KOSMOS ICD 5.1 Instrument Controller to Telescope System

P. N. Daly

National Optical Astronomy Observatories, 950 N. Cherry Avenue, P. O. Box 26732, Tucson AZ 85726–6732, USA
pnd@noao.edu

Abstract. This document describes the interface between the instrument controller and the telescope control system. Primarily, this identifies the various levels of interaction between the GWC-based TCS and NOCS software.

Contents

1. Document Revision History 2
2. Purpose And Scope Of Document 2
3. WBS Element(s) and NOAO Account Code(s) 2
4. System Architecture 2
   4.1. Message Sequence Chart 4
   4.2. Hardware Configuration 5
5. Interface Description 5
   5.1. Internal Command(s) 5
       init 5
       help 5
       test 5
   5.2. TCS Command(s) 5
       focus 5
       instname 5
       moveto 5
       offset 5
   5.3. The GWC Interface 7
   5.4. Example(s) 7
       testntcs 7
A. Telescope Control System GWC Interface 8
1. Document Revision History

6 July 2010: original version, (pnd@noao.edu).

2. Purpose And Scope Of Document

This document identifies the interface between the instrument controller and the telescope control system. It is intended for software and/or hardware engineers on either side of this divide to clearly identify their rôle within the overall system architecture and to implement any sub-system to achieve the desired objective.

This document is under (manual) revision control. All corrections, additions or comments should be addressed to the principal author.

3. WBS Element(s) and NOAO Account Code(s)

KOSMOS WBS v1.9[1] shows this interface to be described by element D.N.9.6 (Telescope Interface) described therein as “design and coding of software to interface to the telescope control system”. The appropriate NOAO account code is N-MR210-D96.

4. System Architecture

The original implementation of the NOCS[1] is described elsewhere[2]. The KOSMOS implementation of this architecture is shown in the cartoon of Figure 1 on page 3. The main elements of the NOCS are:

NGUI defines the observation scripting engine and is the only interface into the system. The motivating document behind NGUI is the Operating Concepts Definition Document[3].

NICS (NOCS Instrument Control System) defines the interface to the instrument, specifically the hardware elements. The motivating documents behind NICS are ICD 3.1[7] and ICD 3.1[8].

NSML (NOCS Monsoon Supervisor Layer) defines the interface to the detector system. The motivating document behind NSML is ICD 4.1 and describes the detailed interface of an implementation of the generic pixel server dictionary[4].

NTCS (NOCS Telescope Control System) defines the interface to the telescope control system. The motivating document behind NTCS is the ICD 5.1[6] (this document).

NOHS (NOCS Observation Header System) defines the interface to the environmental and observational meta-data which is published to the DHS. The motivating document behind NOHS is the ICD 6.1[5].

The guiding principles behind the NOCS design are (were):

- Simplicity. The amount of coding required is the minimum necessary to achieve the science objective;
- Modularity. Only those parts of the system required at any specific instance need be started;

---

[1]This section is common to several ICDs so that each ICD can be read as a standalone document.
Figure 1.: KOSMOS Implementation of the NOCS Architecture
- **Supportability.** The system is written primarily in Tcl/tk which is widely used at the Mayall 4m;

- **Separability.** The system has clearly defined interfaces;

- **Repeatability.** Any script should be re-usable;

- **Consistency.** The science scripts ensure data is taken in a consistent manner with the minimum of human intervention and present ‘well known’ data products form ingestion downstream of the acquisition (e.g., data analysis pipelines and/or data archives).

Further, various levels of simulation exist within the system so that laboratory testing can proceed without external hardware (or software) being present.

### 4.1. Message Sequence Chart

The fundamental unit of the **NOAO Observation Control System** is, by definition, the observation. This unit is mapped to the message sequence chart of Figure 2 on page 4. In short, it is the job of NGUI to re-produce a science-oriented recipe as an executable script and, essentially, create a series of linked observations to achieve the given science objective. Although the GUIs are written in Tcl/tk, the underlying re-scheduling mechanism is DRAMA\(^9\). Thus, a script is a series

![Figure 2.: NOCS Message Sequence Chart](image-url)
of \textit{ditscmd} directives to the other tasks in the system. The GUIs do the work ‘behind the scenes’ and return a simple SUCCESS or FAILURE status on completion of the action. If successful, the script continues. If not, the script aborts with an indication as to where in the script is failed and the task executing at that moment.

