

SAM LGS software description

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File: soar/software/lgs/lgs-sw.odt

This document describes the functionality of the LabView software that controls the SAM LGS sub-system – the LGS SW. It is an engineering software created by M. Martinez which is normally not used in the SAM operation, the instrument being controlled by the user software. The LGS SW interacts with the user SW by receiving commands, executing them and sending the responses.

1. Location and startup

The LGS SW is installed on the SAM AOM computer (located in the rack on the SOAR platform), IP 139.229.15.32. The AOM computer is a PC running under Linux Fedora core 9. The SW is located in the `/user/slgm` directory and is run by the user `slgm`. It is normally accessed by the VNC in the work space 1, leaving other work spaces for other SAM SW components that run on the same PC (AOM, SLCH, ICSOFT).

To get access to the LGS SW, connect by VNC to **139.229.15.32:1**. To start, click once on the icon “SAM LGS” in the graphic menu (in the lower-right corner of the screen). This evokes the 1-line script `SAMLGS.csh` in the `SAMLGS` directory. Upon startup, three windows appear:

- `LGSGUI_Main.vi` (small window with *Exit* switch)
- `Env_Main.vi` (grey window)
- `LGSGUI_Logic.vi` (main GUI)

Only the last window is used for control (this is the actual GUI), the first two are for technical use and can be minimized (but don't close them!). The button *Exit* in the GUI should be used for exiting the LGS SW.

2. Structure of the program

The structure of the LGS SW follows the standard adopted at SOAR. The main application is `Env_Main.vi`. It calls other LabView modules, or devices (their code is in the `/user/slgm/SAMLGS/modules/*` directories). See the description of the AOM SW [3] for general principles, connections, and interaction with the hardware.

Figure 1 shows the `Env_Main.vi` window. It contains the list of 13 devices and their status which can take four possible values: `IDLE`, `ACTIVE`, `OFFLINE`, `SHUTDOWN`. The buttons *Show* are used to open specific GUIs for each device (normally they are not opened). The three buttons on the right, *INIT*, *OFFLINE*, and *SHUTDOWN*, serve to control the whole application.

The LGS SW controls motors and other devices via two RS-485 lines through a serial communication board installed in the AOM computer (another such board is occupied by the AOM SW control). One line is a bus connected to the mechanisms and telemetry. Another line controls the laser power supply through an RS485/RS232 converter which is located inside the laser power rack.

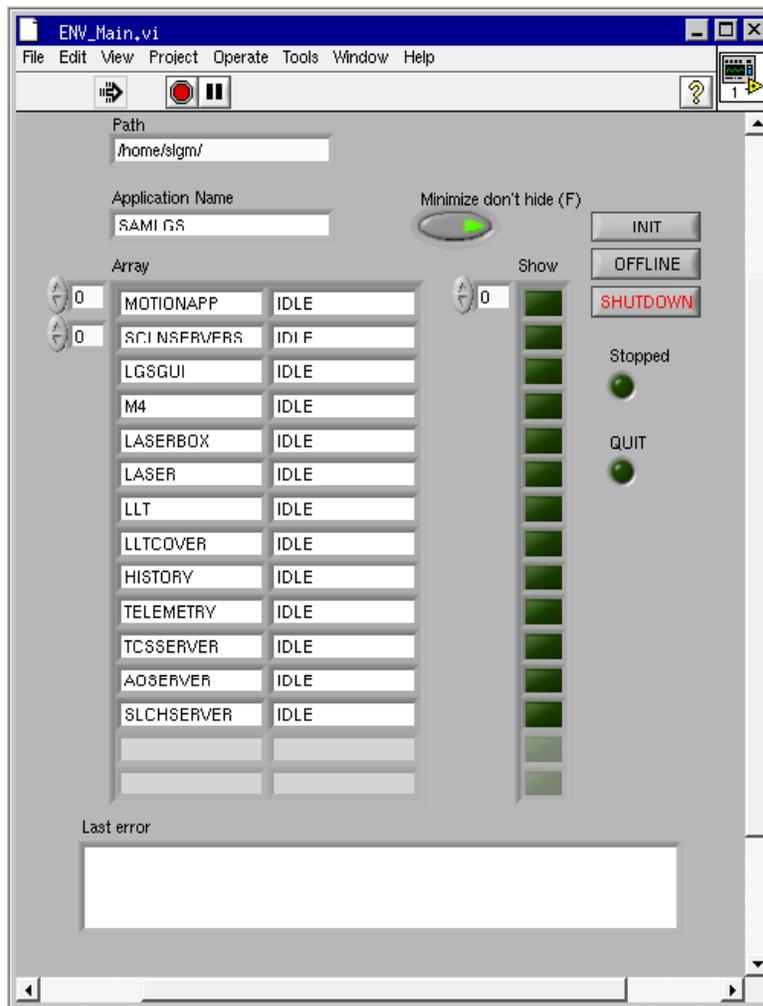


Fig. 1. The ENV_Main.vi window.

