ICD ?.?/?.? “The NICI to DHS Interface”

James A. Hinds

February 9, 2002
Ver 1.2

Issued By: MKIR

Revision Control

1.0 Initial ICD
1.1 Corrections from Doug Toomey
1.2 DHS sequencing from William Rambold

Table of contents

1 Description

1.1 Purpose

This Interface Design Description describes the interface between NICI and the Data Handling System (DHS). This specific interface is governed by the following parent ICDs, which describe the general properties for interfaces such as this one:

- ICD [3], which provides the foundation on which bulk data is transferred between Gemini systems.
- ICD [4], which provides the basic low-level command interface to the DHS, which the capabilities of ICD 3 are built upon.

NICI communicates with the DHS for two purposes:

- storage of image data.
- the Quick-Look display of images.

1.2 Scope

This document describes the interactions between the DHS and NICI . This is limited to the transfer of images to the DHS for Quick Look Display.
All other data that NICI will be providing for displays, instrument state and status, AO statistics and other monitoring items are covered in ICD xxx.xx (Williams NICI2ICS doc) [11] and use the facilities of EPICS.

1.3 Stylistic Conventions

Text within angle brackets like this < > is used to indicate a range of possible values. Discrete choices are separated by a vertical bar like '|', while a range of choices are separated by a pair of periods like '..'. Units or data type are presented in square brackets like this [ ].

2 Related Documents, glossary and acronyms

2.1 References

[1] *Channel Access Reference Manua*l, J. O. Hill, Los Alamos National Laboratory
[2] *dhs_pdr_icd3/22, ICD3 – Bulk Data Transfer, Gemini 8m Telescopes Project*
[3] *dhs_pdr_icd1c/05, ICD1c – Baseline DHS Interface, Gemini 8m Telescopes Project, Norman Hill, Séverin Gaudet,*Dayle Kotturi
[4] *OCDD for NICI, Doug ToomeyNOST 100-1.0, "Definition of the Flexible Image Transport System (FITS)", NASA Office of Standards and Technology.*
[6] *SPE-C-G0009 -Gemini Software Programming Standards,* Peregrine McGehee & Steve Wampler

2.2 Abbreviations and Acronyms

DHS Data Handling System
EPICS Experimental Physics and Industrial Control System
IC Instrument Controller
IOC Input-Output Controller

MKIR Mauna Kea Infrared
NICI Near Infrared Coronagraphic Instrument
N/A Not applicable here
NGS Natural Guide Star

QL Quick Look, part of the DHS
RISC
SBC Single Board Computer
TBD To Be Determined
TCS Telescope Control System

2.3 Glossary

IS Instrument Sequencer One of the data processing elements of NICI dedicated to converting control information from Gemini's epics system into discrete commands for the NICI instrument to perform. The IS will report back to epics on actions taken by NICI.
IC Instrument Controller – One of the data processing elements of NICI dedicated to processing specific commands intended for NICI. This is the primary interface into NICI for the instrument sequencer or for stand-alone (engineering) mode.
PS Pixel Server – One of the data processing elements of NICI dedicated to receiving images from an Aladdin III imaging array and preparing it for DHS, disk file or human viewing.

2.4 Related Interface Control Drawings

Not applicable

3 Physical System Interfaces

This interface will be implemented among the NICI Instrument Sequencer (IS), NICI instrument control CPU (IC), the dual pixel servers (PS) and the DHS running on a variety of Sun workstations. The DHS library will be used on Linux based x86 processors and must be ported to that architecture.

3.1 Mechanical Interface

Not applicable

3.2 Optical Interface

Not applicable

3.3 Electronic Interface

The interface will be via the Control LAN and Data LAN of the Gemini system using the facilities provided by the DHS libraries described in **Error! Reference source not found.**and **Error! Reference source not found.**. In general, commands and replies/status are passed over the Control LAN while bulk data is passed over the higher bandwidth Data LAN.

The implementation of the LANs is the responsibility of IGPO.

3.4 Mass/Balance

Not applicable

3.5 Thermal Interface

Not applicable

4 Software/Control Function Interface

4.1 Communication Infrastructure

The communication of information is achieved by using the facilities of the DHS libraries described in **Error! Reference source not found.**and **Error! Reference source not found.**. These provide the functionality required to format and exchange bulk data structures over the Data LAN between a client and the DHS Data Server.

NICI will be a “client” of the DHS “server” and will initiate all transactions.

In the following text a “date set item” is considered to be a single complete group of data that the DHS Data Server will treat as a single, complete file. Or in DHS terms this would be considered a single dataset. An image is considered to be a single frame of data that contains a complete image..

5 Behavior

To put the rest of this document in context, this section will describe both instances of the NICI to DHS interactions and the next section will provide a scenario for each. The interactions are:

- Storage of images scanned from the NICI image sensor arrays.
- Display of images scanned from the NICI image sensor arrays.

