LSST Telescope/Site Middleware - Datastream prototyping

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Introduction

This document describes a strawman set of datastream prototypes which will be used to evaluate the capability of various software components (middleware) for use in the LSST software infrastructure.

For each datastream type, we provide a brief description of the item, plus an estimate of the number of subsytems likely to produce and subscribe to items of this type. The update frequency and likely size of components of the datastream are provided, and finally a list of any Binary Large Object (BLOB's) which might be produced in association with the datastream.

The objective is to produce a comprehensive list which can be used to help automate the testing of middleware components. A database will be generated using the information herein, and software written to autogenerate sample code to simulate interactions between any 2 (or more) of the subsystems described.

A full list of the subsystems can be found in Appendix A.

Subsystem : auxscope

Auxiallary telescope, 1.5 m photometric telescope with LSST TCS

Topic : auxscope.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 1**
- **Frequency : 1 Hz**

- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**
- **Item / type / count : Status / String / 16**
- **BLOBs : None**

Topic : auxscope.Camera

Description

**This subsystem maintains high level data pertaining to the state
of the Auxillary Telescope camera (May be split into subtopics).**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : 256x4096x1 16bit images**

Topic : auxscope.Electrical

Description

**Electrical monitoring for devices located in the Auxillary Telescope subsystem.
Raw data, calibrated voltages, calibrated current, device power status.**

- **Number of sources : 1**
- **Number of subscribers : 1**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : auxscope.Metrology

Description

**Position control for sensors located in the Auxillary Telescope subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.**

- **Number of sources : 1**

- **Number of subscribers : 3**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : auxscope.Spectrometer

Description

**This subsystem maintains high level data pertaining to the state
of the Auxillary Telescope Spectrograph (May be split into subtopics).**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : 256x2048x1 16bit images**

Topic : auxscope.TC

Description

**Temperature monitoring for sensors located in the Auxillary Telescope subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Topic : auxscope.TCS

Description

**This subsystem maintains high level data pertaining to the state
of the Auxillary Telescope Control System (May be split into subtopics).**

- **Number of sources : 1**
- **Number of subscribers : 3**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 200**
- **Item / type / count : Raw / Int / 200**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Subsystem : calibration

Calibration equipment

Topic : calibration.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 3**
- **Frequency : 1 Hz**
- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**
- **Item / type / count : Status / String / 16**
- **BLOBs : None**

Topic : calibration.Electrical

Description

Electrical monitoring for devices located in the calibration subsystem.
Raw data, calibrated voltages, calibrated current, device power status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : calibration.Metrology

Description

**Position control for sensors located in the calibration subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : calibration.TC

Description

**Temperature monitoring for sensors located in the calibration subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Subsystem : camera

The camera is one of the three primary LSST technical subsystems (along with the Telescope/Site Subsystem and the Data Management Subsystem). It contains a 3.2 Gigapixel focal plane array, comprised of roughly 200 4K x 4K CCD sensors, with 10 micron pixels.

The sensors are deep depleted, back illuminated devices with a highly segmented architecture that enables the entire array to be read out in 2 s or less. These detectors are grouped into 3 x 3 arrays called rafts. Each raft contains its own dedicated front end and back end electronics boards, which fit within the footprint of its sensors, thus serving as a 144 Megapixel camera on its own.

All of the rafts, with their associated electronics, are mounted on a silicon carbide grid inside a vacuum cryostat, with an intricate thermal control system that maintains the CCDs at an operating temperature of roughly minus 90 degrees centigrade.

The grid also contains sets of guide sensors and wavefront sensors at the edge of the field. The entire grid, with the sensors, is actuated at a rate ~ 30 Hz in a fast guiding mode to maintain a very narrow psf (0.7 arcseconds median), which is limited mainly by seeing fluctuations in the overlying atmosphere.

The entrance window to the cryostat is the third of the three refractive lenses. The other two lenses are mounted in an optics structure at the front of the camera body. The camera body also contains a mechanical shutter, and a carrousel assembly that holds five large optical filters, any of which can be inserted into the camera field of view for a given exposure. A sixth optical filter will also be fabricated which can replace any of the five via an automated procedure accomplished during daylight hours.

The camera system consists of multiple subsystems that include utilities, the camera body vessel and mechanisms for shuttering and optical filtering, the imaging sensors, optical lenses and filters, a computerized data acquisition and control system, the cryostat holding the detector array, readout and control electronics, wavefront sensors, and guide sensors.

Topic : camera.BEE.biases

Description

This subsystem comprises 25 computers (one per raft, not including spares), each hosting a fiber interface card to receive the image data generated by a raft. These computers would buffer the image data in memory and transfer the data into the Data Management stream. Iitial data quality assessment), may also be carried out on these hosts. The state of the bias voltages are monitored in this subsystem.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : operate / long / 201**
- **Item / type / count : reset / long / 201**
- **Item / type / count : substrate / long / 201**
- **BLOBs : None**

Topic : camera.BEE.clocks

Description

This subsystem comprises 25 computers (one per raft, not including spares), each hosting a fiber interface card to receive the image data generated by a raft. These computers would buffer the image data in memory and transfer the data into the Data Management stream. Iitial data quality assessment), may also be carried out on these hosts. The state of the clocks are monitored in this subsystem.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**

- **Item / type / count : parallel_1A / long / 201**
- **Item / type / count : parallel_1B / long / 201**
- **Item / type / count : parallel_2A / long / 201**
- **Item / type / count : parallel_2B / long / 201**
- **Item / type / count : serial_1A / long / 201**
- **Item / type / count : serial_1B / long / 201**
- **Item / type / count : serial_2A / long / 201**
- **Item / type / count : serial_2B / long / 201**
- **Item / type / count : serial_3A / long / 201**
- **Item / type / count : serial_3B / long / 201**
- **BLOBs : None**

Topic : camera.BEE.thermal

Description

This subsystem comprises 25 computers (one per raft, not including spares), each hosting a fiber interface card to receive the image data generated by a raft. These computers would buffer the image data in memory and transfer the data into the Data Management stream. Iitial data quality assessment), may also be carried out on these hosts The state of the thermal environment is monitored in this subsystem.

- **Number of sources : 25**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : cfgChkSum / long / 1**
- **Item / type / count : heaterPower / float / 10**
- **Item / type / count : heaterStatus / long / 10**
- **Item / type / count : raftID / short / 1**
- **Item / type / count : temp / float / 20**
- **BLOBs : None**

Topic : camera.CALSYS

Description

The xray calibration subsystem consists of an Fe55 source on wiperblade arm(s) that sweeps across the focal plane for xray calibration of quantum efficiency, electrical gains and offsets, readout noise, and physical/cosmetic features of the CCD array.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.001 Hz**
- **Item / type / count : profile / float / 1024**
- **BLOBs : None**

Topic : camera.CCS

Description

The camera control system is responsible for overall integration of camera subsystem operations, safety interlocks, and inter-subsystem interactions

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : expHist / long / 1024**
- **Item / type / count : flags / long / 10**
- **BLOBs : None**

Topic : camera.FCS

Description

The Filter Controller Subsystem (FCS) manager software controls and synchronizes operation of the filter changer and carousel.

**This subsystem maintains filter positioning and motion information
as well as lower level filter mechanism parameters.**

Components : Filter Carousel with mechanisms, actuators, and power supply and controller

The filter carousel stores a set of color filters and the changer inserts any one as needed for the particular observational task. Five color filters fit within the camera housing on a carousel that rotates about the camera axis. The carousel presents the appropriate filter to the lower station where the exchange can be made through the space between the shutter rollers. . A wheeled cart (transporter) conveys the filter along the tracks between the carousel and use position.

The filter substrates differ from one another in their central thickness, ranging from 13.5 to 22 mm. The convex spherical radius is the same for all filters and is placed the same inside the camera

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : algorithm / string / 32**
- **Item / type / count : flags / long / 1**
- **Item / type / count : motion_profile / float / 60*40**
- **BLOBs : None**

Topic : camera.GAS

Description

Guide Sensor Data Acquisition System

**This subsystem maintains metadata concerning the state of the
guide regions, and the results of the processing of
the subimages. Items such as bax pixel counts, H/V profiles
profile fit results etc. The Guide Sensor System(GSS) produces data that is collected by the Guider Data Acquisition System (GAS) and sent to the Focal Plane Actuator (FPU) and also, possibly, the Telescope Control System (TCS).**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10.0 Hz**
- **Item / type / count : algorithm / string / 32**
- **Item / type / count : parameters / float / 10**
- **Item / type / count : sampleData_00 / float / 25**
- **Item / type / count : sampleData_01 / float / 25**
- **Item / type / count : sampleData_10 / float / 25**
- **Item / type / count : sampleData_11 / float / 25**
- **BLOBs : 64x64x1 16bit images**

Topic : camera.LASERCAL

Description

**Position control for sensors located in the camera subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.001 Hz**
- **Item / type / count : positions / float / 10**
- **BLOBs : None**

Topic : camera.PWR

Description

This unit monitors the power supply demands and statuses for the various parts of the camera subsystem.