It should be heuristically obvious from the above, that the NOCS employs a demarcation paradigm inasmuch as NGUI will create a script but will \textit{not} run it. Executing a script is a manual operation and clearly separates the creation of the script from its execution. A favourable side-effect is that NGUI is \textit{not} required at the telescope and can be delivered to the astronomer prior to his/her observing run for self-paced familiarisation.

4.2. Hardware Configuration

Figure 3 on page 6 shows a typical hardware and network configuration of a NOCS implementation. Specifically, the PAN talks to the DHE (and hence the focal plane array) over an SL100 fiber interface but transfers the data to the primary DHS machine via the private network. Inside the same rack will be a KVM switch (TK-802R) and an Ethernet power controller (ECR2 DLI).

5. Interface Description

The KOSMOS instrument controller to telescope control system interface has enough functionality to bring up the system in a known, safe, state ready to take data. The following commands are currently supported and there are no additions envisaged.

5.1. Internal Command(s)

\texttt{init} \quad This command re-initializes the interface and returns the system interface to a ready state:
\begin{verbatim}
ditscmd ntcs ntcs init
\end{verbatim}

\texttt{help} \quad This command returns simple help text on the functionality contained within the interface:
\begin{verbatim}
ditscmd ntcs ntcs help
\end{verbatim}

\texttt{test} \quad This command performs both the \texttt{init} and \texttt{help} actions to test the underlying communications path:
\begin{verbatim}
ditscmd ntcs ntcs test
\end{verbatim}

5.2. TCS Command(s)

The following set of TCS commands are available. However, such commands are usually ‘hidden’ either behind a GUI-button or within a script and are rarely executed manually.

\texttt{focus} \quad This command sends a focus demand to the TCS:
\begin{verbatim}
ditscmd ntcs ntcs_focus Argument1="value"
\end{verbatim}
\quad where \textit{value} is a secondary focus value in $\mu$m.

\texttt{instname} \quad This command sends an instrument name to the TCS:
\begin{verbatim}
ditscmd ntcs ntcs_instname Argument1="KOSMOS"
\end{verbatim}

\texttt{moveto} \quad This command sends a slew request to the TCS:
\begin{verbatim}
ditscmd ntcs ntcs_moveto Argument1="value"
\end{verbatim}
\quad NB: This command is \textit{disabled} from the NOCS software on safety grounds. However, the value argument can be “RA Dec” co-ordinates or well-known positions such as “dfs” (dome flat screen), zenith or “osun” (point opposite sunset).
Figure 3.: Typical NOCS Hardware and Network Implementation
**offset**  This command sends an offset request to the TCS:

```plaintext
ditscmd ntcs ntcs_offset Argument1="RADec"
```

where RA and Dec are expressed in arcseconds in that order.

### 5.3. The GWC Interface

The NTCS is a GWC-aware[10] client and subscribes to command and telemetry streams to enable the above TCS functionality. The TCS GWC interface is re-produced in appendix A.

### 5.4. Example(s)

**testntcs**  This is a wrapper that allows the end-user to test the system without creating a specific script. The simplest invocation is:

```plaintext
% testntcs
```

which will give a list of instrument-specific options. Some examples are:

```plaintext
% testntcs focus 12000
% testntcs instname KOSMOS
% testntcs offset "45 45"
% testntcs offset "30 30"
```

**Acknowledgments.**  PND thanks Jay Elias and Mark Trueblood for corrections.

### References

5. Daly, P. N., 2010, ICD 6.1, Kosmos Project, NOAO.
6. Daly, P. N., 2010, ICD 5.1, Kosmos Project, NOAO.
7. Daly, P. N., 2010, ICD 3.1, Kosmos Project, NOAO.
8. Pogge, R. et al., 2010, ICD 3.2, Kosmos Project, NOAO.
A Telescope Control System GWC Interface

