

National  
Optical  
Astronomy  
Observatories

950 N. Cherry Ave.  
P. O. Box 26732  
Tucson, Arizona 85726-6732  
(520) 318-8000 FAX: (520) 318-8303  
Telex 1561401 Aura Ut

---

# MONSOON Image Acquisition System (Pixel Server)

## Supervisor Layer Software Design Document

Authored by:  
Nick C. Buchholz

5/17/2002  
**Initial Draft:**  
Please send comments:  
[starr@noao.edu](mailto:starr@noao.edu)

# Revision Chart

Version	Date Approved	Sections Affected	Remarks

## Identification

It is NOAO Document # XXXXXXXXXXX.

## Document Acceptance and Concurrence

This document represents the current understanding of the functional and performance requirements of the MONSOON Image Acquisition System to be developed at NOAO and deployed on systems at Kitt Peak National Observatory (KPNO) and at the Cerro Tello International Observatory (CTIO)

---

Barry Starr, MONSOON Project Manager and System Engineer

---

Michael Merrill, MONSOON Project Scientist IR

---

Chuck Claver, MONSOON Project Scientist Optical

---

Larry Daggert, NOAO ETS Manager

---

Sam Barden, IPAC Chair

---

Richard Green, KPNO Director

---

Alistair Walker, CTIO Deputy Director

# Table of Contents

## List of Figures

## List of Tables

## Preface

**This is an initial draft, submitted for discussion and comment.**

## Document Scope

This MONSOON Supervisor Layer Design document is the top-level subsystem design document for the MONSOON component that handles the upper level Connection and communication with the Science and Engineering Clients. It will incorporate the operational concepts previously defined in the MONSOON Operational Concepts Definition Document (OCDD), and the detailed requirements and constraints from the MONSOON Functional Performance and Requirements Document (FPRD). This Document receives its specification from the MONSOON System Architecture Document.

This document is intended to show the detailed issues of the MSL software. It will flow-down the system requirements from the MONSOON System Architecture Document to the Supervisor Layer Processes and software.

## Document Overview

This MONSOON Supervisor layer Software Design Document is modeled after the IEEE Recommended Practice for Software Design Documents referenced below in Section 1.3. It is intended to communicate system details to the users, developers, and support staff at NOAO.

The intended audience for this document is the Scientific and Technical Staff at NOAO and elsewhere in the astronomical community who are stakeholders in the MONSOON system. A stakeholder being any individual who either uses, supports, or is in some way affected by this system.

# 1.0 Introduction

## 1.1 Acronyms

ADC	Analog to Digital Converter
DAC	Digital to Analog Converter
DCS	Detector Control System
DHE	Detector Head Electronics
DHS	Data Handling System
FITS	Flexible Image Transport System
FPA	Focal Plane Array
<b>GPX</b>	Generic Pixel Server
MONSOON	Not an acronym
MSL	MONSOON Supervisor Layer
ICD	Interface Control Document
ICS	Instrument Control System
IDPS	Image Data Pre-processor System
ID	Identifier
IR	Infrared
LAN	Local Area Network
N/A	Not Applicable
OCS	Observatory Control System
ROI	Region of Interest
TBD	To Be Decided

## 1.2 Glossary

**Attribute** - An entity which describes some aspect of the configuration of a system, subsystem, or component, such as the level of a voltage or the state of a shutter. Certain attributes will be used by as command parameters. The OCS communicates with a science instrument by sending it sets of "attributes" and "values".

**Command** - An instruction commanding a system to start some action. The action may result in a voltage changing or some internal parameters being set to particular values. A command may have command parameters (aka. "arguments") which contain the details of the instruction to be obeyed.

**Pixel Acquisition Node (PAN)**- A component of the MONSOON Image Acquisition System or Pixel Server. The PAN is the computer and associated software which the interface to the Detector Head Electronics (DHE) and provide the image pre-processing of the data stream from the DHE. The PAN was formerly referred to as the Data Acquisition Node in previous MONSOON Documentation.

**Data array** -The data, while it is stored in data processing memory, which resulted from one or more readouts of an IR array or CCD detector.

**Data Set** - A self-contained collection of data generated as a result of an Pixel Server obeying a gpxStartExp command. Each gpxStartExp command results in one and only one data set.