- **Number of sources : 1**

- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : current / float / 25**
- **Item / type / count : supply_voltage / float / 25**
- **BLOBs : None**

Topic : camera.QA.measured

Description

This subsystem monitors the quality assurance feedback from the downstream processing. It is used to verify low-level operation of the on-board timing and A/D conversion in the camera.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : metric1 / float / 132**
- **Item / type / count : metric2 / float / 132**
- **Item / type / count : metric3 / float / 132**
- **Item / type / count : metric4 / float / 132**
- **BLOBs : None**

Topic : camera.SCS

Description

The Shutter Controller Unit (SCU) manager software controls and synchronizes shutter operation.

**This subsystem maintains shutter positioning and motion information
as well as lower level shutter mechanism parameters.Deliverables: Shutter with mechanisms, actuators, and power supply and controller**

- **Shutter life test unit/testbed**
- **Shutter storage/transport container**
- **Test gantry and sensor array**

A rectangular aperture that moves across the array controls the exposure time for all pixels. Equal exposure time requires the opening edge and the closing edge to have the same motion profile in time. This is achieved by using one long sheet with a central rectangular aperture of constant width. For compact storage, the sheet attaches to and wraps around two rollers to form a scroll. Tthere are two closed positions so the sheet advances in the same direction from closed to open to closed. The sheet reverses direction for the next cycle. This would be of great benefit if the minimum exposure time were much shorter than currently required.

Controlling the exposure time to millisecond precision is equivalent to controlling position of the aperture edges to several tenths of millimeters. Standard feedforward and feedback control techniques maintain acceptable following error (i.e., the controller component of error) for this well defined

motion profile. Placing sensors on the rollers is easy and reliable and the average of the two accounts for the effective roller radius changing as the sheet rolls up on itself. This effect is small for a thin metal sheet. In addition, a metal sheet is opaque, does not outgas, can be processed for high fatigue strength and low wear, and is stable and rigid in plane.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.2 Hz**
- **Item / type / count : algorithm / string / 32**
- **Item / type / count : close_profile / float / 1024**
- **Item / type / count : flags / long / 1**
- **Item / type / count : open_profile / float / 1024**
- **BLOBs : None**

Topic : camera.SDS

Description

This subsystem comprises 25 computers (one per raft, not including spares), each hosting a fiber interface card to receive the image data generated by a raft. These computers would buffer the image data in memory and transfer the data into the Data Management stream. Iitial data quality assessment), may also be carried out on these hosts.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : current / float / 80**
- **Item / type / count : flags / long / 20**
- **BLOBs : None**

Topic : camera.SDS.amplifiers

Description

This subsystem monitors the performance and physical operation of all the CCD amplifiers in the focal plane.

- **Number of sources : 25**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : flags / long / 132**
- **Item / type / count : raftID / short / 1**
- **Item / type / count : status / long / 132**
- **Item / type / count : voltage1 / float / 132**
- **Item / type / count : voltage2 / float / 132**
- **Item / type / count : voltage3 / float / 132**

- **Item / type / count : voltage4 / float / 132**
- **BLOBs : None**

Topic : camera.TC.control

Description

The Thermal Control (TCS) manager software controls temperature in multiple thermal zones in the focal plane, cryostat, and camera body. Feedback control is based on trim heaters for actuation and temperature sensors for readback.

Temperature monitoring for sensors located in the camera subsystem.
Raw sensor readings, calibrated temperatures, timeseries statistics, sensor health.

The basic requirement of the Camera Thermal Comtrol System is to allow the solidstate detectors that form the Focal Plane Array (FPA) to operate at ~ 170K to reduce the contribution of thermal noise to the electronic signals while in parallel optimizing quantum efficiency (QE). The thermal gradient across the sensors must also be adequately reduced (±0.30K) to maintain uniform quantum efficiency in each pixel. For efficient camera operation, thermal stability of the FPA is necessary to maintain optical sensor performance as well as to eliminate the growth of mechanical distortions to the FPA, once it is aligned.

The additional functions of the thermal control system are to provide a particulate free environment for the sensor surfaces, heat extraction from both the front end and back end electronics systems, and antifog protection for the three optical elements. The camera is composed of a cryostat containing the FPA and its readout electronics and an outer camera body which houses the cryostat, shutter, L2 optic, and the five filters and filter exchange mechanism. The cryostat is closed by the L3 optic and the outer camera body by the L1 optic. The cryostat is operated at ~10e-6 Torr vacuum while the region between the cryostat and outer body will contain an inert gas (eg: dry nitrogen will be assumed) regulated to be slightly above atmospheric pressure. The temperature of the N2 gas will be controlled to maintain a stable thermal envelope. The other important role of the inert gas is to prevent degradation of the filter coatings.

Components: Off Camera: flex line umbilicals; chillers, auxiliary pumps, reservoirs, purge system, plumbing systems, sensors and flow meters, local operator's terminal, vacuum system for insulating vacuum, racks, consoles.

Requirements:

Control temperature to derived requirement below 3oC
Log temperatures, heater current for all 189 sensor thermal zones
Monitor temperature stability over time
Graph temperatures and heater current vs time for trending analysis
Graphically map temperatures of all Grid bays
Send caution signal if dTemp/dTime approaches limits
Send warning signal if dTemp/dTime exceeds limits
Override of over/undertemp caution and warning alarms
Change/store/download temp setpoints and limits for all control zones
Save configurations of heater power for different operating scenarios
Log temperatures, heater current for all thermal plates

Graph temperatures and heater current vs time for trending analysis
Graphically map temperatures and heater current of all Grid bays
Override of over/undertemp caution and warning alarms
Change/store/download heater current setpoints for all control zones
Provide manual realtime adjustment of individual heater currents
Save configurations of heater current for different operating scenarios
Log temperatures, heater current for all Cold Plate, BEE boards, cryogen line inlets/outlets
Graph temperatures and heater current vs time for trending analysis
Graphically map temperatures and heater current of all BEE module locations
Override of over/undertemp caution and warning alarms
Temperatures from Cold Plate thermal zone can be combined with all other thermal data
Change/store/download heater current setpoints for all control zones
Provide manual realtime adjustment of individual heater currents
Save configurations of heater current for different operating scenarios

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : setpoint / float / 10**
- **Item / type / count : status / int / 10**
- **Item / type / count : temperature / float / 10**
- **BLOBs : None**

Topic : camera.TC.zone1

Description

This subsystem comprises the devices and controllers necessary for monitoring and control of the temperature of the focal plane sensors and front end electronics. This zone must be maintained at approximately -100C to high accuracy (to be specified). Its function is to remove heat from the focal plane due to radiation through L1 as well as heat dissipated in the CCDs and Front End Cards

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : cold_plate / float / 25**
- **Item / type / count : flow_rate / float / 25**
- **Item / type / count : setpoint / float / 25**
- **Item / type / count : status / int / 25**
- **Item / type / count : temperature / float / 25**
- **BLOBs : None**

Topic : camera.TC.zone2

Description

This subsystem comprises the devices and controllers necessary for thermal monitoring and control of the Back End Electronics attached to the bottom plate of the Inner Cryostat. The temperature will be in the neighborhood of -20C but does not require high accuracy or stability. Its function is to remove heat generated by the Back End Electronics.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : cold_plate / float / 25**
- **Item / type / count : setpoint / float / 25**
- **Item / type / count : status / int / 25**
- **Item / type / count : temperature / float / 25**
- **BLOBs : None**

Topic : camera.TC.zone3

Description

This unit monitors and controls temperature in the Timing/Control Crate. Specifically, it removes heat generated by electronics residing in the Crate and monitors crate temperature.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : setpoint / float / 50**
- **Item / type / count : status / int / 50**
- **Item / type / count : temperature / float / 50**
- **BLOBs : None**

Topic : camera.TC.zone4

Description

This unit monitors and controls temperature in the Utility trunk. Specifically, it removes heat generated by electronics residing in the Utility trunk and monitors trunk temperature.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : flow_rate / float / 10**

- **Item / type / count : setpoint / float / 10**
- **Item / type / count : status / int / 10**
- **Item / type / count : temperature / float / 10**
- **BLOBs : None**

Topic : camera.TC.zone5

Description

This unit monitors and controls temperature in the cooling unit. Specifically, it removes heat generated by electronics residing in the cooling units temperature.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : flow_rate / float / 10**
- **Item / type / count : setpoint / float / 10**
- **Item / type / count : status / int / 10**
- **Item / type / count : temperature / float / 10**
- **BLOBs : None**

Topic : camera.TC.zone6

Description

This unit monitors and controls temperature in the External transport. Specifically, it removes heat generated by electronics residing in the transport and monitors temperature.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : flow_rate / float / 10**
- **Item / type / count : setpoint / float / 10**
- **Item / type / count : status / int / 10**
- **Item / type / count : temperature / float / 10**
- **BLOBs : None**

Topic : camera.TCM

Description

Directly beneath each packaged CCD module is a Front End Electronics Module (FEM) containing the following functionality.

