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Gemini Observation Sequencer

The Sequence Executor

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sequencer.fm Version: 1.1

The Sequence Executor executes sequences of observations, coordinating the telescope, instrument and calibration unit and sending FITS headers information obtained from the telescope and the calibration unit to the DHS.

1.0 Introduction

The Sequence Executor is an ocswish program that runs on a Sun workstation and controls the TCS, GCAL, the DHS and an instrument in order to execute a sequence of observations generated by the Observing Tool. The observation description exported by the observing tool is in a format that conforms to the XML standard which can, if necessary, be edited with a text editor or even created from scratch.

The sequence description includes, for each step in the sequence, the configuration of the instrument (filters, masks, exposure times, etc.), the type of the observation (object, flat, dark, etc.), the configuration of GCAL (filters and lamps) and a telescope offset and which wave-front sensors should be used for guiding and M1 active optics correction. For each step the sequencer configures the instrument and GCAL, positions the telescope (disabling and then re-enabling guiding if necessary), positions the science fold mirror and starts the exposure. At the start and end of each exposure FITS header values are collected from the TCS and GCAL and sent to the DHS to be stored with the data from the instrument.

The sequencer user interface allows sequences to be run automatically from start to finished or executed one step at a time and a running sequence can paused and then continued. The TCS, instrument and GCAL can be configured for a selected step and the exposure for a selected step started. An exposure can be paused, continued or aborted provided that the instrument supports the necessary commands.

The sequencer can be run with one or more of the TCS, GCAL, the DHS and instrument simulated so that it can be used for engineering activities without all the systems having to be available.

The instruments currently supported are GMOS, NIRI and the acquisition camera.

1.1 Intended audience

This document is aimed at

- Support Scientists and Science Staff Associates.
- Software Support Staff.

1.2 Scope

This document describes how to use the sequence executor, how it interprets sequence descriptions and what this translates to in terms of controlling the telescope and instruments. It also contains information of interest to programmers adding support for additional instruments or making other modifications.

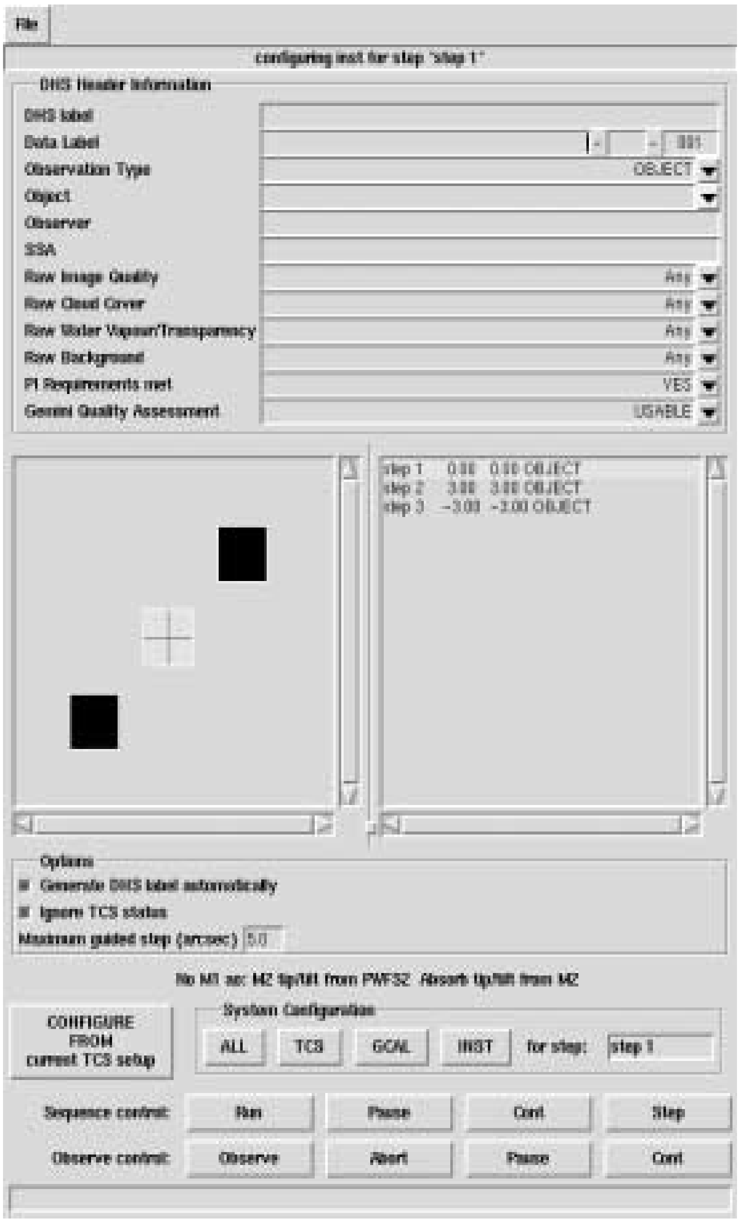
1.3 Definitions, Acronyms and Abbreviations