**Exposure** - The name used to describe the process and the data resulting from the activity of resetting/clearing a detector, exposing it to photons and then reading out the data. This may include multiple sample readout techniques such as Fowler sampling,

sample up the ramp, etc. (For example, an exposure would be the data array which results when a single Reset-Readout-Integrate-Readout cycle is performed on an IR detector or a single CCD Clear-Integrate-Readout cycle.)

**Single Exposure Sequence** – Exposure sequence where all exposure parameters are fixed and the detector is readout (1 to N) times and combined to form a single image. Examples would be a simple reset read cycle of a classic CCD or IR detector, Fowler Sampling, Co-additions of Images, Orthogonal Transfer Imaging (Guide Region Readout followed by centroid calculation followed by image shift, n times til final image formed).

**Multiple Exposure Sequence** – Exposure sequences with potentially varied exposure configurations and the data stored as multiple images. Examples would test routines such as the Photon Transfer Curve, multiple time-stamped exposures, multiple exposures synched to an external source such as a AO system or Chopper system.

**Frame** - A frame is the result of one or more readouts of an array averaged pixel by pixel. Each frame represents the signal values obtained from reading the entire ROI being read out of the detector. Multiple frames may be processed into a single exposure.

**Image** - The array of detector pixel and description data representing a science or diagnostic image or spectrum. An image is capable of being displayed or processed as a discrete entity. The values in the array may be stored in memory or on disk and are related to the data taken by the detector by some processing algorithm, (for example an image may consist of all the coadded and averaged exposures in one beam of a chop mode gpxStartExp command).

**Observation** - The process of exposing the detector to photons in one or more exposures. The result of an observation is a picture???. Observation Data Set???? Image????.

**Readout** - When used as a noun to describe instrument data, this refers to a single read of every pixel in the detector region of interest. A one or more readouts can be averaged pixel by pixel to create a frame.

**ROI** - A Region of Interest is a sub array of the available detector area. There are two types of sub-arrays, which can be defined. The Sequence ROI is an ROI on the active surface of the array used to increase the frequency of the Array readout. The Data Reduction ROI is an arbitrary rectangle of any size, which fits on the Array. Data Reduction ROI's are defined to reduce the volume of data sent to the disk or DHS even when the entire Array is being read out.

**Value** - The value associated with an "attribute".

**Detector Head Electronics (DHE)**- A component of the MONSOON Image Acquisition System or Pixel Server. The lowest level MONSOON subsystem, normally closely connected to the detector and the dewar in which the detector resides for signal integrity issues. The DHE connects to the PAN through a fiberoptic interface cable. Previously called the MONSOON Detector Controller.

**Pixel Acquisition Node** – A component of the MONSOON Image Acquisition System or Pixel Server. The Pixel Acquisition Node runs on a general purpose computer to handle the translation from the GPX interface and the interface to the DHE. This is the node which handles the pixel data pre-processing and the creation of images in the required format. The PAN connects to the DHE through a fiber-optic interface cable.

**Pixel Server** - A system that produces images when requested to do so by some client system. The MONSOON Image Acquisition System is a Pixel Server.

**Generic Pixel Server Interface-** A pixel server command and data interface that conforms to the GPX Interface description. The goal is to allow multiple pixel server implementations conform to the same interface definition.

**Supervisory Layer.** A component of the MONSOON Image Acquisition System or Pixel Server. The Supervisory Layer is the software layer that coordinates multiple Pixel Acquisition node – Detector Head Electronics pairs into a single integrated system. In the event where only a single PAN-DHE node pair is needed the Supervisory layer much reduced in size and Function. The Supervisory Layer adheres to the GPX interface defined in **[9]** below, and in the case of a single PAN-DHE node pair may reside on the PAN hardware if desired or it may run on a separate computer networked to the PAN.

