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# Large Synoptic Survey Telescope (LSST)

Scope Options

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# LSST Scope Options

# Acronyms and Definitions of Terms

* Glossary of Abbreviations ([Document-11921](https://docushare.lsstcorp.org/docushare/dsweb/Get/Document-11921/Glossary%20of%20Definitions.docx))
* Glossary of Definitions ([Document-14412](https://docushare.lsstcorp.org/docushare/dsweb/Get/Document-14412/Glossary%20of%20Definitions.docx))

# Referenced Documents

* Cost Baseline: <https://project.lsst.org/costbaseline/>
* Cost Estimating Plan (LPM-81)
* Contingency Management Plan (LPM-61)
* LSST System Requirements (LSE-29)
* Observatory System Specifications (LSE-30)
* Project Execution Plan (LPM-54)
* Risk & Opportunity Management Plan (LPM-20)
* Science Requirements Document (LPM-17)
* Scope Option Registry (Document-17914)

# LSST Scope Options

# Introduction

The LSST project plan includes contingency reserves for budget, schedule and scope. This document presents the LSST scope options for the NSF MREFC portion of the Project. The goal of the document is to identify and prioritize a compliment of options to the project scope that can be implemented if the LSST project is faced with a substantial shortfall of funding or schedule. The scope plan provides a list of reductions that equal a minimum of 10% of the remaining planned budget. The document also includes a summary of scope opportunities. All scope options will be evaluated for cost, schedule and performance impact. The guiding rationale for proposed scope reductions is to minimize the impact of reductions to the LSST system requirements, to minimize the impact to the science performance, and also to avoid non-recoverable reductions in scope. All increased scope opportunities are still consistent with the approved LSST scope, objectives, and performance. These opportunities primarily address the technical approach to the LSST MREFC development and the performance goals provided in the LSST Science Requirements Document (LPM-17). All options are identified with trigger dates to support the management of the scope item. Any consideration of a scope change implementation would be made only with the approval of the NSF per the CSA requirements.

The project scope options are defined and maintained in a separate spreadsheet and summarized in this document. This document and all scope options are reviewed in a yearly update cycle to remain current and consistent with the ongoing activities of the program.

The use of contingency is managed by the LSST Project Manager in conjunction with the Change Control Board, LSST Director, and the funding agencies. The processes and approval thresholds for each type of contingency allocation are described in the LSST Contingency Management Plan (LPM-61).

# Review of Budget and Schedule Contingency

The LSST Project Office (LSSTPO) has completed an analysis of the cost and schedule contingency using the process and applicable terms and conditions described in the LSST Contingency Management Plan (LPM-61). As described there, this process uses the Baseline Plan and combines it with Technical, Cost, and Schedule uncertainty factors and multipliers along with specific items in the LSST Risk Register to run a Monte Carlo simulation on the plan in order to determine a statistical distribution of the likely cost and schedule duration of the project. The established cost and schedule contingency values were developed and approved under the basis that the project also have scope options identified that value at least 10% of the remaining cost to complete the project.

# Scope Contingency

This section summarizes options for overall scientific and technical scope of the LSST observatory. These reductions in scope (de-scope) would be made if the LSST project is faced with substantial shortfall from the allocation of planned funding, or if total project costs exceed the ability of the project to deal with unexpected costs and schedule delays using budget and schedule contingency. Reductions in scope would be made only with the approval of the NSF. The scope increase opportunities would be implemented if total project funding is healthy and the opportunity advantage is both a) within the overall approved program scope and b) is evaluated as a positive net benefit to the program.

The system requirements for LSST that provide a framework for analysis of reductions in scientific scope are specified in the Science Requirements Document (LPM-17), the LSST System Requirements (LSE-29) and the Observatory System Specifications (LSE-30). These documents identify minimum and stretch requirements between which the baseline design requirements are derived and scope options can be considered.

The details for each scope option are captured in Document-17914, the scope option registry. In the options registry, the scientific, technical, cost and schedule impacts are identified and the trigger dates and status are maintained.

## Scope Reduction Summary

The guiding rationale for identified scope reductions is to minimize the impact of reductions to the LSST system requirements, to minimize the impact to the science performance, and also to avoid reductions to the program plan that are not recoverable. The scope for the construction of the LSST can be reduced in two fundamentally different ways: (1) reductions in the scientific or educational scope or (2) reductions in engineering implementation.

The primary type of scope reduction is a change in the scientific reach of the project. If large cuts to the construction budget are realized, this is the most likely pathway. Such scope reductions reduce the quantity and quality of data products that can be developed by the LSST survey.

Another pathway is to make adjustments to the engineering implementation that supports the project scientific scope. Engineering changes may a) affect data product quality, e.g. a reduction in resolution, precision, or availability; b) reduce construction costs by causing higher costs in operations, e.g. building cheaper infrastructure that will require more frequent or more costly maintenance; c) result in less efficient and more costly operations cost, e.g. spares/backups not embedded within system, which requires additional downtime if these instances occur; or d) increase the risk to the successful on-time and on-budget execution of the baseline plan.

The following tables identify the scope reduction options. The exact order in which they may be executed will depend on the necessary level of financial reduction and the timing of the change. The list is current at the time each version of this document is published but will be reviewed when de-scoping is necessary and prior to recommending any scope changes. Any changes in scope are pursued within the authority levels and approval structure outlined in the Project Execution Plan (LPM-54).

The project has identified 41 scope reduction items with a 2019/07/01 financial value of roughly $30M. This is more than the target 10% of the cost to complete (~$134.5M) the baseline plan but suggests an array of different options that could be considered with various impacts.

| ID | | Title | | 2019-07-01 (k) | |
| --- | --- | --- | --- | --- | --- |
| CO1 | | Eliminate Early System AI&T with ComCam | | 5000 | |
| CO5 | | Eliminate Both Science Validation Surveys | | 4300 | |
| DM6 | | Remove MultiFit Hardware and Test Processing in DR1 and DR2 | | 2800 | |
| CO3 | | Reduce extended observing and Science Pipeline Testing with ComCam | | 2700 | |
| CO4 | | Reduce Extended Observing and Science Pipeline Testing with LSSTCam | | 2100 | |
| CO6 | | Eliminate SV Survey for Alert Production | | 1600 | |
| CO7 | | Eliminate SV Survey for Date Release Processing | | 1600 | |
| DM18 | | Delete Data Backbone and Data Access Center in Chile: serve data from NCSA only. Only have commissioning cluster and other smaller systems required at Base Data Center for staff | | 1500 | |
| SY2 | | Reduce System Process and Storage to SRD Minimum Specifications | | 1200 | |
| DM16 | | Relax the Prompt Processing Ingest Service latency to several minutes | | 1000 | |
| DM17 | | Provide only notebook aspect and portal aspect of LSP at Chile: serve data from the Data Facility only | | 1000 | |
| CO8 | | Eliminate Calibration AI&T | | 1000 | |
| EP1 | | classroom loaner tablet sets | | 566 | |
| DM15 | | Reduce Prompt Processing Ingest Service availability and reliability | | 500 | |
| DM13 | | Store only frequently accessed data in the Chilean DAC; size DAC strictly according to MOU. | | 360 | |
| DM14 | | Don't provide notebook templates and other advanced usability aids | | 360 | |
| DM12 | | Relax MOPS Completeness Requirements | | 298 | |
| TS12 | | OCS gui interface | | 250 | |
| SY5 | | Reduce System Verification Close Out Documentation | | 210 | |
| TS11 | | Eliminate M3 Interferometer Testing | | 180 | |
| TS13 | | Operations from Summit Only | | 150 | |
| DM7 | | Defer MultiFit Software Development | | 142 | |
| SY6 | | Eliminate System-Level FMECA scope | | 136 | |
| DM4 | | Reduce Data Release Hardware by 10% (DR 1) | | 123 | |
| TS6 | | Reduce Summit Lodging Expansion | | 120 | |
| DM9 | | Do not observe/process crowded stellar fields at all. | | 114 | |
| EP4 | | Solar System 3D model | | 80 | |
| DM11 | | Relax Alert Completeness or Purity Requirements | | 76 | |
| EP7 | | De-scope citizen science as an EPO deliverable | | 72 | |
| TS20 | | AT Primary mirror recoating | | 67 | |
| TS19 | | GPS | | 52 | |
| TS14 | | Reduce Environmental Awareness System's "Awareness" | | 50 | |
| DM10 | | Eliminate the Portal Aspect of the Science Platform | | 40 | |
| TS18 | | Guider | | 23 | |
| DM1 | | Eliminate Real-Time Data Products | | 18 | |
| EP5 | | 3D tour of the LSST facility | | 15 | |
| SY4 | | Eliminate Component Spares | | 10 | |
| DM3 | | Eliminate or Defer Forced Source Catalog | | 2 | |
| DM2 | | Eliminate Support for non project staff and User-Generated Data Products | | 1 | |
| TS2 | | Reduced Base Facility Functionality | | 0.06 | |
| TS10 | | Eliminate ComCam | | 0.01 | |
|  | |  | | **29814** | |