4-meter TCS

GWC Streams and Commands

2004 April 7

GWC Data Streams

-----------------

<table>
<thead>
<tr>
<th>system</th>
<th>stream</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>kpno_4m</td>
<td>tcs.main</td>
<td>TCS computer status</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.time</td>
<td>TCS time</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.target</td>
<td>TCS target</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.telescope</td>
<td>Telescope status</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.alert</td>
<td>TCS alerts</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.guider</td>
<td>Guider control</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.dome</td>
<td>Dome status</td>
</tr>
<tr>
<td>kpno_4m</td>
<td>tcs.instrument</td>
<td>Instrument status</td>
</tr>
</tbody>
</table>

Data Stream Attributes:

----------------------

<table>
<thead>
<tr>
<th>Attribute</th>
<th>type</th>
<th>number</th>
<th>keyword</th>
<th>units</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>link</td>
<td>string</td>
<td>1</td>
<td>TCSLINK</td>
<td>None</td>
<td>TCP link (up</td>
</tr>
<tr>
<td>host</td>
<td>string</td>
<td>1</td>
<td>TCSHOST</td>
<td>None</td>
<td>Host for tcs4m</td>
</tr>
<tr>
<td>pid</td>
<td>integer</td>
<td>1</td>
<td>TCSPID</td>
<td>None</td>
<td>Process ID for tcs4m</td>
</tr>
<tr>
<td>computer</td>
<td>string</td>
<td>1</td>
<td>TCSCOMPU</td>
<td>None</td>
<td>Name of TCS Computer</td>
</tr>
<tr>
<td>updates</td>
<td>string</td>
<td>1</td>
<td>TCSUPDAT</td>
<td>None</td>
<td>tcs4m polling enable (on</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>type</th>
<th>number</th>
<th>keyword</th>
<th>units</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ut</td>
<td>string</td>
<td>1</td>
<td>UT</td>
<td>HH:MM:SS</td>
<td>Universal Time</td>
</tr>
<tr>
<td>utdate</td>
<td>string</td>
<td>1</td>
<td>UTDATE</td>
<td>MM/DD/YYYY</td>
<td>Universal Date</td>
</tr>
<tr>
<td>st</td>
<td>string</td>
<td>1</td>
<td>ST</td>
<td>HH:MM:SS</td>
<td>Sidereal Time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>type</th>
<th>number</th>
<th>keyword</th>
<th>units</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ra</td>
<td>string</td>
<td>1</td>
<td>RA</td>
<td>HH:MM:SS.SS</td>
<td>Right Ascension</td>
</tr>
<tr>
<td>dec</td>
<td>string</td>
<td>1</td>
<td>DBC</td>
<td>DD:MM:SS.S</td>
<td>Declination</td>
</tr>
<tr>
<td>epoch</td>
<td>string</td>
<td>1</td>
<td>EPOCH</td>
<td>Year</td>
<td>Epoch</td>
</tr>
<tr>
<td>ra_preset</td>
<td>string</td>
<td>1</td>
<td>RAPRE</td>
<td>HH:MM:SS.SS</td>
<td>Right Ascension Preset</td>
</tr>
<tr>
<td>dec_preset</td>
<td>string</td>
<td>1</td>
<td>DECPRE</td>
<td>DD:MM:SS.S</td>
<td>Declination Preset</td>
</tr>
<tr>
<td>epoch_preset</td>
<td>string</td>
<td>1</td>
<td>EPOCHPRE</td>
<td>Year</td>