### 1.3 References

- 1) SPE-C-G0037, "Software Design Description", Gemini 8m Telescopes Project.
- 2) "ICD/16 — The Parameter Definition Format", Steve Wampler, Gemini 8m Telescopes Project.
- 3) WHT-PDF-1, "FITS headers for WHT FITS tapes", Steve Unger, Guy Rixon & Frank Gribbin, RGO.
- 4) NOST 100-1.0, "Definition of the Flexible Image Transport System (FITS)", NASA Office of Standards and Technology.
- 5) GEN-SPE-ESO-00000-794, "ESO Data Interface Control Document", Miguel Albrecht, ESO.
- 6) IEEE Std 610.12-1990 - "IEEE standard glossary of software engineering terminology", Standards Coordinating Committee of the IEEE Computer Society, USA, 19901210
- 7) ANSI/IEEE Std 754-1985 - "IEEE Standard for binary floating-point arithmetic" - Standards Committee of the IEEE Computer Society, USA 19850812
- 8) xxxx "XDR - Extended data representation Standard" ????
- 9) NOAO Document ###.###.&&& - ICD 4.0 Version 0.1.2 - "Generic Pixel Server-Communications, Command/Response and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- 10) NOAO Document ###.###.&&& - ICD 4.1 Version 0.1.2 - "Generic Pixel Server-Communications, Command/Response and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- 11) NOAO Document ###.###.&&& - ICD 6.0 Version 0.1.2 - "Generic Head Electronics - Command and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- 12) NOAO Document ###.###.&&& - ICD 6.1 Version 0.1.2 - "MONSOON DHE - Command and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- 13)