These will be sent to the DHS, using the formatting and communication functions provided in the DHS libraries **Error! Reference source not found.** and **Error! Reference source not found.**.

5.1 DHS storage

NICI will need to send data items with the DHS. This is for permanent storage of images. These will be destined for permanent storage and will have a lifetime of “DHS_BD_LT_PERMANENT”. For each data item there will be one frame (one DHS data set for each of NICI’s two imaging arrays).
The Instrument Sequencer will obtain data set identifiers from the DHS system, the Instrument Controller will populate the data set with header information, and the pixel server will continue with further header information as well as the data from the image.

5.2 QLT display

Observers will require a pseudo real-time display of various aspects of the operating instrument. These will be provided by using the quick look tool.
NICI is responsible for formatting signals into a rectangular image that can be displayed by the QLT. Any scan from either imaging arrays will be able to be sent to the quick look system. The DHS will not attempt any interpretation of these images.

6 Scenarios

This section describes the interactions for data set storage to DHS and the use of the quick look system.

6.1 Image Data-set Operation of the NICI to DHS Communication

The following scenarios illustrate how NICI will interact with the Gemini Data Handling System during normal operation.

6.1.1 Connecting to DHS on startup.

Whenever the instrument control program is re-started the following actions must take place to re-establish communications with the Data Handling System.

6.1.1.1 Nici controller:

1. Initialize the DHS interface library.
2. Define write callback function.
3. Define error callback function.
4. Start the DHS event loop.
5. Set the DHS debugging level. Normal operation runs with debugging disabled.
6. Establish the instrument controller connection to the DHS.

6.1.1.2 Pixel server 1:

1. Initialize the DHS interface library.
2. Define write callback function.
3. Define error callback function.
4. Start the DHS event loop.
5. Set the DHS debugging level.
6. Establish the first pixel server connection to the DHS.

6.1.1.3 Pixel server 2:

1. Initialize the DHS interface library.
2. Define write callback function.
3. Define error callback function.
4. Start the DHS event loop.
5. Set the DHS debugging level.
6. Establish the second pixel server controller connection to the DHS.

6.1.2 Saving a single full-frame exposure.

Before sending the observe command to NICI the higher-level software will request a data label from the DHS and will populate the FITS header with the information gathered from other Gemini systems. It will also include “NICI”, “NICIps1” and “NICIps2” in the list of contributors to this exposure. The data label (dataLabel) is passed to NICI when the observe command is issued.

6.1.2.1 Nici Controller:

This scenario will create a single dataset containing just the instrument configuration information for this exposure.

1. Indicate that the data for this exposure is for permanent storage.
2. Create a dataset for the exposure.
3. Identify the instrument creating the dataset.
4. Write the fits keywords that define the instrument configuration at the start of exposure such as AO configuration parameters, filter names, mask names, tracking modes, number of detectors saving data, etc.
5. Start the exposure and pass the data label to the two pixel servers. The following pixel server action sets should take place in parallel. Wait for both servers to indicate that the exposure is complete and they have written the data to the DHS successfully.
6. Write any fits keywords that describe the instrument configuration at the end of exposure. These would only contain things that changed during the exposure.
7. Transfer the header to the DHS (tell it that this the last put for this dataset), wait for the header to be written then free up the dataset resources since we have nothing else to do for this exposure.
8. Indicate to the higher-level software that the exposure has finished.

6.1.2.2 Pixel server 1:

Start the exposure and wait for it to complete. It is assumed here that the data is saved internally somehow before being transferred to the DHS when the exposure is finished. This scenario will create a single dataset for the detector with a single frame containing the exposure data.

1. Indicate that the data from this array is for permanent storage.
2. Create a dataset for the exposure.
3. Identify the instrument creating the dataset.
4. Write the fits keywords that describe the exposure such as start time, stop time, integration time, elapsed time etc.
5. Prepare the storage array information that the DHS will need.
6. Create a frame in the dataset to hold the array data from pixel server 1. Note that this returns a pointer to a buffer into which the exposure data must be put.
7. Add the mandatory axis size and origin attributes.
8. Define other stuff of interest to the end user.
9. Recover the exposure data from wherever it was stored and copy it into the data frame buffer created by the dhsFrameNew call.
10. Transfer the data to the DHS and wait for it to be accepted before releasing the resources. For this example it is assumed that the entire exposure can be sent as a single put. Since there is only one transfer required and all of the keywords have already been defined the dataset is complete at this point. TRUE means that the dataset if finished. Append the frame number to the dataLabel (dataLabel.1) to indicate that this is the first frame of the dataset.
11. Indicate to the NICI controller that the exposure is finished and that the data has been saved to the DHS successfully.

