

LARGE SYNOPTIC SURVEY TELESCOPE

# Large Synoptic Survey Telescope (LSST) Telescope and Site Software Organization and Management William O'Mullane and Andy Clements

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# **Telescope and Site Software Organization and Management** 1 Introduction

#### 1.1 Purpose

This document defines the mission, goals and objectives, organization and responsibilities of the LSST Telescope and Site Software subsystem ("TSSW"). The document is currently scoped to define these elements for the LSST Design, Construction, and Commissioning phases. It does not address any ongoing mission for TSSW during LSST Operations.

#### **1.2 Mission Statement**

Create operable, maintainable, high-quality software products for controlling, monitoring and maintenance of the telescope and its facility, all on time and within reasonable cost.

#### **1.3 Goals and Objectives**

LSST Telescope and Site Software will:

- Define the subsystem products, data logging mechanisms, data interface and curation requirements for LSST (with approval by others).
- Assess current and operations-era technologies for use in providing engineered solutions to the requirements.
- Select, implement, construct, test, document, and deploy the software infrastructure, middleware, applications, and external interfaces.
- Document the operational procedures associated with using and maintaining software capabilities.
- Evaluate, select, recruit, hire/contract and direct permanent staff, contract, and in-kind resources in LSST and from partner organizations participating in LSST software initiatives.

The TSSW goals in developing LSST software solutions are:

- Acquire and/or develop solutions: To achieve its mission, LSST TSSW prefers to acquire and configure existing, off-the-shelf, solutions. Where no satisfactory off-the-shelf solutions are available, TSSW develops the software systems necessary to:
  - Enable the generation and deployment of LSST telescope control products at the LSST Summit and Base Facility
  - Enable the automatic control and monitoring of the LSST Telescope from multiple places.
  - Enable the communication of each software component to any other software component through a publish/subscribe interface
  - Have the ability to store and query all telemetry, events & commands for a 30 day period at the summit and for the entire survey at the base.

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 Maintain coherent architecture: TSSW software architecture is actively managed at the subsystem level. A well-engineered and cleanly designed codebase is less buggy, more maintainable, and makes developers who work on it more productive. Where there is no significant impact on capabilities, budget, or schedule, LSST TSSW prefers to acquire and/or develop reusable, open source, solutions.

- Support reproducibility and insight into algorithms: Other than when prohibited by licensing, security, or other similar considerations, TSSW makes all newly developed source code, and in particular that pertaining to scientific algorithms, public. Our primary goals in publicizing the code are to simplify reproducibility of LSST telescope control products and to provide insight into algorithms used. Achieving these goals requires that the software be properly documented.
- Opportunities beyond LSST: the LSST TSSW codebase may be of interest and (re)used beyond the LSST project (e.g., by other telescopes). While enabling or supporting such applications goes beyond LSST's construction requirements, cost and schedule-neutral technical and programmatic options that do not preclude them and allow for future generalization should be strongly preferred.
- Background decision material on choices made in TSSW will be documented in technical notes which will be lodged in DocuShare (see Section 4.10 & 4.11) with "LTS" series handles.



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## 2 Telescope and Site Conceptual Architecture

The TSSW Subsystem Architecture is detailed in LSE-150. A few of the higher level diagrams are reproduced here to orient the reader within TSSW.

During Operations, the control components of the TSSW Subsystem will be installed and run at the summit computer room at Cerro Pachon. This telescope is designed to be an autonomous system - running the survey all night with little interaction from the operator. This complex hierarchy of computer systems is divided out into several namespaces:





Figure 1 shows the various TSSW namespaces and which current components each will contain. The Observatory Control System (OCS) allows for operation personnel to interact with the telescope and the telescope's environment. This contains the scheduler for deciding the survey for the night, the L.O.V.E. (LSST Operator's Visualization Environment) for monitoring of activities and interaction with the telescope for triaging problems, the Watcher for monitoring alerts and the EAS (Environmental Awareness System) for monitoring and controlling the telescope



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environment. These components will be used in controlling and monitoring the Telescope Control System (TCS). The TCS can be subdivided further into the Auxiliary Telescope and Main Telescope. There are also several groupings of components within each of these namespaces. Most components communicate through the middleware called Service Abstract Layer (SAL). Telemetry, Event and Command storage and transport between components is provided by SAL. SAL is an in-house wrapper for the Vortex OpenSplice Data Distribution Service (DDS), a third party communications protocol technology provided by ADLink. This third party technology is one implementation of many of the DDS (Data Distributed System) specifications. The storage component of SAL is the Engineering Facility Database (EFD). This complex piece of infrastructure is displayed in Figure 2.



Figure 2

Figure 3 shows the common infrastructure and services layer which underlies the computing environments. This does list specific technologies for managing/monitoring, provisioning/deploying, or workload/workflow — however these are still being selected — but under consideration are industry-standard tools such as GitHub, Jenkins, Puppet, Kubernetes, Grafana, etc.



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The TSSW can be commanded from multiple locations via the L.O.V.E. interface. These include:

- The Telescope itself at Cerro Pachon, Chile
- The Base Facility in La Serena, Chile
- The Simulation Cluster in Tucson Arizona
- Sending Monitor Information to any web-enabled device with authorized access.

#### 2.1 External Interfaces & Auxiliary Data

The TSSW external interfaces are defined by the ICDs listed in Table 1.

LSE-66	Guider interface between the Camera and the Telescope
LSE-67	Wavefront Sensor Interface between the Camera and Telescope
LSE-70	LSST Observatory Control System Communication Interface
LSE-71	OCS-Camera Software Communication Interface
LSE-72	OCS - Data Management Software Communication Interface
LSE-73	OCS-Telescope Software Communication Interface
LSE-75	Control System Interfaces between the Telescope and Data Management



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LSE-132	OCS to Summit Facility Monitoring Interface
LSE-140	Auxiliary Instrumentation Interface between DM & Telescope
LSE-209	Software Component to OCS interface Control Document

Table 1



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### **3** Telescope and Site Software Organizational Structure

This section defines the organizational structure during the period in which the TSSW Subsystem software is developed and commissioned, up to the start of LSST Observatory operations.

The Software Deputy Project Manager leads the DM Subsystem and TSSW. The Telescope and Site Project Manager leads the Telescope and Site construction efforts at both the Telescope at Cerro Pachon and the Base Facility at La Serena. Both the Director of Software and Telescope and Site Project Manager have direct responsibility for coordination with the overall LSST Project Office, the LSST Change Control Board, the LSST Corporation, and LSST partner organizations on all budgetary, schedule, and resource matters.

TSSW Manager leads the TSSW group. The TSSW Manager is responsible for schedules, budgetary determination and resource allocation for the TSSW group. The TSSW Architect and Lead Developer help decide technical direction and overall architecture of the LSST Telescope and Site Control System. The Product Owners are scientists and system engineers, representing various disciplines, making sure the software produced is able to generate the science required from the telescope. The Product Owner state WHAT the software should produce, the architect and lead developer in conjunction with the developers will determine HOW it is produced.



FIGURE 4: TSSW organization.



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#### 3.1 Meetings

As part of a diverse organization, TSSW staff will participate in a considerable number of meetings. NSF and AURA have many rules on meeting attendance and LSST keeps policies updated accordingly in LPM-191 and Document-13760. This includes the travel summary report template [Document-13762] every traveler must fill after attending a meeting.

The TSSW Manager may, on occasion, require that travelers to a specific meeting provide a detailed debriefing note or presentation.

#### 3.2 Working Groups

The regular decision making process within TSSW is based on individual empowerment and a mechanism to develop consensus. This Request for Comment, or RFC, process is described in Appendix C.

However, some issues in the development of a system that comprises many subsystems is that it requires more effort to reach resolution than can be reasonably addressed through an RFC. When required, the Director of Software will address these issues through the creation of a short-lived "working group". The working group will be given a specific narrow charge, it will be a small group (of perhaps around seven people), its activities will be bounded in time, and it will have a clear deliverable. Members of the group will be agreed by the TSSW Manager to provide the best technical input from the perspective of all stakeholders. Since most members of TSSW have their time scheduled in advance (following the procedure described in Section 4.3), it is important to consider the impact of working group activities on the overall TSSW schedule. In particular, the consent of the relevant T/CAM should be obtained before a member of their teams is added to a working group. Members of the working group should discuss in their local organizations and socialize recommendations ahead of adoption. The working group charge will be "RFC"ed in the usual manner to reach an agreed version and to broadly communicate the formation of the Workgroup. The RFCs for working groups are considered automatically flagged (i.e., not subject to self-adoption); typically, the Director for Software will adopt them by executive decision after consulting with the TSSW Manager. The adopted version of the charge will be issued as an LTS document.

#### **3.3 External Studies**

The Director of Software may initiate or request studies by external parties to investigate or report on technological or other choices facing the TSSW software.

#### 3.4 Document Management

TSSW documents will follow the Systems Engineering Guidelines of LSST. PDF versions of released documents shall be deposited in DocuShare in accordance with the Project's Document Management Plan [LPM-51].