## 2.0 MONSOON System Description

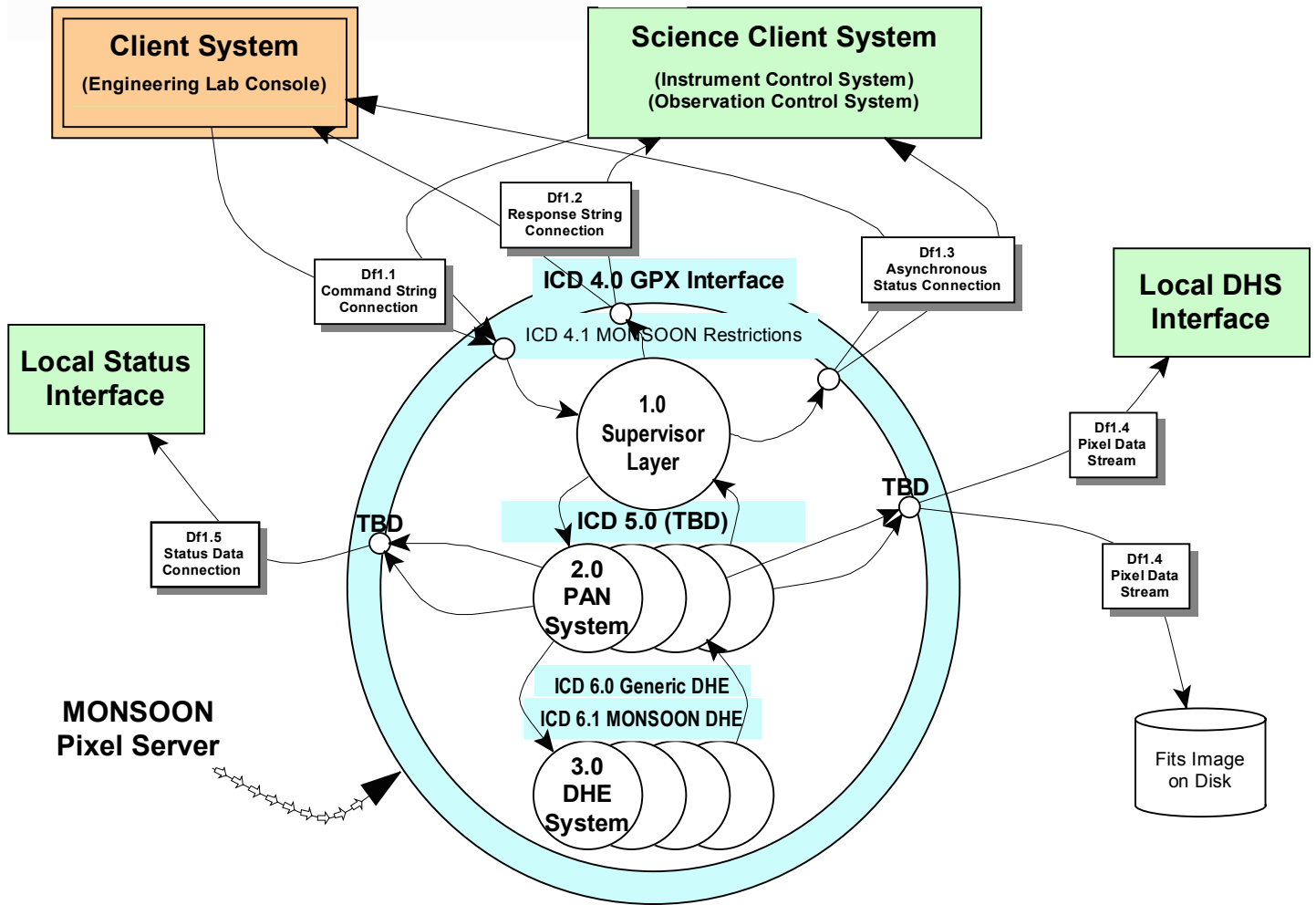
### 2.1 MONSOON System Overview

The MONSOON Supervisor layer software is the top-level system in the decomposition of the MONSOON System Architecture. It provides the interface to the Science and Engineering Clients and handles the connection protocols, Connection and network security and in the case of multiple PAN-DHE pairs will handle the scatter gather functions required to control the multiple nodes. It handles no pixel data but may provide coordination of an exposure data transfer from the PAN's to the Final Data destination. Figure 1 below, from the MONSOON System Architecture Document, shows the MSL in the context of the entire MONSOON system.



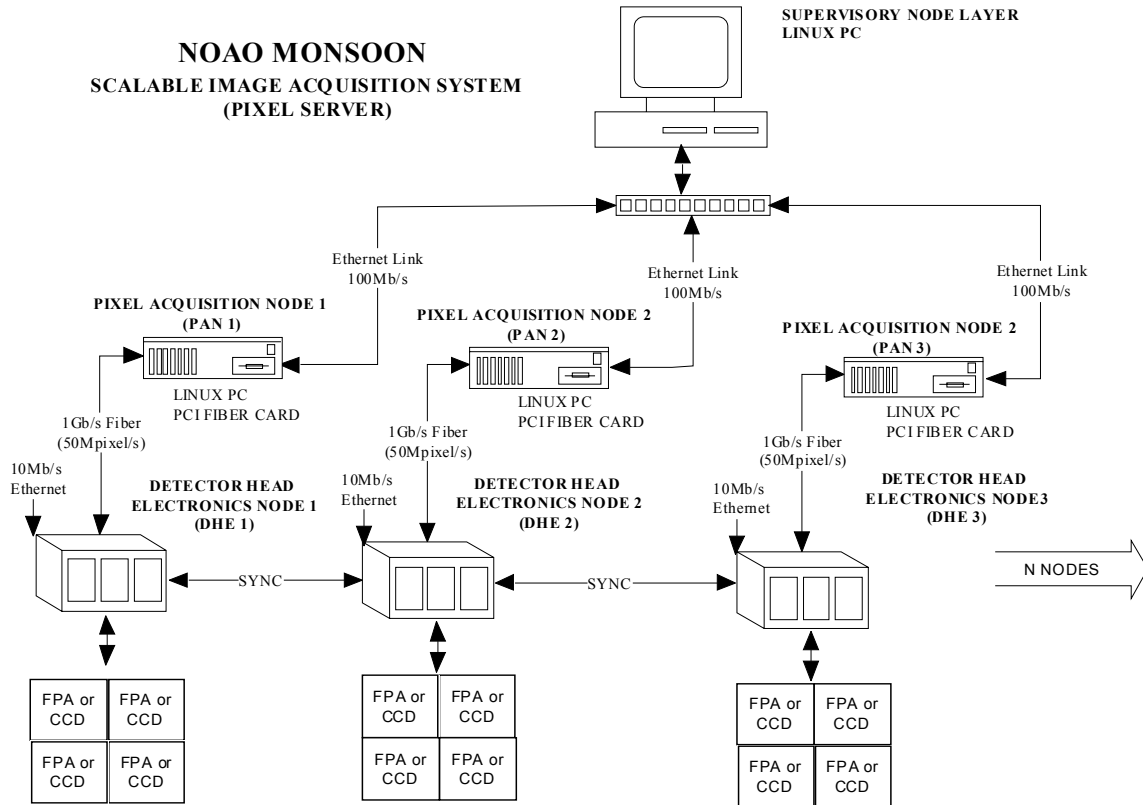


# Monsoon System Context Diagram (Level 0)



**Figure 1 MONSOON System Context Data Flow Model.** Shows the major “layers” of the MONSOON System. The Supervisor Layer, the Pixel Acquisition Node (PAN) Layer, and the Detector Head Electronics (DHE) Layer, as well as external entities, that are sources and sinks of data in and out of MONSOON.