A&G	Acquisition & Guidance Unit
DHS	Data Handling System
GCAL	Gemini Calibration Unit
GMOS	Gemini Multi-Object Spectrograph
EPICS	Experimental Physics and Industrial Control System
FITS	Flexible Image Transport System
ISS	Instrument Support Structure
ocswish	A Tcl/Tk interpreter with additional commands for controlling and communicating with EPICS and the DHS.
NIRI	Near-Infra-Red Imager
OIWFS	On-Instrument Wave-Front Sensor
OT	Observing Tool
PWFS	Peripheral Wave-Front Sensor
XML	Extended Markup Language.
Tcl	Tool command language
TCS	Telescope Control System

1.4 History

V1.0 - initial version

2.0 User Interface



configuring inst for step "step 1"

DHS Header Information

DHS label

Data Label - - 001

Observation Type OBJECT

Object

Observer

SSA

Raw Image Quality Any

Raw Cloud Cover Any

Raw Water Vapour/Transparency Any

Raw Background Any

PI Requirements met YES

Gemini Quality Assessment USABLE

```
step 1    0.00    0.00 OBJECT
step 2    3.00    3.00 OBJECT
step 3   -3.00   -3.00 OBJECT
```

Options

■ Generate DHS label automatically

■ Ignore TCS status

Maximum guided step (arcsec) 5.0

No M1 as: M2 tip/tilt from PWFS2 Absorb tip/tilt from M2

for step: step 1

FIGURE 1. Sequence executor main window

2.1 Interface elements

The user interface consists of a single control panel illustrated by Figure 1 with the following elements (from top to bottom):

- A **File** menu with the following commands:

Load Sequence	Displays an “open-file” dialog box for selecting a sequence file to be loaded into the sequencer
View Sequence	Displays the XML source of the currently loaded sequence in a top-level window. This window can be closed with the usual window manager menu.
Exit	Terminates the sequencer program.

- A line of text that describes the current execution state of the sequence (idle, configuring the instrument, paused, etc.)
- A set of data entry fields for setting the values of various FITS header keywords. The first three, *DHS label*, *Data label* and *Observation Type*, have special meanings and behaviour as described in section 2.3; the remainder simply set the value of the corresponding FITS keyword in the data header. Some of the fields have drop-down lists of pre-defined values but additional values can by typed into the field and will be added to the list.
- A diagram that illustrates the telescope offsets for each step in the sequence. As the sequence is executed, the currently executing step is coloured yellow and then turns grey when it has finished.
- A list of all the steps in the sequence with the name of the step, the telescope offsets, the type of the observation and a brief description of the configuration of the instrument.

The amount of screen space allocated to the diagram and the list can be changed by resizing the entire application window by dragging on its border or by dragging on the border between the two widgets to allocate more space to the list and less to the diagram or *vice-versa*.

- A check boxes for setting the following options:
  - Turning on and off the automatic generation of DHS labels. If automatic generation is turned off it is not possible to run sequences automatically because the same data label would then be used for each observation.
  - Ignoring the TCS *in-position* status. The sequencer normally waits for the TCS to signal that all its sub-systems are in their demanded positions before re-enabling guiding and starting an exposure. Selecting this option allows engineering exposures to be started without having to wait for the telescope to be ready.
- A field for setting the largest offset that the telescope will make without guiding first being disabled.

These settings can be changed at any time and will apply as soon as the sequencer executes the next operation.

- A line of text that describes the guiding and active optics configuration that the sequencer will use at each step, subject to the necessary wave-front sensors being deployed.
- A button labeled *CONFIGURE FROM current TCS setup* that updates the current guiding and active optics configuration from the current state of the TCS.