An "LTS-" prefix on a document handle indicates that the document is change-controlled at the subsystem level; i.e., it may be released or modified only with the agreement of the TSCCB<sup>1</sup> (Telescope and Site Change Control Board). Uncontrolled documents, such as technical notes

<sup>&</sup>lt;sup>1</sup> https://confluence.lsstcorp.org/pages/viewpage.action?pageId=3113550

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(prefix "Document-"), may be released whenever the author decides it is appropriate (or when a release is requested by the Director of Software).

The document tree for TS is shown in Figure 5. This is not exhaustive, but serves to give a high level overview of the main documents in TS and the relationships between them.



FIGURE 5: The document tree for the Telescope and Site subsystems.

#### **3.4.1 Draft Documents**

Draft TSSW documents will be kept in Confluence. Use of Google Docs or Confluence is tolerated but final delivered documents must conform to the standard LSST format, and hence either produced with LaTeX, using the lsst-texmf package<sup>2</sup>, or Word, using the appropriate LSST template [Document-9224, Document-11920]. The precursor document should then be erased with a pointer to the baseline document, stored in Docushare.

<sup>&</sup>lt;sup>2</sup> https://lsst-texmf.lsst.io/

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#### 3.4.2 End-User Documentation

# https://[subsystem].lsst.io

#### HowTo's

Guides on how to do specific tasks. Including but not limited to install the software software, adding or editing components and how to operate/use the software.

#### index.rst

Summary of this repositories software. Tell the story of what this software does while including links to important installation guides and relevant doc's.

#### Troubleshooting

Guides on how to troubleshoot. Including but not limited to debugging common problems, resolving and correcting known issues.

## releaseNotes.rst <

Release notes with a summary of the changes along with tag version for this document.

FIGURE 6: Outline of the web hierarchy for the TSSW end user documentation.

As shown in Figure 6, end-user documentation has been subdivided into four folders, HowTos, Troubleshooting, Repository indexes & Release Notes. Appropriate web-based, user-focused documentation is regarded as a major TSSW deliverable.

#### 3.5 Configuration Control

Configuration control of documents is addressed in Section 3.4. In this section, we consider instead how configuration control is applied to operational systems and software development.

#### **3.5.1 Software Version Control**

TSSW follows a git based versioning system based on public git repositories. The approach is covered in the Developer Guide<sup>3</sup> and is consistent with the Project-level Systems Engineering

<sup>&</sup>lt;sup>3</sup>https://tssw-developer.lsst.io/v/couger01-feature-initial\_port/index.html

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Management Plan LSE-17. The master branch of the repository will be used for production - the current version running the telescope. With the develop branch attempts are made to have stable code with the development work being done in the offshoot branches (named with the ID of the corresponding Jira Task describing the work). Once reviewed, an offshoot branch is unit tested and merged to develop. It should be functional and releasable for test. Releases are recorded by tagging the master branch; hot-fix branches are created if patches are required in the master branch.

As we approach commissioning and operations TSSW will have much stricter version control. At this point there will be a version of the software which may need urgent patching, a next candidate release version of the software, and the master. A patch to the operational version will require the same fix be made in the two other versions. The role of the TS Change Control Board (TSCCB) becomes very important at this point to ensure only essential fixes make it to the live system as patches and that required features are included in planned releases.

We cannot escape the fact that we will have multiple code branches to maintain in Commissioning which will lead to an increase in workload. Hence one should consider that perhaps more manpower may be needed in commissioning to cope with urgent software fixes while continuing development. The other consideration would be that features to be developed post commissioning will probably be delayed more than one may think, as maintenance will take priority.<sup>4</sup>

#### 3.5.2 Hardware Configuration Control

On the hardware side we have multiple configurable items; we need to control which versions of software are on which machines. These days tools like Puppet make this reasonably painless. Still the configuration must be carefully controlled to ensure reproducible deployments providing correct and reproducible results. The exact set of released software and other tools on each system should be held in a configuration management database. Changes to the configuration should be endorsed by the TSCCB.

#### 3.6 Risk Management

Risks will be dealt with within the LSST Project framework as defined in LPM-20. Risks in TSSW may be sent to the Director for Software at any time for consideration to be included in the formal risk register (appropriately costed and weighted). All risks are reviewed regularly by the Director for Software and the Systems Engineer (minimum every 3 months).

#### 3.7 Quality Assurance

In accordance with the project QA plan [LPM-55] we will perform QA on the software products. This work will mainly be carried out by the Quality Assurance Lead (Section 6.7). Quality Assurance here means compliance with project guidelines for production, in our case for software production. A part of this is to have a verification/validation plan(s) which in and of itself is a major task (see Section 3.9).

#### 3.8 Action Items

Actions in TSSW are tracked as Jira issues and periodically reviewed at TSSW meetings.

<sup>&</sup>lt;sup>4</sup> WOM identifies this as the maintenance surge.

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### 3.9 Verification and Validation

We intend to verify and validate as much of TSSW software as possible before commissioning and operations. This will be achieved through testing and operations rehearsals/data challenges. The verification and validation approach is detailed in LTS-760, which includes a detailed discussion of the test schedule summarized in Figure 7.



Figure 7 - Assembly, Integration & Verification (AIV) Process Schedule

# **4** Project controls

TSSW follows the LSST project controls system, as described in LPM-98. Considerations specific to TSSW are outlined in Section 4.3.

The TS Software Manager is responsible for the PMCS (Project Management and Control System) and, in particular, for ensuring that TSSW properly complies with our earned value management requirements. The Manager is the first point of contact for all questions about the PMCS.



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#### 4.1 Schedule

The entire LSST project schedule is held in Primavera. Tied to major project milestones we have a series of TSSW tests which need to be performed to show readiness for the different project phases. The project schedule is updated according to the demands of the project every 3 to 6 months. An example of this schedule can be seen in Appendix F.

#### 4.2 Work breakdown structure

While the original Telescope and Site WBS is laid out in LPM-43 with definitions provided in LPM-44, the current WBS is detailed in Appendix B.

The WBS provides a hierarchical index of all hardware, software, services, and other deliverables which are required to complete the LSST Project. It consists of alphanumeric strings separated by periods. The first component is always "1", referring to the LSST Construction Project.

#### 4.3 Planning Process

Milestones have been defined to describe the major goals of the TSSW subsystems for the next 3 to 6 months of the project. New milestones are added each 3-6 months depending on the work needing to be done. Each milestone has a description, a level and an associated JIRA epic. Four levels are defined:

Level 1	The most important milestones exposed at the NSF level.
Level 2	Cross-subsystem milestones (for example, TSSW milestones that affect the Camera Subsystem).
Level 3	Cross-team milestones within TSSW (for example, Middleware milestones that affect the TMA Team).
Level 4	Internal milestones within a team.

Table 2: TSSW top level Work Breakdown Structure

The completion and testing of major TSSW subsystems described in Section 2 are defined as level 2 milestones. Teams plan their work towards each test by defining a series of level 3 milestones. Teams may define level 4 milestones for their own use.

You can see the list of current milestones in Appendix E.

Resources to achieve the milestones throughout the duration of construction have been allocated by means of being loaded into the PMCS. Each top level WBS within TSSW (per Table 2) is divided into some tens of planning packages, each of which addresses some part of the TSSW baseline design with a clearly defined scope, deliverable, resource cost, and end date.



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As the due date for work approaches, the actions required to complete each planning package— and hence meet the associated milestone *cycles* —must be defined in detail. This detail is defined in the TSSW Developer Guide<sup>5</sup>.

<sup>&</sup>lt;sup>5</sup> https://tssw-developer.lsst.io/

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# 5 Products

The products of TSSW are the artifacts, systems, and services which will be used to operate LSST as an observatory. These are mapped fairly closely to the items listed in Appendix A. Each TSSW product is being developed to satisfy one or more of the requirements placed upon the TSSW subsystem.



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# 6 Roles in Telescope and Site Software

This section describes the responsibilities associated with the roles shown in Section 3.

#### 6.1 Director for Software (Deputy Project Manager)

The Director for Software is responsible for the efficient coordination of all LSST activities and responsibilities assigned to the Data Management Subsystem and Telescope and Site software. The Director for Software has the responsibility of establishing the organization, resources, and work assignments to provide TSSW solutions. The Director for Software serves as the software representative in the LSST Project Office and in that role is responsible for presenting software initiative status and submitting new software initiatives to be considered for approval. Ultimately, the Director for Software, in conjunction with his/her peer Project Managers (Telescope and Site, Camera), is responsible for delivering an integrated LSST system. The Director for Software reports to the LSST Project Manager. Specific responsibilities include:

- Manage the overall Software
- Define scope and request funding for Software
- Develop and implement the software project management and control process, including earned value management
- Approve the software Work Breakdown Structure (WBS), budgets and resource estimates
- Approve or execute as appropriate all software outsourcing contracts
- Convene and/or participate in all software reviews

#### 6.2 Technical/Control Account Manager (T/CAM) – Software Manager

The Technical/Control Account Manager has managerial and financial responsibility for the engineering teams within TSSW. The T/CAM is responsible for a specific set of WBS elements and reports activities as required, including providing input for monthly status reports. The T/CAM is responsible for integrating TSSW's agile planning process with the LSST Project Management and Control System (PMCS). Specific responsibilities are to: Develop, resource load, and maintain the plan for executing the Telescope and Site construction project within the scope of their WBS, as well as to

- Synchronize the construction schedule with development in WBS elements managed by other T/CAMs
- Maintain the budget for their WBS and ensuring that all work undertaken is charged to the correct accounts
- Work with the Telescope and Site Project Controller (see Section 6.4) to ensure that all plans and milestones are captured in the LSST Project Controls system
- Perform day-to-day management of staff within their WBS
- Assist Director for Software in developing the TSSW plan
- Synchronize the TSSW plan, managed as per Section 4.3, with the LSST PMCS
- Ensure that the plan is kept up-to-date and milestones are properly tracked
- Create reports, Gantt charts and figures as requested by the Director for Software
- Serves as a member of the TSCCB.