- **Analog signal processing ASIC**
- **CCD clock drivers, ASIC or hybrid**
- **Bias voltage dsitribution**

This architecture minimizes the physical distance from CCD output amplifiers to the analog signal processing circuits, thus minimizing power dissipation and risk of noise pickup. The CCD clock drivers are assumed to be simple level translators, with no pattern generation at this point. Beyond generating clock signals, there is no digital activity at this level. All analog signals are buffered and fully differential for purposes of noise immunity. Similarly, all timing signals comply with the Low Voltage Differential Signaling (LVDS) standard. Both the clock drivers and the bias generators will be programmable by means of a slow serial link.

- **Number of sources : 25**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : parameters / float / 10**
- **BLOBs : None**

Topic : camera.UTIL

Description

This subsystem monitors the health and operational parameters of the hardware in the Utility trunk section of the camera.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : flow_rate / float / 10**
- **Item / type / count : setpoint / float / 10**
- **Item / type / count : status / int / 10**
- **Item / type / count : temperature / float / 10**
- **BLOBs : None**

Topic : camera.VCS

Description

The Vacuum Control Subsystem (VCS) manager software controls and synchronizes operation of the vacuum and purge subsystem in the camera cryostat and utility trunk (either on the mountain or in the lab). Feedback control is based on vacuum pumps and pressure gauges.

**This subsystem maintains application level data for the dewar
vacuum systems. Target and actual statuses
health , limits, etc.**

The inner cryostat housing contains the focal plane array with its frontend and backend electronics, elements of the thermal management system, and all lectrical, optical, fluid and mechanical feedthroughs. The lens, L3, forms the window on the ront end of the cryostat housing. A rear flange to the inner housing provides primary access to components inside.

- **On Camera vacuum manifolds, valves, pump ports, transfer lines, and plena. Getter and ion holding pumps on Cryostat, including regeneration heaters and valving. RGA, ion gauge, TQCM, and controllers.**
- **On Camera purge manifolds, valves, pump ports, and pressure vessel. Metering, temp sensors, reheaters, power supplies and controllers. Insulated purge flex lines to camera.**
- **On the ground: Purge reheat controller, chiller, meters, filters, sensors, flow control valves, racks and consoles.**

The focal plane array is contained in vacuum to minimize its environmental heat load. While vacuum eliminates natural convection, other modes of heat transfer are still present. Multi layer insulation applied to the cryostat housing all but eliminates radiation heat transfer except where it cannot be such as the vacuum window (L3). Supporting the focal plane array on flexures naturally minimizes conduction through structures.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : control / float / 10**
- **Item / type / count : pressure / float / 10**
- **BLOBs : None**

Topic : camera.WDS.wfsRaft

Description

Wavefront System Manager

**This subsystem maintains metadata concerning the state of the
wavefront sensors, and the results of the processing of
images. Items such as chip voltages, health, per chip temps
bad pixel/line/column counts, image pair counts, zernike results
and so on. The wavefront sensing system will consist of wavefront curvature monitors and/or Shack Hartmann sensors in or around the science array. Data from these sensors will be used to monitor and improve the quality of the science data by using WF measurements for feedback compensation. The feedback control of telescope alignment will be handled by the Telescope Control System.**

Four special purpose rafts, mounted at the corners of the science array, will contain wavefront sensors and guide sensors. Wavefront measurements are accomplished using curvature sensing, where the spatial intensity distribution of stars is measured at equal distances on either side of focus. Each curvature sensor will be composed of two CCD detectors, with one positioned slightly above the focal plane, and the other positioned slightly below the focal plane. The CCD technology for the curvature sensors will be identical to that used for the science detectors in the focal plane except that the curvature sensor detectors will be half size so they can be mounted as an in/out defocus pair. Detailed analyses have verified that this configuration can recover the wavefront to the required accuracy.

- **Number of sources : 4**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : CalcImage1 / string / 128**
- **Item / type / count : CalcImage2 / string / 128**
- **Item / type / count : avgInsideImage / string / 128**
- **Item / type / count : avgOutsideImage / string / 128**
- **Item / type / count : metrics / float / 32**
- **Item / type / count : parameters / float / 32**
- **Item / type / count : status / long / 1**
- **Item / type / count : zernikes / float / 16**
- **BLOBs : 100x100x8 32bit analysis images**

Topic : camera.WTCM

Description

This subsystem monitors the timing and control modules for the Wavefront rafts.

- **Number of sources : 4**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : parameters / float / 10**
- **BLOBs : None**

Subsystem : dm

The Data Management system provides all downstream anaylsis, alerting, image processing, reduction , publishing, and archiving , for the LSST image data.

Topic : dm.derived.dataquality

Description

This data quality component reports the derived data quality for each ccd.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : metric1 / double / 200**
- **Item / type / count : metric2 / double / 200**
- **Item / type / count : metric3 / double / 200**
- **Item / type / count : metric4 / double / 200**
- **Item / type / count : metric5 / double / 200**

- **Item / type / count : metric6 / double / 200**
- **Item / type / count : summary / double / 100**
- **BLOBs : None**

Topic : dm.derived.psf

Description

This data quality component reports the derived PSF for each ccd.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : metric1 / double / 200**
- **Item / type / count : metric2 / double / 200**
- **Item / type / count : metric3 / double / 200**
- **Item / type / count : metric4 / double / 200**
- **Item / type / count : metric5 / double / 200**
- **Item / type / count : metric6 / double / 200**
- **BLOBs : None**

Topic : dm.pointing.wcs

Description

This data quality component reports the derived WCS pointing data.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : coeff / double / 32**
- **Item / type / count : dec / double / 200**
- **Item / type / count : ra / double / 200**
- **BLOBs : None**

Topic : dm.raw.dataquality

Description

This data quality component reports the raw data quality for each ccd.

- **Number of sources : 1**
- **Number of subscribers : 2**

- **Frequency : 0.1 Hz**
- **Item / type / count : metric1 / double / 200**
- **Item / type / count : metric2 / double / 200**
- **Item / type / count : metric3 / double / 200**
- **Item / type / count : metric4 / double / 200**
- **Item / type / count : metric5 / double / 200**
- **Item / type / count : metric6 / double / 200**
- **Item / type / count : summary / double / 100**
- **BLOBs : None**

Subsystem : enclosure

Dome and enclosure
1.1.Basic Functions: The purpose of the dome is to protect the telescope and camera from adverse environmental conditions both during observing and when not in operation. The clear optical path provided by the dome, the contribution of dome seeing to the overall error budget, and the operational parameters of the dome will be consistent with the Telescope Requirements Document (Doc # 2389)

Thermally Benign: A fundamental objective in the dome design will be maintaining a beneficial thermal environment for the seeing performance of the telescope. Preconditioning of the telescope environment, passive ventilation, the use of materials with low thermal inertia, and other strategies will be employed for that purpose.

Special LSST Survey Requirements: As a telescope dedicated to a demanding survey program, LSST has some special characteristics that are reflected in the dome requirements: A critical need to shield the telescope from stray light due to the wide 3.5º telescope observing angle A higher than normal requirement for dome reliability imposed by the continuous nature of the survey observing regime. A faster than normal dome tracking speed required by the rapid paced, robotic observing cadence.

Maintenance: In addition to its operational characteristics, the dome provides adequate enclosed space and appropriate facilities for engineering and maintenance work on the telescope, camera, and on the dome itself.

Coordination with Telescope, Optics and Instrument Design: Designs for the telescope mount, optics, and camera are ongoing. The baseline dimensions and operational characteristics of these elements are, however, well enough understood to allow development of an appropriate dome to enclose and service these systems. Further refinements in telescope and camera design will be incorporated into future versions of this document, and later reflected in the detailed design of the dome.