Table 1 Descope options value 1 July 2019

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| --- | --- |
| **Descope Options** | |
| **SY2** |  |
| Description | Reduce System Process and Storage to SRD Minimum Specifications |
| Value Potential ($k) | 1200 |
| Profile | Flat |
| Early date | 2020-01-01 |
| Latest date | 2020-10-01 |
| Status | Available |
| Scientific Impact | The full science impact is dependent on how the data volume is reduced or what data is in the 10% left unprocessed. A reduction of visits per unit area to the SRD minimum spec would result in a depth reduction of ~0.1 magnitudes in the final stack, assuming the main survey area is preserved. However, the decreased number of visits has a larger impact on weak lens systematics reduction and some types of transient object detection and monitoring depends on a higher power of the number of visits. The temporal impact is un-recoverable but the number of visits can be restored through another year of survey operation. |
| Technical Impact | This descope is the reduction of the data management capacity to process and store data coming off the telescope. The reduction of data volume is the result of either fewer images, fewer sensors or, dropped data. The visits per unit area of sky design point is 825 (SRD design spec) and the minimum is 750 (SRD minimum spec.) Reducing the number of visits to the minimum spec reduces the data volume. The data volume may be reduced by eliminating 20 sensors from the focal plane array or, if there are no changes to the focal plane or cadence, 10% of the data coming off the telescope is not stored or processed.   This descope is a 10% reduction in the DM hardware to process and store data. Less equipment will be purchased and setup to provide the savings. To preserve full recovery, the network bandwidth is maintained. |
| Budget Impact | The Data Management Subsystem would reduce its data volume sizing by ~10%, both in single image size and in the total number of epochs processed (affecting the size of the database). Analysis from the DM sizing model shows that this descope would result in a cost reduction of ~$1.2M in the construction phase of the project. |
| Schedule Interactions | The Data Management Procurement strategy purchases hardware as late as possible therefore this descope can be realized or restored up until 6 months prior to the start of integration and test in 2019. |
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| **Descope Options** | |
| **SY4** |  |
| Description | Eliminate Component Spares |
| Value Potential ($k) | 376 |
| Profile | Taper |
| Early date | 2017-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | No immediate scientific impact, but can lead to excessive down time when repair or replacement of critical components is needed. |
| Technical Impact | This de-scope eliminates component spares from DM  Eliminating such spares increases the risk of schedule overruns during commissioning should a component suffer early life failure and will impact system up-time requirements. |
| Budget Impact | Budget impact is based on estimated sparing costs from Data Management. This amount to ~3% of purchased hardware and capitol expenses related items spared (see LSE-170).  For DM: 3% of $12.54M = $376K |
| Schedule Interactions | No Budget impact |
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| **Descope Options** | |
| **SY5** |  |
| Description | Reduce System Verification Close Out Documentation |
| Value Potential ($k) | 210 |
| Profile | Taper |
| Early date | 2020-01-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | No immediate scientific impact, but can lead to excessive down time when failures occur and root cause analysis and repairs take longer than they would otherwise due to lack of complete verification documentation. |
| Technical Impact | Increases risk of not completely understanding if requirements have been fully verified when verification of requirements spans multiple Test Cases/Verification Events. This increases the risk to Operations that unexpected or unintended behavior may emerge over time, and some of the documentation that would help with root cause(s) investigations will not be available. |
| Budget Impact | Budget impact is based on assuming the effort of System Verification Team can be reduced by 1 FTE for 1 year in the Commissioning Phase.  1 Sr. Systems Engineering, fully burdened for 1 year in FY2021 is $210,024. |
| Schedule Interactions | No impact on schedule. |
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| **Descope Options** | |
| **SY6** |  |
| Description | Eliminate System-Level FMECA scope |
| Value Potential ($k) | 207 |
| Profile | Taper |
| Early date | 2019-01-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | No immediate scientific impact, but can lead to excessive down time when failures occur and root cause analysis and repairs take longer than they would otherwise due to lack of complete Failure Modes, Effects and Causality Analysis. |
| Technical Impact | Increases risk to Operations that root cause and corrective action investigations will take much longer after a failure than they would if FMECAs have been completed. |
| Budget Impact | Budget impact is based on the assumption that 1 SE will be working on this effort half time for two years.   1 Sr. Systems Engineering, fully burdened at 1/2 time for FY2020 and 1/2 time FR2021 is $207,000 |
| Schedule Interactions | 0 |
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| **Descope Options** | |
| **DM1** |  |
| Description | Eliminate Real-Time Data Products |
| Value Potential ($k) | 25300 |
| Profile | Tapered |
| Early date | 2015-01-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | Eliminates all time-domain science dependent on real-time alerts.  Eliminates image differencing data products and software. The transient alerts would have to be generated by a third party in the vicinity of the Base Facility in La Serena, Chile, using non-LSST software.  Violates SRD requirements. |
| Technical Impact | This descope would eliminate the infrastructure for the alert production processing, distribution, and archiving. It would also reduce the Base to Archive network bandwidth requirements to roughly 5 Gbps. |
| Budget Impact | Eliminating the real-time alerts would result in a reduction of $25,300K in then-year dollars from reduced hardware and network costs ($18,300k) and labor ($7,000k). This includes labor saved by not developing those portions of the Alert Production software not also needed for Level 2 processing. |
| Schedule Interactions | While several scheduled elements and milestones would be eliminated, the project critical path would be unaffected. There would be ~2 months less integration time required during Construction/Commissioning as the Archive Center would be smaller and simpler. |
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| **Descope Options** | |
| **DM2** |  |
| Description | Eliminate Support for non project staff and User-Generated Data Products |
| Value Potential ($k) | 2240 |
| Profile | Tapered |
| Early date | 2015-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Eliminates capability to perform science analyses at LSST archive center. Eliminates support to use LSST software to build end-user science analysis tools.  Violates SRD requirements. |
| Technical Impact | The current DAC design includes extensive support for user analysis, including hosting datasets that are not of LSST origin. The current model of operation of the DAC requires long-term storage of user-created data. This option would constrain the role of the DAC such that user storage is ephemeral. This would eliminate the infrastructure required to support user generated data products at the Data Access Centers. It might also require a re-negotiation of at least the intent, if not the letter, of the AURA - Chile agreement regarding LSST, since while that agreement only calls for a copy of a portion of the data to resided in Chile, there have been communications and expectations of a Data Access Center in Chile. User DB and user file systems would be smaller along. Qserv requirements would be simplified since no joins with user tables would be required. There would be a reduction in the LSP nodes/and compute requirements |
| Budget Impact | Eliminating the user generated data product support would result in a reduction of $2240K in then-year dollars from reduced hardware ($1500K) and labor ($740K) that includes labor removed by not developing the Science Pipeline Toolkit. There are on going operations savings here as well. |
| Schedule Interactions | There would be ~2 months less integration time required during Construction/Commissioning as the DACs would be smaller and simpler. |
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| **Descope Options** | |
| **DM3** |  |
| Description | Eliminate or Defer Forced Source Catalog |
| Value Potential ($k) | 4800 |
| Profile | Tapered |
| Early date | 2015-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Eliminates ability to study low-level variability using LSST catalog data products. Scientists would not be able to analyze time-dependent behavior of faint objects. This would particularly impact time domain science for faint objects, including AGN. This science could be done with L3 resources, but at greatly reduced efficiency compared to that of the Data Release Production. |
| Technical Impact | This descope would eliminate infrastructure for performing forced source measurement and storage of the catalog. |
| Budget Impact | Eliminating the ForcedSource Catalog would result in a reduction of $4800K then-year dollars from reduced hardware and removed integration activity at the Archive. |
| Schedule Interactions | There would be ~1 month less integration time required during Construction/Commissioning as the Archive Center would be slightly smaller. |
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| **Descope Options** | |
| **DM4** |  |
| Description | Reduce Data Release Hardware by 10% (DR 1) |
| Value Potential ($k) | 650 |
| Profile | Tapered |
| Early date | 2018-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | There is a higher risk to the schedule of processing the first data release. The time required for processing the first data release will cause a 10% delay in DR1 and DR2 and a corresponding offset to subsequent releases. |
| Technical Impact | There is no engineering impact. |
| Budget Impact | This reduces the hardware and configuration costs for the initial DM hardware system put in place for the data processing for data release 1 by $650K. (LDM-144-v147, SiteRollup tab, cell M8). But at some future point this will need to purchased so at best we may be putting off to ops - at worst cause cascading delay in releases. |
| Schedule Interactions | There is no impact on the schedule of construction - the data release schedule could be impacted. This impact would roll on to at least DR2. |
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| **Descope Options** | |
| **DM6** |  |
| Description | Remove MultiFit Hardware and Test Processing in DR1 and DR2 |
| Value Potential ($k) | 2800 |
| Profile | Tapered |
| Early date | 2020-01-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | Strongly degrades systematics-limited science (e.g. weak lensing) enabled by first two LSST Data Releases. No measurements of proper motions at low SNR in DR1 and DR2. Expect reduced quality in these areas in DR3.  Does not formally violate the normative portions of the SRD, but changes the Project-Community boundary on weak lensing science (or delays the weak lensing science).  We are currently studying the possibility to do lensing science on coadds using better algorithms - this may mitigate the use of MultiFit but may not bring the processor load significantly below the original envelope for multifit. |
| Technical Impact | This would eliminate a portion of the infrastructure needed for the first 18 months of operations, as compute-intensive measurements would not be made in Data Releases 1 and 2. There is a second order risk here in the uncertainty built into the entire processing need which incorporates MultiFit. Reducing the MultiFit hardware may exacerbate any shortcoming/under sizing of the remaining DRP hardware causing an unforeseen delay in regular release. |