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#### 6.3 Product Owner

A product owner is responsible for signing off on the functional requirements, the quality, prioritization and acceptance of a particular software product. The product owner works with the Customers (often a T&S CAM) and Stakeholders (end users such as the commissioning/operations teams) to ensure proper functionality is being delivered and determining the priority of feature implementation. The product owner then acts as the single point of communication from the stakeholders/customers to the software developers, translating the functionalities/requirements into user stories, reviewing acceptance test criteria, details for implementation and technical expertise.

The Telescope & Site software can be divided into three product categories (SAL, OCS and TCS), each with multiple components. Each product category is overseen by the Software Architect and each component has a Product Owner. The T&S subsystem scientist is the Product Owner of the final product as well as the integration of all the different areas.

The list of products and areas are as follows:

- Middleware (SAL), EFD
- Observatory Control System:
  - OCS executer, Scripting, Observing modes
  - o Environment Awareness System: EAS
  - Visualization: LOVE
  - o Scheduler
- Telescope Control System:
  - Calibration: in dome calibration and AuxTel
  - Active Optics System: M1M3, M2, Hexapods/Rotator Alignment System
  - Observing tools: TMA, Pointing, Guider, Dome
  - o Generic Camera CSC

Each product owner shall:

- Participate in bi-weekly sprint planning meetings, defining and reviewing each sprint
- Participate in the product owners bi-weekly meeting
- Gather the relevant stakeholders of each area and coordinate necessary meetings
- Define long term milestones (in collaboration with non-software CAMs when applicable)
- Sign off on the prioritization and descoping of functionality
- Work as a group, with T&S Software Manager, to assign personnel/resources appropriately
- Responsible for choosing the appropriate Working Group (as defined in section 3.2) in collaboration with the T&S Software Manager, T&S Subsystem Scientist, and T&S Project Manager.

The Product Owners will organize the necessary meetings with the relevant stakeholders to ensure buy-in on all of these issues. If there is a problem with agreements this may be escalated to the TSSW Manager and the T&S Subsystem Scientist. If the problem persists, this may be escalated to the Director of Software.

#### 6.4 Telescope and Site Project Controller/Scheduler

The Project Controller is responsible for integrating TSSW's agile planning process with the



LSST Project Management and Control System (PMCS). Specific responsibilities include:

TSSW PMP

- Assist T/CAMs in developing the TSSW plan
- Synchronize the TSSW plan, managed as per Section 4.3, with the LSST PMCS
- Ensure that the plan is kept up-to-date and milestones are properly tracked
- Create reports, Gantt charts and figures as requested by the Software Deputy Project Manager.

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#### 6.5 Software Architect

The Software Architect has the responsibility for the design of the TSSW Software Architecture and for maintaining adherence to the agreed architecture. Specific responsibilities include:

- Define the overall architecture of the system and ensuring that all products integrate to form a coherent whole
- Identify appropriate technologies to be used in specific areas of subsystem development
- Minimize the exposure of TSSW to volatile external dependencies

The Architect will work closely with the Telescope and Site Systems Engineer and the Quality Assurance Lead to ensure that processes are in place for tracing requirements to the codebase and providing hooks to ensure that requirement verification is possible.

#### 6.6 Lead Developer

The Lead Developer serves as owner for the major sections of the TSSW System (Test, Integration, Development, Architecture, etc.).

In addition, the Lead Developer provides technical expertise to the TSSW team. The Lead Developer will also work with LSST Project Systems Engineering on coordinating and executing Commissioning Activities Planning (CAP). The Lead Developer will select and advocate appropriate software engineering techniques and choose the technologies which are used within the codebase They work with the T/CAM who has managerial responsibility for their product to define the overall construction plan and the detailed cycle plan for TSSW.

#### 6.7 Integration Lead

The Integration Lead has the responsibility for integrating software applications, both within the TSSW engineering team and with external software providers (i.e. Camera). The Integration Lead works with the LSST Project Systems Engineering team to prioritize and execute Early Integration testing. Report activities as required, including providing input for monthly status reports.

- Develop and maintain the TSSW Simulation Cluster for testing reliability
- Define the contents of releases, in conjunction with the product owners, the TS Subsystem Scientist, and the technical managers
- Manage the software releases to the Simulation Cluster
- Works with LSST Project System Engineering on coordinating and executing Commissioning Activities Planning (CAP).
- Work with LSST AIV Management to coordinate TSSW deliveries to Telescope Integration process
- Work with technical managers to coordinate releases to match CAP and AIV testing schedules

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#### 6.8 Quality Assurance Lead

The Quality Assurance Lead has the responsibility for adherence to testing process for the TSSW engineering team. The Quality Assurance Lead works with the Lead Developer to prioritize development activities to address bug reports from testing. The Quality Assurance Lead also reports activities as required, including providing input for monthly status reports.

- Develop and maintain the integration tests between components and/or subsystems
- Develop and maintain the TSSW Release Policy as a change controlled document
- Manage the software release process and its compliance with documented policy
- Ensure that each release is accompanied by an appropriate documentation pack, including user manuals, test specifications and reports, and release notes
- Work with technical managers to coordinate bug fixes and maintenance of long-term support releases

#### 6.9 Scrum Master

The Scrum Master has the responsibility for adherence to the agile development process for the TSSW engineering team. The Scrum Master works with the Product Owners and the T/CAM to maintain and react to priority changes in the development schedule. Report activities as required, including providing input for monthly status reports.

- Work with the relevant Telescope and Site Science Leads and Product Owners to develop a detailed plan for each cycle and sprint as required
- Create reports, charts and other metrics as requested by the T/CAM
- Perform the role of "Sprint-Lead" during agile development which include sprint task maintenance.

#### 6.10 Senior Software Engineer

The Senior Software Engineers serve as mentors and provide technical expertise for the subsystem currently assigned (Auxiliary Telescope, M1M3, etc.).

Senior Software Engineers work with the Engineering Leaders who have responsibility for their subsystem to define and verify the overall completeness of the subsystem.

Senior Software Engineers develop quality subsystem software that meets the Product Owners supplied requirements. Senior Software Engineers develop Unit Tests and document the software produced for the subsystem.

#### 6.11 Software Engineers

Software Engineers work with the Senior Software Engineers to develop quality subsystem software that meets the Product Owners supplied requirements. Software Engineers develop Unit Tests and document the software produced for the subsystem.

#### 7 Development Process

Product development should follow a "Best Practices" approach to product generation. The TSSW team will follow the practices outlined in LTS-224<sup>6</sup> "Control Software Development Best Practices". Some of the implementation of those practices are outlined in this document.

https://docushare.lsst.org/docushare/dsweb/Get/LTS-224/LTS-224%20Control%20Software%20Development%20Best%20Practices%20V2.1.pdf

The contents of this document are subject to configuration control by the LSST T&S Change Control Board.



An agile process<sup>7</sup> is followed in TSSW. We have adopted a cyclical approach to software development, with major integration and operations activities as delivery points. TSSW will use JIRA as a tool to facilitate the agile process. Every three months, we define/refine a set of "epics", which correspond to major pieces of work to be undertaken during the cycle.

During the development cycle, all code is kept under continuous integration<sup>8</sup> (CI). Code versioning is managed in a Git<sup>9</sup> repository and is made available using an open source license. The release process of the code is defined using a modified version of the GitFlow workflow, detailed in section 3.5.1.

#### 7.1 JIRA set-up

The JIRA tool that is used to facilitate the agile process. The workflow to be used is detailed in Figure 10.



Figure 10: JIRA Workflow

<sup>&</sup>lt;sup>7</sup> https://en.wikipedia.org/wiki/Agile\_software\_development

<sup>&</sup>lt;sup>8</sup> Currently using the Jenkins tool; https://jenkins.io

<sup>&</sup>lt;sup>9</sup> Currently using GitHub (https://github.com)



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Description of the JIRA workflow is detailed in Appendix D.

#### 7.2 Continuous Integration

Jenkins is the chosen Continuous Integration platform. Each application should have a build project in Jenkins. These applications should then have a dedicated build server.

