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# **GMT Software and Controls Work Breakdown Structure**

***Release 1.2-6***

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## **INTRODUCTION**

This document includes the definition of the Software and Controls System (SWCS) Work Breakdown Structure (WBS).

The SWCS is breakdown in subsystems, packages and components. For each SWCS subsystem the following information is included:

- A short description of the subsystem
- A diagram of the subsystem packages
- A listing of the components that conform each package. For each

component the component id and a short description are listed. Each component id includes a suffix that represents the component class. Component classes are defined formally in the SWCS metamodel. For each component class a workflow for producing instances of those components is included in the SWCS Handbook.

## SOFTWARE AND CONTROLS WBS

The GMT Software and Controls System (SWCS) provides the software and hardware necessary to operate the GMT observatory and to control and monitor the GMT optomechanical subsystems. Additionally the SWCS provides a set of observatory services common to all the software subsystems.

### 2.1 Software System Engineering and Management

The Engineering and Management Domain provides support for the system engineering level tasks necessary for the development of the GMT Software and Controls System.

#### 2.1.1 System Engineering and Management

The System Engineering and Management System includes the resources and activities for the overall management of the activities necessary for the development of the GMT SWC System.

##### 2.1.1.1 SWC System Travel Package

SWC System Travel Package includes the resources for the travel of group members during the life of the project. Travels include coordination meeting with partner institutions, oversight of software deliverables procured by external parties, Factory and Site Acceptance Testing and system commissioning.

##### 2.1.1.2 SWC System Management Package

The SWCS Management Package includes the activities for the coordination and planning of the SWCS development effort.

##### 2.1.1.3 SWC System Engineering Package

The SWC System Engineering Package includes the resources necessary for the system engineering effort during the inception phase and for the coordination between the project and the SWCS system engineering activities.

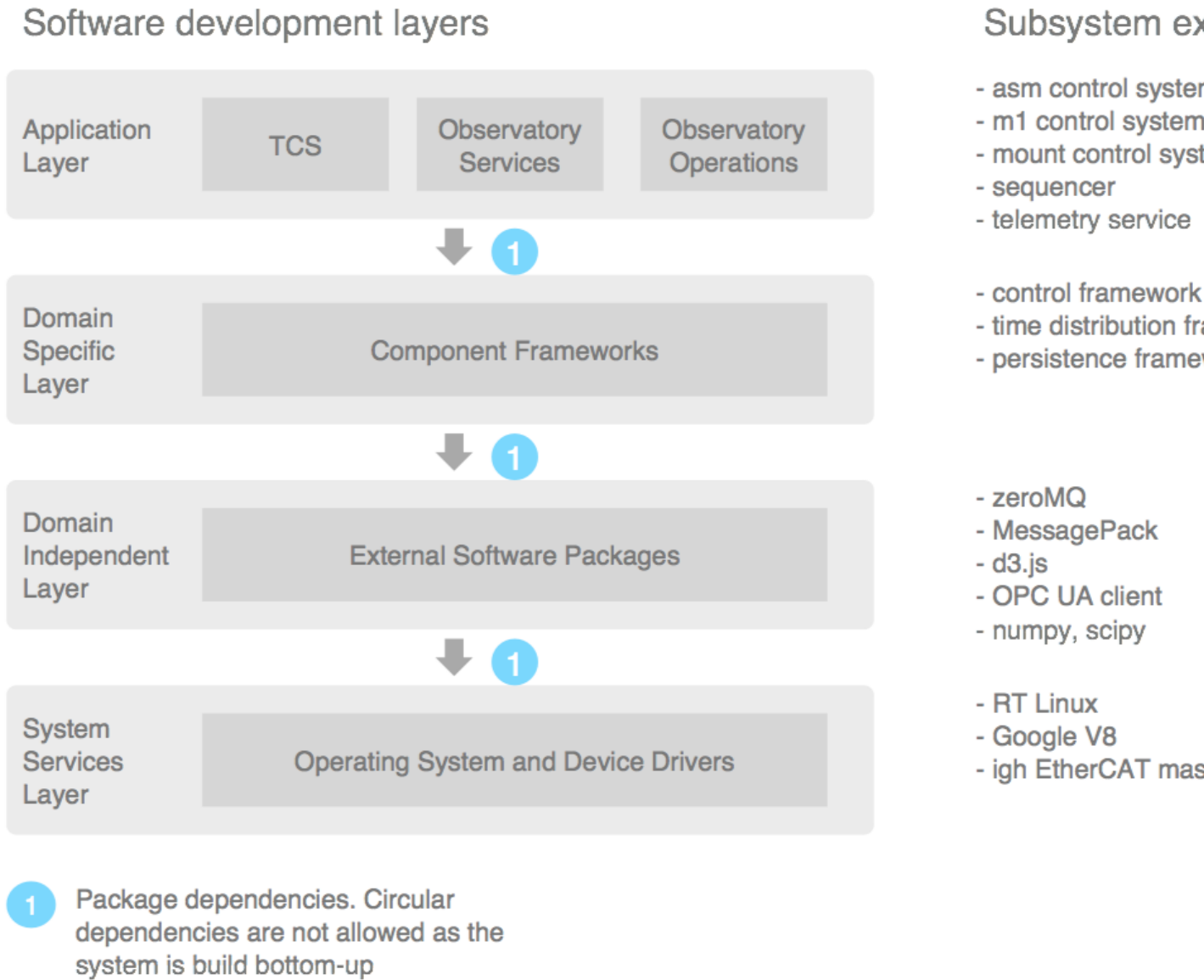


Fig. 2.1: SWC development view

#### **2.1.1.4 SWC System Shipping Package**

SWCS Shipping Package includes the resources for the delivery of SWCS hardware systems to the GMT site before the integration of the system on site.

### **2.1.2 Software Device System**

Software Device System

#### **2.1.2.1 SWC Development Environment Package**

The SWC Development Environment Package provides the software tools, both OTS and developed in-house, to support the development of the GMT SWC System.

#### **2.1.2.2 Software Development Modeling Package**

The Software Development Modeling Package includes the resources necessary for the development of the GMT SWC models.

#### **2.1.2.3 Software Development Process Package**

The Software Development Process Package includes the resources and tools necessary to define and specify the GMT SWC development process. Several factors are worth considering: - The software effort involves both developers inside the project office and project partners. Is important to provide an specific definition of the development workflows to ensure that all the product developed are consistent, compatible and are integrated in a seamless way. - The GMT project is a classical stage-gate project, where several reviews, often external, open the gates to further financing. On the other hand, the last decade has seen an almost general adoption of agile [bib] software development processes. Special care has to be taking in ensuring that the project benefits from the use of Agile techniques while supporting the reporting and documentation needs common in stage-gate projects. .. todo:: Short description of GMT process strategy .. todo:: Add Agile references

#### **2.1.2.4 Software Device Document Package**

Software Device Document Package

#### **2.1.2.5 Software Development Simulation Package**

The Software Development Simulation Package includes the resources and tools necessary to develop several integration simulators. The use of simulators is often required to facilitate the integration and test of subsystem that are developed in parallel by different groups. (e.g. TCS simulator for science instruments)

### **2.1.3 Hardware Development System**

The Hardware Development System provides the hardware tools and environment necessary for the development of the GMT SWC system.

#### **2.1.3.1 Hardware Device Simulator Package**

Hardware Device Simulator Package

### **2.1.4 Architectural Prototype**

The Architectural Prototype Subsystem includes software, hardware and manpower resources to develop SWC prototypes.

#### **2.1.4.1 Architecture Simulator Package**

Architecture Simulator Package

#### **2.1.4.2 Instrument Simulator Package**

Instrument Simulator Package

## **2.2 Observatory Common Frameworks**

The Observatory Component Frameworks implements reusable frameworks that implement the skeleton of a solution to a common problem and a set of components libraries that can be reused in the implementation of several subsystems.

### **2.2.1 Core Framework**

The Core Framework (CF) implements the GMT distributed component model. The CF supports different communication patterns, connection ports and transports. The CF hides implementation details, like the middleware software used or the transport protocol. The CF defines the BaseComponent class that injects cross-cutting concerns with the use features that provide a native API to the Observatory Services.

#### **2.2.1.1 Core Ext Software Wrapper Package**

Core Ext Software Wrapper Package



### **2.2.1.2 Core Component Package**

Core Component Package

### **2.2.1.3 Core Visualization Package**

Core Visualization Package

### **2.2.1.4 Core Sequence Package**

Core Sequence Package

### **2.2.1.5 Core Analysis Package**

Core Analysis Package

### **2.2.1.6 Core Workflow Package**

Core Workflow Package

### **2.2.1.7 Core Management Package**

Core Management Package

## **2.2.2 Device Control Framework**

The Device Control Framework (DCF) provides a set of specialized components to solve recurrent problems in Device Control Subsystems. The DCF defines the classes BaseController and BaseSupervisor that provide the basis for the control and supervisory hierarchy of the SWCS. The DCF also includes a library of controllers that address common control system configurations based on the IEC 61800-7-201 standard

### **2.2.2.1 Control Framework Component Package**

Control Framework Component Package

#### **2.2.2.2 Control Framework Visualization Package**

Control Framework Visualization Package

#### **2.2.2.3 Ctrl Sequence Package**

Ctrl Sequence Package

#### **2.2.2.4 Ctrl Analysis Package**

Ctrl Analysis Package

#### **2.2.2.5 Ctrl Workflow Package**

Ctrl Workflow Package

#### **2.2.2.6 Ctrl Management Package**

Ctrl Management Package

### **2.2.3 Persistence Framework**

The Persistence Framework (PF) provides support for the storage of data structures and files. It acts as a data access layer between the components and the databases and file systems, and provides a mapping between application data structures and the database.