| Budget Impact | $2,800K reduction due to reduced infrastructure at Archive Center. |
| Schedule Interactions | 2021 / can restore if not implemented or anytime thereafter. |
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| **Descope Options** | |
| **DM7** |  |
| Description | Defer MultiFit Software Development |
| Value Potential ($k) | 500 |
| Profile | Tapered |
| Early date | 2018-01-01 |
| Latest date | 2022-10-01 |
| Status | Available |
| Scientific Impact | Strongly degrades systematics-limited science (e.g. weak lensing) until deferred work is completed. Little long-term damage to end-of-survey LSST science goals if deferred work is completed by DR4 or DR5.  Does not formally violate the normative portions of the SRD, but changes the Project-Community boundary on weak lensing science (or delays the weak lensing science).   We are currently studying the possibility to do lensing science on coadds using better algorithms - this may mitigate the use of MultiFit but may not bring the processor load significantly below the original envelope for multifit. |
| Technical Impact | This eliminates software development for significant science pipelines and middleware components from the construction plan, allowing experts in these areas to focus on other tasks in the short- or medium-term. MultiFit could be added to the existing software stack during Operations. There is a second order risk here in the uncertainty built into the entire processing need which incorporates MultiFit. Reducing the MultiFit hardware may exacerbate any shortcoming/under sizing of the remaining DRP hardware causing an unforeseen delay in regular release. |
| Budget Impact | Labor cost saving of $500k in 02C.04.  This scope option is likely to automatically trigger DM6. |
| Schedule Interactions | Science Pipeline work could be completed earlier |
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| **Descope Options** | |
| **DM9** |  |
| Description | Do not observe/process crowded stellar fields at all. |
| Value Potential ($k) | 600 |
| Profile | Tapered |
| Early date | 2018-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Galactic science (Stellar Populations and Milky Way and Local Volume Structure) would be severely impacted. It would not be possible to conduct the research described in Chapters 7.3, 7.4, 7.5 of the LSST Science Book.  Though no normative SRD requirement would be violated, the SRD states that "the full avoidance of the Galactic plane would have a severe impact on the Galactic structure studies".  Recent analysis suggests not observing crowded fields would not allow us to complete 18K degrees survey by a large extent. This would be a major violation of the SRD. |
| Technical Impact | Being able to assume the sky is uncrowded makes the algorithmic problems in image differencing and image characterization significantly easier, reducing software development costs. Integration and testing for high-level processing is also reduced, as crowded fields represent a qualitatively different testing regime even for algorithms that are not any more difficult in crowded fields. |
| Budget Impact | Saving is due to labor costs in Science Pipelines. |
| Schedule Interactions | Science Pipeline work could be completed earlier |
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| **Descope Options** | |
| **DM10** |  |
| Description | Eliminate the Portal Aspect of the Science Platform |
| Value Potential ($k) | 4000 |
| Profile | Tapered |
| Early date | 2017-01-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | Descoping the Portal aspect is preferred as JupyterLab is key to commissioning.  Would result in an extremely poor support of the broad science community, especially the less capable and casual users. Would force users to use JupyterLab aspect for all LSST data access, or perform analysis and downloads via remote analysis tools (e.g., TOPCAT). |
| Technical Impact | Reduce development effort significantly on user interface and data access. A single aspect platform i.e. only one of DAX, JupyterLab or Portal is not really possible, or if it were to be one it would have to be the Data Access Services (DAX). The portal then could be very simple layer on DAX to discover data - no MYDB, no next-to-the-data processing. |
| Budget Impact | Considerable savings if done now - less as each year passes. Significant effort has already been invested in the Science Platform. |
| Schedule Interactions | If done early not much impact on schedule. Considerable user expectation management would need to be done. |
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| **Descope Options** | |
| **DM11** |  |
| Description | Relax Alert Completeness or Purity Requirements |
| Value Potential ($k) | 400 |
| Profile | Tapered |
| Early date | 2018-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Relaxes OSS-REQ-0353. Greater numbers of false positives are allowed in the alert stream, or less completeness is tolerated. It may become more difficult to discover some classes of transients, or transient samples may be more contaminated by false detections. |
| Technical Impact | Reduced development effort would be possible on some aspects of the L1 pipeline, such as image characterization, crowded field processing, correction of Differential Chromatic Refraction, or spuriousness measures. More storage might be required to accommodate the increased number of false detections. |
| Budget Impact | Savings due to labor costs in science pipelines. |
| Schedule Interactions | Science Pipeline work could be completed earlier |
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| **Descope Options** | |
| **DM12** |  |
| Description | Relax MOPS Completeness Requirements |
| Value Potential ($k) | 400 |
| Profile | Tapered |
| Early date | 2019-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Relaxes OSS-REQ-0354. Less completeness is allowed for asteroid discoveries within the Solar System.  While it does not violate the normative aspects of the SRD, it may compromise some SRD science goals described in "Taking an Inventory of the Solar System". |
| Technical Impact | This permits less work developing and tuning MOPS algorithms. |
| Budget Impact | Savings due to labor costs in science pipelines. |
| Schedule Interactions | Science Pipeline work could be completed earlier |
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| **Descope Options** | |
| **DM13** |  |
| Description | Store only frequently accessed data in the Chilean DAC; size DAC strictly according to MOU. |
| Value Potential ($k) | 500 |
| Profile | Tapered |
| Early date | 2019-01-01 |
| Latest date | 2021-07-01 |
| Status | Available |
| Scientific Impact | Reduces the amount of resources to Chilean science but maintains consistency with the LSST MOU with Chilean scientists. |
| Technical Impact | Primarily substitutes access at NCSA for infrequently used datasets, for datasets being present at the Base DAC. Candidate datasets are estimated to include template files and less accessed relational tables, for example the reformatted EFD. Computational resources available to Chilean scientists would be reduced in size according to 10% of the US DAC standard in the MOU. |
| Budget Impact | LDM\_144 V145 indicated expense of about $1.3M, in hardware. Subject to a change control analysis, I estimate saving at $500K, +- $200K. (There an absolute pedestal for a full QSERV and the raw data) |
| Schedule Interactions | Minimal. |
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| **Descope Options** | |
| **DM14** |  |
| Description | Don't provide notebook templates and other advanced usability aids |
| Value Potential ($k) | 360 |
| Profile | Tapered |
| Early date | 2020-01-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | We currently plan to provide a tested template library of notebooks performing common LSST data analysis tasks (in order to bootstrap commissioning and general science user notebook development; and as tutorials of the capabilities of the platform) and an easy way to enable users to use them by starting from the templates and adapting them to their own use. Eliminating this work will be detrimental to the user experience, and will provide a significant barrier to JupyterLab adoption by project engineers and science users who are not fluent python programmers. |
| Technical Impact | Users may create notebooks that use L3 resources inefficiently or require increased post-facto helpdesk support |
| Budget Impact | Saving is due to labor costs in SQuaRE |
| Schedule Interactions | SQuaRE effort could be reduced before start of operations |
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| **Descope Options** | |
| **DM15** |  |
| Description | Reduce Prompt Processing Ingest Service availability and reliability |
| Value Potential ($k) | 500 |
| Profile | Flat |
| Early date | 2019-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | higher latency for raw image to NCSA and hence slower alert publication |
| Technical Impact | Data distribution environment minimized image can be sent as 1 file normally, and only send 1 copy of the file, cross talk from the camera not required and can be computed. |
| Budget Impact | Maintaining a 99.8% reliability requires failover/maintenance systems, non-interruptible environments (network, power, filesystems, transfer mechanisms...), reduce redundant provisioning; not requiring a specialized environment; isolation enclave (requires redundant environments for failover)   Reduced costs here come from reducing the requirements on these systems at NCSA and in Chile, and lowering the level of wide area network support. |
| Schedule Interactions | This is not on the critical path, and would reduce overall work required. |
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| **Descope Options** | |
| **DM16** |  |
| Description | Relax the Prompt Processing Ingest Service latency to several minutes |
| Value Potential ($k) | 1000 |
| Profile | Flat |
| Early date | 2019-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | higher latency for raw image to NCSA and hence slower alert publication |
| Technical Impact | Data distribution environment minimized image can be sent as 1 file normally, and only send 1 copy of the file, cross talk from the camera not required and can be computed. |
| Budget Impact | Data arrive at NCSA on the order of minutes after camera readout. That data is then available for batch processing. Relaxing the latency requirement to use normal routed networks and very prompt batch processing reduces system complexity very substantially. |
| Schedule Interactions | Not on the critical path |
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| **Descope Options** | |
| **DM17** |  |
| Description | Provide only notebook aspect and portal aspect of LSP at Chile: serve data from the Data Facility only |
| Value Potential ($k) | 1000 |
| Profile | Flat |
| Early date | 2019-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Chilean scientists (100) would need to retrieve data from NCSA instead of Chile. |
| Technical Impact | All Chilean scientists need to get resources from LDF. US DAC becomes LSST DAC. |
| Budget Impact | Reduce costs by eliminating the DAC in Chile. Qserv + Kubernetes notebook infrastructure could still be provided for 100 Chilean scientists. |
| Schedule Interactions | Not on the critical path |
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| **Descope Options** | |
| **DM18** |  |
| Description | Delete Data Backbone and Data Access Center in Chile: serve data from NCSA only. Only have commissioning cluster and other smaller systems required at Base Data Center for staff |
| Value Potential ($k) | 1500 |
| Profile | Flat |
| Early date | 2019-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Chilean scientists (100) would need to retrieve data from NCSA instead of Chile. |
| Technical Impact | A secondary disk copy of all the raw data would not be managed by the project. IN2P3 is supposed to contain the entire RAW set of data also, but the 2nd copy would not be transferred and managed by tools at LDF. It would be delivered to IN2P3. If there was a problem with the data at IN2P3, it would not be known by tools at LDF. This would impact disaster recovery in that restore of data would require from tape, and a purchase of media to cover that cost. To mitigate this risk: a copy of the data stored into the “deep freeze” cloud never to really be retrieved. This does need to be studied to see if the cost savings is really that. Need rainy-day fund to prepare in case we ever need to get data out of deep freeze storage. Extremely human intense process to get data from deep freeze. |
