Vera C. Rubin Observatory
Systems Engineering

An Interim Report on the ComCam On-Sky Campaign

Many authors

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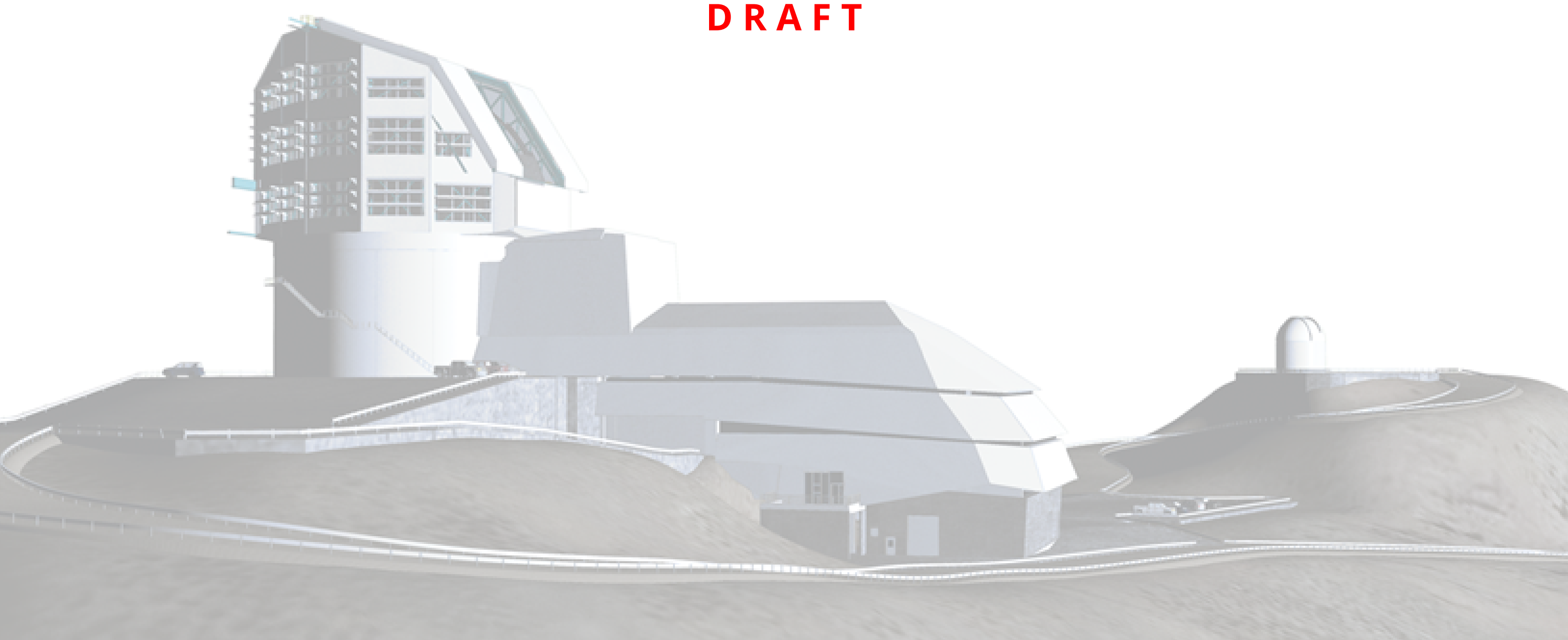

Abstract

A summary of what we have learned from the initial period of ComCam observing

Change Record

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1	YYYY-MM-DD	Unreleased.	Robert Lupton

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An Interim Report on the ComCam On-Sky Campaign

1 Introduction

The Vera C. Rubin Observatory on-sky commissioning campaign using the Commissioning Camera (ComCam) began on 24 October 2024 and is forecasted to continue through mid-December 2024. This interim report provides a concise summary of our understanding of the integrated system performance based tests and analyses conducted during the first weeks of the ComCam on-sky campaign. The emphasis is distilling and communicating what we have learned about the system. The report is organized into sections to describe major activities during the campaign, as well as multiple aspects of the demonstrated system and science performance.

