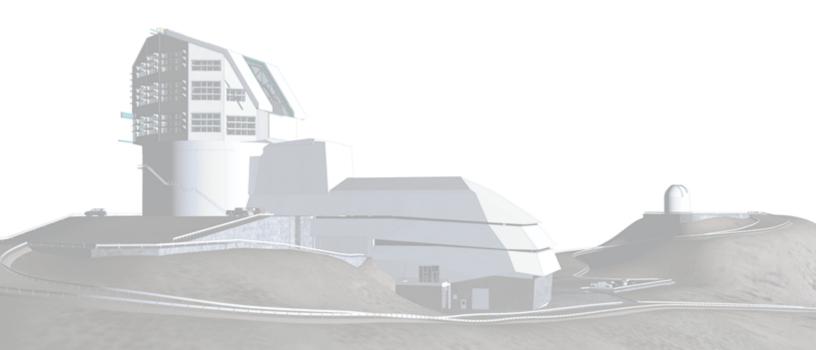**Vera C. Rubin Observatory
Systems Engineering**

Integration Milestones

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SITCOMTN-006

Latest Revision: 2021-09-03

Abstract

A proposal for ways to work on predominantly software subsystem commissioning, building on the Rubin AuxTel (née auxTel) experience

Change Record

Version	Date	Description	Owner name
1	YYYY-MM-DD	Unreleased.	Robert Lupton

Document source location: `https://github.com/lsst-sitcom/sitcomtn-006`

Contents

Integration Milestones

1   Introduction

The Rubin construction project is composed of three main subsystems: DM, Camera, and T&S.[1] but in operations there is only one survey. The task of merging the projects is not easy, especially when some of the interfaces are underspecified, or turn out to need modification based on experience. This is primarily a problem for the software — the hardware interfaces, specified in mm and screw threads, are generally well defined.

Once we accept that the only way to complete the integration of the subsystems is to actually integrate them, while expecting that the interfaces and requirements will evolve, we recognise that our situation is analogous to the way that software development has moved from waterfall to agile development models.

This technote proposes that we introduce the concept of an IM which defines a specified set of functionalities that are available to the Rubin project. This is slightly different from DM's current OR concept which tests the state of DM systems at a certain time rather than guaranteeing continued cross-subsystem functionality. I envisage that an IM would be followed by an OR to test the deliverable, and to carry out an internal ORR for the functionality delivered by the IM.

1.1   Dependencies

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[1]And also EPO, but this is probably not relevant here.

FIGURE 1: The dependencies between the IMs and other entities, either external hardware or software (*e.g.* ComCam, Nublado shown in hexagons), or systems being produced during the completion of the Rubin system (*e.g.* the OCPS, shown in ellipses and whose first appearance is shown as a green line). The rectangular boxes are IMs; red means complete. The blue arrows show IM's prerequisites, and black arrows indicate other dependencies.

Not all IMs are shown at this point. The mapping to P6 is also omitted as it is not yet clear enough to be useful (but see App. A).

2   Schedule

IM		Sim?	Target Date	Completion	Comments
IM_1	CC Capture/Archive	N	2021-04-23	2021-05-01	
IM_{3a}	AT Scripted	N	2021-05-31	2021-06	no logging
IM_3	AT Scripted/OCPS	N	2021-05-31		
$IM_{pre-pre-G}$	AOS Zernikes	Y	2021-04-30	2021-05-27 (DM-28667)	In parallel with IM_F
IM_{2a}	CC Calib Gen'n	N	2021-05-21	2021-08-01 only biases	
IM_2	CC Calib Gen'n	N	2021-05-21		no logging
IM_4	MT Full Slew	Y	2021-07-01	2021-08-05	
IM_{pre-G}	AOS MT	Y	2021-05-21	2021-08-27 (DM-31357)	In parallel with IM_F.
$IM_{pre-pre-F}$	AOS Corner	Y	2021-06-04	2021-09-01 (DM-30764)	
IM_{pre-F}	AOS MT	Y	2021-08-26	projected 2021-09-09	In parallel with IM_{pre-G}
IM_F	AOS Corner	Y	2021-06-15		In parallel with IM_G
IM_G	AOS CC/MT	Y	2021-06-30		Blocked by DAQ playback
IM_E	AT Sustained	N	2021-07-01		
IM_H	AOS Full Ops	Y	2021-09-30		Blocked by DAQ playback
IM_{pre-M}	AT Zernikes	Y/N	2021-10-01		
IM_M	AT AOS	N	2021-11-01		
IM_N	DRP with auxTel	N	2022-01-01		
IM_O	AP with auxTel	N	2022-08-01		
IM_I	Full AOS	Y	2022-XX-YY		
IM_J	AT start/end night	N	2021-XX-YY		
IM_K	L'Cam Calib Gen'n	Y	2022-XX-YY		
IM_L	CBP	N	2022-XX-YY		

3   IM$_1$ [a]: ComCam Image Capture and Archive (2021-04-23)

Executive Summary:

Run ComCam from notebooks, with generation and certification of ComCam calibrations. **Completion of exercise maps to (SUMMIT-2983 COMP: ComCam re-Verification Complete)**

3.1   Goals of IM

- Taking ComCam images in Chile using nublado **(SUMMIT-2979 (and (SUMMIT-2980)) - ComCam CCS - OCS Command ICD Bench Testing)**

- Taking calibration and other images using the scriptQueue

- Automatic ingestion into a gen3 butler in Chile **(SUMMIT-2982 (and (SUMMIT-2869)) ComCam DAQ - DMS ICD Bench Testing)**

- Transfer over DBB Buffer manager and the LHN to a gen3 repo on the RSP

- Human generation and availability of master calibrations in Chile

3.2   Prerequisites

- ComCam on summit

  - cold and functional
  - incoherent light source available to take flats

- gen3 butler ingestion for ComCam

- Nublado running in Chile

3.3   Procedure

The following procedure is to be executed by a general commissioning team member. The script creation and scriptQueue requires a minor amount of training and may require assistance.

1. Following a procedure, instantiate the OCS bridge

2. Using Nublado, bring to enabled state using Notebook

3. Using Nublado and the ComCam class:

   (a) Take a single OBJECT, BIAS, FLAT, DARK image

   (b) For each image, monitor event for CCCamera completion, monitor OODS event saying image is ready, use butler to grab image, display image locally using Firefly/DS9 or camera display tool

4. In a notebook, create cells to take bias, dark, flat, and PTC calibration data

5. Convert Nublado cells to scriptQueue, creating a "standard Calibration" script and execute them

6. From the Commissioning Cluster at the base:

   (a) Display one of each image type locally using Firefly/DS9 or camera display tool

   (b) Run gen3 cp_pipe by hand from a Nublado terminal

       i. Create master biases, flats, darks using "auto-certify" mode which assumes that the derived products are good [2]

       ii. Copy images to summit and include in summit Butler repo.

7. Take further exposures with structured illumination, preferably different from what was used to generate the flat.

8. From the summit, run ISR processing, display images and confirm new calibs are being applied

9. Once data is synced to NCSA via the LHN, Repeat the generation of calibration images using the RSP

10. Re-verify that RSP generated calibration images can be used on the summit.

3.4 Status

2021-02-08 Tested using AuxTel

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[2]This results in the calibrations being available for use

- Images taken using nublado and scriptQueue (no demonstration of calibrations with scriptQueue)

- Automatic ingestion into gen3 butler in Chile (no demonstration of functional re-run/calibrations)

- Transfer to NCSA and ingestion in gen3 butler visible from RSP

- Calibs (bias, dark) generated in Chile and used with gen2 butler (exposing a per-day lookup bug in gen2 butler)

4 IM$_{2a}$ [pb]: ComCam Calibration Acquisition, Transfer, and Processing (2021-05-21)

Executive Summary:

Run ComCam from notebooks and the scriptQueue, with automated generation of ComCam calibrations

Does not map well. Somewhat maps to same milestones as previous exercise, but no solid mapping as this is more about operator awareness and DM related functionality.

N.b. **this is the IM that mentions the use of the EFD. We should expand this, and maybe split it out.**

4.1 Goals of IM

- Triggering OCPS processing from nublado/scriptQueue

- Automated generation and availability of ComCam master calibrations in Chile

- Use of LOVE to manage scriptQueue

    – including monitoring of data transfer to NCSA

- Demonstration that the operator can cycle through states, bring the system up from STANDBY, and take data without any intervention from developers

- Monitor the health of the CCS from the observatory environment (e.g. Chronograph/LOVE)

4.2 Prerequisites

- IM$_1$ completed with functionality maintained

- ComCam cold and functional with light source available for flat

4.3   Procedure

The following procedure is to be executed by an observing specialist. Assistance may be provided in the script editing and database querying by other commissioning team members.

- Following a procedure, bring up the LOVE interface for ComCam

- Using Nublado, without assistance from developers, the operator should bring ComCam to ENABLED from STANDBY

- Take an OBJECT image using the ComCam class

    – Verify functionality of the LOVE interface, including the state and health

    – Display the raw image locally

    – Using the OCPS, perform basic ISR on the image and wait for the result (e.g. "await ocps.process(visitID, task_name)")

    – Display the ISR-corrected image

    – Monitor the transfer status and elapsed time between when the image is written on the summit to when it can be accessed at NCSA.

- Modify the script from IM_1 used to take calibrations to also command the OCPS to reduce the data

    – Take *only* a stack of ~10 bias frames

    – Using the OCPS, build a master bias from inside the script. Do not wait for the processing to finish

        * One could use "asyncio.future(ocps.process(visitID, task_name))"

    – Ensure the bias builds and is certified

- From the RSP, query the local copy of the EFD and plot exposure time versus number since the start of this exercise

- From the RSP, make the same plot using data from the Camera Trending Database

5   IM$_2$ [b]: ComCam Calibration Acquisition, Transfer, and Processing (2021-05-21)

Executive Summary:

Run ComCam from notebooks and the scriptQueue, with automated generation and certification of ComCam calibrations

Does not map well. Somewhat maps to same milestones as previous exercise, but no solid mapping as this is more about operator awareness and DM related functionality.

