ICD 1.6/1.10f

A&G to Near-infrared Integral Field Spectrograph (NIFS) On Instrument Wavefront Sensor

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Revision Control

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Chapter 1 Introduction

1–1.0 Description

1–1.1 Purpose

This Interface Control Document (ICD) serves the following purpose:

- To describe the commands and parameters that will pass between the A&G system and the On-Instrument Wavefront Sensor (OIWFS) Components Controller (CC).

The specific interfaces described in this document are governed by the following parent Interface Control Documents, which describe the general properties of particular kinds of interface:

- ICD 1a [1], which describes how the OCS deals with commands and attributes and the behavior the OCS expects from the systems it commands.
- ICD 1b [2], which gives a general description of the way the Observatory Control System communicates with the other principal systems. It is also related to ICD 7a, [3], which describes the way an Instrument Control System communicates with its subsystems.
- ICD 2 [4], which describes the way in which an Instrument Control System makes information available to the outside world (and the OCS) by means of "Status Information Records".
- ICD 7b [5], which describes the way that the Telescope Control System (TCS) interacts with its subsystems. (From a control standpoint, the OIWFS CC is a subsystem of the A&G, which is a subsystem of the TCS.)

The intended audience for this document is:

- The NIFS reviewers;
- The developers of the Gemini Acquisition and Guidance units;

1–1.2 Scope

This document describes only aspects of the NIFS OIWFS software system which differ from, or are more specific than, the Gemini standard OIWFS, described in [6].

This document does *not* describe the following topics:

- The NIFS OIWFS CC hardware and electronics (see [8] and [9]);
- The NIFS OIWFS DC software, hardware, and electronics (see [8] and [9]);
- The NIFS Interlock system;
- The software design (see [8], and [9]).

1–2.0 Related Documents and Drawings

1–2.1 References

[1] gscg.kkg.009, *"ICD 1a — The System Command Interface"*, Kim Gillies, NOAO.

[2] gscg.kkg.024, *"ICD 1b — The Baseline Attribute/Value Interface"*, Kim Gillies, NOAO.

[3] gscg.grp.015, *"ICD 7a — ICS Subsystem Interfaces"*, Steven Beard, Steve Wampler and Chris Mayer, Gemini 8m Telescopes Project.

[4] gscg.kkg.010, *"ICD 2 — Systems Status and Alarm Interfaces"*, Gemini 8m Telescopes Project.

[5] gscg.grp.009, "*ICD 7b— TCS Subsystem Interfaces",* Philip Taylor

[6] ic16110.doc, "ICD 1.6/1.10 A&G to On-Instrument Wavefront Sensors", Nick Dillon, Malcolm Stewart, Steven Beard, Brian Leckie.

[7] niri_hty_005.fm "ICD 1.6/1.10[ab] NIRI Science Instrument to On Instrument Wavefront Sensor", Hubert Yamada, University of Hawaii, Institute for Astronomy.

[8] *"NIFS Conceptual Design Review Vol 1"*, Research School of Astronomy and Astrophysics, Australian National University

[9] *"NIFS Critical Design Review Vol 1"*, Research School of Astronomy and Astrophysics, Australian National University

[10] cics_smb_013, "Science Instrument to Observatory Control System", Steven Beard, Royal Observatory Edinburgh.

[11] ag_jms_004, "Control of Wavefront Sensors", Malcolm Stewart

[12] SPE-C-G0037, *"Software Design Description"*, Gemini 8m Telescopes Project

[13] *"NIFS Software Maintenance Manual" - To be written,* Research School of Astronomy and Astrophysics, Australian National University

1–2.2 Acronyms and Abbreviations

A&G	Acquisition and Guidance
CAD	Command Action Directive
CAR	Command Action Response
CC	Components Controller
DC	Detector Controller (software system)
DHS	Data Handling System
EPICS	Experimental Physics and Industrial Control System
FITS	Flexible Image Transport System
ICD	Interface Control Document
IOC	Input Output Controller
IS	Instrument Sequencer
ISS	Instrument Support Structure
N/A	Not Applicable
OCS	Observatory Control System
OIWFS	On Instrument Wavefront Sensor
SAD	Status and Alarm Database
SIR	Status and Information Record
TCS	Telescope Control System
WFS	Wavefront Sensor

1–2.3 Definitions

Action. The process started as a result of a **Command**. For example, a command to select a new filter will start the filter wheel mechanism in motion. There can be a many-to-one correspondence between commands and actions. For example, several different filter commands can all result in the same filter wheel movement action. The status of an action is reported through a CAR record.

Attribute. An entity which describes some aspect of the configuration of a science instrument, such as the name of a filter or the tilt angle of a grating. Some attributes will be used by the Instrument Control System as command parameters. The OCS communicates with a science instrument by sending it sets of "**Attribute**" and "**Value**s".

Command. An instruction commanding the Instrument Control System to start some action. The action may result in a mechanism moving or some internal parameters being set to particular values. A command may have command parameters (aka "command arguments") which contain the details of the instruction to be obeyed. Commands are activated by means of CAD records, and the OCS maps each command arguments onto an "**Attribute**".

Components Controller (CC). An instrument subsystem responsible for the various mechanisms (e.g. motors and heaters) contained in an instrument.

Datum. The reference point used to define the coordinate system of a mechanism which does not have absolute encoders. Also knows as "**Index**" and "**Home**".

Detector Controller (DC). An instrument subsystem responsible for controlling a detector array and reading data from it. Note that this term has been used in Gemini documentation to refer both to the detector control *electronics* and the detector control *software system*. In the context of this software document the term refers to the detector control *software system* unless otherwise stated.

Hall-effect Sensor. An electronic component which is used to detect and to measure magnetic field strength.