| Budget Impact | No Data Access Center or Data Backbone environments in Chile. This is a substantial saving, but runs the risk of a large operational human and operational cost to restore lost files in a disaster recovery scenario. |
| Schedule Interactions | Not on the critical path |
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| **Descope Options** | |
| **TS2** |  |
| Description | Reduced Base Facility Functionality |
| Value Potential ($k) | 100 |
| Profile | Taper |
| Early date | 2017-01-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | Negligible. |
| Technical Impact | The Base Facility scope is derived from the use cases to support the Operations Phase as well as the support of the construction and commissioning. The design of the facility is complete. Construction bidding resulted in ~25% overbudget condition which was reduced to ~15% by descope, which had no significant technical impact. Construction is now substantially complete. Any available scope options that remain at this point would be relatively minor, related to post construction improvements for intended use, (e.g. Remote Operations room outfitting, furnishings budget, reduction in computing rack utilities). |
| Budget Impact | Reduction of approximately 1% of the budget is considered to be available. |
| Schedule Interactions | Negligible |
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| **Descope Options** | |
| **TS6** |  |
| Description | Reduce Summit Lodging Expansion |
| Value Potential ($k) | 120 |
| Profile | Flat |
| Early date | 2018-01-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | There is no measurable science impact perceived from this descope. More intangible impact on science could result if adequate lodging is not available on Pachón for night crew. |
| Technical Impact | The element includes the construction of the summit lodging facilities to support LSST integration, commissioning, and operations teams. The facility is an addition to the existing Pachón lodging and dining building. Facilities on Pachón are highly beneficial to support the operations team and the large teams of engineers, scientists, and workers who will be performing time-critical integration, assembly, test, commissioning activities. Utilization of facilities on the adjacent summit are significant safety concerns and will require additional travel resources, and increased wear on roads and equipment. |
| Budget Impact | The original overall project budget for a permanent lodging addition was $857 K. The implemented descoped option budget is $535 K which is currently under construction. There is a need for ~$200 K in other temporary lodging provisions during peak occupancy of AIV to compensate for the descoped lodging addition. Given these anticipated expenditures there is a potential for ~$120K potentially available descope. |
| Schedule Interactions | The summit lodging room addition is under construction with anticipated completion in September 2019. This activity will not impact overall project schedule. |
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| **Descope Options** | |
| **TS10** |  |
| Description | Eliminate ComCam |
| Value Potential ($k) | 100 |
| Profile | Taper |
| Early date | 2016-07-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | ComCam was designed as a pathfinder for the DM and Camera interfaces as well as validating the mirror support systems. Eliminating this scope could severely diminish the commissioning effort and cause significant delays in transition to operations. |
| Technical Impact | The impact will significantly slow the understanding of the telescope/camera performance and could prevent the successful integration of them in the worst scenario. |
| Budget Impact | The ComCam budget is approx $1.3M (about $400k has already been spent). |
| Schedule Interactions | This descope could also be selected if the T&S completion is later and the camera arrives early. |
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| **Descope Options** | |
| **TS11** |  |
| Description | Eliminate M3 Interferometer Testing |
| Value Potential ($k) | 180 |
| Profile | Flat |
| Early date | 2017-01-01 |
| Latest date | 2019-10-01 |
| Status | Available |
| Scientific Impact | The ability to control the mirror surfaces is paramount to providing good image quality. Verification of the M1M3 active optics system (by measuring M3) is necessary to confirm the telescope system is performing to specification to enable science requirements to be achieved. Eliminating the Interferometric testing of M3 on the telescope will increase the risk of decreased performance early in the commissioning. |
| Technical Impact | The impact will significantly slow the understanding of the telescope/camera performance and could prevent the successful integration of them in the worst scenario. |
| Budget Impact | The M3 interferometer budget is approx $230k (about $30k has already been spent). |
| Schedule Interactions | This descope could be selected if the M1M3 system is substantially late to Chile and is impacting the overall schedule. |
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| **Descope Options** | |
| **TS12** |  |
| Description | OCS gui interface |
| Value Potential ($k) | 250 |
| Profile | Flat |
| Early date | 2017-01-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | Possible increase of downtime due to inability to access to the information quickly |
| Technical Impact | More difficult to inability to solve problems in a timely fashion |
| Budget Impact | Some visualization would still be needed so only ~$250K of the remaining ~$400K would be saved. |
| Schedule Interactions | This descope would not have much impact on the schedule since some of the functionality would still need to be developed |
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| **Descope Options** | |
| **TS13** |  |
| Description | Operations from Summit Only |
| Value Potential ($k) | 150 |
| Profile | Flat |
| Early date | 2018-01-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | Potential for slower troubleshooting responses. More frequent trips for people to Chile. |
| Technical Impact | Reduction in the hardware, software and safety oversight needed to be able to operate from remote locations. |
| Budget Impact | Significant, not sure the scope of this work has been addressed in the first place, which requires much more monitoring equipment and safety considerations. But the control room could reduce the number of trips from the Tucson and SLAC staff to the site |
| Schedule Interactions | More remote operations centers it will negatively impact the schedule. |
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| **Descope Options** | |
| **TS14** |  |
| Description | Reduce Environmental Awareness System's "Awareness" |
| Value Potential ($k) | 50 |
| Profile | Flat |
| Early date | 2018-01-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | Could impact the scheduler's decision making if some functionality is missing from the EAS. It would also impact the image quality diagnostics |
| Technical Impact | Would limit our baseline environmental data that will help characterize the dome + telescope environment. |
| Budget Impact | Save $ on weather sensors and labor costs. |
| Schedule Interactions | Save time on development, testing and verification of EAS. |
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| **Descope Options** | |
| **TS18** |  |
| Description | Guider |
| Value Potential ($k) | 23 |
| Profile | Taper |
| Early date | 2019-07-01 |
| Latest date | 2020-07-01 |
| Status | Available |
| Scientific Impact | Negligible if we have a tracking system that meets requirement for the 30s exposure. The guider show also lower performance and some have glowing issues which would impact the performance of the actual science camera. |
| Technical Impact | Put more pressure on the TMA requirements. |
| Budget Impact | Software development saving |
| Schedule Interactions |  |
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| **Descope Options** | |
| **TS19** |  |
| Description | GPS |
| Value Potential ($k) | 52 |
| Profile | Flat |
| Early date | 2020-01-01 |
| Latest date | 2020-07-01 |
| Status | Available |
| Scientific Impact | Essentially none so long as the AT is operational. Also recent DES analyses have shown the water data can be determined (to first order) from photometery |
| Technical Impact | Will reduce the number of systems to install/commission |
| Budget Impact | About 60k in hardware, then software dev time as well (but you'll have to ask Andy how much) |
| Schedule Interactions | Minor amount of savings in time. No hugely significant |
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| **Descope Options** | |
| **TS20** |  |
| Description | AT Primary mirror recoating |
| Value Potential ($k) | 67 |
| Profile | Flat |
| Early date | 2019-09-01 |
| Latest date | 2022-07-01 |
| Status | Available |
| Scientific Impact | Will result in a ~10% decrease in throughput and more scattered light. |
| Technical Impact | Delays any modifications required to the coating chamber (or one of the adjacent coating chambers that could do it e.g. Gemini). The mirror will one day need recoating, and delaying the building up of the capability increases the risk of significant schedule hits should the coating start to degrade or be damaged |
| Budget Impact | 60k for coating, but again the recoating capability is still required, so the gain in cost is essentially zero unless the recoating becomes an operations activity. |
| Schedule Interactions | This is an easily parallelized activity. Don't expect any significant schedule gain. |
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| **Descope Options** | |
| **EP1** |  |
| Description | classroom loaner tablet sets |
| Value Potential ($k) | 566 |
| Profile | flat |
| Early date | 2020-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | The bulk of EPO deliverables require an online compute device (laptop, tablet, etc.) Many underserved communities which EPO is targeting to meet our diversity requirements are financially disadvantaged and don't have the monetary resources to provide these prerequisite devices to their students. To offer an equal opportunity to schools that would otherwise not be able to participate, LSST EPO is planning to purchase a number of tablet devices and loan sets of them to schools that participate in our professional development program and have demonstrated strong commitment and sincere need. |
| Technical Impact | Without Internet-enabled devices, schools cannot participate in our science notebook-powered education program. |
| Budget Impact | $566,381 is allocated in FY21 for the purchase of modern tablets, storage, and shipping containers. Existing EPO staff will absorb the administrative overhead of managing the distribution and tracking. |
| Schedule Interactions | Purchase occurs in FY21 to avoid technology outdating if a large hardware investment was made earlier in construction. |
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| **Descope Options** | |
| **EP4** |  |
| Description | Solar System 3D model |
| Value Potential ($k) | 80 |
| Profile | flat |
| Early date | 2018-10-01 |
| Latest date | 2020-10-01 |
| Status | Available |
| Scientific Impact | A 3D model of the solar system will be a powerful tool for non-specialists to visualize the distances, sizes, and sheer number of new solar system objects LSST will uncover. This will also help people explore where the near-flying asteroids are relative to Earth, which is a major science goal of LSST. |
| Technical Impact | LSST EPO would likely contract this work since the required development skills are specialized. |
| Budget Impact | $80K is allocated (combined) in FY19 and FY20 for the contractual development of this deliverable. |
| Schedule Interactions |  |
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| **Descope Options** | |
| **EP5** |  |
| Description | 3D tour of the LSST facility |
| Value Potential ($k) | 15 |
| Profile | flat |
| Early date | 2019-10-01 |
| Latest date | 2020-10-01 |