Each build should run the unit tests. If the unit tests pass, the application should generate the deployable package and feed into the deployment system. Puppet<sup>10</sup> is the Deployment application.

The packaging system is still being investigated, but is leaning towards using RPMs, in general. For pure Python only applications, setuptools is a fine solution. LabVIEW may require another solution as well. This area is quite flexible, as the only real constraint is that it must be compatible with Puppet.

# Appendices:

# A. Components Listing

https://ts-xml.lsst.io/v/tickets-dm-20234/index.html

WBS Title	WBS no.	Charge no.	Charge no. Title
Management	1.04C.15.1	KLM41501A	T&S Software Management
Architecture	1.04C.15.1	KLM41501A	
Main Telescope	1.04C.15.2	KLM41502A	T&S Main Telescope Software
Pointing contract (remaining)	1.04C.15.2	KLM41502A	
AuxTel	1.04C.15.3	KLM41503A	T&S Auxiliary Tel Software
EFD/Middleware	1.04C.15.4	KLM41504A	Software Infrastructure
QA	1.04C.15.5	KLM41505A	T&S Software QA
Build system	1.04C.15.6	KLM41506A	T&S Software Build
Contracts INRIA	1.04C.15.7	KLM41507A	LSST Operator Vis Env (LOVE)
Contract INRIA 2	1.04C.15.7	KLM41507A	
OCS/TCS hardware	1.04C.15.8	KLM41508A	T&S Computing Hardware

## **B. WBS and products**

<sup>10</sup> <u>https://puppet.com/</u>



	TS	SW PMP	LTS-928	Latest Revision 2019-06-19				
Integration/Test (inc AIT)	1.04C.15.9	KLM41509A	T&S Software Int and Test					

# **C. RFC Process**

A larger change is proposed through a "Request for Comments" (RFC) that is managed through Confluence, since TSSW developers are familiar with the tool. By default, the proposer of an RFC is expected to be responsible for handling any effects of the change. If they propose an API change, they are agreeing that they will fix any breakage in other TSSW code; if they are proposing a change to the style guide, they will make the change. When an RFC is submitted it enters the Proposed state, the proposal is mailed to the TSSW developer list, and an announcement is made on the main TSSW Slack channel. Each RFC has a defined due date by which a decision is to be made. For changes that are expected to have no real impact outside of a single package, a due date of 3 days is acceptable. For changes that might result in significant debate, for example adding a new package to be supported by TSSW or changing an API used by many packages, the proposer is advised to give at least a week and possibly two weeks for debate. Anyone can comment on the RFC, and when consensus is reached the RFC can be Adopted by the proposer. If consensus could not be reached the proposer has the option of withdrawing the RFC completely, adding more time, or flagging the RFC to the Change Control Board for more formal decision making. On adoption, an RFC must be associated with actual work by filing tickets in TSSW Jira and connecting them with an "is triggering" relationship. The Implemented state is recognized by scanning all the Adopted RFCs and seeing that all triggered work has been completed.

## **D. JIRA Workflow description**

Please refer to Figure 10 in regards to the description below:

- Initial/Triage
  - Create the Task, Bug or Improvement.
  - The initial assignee houd triage the ticket.
    - Ensure it is assigned correctly (Assignee, Component, etc)
      - Ensure the ticket is assigned to an actual, currently employed at LSST, person.
      - Each ticket is assigned a JIRA Component. If an Assignee is not designated, the JIRA Component will determine the assignee.
        - The component to assignee designation can be found <u>here</u>.
    - Ensure the Priority is set correctly (Ticket should not have the "Undefined" priority).



- A Sprint can be chosen at creation (preferably by the person doing the work for this ticket). Otherwise the ticket is automatically placed in the Backlog. If the ticket is in Backlog, once the sprint is known, the ticket should be updated with the current sprint.
- Once work begins, move the ticket to In Progress
- In Progress
  - Create the feature branch in the git repo and link the branch to the JIRA component.
    - No active development is ever done on the Master or Develop branches.
  - Document the requirements (via Requirements Template)
  - Write the code.
  - Write the unit tests.
  - Update release Notes & pertinent doc strings
  - When complete, move to In Review.
    - Complete meaning:
      - Add a link of the commit to the ticket.
      - Unit tests exist, have been successfully run and results have been added to the ticket or commit.
      - Add a link to the completed release notes
- In Review
  - Once the code is complete and all unit tests are passing, initiate a pull request on the develop branch and assign it to the Reviewer(s).
  - The Reviewer ensures
    - Code is complete and understandable.
    - Unit tests are passing.
    - Documentation is done, including a reference to the lsst.io site
    - All Requirements, as defined in the ticket Description, are met.
  - If findings occur
    - Updates Jira with findings
    - Sends back to developer
  - If no findings occur
    - Moves Jira ticket to review complete with approval/minor changes.
- Reviewed
  - The Developer then merges the pull-request (see Merge Process, below).
  - Moves ticket to Resolved.
- Resolved
  - This is the purview of QA.
  - QA does another spot review, to ensure the requirements are spelled out and properly met, all documentation is provided and the unit tests are passing.



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- This is also when QA works on the higher level tests (Functional, Integration, etc).
- Once this is Complete, QA moves to Closed.
- Closed
  - The ticket is complete.
    - Feature was successfully implemented.
    - Feature was de-scoped; proper explanation provided.
    - Ticket was not implemented for some other reason; proper explanation provided.



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# E. Currently Defined Milestones (as of June 2019)

т	Key	Summary	Labels	Status
$\bigcirc$	DM-19395	Support M1M3 Cell w/Surrogate Mirror on TMA Testing	L2Milestone	TO DO
$\oslash$	DM-19394	Support M1M3 cell and surrogate mirror test with coating chamber	L2Milestone	TO DO
$\oslash$	DM-19396	Support for M2 Hexapod installation and test on TMA	L2Milestone	TO DO
$\oslash$	DM-19381	MainTel Calibration System Integration Tests in Chile	L2Milestone	TO DO
$\oslash$	DM-19369	M2 Functionality Check with CSC Controller + SAL - pt. 2	L2Milestone	TO DO
$\oslash$	DM-19368	M2 Functionality Check with CSC Controller	L2Milestone	TO DO
$\oslash$	DM-19380	AuxTel 1st Light Support	L2Milestone	TO DO
$\oslash$	DM-19379	Spectrograph On-Sky Support	L2Milestone	TO DO
$\oslash$	DM-19378	Auxtel Calibration System Integration Tests in Chile	L2Milestone	TO DO
$\oslash$	DM-19365	AuxTel & (Closed) Dome Pointing Control Test	L2Milestone	TO DO
$\odot$	DM-19426	Support EAS instrument Site Testing	L3Milestone	TO DO
$\bigcirc$	DM-19413	MTWEP & MTOFC SW Int in Tucson	L3Milestone	TO DO
$\bigcirc$	DM-19406	AuxTel & Dome Pointing Control Test in Tucson	L3Milestone	TO DO
$\odot$	DM-19415	Unpack & Install M2 controller in Summit computer room	L3Milestone	TO DO
$\oslash$	DM-19407	AuxTel Pneumatics & Pointing Configuration Integration w/ Hardware in Chile	L3Milestone	TO DO
$\oslash$	DM-19423	Support M1M3 Thermal Testing on TMA in Chile	L3Milestone	TO DO
$\bigcirc$	DM-19416	M2 Functionality Check with CSC Controller + SAL - pt. 1	L3Milestone	TO DO
$\bigcirc$	DM-19417	Auxtel Calibration System Integration Tests in Tucson	L3Milestone	TO DO
$\bigcirc$	DM-19418	Spectrograph On-Sky Integration	L3Milestone	TO DO
$\bigcirc$	DM-19419	AuxTel On-Sky w/ Spectrograph + Scheduler Support	L3Milestone	TO DO
$\oslash$	DM-19420	AuxTel 1st Light Integration	L3Milestone	TO DO
$\oslash$	DM-19421	MainTel Calibration System Integration Tests in Tucson	L3Milestone	TO DO
$\odot$	DM-19422	Testing of M1M3 New Features w/ Hardware in Chile	L3Milestone	TO DO
$\bigcirc$	DM-19414	TMA Test Support	L3Milestone	TO DO
$\bigcirc$	DM-19425	Support M1M3 installation on TMA	L3Milestone	TO DO
$\bigcirc$	DM-19408	AuxTel Mount Control & Pointing Integration w/ Hardware in Chile	L3Milestone	TO DO
$\oslash$	DM-19427	Support M1M3 Thermal Testing on TMA in Chile	L3Milestone	TO DO
$\odot$	DM-19434	Test ATHexapod Algorithm w/ Hardware	L4Milestone	REVIEWED
$\odot$	DM-19437	MTDome Planning & Management	L4Milestone	TO DO
$\oslash$	DM-19431	AuxTel Mount Control & Pointing Integration in Tucson	L4Milestone	TO DO
$\bigcirc$	DM-19401	Testing of Weather Station SW	L4Milestone	TO DO
$\bigcirc$	DM-19402	Testing of DIMM SW	L4Milestone	TO DO
$\bigcirc$	DM-19429	Prepare Tucson Integration & Test Environment	L4Milestone	TO DO
$\bigcirc$	DM-19432	AuxTel Pneumatics & Pointing Configuration Integration in Tucson	L4Milestone	TO DO
$\oslash$	DM-19433	Test ATDome Algorithm w/ Hardware	L4Milestone	TO DO
$\oslash$	DM-19435	Test ATPneumatics Algorithm w/ Hardware	L4Milestone	TO DO
$\bigcirc$	DM-19436	Testing of M1M3 Mirror Thermal Control SW	L4Milestone	TO DO
$\bigcirc$	DM-19438	AuxTel On-Sky w/ Spectrograph + Scheduler Integration	L4Milestone	TO DO
$\oslash$	DM-19439	Testing of M1M3 New Features w/ Simulator in Tucson	L4Milestone	TO DO