6.1.2.3 Pixel server 2:

Identical to pixel server 1 only using the array configuration information and data from the second detector.

6.1.3 Saving a multiple frame exposure.

Before sending the observe command to NICI the higher-level software will request a data label from the DHS and will populate the FITS header with the information gathered from other Gemini systems. It will also include “NICI”, “NICIps1” and “NICIps2” in the list of contributors to this exposure. The data label (dataLabel) is passed to NICI when the observe command is issued. Since all of the exposure data has been saved internally already the transfer to the DHS is not a “real time” action. As such, it is possible to be safe and wait for each frame to be accepted by the DHS before sending the next one.

6.1.3.1 Nici Controller:

Identical to the single frame scenario.

6.1.3.2 Pixel server 1:

Start the exposure and wait for it to complete. It is assumed here that the data is saved internally somehow before being transferred to the DHS when the exposure is finished. This scenario will create a single dataset for the detector containing a single data frame for each readout frame saved during the exposure.

1. Indicate that the data from this array is for permanent storage.
2. Create a dataset for the exposure.
3. Identify the instrument creating the dataset.
4. Write the fits keywords that define the array configuration at the start of exposure such as detector temperature, clock voltages, number of coadds etc.
5. Write the fits keywords that define the exposure such as integration time, number of co-adds, start and end times, etc.
6. Prepare the storage array information that the DHS will need.

For each data frame in the exposure:

7. Create a frame in the dataset to hold the data frame from pixel server 1. Note that the call returns a pointer to a buffer into which the exposure data must be put for that frame.
8. Add the mandatory axis size and origin attributes.
9. Define other stuff of interest to the end user.
10. Write the fits keywords that define the exposure such as integration time, number of co-adds, start and end times, etc.
11. Recover the exposure data from wherever it was stored and copy it into the data frame buffer created by the dhsFrameNew call.
12. Transfer the frame to the DHS. Wait for the transfer to complete successfully before sending the next frame. For all but the last fame the “last frame” argument will be false. When sending the last frame set it to TRUE. For each frame append the frame number to the dataLabel (dataLabel.1, dataLabel.2, etc.) to indicate the frame order.
13. When all of the data frames have been saved to the DHS then the dataset is complete and the dataset resources can be freed.
14. Indicate to the NICI controller that the exposure is finished and that the data has been saved to the DHS successfully.

6.1.3.3 Pixel server 2:

Identical to pixel server 1 only using the array configuration information and data from the second detector.

6.1.4 Saving a multiple sub-array exposure.

6.1.4.1 Nici Controller:

Identical to the other exposure scenarios.

6.1.4.2 Pixel Server 1:

Start the exposure and wait for it to complete. It is assumed here that the data is saved internally somehow before being transferred to the DHS when the exposure is finished. This scenario will create a separate dataset for the each sub-array. Each dataset will contain a single data frame for the sub-array data.

1. Indicate that the data from this array is for permanent storage.

For each sub-array:

2. Create a dataset for the sub-array.
3. Identify the instrument creating the dataset.
4. Write the fits keywords that define the array configuration at the start of exposure such as detector temperature, clock voltages, number of coadds etc.
5. Write the fits keywords that define the exposure such as integration time, number of co-adds, start and end times, etc.
6. Prepare the storage array information that the DHS will need. The size and origin are set to the values for the sub-array being saved.
7. Create a data frame in the dataset to hold the sub-array data from pixel server 1. Note that the call returns a pointer to a buffer into which the exposure data must be put for that frame.
8. Add the mandatory axis size and origin attributes.
9. Define other stuff of interest to the end user (e.g. axis labels).
10. Write the fits keywords that define the exposure such as integration time, number of co-adds, start and end times, etc.Recover the sub-array data from wherever it was stored and copy it into the data frame buffer created by the dhsFrameNew call.
12. Transfer the frame to the DHS. Since this is the only frame the lastFrame argument can be set to TRUE. Append the frame number to the dataLabel (dataLabel.1) to indicate that this is the first frame of the dataset.
13. Since there is nothing more to be sent for this dataset the associated resources can be freed up at this time.
14. When all sub-array datasets have been written successfully to the DHS indicate to the NICI controller that the exposure is finished and that the data has been saved to the DHS successfully.

6.1.4.3 Pixel server 2:

Identical to pixel server 1 only using the array configuration information and data from the second detector.

6.2 Images sent for QLT

If the information is to be sent to the quick look system instead (or additionally), the identical sequence will be done with the quick look tool as the subscriber and lifetime of “DHS_BD_LT_TEMPORARY”. The ability to re-send the pixel contents of a single scan to multiple destinations will be implemented. Here NICI sends a series of images to be displayed in a DHS QLT window. NICI is responsible for formatting any images into rectangular arrays of data.

