CALTECH OPTICAL OBSERVATORIES / NASA JET PROPULSION LABORATORY
PALM-3000 PROJECT

PALM-3000
Software Requirements Document (SwRD)

CIN #628

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Revision Sheet

Revision No.	Date	Revision Description
Rev. 0.1	10/30/07	Initial draft by T. Trinh
Rev. 0.3	11/8/07	Added Angione, Bouchez, Guiwits, and Truong sections. No IRTT requirements yet included. –A. Bouchez.

Contents

1 GENERAL INFORMATION

1.1 Purpose

This Software Requirements Document (SwRD) establishes the software requirements for the PALM-3000 (P3K) Upgrade Task of the Palomar Adaptive Optics (PALMAO) system.

1.2 Scope

This document specifies in detail the software requirements for the PALM-3000 AO system and serves as the basis for its development and formal testing.

1.3 Notation

Reference numbers in square brackets are used to denote traceability to the higher-level requirements in the referenced controlling document. For example, [IRD-415] refers to requirement number 415 in the Instrument Requirements Document (IRD).

1.4 Acronyms and Abbreviations

AO	Adaptive Optics
BTO	Beam transfer optics (for laser beam transport from Coude to Prime focus)
DM	Deformable mirror
HOWFS	High-order wavefront sensor
LGS	Laser guide star
LOWFS	Low-order wavefront sensor (for PALM-3000 indicating tip/tilt/focus sensing)
NGS	Natural guide star
PALAO	The original NGS AO system at Palomar commissioned in December 1999
PALM-3000	The visible light AO upgrade to PALMAO
PALMAO	Upgrades to PALAO, particularly after the April 2003 upgrade
PALM LGS	The laser guide star upgrade to PALMAO
PALM LGS+	The (potential) PALM LGS sodium laser upgrade from 6-8 W to 20-50 W or more via new technologies
TWFS	Truth wavefront sensor
TT	Tip/tilt
TTF	Tip/tilt/focus
TTFA	Tip/tilt/focus/astigmatism (often synonymous with TTF when describing LOWFS)

1.5 Point of Contact

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2 INTERFACE REQUIREMENTS

Figure 1 depicts the PALM-3000 AO system context diagram. The interfaces are shown on the diagram and described below:

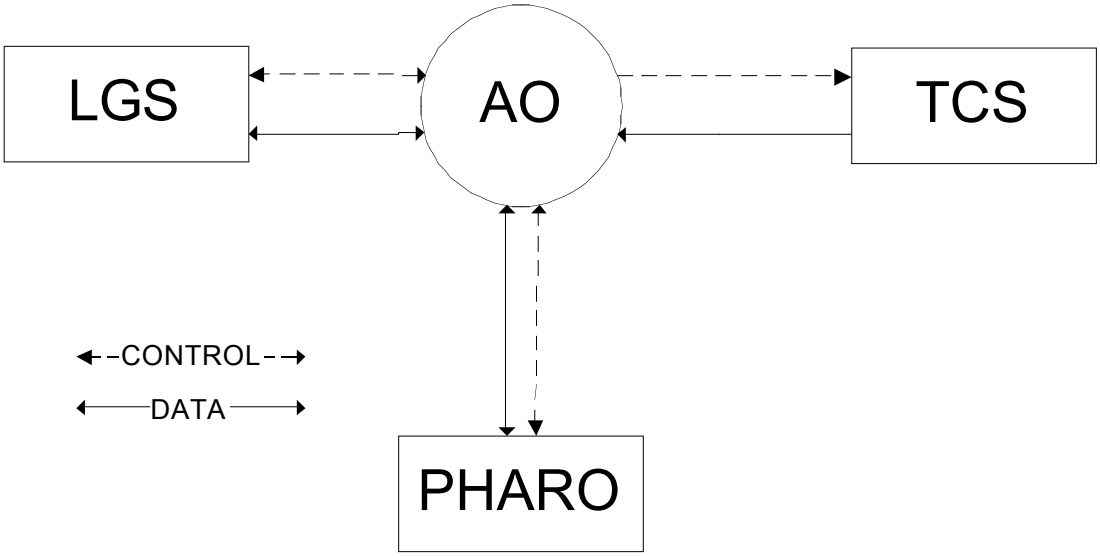

Figure 1: PALM-3000 Software Context Diagram.

3 FUNCTIONAL REQUIREMENTS

The PALM-3000 AO system is subdivided into the following major functions:

1. High-Order Wavefront Processor
2. Low-Order Wavefront Processor
3. AO Supervisory Control
4. Telemetry Database
5. User Interface

This functional decomposition is illustrated in Figure 2, and a data flow diagram is shown in Figure 3.