Warning: Preliminary Results

All of the results presented here are to be understood as work in progress using engineering data. It is expected at this stage, in the middle of on-sky commissioning, that much of the discussion will concern open questions, issues, and anomalies that are actively being worked by the team. Additional documentation will be provided as our understanding of the demonstrated performance of the as-built system progresses.

1.1 Charge

We identify the following high-level goals for the interim report:

- **Rehearse workflows for collaboratively developing documentation** to describe our current understanding of the integrated system performance, e.g., to support the development of planned Construction Papers and release documentation to support the Early Science Program [RTN-011]. This report represents an opportunity to collectively exercise the practical aspects of developing documentation in compliance with the policies and guidelines for information sharing during commissioning [SITCOMTN-076].
- **Synthesize the new knowledge** gained from the ComCam on-sky commissioning cam-

paign to inform the optimization of activities between the conclusion of the ComCam campaign and the start of the on-sky campaign with the LSST Camera (LSSTCam).

- **Inform the Rubin Science Community** on the progress of the on-sky commissioning campaign using ComCam.

Other planned systems engineering activities will specifically address system-level verification ([LSE-29] and [LSE-30]) using tests and analysis from the ComCam campaign. While the analyses in this report will likely overlap with the generation of verification artifacts for systems engineering, and system-level requirement specifications will serve as key performance benchmarks for interpreting the progress to date, formal acceptance testing is not an explicit goal of this report.

The groups within the Rubin Observatory project working on each of the activities and performance analyses are charged with contributing to the relevant sections of the report. The anticipated level of detail for the sections ranges from a paragraph up to a page or two of text, depending on the current state of understanding, with **quantitative performance** expressed as summary statistics, tables, and/or figures. The objective for this document is to **summarize the state of knowledge of the system**, rather than how we got there or "lessons learned". The sections refer to additional supporting documentation, e.g., analysis notebooks, other technotes with further detail, as needed. Given the timelines for commissioning various aspects of the system, it is natural that some sections will have more detail than others.

The anticipated milestones for developing this interim report are as follows:

- 18 Nov 2024: Define charge
- 4 Dec 2024: First drafts of report sections made available for internal review
- 11 Dec 2024: Revised drafts of report sections made available for internal review; editing for consistency and coherency throughout the report
- 18 Dec 2024: Initial version of report is released

Warning: On-sky Pixel Image Embargo

All pixel images and representations of pixel images of any size field of view, including individual visit images, coadd images, and difference images based on ComCam commissioning on-sky observations must be kept internal to the Rubin Observatory Project team, and in particular, cannot be included in this report. Embargoed pixel images can only be referenced as authenticated links. See [SITCOMTN-076] for details.

2 System Performance Analysis

3 Active Optics System Commissioning

4 Image Quality

5 Data Production

6 Calibration Data

7 Science Pipelines Commissioning Observations

8 Throughput for Focused Light

9 Delivered Image Quality and PSF

10 Istrument Signature Removal

11 Low Surface Brightness

12 Astrometric Calibration

13 Photometric Calibration

14 Survey Performance

Understanding and predicting survey performance includes modeling the likely input telemetry, the expected performance of the telescope and observatory, as well as understanding the survey strategy and its interaction with science outcomes.

At this point in commissioning, the operations of the observatory are focused on obtaining specific observations, with very different strategies than will be employed during operations. This includes very different configurations of the Feature Based Scheduler. Thus, we are not testing the Feature Based Scheduler as it would be used in operations yet, and have no comment about issues that may be related specifically to survey strategy implementation.

We can however begin to evaluate how our models may be validated or not by the currently acquired observations. We focus on the observations acquired for the science program, BLOCK-320.

First, clearly bad visits (where stars were clearly trailed in the images, as visible in rubintv) were removed from the set of science visits. Two additional visits had zeropoints which were clearly outliers compared to expected values (more than 1 magnitude away) are were associated with messages in the logs indicating hexapod issues. These visits were also removed. This left 235 ”good” science visits between 2024-11-14 to 2024-11-21.