Home. See "**Datum**".

Index. See "**Datum**".

Instrument Sequencer (IS). That part of an Instrument Control System responsible for coordinating the actions of a Detector Controller and one or more Components Controllers. The A&G subsystem has a "Guidance and Beam Direction Sequencer" for coordinating its components.

Principal Systems. The Gemini Control System is made up of the OCS, TCS, DHS and one ICS for each instrument. These systems constitute the principal systems of the Gemini Control System.

Status information. Small quantities of information describing the configuration or status of a system. This information is usually stored in an EPICS database and communicated by channel access.

Sequence Commands. The set of standard commands mandated by the OCS which all instruments must obey. These are described in reference[1].

Status/Alarm Database (SAD). This is an EPICS database containing the public status information for a Gemini principal system. For an Instrument Control System, the SAD would contain information about the configuration of the instrument's mechanisms, its current state and health, and information obtained from sensors.

Value. The value associated with an "**Attribute**".

VME. A real-time system obeying the ANSI/IEEE 1014-1987 Versatile Backplane Bus standard.

VxWorks. The Real Time Operating system from Wind River.

1–2.4 Stylistic Conventions

References to documents are given like this [1].

Chapter 2 Details of the A&G to NIFS OIWFS Interface

2–1.0 Introduction

2–2.0 Physical System Interfaces

2–2.1 Mechanical Interface

Not Applicable for a software ICD.

2–2.2 Optical Interface

Not Applicable for a software ICD.

2–2.3 Electronic Interface

2–2.3.1 NIFS

The NIFS electronic system uses the following VME modules:

- The XVME-240 Digital I/O Board, (shared between the NIFS CC, the NIFS OIWFS, and the interlock bus):
  - To monitor the status of the stepper-motor control modules;
  - To reset the stepper-motor control modules;
  - To handle the cabinet door interlock
- Four custom-built VME sensor-support boards:
  - To read out the NIFS OIWFS Hall-effect sensors;
- Two XVME-566 Analog Input Modules:
  - To read out the VME sensor-support boards for the NIFS OIWFS Hall-effect sensors;
- A XYCOM-490 serial I/O board:
  - To control the temperature controllers and the Omega CYD208 digital thermometer
- Two Oregon Microsystems VME8-8 Stepper-motor controller boards
  - To control the NIFS OIWFS stepper-motors.

Note that these boards will be shared between the NIFS OIWFS hardware and the NIFS hardware, and will perform other functions that are not listed above..

2–2.4 Mass/Balance

Not Applicable for a software ICD.

2–2.5 Thermal Interface

Not Applicable for a software ICD.

2–3.0 Software/Control Function Interface

2–3.1 Overview

2–3.1.1 Communications infrastructure

The communications infrastructure is the same as described in [10].

2–3.1.2 Software architecture

The software architecture is described in [8] and [9].

2–3.2 Behavior

The behavior of the NIFS OIWFS/A&G interface is the same as described in [6] and [11].

2–3.3 Implementation

This section contains tables summarizing the EPICS records used for the interface. The next sections (Section 2–3.5 on page 18 and Section 2–3.6 on page 22) contain the details of what those records do.

It is assumed in all cases that the record names given in this document will be prefixed by the string “nifs:” except for the SAD database which will be prefixed by “nifs:sad”.

2–3.4 Command (CAD/CAR) records

The columns of the command record tables are as follows:

Description. A brief description of the command.

Attribute. The name of the attribute which the Observatory Control System associates with a particular parameter of a particular command. Component position names are listed separately in Table 8.

CAD Record / Cad Record.FIELD. The name of the EPICS (minus the “nifs:” prefix) together with the field in that CAD record associated with each parameter of the command.

CAD ordering number. The recommended order in which this command should be executed. CAD records should be connected to their associated APPLY record in the order 1, 2, 3, 4, 5, etc... CAD records within the same ordering number set can be connected to the APPLY record in any order in that set.

CAR record. The CAR record associated with the command. Note that several CAD records may share the same CAR record.

2–3.4.0.1 CAD/CAR records—System Commands

These commands affect the overall behavior of the NIFS OIWFS. Note, in particular, that it is not possible to reboot NIFS and the NIFS OIWFS separately..

TABLE 1. NIFS system command CAD/CAR records

Description	Attribute[a]	CAD record / CAD record.FIELD ("nifs:" +)	CAD ordering number	CAR record ("nifs:" +)
Test.	(none)	wfs:test	1	testC
Initialize	(none)	wfs:init	2	initC
Datum mechanisms.	(none)	wfs:datum	3	datumC
Park	(none)	wfs:park	4	parkC
Verify	(none)	wfs:verify	5	verifyC
End verify	(none)	wfs:endVerify	6	endVerifyC

a. "(none)" means that there are no arguments

TABLE 2. NIFS system engineering command CAD/CAR records

Description	Attribute[a]	CAD record / CAD record.FIELD ("nifs:" +)	CAD ordering number	CAR record ("nifs:" +)
Select debug mode	debug mode (NOLOG | NONE | MIN | FULL)	wfs:debug.A	7	
Reboot the system	(none)	wfs:reboot	8	rebootC

a. "(none)" means that there are no arguments

2–3.4.0.2 OIWFS command CAD/CAR records—OIWFS components

The commands in Table 3 are the only ones that are used during routine observation.