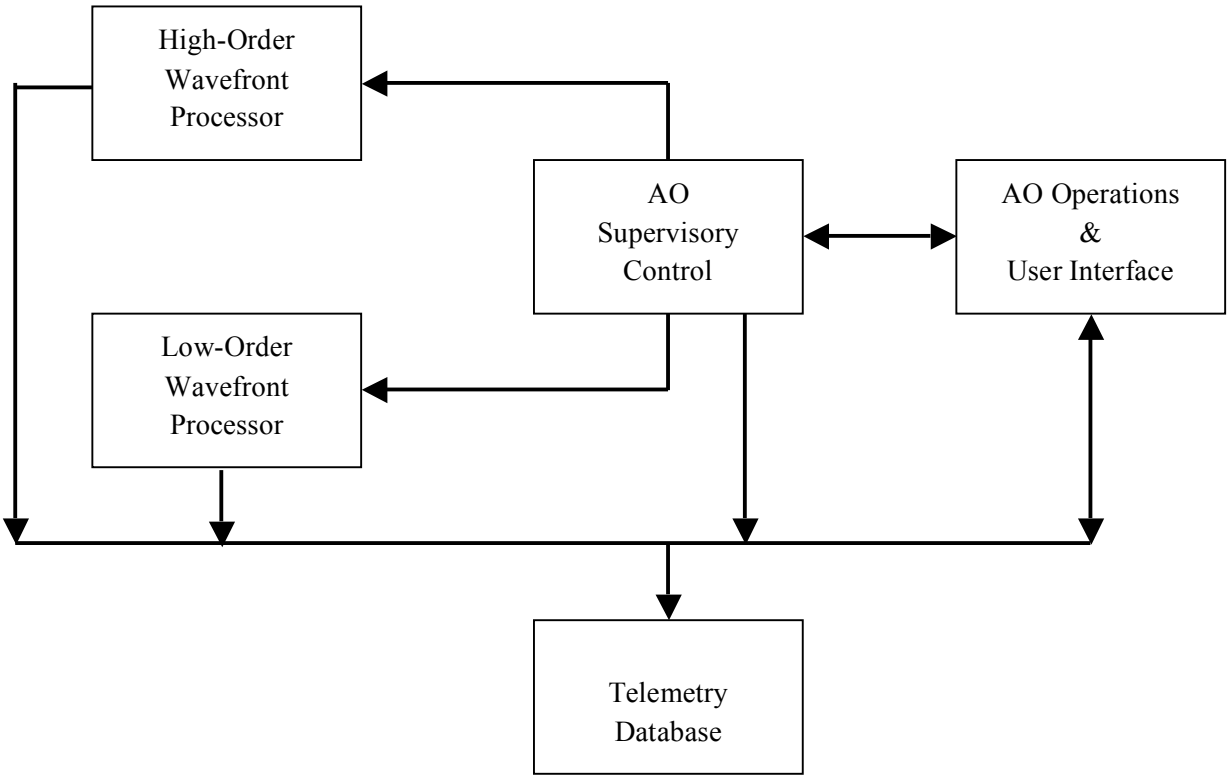

Figure 2: PALM-3000 Functional Decomposition

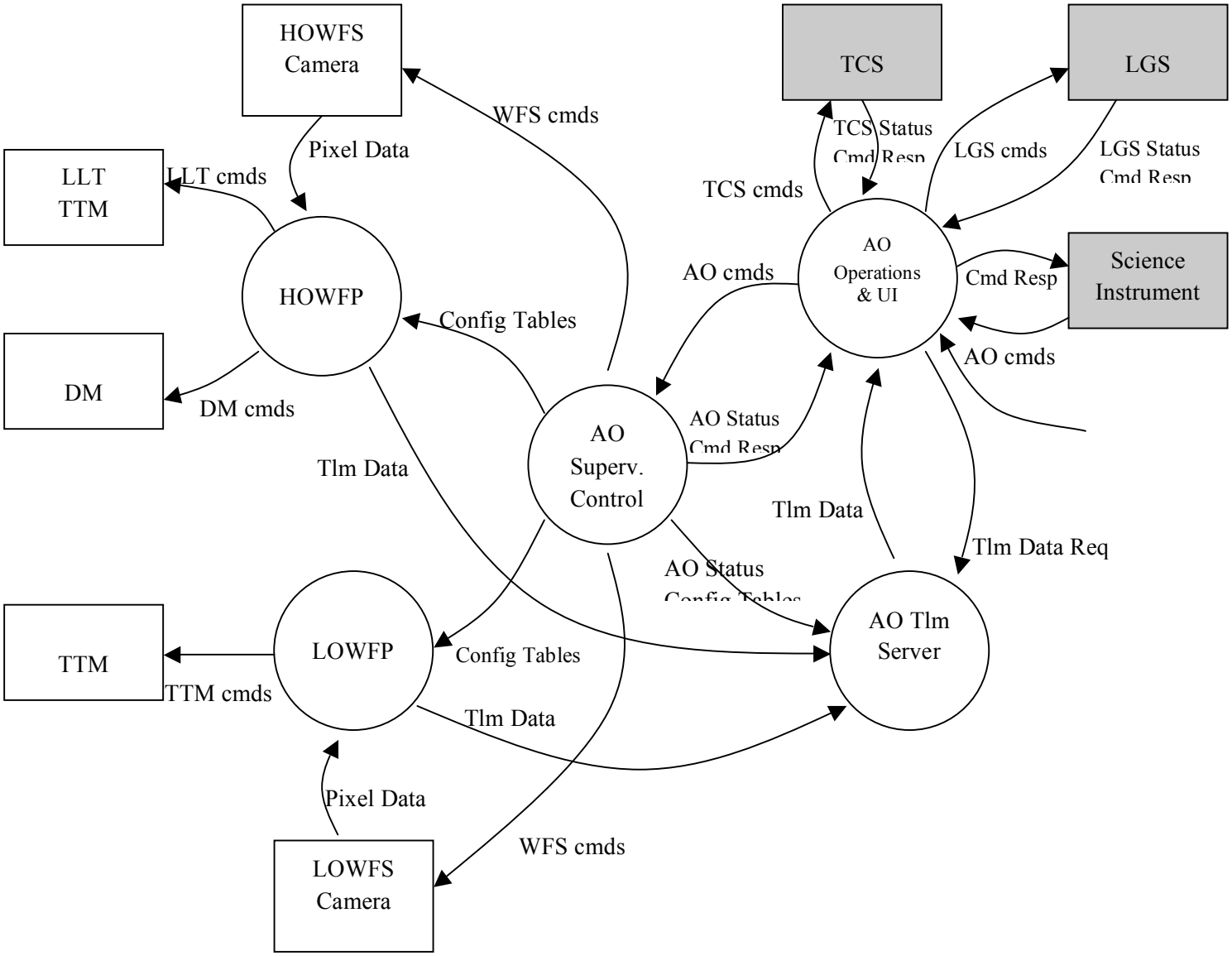

Figure 3: PALM-3000 Data Flow Diagram.

3.1 System-level Requirements

P3K-SW-0005: The PALM-3000 software system shall boot up from a cold start in under 120s (60s goal). This does not include the time required for motors to reach their default positions. [IRD-500]

3.2 High-Order Wavefront Processor (HWFP)

P3K-SW-0010: The HWFP shall receive pixel data directly from the HOWFS in all modes. Every frame of pixel data will be preceded by a start of frame signal. [IRD xxx]

P3K-SW-0015: The HWFP shall be able to process data in all formats and frame rates output by the HOWFS. Currently the HOWFS is designed to operate at 30Hz-2000Hz. [IRD xxx]

P3K-SW-0020: The HWFP shall subtract a sky background from the pixel data. [IRD xxx]

P3K-SW-0025: The sky background table shall be user selectable. [IRD xxx]

P3K-SW-0030: The HWFP shall flat field the pixel data. [IRD xxx]

P3K-SW-0035: The flat field table shall be user selectable. [IRD xxx]

P3K-SW-0040: The HWFP shall calculate the X and Y centroid for each subaperture using the flat fielded pixel values. [IRD xxx]

P3K-SW-0045: The HWFP shall subtract a reference value from each centroid. [IRD xxx]

P3K-SW-0050: The centroid reference value shall be user selectable. [IRD xxx]

P3K-SW-0055: The HWFP shall calculate the residual wavefront error from the centroid values. [IRD xxx]

P3K-SW-0060: The reconstruction matrix shall be user selectable. [IRD xxx]

P3K-SW-0065: The HWFP shall calculate the offloading from the tweeter DM to woofer DM.

P3K-SW-0070: The tweeter-to-woofer projection matrix shall be user selectable. [IRD xxx]