The MONSOON system is based on a scalable network of powerful, low-cost LINUX-based PC's, each supporting a commercial 1Gb/sec (or 2.4Gb/s) fiber optic link. This architecture, shown below in Figure 2, yields digital communications and processing platform which can be used for large imaging systems.



**Figure 2 MONSOON Scalable Image Acquisition System Architecture.** Illustrates a possible  $N$  node implementation. Nodes are added to the system as needed and or as costs permit.

In the case of a 1-node system, which will be the case for the ORION, NEWFIRM or QUOTA systems, the “Supervisory layer” may run on the PAN. The supervisory layer of the software provides single entry point to the MONSOON system for the Client systems. Whether or not multiple Pixel Acquisition Nodes – DHE pairs are needed in a given application is unnecessary information to the client systems and can therefore be mostly hidden. In this design PAN-DHE node pairs can be added as needed up to an arbitrarily large limit.

## 2.2 MONSOON System Performance Specification

Detector technology should be the limiting system performance parameter for this system. A formal analysis and requirements flowdown to the interface electronics has been performed based on the most optimistic and demanding performance parameters projected. These general requirements are as follows:

- All Data Pipelines to Support 32-bit Transfer for Future Expansion
- Current Dynamic Range: > 60,000:1 – 16-Bit 1MHz ADC Resolution, supporting S/N > 90dB
- NonLinearity: < 0.01% over Entire Range
- ReadNoise: < 10% Contribution to Total System Readnoise – Actual Input Noise and System Gain & Bandwidth Set By Detector Used

- Channel to Channel Crosstalk: < 0.005%
- Pixel to Pixel Crosstalk: < 0.01%
- Data Rates: Upto 120Mpixel/sec per Controller Chassis
- Data Processing Rates at Controller
- # of Channels/Controller: Upto 256 Channels per Controller Chassis
- Calibrated, Measured, Recorded Performance.

## 2.3 MONSOON MSLHardware Description

The MONSOON Image Acquisition System Architecture Diagram in Figure 2 above outlines the most general form of a MONSOON system. A simplification of the general case, consisting of a single PAN-DHE node pair, will be used in the description process. Since the PAN-DHE node pairs in a system use identical software and the Supervisory layer is the only part of the system which needs to know the actual configuration for most purposes the description of a single node system is sufficient to outline the basic design of the software. MSL software is an independent low resource process which may run on the PAN node or in a separate node in the system.

### 2.3.1 MSL Computer Description

The MSL hardware consists of a single general purpose computer equipped with Ethernet connections to external systems, an internal hard disk and internal memory equivalent to at least .25 Giga-Byte. The current design calls for the use of LINUX PCI bus based systems with giga-Hz class CPU's.