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# F. Current Primavera Schedule (as of June 2019)

	AdivityID	Activity Name	Adivity 0 Step	Driginal Duration	BL Project Start	BL Project Finis	h Adual Start	Adual Finish	Expected Finish	Physical To	tal Rost Start	Finish	Variance - BL Project Finjeh	Budgeted Material	PY2019 2018-10-01	FY2020 2019-10-01	FY2021 2020-10-01	FY2022 2021-10-01
ME 19-04 LSSTAD	ril 2019 Month E	nd Forecast	497	567	17-Od-17	05-Nov-20	01-Jun-17		17-Jul-20		683 01-Jun-17A	01-Feb-21	-67	\$1,247,062.57			ALL OF UT	202.110-01
T ME 19-04 04C Teles	scope and Site Co	estruction	497	567	17-04-17	05-Nov-20	01-Jun-17		17-34-20		683 01-Jun-17A	01-Feb-21	-57	\$1,247,062,57				
ST ME 19-04-04C-15 Teles	score and Site Softwa	F.	497	547	17-Ort-17	05-Nov-20	01-40-17		17-16-20		683 01-Jun-17A	01-Feb-21	-57	\$1 247 042 57				
LSST ME 19-04.04C.15.01 Tel	lescope and Site Softw	are Mana gement	1	392	02-Jan-19	17-Jul-20	03-Dec-18		17-34-20		77 03-Dec 18 A	17-34-20	-07	\$40,706,81				
LSST ME 19-04.04C.15.01	T&SC-1501-0000	Start Project Transition planning	0	0	02-Jan-19		03-Dec-18			100%	03-Dec-18 A		19	\$0.00	Start Propert Tr	analtion planning		
LSST ME 19-04.04C.15.01	T&SC-1501-0050	Software and Control Subsys Mgmt NonLabor	0	380	02-Jan-19	17-Jul-20	01-Jan-19		17-Jul-20	21%	75 01-Jan-19A	17-Jul-20	0	\$40,706.81			ofware and Control Subays Mgmt Noni.	abor
LSST ME 19-04.04C.15.01	T&SC-1501-0030	Software and Control Suboys Mgmt - FY 19 - Labor	0	186	02-Jan-19	30-Sep-19	01-Jan-19		30-Sep-19	42%	74 01-Jan-19A	30-Sep-19	0	\$0.00		Software and Control Subays	April - FY 19 - Labor	
LSST ME 19-04.04C.15.01	T&SC-1501-0010	Transition planning	0	83	02-Jan-19	30-Apr-19	02-Jan-19	30-Apr-19		100%	02-Jan-19A	30-Apr-19 A	1	\$0.00	Tre	nation planning		
LSST ME 19-04.04C.15.01	T&SC-1501-90	Planning Package Marker	0	0	22-JJ-19					0%	105 24-Jun-19		19	\$0.00	•	Planting Package Marker		
LSST ME 19-04.04C.15.01	T&SC-1501-0020	Begin Project Execution	1	0	01-May-19		01-May-19			10.0%	01-May-19A		0	\$0.00	1 t Bec	in Project Execution		
LSST ME 19-04.04C.15.01	T&SC-1501-0040	Software and Control Suboys Mgmt - FY 20 - Labor	0	194	01-Od-19	17-Jul-20				0%	74 01-Oct-19	17-Jul-20	0	\$0.00	1 T	s	of ware and Control Subevs Marnt - FY:	20 - Labor
LSST ME 19-04.04C.15.02 Ma	ain Telescope Software		110	393	17-Od-17	20-Jul-20	31-Jan-19		04-Nov-19		817 31-Jan-19A	20-Jul-20	0	\$760,765.76	1			
LSST ME 19-04.04C.15.02	DM-17094	M1M3 Mirror Test Campaign I	5	17	02-Jan-19	25-Jan-19	31-Jan-19	31-Jan-19		100%	31-Jan-19A	31-Jan-19 A	-3	\$0.00	MIM3 Mirro	Test Campaign I		
LISST ME 19-04.04C.15.02	DM-17099	M1M3 Mirror Test Campaign I Data Analysis	2	11	28-Jan-19	11-Feb-19	31-Jan-19	28-Feb-19		100%	31-Jan-19A	28-Feb-19A	-11	\$0.00	P M103 M	ror Test Campaign I Data Analysis		
LSST ME 19-04.04C.15.02	DM-17404	Finishing Line arStage CSC Development	3	11	02-Jan-19	16-Jan-19	31-Jan-19			6.0%	1110 31-Jan-19A	15-May-19	-83	\$0.00		ishing LinearStage CSC Development		
LSST ME 19-04.04C.15.02	DM-17403	Finishing TunableLaser CSC Development	5	11	02-Jan-19	16-Jan-19	31-Jan-19			90%	1110 31-Jan-19A	15-May-19	-83	\$0.00		tishing TunableLaser CSC Development	1	
LSST ME 19-04.04C.15.02	DM-17251	HNAC Vendor Software Requirements	4	20	02-Jan-19	30-Jan-19	31-Jan-19			13.33%	175 31-Jan-19A	28-May-19	-83	\$0.00	<b></b> ,	NAC Verdor Software Requirements		
LSST ME 19-04.04C.15.02	DM-17198	Finishing DIMM SW Development	- 4	11	02-Jan-19	16-Jan-19	31-Jan-19			66.78%	1116 31-Jan-19A	15-May-19	-83	\$0.00		sishing DIMM SW Development		
LSST ME 19-04.04C.15.02	DM-17178	Finishing MTWEP Algo & SW Dev	10	17	02-Jan-19	25-Jan-19	31-Jan-19			70%	1110 31-Jan-19A	23-May-19	-83	\$0.00		inishing MTWEP Algo & SW Dev		
LSST ME 19-04.04C.15.02	DM-17177	MTWEP+MTOFC SW Int in Tucson	14	11	05-Feb-19	19-Feb-19	31-Jan-19			76.66%	513 31-Jan-19A	15-May-19	-60	\$0.00		TWEP + MTOFC SW Int in Tucson		
LSST ME 19-04.04C.15.02	DM-17468	Align Sys Control Algo & SW Dev	2	17	02-Jan-19	25-Jan-19	31-Jan-19			0%	1110 31-Jan-19A	23-May-19	-83	\$0.00	- <b>-</b>	lign Sys Control Algo & SW Dav		
LSST ME 19-04.04C.15.02	DM-17100	M1M3 Mirror Test Campaign II	5	12	12-Feb-19	28-Feb-19	01-Feb-19	29-Mar-19		100%	01-Feb-19 A	29-Mar-19A	-20	\$0.00	1M3	Mirror Test Campaign II		
LSST ME 19-04.04C.15.02	DM-17312	MTHerapod Seli-off Support	2	20	02-Jan-19	30-Jan-19	01-Feb-19	28-Feb-19		100%	01-Feb-19 A	28-Feb-19A	-19	\$0.00	Milesap	od Sell-off Support		
LSST ME 19-04.04C.15.02	DM-17311	TMA Test Support	9	6	02-Jan-19	09-Jan-19	01-Feb-19			16.66%	241 01-Feb-19 A	08-May-19	-83	\$0.00	- n	4 Test Support		
LSST ME 19-04.04C.15.02	T&SC-7000-0165	TCS Pointing Application - Phase 3 Software Integr	0	233	04-Dec-18	04-Nov-19	01-Mar-19		04-Nov-19	20%	154 01-Mar-19 A	04-Nov-19	0	\$0.00	_	TCS Pointing Application - I	hase 3 Software Integration	
LISST ME 19-04.04C.15.02	DM-17101	M1M3 Mirror Thermal Control Integration	5	20	02-Jan-19	30-Jan-19	01-Mar-19			30%	1107 01-Mar-19 A	28-May 19	-83	\$0.00	⊢===•	11M3 Minfor Thermal Control Integration		
LSST ME 19-04.04C.15.02	DM-17667	Finishing We after Station SW Development	2	11	01-Mar-19	15-Mar-19	01-Apr-19			40%	1116 01-Apr-19A	15-May-19	-43	\$0.00	- <b>-</b> P R	nishing Weather Station SW Development		
LSST ME 19-04.04C.15.02	DM-17668	Testing of Weather Station SW	3	11	18-Mar-19	01-Apr-19	01-Apr-19			19.96%	285 01-Apr-19A	15-May-19	-32	\$0.00	J Te	sting of Weather Station SW		
LSST ME 19-04.04C.15.02	DM-17821	MTAOS SW Dev	2	22	01-Mar-19	01-Apr-19	01-Apr-19			28.67%	166 01-Apr-19.A	30-May-19	-43	\$0.00		ITAOS SW Dev		
LSST ME 19-04.04C.15.02	DM-17723	IOTA CMOS API Dev	4	17	01-Mar-19	25-Mar-19	01-Apr-19			46.67%	267 01-Apr-19A	23-May-19	-43	\$0.00	_ <b>_</b> _×	DTA CMC/SAPI Dev		
LSST ME 19-04.04C.15.02	DM-18309	MTDome Planning & Management	6	22	18-Mar-19	16-Apr-19	01-Apr-19			16.66%	502 01-Apr-19A	30-May-19	-32	\$0.00		TD ome Planning & Management		