Coordination with the Lower Enclosure: The lower enclosure that supports the dome is a fixed building with requirements described in the Support Facility Design Requirements Document (Doc # 342). The dimensional and structural criteria for the lower enclosure are dictated by the dome.

Code Compliance and Structural Loads: All aspects of the LSST dome will comply with current editions of the International Building Code, OSHA regulations, and other applicable design and construction standards as specified by LSST. Wind and seismic loads for dome design will be developed based on the latest available historical and regional data.

Site: The LSST observatory will be located at the El Peñón peak on Cerro Pachón in Chile. This is a mountaintop location at an elevation of approximately 2650m (8692 ft.) above sea level, and is subject

to severe weather conditions. This site is also subject to relatively high earthquake risk, with correspondingly high design factors for seismic acceleration. The dome will be designed to withstand these and other specific environmental conditions of the site.

Topic : enclosure.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**
- **Item / type / count : Status / String / 16**
- **BLOBs : None**

Topic : enclosure.Azimuth

Description

This subsystem maintains high level information pertaining to the enclosure positioning demand and performance, wind loading etc.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : enclosure.Electrical

Description

**Electrical monitoring for devices located in the enclosure subsystem.
Raw data, calibrated voltages, calibrated current, device power status.**

- **Number of sources : 1**
- **Number of subscribers : 2**

- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : enclosure.Metrology

Description

**Position control for sensors located in the enclosure subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : enclosure.Shutter

Description

This subsystem maintains high level information pertaining to the dome shutter positioning demand and performance, wind loading etc.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : enclosure.TC

Description

**Temperature monitoring for sensors located in the enclosure subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Topic : enclosure.Thermal_control

Description

This subsystem maintains high level information pertaining to the control and monitoring of the thermal environment inside the dome.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : enclosure.Vents

Description

This subsystem maintains high level information pertaining to the dome vents positioning demand and performance, wind loading etc.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Subsystem : environment

Internal and external environmental monitoring systems

Topic : environment.Dust_monitor

Description

**This subsystem maintains information from the Dust Monitor subsystem.
Both low level mechanical status , and calculated result data
are included.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : environment.Electrical

Description

**Electrical monitoring for devices located in the environment subsystem.
Raw data, calibrated voltages, calibrated current, device power status.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : environment.Lightning_detector

Description

**This subsystem maintains data from the Lightning detection subsystem
and current predictive data.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**

- **BLOBs : 1024x1024x1 8bit history image**

Topic : environment.Seismometer

Description

This subsystem maintains data from the Siesmometer subsystem.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : environment.TC

Description

Temperature monitoring for sensors located in the environment subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 64**
- **Item / type / count : Health / Byte / 64**
- **Item / type / count : Raw / Int / 64**
- **BLOBs : None**

Topic : environment.Video_cameras

Description

This subsystem maintains system status for the video monitoring
systems. The video system is a distributed network of addressable cameras located throughout the facility to give the operators visual feedback of activity in and around the facility.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**

- **Item / type / count : Status / Byte / 16**
- **BLOBs : 640x480x16 8bit images**

Topic : environment.Weather

Description

This subsystem maintains weather data, both current predictions and actual measurements.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 256**
- **Item / type / count : Raw / Int / 128**
- **Item / type / count : Status / Byte / 128**
- **BLOBs : None**

Subsystem : lasercal

LSST Focal plane Laser Spot Alignment Pattern Projection System
An array of laser spots generated by shining a laser through a diffraction grating is projected onto the focal plane imaging sensors as a fixed reference pattern

The CCDs are read out and the locations of these laser spots are stored

Displacements of the apparent spot locations on subsequent read outs can be used to infer shifts in the positions of the CCD sensors

Spot generation using an optimized micromachined 2D array of apertures A diffraction grating where the dimensions of the open apertures are on the order of the wavelength of the laser will generate a projected array of spots with relatively uniform amplitudes

Topic : lasercal.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**

- **Item / type / count : Status / String / 16**
- **BLOBs : None**

Topic : lasercal.Electrical

Description

**Electrical monitoring for devices located in the laser calibration subsystem.
Raw data, calibrated voltages, calibrated current, device power status.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : lasercal.TC

Description

**Temperature monitoring for sensors located in the laser calibration subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Subsystem : m1m3

Primary mirror system

The primary is made from spun cast borosilicate blanks cast at the University of Arizona’s Mirror Laboratory. These mirrors will use the standard hex cell pattern so the existing load spreader designs can be used without modification. The arrangement of actuators and load spreaders has been adjusted near the ID of the primary to adapt to the large center hole and the arrangement on the tertiary is adjusted as required at the OD. Since we assume the use of the same support actuators as are in service on the LBT 8.4 m primary, the test data from this set of actuators is relevant to the evaluation of support force errors.

Weight of the primary is 12,526 kg. This includes the weight of the bonded on load spreaders. Primary results are based on frequent system corrections for focus, coma and astigmatism. The primary benefits from this due to a relatively soft astigmatic bending mode attributable to the large center hole. This correction, while desirable, is not necessary.

Topic : m1m3.ActuatorSample

Description

A full 1 second sampling of actuator telemetry at a resolution of 10ms per sample

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : actuatorID / short / 1**
- **Item / type / count : error / long / 100**
- **Item / type / count : position / long / 100**
- **Item / type / count : setpoint / long / 100**
- **Item / type / count : status / long / 100**
- **BLOBs : None**

Topic : m1m3.Actuators

Description

This subsystem maintains information on a per actuator basis persuant to the low level behaviour of the components of the m1 support system.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : cyltemp / float / 120**
- **Item / type / count : envtemp / float / 120**
- **Item / type / count : error / long / 120**
- **Item / type / count : lvdtcorr / float / 120**
- **Item / type / count : position / long / 120**
- **Item / type / count : pressure / float / 120**
- **Item / type / count : setpoint / long / 120**
- **Item / type / count : status / long / 120**
- **BLOBs : None**

Topic : m1m3.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : demand / float / 6**
- **Item / type / count : error / float / 6**
- **Item / type / count : position / float / 6**
- **Item / type / count : status / short / 16**
- **BLOBs : None**

Topic : m1m3.Electrical

Description

Electrical monitoring for devices located in the m1 subsystem.
Raw data, calibrated voltages, calibrated current, device power status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : error / long / 16**
- **Item / type / count : status / short / 16**
- **Item / type / count : voltage / long / 16**
- **BLOBs : None**

Topic : m1m3.LUT

Description

Look-up-table parameters

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : algorithm / string / 32**
- **Item / type / count : param / float / 32**
- **BLOBs : None**

Topic : m1m3.LimitSensors

Description

State of the liftoff switches and limit switches

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : liftoff / short / 64**
- **Item / type / count : limit / short / 64**
- **BLOBs : None**

Topic : m1m3.Metrology

Description

Position control for sensors located in the m1 subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : distance / long / 16**
- **Item / type / count : error / long / 16**
- **Item / type / count : status / short / 16**
- **BLOBs : None**

Topic : m1m3.Supports

Description

Status and position feedback from the passive supoprts

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : force / float / 6**
- **Item / type / count : stepcnt / long / 6**
- **Item / type / count : targetpos / long / 6**
- **BLOBs : None**

Topic : m1m3.TC

Description

**Temperature monitoring for sensors located in the m1 subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : error / float / 16**
- **Item / type / count : setpoint / float / 16**
- **Item / type / count : status / short / 16**
- **Item / type / count : temperature / float / 16**
- **BLOBs : None**

Subsystem : m2

Secondary mirror system

This mirror is designed to be made from an existing 350 mm thick Zerodur blank. It is a bit thinner than would be needed to provide a completely passive support (one that would never need to have the surface figure measured and corrected by adjusting the actuator forces). The secondary has a back sheet thickness of 3.81 cm (1.5 inches), and a face sheet of similar thickness except near the OD where the fabrication process requires that the internal surface of the face sheet be parallel to the back surface resulting in an increase in the average face sheet thickness toward the OD. . It is approximately 63% lightweighted. The LSST secondary is axially supported through load spreaders and pucks bonded to the back of the mirror . Fourteen three puck load spreaders are used along with 62 single puck actuator interfaces. A single axial actuator loads the six inner three puck load spreaders. Two axial actuators load four of the three puck load spreaders and three axial actuators load the remaining four. The three puck loadspreaders loaded by multiple actuators are provided where static supports are used since these require the three puck frame to carry lateral loads. All load spreaders are similar to the loadspreaders already in use on 6.5 and 8.4 m primary mirrors and consist of an Invar 36 frame bolted to puck assemblies that are bonded to the mirror with a 4 mm layer of silicone adhesive (GE RTV630). The silicone adhesive layer is perforated with 2 mm diameter holes spaced 20 mm apart to reduce the axial stiffness of the bond to approximately 120 kN/mm. Lateral support is provided at twenty of the pockets at two different depths. The six innermost laterals support 46% of the weight 60.2 mm (2.37”) in front of the CG (center of gravity) plane. The remaining 14 lateral supports carry 54% of the weight 82.6 mm (2.03”) behind the CG plane.