TABLE 3. NIFS OIWFS CC command CAD/CAR records

Description	Attribute[a]	CAD Record / CAD Record.FIELD ("nifs:" +)	CAD ordering number	CAR record ("nifs:" +)
Select a filter in the filter wheel[b].	filter name	wfs:filtMove.A	17	wfs:filtC
Park the filter wheel.	(none)	wfs:filtPark	16	
Move gimbal mirrors, to given (x, y) position and leave it stationary. (x, y) is the position in the focal plane measured in mm in the instrument's frame of reference.	x y	wfs:prbMove.A wfs:prbMove.B	37	wfs:prbC
Park the gimbal mirror.	(none)	wfs:prbPark	36	

TABLE 3. NIFS OIWFS CC command CAD/CAR records

Description	Attribute[a]	CAD Record / CAD Record.FIELD ("nifs:" +)	CAD ordering number	CAR record ("nifs:" +)
The gimbal and focus stage are caused to follow a continuous stream of updated (x=gimbal x, y=gimbal y, z=focus) positions. These positions are not defined as CAD record arguments but in separate records (see ICD 1.6/1.10).	(none)	wfs:folFollow	39	folC
"Follow" mode, initiated by the wfs:folFollow command, is terminated.	(none)	wfs:folStop	40	
Set the tolerance values for all three axes (x=gimbal x, y=gimbal y) in mm. The tolerance is used to calculate the wfs:folInToler SIR record.	x y	wfs:folSetTol.A wfs:folSetTol.B	38	folSetC

a. "(none)" means that there are no arguments.

b. ICD 1.6/1.10 [6] has three separate components: a field-stop, a neutral-density filter, and a color filter. For the NIFS OIWFS CC, these are combined into a single wheel which may have multiple optical elements at each position.

2–3.4.0.3 OIWFS Engineering commands CAD/CAR records—OIWFS components

The following commands are used for engineering purposes, and are not expected to be used during normal observing. Note that, although these commands are connected to the OIWFS APPLY record, they are normally activated directly by the engineering user interface.

The following commands affect the overall behavior of the OIWFS but do not affect the science detector.

TABLE 4. NIFS OIWFS CC engineering command CAD/CAR records

Description	Attribute	CAD Record / CAD Record.FIELD ("nifs:" +)	CAD ordering number	CAR record ("nifs:"+)
Datum filter wheel.		wfs:filtDatm	13	wfs:filtC
Set filter wheel position in position numbers[a].	position	wfs:filtMove.A	16	
Set filter wheel position in engineering units (motor microsteps)[a].	motor position	wfs:filtEngMove.A	18	
Confirm that filter wheel has not lost its datum position.		wfs:filtRdtm	14	
Confirm that filter wheel and its Hall-effect sensors are operational		wfs:filtDiag	15	
Datum the gimbal mirror.		wfs:prbxDatm	34	wfs:prbC
Datum the x-axis of the gimbal mirror.		wfs:prbDatm	18	wfs:prbxC
Tip gimbal mirror along its x-axis, given x position in engineering units (motor microsteps).	motor position	wfs:prbxEngMove.A	23	
Confirm that the OIWFS gimbal mirror x-axis motor has not lost its datum position.		wfs:prbxRdtm	19	
Confirm that the OIWFS gimbal mirror x-axis and its Hall-effect sensors are operational		wfs:prbxDiag	20	
Datum the y-axis of the gimbal mirror.		wfs:prbyDatm	26	wfs:prbyC
Tip gimbal mirror along its y-axis, given y position in engineering units (motor microsteps).	motor position	wfs:prbyEngMove.A	31	
Confirm that OIWFS gimbal mirror y-axis motor has not lost its datum position.		wfs:prbyRdtm	27	
Confirm that OIWFS gimbal mirror y-axis motor and its Hall-effect sensors are operational		wfs:prbyDiag	28	

a. Only the standard positions (excluding datum and park) are fully repeatable.

2–3.4.1 Status Information Records

The following tables show the status information provided by the OIWFS. The tables have the following columns:

SIR record. The part of the name of the EPICS SIR record which follows the "nifs:sad" prefix..

Units. The units in which the quantity is stored. (Ustep refers to units of motor microsteps; "user units" or "real-world units" refer to the arbitrary units described by the Units SIR variable.)

Comments. A description of the item. The first paragraph of this will go into the SIR record description and also the comment field in the FITS header.

Note that only the type, units and comments are actually contained in the SIR records. The FITS keyword is provided by the DHS.

2–3.4.1.1 WFS Status Information

Table 5 contains status information for all of the WFS.

TABLE 5. The WFS Overall Status Information

SIR record ("nifs:"+)	FITS Keyword	FITS included	Type	Units	Comments
wfs:sad:debugMode		Never	string		Debugging mode [NOLOG | NONE | MIN | FULL]
wfs:sad:health		Never	string		WFS Health [GOOD | WARNING | BAD]
wfs:sad:heartBeat		Never	long	count	Heart beat record: Shows that WFS software is alive by returning a constantly increasing value.
wfs:sad:historyLog		Never	array of char[a]		History log record[b]
wfs:sad:issPort		Never	long	number	ISS port on which instrument is installed
wfs:sad:label		Never	string		The FDSC field describes the WFS Components Controller
wfs:sad:name		Never	string		WFS Components Controller Name
wfs:sad:simMode		Never	string		Simulation mode [NONE | FULL | FAST | VSM]
wfs:sad:state		Never	string		Inst. state [BOOTING | INITIALIZING | RUNNING | CONFIGURING]
wfs:sad:wfsBeam		Never	long	0/1	Is the WFS detector unobstructed? [YES=0 | NO=1][c]

a. Should be "bigstring"

b. This record is not useful, because of various EPICS limitations.

c. The wfs:sad:wfsBeam record only indicates whether the OIWFS components controller mechanisms are obstructing the beam; it does not indicate that light is actually getting to the detector. The instrument needs to combine the wfs:sad:wfsBeam with information about any other components in order to provide an instrument-wide wfsBeam record.