#### **2.2.3.1 Persistence Hardpoint File System Wrapper Package**

Persistence Hardpoint File System Wrapper Package

#### **2.2.3.2 Persistence Component Package**

Persistence Component Package

#### **2.2.3.3 Persistence Visualization Package**

Persistence Visualization Package

#### **2.2.3.4 Persistence Sequence Package**

Persistence Sequence Package

#### **2.2.3.5 Persistence Analysis Package**

Persistence Analysis Package

#### **2.2.3.6 Persistence Workflow Package**

Persistence Workflow Package

#### **2.2.3.7 Persistence Management Package**

Persistence Management Package

#### **2.2.3.8 Persistence Hardware Package**

Persistence Hardware Package

### **2.2.4 Data Processing Framework**

The Data Processing Framework (DPF) provides support for the development of data processing pipelines. Specific examples of data processing pipelines include: statistics (image noise and S/N estimation, sky brightness, seeing estimation, number of sources), astrometry (computing WCS for imaging detectors), image matching (coordinate transformation, image registration), data filtering, image cube construction, data extraction (e.g., IFS wavelength slices), image manipulation (masking, interpolation), image analysis, PSF creation (AO PSF simulation), spectral analysis, photometric calibration, spectral reduction, image reduction, image mosaic creation, etc.

#### **2.2.4.1 Ext Software Wrapper Package**

Ext Software Wrapper Package

#### **2.2.4.2 Data Processing Component Package**

Data Processing Component Package

#### **2.2.4.3 Visualization Package**

#### **2.2.4.4 Sequencing Package**

#### **2.2.4.5 Data Processing Analysis Package**

A processing pipeline is a chain of processing elements (processes, threads, etc.) arranged so that the output of one task feeds the input of the next. Data pipelines perform preprocessing of raw or reduced data (images, spectra, data cubes), information extraction, analysis on the outcome, post-processing, visualization, storage, and propagation of the results to other algorithms. Preprocessing may involve identifying relevant data sets, masking, data curation, etc., while information extraction may involve data processing steps to identify, filter, and fit features depending on the types of data (e.g. lines, stars, galaxies).

#### **2.2.4.6 Data Processing Workflow Package**

Data Processing Workflow Package

#### **2.2.4.7 Data Processing Management Package**

Data Processing Management Package

#### **2.2.4.8 Data Processing Hardware Package**

Data Processing Hardware Package

### **2.2.5 Time Distribution Framework**

The Time Distribution Framework (TDF) provides the capability to obtain absolute timestamps. The TDF uses the IEEE 1588 standard for time distribution and provides a wrapper around the PTP version 2 protocol

#### **2.2.5.1 Ext Software Package**

Ext Software Package

#### **2.2.5.2 Time Cmp Package**

Time Cmp Package

#### **2.2.5.3 Time Visualization Package**

Time Visualization Package

#### **2.2.5.4 Time Sequence Package**

Time Sequence Package

#### **2.2.5.5 Time Analysis Package**

Time Analysis Package

#### **2.2.5.6 Time Workflow Package**

Time Workflow Package

#### **2.2.5.7 Time Management Package**

Time Management Package

#### **2.2.5.8 Time Hardware Package**

Time Hardware Package

### **2.2.6 User Interface Framework**

The User Interface Framework (UIF) provides a set of common reusable Widgets (user interface graphic elements) and Panels. Widgets and Panels are the building blocks used to construct the GMT user interfaces. The UIF facilitates a consistent design and documentation, improves system predictability as all widgets operate consistently in different scenarios, and reduces development costs.

### **2.2.6.1 User Interface Ext Software Wrapper Package**

User Interface Ext Software Wrapper Package

### **2.2.6.2 User Interface Component Packages**

User interface components define how observers and telescope operators interface with the telescope, instruments, software, and how they may visualize data. [TBC]

### **2.2.6.3 User Interface Visualization Package**

User Interface Visualization Package

### **2.2.6.4 User Interface Analysis Package**

User Interface Analysis Package

### **2.2.6.5 User Interface Workflow Package**

User Interface Workflow Package

### **2.2.6.6 User Interface Management Package**

User Interface Management Package

### **2.2.6.7 User Interface Hardware Package**

User Interface Hardware Package

## **2.2.7 IO Framework**

The I/O Framework (IOF) provides the infrastructure to develop observatory compliant Device Controllers based on EtherCAT technology.

#### **2.2.7.1 Io EtherCAT Package**

Io EtherCAT Package

#### **2.2.7.2 Io Component Package**

Io Component Package

#### **2.2.7.3 Io Visualization Package**

Io Visualization Package

#### **2.2.7.4 Io Sequence Package**

Io Sequence Package

#### **2.2.7.5 Io Analysis Package**

Io Analysis Package

#### **2.2.7.6 Io Workflow Package**

Io Workflow Package

#### **2.2.7.7 Io Management Package**

Io Management Package

## **2.3 Device Control Systems**

The telescope control system (TCS) provides the software and hardware necessary to efficiently operate, monitor, calibrate, diagnose and control the optomechanical system of the GMT system.

### **2.3.1 Primary Mirror Control System**

The Primary Mirror (M1) Control System (m1\_cs) consists of a set of components organized in a hierarchy. A global controller acts as a front-end to the seven segments, dispatching commands and combining status to and from its underlying sub-systems; and provides a unified, simplified interface to the telescope's single 24.5m aperture optical surface. The segment controller holds its mirror segment so that the forces of gravity, wind and telescope acceleration do not significantly distort its surface. Segment position is controlled by six hardpoints, constraining the six degrees of freedom of solid body motion of the mirror segment. The hardpoints are actively controlled to keep the mirror segment aligned with the other parts of the telescope optical system. The segment active support consists of one hundred sixty five pneumatic actuators. The control system serves two purposes: firstly, it actively holds the mirror segment to the definition set by the hardpoints, effectively floating the segment blank at its nominal position; secondly, it applies figure corrections to the segment optical surface as provided by the active optics system. Each segment resides in its own independent cell. Thermal management is handled on a per segment basis and follows a similarly layered concept.

#### **2.3.1.1 M1 Controller Package**

M1 Controller Package

#### **2.3.1.2 Primary Mirror Visualization Package**

Primary Mirror Visualization Package

#### **2.3.1.3 Primary Mirror Sequence Package**

Primary Mirror Sequence Package

#### **2.3.1.4 M1 Diagnostics Package**

M1 Diagnostics Package

#### **2.3.1.5 M1 Calibration Package**

M1 Calibration Package

#### **2.3.1.6 Primary Mirror Workflow Package**

Primary Mirror Workflow Package



#### **2.3.1.7 Primary Mirror Management Package**

Primary Mirror Management Package

#### **2.3.1.8 Primary Mirror Hardware Package**

Primary Mirror Hardware Package

#### **2.3.1.9 M1 Safety Package**

M1 Safety Package

### **2.3.2 Secondary Mirror Positioner Control System**

The Secondary Mirror (M2) Positioner Control System (m2pos\_cs) provides the capability to operate and control the M2 Positioning system integrated with the rest of the observatory.

#### **2.3.2.1 M2 Positioner Controller Package**

M2 Positioner Controller Package

#### **2.3.2.2 M2 Positioner Visualization Package**

M2 Positioner Visualization Package

#### **2.3.2.3 M2 Positioner Sequencing Package**

M2 Positioner Sequencing Package

#### **2.3.2.4 M2 Positioner Diagnosis Package**

M2 Positioner Diagnosis Package

#### **2.3.2.5 M2 Positioner Calibration Package**

M2 Positioner Calibration Package

#### **2.3.2.6 M2 Positioner Workflow Package**

M2 Positioner Workflow Package

#### **2.3.2.7 M2 Positioner Management Package**

M2 Positioner Management Package

#### **2.3.2.8 M2 Positioner Hardware Package**

M2 Positioner Hardware Package

### **2.3.3 Fast Steering Mirror Control System**

The Fast Steering Mirror (FSM) Control System (fsm\_cs) consists of a set of components organized in a hierarchy: - The FSM Supervisors are responsible for the startup and shutdown procedures, overall health status, fault management and coordination of the components of the FSM Control System. They also provide a high level interface that receives new position demands and new commands from the WFC System and allows sending the telemetry samples for operator feedback and persistent storage. - The FSM piezo actuators and pressure/vacuum controllers, access the state variables of the plant through the EtherCAT master. These controllers read the input state variables; apply the control, alarm detection and logic functions; and update the output state variables to implement the control of the corresponding mechanisms. The EtherCAT fieldbus communication refreshes with a cycle time of 0.5 ms, generating time stamping at 2 kHz and telemetry accordingly.

#### **2.3.3.1 FSM Controller Package**

FSM Controller Package

#### **2.3.3.2 Fast Steering Mirror Visualization Package**

Fast Steering Mirror Visualization Package

#### **2.3.3.3 Fast Steering Mirror Sequence Package**

Fast Steering Mirror Sequence Package

#### **2.3.3.4 Fast Steering Mirror Diagnostics Package**

Fast Steering Mirror Diagnostics Package

#### **2.3.3.5 Fast Steering Mirror Calibration Package**

Fast Steering Mirror Calibration Package

#### **2.3.3.6 Fast Steering Mirror Workflow Package**

Fast Steering Mirror Workflow Package

#### **2.3.3.7 Fast Steering Mirror Management Package**

Fast Steering Mirror Management Package

#### **2.3.3.8 Fast Steering Mirror Hardware Package**

Fast Steering Mirror Hardware Package

### **2.3.4 Adaptive Secondary Mirror Control System**

Adaptive Secondary Mirror Control System

#### **2.3.4.1 Adaptive Secondary Mirror Ctrl Package**

Adaptive Secondary Mirror Ctrl Package

#### **2.3.4.2 Adaptive Secondary Mirror Visualization Package**

Adaptive Secondary Mirror Visualization Package

#### **2.3.4.3 Adaptive Secondary Mirror Sequence Package**

Adaptive Secondary Mirror Sequence Package

#### **2.3.4.4 Adaptive Secondary Mirror Diagnostics Package**

Adaptive Secondary Mirror Diagnostics Package

#### **2.3.4.5 Adaptive Secondary Mirror Calibration Package**

Adaptive Secondary Mirror Calibration Package

#### **2.3.4.6 Adaptive Secondary Mirror Workflow Package**

Adaptive Secondary Mirror Workflow Package

#### **2.3.4.7 Adaptive Secondary Mirror Management Package**

Adaptive Secondary Mirror Management Package

#### **2.3.4.8 Adaptive Secondary Mirror Hardware Package**

Adaptive Secondary Mirror Hardware Package

### **2.3.5 Tertiary Mirror Control System**

The Tertiary Mirror (M3) Control System (m3\_cs) provides the capability to operate and control the M3 subsystem integrated with the rest of the observatory.