The axial support force actuators are counterweight mechanisms. They are equipped with load cells and an active force capability for the compensation of thermal distortion due to thermal expansion inhomogeneity and to provide axial correction forces proportional to the lateral gravity component. Additionally, forces will be adjusted to obtain the desired reactions at the position constraints (hardpoints). Tapered roller bearings are used at all rotating joints including the two universal joints in the connecting rods.

Topic : m2.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : demand / float / 6**
- **Item / type / count : error / float / 6**
- **Item / type / count : position / float / 6**
- **Item / type / count : status / short / 16**
- **BLOBs : None**

Topic : m2.Electrical

Description

Electrical monitoring for devices located in the m2 subsystem.
Raw data, calibrated voltages, calibrated current, device power status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : error / long / 16**
- **Item / type / count : status / short / 16**
- **Item / type / count : voltage / long / 16**
- **BLOBs : None**

Topic : m2.Hexapod

Description

This subsystem maintains application level data concerning the
requested and actual state of the haxapod support system.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : error / long / 16**
- **Item / type / count : status / short / 16**
- **Item / type / count : targetpos / long / 16**
- **BLOBs : None**

Topic : m2.LimitSensors

Description

State of the liftoff switches and limit switches

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : liftoff / short / 64**
- **Item / type / count : limit / short / 64**
- **BLOBs : None**

Topic : m2.Metrology

Description

Position control for sensors located in the m2 subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : distance / long / 16**
- **Item / type / count : error / long / 16**
- **Item / type / count : status / short / 16**
- **BLOBs : None**

Topic : m2.TC

Description

Temperature monitoring for sensors located in the m2 subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : error / float / 16**
- **Item / type / count : setpoint / float / 16**
- **Item / type / count : status / short / 16**
- **Item / type / count : temperature / float / 16**
- **BLOBs : None**

Topic : m2.actuators

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1.0 Hz**
- **Item / type / count : force / float / 72**
- **Item / type / count : stepcnt / long / 72**
- **Item / type / count : targetpos / long / 72**
- **BLOBs : None**

Subsystem : mount

Telescope mount and axes
Optically the LSST telescope has a unique 3 mirror system. The primary mirror circumscribes the tertiary mirror such that both surfaces can be made into a single monolithic substrate The camera assembly is also circumscribed within the secondary mirror assembly, forming a convenient package at the telescope top end. Although the LSST optical design is unique, it can be supported by a conventional telescope structural arrangement. A stiff mirror cell is used to support the primary and tertiary mirrors, and the top end assembly supports both the secondary mirror assembly and the camera assembly. Both the elevation axis and the azimuth axis are expected to utilize hydrostatic bearings, which are common on large telescopes.

The LSSTs structural arrangement facilitates maintainability. The primary/tertiary mirror cell is connected to the rest of the elevation assembly at four flange locations. This facilitates convenient removal and reinstallation of the mirror cell for recoating and any significant maintenance needs. The top end assembly is also only attached at four flange locations to facilitate removal. The hydrostatic bearing surfaces are enclosed to reduce contamination and susceptibility to damage.

The mount design also incorporates many essential auxiliary components. Among these are the baffle system, balancing system, damping system, mirror cover, cable wraps and motor drives. The mirror cell is a 2 m deep sandwich with access to the complex systems required for mounting and thermal control of the primary and tertiary mirrors.

Preliminary analysis determined that the lowest natural frequencies of the telescope assembly should be 10 Hz or greater to meet the slew and settling requirements. The telescope mount assembly was designed and analyzed with FEA, with the goal of meeting this 10 Hz requirement. The top end assembly supports the mass of the secondary mirror assembly and camera assembly through the use of 16 hollow rectangular spiders.

These hollow spiders are structurally efficient, and the interior provides a convenient location to route the many cables required by the camera and the secondary mirror. These spiders have exterior dimensions of 300 mm x 50 mm and interior dimensions of 210 mm x 36 mm.

The spiders are arranged to minimize the image degradation. All the spiders are arranged in axially aligned pairs. Consequently, the focal plane only sees eight spiders. The eight spider pairs are in a parallel/perpendicular arrangement, which only produces 2 diffraction spikes.

The instrument assembly includes the camera, rotator, hexapod, cable wrap, integrating structure and electronics assemblies. The rotator is located between the hexapod and the camera to provide rotation about the optical axis during tracking. The hexapod resides between the rotator and integrating structure, and is used to provide alignment and positioning. The electronics assemblies mount to the interior of the integrating structure. The cable wrap resides on the top of the integrating structure.

The entire instrument assembly can be installed and removed as a single unit. This allows the entire instrument assembly to be put together and tested before integration into the telescope. It also provides for the removal for service and repairs. This installation feature requires that all cabling for the camera be routed from the camera's top surface, through the hexapod and the cable wrap and to the integrating structures top surface.

The secondary mirror assembly is a 100 mm thick glass meniscus supported by 120 axial actuators and 6 tangent actuators and a structural cell for support. The entire secondary mirror assembly is attached to the top end spider spindle by 6 positioning actuators. The mounting system includes an interface plate to allow removal of the secondary mirror assembly without disconnecting the position actuators. The secondary mirror assembly also incorporates a large baffle.

Topic : mount.Alt

Description

This subsystem maintains application level information about the Altitude axis requested and actual position and status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : mount.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**
- **Item / type / count : Status / String / 16**

- **BLOBs : None**

Topic : mount.Az

Description

This subsystem maintains application level information about the Azimuth axis requested and actual position and status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : mount.Electrical

Description

**Electrical monitoring for devices located in the mount subsystem.
Raw data, calibrated voltages, calibrated current, device power status.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : mount.Metrology

Description

**Position control for sensors located in the mount subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**

- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : mount.Rotator

Description

This subsystem maintains application level information about the instrument rotator requested and actual position and status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : mount.TC

Description

**Temperature monitoring for sensors located in the mount subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Topic : network.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 10**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : Data / Int / 64**

- **Item / type / count : Status / String / 16**
- **BLOBs : None**

Subsystem : ocs

The Observatory Control System (OCS) is the master control system that schedules, coordinates, commands and monitors the observatory. Through the OCS the system can be started, adjusted during operations, monitored and stopped, both locally and remotely. The OCS provides the means to support safe observatory operations day and night.

Topic : ocs.activity.planning

Description

The OCS Activity componenent is supervisor and monitor for hardware and software maintenance activities

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : component / string / 128**
- **Item / type / count : start / 0.1 / double**
- **Item / type / count : status / 0.1 / double**
- **Item / type / count : subsystem / string / 128**
- **Item / type / count : supervid / string / 128**
- **Item / type / count : type / string / 128**
- **Item / type / count : uuid / string / 32**
- **BLOBs : None**

Topic : ocs.activity.record

Description

The OCS Activity componenent is supervisor and monitor for hardware and software maintenance activities

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : component / string / 128**
- **Item / type / count : end / 0.1 / double**
- **Item / type / count : start / 0.1 / double**
- **Item / type / count : status / 0.1 / double**
- **Item / type / count : subsystem / string / 128**
- **Item / type / count : supervid / string / 128**

- **Item / type / count : type / string / 128**
- **Item / type / count : uuid / string / 32**
- **BLOBs : None**

Topic : ocs.command.health

Description

The component supervises and monitor the command status of all OCS subsystems.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : device / string / 128**
- **Item / type / count : hardfaults / 0.1 / string**
- **Item / type / count : softfaults / 0.1 / string**
- **Item / type / count : subsystem / string / 128**
- **BLOBs : None**

Topic : ocs.command.permit

Description

The component supervises and monitor the command permit status of all OCS subsystems.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : actionmask / int / 8**
- **Item / type / count : command / string / 32**
- **Item / type / count : device / string / 128**
- **Item / type / count : subsystem / string / 128**
- **BLOBs : None**

Topic : ocs.database.state

Description

This component provides supervision and monitoring of facility database state, replication, report generation etc.