***N.b.* this is the IM that mentions the use of the EFD. We should expand this, and maybe split it out.**

5.1   Goals of IM

- Triggering OCPS processing from nublado/scriptQueue

- Automated generation and availability of ComCam master calibrations in Chile

- Use of RLS and LOVE to manage scriptQueue

    - including monitoring of data transfer to NCSA

- Demonstration that the operator can cycle through states, bring the system up from STANDBY, and take data without any intervention from developers

- Monitor the health of the CCS from the observatory environment (e.g. Chronograph/LOVE)

- Explore relationship between EFD and Camera trending databases

- Query capability (TAP/ADQL) access to EFD from RSP

5.2   Prerequisites

- IM$_{2a}$ completed with functionality maintained

5.3 Procedure

The following procedure is to be executed by an observing specialist. Assistance may be provided in the script editing and database querying by other commissioning team members.

- Following a procedure, bring up the LOVE interface for ComCam

- Using Nublado, without assistance from developers, the operator should bring ComCam to ENABLED from STANDBY

- Take an OBJECT image using the ComCam class

  - Verify functionality of the LOVE interface, including the state and health
  - Display the raw image locally
  - Using the OCPS, perform basic ISR on the image and wait for the result (e.g. "await ocps.process(visitID, task_name)")
  - Display the ISR-corrected image
  - Monitor the transfer status and elapsed time between when the image is written on the summit to when it can be accessed at NCSA.

- Modify the script from IM_1 used to take calibrations to also command the OCPS to reduce the data

  - Take *only* a stack of ~10 bias frames
  - Using the OCPS, build a master bias from inside the script. Do not wait for the processing to finish
    * One could use "asyncio.future(ocps.process(visitID, task_name))"
  - Ensure the bias builds and is certified

- From the RSP, query the local copy of the EFD and plot exposure time versus number since the start of this exercise

- From the RSP, make the same plot using data from the Camera Trending Database

6 IM$_{3a}$ [pc]: Rubin AuxTel Standard Star Campaign (2021-05-31)

Executive Summary:

Demonstrates ability to take and reduce AuxTel data

No direct mapping to P6 activity, indirect mappings are below

6.1 Goals of IM

- Automated generation and availability of AuxTel master calibrations in Chile (cf. IM$_2$) - (**SUMMIT-2989 Atmospheric Calibration Products Pipeline Testing)**

- Annotate exposures using RLS

- Take data in a standard star field, including interactive re-centering

- Run AuxTel data analysis package in Chile and NCSA, triggered by OCPS **Partial mapping to (SUMMIT-2987 Calibration Telescope Instrumental Signature Removal Testing & Verification) and (SUMMIT-2871 Aux. Tel. DAQ + DMS Interface Testing)**

    – Display results to operators

6.2 Prerequisites

- IM$_2$ Completed

- AuxTel and LATISS functional and ready to track a target. Rough focus should be achieved.

- Available staff for night time operations

- User commenting in RLS available

6.3 Procedure

The following procedure is to be executed by an observing specialist.

1. Using Nublado, slew to ∼ 60 degree elevation target and start tracking

2. Using Nublado, measure the focus offset using the CWFS focus script, but launched from the notebook.

3. Annotate results using the RLS

4. Apply the focus offset using the ATAOS, record the applied offset in the RLS

5. Manually take a single OBJECT image:

   (a) Verify functionality of the LOVE interface, including instrument setup and applied focus offset(s).

   (b) Perform basic ISR on the image using DM code

   (c) Display the image after running ISR

6. Using the standard visit script launched from a notebook, slew to new target and perform automated acquisition only, script must have user verify offset prior to motion.

7. Perform the standard data taking sequence using the standard visit script

8. Perform a single image with the instrument in its standard spectral mode

9. Perform a custom sequence using at least two items in the grating wheel and two in the filter wheel, all with different exposure times

   (a) Verify functionality of the LOVE interface, including filter/grating changes/shutter movement, focus/pointing offsets

   (b) Display the ISR processed images as they are available

10. Manually and off-line:

   (a) Perform standard observations of 3 targets spanning the elevation range sequentially

   (b) Display extracted atmospheric parameters for each target

7   IM$_3$ [c]: Rubin AuxTel Standard Star Campaign (2021-05-31)

Executive Summary:

Demonstrates ability to take and reduce AuxTel data using the scriptQueue.

No direct mapping to P6 activity, indirect mappings are below

7.1   Goals of IM

- Automated generation and availability of AuxTel master calibrations in Chile (cf. IM$_2$) - **(SUMMIT-2989 Atmospheric Calibration Products Pipeline Testing)**

- Annotate exposures using RLS

- Take data in a standard star field, including interactive re-centering

- Run AuxTel data analysis package in Chile and NCSA, triggered by OCPS **Partial mapping to (SUMMIT-2987 Calibration Telescope Instrumental Signature Removal Testing & Verification) and (SUMMIT-2871 Aux. Tel. DAQ + DMS Interface Testing)**

    - Display results to operators

7.2   Prerequisites

- IM$_2$ Completed

- IM$_{3a}$ Completed

- AuxTel and LATISS functional and ready to track a target. Rough focus should be achieved.