P3K-SW-0075: The HWPF shall compute the cleanup null modes as part of the offloading. [IRD xxx]

P3K-SW-0080: The cleanup null modes matrix shall be user selectable. [IRD xxx]

P3K-SW-0085: The HWFP shall calculate the new positions of the woofer DM, tweeter DM, TTM and UTT using a PI servo control loop in all modes. [IRD xxx]

P3K-SW-0090: The servo control loop parameters to control the woofer DM, tweeter DM, TTM and UTTT shall be user selectable. [IRD xxx]

P3K-SW-0095: The HWFP shall have the ability to independently turn on/off the woofer DM, tweeter DM, TTM and UTT servo control loops. [IRD xxx]

P3K-SW-0100: The HWFP shall use the current positions of the woofer DM, tweeter DM, TTM and UTT to initialize the servo control loops. [IRD xxx]

P3K-SW-0105: The HWFP shall provide the telemetry data specified to be recorded. The telemetry data that can be selected includes: raw pixel values, centroid positions, subaperature flux, residual wavefront error, all DM commands, TTM commands, UTT commands and servo loop parameters. [IRD xxx]

P3K-SW-0110: The HWFP shall provide the telemetry data at the recording rate specified by AOSC. [IRD xxx]

3.3 Low-Order Wavefront Processor (LWFP)

P3K-SW-0115: The LWFP shall receive pixel data directly from the LOWFS in all modes. Every frame of pixel data shall be preceded by a start of frame signal. [IRD-xxx]

P3K-SW-0120: LWFP shall process data at the same frame rate as the LOWFS. Currently the LOWFS is to be designed to operate at 30Hz-2000Hz. [IRD xxx]

P3K-SW-0125: The LWFP shall subtract a sky background from the pixel data. [IRD xxx]

P3K-SW-0130: The sky background table shall be user selectable. [IRD xxx]