- **Number of sources : 1**
- **Number of subscribers : 2**

- **Frequency : 0.1 Hz**
- **Item / type / count : capacity / int / 32**
- **Item / type / count : lastrep / int / 32**
- **Item / type / count : name / string / 64**
- **Item / type / count : recin / int / 32**
- **Item / type / count : recout / int / 32**
- **Item / type / count : status / int / 32**
- **Item / type / count : table / string / 64**
- **BLOBs : None**

Topic : ocs.operator.log

Description

This component provides OCS operator activity logging.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : event / string / 128**
- **Item / type / count : interface / string / 32**
- **Item / type / count : opid / int / 1**
- **Item / type / count : stationid / int / 1**
- **Item / type / count : subsystem / string / 32**
- **BLOBs : None**

Topic : ocs.pointing.wcs

Description

This component provides supervision and monitoring of telescope pointing information.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : coeff / double / 32**
- **Item / type / count : dec / double / 200**
- **Item / type / count : ra / double / 200**
- **BLOBs : None**

Topic : ocs.scheduler.econstraints

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : Hz**
- **Item / type / count : maxval / string / 32**
- **Item / type / count : minval / string / 32**
- **Item / type / count : paramid / 0.1 / 32**
- **Item / type / count : type / string / 32**
- **BLOBs : None**

Topic : ocs.scheduler.iconstraints

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : Hz**
- **Item / type / count : maxval / string / 32**
- **Item / type / count : minval / string / 32**
- **Item / type / count : paramid / 0.1 / 32**
- **Item / type / count : type / string / 32**
- **BLOBs : None**

Topic : ocs.scheduler.parameters

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : algorithm / string / 32**
- **Item / type / count : p1 / string / 32**
- **Item / type / count : p2 / string / 32**
- **Item / type / count : p3 / string / 32**
- **Item / type / count : p4 / string / 32**
- **BLOBs : None**

Topic : ocs.scheduler.program

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : completion / float / 1**
- **Item / type / count : id / int / 1**
- **Item / type / count : priority / int / 1**
- **Item / type / count : status / int / 1**
- **BLOBs : None**

Topic : ocs.scheduler.progress

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : completion / double / 32**
- **Item / type / count : priority / int / 32**
- **Item / type / count : projection / int / 32**
- **Item / type / count : taskid / int / 32**
- **BLOBs : None**

Topic : ocs.scheduler.targets

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : airmass / double / 10**
- **Item / type / count : catid / double / 10**
- **Item / type / count : dec / double / 10**
- **Item / type / count : filter / int / 10**
- **Item / type / count : numexp / int / 10**
- **Item / type / count : ra / double / 10**
- **Item / type / count : rotangle / double / 10**
- **BLOBs : None**

Topic : ocs.staticanalysis

Description

This subsystem is responsible for anaylzing day-to-day and long-term telemetry data and performing trending, fault prediction and diagnosis etc.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : action / int / 1**
- **Item / type / count : actuuid / string / 32**
- **Item / type / count : component / string / 128**
- **Item / type / count : end / double / 1**
- **Item / type / count : result / int / 1**
- **Item / type / count : start / double / 1**
- **Item / type / count : subsystem / string / 128**
- **BLOBs : None**

Topic : ocs.system

Description

The OCS System componenent is the high level supervisor and monitor for all OCS subsytems

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : health / int / 500**
- **Item / type / count : power / int / 500**
- **Item / type / count : thermal / int / 500**
- **BLOBs : None**

Topic : ocs.system.accesscontrol

Description

The OCS System componenent is the high level supervisor and monitor for all OCS access control

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : byoperator / string / 500**
- **Item / type / count : bypolicy / string / 500**

- **Item / type / count : bystation / string / 500**
- **Item / type / count : device / string / 128**
- **Item / type / count : subssystem / string / 128**
- **BLOBs : None**

Topic : ocs.system.configuration

Description

The OCS System componenent is the high level supervisor and monitor for all OCS configuration

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : device / string / 128**
- **Item / type / count : stationid / int / 1**
- **Item / type / count : subssystem / string / 128**
- **BLOBs : None**

Topic : ocs.system.networking

Description

The OCS System componenent is the high level supervisor and monitor for all OCS networking status

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : ip / long / 4**
- **Item / type / count : mac / string / 32**
- **Item / type / count : rx / long / 6**
- **Item / type / count : subsystem / string / 128**
- **Item / type / count : tx / long / 6**
- **BLOBs : None**

Topic : operations.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 10**
- **Number of subscribers : 2**

- **Frequency : 0.1 Hz**
- **Item / type / count : Status / String / 50**
- **Item / type / count : data / Float / 200**
- **BLOBs : None**

Subsystem : power

Power supply and distribution systems

Topic : power.Electrical

Description

Electrical monitoring for devices located in the power subsystem.
Raw data, calibrated voltages, calibrated current, device power status.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : power.TC

Description

Temperature monitoring for sensors located in the power subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Topic : power.UPSs

Description

**This topic record parameters for devices located in the UPS subsystems.
Raw data, calibrated voltages, calibrated current, device power status,
demand, usage, etc.**

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : scheduler.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : Status / String / 50**
- **Item / type / count : data / Float / 200**
- **BLOBs : None**

Subsystem : seeing_dimm

Seeing canmera, differential image motion monitor

The first DIMM was developed by M. Sarazin and F. Roddier (Sarazin, M., Roddier, F., The ESO differential image motion monitor, 1990, Astron. Astrophy. 227, 294). Refer to this paper for more complete information, especially on the theory.

Image quality through a telescope is directly related to the statistics of the perturbations of the incoming wavefront. The DIMM method consists of measuring wavefront slope differences over 2 small pupils some distance apart. Because it is a differential method, the technique is inherently insensitive to tracking errors and wind shake. In practice, starlight goes through 2 small circular subapertures, cut in a mask placed at the entrance of a small telescope. One of the subapertures contains a prism in order to create a second image of the star on the detector. The dual star images obtained exhibit a relative motion in the image plane that represents the local wavefront tilts, which can be expressed in terms of an absolute seeing scale

Sources of error:
Pixel scale: the FWHM varies as the 6/5 power of the standard deviation of the motion, which is measured in fractions of pixels. The pixel angular scale is determined typically with a 1% accuracy, leading to a 1.2% error in the FWHM.

Instrumental noise: the accuracy of the centroid algorithm, measured in laboratory on 2 fixed spots, corresponds to an equivalent random error of about 0.03 arcsec rms.

Statistical errors: it decreases with the square root of the sampling (number of images used). In our case, the variance of image motion is obtained from typically 250 short exposures per minute in each direction (i.e.. 500 in total), which leads to an accuracy of 3.8% in the image size.

Exposure time: the error caused by the finite exposure time is minimized by using very short exposures that can freeze the motion of the atmosphere in most conditions. We implemented the 5ms to 10ms (the minimum CCD frame transfer time is 1ms) interleaving technique and calculate (and log) the extrapolated seeing for a virtual integration time of 0ms (we know from ESO that 5ms is freezing the image motion 99% of the time in Chilean sites).

Topic : seeing_dimm.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 30 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / String / 16**
- **BLOBs : 64x64x4 16bit images**

Topic : seeing_dimm.Electrical

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : seeing_dimm.Metrology

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : seeing_dimm.TC

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 30 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Subsystem : seeing_mass

Seeing camera, Multi aperture turbulence measurement
Multi Aperture Scintillation Sensing (MASS). By correlating scintillation patterns in different annular pupils in a telescope the altitude and strength of turbulent motions in the atmosphere, where the scintillation originates, can be deduced.

When stellar light passes through a turbulent layer and propagates down, its intensity fluctuates. Spatial scale of these variations depends on the distance to the layer. This dependence is used to separate the contributions from different layers by means of four concentric ring apertures that work as a matched spatial filter. Turbulence profile is derived from the statistical processing of the series of photon counts with 1 ms sampling.

Intensity of light falling into each of the ring apertures A, B, C, and D (see below) is measured by photon counters. Scintillation index in each aperture is computed as the variance (dispersion) of intensity normalized by the average intensity squared (or, equivalently, variance of the natural logarithm). In this way the scintillation index does not depend on the brightness of the star and reflects only the strength of atmospheric scintillation. Contribution of photon noise is carefully subtracted in the calculation.

Similarly, differential scintillation index for a pair of apertures (e.g. A and B) is defined as the variance

of the ratio of intensities in A and B normalized by the square of the average intensity ratio A/B (or, equivalently, the variance of the natural logarithm of the intensity ratio).

Both normal and differential scintillation indices produced by a given turbulent layer are computed as product of the turbulence intensity in this layer (integral of Cn2 measured in m^1/3) by some weighting function which depends on the distance to the layer as well as on the shape and size of the apertures.