2–3.4.1.2 The Wavefront Sensor Components Status Information

The following table summarizes the information for the various components.

TABLE 6. NIFS On-Instrument Wave-Front Sensor Status Records

SIR record ("nifs:sad" +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:filtDatumed		Never	long	0/1	Is the filter wheel datumed? [YES=0 | NO=1]
wfs:sad:filtEngCyclic		Never	long	0/1	Ignore limits for the filter wheel? [YES=0 | NO=1]
wfs:sad:filtEngMax		Never	long	motor microsteps	Maximum position of the filter wheel in engineering units (motor microsteps)

TABLE 6. NIFS On-Instrument Wave-Front Sensor Status Records

SIR record ("nifs:sad" +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:filtEngMin		Never	long	motor microsteps	Minimum position of the filter wheel in engineering units (motor microsteps)
wfs:sad:filtEng-Name		Never	string		Engineering name of the filter wheel position
wfs:sad:filtEngPos		Never	long	motor microsteps	Position of the filter wheel in engineering units (motor microsteps)
wfs:sad:filtLabel		Never	string		The FDSC field describes the filter wheel
wfs:sad:filtMax		Never	double	position number	Maximum position of the filter wheel in real-world units (position number)
wfs:sad:filtMin		Never	double	position number	Minimum position of the filter wheel in real-world units (position number)
wfs:sad:filtName	OIFILTER	Start	string		User name of the filter wheel position
wfs:sad:filtParked		Never	long	0/1	Is the filter wheel parked? [YES=0 | NO=1]
wfs:sad:filtPos	OIFLTPOS	Start	double	position number	Position of the filter wheel position in real-world units (position number)
wfs:sad:filtRdtmVal		Never	long	motor microsteps	Returned value from the filter wheel redatum command
wfs:sad:filtReject		Never	long	0/-1	Combined the filter wheel CAR state [GOOD=0 | REJECT=-1]
wfs:sad:filtState		Never	string		the filter wheel SNL state
wfs:sad:filtUnits		Never	string		Definition of real-world units ("user units") for the filter wheel ("pos num").
wfs:sad:folIsFollow		Never	long	0/1	Are all dynamic components in follow mode? [YES=0 | NO=1]
wfs:sad:folIsIdle		Never	long	0/1	Are all components idle? [YES=0 | NO=1]
wfs:sad:folReject		Never	long	0/1	Combined reject state for Follow Command
wfs:sad:prbDatumed		Never	long	0/1	Is/Are Gimbal Mirror datumed? [YES=0 | NO=1]
wfs:sad:prbLabel		Never	string		The FDSC field describes the gimbal mirror
wfs:sad:prbName	OIPBSNAM	Start	string		the gimbal mirror name of current position[a]
wfs:sad:prbParked		Never	long	0/1	Is the gimbal mirror parked? [YES=0 | NO=1]
wfs:sad:prbReject		Never	long	0/1	Combined reject state for the gimbal mirror
wfs:sad:prb-Sky:xPos		Never	double	sky units	Position of the gimbal mirror x in sky units
wfs:sad:prb-Sky:yPos		Never	double	sky units	Position of the gimbal mirror y in sky units
wfs:sad:prbSkyLabel		Never	string		The FDSC field describes the gimbal mirror

TABLE 6. NIFS On-Instrument Wave-Front Sensor Status Records

SIR record ("nifs:sad" +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:prb-SkyUnits		Never	string		Definition of "sky units"
wfs:sad:prbxAgDiff		Never	double	mm	The gimbal-mirror x-axis offset error in real-world units (mm in the focal plane)
wfs:sad:prbx-AgEngDiff		Never	double	motor microsteps	The gimbal-mirror x-axis offset error in engineering units (motor microsteps)
wfs:sad:prbxDa-tumed		Never	long	0/1	Is the gimbal-mirror x-axis datumed? [YES=0 | NO=1]
wfs:sad:prbxEng-Cyclic		Never	long	0/1	Ignore limits for the gimbal-mirror x-axis? [YES=0 | NO=1]
wfs:sad:prbxEng-Max		Never	long	motor microsteps	Maximum position of the gimbal-mirror x-axis in engineering units (motor microsteps)
wfs:sad:prbxEng-Min		Never	long	motor microsteps	Minimum position of the gimbal-mirror x-axis in engineering units (motor microsteps)
wfs:sad:prbxEng-Name		Never	string		Engineering name of the gimbal-mirror x-axis position[b]
wfs:sad:prbxEng-Pos		Never	long	motor microsteps	Position of the gimbal-mirror x-axis in engineering units (motor microsteps)
wfs:sad:prbxInToler		Never	long	0/1	Is the gimbal-mirror x-axis offset in tolerance? [YES=0 | NO=1]
wfs:sad:prbxLabel		Never	string		The FDSC field describes the gimbal-mirror x-axis
wfs:sad:prbxMax		Never	double	mm	Maximum position of the gimbal-mirror x-axis in real-world units (mm in the focal plane)
wfs:sad:prbxMin		Never	double	mm	Minimum position of the gimbal-mirror x-axis in real-world units (mm in the focal plane)
wfs:sad:prbxName	OIPBXNAM	Start	string		User name of the gimbal-mirror x-axis position[c]
wfs:sad:prbxParked		Never	long	0/1	Is the gimbal-mirror x-axis parked? [YES=0 | NO=1]
wfs:sad:prbxPos	OIPBXPOS	Always	double	mm	Position of the gimbal-mirror x-axis position in real-world units (mm in the focal plane)
wfs:sad:prbxRdtm-Val		Never	long	motor microsteps	Returned value from the gimbal-mirror x-axis redatum command
wfs:sad:prbxReject		Never	long	0/-1	Combined the gimbal-mirror x-axis CAR state [GOOD=0 | REJECT=-1]
wfs:sad:prbxState		Never	string		the gimbal-mirror x-axis SNL state