P3K-SW-0135: The LWFP shall flat field the pixel data. [IRD xxx]

P3K-SW-0140: The flat field table shall be user selectable. [IRD xxx]

P3K-SW-0145: The LWFP shall calculate the X and Y centroid for each subaperture using the flat fielded pixel values. [IRD xxx]

P3K-SW-0150: The LWFP shall subtract a reference value from each centroid. [IRD xxx]

P3K-SW-0155: The centroid reference value shall be user selectable. [IRD xxx]

P3K-SW-0160: The LWFP shall calculate the residual wavefront error from the centroid values. [IRD xxx]

P3K-SW-0165: The reconstruction matrix shall be user selectable. [IRD xxx]

P3K-SW-0170: The LWFP shall calculate the new TTM positions using a PI servo control loop in DNGS and LGS modes. [IRD xxx]

P3K-SW-0175: The TTM servo control loop parameters shall be user selectable. [IRD xxx]

P3K-SW-0180: The LWFP shall have the ability to turn on/off the TTM servo control loop. [IRD xxx]

P3K-SW-0185: The LWFP shall use the current position of the TTM to initialize the servo control loop. [IRD xxx]

P3K-SW-0190: The LWFP shall provide only the telemetry data specified to be recorded. The telemetry data that can be selected includes: raw pixel values, centroid positions, subaperature flux, residual wavefront error, TTM commands, and servo loop parameters. [IRD xxx]

P3K-SW-0195: The LWFP shall provide the telemetry data at the recording rate specified by AOSC. [IRD xxx]

3.4 AO Supervisory Control (AOSC)

3.4.1 Motion Control

P3K-SW-0200: AOSC shall provide the ability to turn stimuli on/off. [IRD-xxx] (LGS AO)

P3K-SW-0205: AOSC shall provide the ability to move individual motors back to a default position. [IRD-xxx] (LGS AO)

P3K-SW-0210: AOSC shall provide the ability to move motors by either a relative distance or to an absolute position. [IRD-xxx] (LGS AO)

P3K-SW-0215: AOSC shall provide the ability to save the current position of all motors or restore any set of saved positions. [IRD-xxx] (LGS AO)

P3K-SW-0220: AOSC shall provide the ability to query motor positions. [IRD-xxx] (LGS AO)

P3K-SW-0225: AOSC shall provide the ability to query motor status (moving, stopped, disconnected, or error)

P3K-SW-0230: AOSC shall provide the ability to stop any motor (overriding any motor move currently in progress).

P3K-SW-0235: AOSC shall provide the ability to move a motor at a specified rate

3.4.2 Video Control

P3K-SW-0240: AOSC shall provide the ability to vary the integration time on the acquisition camera. Integration time is TBD. [IRD-xxx]

P3K-SW-0245: AOSC shall be able to record images from the acquisition camera. [IRD-xxx]

P3K-SW-0250: AOSC shall provide the ability to send the most recent image to the user interface

3.4.3 High Order Wavefront Sensor Control

P3K-SW-0255: AOSC shall provide the ability to turn on/off the woofer DM control loop. [IRD-190] (LGS AO)

P3K-SW-0260: AOSC shall provide the ability to turn on/off the tweeter DM control loop. [IRD-195]

P3K-SW-0265: AOSC shall provide the ability to set the high order WFS camera on/off. [IRD-xxx] (LGS AO)

P3K-SW-0270: AOSC shall provide the ability to load a reconstructor matrix for the HWFP. [IRD-xxx]

P3K-SW-0275: AOSC shall provide the ability to specify the telemetry data to be recorded by the HWFP. [IRD-xxx]

P3K-SW-0280: AOSC shall provide the ability to select various rates for the high-order wavefront sensor camera.[IRD-xxx] (LGS AO)

P3K-SW-0285: AOSC shall provide the ability to select the various CCD gains for the high-order wavefront sensor camera. [IRD-xxx] (LGS AO)

P3K-SW-0290: AOSC shall provide the ability to select the various CCD biases for the high-order wavefront sensor camera. [IRD-xxx] (LGS AO)

P3K-SW-0295: AOSC should provide the ability to select the pixel readout rate for the high-order wavefront sensor camera. [IRD-xxx] (LGS AO)

P3K-SW-0300: AOSC shall provide the ability to load a sky background table for the HWFP. [IRD-xxx] (LGS AO)

P3K-SW-0305: AOSC shall provide the ability to load a flat field pixel table for the HWFP. [IRD-xxx] (LGS AO)

P3K-SW-0310: AOSC shall provide the ability to load a reference centroid position table for the HWFP. [IRD-xxx] (LGS AO)

P3K-SW-0315: AOSC shall provide the ability to change the servo control loop parameters in the HWFP. [IRD-xxx] (LGS AO)

P3K-SW-0320: AOSC shall provide the ability to select the rate at which the telemetry data will be recorded by the HWFP. [IRD-xxx] (LGS AO)

P3K-SW-0325: AOSC shall provide the ability to turn the uplink tip/tilt on and off

P3K-SW-0330: AOSC shall provide the ability to set the UTT gains

P3K-SW-0335: AOSC shall provide the ability to control offloading between DMs, including gains and number of modes.