Topic : seeing_mass.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Demand / Float / 4**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Position / Float / 4**
- **Item / type / count : Status / String / 16**
- **BLOBs : 64x64x4 16bit images**

Topic : seeing_mass.Electrical

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : seeing_mass.Metrology

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**

- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : seeing_mass.TC

Description

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Subsystem : skycam

Sky cameras
The primary goal is to provide qualitative assessment of cloud patterns (detection, layout and motion). Thick clouds on large spatial scales can be detected by almost any camera, but as they can also be readily seen by eye, this is not a very interesting case ...except for remote users. The primary goal of this project is to detect diffuse Cirrus which is more common and very difficult or impossible to see by eye in the moonless sky. Side benefits (which I will discuss later) are aircraft detection (for laser safety), sky brightness monitoring (light pollution versus cloud cover and time of day), monitoring of OH emissions and auroras, and monitoring of clouds under moonlight or even daylight for remote observers. Finally, the impact of high quality images of the skies over Tololo on the public, particularly the astronomical community, should not be overlooked, particularly if they are superior in quality to those offered in the North (e.g. Mauna Kea, and Kitt Peak)

Since the dark sky is almost invariant from night to night it is possible to subtract a reference frame formed from the median of previous (dark) nights so that a nominally flat image can be displayed at sufficient contrast to allow extinction and scattering to be perceived down to the limit imposed by the photon shot noise. This has been demonstrated crudely by derotating clear frames taken on the same night. Much better results will be obtained when the camera remains in a fixed position from night to night so that no derotation is needed.

Pixels can be binned together to improve the noise statistics, but only until the typical spatial scale of the clouds is reached. Unfortunately a comparison of the angular scale of daytime Cirrus with that of the the moon or an outstretched thumb will quickly confirm that the proposed resolution of 0.18 degrees (960 pixels across the sky) is not excessive, and that only slight binning can be used if at all. This fine angular scale and the high winds found at altitude combine to require exposure times shorter than ~3 seconds to maintain acceptable contrast for Cirrus.

Topic : skycam.Application

Description

This subsystem generates application level items calculated from subsystem raw data

- **Number of sources : 2**
- **Number of subscribers : 2**
- **Frequency : 0.03 Hz**
- **Item / type / count : Catalog / String / 4096**
- **Item / type / count : Data / Float / 64**
- **Item / type / count : Error / Float / 4**
- **Item / type / count : Sky_parms / Float / 32**
- **Item / type / count : Status / String / 16**
- **BLOBs : 1024x1024x4 16bit images**

Topic : skycam.Electrical

Description

Electrical monitoring for devices located in the All sky cameras subsystem.
Raw data, calibrated voltages, calibrated current, device power status.

- **Number of sources : 2**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : skycam.Metrology

Description

Position control for sensors located in the All sky cameras subsystem.
Raw sensor readings, calibrated positions, limit switches, status bits.

- **Number of sources : 2**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Limits / Byte / 64**
- **Item / type / count : Raw / Int / 16**

- **Item / type / count : Status / Byte / 64**
- **BLOBs : None**

Topic : skycam.TC

Description

**Temperature monitoring for sensors located in the All sky cameras subsystem.
Raw sensor readings, calibrated temperatures, time series statistics, sensor health.**

- **Number of sources : 2**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Calibrated / Float / 16**
- **Item / type / count : Health / Byte / 16**
- **Item / type / count : Raw / Int / 16**
- **BLOBs : None**

Topic : system.Command_history

Description

This item records all commands and their responses.

- **Number of sources : 50**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : Command / String / 1**
- **Item / type / count : Data / Float / 16**
- **Item / type / count : Status / Byte / 16**
- **BLOBs : None**

Topic : system.Computer_status

Description

This subsystem records the status of every computer hardware item

- **Number of sources : 100**
- **Number of subscribers : 2**
- **Frequency : 0.1 Hz**
- **Item / type / count : Calibrated / Float / 32**
- **Item / type / count : Raw / Int / 16**

- **BLOBs : None**

Topic : system.Hardware_revision_history

Description

This item records all hardware revisions made to items in the system

- **Number of sources : 100**
- **Number of subscribers : 2**
- **Frequency : 0.001 Hz**
- **Item / type / count : Component / String / 1**
- **Item / type / count : Reason / String / 1**
- **Item / type / count : Version / Int / 3**
- **BLOBs : None**

Topic : system.Software_revision_history

Description

This item records all software revisions made to items inthe system

- **Number of sources : 100**
- **Number of subscribers : 2**
- **Frequency : 0.001 Hz**
- **Item / type / count : Module / String / 1**
- **Item / type / count : Notes / String / 1**
- **Item / type / count : Version / Int / 3**
- **BLOBs : None**

Subsystem : tcs

The main purpose of the Telescope Control System (TCS) software is to accept the target position of a celestial object, which can be given in a variety of coordinate systems, and calculate mount, rotator and optical surface positions, so that the target is imaged perfectly at a given point in the focal plane. Furthermore, the TCS is characterized by the need to integrate a number of heterogeneous subsystems, which exhibit complex interactions. These interactions, although not hard realtime bounded, need a high level of synchronization.

The Telescope Control System (TCS) is the central coordination facility for the delivery of high quality field images to the camera. It is responsible for the precise pointing and tracking calculations necessary to observe a certain field. The TCS does not itself operate any mechanical component; rather it delegates this responsibility to the various telescope subsystems and manages them according to the observation requests.

The TCS design is based on a distributed system model. Under this model, the components interact through well defined interfaces, to accomplish the desired system behavior. The maincomponents in the proposed implementation, are tied together by the use of an Ethernet Bus, thus permitting the efficient exchange of commands and status among them.

The distributed nature of the TCS is complemented by the control model based on a supervisory control strategy. Under this model, a supervisor agent computes the "setpoint" to be applied to a controllable device. The time critical loops are closed locally at the device level, and the device makes status information available for monitoring purposes.

The TCS itself will be controlled either directly by a telescope operator, or by commands initiated by the Observatory Control System (OCS). Its role therefore, is to act as intermediary between the observer(s) and the telescope hardware, translating high level user commands into low level subsystem commands. Consistent with our control model, the TCS will return status information to be distributed system wide.

Topic : tcs.kernel.DawdleFilter

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Bypass / Int / 1**
- **Item / type / count : T / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.FK5Target

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : dec / Float / 1**
- **Item / type / count : epoc / Float / 1**
- **Item / type / count : equinox / Float / 1**
- **Item / type / count : parallax / Float / 1**
- **Item / type / count : pmDec / Float / 1**
- **Item / type / count : pmRA / Float / 1**
- **Item / type / count : ra / Float / 1**
- **Item / type / count : rv / Float / 1**

- **BLOBs : None**

Topic : tcs.kernel.OpticsVt

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : tilt / Float / 1**
- **Item / type / count : tip / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.PointingControl

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 10 Hz**
- **Item / type / count : AGuide / Float / 1**
- **Item / type / count : ALocal / Float / 1**
- **Item / type / count : BGuide / Float / 1**
- **Item / type / count : BLocal / Float / 1**
- **Item / type / count : PitchFilter / String / 1**
- **Item / type / count : RollFilter / String / 1**
- **BLOBs : None**

Topic : tcs.kernel.PointingLog

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Aux / Float / 3**
- **Item / type / count : Casspa / Float / 1**

- **Item / type / count : Dec / Float / 1**
- **Item / type / count : Fl / Float / 1**
- **Item / type / count : Humid / Float / 1**
- **Item / type / count : Marked / Int / 1**
- **Item / type / count : Pitch / Float / 1**
- **Item / type / count : Press / Float / 1**
- **Item / type / count : Ra / Float / 1**
- **Item / type / count : Rcorr / Float / 1**
- **Item / type / count : Roll / Float / 1**
- **Item / type / count : Temp / Float / 1**
- **Item / type / count : Tlr / Float / 1**
- **Item / type / count : Wavel / Float / 1**
- **Item / type / count : Xr / Float / 1**
- **Item / type / count : Yr / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.PointingModel

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : Coeff1 / String / 32**
- **Item / type / count : Coeff2 / String / 32**
- **Item / type / count : Coeff3 / String / 32**
- **Item / type / count : Coeff4 / String / 32**
- **Item / type / count : Coeff5 / String / 32**
- **Item / type / count : Coeff6 / String / 32**
- **Item / type / count : Coeff7 / String / 32**
- **Item / type / count : Coeff8 / String / 32**
- **Item / type / count : Coeff9 / String / 32**
- **Item / type / count : Coeffv / Float / 100**
- **Item / type / count : Cofor1 / String / 32**
- **Item / type / count : Cofor2 / String / 32**
- **Item / type / count : Cofor3 / String / 32**
- **Item / type / count : Cofor4 / String / 32**
- **Item / type / count : Cofor5 / String / 32**
- **Item / type / count : Cofor6 / String / 32**
- **Item / type / count : Cofor7 / String / 32**
- **Item / type / count : Cofor8 / String / 32**
- **Item / type / count : Cofor9 / String / 32**
- **Item / type / count : Model / Int / 30**
- **Item / type / count : Nterml / Int / 1**
- **Item / type / count : Nterms / Int / 1**