| Status | Available |
| Scientific Impact | Since people will not visit the site at Cerro Pachón, a 3D tour allows everyone to understand the immensity of the telescope, the size of the camera, and how quickly the telescope can move to new positions. The personalized experience of being on the mountain top with the telescope makes the science more relatable to EPO audiences. |
| Technical Impact | LSST EPO would likely contract this work since the required development skills are specialized. |
| Budget Impact | $150K is allocated in FY20 for the contractual development of this deliverable. |
| Schedule Interactions |  |
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| **Descope Options** | |
| **EP7** |  |
| Description | De-scope citizen science as an EPO deliverable |
| Value Potential ($k) | 280 |
| Profile | tapered |
| Early date | 01-07-18 |
| Latest date | 01-10-20 |
| Status | Available |
| Scientific Impact | Citizen Science is a pillar of the EPO program and offers tremendous value to the scientific community (crowdsourcing data analysis when machine learning automation isn't available) as well as engaging the general public and raising awareness of LSST data. |
| Technical Impact | LSST EPO would likely contract this work since the required development skills are specialized. |
| Budget Impact | $280K is allocated for the contractual development of this deliverable. |
| Schedule Interactions | 0 |
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| **Descope Options** | |
| **CO1** |  |
| Description | Eliminate Early System AI&T with ComCam |
| Value Potential ($k) | 5000 |
| Profile | tapered |
| Early date | 2020-07-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | Eliminates science algorithm and pipeline testing with ComCam. This will reduce feedback to the ongoing Data Management development effort and result in under developed algorithms and reduced pipeline performance at the start of operations. |
| Technical Impact | Risk of schedule delays for Full System AI&T with LSSTCam increases substantially.  Late verification of system ICDs exposes schedule risk when these are tested for the 1st time with LSSTCam.  Refrigeration startup is pushed to Full System AI&T resulting in the startup time with LSSTCam on the TMA taking much longer than currently planned.  Active Optics System performance verification is not understood and leads to software development delays, extended unplanned testing and/or reduced system performance impacting image quality and science value of the survey data.  Science pipeline algorithms do not achieve desired performance without early ComCam data leading to lower performance in early phases of operations affecting science quality of early data releases.  Delays in Full AI&T with LSSTCam schedule would put Science Validation mini-Surveys at risk increasing likelihood of lower science pipeline performance at start of operations.  Early interface verification between OCS, T&S, LSSTCam and DM is eliminated increasing risk during Full System AI&T. |
| Budget Impact | Depending on when and how this scope option is exercised the budget impact will be different than the maximum potential indicated. Most of the budget potential is labor. ~$2000K in capital budget reduction can only be realized if this scope option is exercised before the end of FY18, otherwise the non-labor components will have been procured. |
| Schedule Interactions | Maximum potential of 6 months in schedule savings. |
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| **Descope Options** | |
| **CO3** |  |
| Description | Reduce extended observing and Science Pipeline Testing with ComCam |
| Value Potential ($k) | 2700 |
| Profile | tapered |
| Early date | 2020-10-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | Reduces early testing of science pipeline with LSST data reducing feedback to ongoing Data Management development efforts. This will cause reduced refinements in science algorithms and reduced pipeline performance in the early years of operations. |
| Technical Impact | If 1st, 2nd and 3rd observing blocks are eliminated then the science pipeline algorithms may not achieve desired performance without early ComCam data for algorithm development and corrections leading to lower performance in early phases of operations affecting science quality of early data releases. All items below are in play.  If the 2nd and 3rd observing blocks are eliminated exploration of systematics in the science algorithms is limited resulting in reduced development and initial performance. All items below are in play.  If 3rd observing block is eliminated then verification of scheduling algorithms will be delayed reducing time to modify scheduler software prior to the start of operations |
| Budget Impact | The observing block + associated punch list allocations are each 1 month long. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | Maximum potential of 3 months of schedule. |
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| **Descope Options** | |
| **CO4** |  |
| Description | Reduce Extended Observing and Science Pipeline Testing with LSSTCam |
| Value Potential ($k) | 2100 |
| Profile | tapered |
| Early date | 2021-07-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Reduces testing of science pipeline with full scale LSST data reducing feedback to ongoing Data Management development efforts. This will cause reduced refinements in science algorithms and reduced pipeline performance in the early years of operations. There is a risk that science pipeline efficiency is initially inadequate to handle full scale LSST data and production of data products is delayed until solution can be found. |
| Technical Impact | If the 1st and 2nd observing blocks from LSSTCam are eliminated then the science pipeline algorithms may not achieve desired performance for algorithm development and their corrections over the full 3.5 degree field-of-view leading to lower performance in early phases of operations affecting science quality of early data releases. All items below are in play.  If the 2nd observing block from LSSTCam is eliminated exploration of systematics in the science algorithms over the full 3.5 degree field-of-view will result in reduced algorithm development and initial performance prior to the start of operations. This will result in lower performance of early alert production and data releases. |
| Budget Impact | The observing block + associated punch list allocations are each 1 month long. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | Maximum potential of 2 months of schedule. |
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| **Descope Options** | |
| **CO5** |  |
| Description | Eliminate Both Science Validation Surveys |
| Value Potential ($k) | 4300 |
| Profile | tapered |
| Early date | 2021-10-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | Unable to verify/validate prompt processing of alerts and data release processing. Increases risk that production of LSST data products in the early years of operations will be at a reduced efficiency. |
| Technical Impact | Without conducting SV mini-surveys the full demonstrations of operations readiness will not be achieved thereby increasing the risk of system level deficiencies that would impact early operational effectiveness.  Full SRD / LSR compliance would not be demonstrated, particularly the ability to keep up with alert production and demonstrate 10-year survey performance on a limited number of field.  Lack of full bandwidth, in survey type mode, will limit the ability to test and verify the system wide data processing infrastructure and capabilities. This exposes significant risks to the efficiencies and cost of operations. |
| Budget Impact | Science validation spans 3.5 months including observations for the mini-surveys and subsequent data processing. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | Maximum potential of 3.5 months of schedule. |
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| **Descope Options** | |
| **CO6** |  |
| Description | Eliminate SV Survey for Alert Production |
| Value Potential ($k) | 1600 |
| Profile | tapered |
| Early date | 2021-10-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | Without conducting SV mini-survey for alert production the full demonstrations of differencing template will not be achieved increasing the risk of system level deficiencies that would impact early operational effectiveness.   This would also affect the ability to bootstrap the production of differencing templates for early operational alert production potentially delaying alert production by at least 1-year affecting LSST’s early science footprint. |
| Technical Impact | Final development of DM final Alert Products Production algorithms for operational readiness would be reduced. |
| Budget Impact | Alert production mini-survey spans 1.5 months including observations and subsequent data processing. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | 1.5 months of schedule potential. |
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| **Descope Options** | |
| **CO6** |  |
| Description | Eliminate SV Survey for Alert Production |
| Value Potential ($k) | 1600 |
| Profile | tapered |
| Early date | 2021-10-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | Without conducting SV mini-survey for alert production the full demonstrations of differencing template will not be achieved increasing the risk of system level deficiencies that would impact early operational effectiveness.   This would also affect the ability to bootstrap the production of differencing templates for early operational alert production potentially delaying alert production by at least 1-year affecting LSST’s early science footprint. |
| Technical Impact | Final development of DM final Alert Products Production algorithms for operational readiness would be reduced. |
| Budget Impact | Alert production mini-survey spans 1.5 months including observations and subsequent data processing. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | 1.5 months of schedule potential. |
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| **Descope Options** | |
| **CO7** |  |
| Description | Eliminate SV Survey for Date Release Processing |
| Value Potential ($k) | 1000 |
| Profile | tapered |
| Early date | 2021-10-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | Without conducting SV mini-survey for 10-year performance the full demonstrations of system performance will not be achieved increasing the risk of system level deficiencies that would impact early operational effectiveness. |
| Technical Impact | Final development of DM final Data Release Production algorithms for operational readiness would be reduced. |
| Budget Impact | Data Release Production mini-survey spans 1.5 months including observations and subsequent data processing. Much of the associated cost with this descope would be used to cover schedule delay in the subsystems and reduce potential draw on MREFC contingency.  The budget estimate is derived from the budgeted labor during these observing blocks plus the data services running at NCSA during this time period. |
| Schedule Interactions | 1.5 months of schedule potential. |
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| **Descope Options** | |
| **CO8** |  |
| Description | Eliminate Calibration AI&T |
| Value Potential ($k) | 2170 |
| Profile | tapered |
| Early date | 2019-07-01 |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | The calibration data products needed by the science pipeline validation would not be viable. This would compromise the general science validation effort. |
| Technical Impact | Without the auxiliary telescope generating atmospheric transmissioning maps the DM development relying on them would not be implemented and could compromise the early DRP data quality from first year data. |
| Budget Impact | Budget savings is estimated on the cost to operate the Auxiliary Telescope to support calibration products for validating the science pipelines. |
| Schedule Interactions | No real schedule impact since the integration of the Auxiliary Telescope occurs in parallel with other planned activities that are not port of this de-scope option. |



















































































































