LSST ME 19-04.04C.15.02	DM-17515	Unpack & Install M2 controller in Summit computer	4	11	01-Mar-19	15-Mar-19	01-Apr-19			99.83%	336 01-Apr-19A	15-May-19	-43	\$0.00		pack & Install M2 controller in Summit con	nputer room	
LSST ME 19-04.04C.15.02	T&SC-7000-0155	TCS Pointing Application - Phase 2 Software Integr	0	0	17-Od-17	03-Dec-18			30-Nov-18	0%	1127 01-May-19	01-May-19	-101	\$0.00	TC	S Pointing Application - Phase 2 Software	ntegration	
LSST ME 19-04.04C.15.02	DM-17411	Integration of ACICLC Algo & SW	1	6	02-Jan-19	09-Jan-19				0%	1115 01-May-19	08-May 19	-83	\$0.00	- Pine	egration of AOCLC Algo & SW		
LSST ME 19-04.04C.15.02	DM-17410	ACCLC Ago & SW Dev	1	11	02-Jan-19	16-Jan-19				0%	1110 01-May-19	15-May-19	-83	\$0.00		CLC App & SW Dev		
LSST ME 19-04.04C.15.02	DM-17407	Rinkhing of CBP CSC Development	3	11	02-Jan-19	16-Jan-19				0%	1110 01-May-19	15-May-19	-83	\$0.00	- Pa	tishing of CBP CSC Development		
LSST ME 19-04.04C.15.02	DM-17378	Testing of M1M3 Mirror The mail Control	8	20	28-Jan-19	25-Feb-19				0%	1107 01-May-19	28-May-19	-66	\$0.00	- Pı	esting of M1M3 Minor Thermal Control		
LSST ME 19-04.04C.15.02	DM-17179	PhoSim SW Integration	1	6	02-Jan-19	09-Jan-19				0%	1121 01-May-19	08-May-19	-83	\$0.00	) <sup>р</sup> ен	oSim SW integration		
LSST ME 19-04.04C.15.02	DM-18717	M1M3 New Features Development	1	22	01-Mar-19	01-Apr-19				0%	189 01-May-19	30-May-19	-43	\$0.00		#1M3 New Features Development		
LSST ME 19-04.04C.15.02	DM-17200	DIMM + EFD HW Integration	1	6	28-Jan-19	04-Feb-19				0%	1110 16-May-19	23-May-19	-77	\$0.00	. 0 0	IMM + EFD HW Integration	1	
LISST ME 19-04.04C.15.02	DM-17516	M2 Functionality Check with CSC Controller	1	11	18-Mar-19	01-Apr-19				0%	336 16-May 19	30-May-19	-43	\$0.00	- 0,	#2 Functionality Check with CSC Controls	r	
LSST ME 19-04.04C.15.02	DM-18331	M2 Functionality Check with CSC Controller + SAL	0	11	02-Apr-19	16-Apr-19				0%	336 31-May-19	14-Jun-19	-43	\$0.00	- 0	M2 Functionality Check with CSC Control	kers-SAL-pt.1	
LSST ME 19-04.04C.15.02	DM-18449	MainTel Calibration System Integration Tests in Tuo	2	22	07-Mar-19	05-Apr-19				0%	235 06-Jun-19	08-Jul-19	-65	\$0.00	- 5	MainTel Calibration System Integration	Teets in Tucson	
LSST ME 19-04.04C.15.02	T&SC-1502-0000	allSky	0	1	22-JJ#19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>alSky</li> </ul>		
LISST ME 19-04.04C.15.02	T&SC-1502-0010	ADOLO	0	1	22-JJ-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>ADOLC</li> </ul>		
LISST ME 19-04.04C.15.02	TASC-1502-0020	archive r	0	1	22-34-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		- achier		
LSST ME 19-04.04C.15.02	T&SC-1502-0030	CalCS	0	0	22-JJF 19	22-Jul-19				0%	485 24-Jun-19	24-Jun-19	19	\$0.00		<ul> <li>Caldis</li> </ul>		
LSST ME 19-04.04C.15.02	T&SC-1502-0040	CalibrationScreen	0	1	22-JJF 19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>CalibrationScreen</li> </ul>		
LSST ME 19-04.04C.15.02	T&SC-1502-0050	camera	0	1	22-34-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		- cemera		
LISST ME 19-04.04C.15.02	TASC-1502-0060	aldrup Archiver	0	1	22-34-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>outdrup Archiver</li> </ul>		
Lass / ME 19-04.04C.15.02	1 &SC-1502-0070	UMM Demo	0	0	22-JJ-19	22-JUF19				0%	485 24-Jun-19	24-Jun-19	19	\$0.00		DIMM		
LOD / ME 19-04.04C.15.02	radC-1502-0080	USING STOLEN	0	0	22-339-19	222-208-119				0%	+d6 24-Jun-19	24-Jun-19	19	\$0.00		- Dome		
Lop / ME 19-04.04C.15.02	1 a/sC-1502-0090	EEG	0	1	22-34-19	23-34-19				0%	ed5 24-Jun-19	25-Jun-19	19	\$0.00		- EEC		
LISST ME 19-04.04C.15.02	TASC-1502-0100	EMCS	0	1	22-34-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		- BACS		
Last ME 19-04.04C.15.02	1 &SC-1502-0110	975	0	1	Z2-JA-19	23-Jul-19				0%	465 24-Jun-19	25-Jun-19	19	\$0.00		GPG	1	
LISST ME 19-04.04C.15.02	1850-1502-0120	Guider	0	1	22-30-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		Guider		
Loo / ME 19-04.04C.15.02	1 a:SC-1502-0130	neader service	0	1	22-34-19	23-308-19	-			0%	ed5 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>headerService</li> </ul>	1	
L3S1 ME 19-04.04C.15.02	1850-1502-0140	newapod	0	1	22-JJ-19	23-JU-19				0%	485 24-Jun-19	20-Jun-19	19	\$0.00		<ul> <li>hexapod</li> </ul>		
L351 ME 19-04.04C.15.02	1850-1502-0150	NIA	0	0	22-30-19	22-JU-19				0%	485 24-Jun-19	24-Jun-19	19	\$0.00		- IOTA		
L351 ME 19-04.04C.15.02	1 &SC-1502-0160	LaserTracker	0	1	22-Jul-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>LaseTracker</li> </ul>		
Lop / ME 19-04.04C.15.02	1 a:SC-1502-0170	minu	0	0	22-34-19	222-308-19				0%	ed5 24-Jun-19	24-Jun-19	19	\$0.00		- mind		
Las / ME 19-04.04C.15.02	1 &SC-1502-0180	mone	0	1	ZZ-JAF 19	23-Jul-19				0%	465 24-Jun-19	25-Jun-19	19	\$0.00		· m2ms	1	
L351 ME 19-04.04C.15.02	1850-1502-0190	MIMOUR	0	0	22-33-19	22-JU-19				0%	485 24-Jun-19	24-Jun-19	19	\$0.00		<ul> <li>MTMount</li> </ul>		
Los / ME 19-04.04C.15.02	1 adC-1502-0200	Paning_onponent	0	1	22-34-19	20-308-19	-			0%	ed5 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>PointingComponent</li> </ul>	1	
LISST ME 19-04.04C.15.02	TASC-1502-0210	Hotator	0	1	22-34-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		<ul> <li>Rotator</li> </ul>		
LSST ME 19-04.04C.15.02	T&SC-1502-0220	scheduler	0	1	22-JA-19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		- scheduler		
LSST ME 19-04.04C.15.02	T&SC-1502-0230	TCS	0	1	22-JJ#19	23-Jul-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		- TCS		
LISST ME 19-04.04C.15.02	TASC-1502-0240	taOFC	0	1	22-34-19	23-34-19				0%	485 24-Jun-19	25-Jun-19	19	\$0.00		+ telOFC		
Los F ME 19-04.04C.15.02	1 a/sC-1502-0250	100W UP	0	1	22-34-19	23-Jul-19				0%	465 24-Jun-19	20-Jun-19	19	\$0.00		torWEP	1	
L3S1 ME 19-04.04C.15.02	1850-7000-0170	Phase 3 Software Integration Payment	0	1	05-Nov-19	05-Nov-19				0%	149 05-Nov-19	00-Nov-19	0	368,124.76		Phase 3 Software Integral	on Payment	
	1ASC-2000-2025	TCIS Pointing Application - Test Readness Preparal	0	58	05-Nov-19	03-Feb-20				0%	154 06-Nov-19	03-Feb-20	0	\$0.00	· ·	TCS Pointing App	cation - Test Readiness Preparation	