Table 1 lists the mechanisms and other hardware controlled by the LGS SW and corresponding LabView devices. The column N contains the number of mechanisms, “PI SM” and “Thorlabs SM” denote DC motors with encoders (servo motors) from Physik Instrumente and Thorlabs, respectively. Both are used with the Allmotion controllers, see <http://www.allmotion.com>.

The LGS SW communicates with other SAM SW modules by the Ethernet, though sockets. The IP addresses of relevant servers and clients are specified in the configuration files. Actually the LGS SW communicates only with the ICSOFT and SLCH (communication with the SOAR TCS is defined, but not used). During normal operation, the LGS is commanded by the ICSOFT. Those commands are passed to the LGS SW which actually executes them.

Table 1. List of LGS devices and controlled “mechanisms”

Device	Mechanism(s)	N	Hardware	What's controlled
M4	Axis1, Axis2	2	Thorlabs SM, linear translation	Position
LLT	M1a, M1b	2	PI SM, linear translation	Position
	Focus	1	PI SM, linear translation	Position
LLTCOVER	Environmental shutter	1	DC servo, rotation	IN/OUT
LASERBOX	Laser selector	1	DC servo, linear translation	IN/OUT, position
	Temperature	1	Omega controller CNi8	Set-point
LASER	Power, Shutter	2	Commands to laser power supply	ON/OFF
	Mode	1	Commands to laser power supply	Laser mode
TELEMETRY	LLT Prosilica camera	1	Power 12V	ON/OFF
	Green laser power	1	Power 12V	ON/OFF