#### **2.3.5.1 M3 Controller Package**

Controls Overview

#### **2.3.5.2 M3 UI Panels**

M3 UI Panels

#### **2.3.5.3 M3 Sequence Packages**

M3 Sequence Packages

#### **2.3.5.4 M3 Diagnostics Package**

M3 Diagnostics Package

#### **2.3.5.5 M3 Calibration Utilities**

M3 Calibration Utilities

#### **2.3.5.6 M3 Observatory Workflows Package**

M3 Observatory Workflows Package

#### **2.3.5.7 M3 Process and Management Workflows**

M3 Process and Management Workflows

#### **2.3.5.8 M3 Hardware Package**

M3 Hardware Package

### **2.3.6 Mount Control System**

The Mount Control System (mount\_cs) provides the capability to operate and control the telescope mount integrated with the rest of the observatory.

#### **2.3.6.1 Mount Control Package**

Mount Control System Controllers

#### **2.3.6.2 Mount UI Panels Package**

Mount UI Panels Package

#### **2.3.6.3 Mount Sequence Packages**

Mount Sequence Packages

#### **2.3.6.4 Mount Diagnostics Package**

Mount Diagnostics Package

#### **2.3.6.5 Mount Calibration Utilities**

Mount Calibration Utilities

#### **2.3.6.6 Mount Observatory Workflows Package**

Mount Observatory Workflows Package

#### **2.3.6.7 Mount Process and Management Workflows**

Mount Process and Management Workflows

#### **2.3.6.8 Mount Hardware Package**

Mount Hardware Package

### **2.3.7 Corrector-ADC Control System**

The Corrector-ADC Control System (cadc\_cs) consists of a set of Supervisor and Controllers organized in a hierarchy. The Corrector-ADC Supervisor is responsible for the startup and shutdown procedures, overall health status, fault management and coordination of the components of the Corrector-ADC control system. It also provides a high level interface that receives new position demands from the TCS or new commands from the Sequencer and allows sending telemetry samples for operator feedback and persistent storage. The Corrector-ADC Controllers for the two-prism rotation and stage deployment, access the state variables of the Corrector-ADC through the EtherCAT master. The controllers read the input-state variables; apply the control, alarm detection and logic functions; and update the output-state variables to implement the control of the corresponding mechanism. The EtherCAT fieldbus refreshes with a cycle time of 0.5 ms, generating telemetry at 2 kHz and time stamping accordingly.

#### **2.3.7.1 Corrector and Atmospheric Dispersion Ctrl Package**

Corrector and Atmospheric Dispersion Ctrl Package

#### **2.3.7.2 Corrector and Atmospheric Dispersion Visualization Package**

Corrector and Atmospheric Dispersion Visualization Package

#### **2.3.7.3 Corrector and Atmospheric Dispersion Sequence Package**

Corrector and Atmospheric Dispersion Sequence Package

#### **2.3.7.4 Corrector and Atmospheric Dispersion Diagnostics Package**

Corrector and Atmospheric Dispersion Diagnostics Package

#### **2.3.7.5 Corrector and Atmospheric Dispersion Calibration Package**

Corrector and Atmospheric Dispersion Calibration Package

#### **2.3.7.6 Corrector and Atmospheric Dispersion Workflow Package**

Corrector and Atmospheric Dispersion Workflow Package

#### **2.3.7.7 Corrector and Atmospheric Dispersion Management Package**

Corrector and Atmospheric Dispersion Management Package

#### **2.3.7.8 Corrector and Atmospheric Dispersion Hardware Package**

Corrector and Atmospheric Dispersion Hardware Package

### **2.3.8 Acquisition Guiding and Wavefront Sensing Control System**

The Acquisition Guiding and Wavefront Sensing (AGWS) Control System (agws\_cs) consists of a set of Supervisors and Controllers organized in a hierarchy (**Figure 1**). The AGWS Supervisors are responsible for the startup and shutdown procedures, overall health status, fault management and coordination of the components of the AGWS Control System. The AGWS Supervisors also provide a high level interface that receives new position demands and new commands from the Pointing Kernel and allows sending telemetry samples for operator feedback and persistent storage. Individual unit supervisors are responsible for stages positioning, mirror tilts and optics rotation, via the state variables of the AGWS through the EtherCAT master. These Controllers read the input-state variables; apply the control, alarm detection and logic functions; and update the output-state variables to implement the control of the corresponding mechanisms.

#### **2.3.8.1 AGWS Controller Package**

**AGWS Controller Package** The Controllers and Supervisory components of the AGWS Control System are deployed in a GMT standard Device Control Computer (DCC) that is installed in the electronics room. The DCC runs the EtherCAT bus master in RT Linux and connects with the AGWS input/output modules by means of an EtherCAT fieldbus in ring topology that supports cable redundancy. Each AGWS Unit contains three dual-axis motion drives, two voice coil controllers and two piezo controllers, all of them with the proper feedback attached. Refer to **Figure 1** for a layout on each of the 4 AGWS Units and the Phasing Camera. The On-axis AGWS is constructed in a similar way.

#### **2.3.8.2 AGWS Data Acquisition Package**

AGWS Data Acquisition Package

#### **2.3.8.3 AGWS visualization package**

AGWS visualization package

#### **2.3.8.4 Acquisition Guiding and Wavefront System Sequence Package**

Acquisition Guiding and Wavefront System Sequence Package

#### **2.3.8.5 Acquisition Guiding and Wavefront System Diagnostics Package**

Acquisition Guiding and Wavefront System Diagnostics Package

#### **2.3.8.6 Acquisition Guiding and Wavefront System Calibration Package**

Acquisition Guiding and Wavefront System Calibration Package

#### **2.3.8.7 AGWS workflow package**

AGWS workflow package

#### **2.3.8.8 Acquisition Guiding and Wavefront System Management Package**

Acquisition Guiding and Wavefront System Management Package

#### **2.3.8.9 Acquisition Guiding and Wavefront System Hardware Package**

Acquisition Guiding and Wavefront System Hardware Package



### **2.3.9 Facility Calibration Control System**

The Facility Calibration Control System (fac\_cal\_cs) provides the supervision and control of the Facility Calibration System, which is formed by the AO Retro-reflector and the LTAO Calibration Source. The AO Retro-reflector positioned at the telescope prime focus, is used to test the optical layout when a source at the Gregorian focal plane is reflected by the ASM. The LTAO Calibration Source provides the means to calibrate and verify the performance of both the NGS AO and LTAO observing modes. The AO Retro-reflector shares the same deployment system as the LTAO Calibration Source.

#### **2.3.9.1 Facility Calibration System Ctrl Package**

Facility Calibration System Ctrl Package

#### **2.3.9.2 Facility Calibration System Visualization Package**

Facility Calibration System Visualization Package

#### **2.3.9.3 Facility Calibration System Sequence Package**

Facility Calibration System Sequence Package

#### **2.3.9.4 Facility Calibration System Diagnostics Package**

Facility Calibration System Diagnostics Package

#### **2.3.9.5 Facility Calibration System Calibration Package**

Facility Calibration System Calibration Package

#### **2.3.9.6 Facility Calibration System Workflow Package**

Facility Calibration System Workflow Package

#### **2.3.9.7 Facility Calibration System Management Package**

Facility Calibration System Management Package

#### **2.3.9.8 Facility Calibration System Hardware Package**

Facility Calibration System Hardware Package

### **2.3.10 Enclosure Control System**

The Enclosure Control System (enc\_cs) provides the monitoring and control for all enclosure related functions including: rotation, shutters, wind vents, ventilation, lift platforms, hatches, cranes and building functions, such as HVAC and lighting. The enclosure systems are controlled with a series of PLCs interconnected with the EtherCAT industrial Ethernet fieldbus. The PLC system consists of Industrial PCs (IPCs), remote PCs, and remote I/O stations located in the enclosure. The ECS communicates with the GMT Telescope Control System using the communications standard OPC Unified Architecture (OPC UA).

#### **2.3.10.1 Enclosure Control Package**

The Enclosure control system will operate the Enclosure drive bogies using variable frequency drives (*VFD*), adjust the ventilation doors, and open and close the vertical and horizontal shutters.

#### **2.3.10.2 Enclosure UI Panels Package**

Enclosure UI Panels Package

#### **2.3.10.3 Enclosure Sequencing Package**

Enclosure Sequencing Package

#### **2.3.10.4 Enclosure Diagnostics Package**

Enclosure Diagnostics Package

#### **2.3.10.5 Enclosure Calibration Utilities**

Enclosure Calibration Utilities

#### **2.3.10.6 Enclosure Workflow Package**

Enclosure Workflow Package

### **2.3.10.7 Enclosure Management Package**

Enclosure Management Package

### **2.3.10.8 Enclosure Hardware Package**

Enclosure Hardware Package

## **2.3.11 Facilities Control System**

The Facilities Control System (fac\_cs) provides the monitoring and control for all building and facilities related functions including HVAC and lighting.