TABLE 6. NIFS On-Instrument Wave-Front Sensor Status Records

SIR record ("nifs:sad" +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:prbxTol		Never	double	mm	Tolerange of the gimbal-mirror x-axis offset in real-world units (mm in the focal plane)
wfs:sad:prbxUnits		Never	string		Definition of real-world units ("user units") for the gimbal-mirror x-axis. ("mm").
wfs:sad:prbyAgDiff		Never	double	mm	The gimbal-mirror y-axis offset error in real-world units (mm in the focal plane)
wfs:sad:prby-AgEngDiff		Never	double	motor microsteps	The gimbal-mirror y-axis offset error in engineering units (motor microsteps)
wfs:sad:prbyDatumed		Never	long	0/1	Is the gimbal-mirror y-axis datumed? [YES=0 | NO=1]
wfs:sad:prbyEng-Cyclic		Never	long	0/1	Ignore limits for the gimbal-mirror y-axis? [YES=0 | NO=1]
wfs:sad:prbyEng-Max		Never	long	motor microsteps	Maximum position of the gimbal-mirror y-axis in engineering units (motor microsteps)
wfs:sad:prbyEng-Min		Never	long	motor microsteps	Minimum position of the gimbal-mirror y-axis in engineering units (motor microsteps)
wfs:sad:prbyEng-Name		Never	string		Engineering name of the gimbal-mirror y-axis position[d]
wfs:sad:prbyEng-Pos		Never	long	motor microsteps	Position of the gimbal-mirror y-axis in engineering units (motor microsteps)
wfs:sad:prbyInToler		Never	long	0/1	Is the gimbal-mirror y-axis offset in tolerance? [YES=0 | NO=1]
wfs:sad:prbyLabel		Never	string		The FDSC field describes the gimbal-mirror y-axis
wfs:sad:prbyMax		Never	double	mm	Maximum position of the gimbal-mirror y-axis in real-world units (mm in the focal plane)
wfs:sad:prbyMin		Never	double	mm	Minimum position of the gimbal-mirror y-axis in real-world units (mm in the focal plane)
wfs:sad:prbyName	OIPBYNAM	Start	string		User name of the gimbal-mirror y-axis position[e]
wfs:sad:prbyParked		Never	long	0/1	Is the gimbal-mirror y-axis parked? [YES=0 | NO=1]
wfs:sad:prbyPos	OIPBYPOS	Always	double	mm	Position of the gimbal-mirror y-axis position in real-world units (mm in the focal plane)
wfs:sad:prbyRdtm-Val		Never	long	motor microsteps	Returned value from the gimbal-mirror y-axis redatum command
wfs:sad:prbyReject		Never	long	0/-1	Combined the gimbal-mirror y-axis CAR state [GOOD=0 | REJECT=-1]

TABLE 6. NIFS On-Instrument Wave-Front Sensor Status Records

SIR record ("nifs:sad" +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:prbyState		Never	string		the gimbal-mirror y-axis SNL state
wfs:sad:prbyTol		Never	double	mm	Tolerange of the gimbal-mirror y-axis offset in real-world units (mm in the focal plane)
wfs:sad:prbyUnits		Never	string		Definition of real-world units ("user units") for the gimbal-mirror y-axis ("mm").

a. For the gimbal mirror, the position returned by wfs:sad:prbName will often be "INVALID". This should not be treated as an error, merely as an indication that only a few positions (e.g., the PARK position) have names.

b. For the gimbal mirror x-axis, the position returned by wfs:sad:prbxEngName will often be "INVALID". This should not be treated as an error, merely as an indication that only a few positions (e.g., the PARK position) have names.

c. For the gimbal mirror x-axis, the position returned by wfs:sad:prbxName will often be "INVALID". This should not be treated as an error, merely as an indication that only a few positions (e.g., the PARK position) have names.

d. For the gimbal mirror y-axis, the position returned by wfs:sad:prbyEngName will often be "INVALID". This should not be treated as an error, merely as an indication that only a few positions (e.g., the PARK position) have names.

e. For the gimbal mirror y-axis, the position returned by wfs:sad:prbyName will often be "INVALID". This should not be treated as an error, merely as an indication that only a few positions (e.g., the PARK position) have names.

2–3.4.1.3 Component Health Information

The following table summarizes the health information records. All records return one of the strings: “GOOD”, “WARNING”, or “BAD”. Each record describes one aspect of the health of a component