3. The user interface (GUI) and operation

3.1 General description

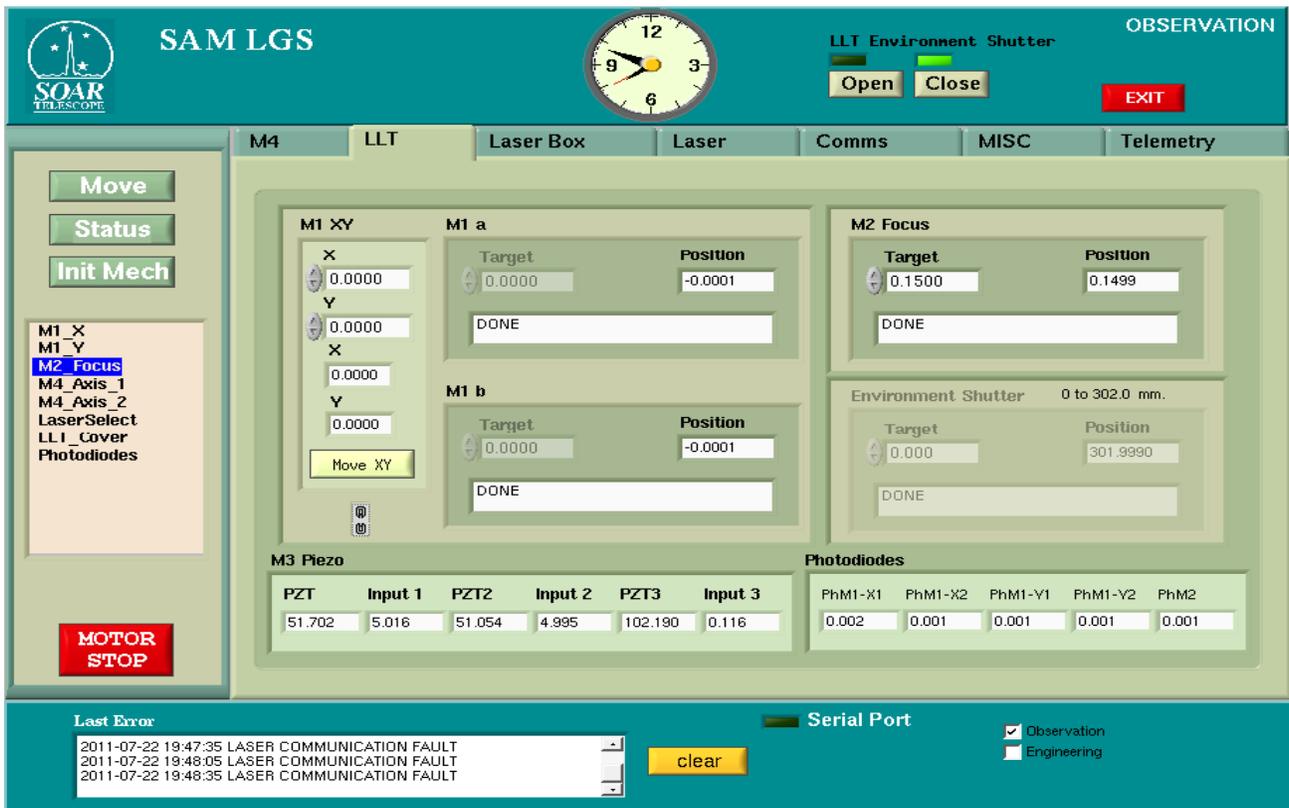


Fig. 2. LGS GUI with the LLT tab opened.

The screen-shot of the LGS GUI is shown in Fig. 2. The *upper part* contains the window title, clock, control of the LLT environmental shutter, and the *Exit* button. The *left part* is a list (menu) of mechanisms. After selecting a mechanism, it can be initialized or moved to some position with the buttons *InitMech* and *Move*. The motion can be stopped at any moment by the red button *Stop*. The button *Status* refreshes immediately the status of the selected mechanism (otherwise, the status field is refreshed with the polling cycle or upon completion of the current action).

The *central part* of the GUI contains several tabs (M4, LLT, Laser Box, Laser, Comms, MISC, Telemetry). Each tab corresponds to a group of functionally related hardware (they may or may not belong in the same device). After selecting a motor in the left-hand menu, the corresponding tab opens automatically.

The *lower part* of the GUI contains a space for error messages with a *Clear* button, indicator of serial communication, and the check-box to select between observation and engineering modes (the mode is also displayed in the upper-right corner of the GUI). In the observation mode, some controls are disabled.

3.2 LLT

This tab (Fig. 2) serves for controlling the Laser Launch telescope (LLT). Its environmental cover is operated by the buttons in the upper part of the GUI. Apart from this, the LLT contains 3 identical PI motors: two for pointing and one for focusing.

The pointing of the LLT is done with two linear actuators M1a and M1b. Each actuator offsets the pointing at about 45 deg. angle from the standard XY coordinate system (X is left-right, Y is up-down). We need to control the pointing in X,Y coordinates instead. The X-motion is achieved by opposite displacements of M1a and M1b (difference), the Y-motion is done by displacements of the same sign (sum). Mirror displacement in X and Y is 1/5 of the actuator displacement because there is a mechanical lever in the LLT. The commands to move M1 in X or Y (in mm of mirror displacement) can be entered in the left part of the GUI, then press the button *Move* to execute them. The GUI displays the current pointing in X and Y (calculated displacement of M1 in mm) and also the actual positions of both actuators M1a and M1b in mm (5 times larger). The nominal pointing corresponds to zeros in both X,Y and M1a,M1b. The allowed motion range of each actuator is small, +/-1mm. When moving in X,Y, we usually reach the limit on one actuator first.

The LGS SW notation is somewhat confusing here. The motors M1a and M1b are denoted as M1_X and M1_Y in the left-hand menu and in the configuration files.

The piezo-actuated tip-tilt platform with M3 mirror is not controlled by the LGS SW, but the two input low-voltage signals (range 0 to 10V, mid-point 5V) and the three high-voltage signals on the piezos (range 0 to 100V, mid-point ~50V) are displayed. The piezo #3 is not controlled and should be kept at 100V. The voltages are polled by the telemetry and displayed in the LLT tab. Similarly, the signals of the 5 photo-diodes measuring the light intensity around the primary mirror (PhM1-X1, PhM1-X2, PhM1-Y1, PhM1-Y2) and at its center (PhM2) are displayed. These photo-diodes serve to control the beam centering in the LLT. The user can type values into these telemetry fields of the GUI, but they have no effect.