### **2.3.11.1 Facilities Ctrl Package**

Facilities Ctrl Package

### **2.3.11.2 Facilities Visualization Package**

Facilities Visualization Package

### **2.3.11.3 Facilities Sequence Package**

Facilities Sequence Package

### **2.3.11.4 Facilities Diagnostics Package**

Facilities Diagnostics Package

### **2.3.11.5 Facilities Calibration Package**

Facilities Calibration Package

### **2.3.11.6 Facilities Workflow Package**

Facilities Workflow Package

#### **2.3.11.7 Facilities Management Package**

Facilities Management Package

#### **2.3.11.8 Facilities Hardware Package**

Facilities Hardware Package

### **2.3.12 Environmental Monitoring Control System**

The Environmental Monitoring Control System (env\_mon\_cs) is responsible for providing the services for monitoring, logging, and displaying all environmental data. The GMT Environmental Monitoring Facility (GEMF) will provide the required capabilities to monitor weather conditions and integrated seeing conditions using: - weather tower and equipment, - MASS/DIMM facility, - dust monitoring, - seismic sensor.

#### **2.3.12.1 Environment Monitoring Ctrl Package**

Environment Monitoring Ctrl Package

#### **2.3.12.2 Environment Monitoring Visualization Package**

Environment Monitoring Visualization Package

#### **2.3.12.3 Environment Monitoring Sequence Package**

Environment Monitoring Sequence Package

#### **2.3.12.4 Environment Monitoring Diagnostics Package**

Environment Monitoring Diagnostics Package

#### **2.3.12.5 Environment Monitoring Calibration Package**

Environment Monitoring Calibration Package

#### **2.3.12.6 Environment Monitoring Workflow Package**

Environment Monitoring Workflow Package

#### **2.3.12.7 Environment Monitoring Management Package**

Environment Monitoring Management Package

#### **2.3.12.8 Environment Monitoring Hardware Package**

Environment Monitoring Hardware Package

### **2.3.13 Natural Guidestar Wavefront Sensor Control System**

The Natural Guidestar AO Wavefront Sensor (NGWS) Control System (ngws\_cs) is composed of a series of Controllers and Supervisors that interact with the various subsystems within the NGWS optical path: Main arm, Adaptive Optics arm, Technical Viewer arm and 2nd Wavelength arm.

#### **2.3.13.1 NGWS Controller Package**

NGWS Controller Package

#### **2.3.13.2 NGWS Data Acquisition Package**

NGWS Data Acquisition Package

#### **2.3.13.3 NGWS slope processor Package**

NGWS slope processor Package

#### **2.3.13.4 Natural Guide Star Wavefront Sensor FAT Package**

Natural Guide Star Wavefront Sensor FAT Package

#### **2.3.13.5 Natural Guide Star Wavefront Sensor Calibration Package**

Natural Guide Star Wavefront Sensor Calibration Package

#### **2.3.13.6 Natural Guide Star Wavefront Sensor Visualization Package**

Natural Guide Star Wavefront Sensor Visualization Package

#### **2.3.13.7 Natural Guide Star Wavefront Sensor Sequence Package**

Natural Guide Star Wavefront Sensor Sequence Package

#### **2.3.13.8 Natural Guide Star Wavefront Sensor Diagnostics Package**

Natural Guide Star Wavefront Sensor Diagnostics Package

#### **2.3.13.9 Natural Guide Star Wavefront Sensor Workflow Package**

Natural Guide Star Wavefront Sensor Workflow Package

#### **2.3.13.10 Natural Guide Star Wavefront Sensor Management Package**

Natural Guide Star Wavefront Sensor Management Package

#### **2.3.13.11 NGWS Hardware Package**

NGWS Hardware Package

### **2.3.14 Laser Tomography Wavefront Sensor Control System**

The Laser Tomography AO Wavefront Sensor (LTWS) Control System (ltws\_cs) consists of a set of Supervisor and Controllers organized in a hierarchy. The LWFS Supervisor receives commands and also passes status and other requested data to the LTAO Wavefront Controller. The LTWS Controller uses data received from the LTAO Wavefront Controller to drive the mechanisms, which are controlled by a local EtherCAT based control system. The LTWS Controller will interface with both the Telescope Control Network and the Low-Latency Network.

#### **2.3.14.1 LTAO Wavefront Sensor Ctrl Package**

LTAO Wavefront Sensor Ctrl Package

#### **2.3.14.2 LTAO Wavefront Sensor Data Acquisition System Package**

LTAO Wavefront Sensor Data Acquisition System Package

#### **2.3.14.3 LTAO Wavefront Sensor Slp Package**

LTAO Wavefront Sensor Slp Package

#### **2.3.14.4 LTAO Wavefront Sensor FAT Package**

LTAO Wavefront Sensor FAT Package

#### **2.3.14.5 LTAO Wavefront Sensor Calibration Package**

LTAO Wavefront Sensor Calibration Package

#### **2.3.14.6 LTAO Wavefront Sensor Sequence Package**

LTAO Wavefront Sensor Sequence Package

#### **2.3.14.7 LTAO Wavefront Sensor Diagnostics Package**

LTAO Wavefront Sensor Diagnostics Package

#### **2.3.14.8 LTAO Wavefront Sensor Workflow Package**

LTAO Wavefront Sensor Workflow Package

#### **2.3.14.9 LTAO Wavefront Sensor Visualization Package**

LTAO Wavefront Sensor Visualization Package

#### **2.3.14.10 LTAO Wavefront Sensor Management Package**

LTAO Wavefront Sensor Management Package

#### **2.3.14.11 LTAO Wavefront Sensor Hardware Package**

LTAO Wavefront Sensor Hardware Package

#### **2.3.14.12 Electronic Cabinet Ctrl Package**

Electronic Cabinet Ctrl Package

#### **2.3.14.13 Electronic Cabinet Sequence Package**

Electronic Cabinet Sequence Package

#### **2.3.14.14 Electronic Cabinet Calibration Package**

Electronic Cabinet Calibration Package

#### **2.3.14.15 Electronic Cabinet Diagnostics Package**

Electronic Cabinet Diagnostics Package

#### **2.3.14.16 Electronic Cabinet Workflow Package**

Electronic Cabinet Workflow Package

#### **2.3.14.17 Electronic Cabinet Visualization Package**

Electronic Cabinet Visualization Package

#### **2.3.14.18 Electronic Cabinet Management Package**

Electronic Cabinet Management Package

#### **2.3.14.19 Electronic Cabinet Hardware Package**

Electronic Cabinet Hardware Package



## **2.3.15 Adaptive Optics Commissioning Camera Control System**

The Adaptive Optics (AO) Commissioning Camera (ao\_com\_cam\_cs) provides Pupil Lens and Temperature control, as well as Supervisory functions for the AO Camera used during the commissioning phase of GMT.

### **2.3.15.1 Adaptive Optics Commissioning Camera Ctrl Package**

Adaptive Optics Commissioning Camera Ctrl Package

### **2.3.15.2 Adaptive Optics Commissioning Camera Data Acquisition System Package**

Adaptive Optics Commissioning Camera Data Acquisition System Package

### **2.3.15.3 Adaptive Optics Commissioning Camera FAT Package**

Adaptive Optics Commissioning Camera FAT Package

### **2.3.15.4 Adaptive Optics Commissioning Camera Sequence Package**

Adaptive Optics Commissioning Camera Sequence Package

### **2.3.15.5 Adaptive Optics Commissioning Camera Calibration Package**

Adaptive Optics Commissioning Camera Calibration Package

### **2.3.15.6 Adaptive Optics Commissioning Camera Diagnostics Package**

Adaptive Optics Commissioning Camera Diagnostics Package

### **2.3.15.7 Adaptive Optics Commissioning Camera Workflow Package**

Adaptive Optics Commissioning Camera Workflow Package

### **2.3.15.8 Adaptive Optics Commissioning Camera Visualization Package**

Adaptive Optics Commissioning Camera Visualization Package

#### **2.3.15.9 Adaptive Optics Commissioning Camera Management Package**

Adaptive Optics Commissioning Camera Management Package

#### **2.3.15.10 Adaptive Optics Commissioning Camera Hardware Package**

Adaptive Optics Commissioning Camera Hardware Package

### **2.3.16 On Instrument Wavefront Sensor Control System**

The On Instrument Wavefront Sensor (OIWFS) Control System (oiws\_cs) will interface with both the TCS (control, status, and telemetry) and the AO RTS (for real time slopes from the WFS and real time DM actuator commands). The main OIWFS subsystems are the Detector Controller, the Deformable Mirror controller and the Mechanisms control.

#### **2.3.16.1 On Instrument Wavefront Sensor Ctrl Package**

On Instrument Wavefront Sensor Ctrl Package

#### **2.3.16.2 On Instrument Wavefront Sensor Data Acquisition System Package**

On Instrument Wavefront Sensor Data Acquisition System Package

#### **2.3.16.3 On Instrument Wavefront Sensor Slp Package**

On Instrument Wavefront Sensor Slp Package

#### **2.3.16.4 On Instrument Wavefront Sensor FAT Package**

On Instrument Wavefront Sensor FAT Package

#### **2.3.16.5 On Instrument Wavefront Sensor Calibration Package**

On Instrument Wavefront Sensor Calibration Package

#### **2.3.16.6 On Instrument Wavefront Sensor Diagnostics Package**

On Instrument Wavefront Sensor Diagnostics Package

#### **2.3.16.7 On Instrument Wavefront Sensor Workflow Package**

On Instrument Wavefront Sensor Workflow Package

#### **2.3.16.8 On Instrument Wavefront Sensor Visualization Package**

On Instrument Wavefront Sensor Visualization Package

#### **2.3.16.9 On Instrument Wavefront Sensor Management Package**

On Instrument Wavefront Sensor Management Package

#### **2.3.16.10 On Instrument Wavefront Sensor Hardware Package**

On Instrument Wavefront Sensor Hardware Package

### **2.3.17 Phasing Camera Control System**

The Phasing Camera Control System (ph\_cam\_cs) comprises several Supervisors and Controllers that interact with the Phasing Camera at the AGWS. The Phasing Camera System is a dispersed Hartmann wavefront sensor and associated control electronics, which allow the relative phase difference between M1 segments to be determined. The phasing camera will be mechanically and electronically integrated into the AGWS. The relevant controlled mechanisms consist of a deployment stage with azimuth, elevation and focus adjustments, along with pick-off mirror and fold mirror tilts.