P3K-SW-0340: AOSC shall provide the ability to turn the TTM loop on and off

3.4.4 Low Order Wavefront Sensor Control

P3K-SW-0345: AOSC shall provide the ability to turn on/off the TTM control loop in all modes. [IRD-185]

P3K-SW-0350: AOSC shall provide the ability to load the reconstructor matrix for the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0355: AOSC shall provide the ability to select various rates for the low-order wavefront sensor camera. [IRD-xxx] (LGS AO)

P3K-SW-0360: AOSC shall provide the ability to select the various CCD gains for the low-order wavefront sensor camera. [IRD-xxx] (LGS AO)

P3K-SW-0365: AOSC should provide the ability to select the pixel readout rates for the low-order wavefront sensor camera . [IRD-xxx] (LGS AO)

P3K-SW-0370: AOSC shall provide the ability to load the sky background table for the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0375: AOSC shall provide the ability to load the flat field pixel table for the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0380: AOSC shall provide the ability to load the reference centroid position table for the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0385: AOSC shall provide the ability to change the TTM servo control loop parameters in the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0390: AOSC shall provide the ability to select the telemetry data to be recorded by the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0395: AOSC shall provide the ability to select the telemetry data to be recorded by the LWFP. [IRD-xxx] (LGS AO)

P3K-SW-0400: AOSC shall provide the ability to select the rate at which the telemetry data will be recorded by the LWFP. [IRD-xxx] (LGS AO)

3.4.5 Status Monitoring

P3K-SW-0405: AOSC shall record the current configuration and status of the AO system to the telemetry database subsystem once per second.[IRD-xxx] (LGS AO)

P3K-SW-0410: AOSC shall send the current configuration of the AO system to the user interface on startup and on change, within 0.1s. [IRD-xxx]

P3K-SW-0415: AOSC shall record any configuration table names loaded into the wavefront processing system to the telemetry database subsystem. [IRD-xxx] (LGS AO)

P3K-SW-0420: AOSC will provide a "heartbeat" signal once per second.

3.5 Telemetry Database

P3K-SW-0425: The telemetry database shall be able to record telemetry data from the HOWFP Processor. Data types include, but are not limited to, the following: [P3K-IRD-00240]

1. HO Pixel Data
2. HO Pixel Gain Data
3. HO Pixel Offset Data
4. HO Centroid Data
5. HO Centroid Offset Data
6. HO Sub-aperture Flux Data
7. HO Reconstruction Data
8. HO Tip and Tilt Residual Data

P3K-SW-0430: The telemetry database shall be able to record telemetry data from the LOWFP Processor. Data types include, but are not limited to, the following: [P3K-IRD-00240]

1. LO Pixel Data
2. LO Pixel Gain Data
3. LO Pixel Offset Data
4. LO Centroid Data
5. LO Centroid Offset Data
6. LO Sub-aperture Flux Data
7. LO Reconstruction Data
8. LO Tip and Tilt Residual Data

P3K-SW-0435: The telemetry database shall be able to record telemetry data from the TWFS WFP Processor (phase 2). Data types include, but are not limited to, the following: [P3K-IRD-00240]

1. TWFS Pixel Data
2. TWFS Pixel Gain Data
3. TWFS Pixel Offset Data
4. TWFS Centroid Data
5. TWFS Centroid Offset Data
6. TWFS Sub-aperture Flux Data
7. TWFS Reconstruction Data
8. TWFS Tip and Tilt Residual Data

P3K-SW-0440: The telemetry database shall be able to record telemetry data from the IRTT WFP Processor (phase 2). Data types include, but are not limited to, the following: [P3K-IRD-00240]:

1. IRTT Pixel Data
2. IRTT Pixel Gain Data
3. IRTT Pixel Offset Data
4. IRTT Centroid Data
5. IRTT Centroid Offset Data
6. IRTT Sub-aperture Flux Data

7. IRTT Reconstruction Data
8. IRTT Tip and Tilt Residual Data

P3K-SW-0445: The telemetry database shall record any status and configuration table data received from AOSC. [P3K-IRD-00240]

P3K-SW-0450: The telemetry database shall record data received from AOSC. [P3K-IRD-00240]

P3K-SW-0455: The telemetry database shall record telescope control system (TCS) status received from the user interface. [P3K-IRD-00240]

P3K-SW-0460: The telemetry database shall record beam transfer optics (BTO) status data received from the user interface. [P3K-IRD-00240]

P3K-SW-0465: The telemetry database shall record laser guide start (LGS) status received from the user interface. [P3K-IRD-00240]

P3K-SW-0470: The telemetry database shall record data received from the beam transfer optics control system (BTO). [P3K-IRD-00240]

P3K-SW-0475: The telemetry database shall record data received from the laser control system (LGS). [P3K-IRD-00240]

P3K-SW-0480: The telemetry database shall provide the ability to retrieve any recorded data based on time intervals. [P3K-IRD-00235]

P3K-SW-0485: The telemetry database should provide the ability to retrieve any recorded data based on user name tags.