## Scope Opportunity Summary

The scope opportunities developed for the project are primarily for specific risk reduction to accomplish the construction project but also includes items that will address the stretch goals identified in the Science requirements document.

There are 14 identified areas where the baseline plan can be extended at a total cost of ~$20.8M. The following tables provide details of the opportunity items.

|  |  |
| --- | --- |
| **Scope Opportunity** | |
| **DM1-U** |  |
| Description | Store Multi-fit Likelihood Samples for All Six Bands |
| Value Potential ($k) | 125 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2019-01-01 |
| Status | Available |
| Scientific Impact | Currently, the likelihoods are sampled and stored only for g, r, I, and z bands, while only the associated and derived quantities (e.g., maximum likelihood values or means) are stored for u and y. This option would enable science cases dependent on accurate knowledge of extended object shapes in u and y bands. |
| Technical Impact | This would require deployment of additional database hardware to store and query the u and y band likelihood chains. |
| Budget Impact | $603,764, with $125,315 in Construction and an average of $47,845 per year in Operations. |
| Schedule Interactions | Optimal if executed in time for the purchase of database hardware, but also possible afterwards. |
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| **Scope Opportunity** | |
| **DM2-U** |  |
| Description | Store All Raw Data on Disk Rather than Tape |
| Value Potential ($k) | 1500 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2019-01-01 |
| Status | Available |
| Scientific Impact | Enables real-time generation of forced photometry for transient alerts, going back to the beginning of the survey. Makes it feasible to generate image differencing templates on the fly, if needed, rather than from the annual co-adds. |
| Technical Impact | Additional disk storage capacity would need to be added to the LSST processing cluster. The tape archive would need to be removed from the design, and the appropriate middleware redirected to fetch the data from disks instead. Any tape-archive related middleware would not have to be written. Potential additional storage/monitoring middleware may need to be written to oversee the increased disk capacity. The Chilean tape library has been eliminated with the replan. We have sized the pre-operations facility to store most data on disk (in addition to tape at NCSA) to support commissioning, since interaction with data products is expected to be more intense during the commissioning period. |
| Budget Impact | Eliminating the tape library as a primary storage source does simplify the production workflow system. However, the NCSA tape library is seen as a diverse media disaster recovery resource, so eliminating it altogether is a risk. The upscope is minimal during the construction period, but would be more substantial during the operations period. Estimate ~$1.5M extra for Year 1 provisioning to add disk. |
| Schedule Interactions | Cost savings due to the tape archive would be lost if this option is implemented after the tape archive is deployed. |
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| **Scope Opportunity** | |
| **DM3-U** |  |
| Description | Develop Specialized Codes for Crowded Field Processing |
| Value Potential ($k) | 500 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2019-01-01 |
| Status | Available |
| Scientific Impact | The planned LSST data processing codes, though expected to yield acceptable results in areas of moderately high crowding, are not guaranteed to reach the accuracy or completeness of purpose-built crowded field photometry codes. Specifically, they are not required to work well in regions such as dense clusters or the Galactic plane. Developing specialized codes for crowded fields would enable science cases dependent on processing of dense stellar fields. |
| Technical Impact | Implementation will require research and development of additional software, on the level of ~1 FTE/yr for 3-4 years. Possible deployment of additional hardware to support new, more computationally intensive, algorithms may be needed. |
| Budget Impact | Estimating operational hardware impact is unknown, would require analysis and benchmarks, assessing changes to object detection, deblending, measurement in galactic plane. Presumably, impact would be bounded, i.e. we would not do multi-fit there, could use those cycles thus saved.  $0.5M labor |
| Schedule Interactions | Can be implemented at any point in construction and operations. |
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| **Scope Opportunity** | |
| **DM4-U** |  |
| Description | Diverse Network Path from Summit to Base |
| Value Potential ($k) | 350 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2019-01-01 |
| Status | Available |
| Scientific Impact | In the event of a primary path failure, e.g. Fiber cut on the primary route, camera images would no longer flow to the Base, which would cease alerts for the time of the outage. Other operational functions in Chile would also be affected, although we should be able to maintain voice and vital safety-related communications over Microwave radio. Estimated 4-6 hours to repair and restore scientific flows. |
| Technical Impact | As this was never in the baseline plan it does not have any real impact on the Engineering Implementation of the link. Time and minimal funding has been spent exploring the options. There are two options with varying degrees of protection addressing two areas of risk. We can exercise one or both of these options. Risk areas:  1. Fiber in trenches along road from Gate to CP Summit (cut in the fiber)  2. Public highway from Gate to Base.(posts felled by vehicles) |
| Budget Impact | Option 1 ($285k) 1. Install a fiber bundle on poles from Pachón summit to San Carlos Valley floor 2. Splice existing fiber bundle on road to connect to new bundle on poles 3. Add two optical switches  Option 2 ($350k) 1.Install second Optical card in Pachón 2.Utilize spare Telefonica fiber pair to reach Vicuna 3.Install DWDM chassis in Vicuna along with Optical card 4.Configure Layer 2 in Vicuna to tap into REUNA 100G and 40Gb in Santiago for return path |
| Schedule Interactions | If there are still available funds by 2019 and all other related expenditures are completed we may revisit this issue to install partial diverse paths. This was in essence the recommendation of the Network Design Review panel in Tucson on 24 February 2015. |
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| **Scope Opportunity** | |
| **DM6-U** |  |
| Description | Keep Processed Images (Calibrated Exposures) |
| Value Potential ($k) | 700 |
| Profile | flat |
| Early date | 2021-01-01 |
| Latest date | 2021-07-01 |
| Status | Available |
| Scientific Impact | Enhances the reproducibility of LSST catalogs as measurements can be (re)derived from calibrated exposures guaranteed to be bitwise-identical to those used for data release production. Enables Level-3 use-cases requiring access to significant number of calibrated exposures. |
| Technical Impact | Additional disk storage capacity and/or tape archive capacity would need to be added to the LSST processing cluster. The data access middleware would need to be modified to fetch stored exposures, instead of regenerating them on the fly. |
| Budget Impact | This is ~2.5 PB per year stored on disk or tape. For MREFC this cost would be expensed in the last year of construction/commissioning when provisioning for Y1. Extra disk to store for Year 1 would be ~$500K; extra tape would be ~$200K. |
| Schedule Interactions |  |
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| **Scope Opportunity** | |
| **DM10-U** |  |
| Description | Increase bandwidth Tucson Miami |
| Value Potential ($k) | 500 |
| Profile | FLAT |
| Early date | 2022-01-01 |
| Latest date | 2031-01-01 |
| Status | Available |
| Scientific Impact | Increased bandwidth on the link between Tucson and Miami would allow for more reliable and faster transfer of data. This would improve the QA activities and could increase the overall quality of the science products. |
| Technical Impact | Purchase of additional bandwidth, improved network. A better connection may reduce need to travel. |
| Budget Impact | $500K should cover the increase from 10 Gbps to 40 Gbps. |
| Schedule Interactions | Can be implemented at anytime. |
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| **Scope Opportunity** | |
| **TS5-U** |  |
| Description | M1M3 Thermal Control System Testbed |
| Value Potential ($k) | 300 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2019-12-01 |
| Status | Available |
| Scientific Impact | Negligible |