#### **2.3.17.1 Phasing Camera Ctrl Package**

Phasing Camera Ctrl Package

#### **2.3.17.2 Phasing Camera Data Acquisition System Package**

Phasing Camera Data Acquisition System Package

#### **2.3.17.3 Phasing Camera Slp Package**

Phasing Camera Slp Package

#### **2.3.17.4 Phasing Camera FAT Package**

Phasing Camera FAT Package

#### **2.3.17.5 Phasing Camera Calibration Package**

Phasing Camera Calibration Package

#### **2.3.17.6 Phasing Camera Sequence Package**

Phasing Camera Sequence Package

#### **2.3.17.7 Phasing Camera Diagnostics Package**

Phasing Camera Diagnostics Package

#### **2.3.17.8 Phasing Camera Workflow Package**

Phasing Camera Workflow Package

#### **2.3.17.9 Phasing Camera Visualization Package**

Phasing Camera Visualization Package

#### **2.3.17.10 Phasing Camera Management Package**

Phasing Camera Management Package

#### **2.3.17.11 Phasing Camera Hardware Package**

Phasing Camera Hardware Package

### **2.3.18 M1 Edge Sensors Control System**

The baseline for the Primary Mirror Edge Sensors (M1ES) Control System (m1es\_cs) is a hybrid metrology system with fine interferometric sensors that are supplemented with a coarse absolute optical position sensor with large capture range. The interferometric type sensors have high nm range resolution, measuring displacement by counting interference fringes in quadrature, but are inherently relative. The coarse sensors will make it possible to quickly align M1 to within the capture range of the AGWS (for tip-tilt) and Phasing Camera (for piston). Once initial alignment and phasing has been achieved, the interferometric metrology system will maintain the alignment of the M1 segments with high precision and bandwidth, with its absolute reference point updated continuously by the Integrated Optics Piston Sensor or the Phasing Camera.

#### **2.3.18.1 M1 Edge Sensors Ctrl Package**

M1 Edge Sensors Ctrl Package

#### **2.3.18.2 M1 Edge Sensors Data Acquisition System Package**

M1 Edge Sensors Data Acquisition System Package

#### **2.3.18.3 M1 Edge Sensors Pipeline Package**

M1 Edge Sensors Pipeline Package

#### **2.3.18.4 M1 Edge Sensors Calibration Package**

M1 Edge Sensors Calibration Package

#### **2.3.18.5 M1 Edge Sensors Sequence Package**

M1 Edge Sensors Sequence Package

#### **2.3.18.6 M1 Edge Sensors Diagnostics Package**

M1 Edge Sensors Diagnostics Package

#### **2.3.18.7 M1 Edge Sensors Workflow Package**

M1 Edge Sensors Workflow Package

#### **2.3.18.8 M1 Edge Sensors Visualization Package**

M1 Edge Sensors Visualization Package

#### **2.3.18.9 M1 Edge Sensors Management Package**

M1 Edge Sensors Management Package

#### **2.3.18.10 M1 Edge Sensors Hardware Package**

M1 Edge Sensors Hardware Package

### **2.3.19 Secondary Mirror Edge Sensors Control System**

The Secondary Mirror (M2) Edge Sensor (M2ES) Control System (m2es\_cs) provides the measurement of relative displacements between the ASM reference bodies, with sufficient precision and bandwidth to sense wind-induced disturbances of the ASM segments. In addition to segment piston, the M2 Edge Sensors must also accurately measure segment tilt to avoid field-dependent segment piston (phasing) error. The M2ES sensor layout developed by Microgate Corp. is based on the measured sensitivity of currently-available capacitive sensors, and results in an arrangement of 24 sensors total, each measuring two axes of relative motion. Each sensor measures relative  $\xi$  displacement with one capacitor, and relative  $\eta$  displacement with two capacitors (one on each side of the sensor).

#### **2.3.19.1 M2 Edge Sensors Ctrl Package**

M2 Edge Sensors Ctrl Package

#### **2.3.19.2 M2 Edge Sensors Data Acquisition System Package**

M2 Edge Sensors Data Acquisition System Package

#### **2.3.19.3 M2 Edge Sensors Pipeline Package**

M2 Edge Sensors Pipeline Package

#### **2.3.19.4 M2 Edge Sensors Calibration Package**

M2 Edge Sensors Calibration Package

#### **2.3.19.5 M2 Edge Sensors Sequence Package**

M2 Edge Sensors Sequence Package

#### **2.3.19.6 M2 Edge Sensors Diagnostics Package**

M2 Edge Sensors Diagnostics Package

#### **2.3.19.7 M2 Edge Sensors Workflow Package**

M2 Edge Sensors Workflow Package

#### **2.3.19.8 M2 Edge Sensors Visualization Package**

M2 Edge Sensors Visualization Package

#### **2.3.19.9 M2 Edge Sensors Management Package**

M2 Edge Sensors Management Package

#### **2.3.19.10 M2 Edge Sensors Hardware Package**

M2 Edge Sensors Hardware Package

### **2.3.20 Adaptive Optics Calibration Interferometer Control System**

The Adaptive Optics (AO) Calibration Interferometer Control System (ao\_cal\_interferometer\_cs), used in conjunction with the AO retro-reflector at the prime focus forms a critical component of the AO System calibration suite. Used on the M2 Calibration Stand, it will provide the following functions: - Measure the figure of the ASM and FSM segments. - Test the functionality and performance of the M2 Positioner. - Verify the functionality and measure the influence functions of ASM actuators. - Measure the reference ASM flat shape. - Provide the ability to independently phase the ASM segments.

#### **2.3.20.1 Adaptive Optics Calibration Interferometer Ctrl Package**

Adaptive Optics Calibration Interferometer Ctrl Package

#### **2.3.20.2 Adaptive Optics Calibration Interferometer Sequence Package**

Adaptive Optics Calibration Interferometer Sequence Package

#### **2.3.20.3 Adaptive Optics Calibration Interferometer Workflow Package**

Adaptive Optics Calibration Interferometer Workflow Package

#### **2.3.20.4 Adaptive Optics Calibration Interferometer Visualization Package**

Adaptive Optics Calibration Interferometer Visualization Package

#### **2.3.20.5 Adaptive Optics Calibration Interferometer Management Package**

Adaptive Optics Calibration Interferometer Management Package

#### **2.3.20.6 Adaptive Optics Calibration Interferometer Hardware Package**

Adaptive Optics Calibration Interferometer Hardware Package

### **2.3.21 Laser Guide Star Facility Control System**

The Laser Guide Star Facility (LGSF) Control System (lgsf\_cs) includes seven independent control systems in total: six LGS Unit (LGSU) Control Systems and one LGS Acquisition System (LAS) Control System. Each LGSU has its own Control System which interfaces with the TCS, this Control System coordinates all internal operations for its LGSU. Each LGSU interacts with the Beam Conditioning and Diagnostic System through the shutter, jitter loop mirror and focus stage controllers; and with the Laser Launch Telescope through the LLT mechanism controller. The LAS Control Systems operates the LAS focuser motor and LAS shutter mechanism.

#### **2.3.21.1 Laser Guidestar Facility Ctrl Package**

Laser Guidestar Facility Ctrl Package

#### **2.3.21.2 Laser Guidestar Facility Pipeline Package**

Laser Guidestar Facility Pipeline Package



#### **2.3.21.3 Laser Guidestar Facility Calibration Package**

Laser Guidestar Facility Calibration Package

#### **2.3.21.4 Laser Guidestar Facility Sequence Package**

Laser Guidestar Facility Sequence Package

#### **2.3.21.5 Laser Guidestar Facility Diagnostics Package**

Laser Guidestar Facility Diagnostics Package

#### **2.3.21.6 Laser Guidestar Facility Workflow Package**

Laser Guidestar Facility Workflow Package

#### **2.3.21.7 Laser Guidestar Facility Visualization Package**

Laser Guidestar Facility Visualization Package

#### **2.3.21.8 Laser Guidestar Facility Management Package**

Laser Guidestar Facility Management Package

#### **2.3.21.9 Laser Guidestar Facility Hardware Package**

Laser Guidestar Facility Hardware Package

#### **2.3.21.10 Las Ctrl Package**

Las Ctrl Package

#### **2.3.21.11 Las Data Acquisition System Package**

Las Data Acquisition System Package

#### **2.3.21.12 Las Pipeline Package**

Las Pipeline Package

#### **2.3.21.13 Las Calibration Package**

Las Calibration Package

#### **2.3.21.14 Las Sequence Package**

Las Sequence Package

#### **2.3.21.15 Las Diagnostics Package**

Las Diagnostics Package

#### **2.3.21.16 Las Workflow Package**

Las Workflow Package

#### **2.3.21.17 Las Visualization Package**

Las Visualization Package

#### **2.3.21.18 Las Management Package**

Las Management Package

#### **2.3.21.19 Las Hardware Package**

Las Hardware Package

### **2.3.22 Secondary Mirror Calibration Facility Control System**

The Secondary Mirror (M2) Calibration Facility Control System (m2cf\_cs) supports the Fold Mirror 1 and Fold Mirror 2 adjustments at the Calibration Facility. The M2 Calibration Facility is a vertically-oriented optomechanical test stand which can support the GMT Top End Assembly, a Folded Port (FP) Science Instrument, and calibration sources. Its major functions are: - Optical testing and calibration of the ASM and FSM. - Integration and system-level testing of the Adaptive Optics System,

including the ASM, Visible Wavefront Sensor Subsystem, and On-Instrument Wavefront Sensor Subsystem.

