:26.12  -05:29:32.8   2000.0
[3]GB_001-b        00:20:12.22  -05:30:38.1   2000.0
[4]Kron3           00:24:46.28  -72:47:35.8   2000.0
```

[5]Kron3-a	00:24:15.89	-72:45:52.2	2000.0
[6]Kron3-b	00:24:49.77	-72:49:34.4	2000.0
[7]Kron3-c	00:25:12.63	-72:49:6.3	2000.0
[8]Kron3-d	00:25:08.85	-72:47:37.0	2000.0

The second file, `run.list`, simply lists all selected targets with their coordinates and corresponding numbers. It is intended for target selection by the observer and can serve for the PRM requests. Example:

GB_001	00 20 16.40	-05 31 26.0	[1]
Kron3	00 24 46.28	-72 47 35.8	[4]

The third file with a reserved name `usercat.txt` lists only sequential numbers of targets and guide stars and their colon-separated coordinates. This file should be copied to the ISCSOFT computer in the directory `~/Catalogs/`, with this same name. The objects will then be displayed then in the GMAP GUI, and can be used for pointing or guiding. This complements the standard set of catalogs in GMAP (e.g. its USNO catalog is incomplete).

3.5 PRM files

Requests for laser propagation windows are sent to the US Space Command Laser Clearing House (LCH) three working days in advance of the night. The format of these request PRM-files is quite specific and strictly defined. The PRM files for each night can be generated by the button **Make PRM** (next to **List-run**) in the main GUI. It evokes the program `getprm.pro`. The starting date of the night (evening date) and the start and end UT times are queried on the command line. After answering these queries, the PRM file is produced immediately. It is named automatically as

```
PRM_SOAR_SAMLGS_0.355um_10W_4.08urad_15Nov2014_FOR_JDay_319_RADEC
```

where 15Nov is the evening date of the observing night.

4 Support of observations

The same tool can be useful during observations for examining the elevation of targets and the LCH closure windows. This is done by the `getpam.pro` program in two steps. First, it loads the PAM file in the two IDL structures `pamtarg` and `pamwin`. The first contains sequential number of target (in order of appearance in the PAM file) and its coordinates. The second contains the same number and the Julian dates of start and end of propagation windows computed from the PAM times. So, each target has one element in `pamtarg` and several corresponding elements in `pamwin`. Both structures are saved in `pam.idl`.

The second stage involves processing of all targets in the run and calculating the elevation (the SOAR coordinates are hard-coded). Elevation during the LCH closure windows is set to zero (with 1-min extension of the closure on both ends). The duration of the night is determined from the `pamwin`. For the plot, the running UT time is represented by an array of 600 points (about 1 min per point). For each target of the run, corresponding index in the PAM is determined by coordinate match. The result of this operation, performed by `pamproc`, is the elevation array of `]600, ntarget]` elements, the UT array, and the string array of matching target names, all saved in `pamproc.idl`.

To load the PAM file, use the button `Load-PAM` in the main GUI which opens the file-selection dialog. The PAM files must be located in the sub-directory `PAM/` of the current (working) directory. Upon file selection, its loading and processing is done (the run must be loaded as well), and the UT date of the beginning of the night appears in the GUI. Then, after selecting each target, its elevation plot with the LCH windows appears in the graph, as shown in Fig. 1. The information for the plot is taken from `pamproc.idl`.

5 Further work

The IDL tool will be evolved as needed, after some experience is gained. The two functions that still are not programmed is the export/import of the database in text format (ASCII). These files can contain *Label: value* on each line, with labels corresponding to the fields of the `targ` structure.