- **Item / type / count : Ntermx / Int / 1**
- **BLOBs : None**

Topic : tcs.kernel.Site

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : Amprms / Float / 21**
- **Item / type / count : Aoprms / Float / 15**
- **Item / type / count : Daz / Float / 1**
- **Item / type / count : Delat / Float / 1**
- **Item / type / count : Delut / Float / 1**
- **Item / type / count : Diurab / Float / 1**
- **Item / type / count : Elong / Float / 1**
- **Item / type / count : Lat / Float / 1**
- **Item / type / count : Refa / Float / 1**
- **Item / type / count : Refb / Float / 1**
- **Item / type / count : St0 / Float / 1**
- **Item / type / count : T0 / Float / 1**
- **Item / type / count : Tt0 / Float / 1**
- **Item / type / count : Ttj / Float / 1**
- **Item / type / count : Ttmtai / Float / 1**
- **Item / type / count : Uau / Float / 1**
- **Item / type / count : Ukm / Float / 1**
- **Item / type / count : Vau / Float / 1**
- **Item / type / count : Vkm / Float / 1**
- **Item / type / count : delat / Float / 1**
- **Item / type / count : delut / Float / 1**
- **Item / type / count : elongm / Float / 1**
- **Item / type / count : hm / Float / 1**
- **Item / type / count : latm / Float / 1**
- **Item / type / count : tai / Float / 1**
- **Item / type / count : ttmtat / Float / 1**
- **Item / type / count : xpm / Float / 1**
- **Item / type / count : ypm / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.Target

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Humid / Float / 1**
- **Item / type / count : OffSys / String / 128**
- **Item / type / count : Press / Float / 1**
- **Item / type / count : TLR / Float / 1**
- **Item / type / count : Tai / Float / 1**
- **Item / type / count : Temp / Float / 1**
- **Item / type / count : Wavel / Float / 1**
- **Item / type / count : XOffset / Float / 1**
- **Item / type / count : YOffset / Float / 1**
- **Item / type / count : az / Float / 1**
- **Item / type / count : azdot / Float / 1**
- **Item / type / count : el / Float / 1**
- **Item / type / count : eldot / Float / 1**
- **Item / type / count : focalplaneX / Float / 1**
- **Item / type / count : focalplaneY / Float / 1**
- **Item / type / count : site / String / 128**
- **Item / type / count : t0 / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.TimeKeeper

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : Cst / Float / 1**
- **Item / type / count : Dcst / Float / 1**
- **Item / type / count : Dsst / Float / 1**
- **Item / type / count : Sst / Float / 1**
- **Item / type / count : Tai / Float / 1**
- **Item / type / count : Tt / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.TrackRefSys

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 1 Hz**
- **Item / type / count : ae2mt / Float / 9**
- **Item / type / count : amprms / Float / 21**
- **Item / type / count : cst / Float / 1**
- **Item / type / count : diurab / Float / 1**
- **Item / type / count : hm / Float / 1**
- **Item / type / count : humid / Float / 1**
- **Item / type / count : press / Float / 1**
- **Item / type / count : refa / Float / 1**
- **Item / type / count : refb / Float / 1**
- **Item / type / count : sst / Float / 1**
- **Item / type / count : tdbj / Float / 1**
- **Item / type / count : temp / Float / 1**
- **Item / type / count : tlat / Float / 1**
- **Item / type / count : tlr / Float / 1**
- **Item / type / count : wavel / Float / 1**
- **BLOBs : None**

Topic : tcs.kernel.TrackingTarget

Description

This subsystem is internal to the tcs pointing kernel

- **Number of sources : 1**
- **Number of subscribers : 2**
- **Frequency : 0.01 Hz**
- **Item / type / count : PositionX / Float / 1**
- **Item / type / count : PositionY / Float / 1**
- **Item / type / count : T0 / Float / 1**
- **Item / type / count : VelocityX / Float / 1**
- **Item / type / count : VelocityY / Float / 1**
- **BLOBs : None**

Appendix A - Prototype Datastreams

- **auxscope.Application**
- **auxscope.Camera**
- **auxscope.Electrical**
- **auxscope.Metrology**
- **auxscope.Spectrometer**
- **auxscope.TC**
- **auxscope.TCS**
- **calibration.Application**
- **calibration.Electrical**
- **calibration.Metrology**
- **calibration.TC**
- **camera.BEE.biases**
- **camera.BEE.clocks**
- **camera.BEE.thermal**
- **camera.CALSYS**
- **camera.CCS**
- **camera.FCS**
- **camera.GAS**
- **camera.LASERCAL**
- **camera.PWR**
- **camera.QA.measured**
- **camera.SCS**
- **camera.SDS**
- **camera.SDS.amplifiers**
- **camera.TC.control**
- **camera.TC.zone1**
- **camera.TC.zone2**
- **camera.TC.zone3**
- **camera.TC.zone4**
- **camera.TC.zone5**
- **camera.TC.zone6**
- **camera.TCM**
- **camera.UTIL**
- **camera.VCS**
- **camera.WDS.wfsRaft**
- **camera.WTCM**
- **dm.derived.dataquality**
- **dm.derived.psf**
- **dm.pointing.wcs**
- **dm.raw.dataquality**
- **enclosure.Application**
- **enclosure.Azimuth**
- **enclosure.Electrical**
- **enclosure.Metrology**
- **enclosure.Shutter**
- **enclosure.TC**

- **enclosure.Thermal_control**
- **enclosure.Vents**
- **environment.Dust_monitor**
- **environment.Electrical**
- **environment.Lightning_detector**
- **environment.Seismometer**
- **environment.TC**
- **environment.Video_cameras**
- **environment.Weather**
- **lasercal.Application**
- **lasercal.Electrical**
- **lasercal.TC**
- **m1m3.ActuatorSample**
- **m1m3.Actuators**
- **m1m3.Application**
- **m1m3.Electrical**
- **m1m3.LUT**
- **m1m3.LimitSensors**
- **m1m3.Metrology**
- **m1m3.Supports**
- **m1m3.TC**
- **m2.Application**
- **m2.Electrical**
- **m2.Hexapod**
- **m2.LimitSensors**
- **m2.Metrology**
- **m2.TC**
- **m2.actuators**
- **mount.Alt**
- **mount.Application**
- **mount.Az**
- **mount.Electrical**
- **mount.Metrology**
- **mount.Rotator**
- **mount.TC**
- **network.Application**
- **ocs.activity.planning**
- **ocs.activity.record**
- **ocs.command.health**
- **ocs.command.permit**
- **ocs.database.state**
- **ocs.operator.log**
- **ocs.pointing.wcs**
- **ocs.scheduler.econstraints**
- **ocs.scheduler.iconstraints**
- **ocs.scheduler.parameters**
- **ocs.scheduler.program**
- **ocs.scheduler.progress**
- **ocs.scheduler.targets**

- **ocs.staticanalysis**
- **ocs.system**
- **ocs.system.accesscontrol**
- **ocs.system.configuration**
- **ocs.system.networking**
- **operations.Application**
- **power.Electrical**
- **power.TC**
- **power.UPSs**
- **scheduler.Application**
- **seeing_dimm.Application**
- **seeing_dimm.Electrical**
- **seeing_dimm.Metrology**
- **seeing_dimm.TC**
- **seeing_mass.Application**
- **seeing_mass.Electrical**
- **seeing_mass.Metrology**
- **seeing_mass.TC**
- **skycam.Application**
- **skycam.Electrical**
- **skycam.Metrology**
- **skycam.TC**
- **system.Command_history**
- **system.Computer_status**
- **system.Hardware_revision_history**
- **system.Software_revision_history**
- **tcs.kernel.DawdleFilter**
- **tcs.kernel.FK5Target**
- **tcs.kernel.OpticsVt**
- **tcs.kernel.PointingControl**
- **tcs.kernel.PointingLog**
- **tcs.kernel.PointingModel**
- **tcs.kernel.Site**
- **tcs.kernel.Target**
- **tcs.kernel.TimeKeeper**
- **tcs.kernel.TrackRefSys**
- **tcs.kernel.TrackingTarget**