3.3 M4 and laser box

The M4 mirror has two linear actuators for centering the beam in the LLT, called *Axis1* and *Axis2*. They could be used for flexure compensation, in principle. The LGS GUI controls the positions of those two actuators. The button *Park* should send both actuators to some pre-defined position, but it is not used. The little switch below it with the “chain” pictogram slaves both axes together. In this case, we enter the two target positions and move both actuators simultaneously by pressing the button *Move* in the left menu, with either of the actuators selected there. The M4 tab is simple and we do not give its screen-shot here.

The *Laser Box* tab controls the stage in the laser box that blocks the main UV laser beam and injects the green alignment laser instead, if moved to the IN position. In the normal operation the stage is OUT. Arbitrary position can be commanded. Unfortunately, the green laser power cannot be controlled remotely, only by the hardware switch on the laser electronics box. The safety shutter in the laser box is controlled by the interlock system (see below). Also in this tab we find the display of the temperature inside the laser box. The temperature is stabilized by the CNI8 digital controller from Omega which communicates with the LGS SW by the serial

RS-485 bus common to other mechanisms. The set-point can be changed, with a 1-degree step. The actual temperature and the state of the heater (on/off) are read from the controller and displayed in the GUI.

3.4 Laser



Fig. 3. LGS GUI with laser tab opened.

The laser tab (Fig. 3) serves for the remote control of the laser power supply (through its RS-232 serial port) and the laser interlock system. The laser controls work only when its power supply is turned on with the key, otherwise the message `LASER COMMUNICATION FAULT` appears. When the laser is on, its working parameters are displayed. Note that sometimes this display is wrong because the laser power supply sends to the LGS SW a shifted parameter string (the parameters then are misplaced). Only part of the parameters are visible in the laser tab. To see them all, press the button *Open* below the *Extended Parameters* heading. It opens another window with a complete parameter list and useful buttons *Refresh* (otherwise the laser state is refreshed with the 30-s polling period). The check-box *Trigger Mode* in the main GUI selects one of the 4 possible laser operational modes (CW, Internal, External, Burst); press the button *Set* to change the laser mode. SAM uses the mode Internal (10W power, pulsed), the mode CW is handy for alignment (0.1W power, continuous). The other two pairs of ON/OFF buttons under the heading *Laser Power Supply* can switch on/off the current in the laser diodes and open/close the internal shutter in the laser. When both are ON, the laser is emitting the UV light.

The *Laser Clearing House Software*, SLCH, checks the LCH-authorized propagation windows and switches the laser off when the propagation is not allowed. This is an independent SW running on the same computer and communicating with the LGS SW by constantly sending it commands with two possible states,

either AUTHORIZED or FORBIDDEN. The connection to the SLCH and the regularity of this communication (“heartbeat”) are two necessary conditions for allowing laser emission. You can see the current SLCH state and the two green indicators of connection and heartbeat in the laser tab, above the laser parameters. In the FORBIDDEN state the LGS SW closes the internal laser shutter.

The laser safety system contains several stop buttons and switches to prevent accidental exposure of personnel to laser radiation. This *safety interlock* must be activated only in emergency situations, unlike the SLCH which switches the laser off during normal SAM operation. Presently, however, both are implemented as a single common system with different signals mixed together in the hard-wired logic (Fig. 4). The interlock circuit is located in the laser electronic box. All buttons are connected in series and, when one is activated, close both the laser internal shutter and the safety shutter inside the laser box. The state of the individual switches is read by the ADAM telemetry module and displayed in the right part of the LGS SW GUI. The SLCH signal (TTL level) is wired to the same board. Once the interlock condition is triggered by either a stop button or the SLCH, it remains active until the *Reset* signal is received by the interlock circuit.