- Available staff for night time operations

- User commenting in RLS available

7.3   Procedure

The following procedure is to be executed by an observing specialist.

1. Using Nublado, slew to ~ 60 degree elevation target and start tracking

2. Using Nublado, measure the focus offset using the CWFS focus script, but launched from the notebook.

3. Annotate results using the RLS

4. Apply the focus offset using the ATAOS, record the applied offset in the RLS

5. Manually take a single OBJECT image:

   (a) Verify functionality of the LOVE interface, including instrument setup and applied focus offset(s).

   (b) Using the OCPS, perform basic ISR on the image and wait for the result (e.g. "await ocps.process(visitID, task_name)")

   (c) Display the image locally after running ISR

6. Using the standard visit script launched from a notebook, slew to new target and perform automated acquisition only, script must have user verify offset prior to motion.

7. Perform the standard data taking sequence using the standard visit script

8. Perform a single image with the instrument in it's standard spectral mode, then send for reduction with the OCPS. Wait for reduction to complete.

9. View the results locally in the notebook.

10. Perform a custom sequence using at least two items in the grating wheel and two in the filter wheel, all with different exposure times (OCPS should only perform ISR)

    (a) Verify functionality of the LOVE interface, including filter/grating changes/shutter movement, focus/pointing offsets, OCPS status

    (b) Display the ISR processed images locally as they are available

    (c) Monitor the transfer status and elapsed time between when the image is written on the summit to when it can be accessed from the RSP.

11. Using the scriptQueue:

    (a) Perform standard observations of 3 targets spanning the elevation range sequentially, script must send data to OCPS for reduction (but not await results)

    (b) Display extracted atmospheric parameters for each target

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(c) Comment in RLS about the weather or image quality

(d) Perform same observations, but with a custom modified configuration (exposure time or filter adjustment)

12. From the Base and the RSP, redo reduction of scriptQueue visit data

13. From the Base and the RSP, view the log and correlate comments against images.

8   IM$_4$ [d]: MT Full Slew (2021-07-01)

Executive Summary:

Demonstrates ability to slew the MT with Group 2 (Open loop AOS) systems running

Does not map to P6

Note: we can do this on the NTS earlier, say 2021-06-11.

8.1   Goals of IM

- Slew MT to a field using a nublado notebook

- Status displays using LOVE

8.2   Prerequisites

- IM$_2$

  - RLS, LOVE

- Group 2 hardware and CSC all online and enabled

  - Not required for fully simulated exercise at NCSA, but CSCs must be simulated, however, no low-level M2-type simulators required

- User commenting in RLS available

9 IM$_E$ [e]: Rubin AuxTel Standard Star Campaign (2021-07-01)

Executive Summary:

Demonstrates ability to carry out sustained AuxTel observing using the scriptQueue

Maps to (SUMMIT-2990 COMP: Calibration Telescope Ready for Operations) - except missing scheduler integration

9.1 Goals of IM

- Display images using Camera Image Visualization Tool

- Take pointing model using the script queue + OCPS, possibly including interactive recentering

- Take standard set of standard star fields using the script queue

- Visualise the reduced data

- Create observing log using LOVE

9.2 Prerequisites

- IM$_3$

- Camera Image Visualisation Tool or other equivalent tooling

10   IM_{pre-pre-F} [ppf]: AOS using Corner raft (2021-06-04)

Executive Summary: Demonstrate the processing of wave front images for raw corner raft `SW0/1` simulated data to Zernikes.

Does not map to P6

10.1   Goals of IM

Demonstrate ability to:

- Process corner raft Images and Generate Zernike coefficients

10.2   Prerequisites

- PhoSim images with donuts from `SW0/1` ingested into a butler repo.
- Working version of wavefront estimation pipeline (wep).

10.3   Procedure

- Generate and ingest simulated image and appropriate metadata.
  - Boresight and rotator angle
  - Piston from camera hexapod
- Run a Gen3 pipeline from the command line that:
  - gets data from the butler
  - runs the ISR
  - finds and process isolated donuts
  - average the resulting Zernikes over the stars in the field.
- uses the butler to put the description of the wavefront to disk

11 IM_{pre-F} [pf]: AOS using Corner Raft, commanding MT (2021-08-26)

Executive Summary: Process phosim Intra/Extra simulated Corner Raft images with the MTAOS. Assuming that the images where acquired and ingested previously, drive the MTAOS through the data processing steps and produce corrections.

Does not map to P6

11.1   Goals of IM

Demonstrate ability to:

- Have MTAOS process images and publish `{{camera,m2}Hexapod,{m1m3,m2}}Correction` events

11.2   Prerequisites

- IM_{pre-pre-G}
- Working version of MTAOS with access to a butler repo containing simulated ingested data.