TABLE 7. OIWFS Components Controller Component Health Information

SIR record (“nifs:” +)	FITS Keyword	FITS Included	Type	Units	Comments
wfs:sad:filtDatum-Health		Never	string		The health of the filter wheel datum state
wfs:sad:filtHallHealth		Never	string		The health of the filter wheel Hall-effect sensors
wfs:sad:filtHealth		Never	string		The overall health of the filter wheel
wfs:sad:filtModule-Health		Never	string		The health of the filter wheel driver
wfs:sad:filtPosErrHe-alth		Never	string		The health of the filter wheel backlash correction
wfs:sad:filtSnlHealth		Never	string		The health of the filter wheel state code
wfs:sad:prbHealth		Never	string		The overall health of the gimbal mirror
wfs:sad:prbxDatum-Health		Never	string		The health of the gimbal-mirror x-axis datum state
wfs:sad:prbxHall-Health		Never	string		The health of the gimbal-mirror x-axis Hall-effect sen-sors
wfs:sad:prbxHealth		Never	string		The overall health of the gimbal mirror x-axis
wfs:sad:prbxModule-Health		Never	string		The health of the gimbal-mirror x-axis driver
wfs:sad:prbxPosEr-rHealth		Never	string		The health of the gimbal-mirror x-axis backlash correc-tion
wfs:sad:prbxSnlHealth		Never	string		The health of the gimbal-mirror x-axis state code
wfs:sad:prbyDatum-Health		Never	string		The health of the gimbal-mirror y-axis datum state
wfs:sad:prbyHall-Health		Never	string		The health of the gimbal-mirror y-axis Hall-effect sen-sors
wfs:sad:prbyHealth		Never	string		The overall health of the gimbal mirror y-axis
wfs:sad:prbyModule-Health		Never	string		The health of the gimbal-mirror y-axis driver
wfs:sad:prbyPosEr-rHealth		Never	string		The health of the gimbal-mirror y-axis backlash correc-tion
wfs:sad:prbySnlHealth		Never	string		The health of the gimbal-mirror y-axis state code

2–3.4.2 Position names

Table 8 contains a list of valid position names. Note that these names are case sensitive and must be entered exactly as presented here, including underscores. In addition to the listed

positions, all mechanisms respond to the special names “datum” and “park” which may or may not be distinct from the listed positions.

TABLE 8. Position Names (observing commands)

Component	Position Names	Engineering Position[a]	Comments
Filter Wheel	Z10	(comp)	*Z* filter + 1.0” diameter circular aperture
	Z20	(comp)	*Z* filter + 2.0” diameter circular aperture
	J05	(comp)	*J* filter + 0.5” diameter circular aperture
	J10	(comp)	*J* filter + 1.0” diameter circular aperture
	J20	(comp)	*J* filter +2.0” diameter circular aperture
	H05	(comp)	*H* filter + 0.5” diameter circular aperture
	H10	(comp)	*H* filter + 1.0” diameter circular aperture
	H20	(comp)	*H* filter + 2.0” diameter circular aperture
	K10	(comp)	*K* filter + 1.0” diameter circular aperture
	K20	(comp)	*K* filter + 2.0” diameter circular aperture
	Clear	(comp)	Clear
	Blocked	(comp)	Blocked
Gimbal Mirror	Neutral	(comp)	
	Minimum	(comp)	
	Maximum	(comp)	
Gimbal Mirror X-Axis	Neutral	(comp)	Mirror centered
	Minimum	(comp)	Minimum travel location
	Maximum	(comp)	Maximum travel location
Gimbal Mirror Y-Axis	Neutral	(comp)	Mirror centered
	Minimum	(comp)	Minimum travel location
	Maximum	(comp)	Maximum travel location

a. “(comp)” means that the positions are mapped into component positions, and not sent directly to a mechanism.

2–3.5 Detailed Command Description

A general table of the commands accepted by the NIFS OIWFS CC, together with their arguments, is given in Table 1 on page 9. This section contains a detailed description of each of the commands that will be sent between the A&G and the NIFS control software.

If a directive is accepted it will cause the NIFS OIWFS CC to change its configuration. The “applyC” CAR record will go “BUSY” while the OIWFS control software is changing its configuration and go to “IDLE” if completed successfully or to “ERR” if the configuration change fails.

2–3.5.1 Sequence Commands

2–3.5.1.1 INIT

On receipt of this command, the OIWFS control software will execute its initialization sequence, in which it will: read its hardware setup files and lookup tables, and reset itself to

the start-up state. The "initC" CAR record will go "BUSY" while the initialization is being carried out and go to "IDLE" if completed successfully or to "ERR" if the initialization fails. No mechanisms will be moved.

2–3.5.1.2 DATUM

The OIWFS CC will locate the datum (i.e. index, home or reference point) for all its mechanisms. The "datumC" CAR record will go "BUSY" while the datum search is being carried out and go to "IDLE" if completed successfully or to "ERR" if the datum searched fails.

2–3.5.1.3 PARK

On receipt of this command, the OIWFS will move its mechanisms to a configuration in which it can safely be switched off. It will utilize all the low-level CAD records dedicated to parking the individual mechanisms. The "parkC" CAR record will go "BUSY" while the mechanisms are being parked and go to "IDLE" if completed successfully or to "ERR" if any mechanism fails to park successfully.

2–3.5.2 General Engineering Commands

2–3.5.2.1 REBOOT

On receipt of this command, the OIWFS control software will reboot its IOC and go through the same start-up procedure it would normally do when first switched on. The working system will reboot into the simulation mode NONE and debug mode NONE. The simulator will reboot into simulation mode FULL and debug mode NONE. There is no CAR record associated with this command because connection with the IOC will be lost while it reboots.

This command will also reboot the NIFS CC, DC and IS.

2–3.5.2.2 DEBUG

On receipt of this command, the NIFS control software will change to the given debug mode (NONE, MIN or FULL). This mode determines the amount and frequency of information logged by the NIFS control software, as described in the "Debugging Modes" section of ICD 1a, [1]. The "debugC" CAR record will go briefly "BUSY" and then back to "IDLE".

2–3.5.3 NIFS Standard Mechanisms

The NIFS OIWFS will have a filter wheel and a two-axis gimbal mirror. The following commands will act on these mechanisms.