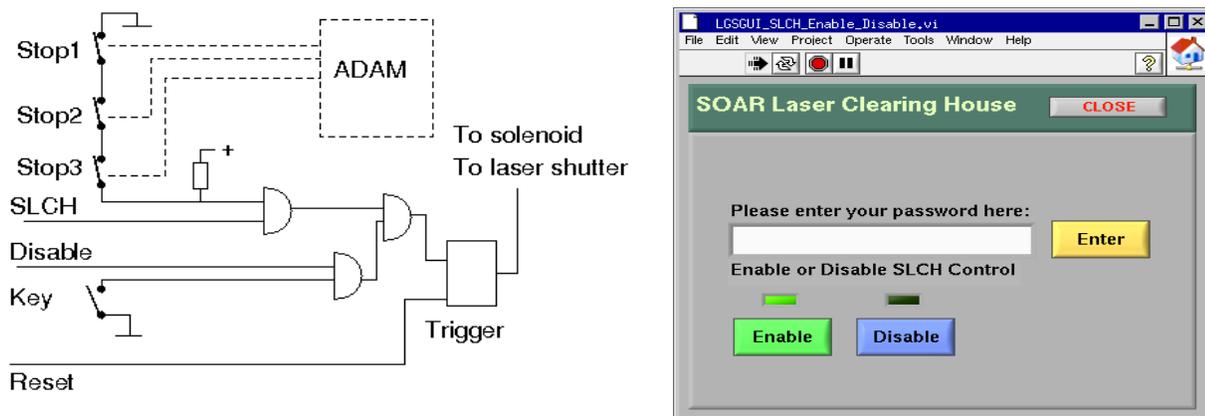


Fig. 4. Simplified logical diagram of the laser interlock system (left) and the SLCH Enable/Disable window (right).

Disabling either interlocks or SLCH is needed for technical work with the laser. While the former is done by the physical key on the laser box (its state is indicated in the upper-left part of the GUI, *Key Interlock State*), the latter is a software action which sends a TTL signal to the interlock board through an ADAM module. The two Enable/Disable signals from the key and the ADAM are mixed and act in the same way, so turning the key or disabling the SCLH produces the same effect. To disable the SLCH, select the *Engineering* mode in the GUI. A button *DISABLE* appears in the lower-right corner. After pressing it, a new window opens (Fig. 4). In this window, type the password [], press *Enter*. Now you can disable the SLCH by the button *Disable*. Then press the button *Reset* on the main GUI (in the laser tab, called *Interlock system*). While the technical work is done, the window *LGSGUI_SLCH_Enable_Disable.vi* can stay open, so we can *Enable* and *Reset* the interlock to return to the normal operation. In the future, the interlock will be automatically enabled when changing to the Observation mode. It is also planned to modify the SCLH and interlock logic.

3.5 Communications

This is a technical tab for monitoring communication with other software. Select the number of server/client in the upper-left panel *Servers and Clients* (the numbering starts at zero) to see the IPs and to examine the connection status in the lower-left panel *Who is connected*. The right panel displays current messages and answers. The button *Release* in the lower-right part should disconnect and reconnect the selected link (either SLCH or ICSofT), but this functionality is not implemented.

3.6 Miscellaneous

This tab is used to change the polling frequency of the status of mechanisms, telemetry and laser (normally the

polling is done every 30s), or to disable the polling (buttons *ON/OFF*). The LGS SW is informed of the status of each mechanism either during its controlled motion (by the “state machine”) or by polling. The buttons *Application Release/bind*, *Send* and *Run* do not work at present. The option for sending commands to mechanisms (button *Send*) is useful only for debugging.

3.7 Telemetry

This tab (Fig. 5) displays the telemetry data: voltages of various power supplies (in V) and temperature of the LLT mirror (in deg. C). It also has ON/OFF buttons for switching the power to the Prosilica camera in the LLT ATP (do not confuse with another Prosilica in the SAM WFS) and to power the red laser diode in the ATP. The voltages of those power supplies are displayed, as well as the voltage of the power supply to the LLT piezo drivers. The two buttons *Read* serve for refreshing the telemetry data on the mechanisms and the laser.