- Integration of the Adaptive Optics System with an FP AO instrument.

#### **2.3.22.1 M2cf Ctrl Package**

M2cf Ctrl Package

#### **2.3.22.2 M2cf Data Acquisition System Package**

M2cf Data Acquisition System Package

#### **2.3.22.3 M2cf Pipeline Package**

M2cf Pipeline Package

#### **2.3.22.4 M2cf Calibration Package**

M2cf Calibration Package

#### **2.3.22.5 M2cf Sequence Package**

M2cf Sequence Package

#### **2.3.22.6 M2cf Diagnostics Package**

M2cf Diagnostics Package

#### **2.3.22.7 M2cf Workflow Package**

M2cf Workflow Package

#### **2.3.22.8 M2cf Visualization Package**

M2cf Visualization Package

#### **2.3.22.9 M2cf Management Package**

M2cf Management Package

#### **2.3.22.10 M2cf Hardware Package**

M2cf Hardware Package

### **2.3.23 Interlock and Safety System Control System**

The Interlock and Safety System (ISS) Control System (iss\_cs) interfaces with the GMT ISS, providing a supervisor to monitor the safety of the Observatory. The ISS provides an indication of any unsafe condition, and automatically controls safety interlocks, through a distributed safety network to remote I/O controllers that make discrete interface connections to various observatory systems. The ISS will communicate with the iss\_cs using the cross-platform framework Open Process Control Unified Architecture (OPC UA) for coordinating control functions, and providing status information.

#### **2.3.23.1 Interlock and Safety System Ctrl Package**

Interlock and Safety System Ctrl Package

#### **2.3.23.2 Interlock and Safety System Visualization Package**

Interlock and Safety System Visualization Package

#### **2.3.23.3 Interlock and Safety System Sequence Package**

Interlock and Safety System Sequence Package

#### **2.3.23.4 Interlock and Safety System Diagnostics Package**

Interlock and Safety System Diagnostics Package

### **2.3.23.5 Interlock and Safety System Workflow Package**

Interlock and Safety System Workflow Package

### **2.3.23.6 Interlock and Safety System Management Package**

Interlock and Safety System Management Package

### **2.3.23.7 Interlock and Safety System Hardware Package**

Interlock and Safety System Hardware Package

## **2.4 Pointing and Wavefront Control Kernels**

The telescope control system (TCS) provides the software and hardware necessary to efficiently operate, monitor, calibrate, diagnose and control the optomechanical system of the GMT system.

### **2.4.1 Pointing Kernel System**

The telescope pointing kernel is the Subsystem that performs essential services to point the telescope to a desired sky location, to track the sky rotation, and to provide fine guiding on a target. The outputs of the pointing kernel are mechanical encoder values that are used to command repositioning of the mount and the instrument rotator. The GMT pointing kernel is built on the TCSpk, tpk, and SLALIB, packages developed by Tpoint Software.

#### **2.4.1.1 Pointing Kernel Control Package**

#### **2.4.1.2 Pointing Kernel System Visualization Package**

Pointing Kernel System Visualization Package

#### **2.4.1.3 Pointing Kernel System Sequence Package**

Pointing Kernel System Sequence Package

#### **2.4.1.4 Pointing Kernel System Diagnostics Package**

Pointing Kernel System Diagnostics Package

#### **2.4.1.5 Pointing Kernel System Calibration Package**

Pointing Kernel System Calibration Package

#### **2.4.1.6 Pointing Kernel System Workflow Package**

Pointing Kernel System Workflow Package

#### **2.4.1.7 Pointing Kernel System Management Package**

Pointing Kernel System Management Package

#### **2.4.1.8 Pointing Kernel System Hardware Package**

Pointing Kernel System Hardware Package

### **2.4.2 Wavefront Control Active Optics (ACO) System**

Wavefront Control Active Optics (ACO) System

#### **2.4.2.1 Active Optics Controller Package**

The WFC Active Optics Controller Package includes active optics controller components that are common to the different GMT wavefront control modes.

#### **2.4.2.2 Wavefront Control Active Optics (ACO) Calibration Package**

Wavefront Control Active Optics (ACO) Calibration Package

#### **2.4.2.3 Wavefront Control Active Optics (ACO) Diagnostics Package**

Wavefront Control Active Optics (ACO) Diagnostics Package

#### **2.4.2.4 Wavefront Control Active Optics (ACO) Sequence Package**

Wavefront Control Active Optics (ACO) Sequence Package

#### **2.4.2.5 Wavefront Control Active Optics (ACO) Analysis Package**

Wavefront Control Active Optics (ACO) Analysis Package

#### **2.4.2.6 Wavefront Control Active Optics (ACO) Visualization Package**

Wavefront Control Active Optics (ACO) Visualization Package

#### **2.4.2.7 Wavefront Control Active Optics (ACO) Workflow Package**

Wavefront Control Active Optics (ACO) Workflow Package

#### **2.4.2.8 Wavefront Control Active Optics (ACO) Management Package**

Wavefront Control Active Optics (ACO) Management Package

#### **2.4.2.9 Wavefront Control Active Optics (ACO) Hardware Package**

Wavefront Control Active Optics (ACO) Hardware Package

### **2.4.3 Wavefront Control Natural Seeing (NS) System**

Wavefront Control Natural Seeing (NS) System

#### **2.4.3.1 GMT WFC Natural Seeing package**

The GMT WFC Natural Seeing package provides the software and hardware necessary to implement the wavefront control in the natural seeing mode.

#### **2.4.3.2 Wavefront Control Natural Seeing (NS) Calibration Package**

Wavefront Control Natural Seeing (NS) Calibration Package

#### **2.4.3.3 Wavefront Control Natural Seeing (NS) Diagnostics Package**

Wavefront Control Natural Seeing (NS) Diagnostics Package

#### **2.4.3.4 Wavefront Control Natural Seeing (NS) Analysis Package**

Wavefront Control Natural Seeing (NS) Analysis Package

#### **2.4.3.5 Wavefront Control Natural Seeing (NS) Visualization Package**

Wavefront Control Natural Seeing (NS) Visualization Package

#### **2.4.3.6 Wavefront Control Natural Seeing (NS) Workflow Package**

Wavefront Control Natural Seeing (NS) Workflow Package

#### **2.4.3.7 Wavefront Control Natural Seeing (NS) Management Package**

Wavefront Control Natural Seeing (NS) Management Package

### **2.4.4 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics System**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics System

#### **2.4.4.1 GLAO Controller Package**

The WFC NGLAO Controller Package includes controller components that implement functionality specific to the GMT NGLAO observing mode.

#### **2.4.4.2 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Supervisor Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Supervisor Package

#### **2.4.4.3 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Calibration Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Calibration Package

#### **2.4.4.4 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Diagnostics Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Diagnostics Package



#### **2.4.4.5 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Analysis Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Analysis Package

#### **2.4.4.6 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Visualization Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Visualization Package

#### **2.4.4.7 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Workflow Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Workflow Package

#### **2.4.4.8 Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Management Package**

Wavefront Control Natural Guidestar Ground Layer Adaptive Optics Management Package

### **2.4.5 Wavefront Control Natural Guidestar Adaptive Optics System**

Wavefront Control Natural Guidestar Adaptive Optics System

#### **2.4.5.1 NGS AO Controller Package**

The WFC NGS AO Controller Package includes controller components that implement functionality specific to the GMT NGS AO observing mode.

#### **2.4.5.2 Wavefront Control Natural Guidestar Adaptive Optics Supervisor Package**

Wavefront Control Natural Guidestar Adaptive Optics Supervisor Package

#### **2.4.5.3 Wavefront Control Natural Guidestar Adaptive Optics Calibration Package**

Wavefront Control Natural Guidestar Adaptive Optics Calibration Package

#### **2.4.5.4 Wavefront Control Natural Guidestar Adaptive Optics Diagnostics Package**

Wavefront Control Natural Guidestar Adaptive Optics Diagnostics Package

#### **2.4.5.5 Wavefront Control Natural Guidestar Adaptive Optics Analysis Package**

Wavefront Control Natural Guidestar Adaptive Optics Analysis Package

#### **2.4.5.6 Wavefront Control Natural Guidestar Adaptive Optics Visualization Package**

Wavefront Control Natural Guidestar Adaptive Optics Visualization Package

#### **2.4.5.7 Wavefront Control Natural Guidestar Adaptive Optics Workflow Package**

Wavefront Control Natural Guidestar Adaptive Optics Workflow Package

#### **2.4.5.8 Wavefront Control Natural Guidestar Adaptive Optics Management Package**

Wavefront Control Natural Guidestar Adaptive Optics Management Package

### **2.4.6 Wavefront Control Laser Tomography Adaptive Optics System**

Wavefront Control Laser Tomography Adaptive Optics System

#### **2.4.6.1 Wavefront Control Laser Tomography Adaptive Optics Fast Ctrl Package**

Wavefront Control Laser Tomography Adaptive Optics Fast Ctrl Package

#### **2.4.6.2 Wavefront Control Laser Tomography Adaptive Optics Supervisor Package**

Wavefront Control Laser Tomography Adaptive Optics Supervisor Package

#### **2.4.6.3 Wavefront Control Laser Tomography Adaptive Optics Calibration Package**

Wavefront Control Laser Tomography Adaptive Optics Calibration Package

#### **2.4.6.4 Wavefront Control Laser Tomography Adaptive Optics Diagnostics Package**

Wavefront Control Laser Tomography Adaptive Optics Diagnostics Package

#### **2.4.6.5 Wavefront Control Laser Tomography Adaptive Optics Analysis Package**

Wavefront Control Laser Tomography Adaptive Optics Analysis Package

#### **2.4.6.6 Wavefront Control Laser Tomography Adaptive Optics Visualization Package**

Wavefront Control Laser Tomography Adaptive Optics Visualization Package

#### **2.4.6.7 Wavefront Control Laser Tomography Adaptive Optics Workflow Package**

Wavefront Control Laser Tomography Adaptive Optics Workflow Package

#### **2.4.6.8 Wavefront Control Laser Tomography Adaptive Optics Management Package**

Wavefront Control Laser Tomography Adaptive Optics Management Package

## **2.5 Observatory Operations System**

The Observatory Operations System (OPS) provides the high level software to support an efficient operation of the GMT observatory.