This sequence will consist of:

1. At start-up, NICI initializes a connection to the DHS.
2. NICI requests a unique data-set label from the DHS and sets the lifetime of the data-set to “DHS_BD_LT_TEMPORARY”.
3. NICI creates a new intensity frame for the data. The data is sent to the DHS. The “last” parameter of the “dhsBdPut()” function is set to DHS_FALSE and the data type is set to “DHS_BD_PT_DS_QL”.
4. The DHS displays the image in a QLT. UNTIL NICI is directed to no longer display the images.
5. NICI then sends a delete command to the DHS for that data-set label.
6. NICI frees up the data structures.

NICI interaction with the DHS summary

7 Detailed Data Description

This section will describe in detail the interface issues.

7.1 Data formats

The data that is to be sent to the DHS will take the form of 2 or 3 dimensional images. Data sent for QLT will always be 2-dimensional images. These may be many arriving at the fastest possible update rate, but each will be a single 2-dimensional image. The dimensionality of images meant for storage, either permanent or temporary, will depend on the sub-array (region of interest) specification.
Single regions of interest will be sent as 2 dimensional images with NAXIS1 and NAXIS2 set to the x and y dimensions of the subarray. Multiple regions of interest will be sent mapped onto the full 1024 by 1024 image area. Multiple regions of interest can be requested to be packaged as unmapped (in hardware scan-out order) along with a mapping vector. This allows for re-mapping to be done downstream The image mapping vector is sent first as a separate array.

7.2 Header Information

The header information that accompanies data transferred to the DHS will depend on whether the data is for store or for QLT only. Some of the header items required for **Error! Reference source not found.** will not be shown here.

7.2.1 Data Store Header Items

As these data items will be archived and/or processed, they will contain as complete a header set as possible. **Error! Reference source not found.** describes the items in common to all image store sources.

Table 1 Header Items Common To All Data Store Images

Name	Type	Units and Range	Comments
NAXIS	integer	1 – 3	FITS standard for dimensionality
NAXIS1	integer		Size of axis 1
NAXIS2	integer		Size of axis 2. This is only in the case of 2-D or 3-D data.
NAXIS3	integer		Size of axis 3. This is only in the case of 3-D data.
BUNIT	string		Data units.
UTSTART	string	“UT“	UT at beginning of observation
UTEND	string	“UT“	UT at end of observation
EXPTIME	float	seconds	Total integration time.
ELAPSED	float	seconds	Total elapsed time (including readout time etc).
XPROBE	float	mm	X position of AOWFS probe in focal plane
YPROBE	float	mm	Y position of AOWFS probe in focal plane
BLANK	integer		The value used to indicate a blank pixel
WFSFOCUS	float	mm	The WFS focus setting
TITLE	string		Title of observation
COMMENT[0-n]	string		Comments for the observation
DETECT	string	TBD	The source of the data
INSTRUME	string	“NICI ”	This instrument
OBSTYPE	string	TBD	The observation type.
OBSID	string		The Observation ID obtained from the OCS

7.2.2 QLT Images

As these images are strictly for QLT, and it is more important for the images to be quickly updated, they will likely only contain the header information necessary for correct display. **Error! Reference source not found.** contains the header items, other than those required for FITS images **Error! Reference source not found.**, that will be present.

Table 2 Header items specifically for Quick Look Images

Name	Type	Units and Range	Comments
NAXIS	integer	2	FITS standard for dimensionality
NAXIS1	integer	Size of axis 1	
NAXIS2	integer	Size of axis 2.	

BUNIT	string	Data units.	
UTSTART	string	“UT“	UT at beginning of observation
UTEND	string	“UT“	UT at end of observation
EXPTIME	float	seconds	Total integration time.
TITLE	string		Title of observation
DETECT	string	“ARRAY1” | “ARRAY2”	The source of the data
INSTRUME	string	“NICI ”	This instrument
OBSTYPE	string	“DARK“ | “FLAT“ | “NGS_WFS“ | “ZERNIKE“ | “DM”	The observation type. DARK and FLAT are for calibration. NGS_WFS is for Natural Guide Star observations
OBSID	string		The Observation ID obtained from the DHS
BLANK	int		The value used to indicate a blank pixel

7.3 Command description

All the commands recognized by the DHS across a data link are described in ICD1c **Error! Bookmark not defined.Error! Reference source not found.**and ICD 3 **Error! Reference source not found.**.

7.4 Status information

N/A

7.5 Alarm conditions

N/A

7.6 Debugging and Maintenance

This interface will be debugged using the Data Server supplied by the DHS.

7.7 Simulation

This interface will be simulated using the Data Server in simulation mode supplied by the DHS group..

8 Safety Issues

At present no safety issues have been identified relating to this interface.