<td>Epoch Preset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attribute</th>
<th>type</th>
<th>number</th>
<th>keyword</th>
<th>units</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alt</td>
<td>string</td>
<td>1</td>
<td>ALT</td>
<td>HH:MM:SS</td>
<td>Telescope Altitude</td>
</tr>
<tr>
<td>az</td>
<td>string</td>
<td>1</td>
<td>AZ</td>
<td>DD:MM:SS</td>
<td>Telescope Azimuth</td>
</tr>
<tr>
<td>equinox</td>
<td>string</td>
<td>1</td>
<td>EQUINOX</td>
<td>Year</td>
<td>Equinox</td>
</tr>
<tr>
<td>zenithdist</td>
<td>string</td>
<td>1</td>
<td>ZD</td>
<td>Degrees</td>
<td>Zenith Distance</td>
</tr>
<tr>
<td>airmass</td>
<td>string</td>
<td>1</td>
<td>AIRMASS</td>
<td>None</td>
<td>Airmass</td>
</tr>
<tr>
<td>parallactic</td>
<td>string</td>
<td>1</td>
<td>PARALL</td>
<td>None</td>
<td>Parallactic</td>
</tr>
<tr>
<td>ra_offset</td>
<td>string</td>
<td>1</td>
<td>RAOFF</td>
<td>Arcsec</td>
<td>RA Offset</td>
</tr>
<tr>
<td>dec_offset</td>
<td>string</td>
<td>1</td>
<td>DECOFF</td>
<td>Arcsec</td>
<td>Dec Offset</td>
</tr>
<tr>
<td>ra_inst_center</td>
<td>string</td>
<td>1</td>
<td>RAINST</td>
<td>Arcsec</td>
<td>RA Instrument Center</td>
</tr>
<tr>
<td>dec_inst_center</td>
<td>string</td>
<td>1</td>
<td>DECINST</td>
<td>Arcsec</td>
<td>Dec Instrument Center</td>
</tr>
<tr>
<td>ra_zero</td>
<td>string</td>
<td>1</td>
<td>RAZERO</td>
<td>Arcsec</td>
<td>RA Zero</td>
</tr>
<tr>
<td>dec_zero</td>
<td>string</td>
<td>1</td>
<td>DEZERO</td>
<td>Arcsec</td>
<td>Dec Zero</td>
</tr>
<tr>
<td>ra_index</td>
<td>string</td>
<td>1</td>
<td>RAINDEX</td>
<td>Arcsec</td>
<td>RA Index</td>
</tr>
<tr>
<td>dec_index</td>
<td>string</td>
<td>1</td>
<td>DECINDEX</td>
<td>Arcsec</td>
<td>Dec Index</td>
</tr>
<tr>
<td>ra_diff</td>
<td>string</td>
<td>1</td>
<td>RADIFF</td>
<td>Arcsec</td>
<td>RA Diff</td>
</tr>
<tr>
<td>dec_diff</td>
<td>string</td>
<td>1</td>
<td>DECDIFF</td>
<td>Arcsec</td>
<td>Dec Diff</td>
</tr>
<tr>
<td>mode</td>
<td>string</td>
<td>1</td>
<td>TCPMODE</td>
<td>None</td>
<td>Telescope mode</td>
</tr>
<tr>
<td>tracking</td>
<td>string</td>
<td>1</td>
<td>TCPTRACK</td>
<td>None</td>
<td>Telescope tracking status</td>
</tr>
<tr>
<td>slew</td>
<td>string</td>
<td>1</td>
<td>TCPSLEW</td>
<td>None</td>
<td>Telescope slew status</td>
</tr>
<tr>
<td>adc</td>
<td>string</td>
<td>1</td>
<td>CASSADC</td>
<td>None</td>
<td>Cass ADC mode</td>
</tr>
<tr>
<td>adctop</td>
<td>string</td>
<td>1</td>
<td>CASSADCT</td>
<td>Degrees</td>
<td>Cass ADC top angle</td>
</tr>
<tr>
<td>adcbot</td>
<td>string</td>
<td>1</td>
<td>CASSADC</td>
<td>Degrees</td>
<td>Cass ADC bottom angle</td>
</tr>
<tr>
<td>focus</td>
<td>float</td>
<td>1</td>
<td>FOCUS</td>
<td>Millimeters</td>
<td>Focus</td>
</tr>
<tr>
<td>fratio</td>
<td>string</td>
<td>1</td>
<td>FOCI</td>
<td>None</td>
<td>Telescope foci</td>
</tr>
</tbody>
</table>
### KOSMOS ICD 5.1 Instrument Controller to Telescope System