11.3   Procedure

- Generate and ingest simulated images with desired pistons (e.g. $[0, -10, 0, 10, 0]$) and appropriate metadata

- As for IM_{pre-pre-F} get data from the butler and generate Zernikes, using OCPS to run the pipeline

- Trigger MTAOS to compute updates for Camera Hexapod, M2 Hexapod, M1M3, M2,

- Check that desired events are in the EFD

11.4 Acceptance Criteria

- A member of SITCom must be able to carry out these operations at NCSA without installing any software for themselves. This need not be done using RSP; a login shell on *e.g.* `lsst-dev13` would be acceptable.

- Confirm that the results are as expected. This should be carried out using a notebook on the RSP, in which case it *is* acceptable to require the tester to install the notebook from `git` themselves due to restrictions on the packages available on the RSP.

12   IM$_F$ [f]: AOS using Corner raft (2021-06-15)

Executive Summary:

Use a notebook to process corner raft `SW0/1` simulated data, publishing wavefront error events

12.1   Goals of IM

Demonstrate ability to:

- Slew to a field (only needed to provide ra, dec, rotator telemetry)

    - Question: does AOS need anything from the scheduler about the next field?

- Command exposure (or pair, if that's required by AOS) from ComCam

- have MTAOS process images, triggered by appropriate events, and publish `{{camera,m2}Hexapod,{m1m3,` events

12.2   Prerequisites

- Recover PhoSim images with donuts from ComCam

    - we may need to fake something here, if ComCam cannot play back corner raft data

- Pointing component generating telemetry

13 IM$_{\text{pre-pre-G}}$ [ppg]: AOS using ComCam; Zernikes (2021-04-30)

Executive Summary: Demonstrate the processing of wave front images for ComCam from raw to Zernikes.

Does not map to P6

13.1 Goals of IM

Demonstrate ability to:

- Process Defocussed Images and Generate Zernike coefficients

13.2 Prerequisites

- PhoSim images with donuts from ComCam ingested into a butler repo.
- Working version of wavefront estimation pipeline (wep).

13.3 Procedure

- Generate and ingest 1 simulated image with each desired piston: ($[0, -1.5, 0, 1.5, 0]$ mm) and appropriate metadata in each image:
  - Boresight and rotator angle
  - Piston from camera hexapod
- Run a Gen3 pipeline from the command line that:
  - gets data from the butler
  - runs the ISR
  - finds and process isolated donuts
  - estimates the wavefront in terms of annular Zernikes from each pair of donuts

- average the resulting Zernikes over the stars in the field.

- uses the butler to put the description of the wavefront to disk

13.4 Acceptance Criteria

- A member of SITCom must be able to carry out these operations at NCSA. This need not be done using RSP; a login shell on *e.g.* `lsst-dev13` is acceptable, and the SITCom member may be required to install and build packages from `git`.

- Confirm that the results are as expected. This should be carried out using a notebook on the RSP, and the tester may be required to install the notebook from `git`.

13.5 Status

2021-07-30   • Images taken using nublado

- Automatic ingestion into gen3 butler in Chile

- Transfer to NCSA and ingestion in gen3 butler visible from RSP

- Calibs (bias, dark) generated in Chile

14   IM$_{pre-G}$ [pg]: AOS using ComCam, commanding MT (2021-05-21)

Executive Summary: Process phosim Intra/Extra simulated ComCam images with the MTAOS. Assuming that the images where acquired and ingested previously, drive the MTAOS through the data processing steps and produce corrections.

Does not map to P6

14.1   Goals of IM

Demonstrate ability to:

- Have MTAOS process images and publish `{{camera,m2}Hexapod,{m1m3,m2}}Correction` events

14.2   Prerequisites

- IM$_{pre-pre-G}$

- Working version of MTAOS with access to a butler repo containing simulated ingested data.

14.3   Procedure

- Generate and ingest simulated images with desired pistons (e.g. $[0, -10, 0, 10, 0]$) and appropriate metadata

- As for IM$_{pre-pre-G}$ get data from the butler and generate Zernikes, using OCPS to run the pipeline

- Trigger MTAOS to compute updates for Camera Hexapod, M2 Hexapod, M1M3, M2,

- Check that desired events are in the EFD

14.4 Acceptance Criteria

- A member of SITCom must be able to carry out these operations at NCSA without installing any software for themselves. This need not be done using RSP; a login shell on *e.g.* `lsst-devl3` would be acceptable.

- Confirm that the results are as expected. This should be carried out using a notebook on the RSP, in which case it *is* acceptable to require the tester to install the notebook from `git` themselves due to restrictions on the packages available on the RSP.

15   IM$_G$ [g]: AOS using ComCam, commanding MT (2021-06-30)

Executive Summary:

Perform wave-front sensing using ComCam and a notebook

Does not map to P6

15.1   Goals of IM

Demonstrate:

- Slew to field, generating telemetry (*cf.* IM$_F$)

- piston camera (e.g. in, -out, in, +out, in).