- A row of button in a frame labeled *System Configuration:* that configure the tcs, instrument and GCAL ready for taking the exposure for the step specified in the adjacent entry field, either all simultaneously or individually. If a step in the list of steps is clicked, the name of the step is automatically entered in the step name field.
- A row of buttons for controlling the execution of the sequence. The buttons are:

Run	Runs the entire sequence from the beginning.
Pause	Pauses the sequence either before the next exposure or before the next telescope and instrument re-configuration, whichever comes next.
Step	Executes the next operation in a paused sequence and then pauses again.
Continue	Continues the execution of a paused sequence and continues to the end of the sequence.

If an error or timeout occurs during the execution of a sequence a dialog box containing an error message (typically a message generated by the tcs, instrument or GCAL) is displayed and the sequence goes into the paused state. To continue executing the sequence you must dismiss the error dialog (by clicking on the *OK* button) and then press the *Continue* button.

- A row of buttons for controlling exposures.

Observe	Takes an exposure without moving the telescope or re-configuring the instrument or GCAL.
Pause	Pauses the current exposure. This function may not be supported by all instruments.
Continue	Continues a paused observation.
Abort	Aborts the current exposure. This will also cause the sequence to be paused.

- A line of text that describes the function of a button or other control when the mount pointer is over the control.

2.2 Command line options

The sequencer recognizes the following command line options in addition the usual options recognised by all Tk interpreters:

-simtcs	Simulate the connection to the TCS. With this option specified the FITS headers values normally collected from the TCS will be set to <undefined>.
-siminst	Simulate the connection to the instrument. Useful for testing the sequencer when no instrument is available.
-simdhs	Simulate the connection to the DHS. If this is option is specified when working with a real instrument it necessary to uncheck the automatic generation of DHS label option and specify the labels manually.

-simgcal Simulate the connection to GCAL.

-tracetcs Print a trace of all commands being sent to the TCS in the terminal window used to start the sequencer.

-tracedhs Trace the commands sent to the DHS.

-tracegcal Trace the commands sent to GCAL.

-tracegmos Trace the commands sent to GMOS.

-traceniri Trace the commands sent to NIRI.

-traceac Trace the commands sent to the acquisition camera.

2.3 Special DHS headers

Some of the DHS header items that can be set by the user have special behaviour.

1. The DHS label for each exposure is normally generated automatically by the DHS and displayed in this field. If the *Generate DHS automatically* option is unchecked, the label can be entered manually but must be changed for each exposure so automatic execution of sequences in no longer possible.
2. The last field in the *Data Label* is a sequence number which is incremented by the sequencer after each exposure. When a new sequence is loaded it is reset to 001. The sequence number can be set to any integer value by typing into this field.
3. The *observation type* is normally set by the sequencer from information in the sequence as each step is configured but can be overridden by typing into this field. However, this only changes the value of the OBSTYPE keyword in the fits header; it does not change the way CGAL, the instrument and the science fold mirror are configured.
4. The SSA field is initialised from the value of the environment variable SSA.
5. The Observer field is initialised from the value of the environment variable OBSERVER.

3.0 Sequence Interpretation

When a sequence file is loaded it has to be converted into a description of the configuration of the instrument, the telescope and the calibration unit for each step in the sequence. To do this, the sequencer must first determine what the observation type is for the step; it does this by searching for the *observeType* keyword in the *observe* element of the step (if there is one). If the keyword has not been found it then searches through the previous steps in the sequence in reverse order. If, after reaching the first step, an *observeType* has still not been found then, for the purposes of configuring the telescope and the calibration unit, it is assumed to be “OBJECT”.

This strategy of first searching the current step and then the preceding steps from the current step to the beginning of the sequence for a keyword value is used for all keywords.

3.1 Telescope configuration

The configuration of the telescope at each step is determined by the *observeType* and the following keywords:

p & q — These are the telescope offsets (in arcsec) relative to the instrument principle direction as specified by the instrument alignment angle set in the TCS. They are converted into x & y instrument offsets in the focal plane coordinates system that rotates with the Cassegrain rotator.

guideWithPWFS1 — Specifies whether the PWFS1 probe arm should be parked (*park*), left in follow mode but not tracking a guide star (*freeze*) or tracking a star (*any other value)*[1].

guideWithPWFS2 — The same as *guideWithPWFS2* but for PWFS2.

guideWithOIWFS — The same as *guideWithOIWFS* but for the on-instrument wave-front sensor.