The throughput curves available in ‘syseng_throughputs‘, the repository that tracks current system engineering summaries of full-focal-plane throughputs, can be used to predict zeropoints for average ITL CCDs. See `https://github.com/lsst-pst/syseng_throughputs/blob/main/notebooks/InterpolateZeropoint.ipynb`, where a simple interpolation function for filter and airmass is defined for the current throughputs (v1.9). The returned zeropoint includes the exposure time, as zeropoints in DM pipelines outputs are for a given exposure with the given exposure time (they are not 1-second zeropoints). A comparison of these predicted zeropoints to the reported median visit zeropoints in the ConsDB (the column ‘cdb_lsstcomcam.visit1_quicklook.z is shown in Figure 1. The mean of these zeropoint variations averages 0.13 magnitudes across all bands, being slightly smaller in r (0.09 mag) and slightly larger in y band (0.18); the RMS scatter in these measurements is < 0.02 magnitudes.

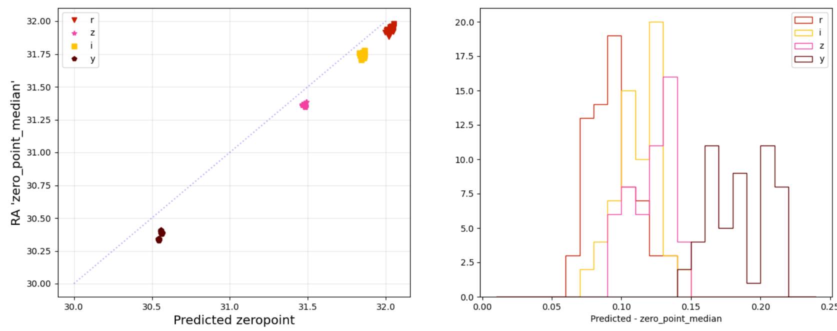

FIGURE 1: Predicted zeropoints from syseng_throughputs (accounting for airmass) compared to measured zeropoints from 'cdb_lsst.comcam.visits1_quicklook'.

Likewise, the survey simulations use a skybackground model as part of the model to determine five sigma visit depths and to choose observation pointings. The outputs available in the ConsDb include a 'sky_bg_median' value, which is in counts per pixel. Together with an estimate of the platescale (0.2"/pixel) and a zeropoint, we can convert this into magnitudes per square arcsecond, to compare to the predicted values from the rubin_scheduler skybrightness model. The results are shown in Figure 2. The values are also remarkably consistent, with a scatter of less than 0.15 magnitudes in all bands, and offsets within 0.1 magnitude except in y band, where the measured sky is 0.5 magnitudes brighter than expected. This is within our expected errors in the skybackground model, particularly in y band where the sky is quite variable and harder to model.

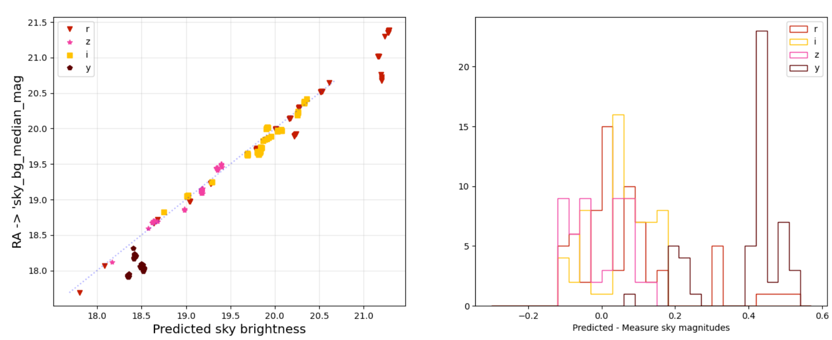

FIGURE 2: Predicted skybrightness values from 'rubin_sim.skybrightness' compared to 'sky_bg_median' converted to mags per sq arcsecond from from 'cdb_lsst.comcam.visits1_quicklook'.

We look forward to comparing seeing performance to survey predictions. Initial estimates indicate that the mean seeing for these visits was around 1.12 arcseconds, which isn't out of line with longer term survey expectations, especially given that we remain in the early stages of commissioning.