2–3.5.3.1 Sel—Select Position by Name

This is the principal interface for all continuous mechanisms. It is provided as a convenience for discrete mechanisms. Note that for multi-axis components (e.g., the gimbal mirror), there are commands that act on the combined components and on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Translate desired position name into an engineering position with the
   aid of a look-up table.
Look up the expected value for the Hall-effect sensors at the desired
   position location.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism to the engineering position corresponding to the
   desired position.
Verify that the expected sensor value matches the measured value.
```

2–3.5.3.2 Move—Move to specified Position

This is the principal interface for all discrete components. It is available for continuous components, but is of limited use for normal use of the instrument[1]. Note that for multi-axis components (e.g., the gimbal mirror), there are commands that act on the combined components and on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the focus mechanism to the engineering position corresponding to
   the desired focus.
For some mechanisms, compute the expected values for the Hall-effect
   sensors.
For some mechanisms, verify that the final hall effect sensors match
   the expected values.
```

2–3.5.3.3 Park—Park Mechanism

This command is used to prepare a mechanism for instrument shutdown. Note that for multi-axis components (e.g., the gimbal mirror), there are commands that act on the combined components and on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism to its parking position.
Verify that the expected sensor value matches the measured value.
```

The park command is not needed for most NIFS components, and is provided for uniformity. The single exception is the focus stage. The focus stage must be parked before disassembly.

2–3.5.3.4 Datm—Datum mechanism

This command is used to find the datum (home) position which defines the mechanism locations. Note that for multi-axis components (e.g., the gimbal mirror), there are commands that act on the combined components and on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism and search for its datum.
Set the hardware datum position.
```

1. For discrete mechanisms, the units are position numbers; i.e., the first position is at 1.0, the second position is at 2.0.

2–3.5.3.5 MoveEng—Set position in engineering units (motor microsteps)

This command is used to move the components to locations using units that are convenient for working directly with the hardware. Note that for multi-axis components (e.g., the gimbal mirror), the command acts only on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism to the specified engineering position.
```

The Hall-effect sensors will not be used for confirmation.

2–3.5.3.6 Rdtm—Redatum mechanism.

This command provides a quick test that will detect a loss of positioning. It will detect small positioning errors, but can underestimate large positioning errors. Note that for multi-axis components (e.g., the gimbal mirror), the command acts only on the individual mechanisms. It returns an estimate of the difference between the actual datum position and the current datum position (which can occur, e.g., if a mechanism is sticking, being driven too quickly, or being driven with too high an acceleration).

On receipt of this command, the NIFS CC control software will:

```
Ensure an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism and search for its datum.
```

The hardware datum position will be left unchanged. This command returns a value in the RdtmVal record for this mechanism.

This command is not supported by the pupil viewer or the window cover, because those mechanisms use a home-finding algorithm which is incompatible with this command.

2–3.5.3.7 Diag—Diagnose mechanism

This is a quick test that will detect a loss of positioning. It will detect arbitrarily large positioning errors, but will fail to detect small positioning errors. Note that for multi-axis components (e.g., the gimbal mirror), command acts only on the individual mechanisms.

On receipt of this command, the NIFS CC control software will:

```
Ensure that an observation is not taking place.
Check to insure that protective interlocks are not set.
Wait until the number of active mechanisms drops below the number of
   mechanisms that the power supply can support.
Move the mechanism and attempt to verify that the motors and Hall-
   effect sensors are operating.
```

If an error is detected, the diagnose command will fail and will return an error code in its CAR record.

2–3.6 Detailed Status information

2–3.6.1 General records

2–3.6.1.1 name

This record contains a string constant describing the name of the instrument. For NIFS this record will contain “NIFS WFS”.

2–3.6.1.2 state

This record will take the values BOOTING, INITIALIZING, RUNNING and CONFIGURING and reflect the state of the NIFS control software while it is initializing. The activities corresponding to these states are

- BOOTING — the state during IOC Init and while any database default values are being set.
- INITIALIZING — the NIFS control software will be checking its own hardware and reading its hardware configuration files during this phase.
- RUNNING — the NIFS control software is ready to accept commands.
- CONFIGURING — the NIFS control software is ready to accept commands but it is busy configuring and unable to make observations.

2–3.6.1.3 health

This record will reflect the overall health of the OIWFS. Expected values are GOOD, WARNING or BAD. If the overall health is BAD then the NIFS control software will be unusable. If the Health is set to WARNING then the OIWFS control software will be able to execute some functions but not perhaps to specification.

2–3.6.2 Component Status Records

2–3.6.2.1 Datumed

This record indicates that a component has been datumed. For multi-axis components, this flag will only be set if all mechanisms have been datumed. This record takes on the following values:

- 0 = Datumed
- 1 = Not Datumed

2–3.6.2.2 EngCyclic

This record indicates that a mechanism may be set to a location beyond its physical limits (convenient for circular mechanisms like filter wheels). Note that this only affects the higher level commands; the low-level software may choose to ignore any invalid requests. This record takes on the following values:

- 0 = Limits can be exceeded
- 1 = Limits may not be exceeded

This record is for internal use by the NIFS software. Its value should not be changed. It is documented here only for completeness.

2–3.6.2.3 EngMax

This record contains the maximum position that the mechanism can be moved to, in engineering units (motor microsteps).

2–3.6.2.4 EngMin

This record contains the minimum position that the mechanism can be moved to, in engineering units (motor microsteps).

2–3.6.2.5 EngName

This record contains the engineering name of the current mechanism position. This represents a physical configuration of a component, and will never change (unlike the "Name" record which may change, if filters or other optical elements are replaced or rearranged). The names of the positions are:

- park;
- home;
- pos00, pos01, pos02, ... , up to the maximum number of positions;
- INVALID (if not in a standard location).

2–3.6.2.6 EngPos

This record contains the current position of a mechanism, in engineering units (motor microsteps).

2–3.6.2.7 Label

The FDSC field of this record contains a text string which describes a component. This is convenient in providing a title string for edd/dm screens.

2–3.6.2.8 Max

This record contains the maximum position that the mechanism can be moved to, in real-world units. A text string describing the real-world units may be found in the Units record. For mechanisms such as a filter wheel in which there are no appropriate units, the position will typically be given as a position number, i.e., position 0 is 0.0, position 1 is 1.0.

2–3.6.2.9 Min

This record contains the maximum position that the mechanism can be moved to, in real-world units. A text string describing the real-world units may be found in the Units record. For mechanisms such as a filter wheel in which there are no appropriate units, the position will typically be given as a position number, i.e., position 0 is 0.0, position 1 is 1.0.

2–3.6.2.10 Name

This record contains the name of the current component position. This name typically describes a filter or other optical element and will be redefined if filters or other optical elements are replaced or rearranged (unlike the "EngName" record which describes a component's physical configuration). The current names are listed in @@@.

Note that for multi-axis components, there will be a Name record for each individual mechanism, as well as for the component as a whole.

2–3.6.2.11 Parked

This record indicates that a component is in a parked state. For multi-axis components, this record will be set only if all mechanisms are parked. This field takes the values:

- 0 = All mechanisms parked;
- 1 = Not all mechanisms are parked.

2–3.6.2.12 Pos

This record contains the current position of a mechanism, in real-world units. A text string describing the real-world units may be found in the Units record. For mechanisms such as a filter wheel in which there are no appropriate units, the position will typically be given as a position number, i.e., position 0 is 0.0, position 1 is 1.0.

2–3.6.2.13 RdtmVal

This record contains the result of the last redatum command, in engineering units (motor microsteps). (The redatum command returns an estimate of the how far the current mechanism datum position is from the actual datum position; it is useful in diagnosing hardware problems.)

2–3.6.2.14 Reject

This record contains a combination of the values of all CAD records for all mechanisms that make up a component. It contains the following values:

- -1 = At least one CAD record is in a reject state;
- 0 = No CAD records are in a reject state.

This record exists as a convenience for the user interface. There is no reason for the OCS to use it. It is documented here only for completeness.

2–3.6.2.15 State

This record contains a string which describes the current state of the mechanism-support code.

This record is for debugging the NIFS software. The possible values that this record may take may change, without notice. It is documented here only for completeness.

2–3.6.2.16 Units

This record contains a text string which describes the real world units (e.g., “mm” or “arc sec”)

2–3.6.3 Component Health Records

All of these records return the standard health values: “GOOD”, “WARNING”, and “BAD”.

2–3.6.3.1 DatumHealth

This record reports “WARNING” if a mechanism (or if any mechanism of a multi-axis component) is not datumed. It is cleared by successful execution of a datum command.

2–3.6.3.2 HallHealth

This record reports “WARNING” if a Hall-effect sensor has been disabled. (The sensors can only be disabled from the engineering user interface, and are normally disabled only to deal with a failed sensor.)

This record reports “BAD” if both sensors of a Hall-effect sensor pair have been disabled. Note that a mechanism is still usable if both sensors are disabled, but cannot be datumed. (The sensors can only be disabled from the engineering user interface, and are normally disabled only to deal with a failed sensor.)

2–3.6.3.3 Health

This record reports the most severe error value of all other health records.

2–3.6.3.4 ModuleHealth

This record reports “BAD” if the stepper-motor driver module has entered a fault state. This normally indicates a serious hardware problem. It may be possible to clear the error state by issuing a driver-reset from the engineering user interface. If it is not possible to clear the error, then the stepper-motor driver module or other related hardware has failed, and must be repaired.

2–3.6.3.5 PosErrHealth

This record reports “WARNING” if a mechanism (or if any mechanism of a multi-axis component) has been moved in such a way that proper backlash correction has not been made. In this case, the reported mechanism position may not be the actual mechanism position. This situation can arise if a movement command has been canceled while a motion is in progress; if a movement command failed to complete correctly, if certain low-level engineering commands are executed, and immediately after the control software has been rebooted. It is cleared by successful execution of any motion command.

2–3.6.3.6 SnlHealth

This record reports “BAD” or “WARNING” if the underlying mechanism support code detects an error while a mechanism is in motion. The only situation which is likely to arise is “WARNING”, if an operation takes longer than expected.

2–3.7 Alarm conditions

The following situations will generate an alarm.

- Hall effect sensor disabled
- Motor-control module fault
- Mechanism not datumed
- Mechanism not backlash corrected
- Problem detected by SNL code (time-out)
- Temperature changing
- Temperature out of range

2–3.8 Debugging and Maintenance

This interface can be tested and debugged by means of an engineering user interface supplied as part of the NIFS.

2–3.8.1 Debugging Modes

The NIFS control software will have the standard debugging modes described in ICD 1a, [1].

2–3.8.2 Calibration

If a hall sensor fails or if a mechanism must be disassembled for maintenance, the sensors will need to be recalibrated. A separate program is be provided for this purpose. Calibration procedures are be described in a separate document [13].

2–3.9 Simulation

The Gemini simulation modes are described in ICD 1a, [1]. The NIFS control software supports only the “NONE” mode. The simulator supports only the “FULL” and “FAST” modes.

The “FAST” simulation mode removes most of the simulated delays which are built into the “FULL” simulation mode, but does not fully meet the Gemini specification for the FAST simulation mode. The “VSM” mode is not available.

To switch from operating mode to simulation mode requires an alternate start-up script to be selected, and a reboot. The command to switch between the “FAST” and “FULL” simulations modes is an engineering-only command and does not fall within the scope of this document.

2–4.0 Safety Issues

It will be necessary to avoid moving OIWFS components while the mechanical components are not at thermal equilibrium. Records are be provided to provide a temperature interlock. Details are described in [6].