- take data using ComCam in playback mode, commanded from OCS

- uses OCPS to reduce data on commissioning cluster

- load Zernikes into EFD

- Use MTAOS to update state of optics

15.2   Prerequisites

- ability to control camera hexapod

- IM$_{pre-G}$

- IM$_F$

    – No need for replaying corner raft data

- notebook/script to perform pistoning of camera hexapod with image acquisition

- OCPS

15.3   Procedure

- Generate simulated images with desired pistons (e.g. $[0, -10, 0, 10, 0]$) and appropriate metadata and load into comCam

- Use scriptQueue to issue slew and camera commands, sending commands to OCPS to process the data. *N.b.* will require the AOS to synchronise the piston values with the OCPS exposure numbers (`seqNum`).

- Check that desired events are in the EFD

16   IM$_H$ [h]: AOS in Regular Operations (2021-09-30)

Executive Summary:

Simulate AOS in regular operations with LSSTCam

Must be completed before (SUMMIT-3073 WFS-FPA & Reconstructor Calibration)

Outstanding questions:

- Are we verifying anything here?
- Should this be split into two IMs?

16.1   Goals of IM

Demonstrate running full AOS functionality script at 3 elevations

- scriptQueue runs SAL script
    - slew to field
    - take an exposure (or snap pair)
    - MTAOS processes data and broadcasts events
        * before starting next field

16.2   Prerequisites

- IM$_4$
- IM$_F$

17 IM$_I$ [i]: Commission Active Optics System (2022-XX-YY)

Executive Summary:

Simulate AOS commissioning, including building LUTs with LSSTCam

Maps to (SUMMIT-3075 Build Operational LSSTCam-Tel AOS Look-up Tables)

Outstanding questions:

- Are we verifying anything here?
- Should this be split into two IMs?

17.1 Goals of IM

Demonstrate running full AOS functionality script at 3 elevations

- scriptQueue runs SAL script
    - pistons camera (in, -out, in, +out, in)
    - uses OCPS to reduce data on commissioning cluster
        * Returns Zernikes
    - Script awaits on OCPS reduction finishing
    - AOS uses returned Zernikes to calculate mirror offsets as part of loop
    - Applies offsets and repeat
    - in-focus images get sent off via OCPS for reduction

- Build LUT for each mirror and hexapod
- Load the LUTs into components
    - Ideally would use new configuration handling tstn-017
- Repeat elevation testing with new LUTs

- results should show zero WFE

- Analysis should be repeated at NCSA

17.2   Prerequisites

- IM_f

18   IM$_J$ [j]: Start/End of Night (with AuxTel) (2021-XX-YY)

Executive Summary:

Exercise handoffs between day crew and night crew. Perform afternoon calibrations. Perform observatory opening/closing. Requires definition of opening/closing procedures and appropriate observing conditions. Also requires mechanism to get knowledge from night crew into Jira tickets which are then subsequently. How do we use LOVE/EUI/notebooks to troubleshoot/resolve faults?

Doesn't map to P6

18.1   Goals of IM

- Have observing specialist run the AuxTel, including

    – Perform nighttime hand off sequence

- Run afternoon calibrations, reduce them using OCPS, run QA, and possibly certify for use

- Test Camera Image Visualization Tool

    – This is a camera deliverable and I'm completely unaware of it's status.

- Verify current environmental conditions against acceptable conditions (Where are these hosted?)

    – Winds, seeing, humidity, windshake conditions (shutter/vent gate configurations), temperature

- Run opening script

    – Functionality requires review to ensure component safety etc.

    – When do we start observing?

- Perform several standard (spectroscopic) AuxTel visits

    – Simulate a fault, have pre-derived written instructions to "reset"

        * Instructions must not include syntax!

> · e.g. unwrap rotator, manually close vent gates 1-3, put down and push up mirror, home hexapod and re-position etc,

- **–** Use logger to record important information
- **–** Create Jira ticket(s)
- **–** Run pre-derived commands

- Recover, Perform more visits

  - **–** Simulate weather event requiring closure of observatories

- Recover, perform more visits

- Sun rising, Close observatory, publish night report

- Perform daytime handoff, including the procedure to getting the JIRA tickets filtered and addressed accordingly

18.2 Prerequisites

- AuxTel system fully functional

- LOVE screens should be operational for mount/dome/mirrors(?)