The *posAngle* keyword currently ignored.

Whether or not tip/tilt guiding and M1 active optics is turned on depends on both which wave-front sensors are tracking a guidestar and the starting configuration of the TCS. The starting configuration is read from the TCS by pressing the button labeled *CONFIGURE FROM current TCS setup*.

The science fold mirror is controlled by the *observeType* for the step; if it is “OBJECT” or “SKY” it is positioned so that light from the sky reaches the instrument, if it is “FLAT” or “ARC” it is positioned so that light from the calibration unit reaches the instrument. If it has any other value, or is not specified at all, it will not be moved when the step is executed.

3.2 Instrument configuration.

When determining the configuration of an instrument there is an additional complication when searching for the exposure time and number of coadds[2]; if the observe type is “ARC”, “BIAS”, “DARK” or “FLAT” then the appearance of either of these keywords in a *calibration* element overrides the values in the *observe* or *instrument* elements except that any definition in the current step takes precedence over a definition in preceding step.

3.2.1 Acquisition Camera

The acquisition camera configuration is controlled by the following keywords:

ndfilter — The name of the neutral density filter.

clfilter — The name of the colour filter.

[1] In the future the values of the *guideWith* keywords will also select a guide star from a list of star positions included in the sequence definition and load the guide-star position into the TCS.

[2] The only instrument that supports the *coadds* keyword at present is NIRI.

windowing	Whether windowing is on or off.
binning	Whether binning is on or off.
overscan	The size of the overscan region.
x & y	The centre of the windowing region (ignored if windowing is off).
width & height	The width and height of the windowing region (ignored if windowing is off).
exposureTime	The exposure time in seconds.

The observe type has no effect on the configuration of the acquisition camera.

3.2.2 GMOS

exposureTime	
ampReadMode	
gainChoice	
ampCount	
gainSetting	
ccdXBinning	
ccdYBinning	
builtinROI	
observeType	OBJECT, FLAT or ARC will force shutterState to OPEN; BIAS will force shutterState CLOSED and the exposureTime to 1
filter	
disperser	
disperserOrder	
disperserLambda	
fpuMode	
fpu	
fpuCustomMask	
stageMode	
adc	

3.2.3 NIRI

builtinROI

camera

beamSplitter

mask	
filter	
disperser	
readMode	
exposureTime	
coadds	
observeType	DARK will automatically set the filter to "blank".

3.3 Calibration Unit configuration

If the observe type is “OBJECT” or “SKY” all the calibration unit lamps are turned off. If it is “ARC” or “FLAT” the configuration is controlled by the following *calibration* element parameters:

lamp	The name of the lamp that should be switched on.
filter	The name of the neutral density filter.
diffuser	The name of the diffuser, either *IR* or *visible*.
shutter	The state of the IR lamp shutter, either *open* or *closed*.

4.0 Sequence Execution

The execution of a step in a sequence happens in two phases; first the instrument, telescope and calibration unit are configured and then, when all the systems indicate that they are ready, the exposure is started. FITS header information is collected from the TCS and its subsystems and the calibration unit as the exposure starts and when it finishes.

Configuring the calibration unit and, usually, the instrument, is straight-forward but configuring the telescope is often not. This is because offsetting the telescope by more than a few arcseconds requires that guiding is turned off[1] while the move is executed and the configuration of tip/tilt guiding and M1 active optics correction after the move also depends on which guide probes are tracking guide stars.

After each move of the telescope the sequencer attempts to configure the guiding and ao correction to match the state read from the TCS when the *Configure from TCS* button was pressed taking in to consideration which wave-front sensors are tracking a guide star as a result of the *guideWith* parameter settings for the step. It will also not enable guiding with the on-instrument wave-front sensor if the science fold mirror is blocking the instrument’s view of the sky.

[1] A brief test carried out in November 2001 indicates that in calm conditions and with a reasonably bright guide star it is possible to move the telescope up to 12 arcsec while continuing to guide with PWFS1 and up to 16 arcsec when guiding with PWFS2.