LTS-928

	AdivityID	Activity Name	Advity	Triginal Duration	BL Project Star	t BL Project Fini	sh Adual Start	Actual Finish	Expected Finish	Physical To	tal Roat Start	Finish	Variance - BL B	udgeted Material	FY2019	FY2020	FY2021	FY202
			Step							%			Project Finish	Cost	2018-10-01	2019-10-01	2020-10-01	2021-10
SST ME 19-04.04C.15.02	T&SC 7000-2035	FinalAcceptance Preparation	0	40	04-Feb 20	31-Mar-20				0%	154 04-Feb-20	31-Mar-20	0	\$0.00		Final Acceptance	Preparation	
SST ME 19-04.04C.15.02	T&SC-7000-2040	FinalAcceptance Review	0	1.	01-Apr-20	01-Apr-20				0%	148 01-Apr-20	01-Apr-20	0	\$68,5 50.00		Final Acceptance	Review	
SST ME 19-04.04C.15.02	T&SC-1502-250	Replan Planning Pack age Budget	0	1	20-34-20	20-Jul-20				0%	76 20-Jul-20	20-Jul-20	0	\$624,091.00		Reci	in Planning Package Budget	
T ME 19-04.04C.15.03 Au	xillary Telescope Softwa	re	179	297	02-Jan-19	09-Dec-19	31-Jan-19				913 31-Jan-19A	06-Mar-20	-60	\$0.00				
SST ME 19-04.04C.15.03	DM-16914	AuxTel Pnoumatics & Pointing Configuration Integrs	4	22	26-Apr-19	27-May-19	31-Jan-19			39.92%	163 31 Jan-19A	30-May-19	-3	\$0.00	Autoli	Insumation & Pointing Configuration In	egration in Tucson	
SST ME 19-04.04C.15.03	DM-16910	Prepare Tucson Integration & Test Environment	15	11	15-Jan-19	30-Jan-19	31-Jan-19			25.03%	163 31-Jan-19A	15-May-19	-74	\$0.00	Proam 1	istano Internation & Text Environment		
SST ME 19-04.04C 15:03	DM-16906	Brithing ATDome Agorithm	8	22	15-Jan-19	14-Feb-19	31-Jan-19			73,28%	111 31-Jan-19A	30-May-19	-74	\$0.00	Estable	ATOmes Alexides		
95T ME 19-04 04C 15 09	DM-10912	Enishing ATLies and Alexandre	10	99	15. Jun. 19	14-Eab-19	91- Jac-19			66.6.2%	1105 21-Jan-19A	20 May 19	-74	\$0.00	Estable	A This second him offers		
OUT ME 10-04 OIC 15 00	DM-1001L	Existing AT Does smaller All colline		40	15 km 10	12.Mar. 10	21- Jac-10	21. Jan.10		50.02.10	21-Jac-10.4	21. he 10 A	- 14	10.00	Contract of Contract	in the spoor ago in the		
PET ME TO OLOHO, TE CO	D14 10000	Existing ATLAND Also other		40	18 he 10	13 Mar 10	31 km 10	STORFIG		E3.0V	10792 31 Jan 10.4	0F. km 10		80.00	- Printigaline	Conside Approxim		
201 NE 19-04.040 IE 00	DM 10040	Painting AT Reading Allow March 19			10-Jan 10	10 Arr 10	31-Jan 10			50.74%	FI DI LINE FOA	20 34 10		50.00	Pege	ing AT MC 5 Agon I m		
381 ME 19-04.04C.15.03	DM-16943	Hindhing All Honong Agorithm	0	60	10-381-19	10-Apr-19	31-386-19			59.76%	51 31 Jan-19A	24-30-19	-74	\$0.00	Pr Pr	ishing ATPointing Algorithm		
2851 ME 19-04.04C.16.03	DM-16920	Aux fel Scripts Development	47	40	15-Jan-19	13-Mar-19	31-Jan-19			64.44%	1087 31 Jan-19A	25-Jun-19	-74	\$0.00	Auto	el Scripts Development		
.SST ME 19-04.04C.15.03	DM-17182	FinishingATWhiteLightSource SW Development	4	17	15-Jan-19	07-Feb-19	31-Jan-19			90%	1110 31 Jan-19A	23-May-19	-74	\$0.00	Brishing	ATWhiteLightSource SW Developme	4	
SST ME 19-04.04C.15.03	DM-17406	Integration of TunableLaser CSC	7	6 1	02-Jan-19	09-Jan-19	31-Jan-19			60%	168 31-Jan-19A	08-May-19	-83	\$0.00	integration	d TunableLaser CSC		
SST ME 19-04.04C.15.03	DM-17286	SAL port for Raspberry PI based AuxTel EAS Sen or	2	20	02-Jan-19	30-Jan-19	31-Jan-19	30-Apr-19		10.0%	31-Jan-19A	30-Apr-19 A	-62	\$0.00	SAL port to	r Ranpberry Pibased AuxTel EAS Ser	sorbox	
SST ME 19-04.04C.15.03	DM-16913	AuxTel Mount Control & Pointing Integration in Tuca	7	11	15-Jan-19	30-Jan-19	01-Feb-19			39.97%	1096 01-Feb-19 A	15-May-19	-74	\$0.00	AuxTel M	ount Control & Pointing Integration in 1	uceon	
SST ME 19-04.04C.15.03	DM-16908	Finishing ATDome Trajectory Algorithm	3	22	15-Jan-19	14-Feb-19	01-Feb-19			40%	1094 01-Feb-19 A	30-May-19	-74	\$0.00	Finishing	ATDome Trajectory Algorithm		
SST ME 19-04.04C.15.03	DM-16945	Finishing ATAOS Algorithm	2	22	15-Jan-19	14-Feb-19	01-Feb-19			20%	1094 01-Feb-19 A	30-May-19	-74	\$0.00	- Freisbirg	ATAOS Aborithm		
SST ME 19-04.04C.15.03	DM-17405	Integration of LinearStage CSC	3	6 1	02-Jan-19	09-Jan-19	01-Feb-19			28.65%	168 01-Feb-19 A	08-May-19	-83	\$0.00	integration	of LinearStage CSC		
SST ME 19-04.04C.15.03	DM-17184	ATThermoele dricCooler SW Development	4	11	15-Jan-19	30-Jan-19	01-Apr-19			10%	1116 01-Apr-19A	15-May 19	-74	\$0.00	AT Dem	wiedric Cooler SW Development		
SST ME 19-04.04C.15.00	DM-17851	Finishing AT Spectrograph Algorithm		6	11-Apr-19	18-Apr-19	01-Apr-19			60%	1116 01-Apr-19A	08-May-19	-14	\$0.00	Ereting A	Eleventrow and Aleveltron		
SST ME 19-04.04C 15:03	DM-18010	ATMon odyromator SW Development	3	6	11-Apr-19	18-Apr-19	01-Apr-19			60%	1116 01-Apr-19A	08-May-19	-14	\$0.00	ATMoort	manator SW Development		
SST ME 19-04.040 15:00	DM-18597	Bestrometer (Au/Tell SW Development	7		11-Arr-19	25-Arr-19	01-400-10			9.995	1116 01-64-194	15 May 19		\$0.00		Charles and Consequences		
99T ME 19-04-040-15-00	Data seaso	Austral Collection Dates Internation To The Toront			10 Mars 10	10-hp-10	01-844.00			10.000	106 01-Apr 10A	29. Mars 12		40.00	Electrome	Inter (Annual State Development		
	011 (011)	num o una ason ayaam integration reats in Tucat	4	17	au-4829-19	-2-201-12	01-Apr-19			19.99%	-00 01-Mpr-19A			90.00	Auxed	watchasion System integration Tests i	190801	
351 ME 19-04.04C.15.03	UM-1/888	Pupper Liepic yment or Austiliary Tele scope Compon	17	22	11-Apr-19	10-May-19	01-Apr-19			0.01%	1105 01-Apr-19A	30-May-19	-14	\$0.00	Puppet	Deployment of Auxiliary Telescop e Cor	ponents	
351 ME 19-04.04C.15.03	DM-17408	integration of CBP CSC	1	6 1	02-Jan-19	09-Jan-19				0%	168 01-May-19	08-May-19	-83	\$0.00	integration	d CBPCSC		
251 ME 19-04.04C.15.03	DM-10915	Aux fet Dome Ponting Control Test in Tucson	2	11 :	31-Jan-19	14-Peb-19				0%	163 16-May 19	30 May 19	-74	\$0.00	- AuxTell	Origine Pointing Control Test in Tucson		
SST ME 19-04.04C.15.03	T&SC-1503-0000	at/OS	0	1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.00	icks		
SST ME 19-04.04C.15.03	T&SC-1503-0010	atArchiver	0	1 3	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	نه ا	k driver		
SST ME 19-04.04C.15.03	T&SC-1503-0020	atBuilding	0	1 :	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1 · at	Nilding		
SST ME 19-04.04C.15.03	T&SC-1503-0030	atCalbration_Electrometer	0	1 1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.85	albration Electrometer		