| Technical Impact | This option would establish a work package to build a M1M3 testbed with surrogate section of a mirror for thermal control system testing. The current plan is to deploy the thermal management system on the operational mirror cell and debug and commission the system on the real mirror. A testbed would significantly reduce the risk of development and allow work to be completed early and decoupled from the mirror system development. |
| Budget Impact | An M1M3 thermal testbed is estimated at $150K in hardware for glass and sensors and the development and test program is estimated at 1 FTE. |
| Schedule Interactions | This option would be executed in parallel with M1M3 system construction and would reduce M1M3 commissioning time by 2 months. Completing this option would significantly reduce schedule risk as well. |
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| **Scope Opportunity** | |
| **TS6-U** |  |
| Description | Photovoltaic System for the Base |
| Value Potential ($k) | 300 |
| Profile | Flat |
| Early date | 2017-10-01 |
| Latest date | 2021-10-01 |
| Status | Available |
| Scientific Impact | Negligible |
| Technical Impact | This option would provide for electricity for the base facility office building and data center. The A&E firm developed the necessary design features needed to support the facility needs |
| Budget Impact | The A&E firm targeted $300-400k to implement this system. During Phase 2 construction bid solicitation, a vendor did submit a proposal for $400k to implement this option. Estimated payback period is ~12 years, so savings in electrical costs would not recover investment until approximately the end of the LSST project survey period. Benefit would be via investment of contingency during construction to help defray future costs during operations |
| Schedule Interactions | No schedule impact |
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| **Scope Opportunity** | |
| **TS7-U** |  |
| Description | M2 Hexapod Installation on TEA Before TMA Integration |
| Value Potential ($k) | 50 |
| Profile | Flat |
| Early date | 2018-10-01 |
| Latest date | 2020-03-31 |
| Status | Available |
| Scientific Impact | Negligible |
| Technical Impact | Will reduce time and risk involved in installing M2 hexapod on telescope |
| Budget Impact | Reduces cost of developing M2 hexapod on telescope installation fixtures |
| Schedule Interactions | Eliminates time budgeted for M2 hexapod installation since M2 hexapod would be installed on Top End Assembly concurrent with TMA assembly. |
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| **Scope Opportunity** | |
| **TS10-U** |  |
| Description | Purchase scaffolding to increase dome assembly efficiency |
| Value Potential ($k) | 200 |
| Profile | Flat |
| Early date | 2018-04-01 |
| Latest date | 2020-01-01 |
| Status | Available |
| Scientific Impact | None |
| Technical Impact | Additional scaffolding onsite will enable better access to the dome for integration and assembly activities. Could also be configured to enable TMA pier work in parallel. |
| Budget Impact | $200k |
| Schedule Interactions | Could enable more efficient simultaneous work on the summit for both dome and TMA vendors. |
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| **Scope Opportunity** | |
| **EP1-U** |  |
| Description | virtual/augmented reality |
| Value Potential ($k) | 500 |
| Profile | flat |
| Early date | 2017-10-01 |
| Latest date | 2021-01-01 |
| Status | Available |
| Scientific Impact | Research studies have demonstrated improved learning comprehension and retention with 3D visualization (http://www.astronomycenter.org/items/detail.cfm?ID=13750). In addition, there is strong interest by the general public (as evidenced by Pokemon Go! and the book/movie Ready Player One), planetarium community (https://www.linkedin.com/pulse/virtual-reality-planetarium-patrick-mcpike), and formal education (https://edu.google.com/expeditions/#about). LSST would like to evaluate this technology to see if it holds promise for our program. |
| Technical Impact | LSST EPO would likely contract this work since the required development skills are specialized. |
| Budget Impact | According to the May 2016 report "Augmented Reality and Virtual Reality Market - Global Forecast to 2022", the global augmented reality and virtual reality market is expected to reach USD 151.30 Billion by 2022 (source: http://www.marketsandmarkets.com/PressReleases/augmented-reality-virtual-reality.asp). Since this technology is in high-demand, hiring or contracting the necessary developers will be expensive. As a rough guide, Kristina Llewellyn, a professor at the University of Waterloo and faculty member at The Games Institute, is working on a $500,000 dollar VR project for Nova Scotia high school students — dubbed the Digital Oral Histories for Reconciliation (DOHR) project (http://www.cbc.ca/news/entertainment/virtual-reality-education-1.4152384). |
| Schedule Interactions | Best to begin as early as possible due to the development complexity and current competition for resources. |
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| **Scope Opportunity** | |
| **CO1-U** |  |
| Description | Extend ORR Mini-Survey by 1-2 Months and Generate an Early Data Release |
| Value Potential ($k) | 3600 |
| Profile | Flat |
| Early date |  |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | By extending the "mini-survey" conducted during the final stages of science verification we can jump start the communities' involvement in science analysis and incorporate feedback earlier in Commissioning. |
| Technical Impact | This opportunity would also further advance the refinement of the data analysis algorithms used to process both Level-1 and Level-2 data products. This opportunity also provides a better verification of the scheduler algorithms and the resulting survey cadence to allow for better feedback earlier in Commissioning. |
| Budget Impact | The budget implication is based only on the "marching army" of the project staff over the extension period. |
| Schedule Interactions | The schedule implication is a 2 month effort before formal declaration of operations readiness. |
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| **Scope Opportunity** | |
| **CO2-U** |  |
| Description | Early Shutdown to Address Improvements Developed out of Commissioning |
| Value Potential ($k) | 3600 |
| Profile | Flat |
| Early date |  |
| Latest date | 2022-01-01 |
| Status | Available |
| Scientific Impact | By programming a complete maintenance effort at the end of Commissioning, the Project can fully address improvements and issues discovered during commissioning. By doing so, the risk to completion is reduced and the risk to quality of the LSST survey will be reduced at the start than if these actions were avoided and the system was accepted into full operations. |
| Technical Impact | The risk of successful completion is reduced and the system would end up having high performance and reliability at the conclusion of commissioning than would otherwise be expected. |
| Budget Impact | There are capital expensing for improvements along with "marching army" costs of the project staff. Two months of staff costs are used for the impact. |
| Schedule Interactions | Implementing this work would require two months of effort to be included in the program prior to the formal declaration of operations readiness. |
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| **Scope Opportunity** | |
| **CO3-U** |  |
| Description | Bootstrap Image Differencing Templates |
| Value Potential ($k) | 11050 |
| Profile | Flat |
| Early date |  |
| Latest date | 01-01-22 |
| Status | Available |
| Scientific Impact | Early generation of Level 1 Alert events at the start of operations. |
| Technical Impact | Currently templates are generated as part of the Level 2 Data Release process, DR1 is planned to be done with the first 6 months of data and will be completed 1 year after operations start. Completion of the commissioning effort on schedule would allow time for the observations needed to deliver the first set of image difference template ahead of the release of DR1. However, the computing infrastructure needed to process images to produce the baseline image differencing templates is required in advance of current plans. |
| Budget Impact | Extended commissioning activities to conduct template observations requires ~$1800K of "marching army" costs. There will be an additional $250K for the early procurement of computing hardware to support the template production. |
| Schedule Interactions | This up-scope would utilize up to the 11 months of schedule contingency currently projected. Cost estimate based on utilizing 6 months, which is enough for the first set of observations to process from behind the sun and be usable at the start of operations. |

























