### 2.3.2 MSL Communications Links

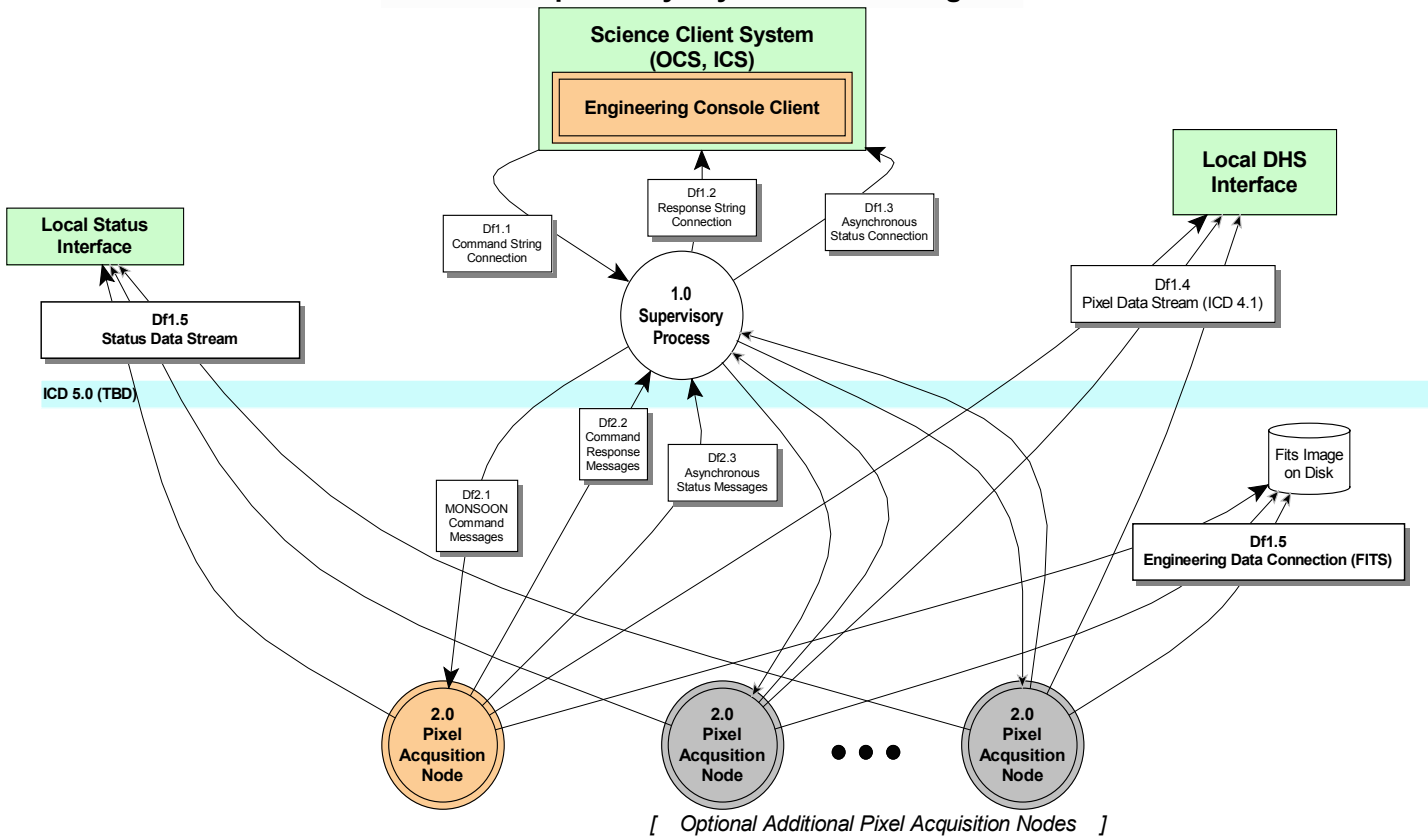
Using Figure 2 above as a reference, the MSL requires only one significant communication links between the MSL and other parts of the system. The Ethernet Link to the outside world. is ground-isolated 100-base-T Ethernet. This can be upgraded to 100-Base-T if necessary or additional links can be added for data transmission.

## 3.0 MONSOON Supervisor Layer Software Design

Figure 1 on page 9 shows where the PAN software exists in the overall MONSOON system. The interface to the PAN nodes will be ICD 5.0, this interface should be a proper subset of ICD 4.0 the GPX interface. The Supervisory Process exists in the system to handle all the details imposed on the system by multiple PAN-DHE node pairs.

Figure 3 below details the context for the PAN software.

**Monsoon Supervisory Layer Data Flow Diagram (Level 0)**



**Figure 3 MONSOON MSL Context diagram** – This diagram shows the data flows between the MSL and the external sources and sinks of data and commands.

The diagram contains an external entitie labeled “Engineering Console Client”. This engineering client accesses the system through the normal interfaces for most purposes but may include methods that will allow the normal ICD 4.0/5.0 interface to be by-passed in the case that this is necessary.

### 3.1 Interfaces

Four Interface documents exist that outline the four command, response and data streams between the MSL and external entities. These include: the GPX interface and Supervisory Node-PAN interfaces in ICD 4.0, ICD4.1 which spells out the restricted commands and parameters which only the engineering interfaces can see, the Generic DHE interface in ICD 6.0 and the MONSOON specific interface between the DHE driver software and the DHE software in the DHE in ICD 6.1.

Interfaces between the various components of the PAN software will be described below in the sections dealing with those components.