#### attribute type number keyword units description

---

**field** string 1 FIELD None Telescope field

**ha** string 1 TCPHA None Telescope HA

**haservo** string 1 HASERVO Degrees Ha servo position

**devservo** string 1 DECSERVO Degrees Dec servo position

**active_primary** string 1 ACTPRI None Primary mirror mode

---

**servo** string 1 ALRTSERV None Servo alert

**ha** string 1 ALRTHA None Ha alert

**dec** string 1 ALRTDEC None Dec alert

**stowed** string 1 ALRTSTOW None Stow alert

---

**az** string 1 DOMEAZ Degrees Dome position

**error** string 1 DOMEERR Degrees Dome error: distance from target

**mode** string 1 DOMEMODE None Dome mode

**status** string 1 DOMESTAT None Dome status

---

**mode** string 1 TCPGDR None Guider status (on|off)

**motion** string 1 TCPGDRMO None Guider motion enable

**probe** string 1 GDRPROBE None Current guider probe

**northx** string 1 TCPGDRNX Millimeters North guider probe X position

**norther** string 1 TCPGDRNY Millimeters North guider probe Y position

**southx** string 1 TCPGDRSX Millimeters South guider probe X position

**souther** string 1 TCPGDRSY Millimeters South guider probe Y position

**leaky** string 1 GDCLEAKY None Guider leaky switch

**update** string 1 GDRUPDAT Seconds Guider update rate

**calibration** string 1 GDRCAL None Guider calibration

---

**position** string 1 NODPOS None Nod position (object|sky)

**offsets** string 1 NODOFF Arcsec X and Y offset for nod

---

**name** string 1 INSTR None Name of current instrument

### GWC Commands:

---

**tcs.telescope.focus move** {integer} move pedestal focus to {position}

**tcs.telescope.focus stop** stop focus motion

**tcs.main.link set** {string} TCP link {up|down}

**tcs.main.updates set** {string} TCP polling {on/off}

**tcs.target.preset set** {string} set target preset to {go|abort}

**tcs.main.ra_inst_center set** {string} set RA inst-center to {value}

**tcs.main.dec_inst_center set** {string} set DEC inst-center to {value}

**tcs.telescope.ra_offset set** {float} set RA offset to {value} east

**tcs.telescope.dec_offset set** {float} set DEC offset to {value} north

**tcs.guider.mode set** {string} guider mode control {on|off}

**tcs.guider.motion set** {string} guider mode control {enabled|disabled}

**tcs.instrument.name set** {string} set instrument name

**tcs.main.command set** {string} TCP command {not implemented}

### GWC Actions:

---

ACKNOWLEDGED

BUSY

DONE

**TCP Command Map (partial)**

---

GWC Variable/Command 4m (tcpShell) 4m (FORTH)

**tcs.main.ut** hw utclock (binary block)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcs.main.st</td>
<td>hwte stClock</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.ra</td>
<td>tele position</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.dec</td>
<td>tele position</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.equinox</td>
<td>tele epoch</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.zenithdist</td>
<td>tele info</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.airmass</td>
<td>tele info</td>
<td>(binary block)</td>
</tr>
<tr>
<td>tcs.main.alt</td>
<td>tele info</td>
<td></td>
</tr>
<tr>
<td>tcs.main.focus</td>
<td>mse.pedestal.focus</td>
<td>%d focus</td>
</tr>
<tr>
<td>tcs.offset.ra</td>
<td>tele offset</td>
<td>%.2f 0.0 toaa</td>
</tr>
<tr>
<td>tcs.offset.dec</td>
<td>tele offset</td>
<td>0.0 %.2f toaa</td>
</tr>
<tr>
<td>tcs.guider.mode</td>
<td>gdr mode</td>
<td>gon</td>
</tr>
<tr>
<td>tcs.main.ra_inst_center</td>
<td>tele collim</td>
<td></td>
</tr>
<tr>
<td>tcs.main.dec_inst_center</td>
<td>tele collim</td>
<td></td>
</tr>
<tr>
<td>tcs.instrument.name</td>
<td>inst config</td>
<td></td>
</tr>
</tbody>
</table>