5.0 FITS keywords

The following fits header values are sent to the DHS at the start of an exposure with values copied from the corresponding fields in the user interface:

OBJECT	Object name
GEMPRGID	*Gemini program id*
DATALAB	*Gemini program id - observation id*
obsid	*Gemini program id - observation id - data label*
OBSTYPE	Observation type
OBSERVER	Observer’s name
SSA	SSA’s name
RAWIQ	Raw image quality
RAWCC	Raw cloud cover
RAWBG	Raw background
RAWWV	Raw water vapor
RAWPIREQ	Raw PI requirements met
RAWGEMQA.	Raw Gemini quality assessment

The following fits header values are sent to the DHS at the start of an exposure with values copied from the TCS:

OBSERVAT	The observatory name; either *Gemini-North* or *Gemini-South.*
telescope	The telescope name; either *Gemini-North* or *Gemini-South.*
UT	The current time in UTC.
DATE	The current date formatted as *yyyy-mm-dd.*
ST	The local sidereal time.
HA	The current hour angle of the target.
LT	The local time.
RA	The right ascension of the target. This is the target position that the telescope was slewed to to acquire the target. It does not reflect any target offsets even if they have been absorbed into the base target position.
DEC	The declination of the target.
FRAME	The coordinate frame of the target position; *FK5, FK4, APPT* or *AZEL_TOPO.*
EQUINOX	The equinox of the frame (if the frame is *FK4* or *FK5).*
EPOCH	The epoch of the target position.

PMRA The proper motion in right ascension of the target in seconds of time per year.

PMDEC The proper motion in declination of the target in arcsec per year.

PARALLAX The parallax of the target in arcsec.

RADVEL The radial velocity of the target in km/s.

DECTTRACK The differential tracking rate in declination in arcsec/sec.

RATTRACK The differential tracking rate in right ascension in arcsec/sec.

TRKFRAME The coordinate frame of the differential rates; *FK5, FK4, APPT* or *AZEL_TOPO.*

TRKEQUIN The equinox of the frame of the differential rates (if the frame is *FK4* or *FK5).*

TRKEPOCH The epoch of the coordinate frame of the differential rates.

WAVLENG The effective wavelength of the observation in Angstrom.

ELEVATIO The mechanical elevation of the telescope in degrees.

AZIMUTH The mechanical azimuth of the telescope in degrees.

CRPA The mechanical position angle of the Cassegrain rotator in degrees.

CGUIDMOD The carousel tracking mode; *Basic*, *Minimum Vibration* or *Minimum Scatter.*

If the on-instrument wave-front sensor is active then the following keywords are added:

OIARA The right ascension of the guide star. This is the position that was used to acquire the star. It does not reflect any target offsets even if they have been absorbed into the base target position.

OIADEC The declination of the guide star.

OIAFRAME The coordinate frame of the guide star position; *FK5, FK4, APPT* or *AZEL_TOPO.*

OIAEQUIN The equinox of the frame (if the frame is *FK4* or *FK5).*

OIAEPOCH The epoch of the guide star position.

OIAPMRA The proper motion in right ascension of the guide star in seconds of time per year.

OIAPMDEC The proper motion in declination of the guide star in arcsec per year.

OIAPARAL The parallax of the guide star in arcsec.

OIARV The radial velocity of the guide in km/s.

OIAWAVL The effective wavelength of the guiding in Angstrom.

Similar keywords are written for the two peripheral wave-front sensors with OIA replaced by P1A or P2A.

The following keywords are written with values copied from the Secondary Control System:

M2BAFFLE	The position of the M2 baffles.
M2CENBAF	The position of the M2 central hole cover.

The following keywords are written with values copied from the Acquisition and Guidance Unit Control System:

SFRT2	The rotation angle of the science fold mirror.
SFTILT	The tilt of the science fold mirror in degrees.
SFLINEAR	The linear position of the science fold mirror.

The following keywords are written with values copied from GCAL.

GCALLAMP	The name of the GCAL lamp currently on.
GCALFILT	The name of the currently deployed GCAL filter.
GCALDIFF	The name of the currently deployed GCAL diffuser.
GCALSHUT	The state of the IR lamp shutter.

6.0 Program Internals

6.1 Installation

The sequence executor is written entirely in tcl so installation is simply a matter of installing the source files and building the tcl index file in the *lib* subdirectory. There is a make file in the application main directory that builds the index.

6.2 Dependencies.

The sequence executor requires that the following software is also installed:

- ocswish.
- The seq ocs support package.
- The dhshdr ocs support package.
- The acqcam ocs support package for acquisition camera sequences.
- The gmos ocs support package for GMOS sequences.
- The niri ocs support package for NIRI sequences.