- NOAO Document ###.###.&&& - ICD 4.0 Version 0.1.2 - “Generic Pixel Server-Communications, Command/Response and Data Stream Interface Description”, Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308

- NOAO Document ###.###.&&& - ICD 4.1 Version 0.0.0 - "Science Client Command and Parameter Restrictions", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- NOAO Document ###.###.&&& - ICD 6.0 Version 0.1.2 - "Generic Head Electronics - Command and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308
- NOAO Document ###.###.&&& - ICD 6.1 Version 0.1.2 - "MONSOON DHE - Command and Data Stream Interface Description", Nick C. Buchholz(NOAO), Barry M. Starr(NOAO), 20020308

### 3.2 MSL Top-level Functions and Requirements

The MONSOON PAN system must be able to perform the following functions:

1. On Boot-up, Initialize the MSL software. **FPRD 2.2.2.1**
2. Connect to the PAN's in the system according to the System configuration **FPRD 2.2.2.1**
3. Start-up the connection handler and connection Security software. **FPRD 2.2.2.1**
4. Accept Client system Connection requests and connect to Client systems.
5. Receive, Verify and reformat (as needed) Client Commands. **FPRD 2.2.2.2**
6. Verify Valid Commands and pass commands to the PAN(s) as required **FPRD 2.2.2.3**
7. Accept and gather Command responses from system components and pass to Clients. **FPRD 2.2.2.3**
8. Accept and gather Asynchronous messages from the PAN-DHE pairs **FPRD 2.2.2.3**
9. Coordinate the boot-up and error recovery of Multiple PAN systems **FPRD 2.2.2.6**
10. Cause the processed data to be preserved or archived for later use **FPRD 2.2.2.6**
11. Detect, log and recover from errors as able. **FPRD 2.3.7**
12. Handle Accesses to the Configuration Database

### 3.3 MSL System Decomposition

This section will decompose the MONSOON Supervisor Layer (MSL) software into modules. The modules are chosen to efficiently accomplish the functions and requirements assigned to the MSL software and to allow independent development of the modules. Some modules may be implemented as Processes and some as libraries of routines to be used by the processes. Part of the decision process for this decomposition was the ability for modules to be developed independently.

Figure 4 below is the first level Data flow decomposition of the MSL software. Following the diagram are explanations of the Data Flows, Data stores, Processes and external entities displayed in the diagram.