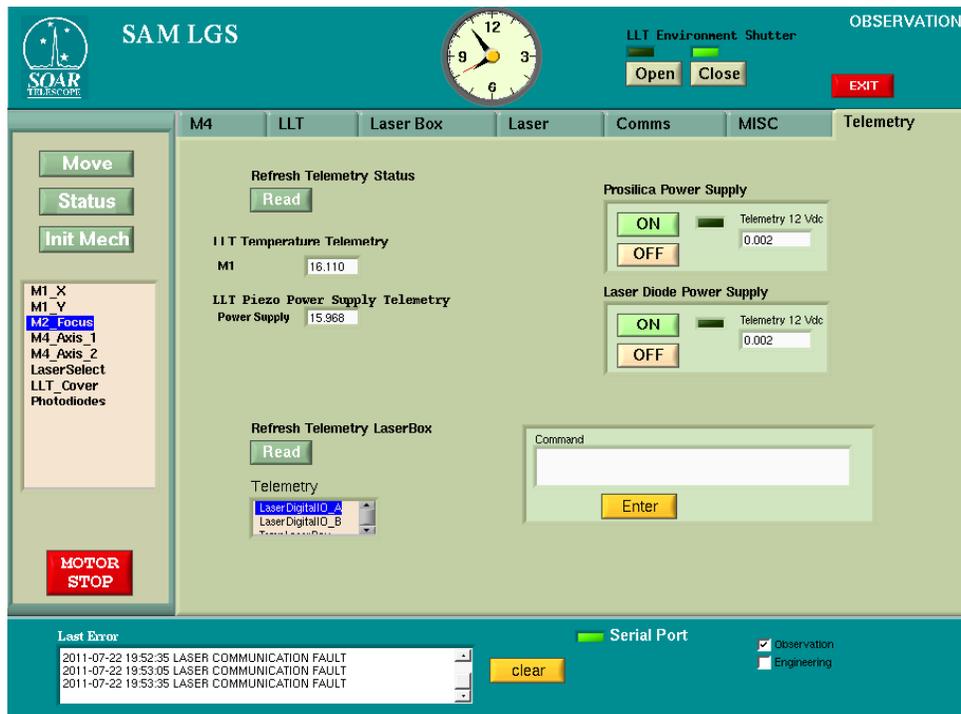


Fig. 5. LGS GUI with the Telemetry tab opened.

4. Configuration files

The configuration files used by LGS SW are located in the `/user/slgm/config/*/` directories which are `LGSMODE`, `LGSPARAMETERS`, `LGSSTATUS`, `SAMLGS`. The list of configuration files follows.

1. `LGSMODE/LGS_ModeConfiguration_Default.cfg` defines the default mode of the LGS SW (engineering).
2. `LGSPARAMETERS/LGS_Mechanism_Default.cfg` lists mechanisms in the left-hand menu of the GUI.
3. `LGSPARAMETERS/LGS_MechanismList_Default.cfg` lists the list of mechanisms for polling status.
4. `LGSPARAMETERS/LGS_Mechanism_Parameters_Default.cfg` is the main configuration file containing parameters of each mechanism (see below).
5. `LGSPARAMETERS/LGS_Mechanism_Sim_Parameters_Default.cfg` and `LGS_Simulated_Mechanism_Default.cfg` list the parameters of simulated mechanisms and the mechanisms that can be simulated, respectively.

6. LGSSTATUS/LGS_Full_Status.cfg is the list of parameters for polling (both mechanisms and laser)
7. LGSSTATUS/LGS_LaserPollingParameters_Default.cfg lists all laser parameters read from its power supply
8. LGSSTATUS/LGS_MechanismStatus_Default.cfg is the list of mechanism status parameters
9. LGSSTATUS/LGS_TelemetryStatus_Default.cfg lists the telemetry parameters
10. SAMLGS/ENV_Default.cfg defines the structure of the LGS SW by listing its main components (devices, servers, etc.). Do not change!
11. SAMLGS/ENV_SCLN_Default.cfg lists the IP numbers and ports of software modules communicating with the LGS SW. The communication with the TCS is defined, but not used. The communication with the SLCH and ICSoft (called AO here) is vital.

The configuration files are read at the start of the LGS SW. However, the parameters can be updated “on-the-fly”, if needed. If the file SAMLGS/LGS_Mechanism_Parameters_Default.cfg is modified while the LGS SW is running, the new values can be read by going offline and then initializing. The corresponding buttons are located in the *Env_Main.vi* window that is not used normally. Changes to other configuration files become effective only after stopping and re-starting the LGS SW.

