Large Synoptic Survey Telescope

MEMORANDUM

FROM: C. CLAVER, M. FISHER-LEVINE, L. GUY, R. LUPTON, W. O'MULLANE, S. RITZ, A. ROODMAN, C.W. STUBBS, J.D. SWINBANK

SUBJECT: DM-CAMERA-SE INFORMATION EXCHANGE SUMMARY AND POINTERS

DATE: 21 SEPTEMBER 2018, V1 INCLUDING ADDITIONAL DM INPUTS

9 AUGUST 2018, V0.1 DRAFT UNDER CONSTRUCTION NOT YET FOR CIRCULATION

The purpose of this memo is to summarize the information flow among Camera, Data Management (DM), and LSST System Engineering (SE). Most of the details are already contained in the following primary documents:

- LDM-151 Data Management Science Pipelines Design. Specifically, Section 4 of that document summarizes the inputs and outputs of the calibration pipeline, including Camera deliverables.
- LCA-283 Camera Verification Test Plan, which summarizes the methods by which each Camera requirement and interface is verified by Camera I&T.
- LSE-130 Support-Data Exchanges Between Data Management and Camera. This was primarily an input to LCA-283.

It has become clear there is value in having a brief overview of how the pieces connect, as well as highlighting the main areas that still need more attention. Specifically, as LDM-151 was developed after LSE-130, **it is useful to map explicitly the needs in LDM-151 to the plans in LCA-283**. Furthermore, not all of the calibration pipeline input quantities can be remeasured and monitored after full LSST integration, so it is particularly important to ensure that information is delivered with the Camera to the needed precision. This also includes instrument signatures and effects that must be taken into account by DM. As we are starting to characterize science rafts in more detail, now is a good time for this memo to be established and updated as needed.

The connections between LDM-151 and LCA-283 are shown in the table below, along with comments and update timeframes.

Although the responsibilities must remain clear, we do not wish to function as separate organizations that pass information over walls. DM and SE personnel are invited to the regular Camera Technical Meetings (https://confluence.slac.stanford.edu/x/GJ3hBw) and Camera Verification Test Meetings. Raft performance characteristics are also discussed at the DESC Sensor Anomaly Working Group (SAWG) meetings, involving many of the same Camera and DM personnel. Note that all Camera component and integrated test data and assembly histories are captured in the Camera eTraveler, which is continuously available.

When formats are defined by DM, the Camera will either update or work together with DM on conversion tools. The simplest example is the throughput-related information, which is tracked by LSST Systems Engineering at https://github.com/lsst-pst/syseng_throughputs . When the Camera team

has an update to the current best estimate of a quantity, the Camera Project Scientist updates via a branch and pull request. The format is set by request of LSST SE, but it can be easily updated.

Analysis software integration is an ongoing challenge, due to parallel development and tight construction schedules. ComCam will be the primary pathfinder, but the date by which the full Camera is tested using only the DM stack and DM algorithms remains to be established. A roadmap for the implementation could be added to this memo. There are also discussions about how DM can best ingest eTraveler information.

ITEM	LDM-151	LCA-283	Comment	Timeframes
Gain	Section 4.2.2	11.1.2.2, 11.1.2.3, 11.6.1 **OK**	LDM-151 section 4.3.5: DM algorithm under development. Opportunity to test in Camera I&T? LDM-151 states 0.1% accuracy, but does not state the stability time. See Camera requirement 394 and 395.	Now, updated through testing.
Non-linearity	4.2.3 Accuracy not specified.	11.1.2.2	Form of correction not yet specified.	Now, updated throughout testing.
Crosstalk	Section 4.2.5	11.1.2.5 **OK**	First raft measurements reported in Camera verification meeting. Sensor-sensor <~10^{-6}.	Raft-raft xtalk first measured in early 2019. Expect it to be essentially zero.
Saturation	Section 4.2.7. Needs further definition,	11.1.2.2	**Needs further definition.**	
Filter transmission	Section 4.2.11 1nm steps or better across filter. Missing specification of transmission accuracy.	15.3 and LCA-11807. Also see CTM presentations and LCA-13387, LCA-11751. **OK**	Delivered by vendor from full-optic direct measurements. See Filter Spectral Metrology Test Plan: 1nm steps, 0.5% accuracy in 193 locations. LSST also checks witness samples.	Subscale samples done. First filter coating is r band in late CY2018.
BBAR coatings	**Not shown as a Camera deliverable.**	15.3 **OK**	Delivered by vendor for each lens.	L2 available July 2018, added to SE github throughput. Some ripple in final L2 coating. L1 and L3 should be complete by January 2019.
Sensor QE	**Not shown as a Camera deliverable.**	14.2, also measured in raft acceptance at SLAC. **OK**	Sensor-to-sensor variations around 5%-10% at blue end, and variations across the sensor at a wide range of spatial scales.	LSST single-sensor data and raft acceptance testing at SLAC.
Pixel sizes	4.3.14 Multiple effects, each needs its own definition. Edge distortions Tree rings	11.1.2.4	Separate static and dynamic effects. Tree rings seen to be well below 1%, delivery format TBD. **Needs another look.**	
Brighter-fatter	4.3.15 TBD. **Not shown as a Camera deliverable**	**Not in I&T plan**	Some work done on physical model using bench test data. Require correction to better than 10%. Test on rafts.	
Fringe corrections	**Not shown as a Camera deliverable**	**Not in I&T plan**		
Bad pixel map	4.2.6	11.1.2.6 **OK**	Camera delivers a set of flags for each category, so "bad" can be defined based on use. **Flag definition TBD?**	
Shutter profile	**Not shown as a Camera deliverable**	11.7.2	**Needs another look.**	

Additional instrument signatures and idiosyncrasies not explicitly listed above, but should be included:

1. "Tearing" and "dipoles" should never be present in the data with the correct, optimized readout configuration. A tearing detection algorithm has been developed and is being integrated into the standard Camera test analysis for routine monitoring, but need to merge with DM.

2. Shallow traps in e2V sensors. ^{55}Fe plus a set of low-level flats to confirm interpretation and levels. Confirm done for all rafts.

3. True parallel and serial CTI. Requirement is $<5 \times 10^{-6}$.

4. Deferred voltage (long time constant) in some ITL sensors and bias measurements. Reconfirming and monitoring stability. Discussing signature removal algorithm to test with upcoming rafts with affected sensors.

5. Full well violations. Optimization ongoing. Impact to cross-talk correction.

6. Optics flaws captured in NCRs and in SE integrated modeling.

7. Filter transmitted internally reflected light. SE integrated modeling study underway. Timeframe: Fall 2018 (TBC).

8. ADC code apparent correlations and bin width structure. These are seen to be small, but non-zero.

9. Noise correlations, particularly for ITL high-bias sensors.

Also see https://confluence.lsstcorp.org/display/SYSENG/Instrument+Signature+Removal+Listing and links therein.

Note that some physical models (*e.g.*, for brighter-fatter) have been derived in lab measurements of individual sensors. These must be checked on full-raft data.