MEMORANDUM

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SUBJECT: ACCEPTANCE OF A LIMITED NUMBER OF ITL SENSORS THAT EXHIBIT CONSTRAINED VIOLATIONS OF SPECIFIC SENSOR-LEVEL REQUIREMENTS: SUMMARY OF SCIENCE PERFORMANCE IMPACTS

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Based on current production projections, it will become necessary to incorporate into Camera science rafts some sensors that do not meet all sensor-level requirements. Of the requirements in LCA-128, the following[1] are relevant: read noise (<9e system-level), charge transfer efficiency (CTE, >1-5x10^{-6}), and defects (<0.5% on a sensor, <2% dead/bad pixels full Camera, see LCA-10074 for a summary). We summarize here the impacts of drawing as needed from the populations of science-grade sensors that have identified high bias (correlated with degraded performance) and science-reserve sensors that have, until now, been set aside in production.

We used the currently known characteristics of these populations, along with selection prioritization criteria discussed with the Project Science Team, to estimate the impacts on science performance. Two categories of impacts were considered: those related to the Science Requirements Document (SRD) and the Key Performance Parameters (KPPs, both Objective and Threshold). Operational mitigations are discussed for each impact. **The conclusion is that use of these sensors is acceptable.** Performance of every science raft will be monitored closely, as always, with all non-conformances documented with the required signatures.

SRD

1. Noise. Elevated read noise in a subset of sensors affects performance against SRD Table 6, median single-visit depth. The LSST end-to-end system limiting magnitude calculation repository, with up-to-date throughput estimates, was used to study the potential impacts. With a simple model of the projected performance (50% of the focal plane having 7e rms read noise, 25% with 9e, 20% with 13e, and 5% with 18e), the current best estimate of the single-visit median[2] depth (2x15s exposures/visit) for (u, g, r, i, z, y) is (23.8, 24.8, 24.4, 23.9, 23.3, 22.4) compared with the SRD Table 6 minimum (23.4, 24.6, 24.3, 23.6, 22.9, 21.7). **Thus, we project that LSST will still meet the SRD Table 6 minimum requirement**.

   SRD Table 7 displays the requirements on variation of the image depth over the field of view, with the minimum requirement of <20% of the focal plane having limiting-magnitude depth

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[1] The full-well requirement is also violated modestly in many of these sensors, but workarounds exist such that science performance will not be significantly compromised.

[2] Calculated in two ways: we used 9e as the median noise to calculate the limiting magnitudes for each band; then, to check the impacts of the high-noise tail, we computed the mean limiting flux sensitivity in each band. The differences between the medians and means were 0.02 magnitudes or less.

>0.4 mag brighter than the median. Relative to 9e rms noise, the u-band (worst case) limiting magnitude is brighter by 0.29 mag for 13e noise (20% of the focal plane) and 0.59 mag for 18e noise (5% of the focal plane). **Thus, we project that LSST will still meet the SRD Table 7 minimum requirement.**

SRD Table 23, the sum of the median number of visits in each band (750 minimum requirement, 825 design), is also relevant here. The variation in u-band sensitivity due to the tail of the noise distribution can be mitigated by redistributing observing time. Indeed, given the distribution of throughput margin[3] and read noise across the six bands, it has always been the plan to optimize exposure times during LSST commissioning. The resulting projected performance change is equivalent to a loss of observing time of 3%, which is small compared with expected weather variation impacts on observing time. The most recent observation simulations[4] estimate 888 visits over 18,000 square degrees in the ten-year survey, so **LSST will still meet the SRD Table 23 requirement**.

Finally, these noise-related estimates assume two readouts per visit. If, instead, a single exposure per visit is assumed, the projected performance would be an effective gain of observing time of 7%, and probably more due to the reduction in noise by the longer read time enabled by 1x30sec visits.

2. CTE. This relatively stringent requirement was self-imposed by the Camera for several reasons[5], and the value does not flow directly from the science requirements. For the affected subpopulation of sensors, even with an uncorrected effective charge transfer inefficiency of 50×10^{-6}, the raw delivered PSF ellipticity would be an order of magnitude better than the requirement (SRD Table 13); however, meeting the full-depth survey requirement (SRD Table 27) relies on DM correcting the effects to a precision of about 10%, requiring sufficiently accurate characterization. Note that this is similar to other known effects that are of this size or larger. There are also operational mitigations, such as angle dithering, that will be explored during commissioning.

3. Defects. We do not project the Camera violating its 2% bad pixel requirement under any circumstances.

KPPs

The relevant Key Performance Parameters (KPPs) are readout time (2s objective, 3s threshold) and read noise (9e objective, 13e threshold). A related threshold KPP is >2.6 gigapixels that meet all the other KPPs. Even with the pessimistic distribution of read noise considered here, we do not project the threshold KPPs to be violated. The performance against the objective KPPs depends on the various operational trades that can only be done once the full Camera is assembled. For example, a longer readout time may significantly reduce the read noise.

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[3] We note all sensors outperform their quantum efficiency requirements across all bands, providing additional throughput margin against the Camera requirements.
[4] http://opsim.lsst.org:8080/allMetricResults?runId=7
[5] The CTE test can identify a variety of potential problems, such as deferred charge (*e.g.*, due to traps) or anomalously large time constants.