The instrument specific packages are only loaded when a sequence using an instrument is loaded so do not have to be present for instruments that are not going to be used.

6.3 Program structure

The sequence executor executable *seqexec* is the usual hybrid bourne shell /tcl script which decodes command lines, loads tcl packages, creates the ocswish epics service and then creates and maps the *SeqExec* widget that forms the main window of the GUI. The simulation and trace settings set by the command line options are stored in the global array **Flags**.

The *SeqExec* widget contains a *HeaderInfo* that contains elements for setting various FITS header values; these are linked to global variables in the *dhshdr* package namespace as is the “Generate DHS label automatically” checkbox in the *SeqExec* widget. The other option setting and status display widgets are linked to class common variables in the *Sequence* and *RealTcs* classes.

When a sequence is loaded a *Sequence* object is created that parses the XML description of the sequence using the procedures in the *seqparse* namespace and converts it into a tree of objects that mirrors the structure of the XML. These objects have parameters that contain the names and values of the entities in the XML but no methods; they just provide a description of the sequence that is easy to navigate and interrogate from tcl. When the construction of the *Sequence* object is complete they are discarded. A *Step* object is then created for each step in the sequence; these *Step* objects contain references to objects that represent the configuration of, and control, the TCS, GCAL, the instrument and the DHS. Finally, these objects are configured with the values of the parameter elements found in the sequence description.

If simulation of a subsystem has been selected with a command line option, the *Step* will contain a reference to a dummy object has the same interface as the genuine subsystem object but prints messages to *stdout* instead of sending commands to the real subsystem.

The command buttons on the user interface are linked to methods of the *Sequence* object. The *Sequence* object keeps track of which step in the sequence is currently being executed and calls methods of the appropriate *Step* object to implement the commands. The *Step* objects contain the logic necessary for sequencing and coordinating moving the telescope and science fold, configuring the instrument, copying FITS header values from the TCS to the DHS and taking exposures.

6.4 Implementing a new instrument.

To support a new instrument you must:

- Implement a new instrument specific class that handles interpretation of instrument specific sequence parameters and handles all communications with the instrument.
- Add the new branch to a switch statement in *Sequence.itcl* that creates an instance of this object for each step in a sequence.
- If the instrument requires any instrument specific FITS headers to be generated by the sequencer, add an instrument specific *HdrInfo* class to the dhshdr ocs support package.
- Create a file containing definitions of all the instrument command senders and status acceptors in the *ca_config* subdirectory and add a statement to *seqexec.ca* to include it.

- If the code for the new instrument supports a trace and/or debug mode, add the appropriate options to the command line options defined in *seqexec*.

The instrument specific class must implement the following public methods:

abort Sends an abort command to the instrument.

continue Sends a continue command to the instrument.

description Returns a description of the instrument configuration suitable for display in the list of steps. This should contain whatever information is likely to help the observer identify each step without being overly long.

endobserve Sends an endObserve command to the instrument.

setup {whendone} Configures the instrument according to the parameters defined by the step and arranges that the command specified in **whendone** is called when the instrument is ready.

observe {label whendone}
Sends an observe command to the instrument with **label** as the dhs label and arranges that the command specified in **whendone** is called when the exposure has finished.

pause Sends a pause command to the instrument.

All these methods return the value 1 if the succeed and 0 if they don't. If they return zero they must also append an error message to the variable **::Sequence::errormsg** (with **lappend**).

The procedure that is executed when the instrument setup or exposure has finished must be called with a argument that is 1 if the operation completed successfully or 0 if it did not. If the latter, an error message must be appended to **::Sequence::errormsg**.

And set the values of the following public variables in its constructor:

agname The instrument name as defined in the EPICS records in the A&G sequencer that indicate what instrument is located on each ISS port.

sfname The instrument part of the science fold mirror positions that are defined in the A&G lookup tables.

The value of **sfname** will usually be same for all steps but may sometimes be different depending on the instrument configuration if different science fold positions are defined for different configurations.

instobj The name of an object that has public variables with names that match the instrument parameters that appear in the sequence files. These variables must include **observeType.**

Because the object referred to by **instobj** is accessed outside the object that created it, the name must be fully qualified with its namespace as in:

```
set instobj [namespace current]::[Acqcam::Acqcam #auto]
```

The instrument specific class can inherit *GenericInst* which provides generic implementations of all the method except *observe* and *setup*.