## Monsoon Supervisory Layer Data Flow Diagram (Level 0)

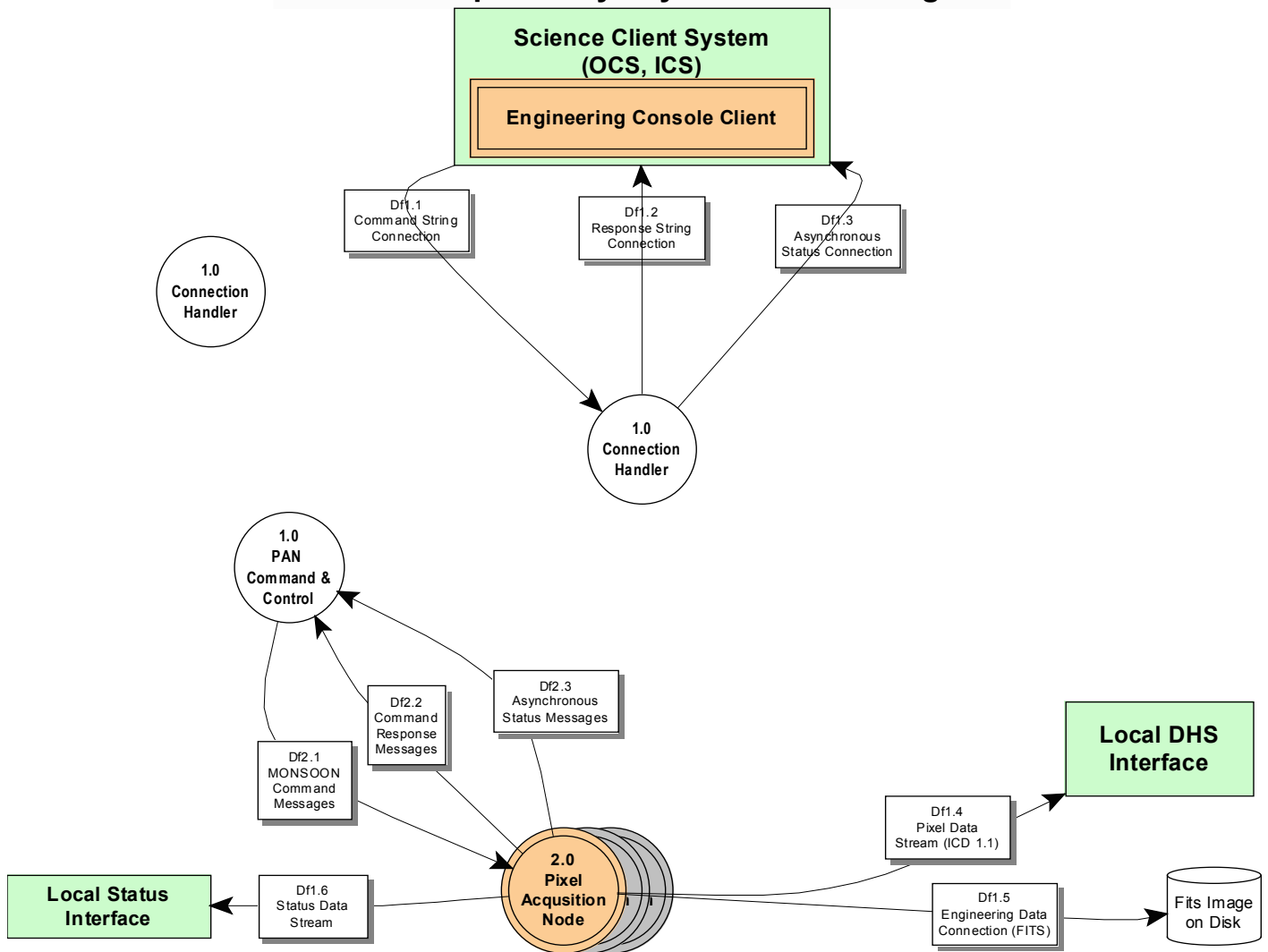


Figure 4 Monsoon PAN Level 1 System Decomposition

### I. External Entities

- Client Systems
- Local DHS Interface
- Local Status Interface
- FITS image on Disk
- Engineering Console Client
- 2.0 Pixel Acquisition Node(s)

### II. MSL Processes

- 1.1 Connection Handler
- 1.2 Connection security
- 1.3 Command Processor
- 1.4 Database Access Routines

- 1.5 PAN Command and Control
- 1.6 Command Response Handler
- 1.7 Asynchronous Message Handler

### **III.** Data Stores

- DS 1.01 – Configuration Database
- DS 1.02 – Connection Data store
- DS 1.03 – Command Structure Data store

### **IV.** Data Flows

- Df 1.4 Pixel Data Stream (ICD 4.1)

## **3.4 MSL Design Decomposition**

**3.4.1**

**3.4.2**

**3.4.3**

**3.4.4**

**3.4.5**

**3.4.6**

**3.4.7**

## **3.5 Module Interface APIs**

**3.5.1**

**3.5.2**

**3.5.3**

**3.5.4**

**3.5.5**

## **3.6 Process Descriptions**

**3.6.1**

**3.6.2**

**3.6.3**

**3.6.4**

**3.6.5**

**3.6.6**

**3.6.7**

## **3.7 Engineering Console Client**

?? Windows based LabView Application ??

### **3.7.1 Test sequencing**

Use LABVIEW scripting language???

### **3.7.2 Test Hardware Control**

Test hardware with provided LabView interfaces and drivers.

### **3.7.3 GPX control**

'C' or Labview implementation of GPX interface ICD 4.0



### 3.7.4 Error handling

LabView error handling

## 4.0 MSL Software Detailed Design

### 4.1 Detailed Interface Support

### 4.2 Process Designs

#### 4.2.1 Initialization / Connection Handler

##### 4.2.1.1 Data Flow Diagrams

##### 4.2.1.2 Process State Diagrams

##### 4.2.1.3 Process Psuedo Code

##### 4.2.1.4 Correctness

#### 4.2.2 Command Acceptor & Interpreter

#### 4.2.3 Command Response Handler

#### 4.2.4 Detector Control System

#### 4.2.5 Image Data Pre-processor System

#### 4.2.6 Asynchronous Response Handler

### 4.3 Engineering Console Support

Console may have a direct link to DHE code to facilitate low level debugging. Though this is **NOT** necessary.