P3K-SW-0490: The telemetry database shall be able to retrieve near real time telemetry data to the requester within 1 second of request. [P3K-IRD-00235] [performance requirements?]

P3K-SW-0495: The telemetry database should provide the ability to retrieve any recorded data directly to IDL (eg. the data should be passed to an IDL variable without being written to disk). [P3K-IRD-00235]

3.6 User Interface (UI)

3.6.1 Startup

P3K-SW-0500: All user interface screens shall be accessible through a hierarchy of pulldown-type menus. [IRD-xxx]

3.6.2 Scripting

P3K-SW-0505: All user AOSC commands and UI automation functions shall be externally callable via an IDL interface. [IRD-xxx]

3.6.3 AO Control

3.6.3.1 AO Modes

P3K-SW-0510: The user interface shall support the ability to select between the following modes of operation: NGS, DNGS, LGS, and LGS-VisTT (phase 2 only). These modes control the behaviour of the TTM, DM394, DM3326, and UTT servo loops. [IRD-2.2.1]

3.6.3.2 WFS Camera Control

P3K-SW-0515: The user interface shall provide the ability to set the following HOWFS camera operating parameters: [IRD-220]

1. Detector gain.
2. Detector bias.
3. Frame rate.

4. Laser pulse synchronization .

P3K-SW-0520: The user interface shall provide the ability to set the following LOWFS camera operating parameters (Phase 1): [IRD-220]

1. Detector gain.
2. Detector bias.
3. Frame rate.

P3K-SW-0525: The user interface shall provide the ability to set the following TWFS camera operating parameters (Phase 2): [IRD-220]

1. Detector gain.
2. Detector bias.
3. Frame rate.

3.6.3.3 Servo Loop Control

P3K-SW-0530: The user interface shall provide the ability to open/close the TTM control loop. [IRD-185]

P3K-SW-0535: The user interface shall provide the ability to open/close the DM349 control loop. [IRD-190]

P3K-SW-0540: The user interface shall provide the ability to open/close the DM3326 control loop. [IRD-195]

P3K-SW-0545: The user interface shall provide the ability to open/close the DM3326 to DM349 offload loop. [IRD-210, IRD-215]

P3K-SW-0550: The user interface shall provide the ability to open/close the UTT loop . [IRD-180]

P3K-SW-0555: The user interface shall provide the ability to open/close the LGS fast focus loop . [IRD-180]

P3K-SW-0560: The user interface shall provide the ability to set the TTM control loop proportional and integral gains. [IRD-220]

P3K-SW-0565: The user interface shall provide the ability to set the DM349 control loop proportional and integral gains. [IRD-220]

P3K-SW-0570: The user interface shall provide the ability to set the DM3326 control loop proportional and integral gains. [IRD-220]

P3K-SW-0575: The user interface shall provide the ability to set the DM3326 to DM349 offload loop proportional and integral gains. [IRD-220]

P3K-SW-0580: The user interface shall provide the ability to set the UTT control loop proportional and integral gains . [IRD-220]

P3K-SW-0585: The user interface shall provide the ability to set the LGS fast focus control loop proportional and integral gains . [IRD-220]

P3K-SW-0590: The user interface shall provide the ability to load the folowing HOWFS tables: [IRD-220]

1. Pixel offset table (aka. background frame).
2. Pixel gain table (aka. flat field).
3. Centroid offset table.
4. HOWFS-DM3326 reconstructor.
5. HOWFS-DM349 reconstructor.

P3K-SW-0595: The user interface shall provide the ability to load the folowing LOWFS tables (Phase 1): [IRD-220]

1. Pixel offset table (aka. background frame).

2. Pixel gain table (aka. flat field).
3. Centroid offset table.
4. Reconstructor.

P3K-SW-0600: The user interface shall provide the ability to load the folowing TWFS tables (Phase 2): [IRD-220]

1. Pixel offset table (aka. background frame).
2. Pixel gain table (aka. flat field).
3. Centroid offset table.
4. Reconstructor.

3.6.3.4 Open-loop adaptive mirror control

P3K-SW-0605: The user interface shall provide the ability to command the TTM to move to a given position. [IRD-470]

P3K-SW-0610: The user interface shall provide the ability to command the UTTM to move to a given position. [IRD-470]

P3K-SW-0615: The user interface shall provide the ability to load an actuator position map on DM349. [IRD-470]

P3K-SW-0620: The user interface shall provide the ability to load an actuator position map on DM3326. [IRD-470]

3.6.3.5 HOWFS Acquisition Camera Control

P3K-SW-0625: The user interface shall provide the ability to set the HOWFS acquisition camera integration time. [IRD-xxx]

3.6.3.6 Motor Control

P3K-SW-0630: The user interface shall provide the ability to command moves of any motor in the AO system, using device units. [IRD-xxx]

P3K-SW-0635: The user interface shall provide the ability to command moves of any motor in the AO system, using named a standard set of named positions (eg. “ngs”). [IRD-xxx]

P3K-SW-0640: The user interface shall provide the ability to update the named positions of every AO system motor. [IRD-xxx]

3.6.4 AO Monitor

3.6.4.1 Status Monitor

P3K-SW-0645: The user interface shall display the current AO mode. [IRD-230]