### **2.5.1 Operations User Interface**

The Operations User Interface (OPUI) provides an integrated way to support GMT operations. While the engineering user interfaces provide comprehensive access to the functionality of any subsystem, the OPUI supports the operational workflows of the Observatory.

#### **2.5.1.1 User Interface Service Package**

User Interface Service Package

#### **2.5.1.2 User Interface Visualization Package**

User Interface Visualization Package

### **2.5.1.3 User Interface Diagnostics Package**

User Interface Diagnostics Package

### **2.5.1.4 User Interface Workflow Package**

User Interface Workflow Package

### **2.5.1.5 User Interface Management Package**

User Interface Management Package

### **2.5.1.6 User Interface Hardware Package**

User Interface Hardware Package

## **2.5.2 Observing Tools**

The Observing Tools subsystem (OT) is composed of several components that can be invoked in different context during the observation life cycle. The OT components provide the following capabilities like model synthesis, astronomy source catalog database interface, sky calculator, overhead time calculator, airmass calculator, asterism facility, guide star finder, object observability, positional astronomy facility, mosaic creation, model database, AO PSF simulator, spectroscopy mask facility and observing data management.

### **2.5.2.1 Observing Tools Visualization Package**

Observing Tools Visualization Package

### **2.5.2.2 Observing Tools Sequence Package**

Observing Tools Sequence Package

### **2.5.2.3 Observing Tools Diagnostics Package**

Observing Tools Diagnostics Package

#### **2.5.2.4 Observing Tools Workflow Package**

Observing Tools Workflow Package

#### **2.5.2.5 Observing Tools Management Package**

Observing Tools Management Package

#### **2.5.2.6 Observing Tools Hardware Package**

Observing Tools Hardware Package

### **2.5.3 Scheduler**

The scheduling system facilitates the creation and maintenance of the operational schedule of the telescope, including observing schedules, engineering, and maintenance schedules.

#### **2.5.3.1 Scheduling Server**

#### **2.5.3.2 Visualization Package**

#### **2.5.3.3 Scheduler Diagnostics Package**

Scheduler Diagnostics Package

#### **2.5.3.4 Scheduler Workflow Package**

Scheduler Workflow Package

#### **2.5.3.5 Scheduler Management Package**

Scheduler Management Package

#### **2.5.3.6 Scheduler Hardware Package**

Scheduler Hardware Package

### **2.5.4 Sequencer**

The sequencer subsystem provides the capability to automate high-level observatory operations that involve the coordination of many subsystems.

#### **2.5.4.1 Sequence Service Package**

Sequence Service Package

#### **2.5.4.2 Sequence Visualization Package**

Sequence Visualization Package

#### **2.5.4.3 Sequence Natural Seeing (NS) Package**

Sequence Natural Seeing (NS) Package

#### **2.5.4.4 Sequence Natural Guidestar Ground Layer Adaptive Optics Package**

Sequence Natural Guidestar Ground Layer Adaptive Optics Package

#### **2.5.4.5 Sequence Natural Guidestar Adaptive Optics Package**

Sequence Natural Guidestar Adaptive Optics Package

#### **2.5.4.6 Sequence Laser Tomography Adaptive Optics Package**

Sequence Laser Tomography Adaptive Optics Package

#### **2.5.4.7 Sequence Diagnostics Package**

Sequence Diagnostics Package

#### **2.5.4.8 Sequence Workflow Package**

Sequence Workflow Package

#### **2.5.4.9 Sequence Management Package**

Sequence Management Package

#### **2.5.4.10 Sequence Hardware Package**

Sequence Hardware Package

### **2.5.5 Aircraft Safety System**

The Aircraft Safety System (as\_sys) provides an interface with the VITRO system. The VITRO system (Visualización de Tránsito Aéreo Oceánico) shows in real-time a feed of aircraft locations, with their altitude, velocity and flight direction, similar to the one used by air traffic controllers. The VITRO system is available from accredited vendors by the Chilean Dirección General de Aeronáutica Civil (DGAC), the Chilean equivalent of the Federal Aviation Administration (FAA) in US. GMTO will contract with VITRO system vendors to provide the system, and to explore the possibility of interfacing with the data feed. This could allow for automation of the telescope control system to trigger appropriate alarms and shuttering of the laser beacons in the event of an impending collision between a laser beam and an aircraft.

#### **2.5.5.1 Aircraft Safety System Service Package**

Aircraft Safety System Service Package

#### **2.5.5.2 Aircraft Safety System Visualization Package**

Aircraft Safety System Visualization Package

#### **2.5.5.3 Aircraft Safety System Sequence Package**

Aircraft Safety System Sequence Package

#### **2.5.5.4 Aircraft Safety System Diagnostics Package**

Aircraft Safety System Diagnostics Package

#### **2.5.5.5 Aircraft Safety System Workflow Package**

Aircraft Safety System Workflow Package

#### **2.5.5.6 Aircraft Safety System Management Package**

Aircraft Safety System Management Package

#### **2.5.5.7 Aircraft Safety System Hardware Package**

Aircraft Safety System Hardware Package

### **2.5.6 Laser Traffic Control System**

Distributed among participating telescopes, the LTCS collects pointing data, laser propagating and laser impact status for all the telescopes. The information is made available by all the telescopes at predefined URLs. The LTCS predicts whether beam collision will occur between observatories based on a geometric model of the telescopes and their pointing field of view.

#### **2.5.6.1 Laser Traffic Control System Service Package**

Laser Traffic Control System Service Package

#### **2.5.6.2 Laser Traffic Control System Visualization Package**

Laser Traffic Control System Visualization Package

#### **2.5.6.3 Laser Traffic Control System Sequence Package**

Laser Traffic Control System Sequence Package

#### **2.5.6.4 Laser Traffic Control System Diagnostics Package**

Laser Traffic Control System Diagnostics Package



#### **2.5.6.5 Laser Traffic Control System Workflow Package**

Laser Traffic Control System Workflow Package

#### **2.5.6.6 Laser Traffic Control System Management Package**

Laser Traffic Control System Management Package

#### **2.5.6.7 Laser Traffic Control System Hardware Package**

Laser Traffic Control System Hardware Package

### **2.5.7 Spacecraft Safety System**

The Spacecraft Safety System includes the software to integrate the interface with the LCH in the observatory operation workflow during observations that require laser guide stars. Basic compliance requires the observatory to send a list of LGS targets a few days in advance, and to obtain clearance, from the Laser Clearinghouse (LCH). The process is handled by e-mail using a data format that can seamlessly integrate into the observatory database, planning tool, and sequencer.

#### **2.5.7.1 Spacecraft Safety System Service Package**

Spacecraft Safety System Service Package

#### **2.5.7.2 Spacecraft Safety System Visualization Package**

Spacecraft Safety System Visualization Package

#### **2.5.7.3 Spacecraft Safety System Sequence Package**

Spacecraft Safety System Sequence Package

#### **2.5.7.4 Spacecraft Safety System Diagnostics Package**

Spacecraft Safety System Diagnostics Package

#### **2.5.7.5 Spacecraft Safety System Workflow Package**

Spacecraft Safety System Workflow Package

#### **2.5.7.6 Spacecraft Safety System Management Package**

Spacecraft Safety System Management Package

#### **2.5.7.7 Spacecraft Safety System Hardware Package**

Spacecraft Safety System Hardware Package

### **2.5.8 Quality Monitoring System**

The quality monitoring system watches over data being produced or coming from the telescope to facilitate proper and efficient operations. Quality monitoring entails performing analysis on data coming from telescope subsystems, telemetry, detectors, facility, and instruments, and compares the results against baseline, nominal, benchmarks that are established for each subsystem. In normal circumstances, the performance results are time stamped and stored in the database for future reference. However, in critical circumstances, the results of quality monitoring may trigger warnings or alarms that call for immediate attention.

#### **2.5.8.1 Quality Monitoring Server Package**

#### **2.5.8.2 Quality Monitoring Visualization Package**

#### **2.5.8.3 Quality Monitoring Sequencing Package**

#### **2.5.8.4 Quality Monitoring Diagnostics Package**

Quality Monitoring Diagnostics Package

#### **2.5.8.5 Quality Monitoring Workflow Package**

Quality Monitoring Workflow Package

#### **2.5.8.6 Quality Monitoring Management Package**

Quality Monitoring Management Package

#### **2.5.8.7 Quality Monitoring Hardware Package**

Quality Monitoring Hardware Package

### **2.5.9 Data Archiving System**

The data archiving system (DAS) manages, stores, and distributes all data products related to the operations of the observatory. All the data in the DAS are maintained on-site at the observatory for operations, and are backed up in at least one off-site location.

#### **2.5.9.1 Data Archiving Server**

#### **2.5.9.2 Visualization Package**

#### **2.5.9.3 Sequencing Package**

#### **2.5.9.4 Diagnosis Package**

#### **2.5.9.5 Data Archiving Workflow Package**

Data Archiving Workflow Package

#### **2.5.9.6 Data Archiving Management Package**

Data Archiving Management Package

#### **2.5.9.7 Data Archiving Hardware Package**

Data Archiving Hardware Package

### **2.5.10 Data Processing System**

Data from the observatory, whether science data, engineering, environment, facility, etc., often need to be processed before being used. The data processing system comprises a set of components that takes input data, then performs processing, analysis, summary, or conversion, to produce useful information. For raw science and detector data, this may mean applying calibrations to the data. For telescope pointing information, that may mean performing statistical summary of the pointing accuracy.