- RLS system with fault reporting

- EAS

19   IM$_K$ [k]: LSSTCam Image Capture and Archive (2022-XX-YY)

Executive Summary:

Run LSSTCam from the scriptQueue, with automated generation and certification of LSSTCam calibrations

Maps to (SUMMIT-3072 LSSTCam Electro-Optical Tests 1)

19.1   Goals of IM

- Taking complete set of LSSTCam calibration data using the scriptQueue

- Reduce the data using OCPS:

  - generating a set of LSSTCam master calibrations **Somewhat maps to (SUMMIT-2944 LSSTCam DAQ+DMS Connectivity Verification)**

  - characterizing the detectors (noise, gain, tearing)

19.2   Prerequisites

- IM$_b$

- Remote OCPS, if necessary

20 IM$_L$ [cbp]: Exercise the CBP (2022-XX-YY)

Executive Summary:

Run the CBP from nublado and the scriptQueue, using ComCam as an imager

N.b.: may need to split this IM

20.1 Goals of IM

- Demonstrate the use of the CBP, including tweaking using the async OCPS

20.2 Prerequisites

- IM$_b$

21 IM~pre-M~ [pm]: Compute Zernikes for AuxTel (2021-10-01)

Executive Summary: Use the butler to retrieve raw auxTel out-of-focus data, and generate Zernikes using the Rubin MT code

21.1 Goals of IM

Demonstrate:

- Retrieve AuxTel data from butler, process through ISR, object detection, etc.

- Generation of Zernikes from real auxTel doughnuts (intra/extra or one sided)

21.2 Prerequisites

- IM~pre-G~

21.3 Procedure

- proc A

- proc Z

22   IM$_M$ [m]: AOS (Zernikes + control) for AuxTel (2021-11-01)

Executive Summary: Use Rubin MT wavefront sensing to generate Zernikes from out-of-focus AuxTel data, and use them to control for closed-loop control of the optics

22.1   Goals of IM

Demonstrate:

- Use ScriptQueue to control AuxTel AOS

    - Take data, process through ISR, object detection, etc.
    - Generation of Zernikes from real auxTel doughnuts (intra/extra or one sided)
    - Update optics

22.2   Prerequisites

- IM$_{pre-M}$

22.3   Procedure

- proc A
- proc Z

23 IM$_N$ [n]: "DRP" Imaging Campaign with AuxTel (2022-01-01)

Executive Summary:

Carry out an imaging campaign using the auxTel, reducing the data in Chile, and carrying out suitable validation on the Mountain

23.1 Goals of IM

Demonstrate:

- Running auxTel using the scheduler

- Generating near-realtime feedback to the observers, using OCPS and FAFF-defined displays

- Reducing data on commissioning cluster to at least full single-frame processing, and probably coadds.

- Generating templates for IM$_O$.

23.2 Prerequisites

- The commissioning cluster

- IM$_E$

23.3 Procedure

- proc A

- proc Z

24   IM$_O$ [o]: "AP" Imaging Campaign with AuxTel (2022-08-01)

Executive Summary: Carry out an imaging campaign using the auxTel, reducing the data using the prompt processing pipeline, and carrying out suitable validation on the Mountain

24.1   Goals of IM

Demonstrate:

- Carrying out an imaging survey using the scheduler

- Running the prompt products pipeline

Enhanced goal? Generating alerts

24.2   Prerequisites

- Prompt Processing (due 2022-06; https://jira.lsstcorp.org/browse/DM-30854

- The AP pipeline

- IM$_M$

24.3   Procedure

- Take data using the auxTel, run from a scheduler

- Carry out difference imaging using the AP, as run using the prompt processing

- Validate the quality of the data using tools from IM$_M$ and feedback from prompt processing

- Involve the Solar System team at UW in assessing the quality of the results

25 Milestone Activity backlog

25.1 Activities that need to be included in an IM

25.1.1 Have operators bring system up from power-off

25.1.2 Test software deployment (daytime) and rollback (nighttime) scenarios.

- Also create a test of setting up individual environments (custom packages/modifications),

- how to run a script that uses a modification to a function.

- How can someone else run someone's code from a previous night if they used a modified environment?

25.1.3 Alert Processing using AuxTel Imaging Data

25.1.4 Restart from power-loss on the Mountain

25.1.5 Promote any remaining CCS functionality needed by observers to OCS

25.1.6 Write data from the CCS, DMTN-143

- Including ComCam, AuxTel

25.1.7 Use PPI to transfer data from Chile

A Mapping to Milestones in P6

This list of project milestones comes from this page on confluence; the descriptions are summarised from the same page. We omit *Integrate ComCam on Hexapod-Rotator and Install on TMA*, *Technical Operations Optimization 1-3*, and *Engineering Punch-list Resolution* milestones.

A.1 on-Telescope ComCam TCS + CCS Interface & Functional Tests

- TCS functional testing of ComCam configuration (Load in guider and WFS applications, check high level functionality/operation without data acquisition)

- CCS functional testing of ComCam - configuration update, shutter testing, filter changer, temperature control, data acquisition, data display, setup of trending analysis. Most of these have to be done as a function of telescope position

Prerequisites: IM_2, IM_G

A.2 on-Telescope ComCam CCS + OCS Interface & Functional Tests

- LSE-71 verification - (filter, shutter, image acquisition commands etc)

- Observatory mode testing (e.g. calibration, daytime, nighttime ops, engineering mode)

- CCS communication with EFD and observatory clock

- OCS Sequencer testing (e.g. take flat field sequence)

Prerequisites: IM_2

A.3 on-Telescope ComCam CCS + DAQ + DMS Interface & Functional Tests

- Take image (start with a bias) and send through DMS

- Test on-summit data access portal, Commissioning Cluster data access

- Test archiving speeds, network speeds/lags, start long-term monitoring

- Test header service

- Test EFD access

- Repeat for all normal exposure types (broadband flats, monochromatic flats, darks, dome-closed "on-sky" image, CBP image

- Attempt ingestion into pipelines to verify header service/EFD access (captured in CPP activity)

- Test base-facility connection loss/recovery

- Test base-facility to NCSA connection loss/recovery

- Test grid-power loss

- A stretched goal is to exercise the interface between the DAQ and potentially both the guider and the wfs

Prerequisites: IM_2, IM_L. IM_G for stretch goal.