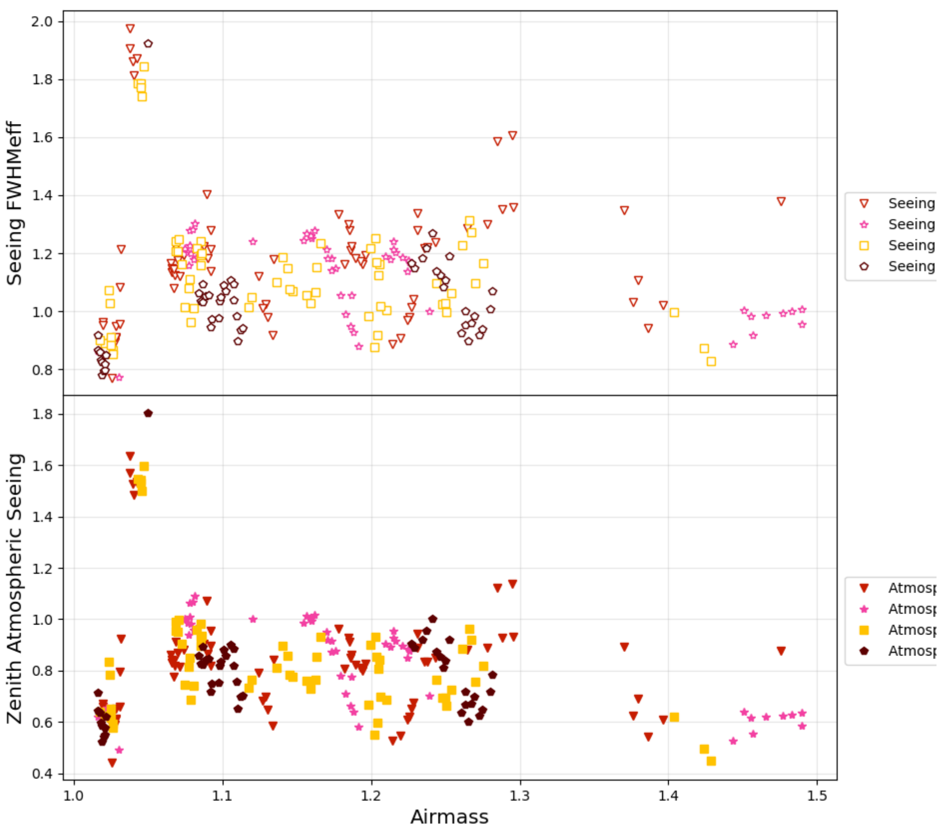

FIGURE 3: Predicted skybrightness values from 'rubin_sim.skybrightness' compared to 'sky_bg_median' converted to mags per sq arcsecond from from 'cdb_lsst.comcam.visits1_quicklook'.

Remaining questions include the efficiency of observations, and in particular the likelihood of whether a single snap will be sufficient.

15 Sample Production

16 Difference Image Analysis: Transience and Variable Objects

17 Difference Image Analysis: Solar System Objects

18 Galaxy Photometry

19 Weak Lensing Shear

20 Crowded Stellar Fields

21 Image Inspection

A References

[SITCOMTN-076], Bechtol, K., on behalf of the Rubin Observatory Project Science Team, S.R., 2024, Information Sharing during Commissioning, URL `https://sitcomtn-076.lsst.io/`, Vera C. Rubin Observatory Commissioning Technical Note SITCOMTN-076

[LSE-29], Claver, C.F., The LSST Systems Engineering Integrated Project Team, 2017, LSST System Requirements (LSR), URL `https://ls.st/LSE-29`, Vera C. Rubin Observatory LSE-29

[LSE-30], Claver, C.F., The LSST Systems Engineering Integrated Project Team, 2018, Observatory System Specifications (OSS), URL `https://ls.st/LSE-30`, Vera C. Rubin Observatory LSE-30

[RTN-011], Guy, L.P., Bechtol, K., Bellm, E., et al., 2024, Rubin Observatory Plans for an Early Science Program, URL `https://rtn-011.lsst.io/`, Vera C. Rubin Observatory Technical Note RTN-011

B Acronyms

Acronym	Description
ComCam	The commissioning camera is a single-raft, 9-CCD camera that will be installed in LSST during commissioning, before the final camera is ready.
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
PSF	Point Spread Function
RTN	Rubin Technical Note
SE	System Engineering