#### **2.5.10.1 Data Processing Server**

#### **2.5.10.2 Visualization Package**

#### **2.5.10.3 Sequencing Package**

#### **2.5.10.4 Data Processing Diagnostics Package**

Data Processing Diagnostics Package

#### **2.5.10.5 Data Processing Workflow Package**

Data Processing Workflow Package

#### **2.5.10.6 Data Processing Management Package**

Data Processing Management Package

#### **2.5.10.7 Data Processing Hardware Package**

Data Processing Hardware Package

## 2.6 Observatory Common Services

The Observatory Services System (OBS\_SRV) provides the common infrastructure that enables TCS and Observatory Operations components to communicate and collaborate in order to perform high-level operations, control and monitoring. Additionally, some of these services include components that allow self-monitoring of their own operation.

### 2.6.1 Engineering User Interface Service

The Engineering user interface subsystem provides a low level detailed graphical interface to the GMT system. This interface is not optimized for scientific operations, and is used in collaboration with the Command Line Interface (CLI) service during the development, testing, integration, and commissioning phases of the GMT subsystems.

#### 2.6.1.1 Engineering User Interface Service Package

Engineering User Interface Service Package

#### 2.6.1.2 Engineering User Interface Visualization Package

Engineering User Interface Visualization Package

#### 2.6.1.3 Engineering User Interface Sequence Package

Engineering User Interface Sequence Package

#### 2.6.1.4 Engineering User Interface Diagnostics Package

Engineering User Interface Diagnostics Package

#### 2.6.1.5 Engineering User Interface Workflow Package

Engineering User Interface Workflow Package

#### 2.6.1.6 Engineering User Interface Management Package

Engineering User Interface Management Package

#### **2.6.1.7 Engineering User Interface Hardware Package**

Engineering User Interface Hardware Package

### **2.6.2 Logging Service**

Logging messages are informative messages. They inform that a relevant event concerning the GMT normal operation has occurred. They do not presume any abnormal behaviour. For example, a User has logged on the GMT, or an observation has just been completed.

#### **2.6.2.1 Log Service Package**

Log Service Package

#### **2.6.2.2 Logging Visualization Package**

Logging Visualization Package

#### **2.6.2.3 Logging Sequence Package**

Logging Sequence Package

#### **2.6.2.4 Logging Analysis Package**

Logging Analysis Package

#### **2.6.2.5 Logging Workflow Package**

Logging Workflow Package

#### **2.6.2.6 Logging Management Package**

Logging Management Package

#### **2.6.2.7 Logging Hardware Package**

Logging Hardware Package

### **2.6.3 Alarm Service**

The alarm system in combination with the system supervisor and the ISS are provide functions to guarantee the overall health of the system.

#### **2.6.3.1 Alarm Service Package**

Server, adapter specification

#### **2.6.3.2 Alarm Service Visualization Package**

The visualization package provides custom panels that allow observatory operators to monitor and manage the alarms of the system. This is done implementing several optimize visulizations.

#### **2.6.3.3 Alarm Sequence Package**

Alarm Sequence Package

#### **2.6.3.4 Alarm Analysis Package**

Alarm Analysis Package

#### **2.6.3.5 Alarm Workflow Package**

Alarm Workflow Package

#### **2.6.3.6 Alarm Management Package**

Alarm Management Package

#### **2.6.3.7 Alarm Hardware Package**

Alarm Hardware Package

### **2.6.4 Telemetry Service**

The Telemetry Service provides the ability to observe the value of any selected magnitudes. The magnitude whose value is to be observed may belong to any hardware or software subsystem.

#### **2.6.4.1 Telemetry Service Package**

Telemetry Service Package

#### **2.6.4.2 Telemetry Visualization Package**

Telemetry Visualization Package

#### **2.6.4.3 Telemetry Sequence Package**

Telemetry Sequence Package

#### **2.6.4.4 Telemetry Analysis Package**

Telemetry Analysis Package

#### **2.6.4.5 Telemetry Workflow Package**

Telemetry Workflow Package

#### **2.6.4.6 Telemetry Management Package**

Telemetry Management Package

#### **2.6.4.7 Telemetry Hardware Package**

Telemetry Hardware Package

### **2.6.5 Configuration Service**

The properties / behaviors of all SWC Subsystems and Components are stored as sets of static properties or metadata in a Configuration Database. Operators or subsystem specialists need to change these properties, so it is not convenient to have them hardcoded. Instead, the configuration Service manages and modifies the behavior of the subsystems and components. Configurations can be changed as a whole, depending on the operation mode (e.g., different values on limits may be used for testing and calibration than during nominal operation).



### **2.6.5.1 Configuration Service Package**

Configuration Service Package

### **2.6.5.2 Configuration Visualization Package**

Configuration Visualization Package

### **2.6.5.3 Configuration Sequence Package**

Configuration Sequence Package

### **2.6.5.4 Configuration Analysis Package**

Configuration Analysis Package

### **2.6.5.5 Configuration Workflow Package**

Configuration Workflow Package

### **2.6.5.6 Configuration Management Package**

Configuration Management Package

### **2.6.5.7 Configuration Hardware Package**

Configuration Hardware Package

## **2.6.6 Command Execution Service**

The Command Line Interface (CLI) complements the graphic user interfaces used for both engineering and operations. It provides low-level access to all the system functionality, and the flexibility often required during testing and commissioning phases. The CLI also provides a way to operate subsystems in early stages of development, when the UI is still being developed and does not provide all the functionality.

#### **2.6.6.1 Command Line Interface Service Package**

Command Line Interface Service Package

#### **2.6.6.2 Command Line Interface Visualization Package**

Command Line Interface Visualization Package

#### **2.6.6.3 Command Line Interface Sequence Package**

Command Line Interface Sequence Package

#### **2.6.6.4 Command Line Interface Management Package**

Command Line Interface Management Package

### **2.6.7 On-line Documentation Service**

The on-line documentation subsystem provides access to the user guides and manual necessary for the operation of the SWCS system. It also provides access to the runtime metadata.

#### **2.6.7.1 Document Service Package**

Document Service Package

#### **2.6.7.2 Document Visualization Package**

Document Visualization Package

#### **2.6.7.3 Document Sequence Package**

Document Sequence Package

#### **2.6.7.4 Document Analysis Package**

Document Analysis Package

#### **2.6.7.5 Document Workflow Package**

Document Workflow Package

#### **2.6.7.6 Document Management Package**

Document Management Package

### **2.6.8 System Supervisor Service**

The GMT has a large number of distributed Subsystems and Components that are deployed in different computers or embedded units to implement telescope control functions. Each Subsystem is required to deploy a Supervisor to coordinate, monitor, and manage, the health status of its respective software and hardware Components. In order to guarantee reliability it is important to monitor and manage the overall health of these Supervisors and Components. The System Supervisor is thus in charge of the overall health of the system by watching over the hierarchy. It ensures that the system as a whole can handle fault tolerance, service availability, and failure detection, thus ensuring the overall robustness.

#### **2.6.8.1 Supervisor Service Package**

Supervisor Service Package

#### **2.6.8.2 SuperVisualizationor vis Package**

SuperVisualizationor vis Package

#### **2.6.8.3 Supervisor Sequence Package**

Supervisor Sequence Package

#### **2.6.8.4 Supervisor Analysis Package**

Supervisor Analysis Package

#### **2.6.8.5 Supervisor Workflow Package**

Supervisor Workflow Package

#### **2.6.8.6 Supervisor Management Package**

Supervisor Management Package

#### **2.6.8.7 Supervisor Hardware Package**

Supervisor Hardware Package

### **2.6.9 Network Infrastructure**

The Network Infrastructure subsystem provides the network equipment and cabling necessary for the operation of the SWCS. It also includes the software necessary to manage and interface networking equipment. A combination of multi-fiber trunks and breakout cables provides galvanic isolation between the different equipment installed in the electronics room and the telescope enclosure. The network layout is based on a switching fabric layout common in High Performance Computing applications.

#### **2.6.9.1 Network Service Package**

Network Service Package

#### **2.6.9.2 Network Visualization Package**

Network Visualization Package

#### **2.6.9.3 Network Sequence Package**

Network Sequence Package

#### **2.6.9.4 Network Analysis Package**

Network Analysis Package

#### **2.6.9.5 Network Workflow Package**

Network Workflow Package

#### **2.6.9.6 Network Management Package**

Network Management Package

#### **2.6.9.7 Network Hardware Package**

Network Hardware Package

### **2.7 Instrument Device Control System**

Instrument Device Control System

#### **2.7.1 GCLEF Device Control System**

GMTIFS Data Acquisition Package

##### **2.7.1.1 GMTIFS Calibration Package**

GMTIFS Calibration Package

##### **2.7.1.2 GMTIFS Diagnostics Package**

GMTIFS Diagnostics Package

##### **2.7.1.3 GMTIFS Observing Tools Package**

GMTIFS Observing Tools Package

##### **2.7.1.4 GMTIFS Visualization Package**

GMTIFS Visualization Package

#### **2.7.1.5 GMTIFS Sequence Package**

GMTIFS Sequence Package

#### **2.7.1.6 GMTIFS Workflow Package**

GMTIFS Workflow Package

#### **2.7.1.7 GMTIFS Management Package**

GMTIFS Management Package

#### **2.7.1.8 GMTIFS Hardware Package**

GMTIFS Hardware Package

#### **2.7.1.9 GMTIFS FAT Package**

GMTIFS FAT Package

### **2.7.2 GCLEF Device Control System**

## **2.7.3 Hardware Developer Kit Control System**

The Hardware Developers Kit (HDK) is a hardware platform that embodies a basic Device Control System that complies with the GMT DCS Reference Architecture (RA)

### **2.7.3.1 HDK Controller Package**

HDK Controller Package

### **2.7.3.2 HDK Calibration Package**

HDK Calibration Package

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