A.4   ComCam Electro-Optical Tests 1

- Master Bias Creation - 30 minutes of data collection ($\sim$100 images at 15s cadence)

- Gain value verification - ?do on 3 filters once? - assume half a day - flat field Photon transfer curve

- Linearity Verification - same data set as above

- Saturation Determination () - same as above - but doesn't infer when bleeding occurs

- Master Dark creation () - 10x300s, 10x30s, 10x60s,10x120s, 10x600s = 11100s = 3 hours

- Master Impure Broadband Flats () - 1 hour for 5/6 filters

- Master Impure Monochromatic Flats (4 hours per filter + 8 hours for no filter (assume 2 hours but needs to be done $\sim$ 4 times depending on separation between filter tests)

Prerequisites: IM_2.

A.5   Collimated Beam Projector Scripting Tests

- Image Quality Checks as a function of telescope Elevation to validate FEA models

- short un-guided images

- Analysis of data

- Develop automated pointing model builder

- Point Model Building - 50 iterations

- Acquire image of known star

- Centroid and offset to pixel X,Y

- Verify star position at pixel X,Y

- Move to next target

- Do touch ups over multiple nights (~1 hour per night for 5 nights)

Prerequisites: IM_L.

A.6   Initial OCS + TCS + CCS Guider Interface & Functional Tests

Initial TCS + DAQ WFS Interface Tests

- obtain in+intra+extra focal images and feed through wavefront analysis system

- generate AOS offsets, correlate with observing conditions (e.g. atl/az, temp, hum)

- update look up tables, re-check

- verify offsets are being propogated properly (purposely deform and measure effect)

- attempt stress the system over wide range of conditions

Prerequisites: pointing model, IM_2, IM_G

A.7   ComCam Electro-Optical Tests 2

- ghosties and ghoulies

- Master Impure and Pure "Monochromatic" Flats

- Master Photoflats, Master Low-resolution narrowband Flats

- strip-chart imaging to measure slew/settle motions/times.

- Try scheduled driven observing with ComCam - digests telemetry, feeds targets, logs observations

Prerequisites: IM$_2$, IM$_G$

A.8 Build Initial AOS Look-up Table

The Look-up-table has been verified on axis during T&S AIV with the high speed camera. This test extend the verification of the lookup table to the wider ComCam field of view

- Conduct the initial alignment using the laser tracker

- Execute script driven sampling of telescope optical deformation by measuring IQ as a function of elevation (and azimuth). The use case is described in the use case document (here)

- Obtain force offsets to adjust optics for each elevation (and azimugh)

- Update/build look up table as a function of elevation (and azimuth)

Prerequisites: IM$_2$, IM$_G$

A.9 AOS Data Analysis 1

- Track IQ, wavefront and AOS telemetry over history to date (1-2 weeks)

- update look up tables expanding to environmental conditions (temp, hum, wind) This is done in parallel with the task above

Prerequisites: IM$_2$

A.10 ComCam Electro-Optical Tests 3

- Combined testing of on-sky data with AT and ComCam - with supporting telemetry (all-sky cameras, dimm, PWV etc)

- Try scheduled driven observing with ComCam (excercising level 2)

- Comparison of star flat to CBP flat, ghost characterization investigation, filter QA system setup/measurement

Prerequisites: IM$_2$, IM$_G$, IM$_L$

A.11 Initial AOS Performance Verification

- track IQ, wavefront and AOS telemetry over history to date ($\sim$1 month)

- update look up tables

Prerequisites: IM$_2$

B References

C Glossary

AOS Active Optics System.

CBP Collimated Beam Projector.

CCS Camera Control System.

cp_pipe The DM package used to generate calibrations products (*e.g.* master biases).

CSC Commandable SAL Component.

DBB Buffer manager OODS-aware transfer of data from Chile to the USDF.

DM Data Management.

EFD Engineering and Facility Database.

IM Integration Milestone.

ISR Instrument Signal Removal.

LHN Long Haul Network.

LOVE LSST Operations Visualization Environment.

MT Main Telescope.

MTAOS Main Telescope Active Optics System.

OCPS OCS Controlled Processing System.

OODS Observatory Operations Data Service.

OR Operation Rehearsal.

ORR Operations Readiness Review.

RLS Rubin Observatory Logging (may be equivalent to OWL).

RSP Rubin Science Platform.

SAL Service Abstraction Layer.

scriptQueue The observatory facility for running sequences of commands and interact with OCPS.