P3K-SW-0650: The user interface shall display the following TTM servo loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0655: The user interface shall display the following DM349 servo loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0660: The user interface shall display the following DM3326 servo loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0665: The user interface shall display the following DM3326-DM349 offload loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0670: The user interface shall display the following UTT servo loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0675: The user interface shall display the following LGS fast focus servo loop parameters: [IRD-230]

1. State (open/closed).
2. Frame rate.
3. Proportional gain.
4. Integral gain.

P3K-SW-0680: The user interface shall display the following HOWFS telemetry status data: [IRD-230]

1. Telemetry rate.
2. Telemetry fields.

P3K-SW-0685: The user interface shall display the following LOWFS telemetry status data: [IRD-230]

1. Telemetry rate.
2. Telemetry fields.

P3K-SW-0690: The user interface shall display the following TWFS telemetry status data: [IRD-230]

1. Telemetry rate.
2. Telemetry fields.

P3K-SW-0695: The user interface shall display the acquisition camera integration time. [IRD-230]

P3K-SW-0700: The user interface shall display the acquisition camera telemetry rate. [IRD-230]

P3K-SW-0705: The user interface shall display the status of the laser shutter. [IRD-230]

P3K-SW-0710: The user interface shall display the laser power. [IRD-230]

P3K-SW-0715: The user interface shall display the status of the BTO. [IRD-230]

3.6.4.2 Engineering Screens

P3K-SW-0950: The user interface shall provide an engineering screen displaying the current positions of every AO system motor, in device units. [IRD.230]

P3K-SW-0955: The user interface shall provide an engineering screen displaying the names of all tables currently loaded. [IRD.230]

3.6.4.3 Performance Monitor

P3K-SW-0720: The user interface shall display the current raw pixel values of the HOWFS as an image, updated at >1 Hz (goal: >10 Hz). [IRD-235]

P3K-SW-0725: The user interface shall display the current raw pixel values of the LOWFS as an image, updated at >1 Hz (goal: >10 Hz) (Phase 1). [IRD-235]

P3K-SW-0730: The user interface shall display the current raw pixel values of the TWFS as an image, updated at >1 Hz (goal: >10 Hz) (Phase 2). [IRD-235]

P3K-SW-0735: The user interface shall display the DM349 actuator voltages, updated at >1 Hz (goal: >10 Hz). [IRD-235]

P3K-SW-0740: The user interface shall display the DM3326 actuator voltages, updated at >1 Hz (goal: >10 Hz). [IRD-235]

P3K-SW-0745: The user interface shall display the TTM position in each axis as a function of time, for the last 120s, updated every 1s, with <1s lag. [IRD-235]

P3K-SW-0750: The user interface shall display the TTM residuals in each axis as a function of time, for the last 120s, updated every 1s, with <1s lag. [IRD-235]

P3K-SW-0755: The user interface shall display the UTT positions in each axis as a function of time, for the last 120s, updated every 1s, with <1s lag . [IRD-235]

P3K-SW-0760: The user interface shall display the UTT residuals in each axis as a function of time, for the last 120s, updated every 1s, with <1s lag . [IRD-235]

P3K-SW-0765: The user interface shall display the DM349 RMS residual as a function of time, for the last 120s, updated every 1s, with <1s lag. [IRD-235]

P3K-SW-0770: The user interface shall display the DM3326 RMS residual as a function of time, for the last 120s, updated every 1s, with <1s lag. [IRD-235]

P3K-SW-0775: The user interface shall display the LOWFS focus as a function of time, for the last 120s, updated every 1s, with <1s lag (Phase 1). [IRD-235]

P3K-SW-0780: The user interface shall display the TWFS focus as a function of time, for the last 120s, updated every 1s, with <1s lag (Phase 2). [IRD-235]

P3K-SW-0785: The user interface shall display the HOWFS focus stage position as a function of time, for the last 120s, updated every 1s, with <1s lag . [IRD-235]

P3K-SW-0790: The user interface shall display the mean counts in the illuminated HOWFS subapertures as a function of time, for the last 120s, updated every 1s, with <1s lag. [IRD-235]

P3K-SW-0795: The user interface shall display the mean counts in the illuminated LOWFS subapertures as a function of time, for the last 120s, updated every 1s, with <1s lag (Phase 1). [IRD-235]

P3K-SW-0800: The user interface shall display the mean counts in the illuminated TWFS subapertures as a function of time, for the last 120s, updated every 1s, with <1s lag (Phase 2). [IRD-235]

P3K-SW-0805: The user interface should display the 1s time average of the subaperture signal-to-noise ratio on the HOWFS. [IRD-230]

P3K-SW-0810: The user interface should display the 1s time average of the subaperture signal-to-noise ratio on the LOWFS (Phase 1). [IRD-230]

P3K-SW-0815: The user interface should display the 1s time average of the subaperture signal-to-noise ratio on the TWFS (Phase 2). [IRD-230]

P3K-SW-0820: The user interface should display the RMS TTM residual over the last 5s. [IRD-230]