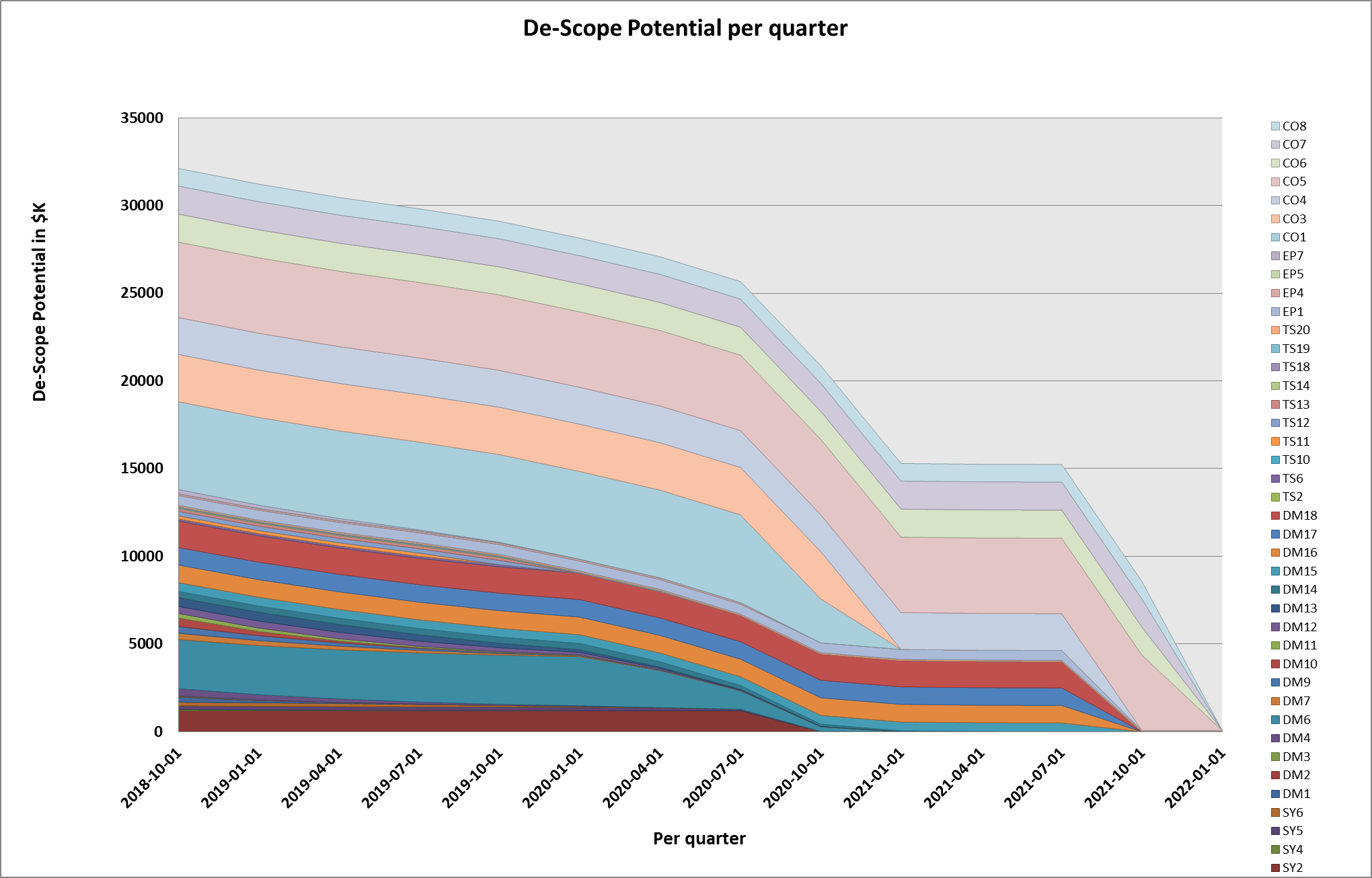




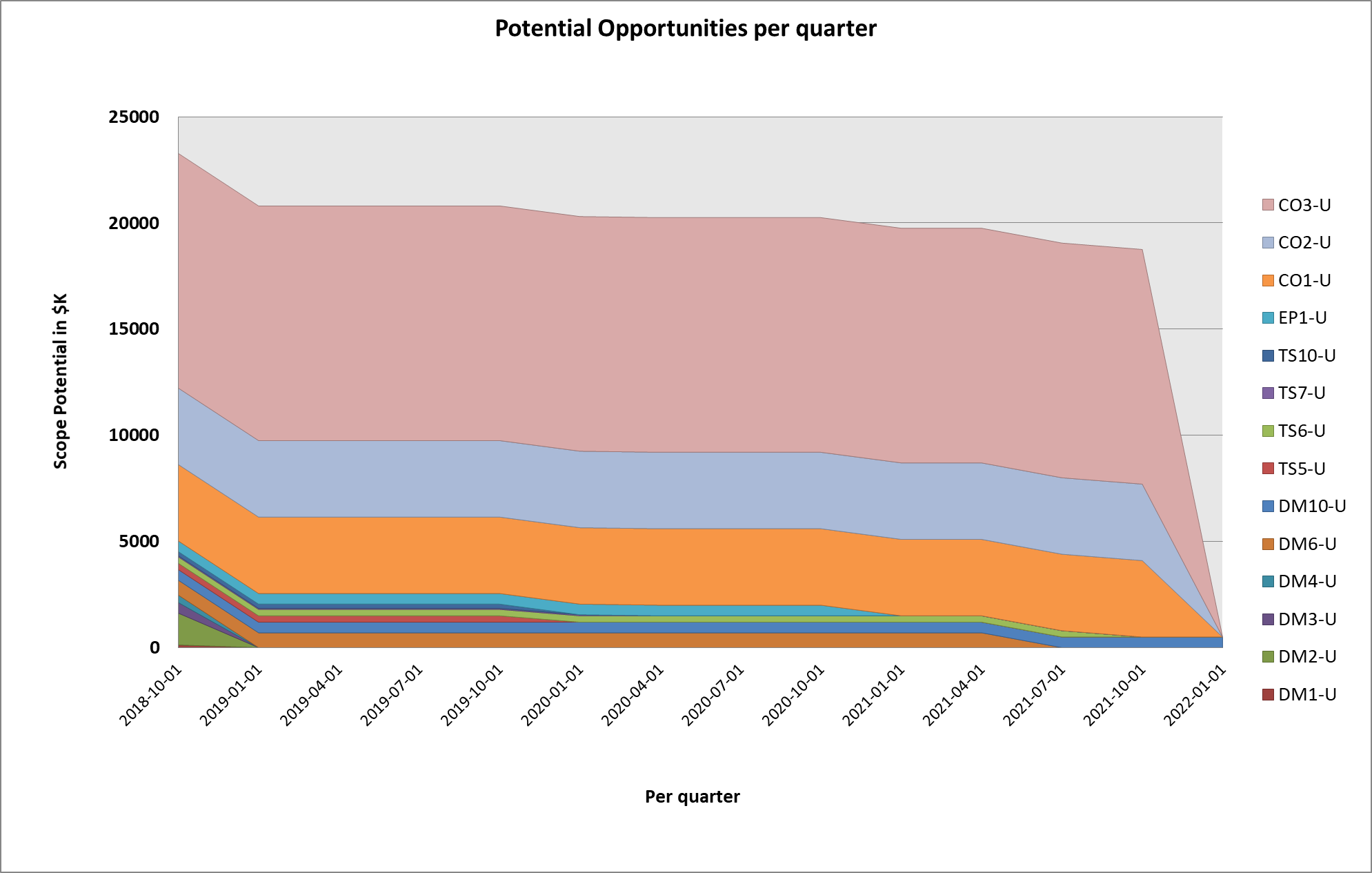


# Scope Option Timeline

The options to reduce the baseline scope are plotted as a function of available value versus time from FY2019 forwards. The sand chart below includes the full list of options currently available with a 20198-07-01 value of ~$30M The legend refers to the Scope ID number.



The scope opportunities can also be plotted as a function of cost versus time.



# Scope Option Conclusion

Scope options have been identified that value more than 10% of the estimate to complete. In July 2019 the baseline plan has a cost to complete of ~$135M. Forty one de-scopes are identified in the scope options registry that have a current value, in July 2019, of ~$30M or 22% of the completion cost.

LSST has also identified and estimated the cost for 14 scope enhancements that would improve the risk profile of the project and extend the performance toward the Science Requirement stretch goals. These 14 items have an estimated cost of $20.8M.