The main configuration file LGS_Mechanism_Parameters_Default.cfg is structured in sections. Each section has a header in square brackets and contains lines “parameter=value”. Comments are not allowed (for now). The order of parameters does not matter, only their names. For example, here is the section describing the LLT M1 X-motion (in fact the M1a motor, see above), where the meaning of each parameter is explained after the # sign.

```
[M1_X]
id=4      # identification of the controller on the RS-485 bus, decimal or hex depending on the controller
port=4    # PC port corresponding to the RS-485 line to the controller
retries=3 # allowed number of re-tries to establish the communication.
enable=1      # set to zero to disable the mechanism
u-limit=1.0  # maximum position, mm
l-limit=-1.0 # minimum position, mm
offset=4.710 # distance in mm from the reference to the zero position
commanded_position=0.001 # position where reference (fiducial) is found
fiducialposition=10.001 # position of the reference sensor, mm
centerposition=0.0      # position after executing the Init command
offsetinit=0           # not used
acceleration=0.9155    # acceleration, mm/sec2
initvelocity=0.9       # velocity setting after initialization
velocity=1.0           # motion velocity
fiducialvelocity=0.14  # velocity to approach reference sensor
fiducialoff=2.0        # not used
simulator=0           # set to 1 to use software-simulated mechanism
park=0.0              # park position, not used here
timeout=100.0         # timeout [s] to execute motion
tolerance=0.002       # tolerance in mm to reach commanded position before reporting DONE
backlash=0.008        # backlash value, mm
init_timeout=100.0    # timeout to initialize, in seconds
maxinit=20.0          # maximum travel allowed when initializing
polarity=HIGH         # state of the reference switch to detect at initialization
force_init=no         # set to FORCE to repeat initialization of mechanism even if already initialized
screw=0.4             # screw pitch, mm/turn
encoder=2048          # encoder steps per revolution
gear=28.4444         # gear ratio from encoder to screw
```

Few comments on these parameters are in order. The number of encoder steps N for a given displacement D (in mm) is calculated as $N = (G * E) * D / P$, where P is the screw pitch, E is the encoder steps/rev., and G is the gear ratio. The motors have some backlash. To eliminate it, the commanded position is always approached from one side (increasing). When we want a smaller (decreasing) position, the motor “overshoots” and then returns back.

Different types of hardware have different configuration parameters. In the case of IN/OUT motion, the *in* and *out* positions (in mm) are given. The ADAM modules for analog input or TTL input/output have specific parameters, such as

```
Adam4019=50 # type of the module (analog input) and its decimal identification
scale=11.174 1.0 1.593 11.135 1.0 11.161 1.0 1.0 # conversion of numbers to volts for each input channel
Adam4050=40 # digital I/O ADAM module
SetDigitalOutputs=0 # no output
InputPolarity=1 1 0 0 0 0 # logical inversion of some input signals
LaserDiode=0 # channel for laser diode power supply
Prosilica=1 # channel for Prosilica power supply
```

A qualified user may need to change some parameters, for example upper and lower limits, enable/disable mechanism, etc.

6. Errors

List of error/alarm messages:

1. Timeout error when the initialization or motion is not finished in allocated time
2. “rejected on state active” when a new command arrives while the device is still active
3. Communication error (fatal for mechanisms, not fatal for the laser)
4. Motor not initialized
5. Outside range
6. Interlock engaged?

If the LGS GUI becomes unresponsive (“frozen”), the program has to be killed manually. In a terminal, issue the command `ps -ax | grep labview` to see the process number (PID) and then kill each process with the command `kill -9 PID`.

7. Logging

The LGS SW logs commands and errors. The log-files are located in `/user/slqm/logs/SAMLGS/**`, where the sub-directories are: `LASER`, `LASERBOX`, `LLT`, `LLTCOVER`, `M4`, `TELEMETRY`.

Each directory contains 10 log-files for corresponding mechanisms, the files are named after date, such as `LLT_20110712_13h44m06s.log`. The files are “rotated”: the oldest one is deleted so that only 10 latest logs are kept. The contents of such log-file looks like:

```
2011-07-14 01:37:06 : LLT COMMAND - MOVE MIXY 0.136993 0.035013
2011-07-14 01:37:16 : LLT COMMAND - MOVE MIXY 0.162493 0.078013
2011-07-14 01:37:18 : LLT ALARM - M1_X DATA OUT OF RANGE
2011-07-14 01:37:29 : LLT COMMAND - MOVE MIXY 0.102807 0.000687
```

The errors are logged with the words “ERROR” or “ALARM” instead of “COMMAND”.

References

1. *The SOAR Communication Library New* (manual, author and year unknown)
2. [AOM SW description](#) (Tokovinin & Martinez, 2011)

3. *Motion Control: LSES motor control board communication protocol.* M. Martinez, Jun 25, 2008