P3K-SW-0825: The user interface should display the RMS UTT residual over the last 5s. [IRD-230]

P3K-SW-0830: The user interface should display the RMS HOWFS residual over the last 5s. [IRD-230]

P3K-SW-0835: The user interface should display the mean focus on DM349 over the last 5s. [IRD-230]

P3K-SW-0840: The user interface should display the mean focus on DM3236 over the last 5s. [IRD-230]

3.6.5 AO Automation

3.6.5.1 Acquisition

P3K-SW-0850: The user interface shall display the most recent HOWFS acquisition camera image, updated at >1 Hz (goal: >10 Hz). [IRD-460]

P3K-SW-0860: The user interface shall allow the operator to adjust the gray-scale contrast of the HOWFS acquisition camera image. [IRD-460]

P3K-SW-0870: The user interface shall allow the operator to center any star in an acquisition camera image on the HOWFS field stop, by sending a TCS telescope offset command. [IRD-460]

P3K-SW-0875: The user interface shall allow the operator to center the LGS on the HOWFS field stop, by sending an offset to the UTT mirror . [IRD-460]

P3K-SW-0880: The user interface shall allow the operator to center any star in an acquisition camera image on the LOWFS field stop, by sending a offset to the LOWFS OSM (Phase 1). [IRD-460]

P3K-SW-0885: The user interface shall allow the operator to center any star in an acquisition camera image on the TWFS field stop, by sending a offset to the TWFS OSM (Phase 2). [IRD-460]

P3K-SW-0890: The user interface shall provide the ability to pre-set the frame rate and pixel gain of each camera based on guidestar magnitude. [IRD-460]

P3K-SW-0895: The user interface shall provide the ability to pre-set the integral and proportional gain of each control loop based on guidestar magnitude. [IRD-460]

3.6.5.2 Wavefront Sensor Backgrounds

P3K-SW-0900: The user interface shall provide the ability to record a HOWFS pixel offset table (aka. background) with a user-defined integration time. [IRD-460]

P3K-SW-0905: The user interface shall provide the ability to record a LOWFS pixel offset table (aka. background) with a user-defined integration time (Phase 1). [IRD-460]

P3K-SW-0910: The user interface shall provide the ability to record a TWFS pixel offset table (aka. background) with a user-defined integration time (Phase 2). [IRD-460]

3.6.5.3 HOWFS to DM registration

P3K-SW-0915: The user interface shall provide the ability to register the HOWFS lenslets to the DM3326 actuators by adjusting the HOWFS OSM upon user request, using either the stimulus sources, NGS, or LGS. [IRD-460]

3.6.5.4 Telescope Offloads

P3K-SW-0920: The user interface shall provide the ability to disable telescope offload procedures. [IRD-xxx]

P3K-SW-0925: The user interface shall offload the average DM focus to the telescope secondary every 60 seconds or upon user request. [IRD-xxx]

P3K-SW-0930: The user interface shall offload the average tip/tilt residual to the telescope tracking every 60 seconds or upon user request. [IRD-xxx]

3.6.5.5 LGS Slow Focus Loop

P3K-SW-0935: The user interface shall provide the ability to open/close the LGS slow focus loop. [IRD-220]

P3K-SW-0940: The user interface shall provide the ability to set the rate of the LGS slow focus loop (1-30s). [IRD-220]

P3K-SW-0945: The user interface shall provide the ability to set the proportional and integral gains of the LGS slow focus loop. [IRD-220]

3.6.5.6 Dithering

P3K-SW-0950: The user interface shall provide the ability to perform NGS mode dithers, for which a move commanded by the operator or the science camera opens the servo loops, offsets the telescope and HOWFS OSM, then re-closes the servo loops. [IRD-375]

P3K-SW-0950: The user interface shall provide the ability to perform "NGS dithers" in LGS mode, for which a move commanded by the operator or the science camera opens the servo loops, offsets the telescope and LOWFS (TWFS) OSM, then re-closes the servo loops. [IRD-365]

P3K-SW-0955: The user interface shall provide the ability to perform "LGS dithers" in LGS mode, for which a move commanded by the operator or the science camera opens the servo loops, offsets the telescope, UTTM, HOWFS OSM, and LOWFS (TWFS) OSM, then re-closes the servo loops. [IRD-370]

3.6.5.7 Image stabilization

P3K-SW-0955: The user interface shall provide the ability to stabilize the image at the science focal plane when the AO control loops are closed, by sending periodic (or continuous rate) commands to the HOWFS/LOWFS/TWFS OSM to compensate for mechanical flexure and differential atmospheric refraction. [IRD-395, IRD-400]

3.6.5.8 Science Camera Control

P3K-SW-0960: The user interface shall provide the ability to perform the following tasks with the science camera (as defined in the IICD): [IRD-xxx]

1. Set the data directory.
2. Set the slit, filter, lyot stop, plate scale, etc. (as applicable)
3. Set the integration time.
4. Record an image.
5. TBD.

4 PERFORMANCE REQUIREMENTS

5 RELIABILITY, MAINTAINABILITY, AND RELATED REQUIREMENTS

6 DESIGN AND IMPLEMENTATION CONSTRAINTS