SST ME 19-04.04C.15.03	T&SC-1503-0040	atCamera	0	1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.00	Comora		
SST ME 19-04.04C.15.03	T&SC-1503-0050	At Dome	0	1 3	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.8	Dame		
SST ME 19-04.04C.15.03	T&SC-1503-0060	atFiberSpectrometer	0	1 1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.00	Her Stort constar		
SST ME 19-04.04C.15.03	T&SC-1503-0070	ati-leader Service	0	12	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun 19	19	\$0.00	1.5	Index Service		
PPT ME TO OLO IC TE OD	T100 1500 0000	at theread	0		22. 14.10	22.14.10	-				947 04 km 10	26. km 10	10	#0.00	1.1.1	the second second		
DET ME IN ON ONC IS ON	T400 1500 0000				00 hd 10	00 14 10					047 Of her 10	Of 1= 10	10	60.00	112	- in the second s		
00T NE 19-04.040.10.00	7400 (500 000)	attenter	0		22-34-19	23 44 19				0%	347 2400F19	25 347 19	10	80.00		410		
201 ME 19-04.040.10.03	7400-1503-0100	androstomator	0		22-309-19	23-309-19	-			0%	347 2430919	25-301-19	19	\$0.00	1.80	Agnodiromator		
351 ME 19-04.04C.15.03	1450-1503-0110	aption match	0		22-30-19	23-30-19				0%	347 24-305-19	25-Jun-19	19	\$0.00	- 25	heumatics		
351 ME 19-04.04C.15.03	T&SC-1503-0120	as-oneng-omponent	0	1	22-30-19	23-JU-19				0%	347 24-Jun-19	20-301-19	19	\$0.00		bentingComponent		
381 ME 19-04.04C.16.03	1880-1909-0130	allscheduler	0	1	22-30-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	- 45	kheduler		
.SST ME 19-04.04C.15.03	T&SC-1503-0150	atTCS	0	1	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	- af	rcis		
SST ME 19-04.04C.15.03	T&SC-1503-0160	afWhite-LightChiller	0	1 :	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	- at	Wite LightChiller		
SST ME 19-04.04C.15.03	T&SC-1503-0170	afWhite-LightSource	0	1 3	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1. 25	Viste LightSource		
SST ME 19-04.04C.15.03	T&SC-1503-0180	08P	0	1	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1 · a	P		
SST ME 19-04.04C.15.03	T&SC-1503-0190	PhotoDiodes	0	1 3	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1. Ph	othDiodes		
SST ME 19-04.04C.15.03	T&SC-1503-0210	TunableLaser	0	1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1 · Tu	nableLaser		
SST ME 19-04.04C.15.03	T&SC-1503-0220	WhiteLightSource	0	1 1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1. w	tel.ightSource		
SST ME 19-04.04C.15.03	DM-18445	AuxTel 1st Light Integration	2	17	08-Apr-19	30-Apr-19				0%	1048 26 Jun-19	19-Jul-19	-57	\$0.00	_ C A.	Tel 1st Light Integration		
SST ME 19-04.04C.15.03	DM-18698	Finishing FibreSpectrograph (AuxTe) SW Develop	6	22	11-Apr-19	10-May-19	-			0%	51 25-Jul-19	23-Aup-19	-74	\$0.00	1 .	Finishing EtraSpectrograph (AusTell	SW Development	
SST ME 19-04.04C.15 09	DM-18441	Spectrograph On-Sky Integration		17	17-04-19	11-Nov-19	-			0%	172 16-Jap-90	10-Feb-20	.00	\$0.00	т –		bitemation (	
SST ME 19-04.04C 15:03	DM-18443	AurTei On-Skyw/ Shedrograph - Scheduler Intera	2	17	11-Nev-19	05-Day 19				0%	172 11-Feb-20	05-Mar-20	-60	\$0.00		- Specrograph On S	Country and a Colorad day below of	
99T ME 19-04 040 17 00	TESC. (509-0140	attractionsh	-		01-Dec-19	00-Dec 10				0%	172 00.44 00 00	00.Mar.01		\$0.00		- Astaron-skyw	sherror Areas a respected to the data	-
	Table 1909 0140	angeve og alphi	0	0		00.000.10	-			0%	.75 00mmar/20		-00-	00.00		atspectrograph		
	1000-0200	an of the second	0	1	00-J80-19	00.1410	84 he (**			0%	1/2 00-Million 20	01 kd 10	-00-	\$0.00		<ul> <li>SED Spedrograph</li> </ul>		
st ME 19-04.04C.15.04 Tel	escope sontware infrast	nucture	70	187	02-Jan-19	23-JU-19	31-Jan-19				1063 31 Jan-19A	01-Jul-19	15	\$0.00	-			
251 ME 19-04.04C.15.04	DM-17150	sw intrastructure support for M1M3 Mirror Test Ci	4	6 1	02-Jan-19	09-Jan-19	31-Jan-19	20 Peb-19		100%	31 Jan-19A	20-Peb-19A	-33	\$0.00	SW Infrastructure	Support for M1M3 Mirror Test Camp	algn I	
251 ME 19-04.04C.15.04	DM-17218	Middeware SW Development	47	17	02-Jan-19	25-Jan-19	31-Jan-19			28.89%	1110 31 Jan-19A	23-May-19	-63	\$0.00	Middew	are SW Development		
SST ME 19-04.04C.15.04	DM-17151	SW Infrastructure Support for M1M3 Mirror Test Ci	2	3	10-Jan-19	14-Jan-19	01-Feb-19	29-Mar-19		100%	01-Feb-19 A	29-Mar-19A	-61	\$0.00	SW Infrastruc	tule Support for M1M3 Mirror Test Ca	hpaign II	
SST ME 19-04.04C.15.04	DM-18555	EFD In trastructure Development & Integration	17	44	11-Apr-19	11-Jun-19	01-Apr-19			34.98%	155 01-Apr-19A	01-Jul-19	-14	\$0.00	ELD ELD	infrastructure Development & Integral	on	
SST ME 19-04.04C.15.04	T&SC-1504-0000	OCS_OCS_Bridge	0	1 3	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.00	S OCS Bridge		
SST ME 19-04.04C.15.04	T&SC-1504-0010	EFD_Science Platform	0	1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.BF	D Science Platform		
SST ME 19-04.04C.15.04	T&SC-1504-0020	eldTransform ation/Service	0	1 1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00		Transform atonService		
SST ME 19-04.04C.15.04	T&SC-1504-0030	008	0	1.1	22-Jul-19	23-Jul-19				0%	347 24-Jun-19	25-Jun-19	19	\$0.00	1.0	3		
SST ME 19-04-04C 15:04	TASC 1504-0040	Ouna	0	1	22-34-19	23-Jul-19				0%	347 24-Jun-19	25-Jan 19	19	\$0.00	1.0	1		
SST ME 19-04-04C 15-04	TASC 1504-0050	WEP Server	0		22.14.19	23-14-19	-			0%	347 24-km-19	25.km 19	10	\$0.00	1	ER Sener		
T MI 19-04 040 15 05 TH	ascone and Site Softwa	ra Quality Assurance	85	414	17. bo. 19	24-14-20	14-10-19			0,4	750 14-140-19.8	09-04-20	-54	\$0.00				
OUT ME 19-04 ONC 15 OF	DM 10921	Test Aux Tel Scribts			14.Mar.19	28 Mar. 17	14-34-10			60%	292 14 Jac 10 1	15.May 12		50.00	Trad in the	-		
997 ME 19-04.040.15.05	DAL 10021	Text AT Deleting Alexandree		11	11-Acc-10	10-Mar-10	14-Jan 19			607%	1110 11-Jan 10-1	15 May 19	-34	\$0.00	Test Aux	aloraha		
DOT ME 19-04.040.15.05	DA4 17140	Testing of ATMANING Interference (194	7	11	08 Eat 10	10-Mpt-19	31-Jan-19			03.0%	10 31 Jan 19A	-3-May-19	- :4	\$0.00	Test ATPo	ining Agorithm		
-con ME 19-04.040.15.05	um 17163	ready on a write great our of a w	8	6 1	ve-r/60-19	-1-1-80-19	31-Jan-19			6075	12/ 31 Jan-19A		-67	\$0.00	Testing of	ArwinteLightSource SW		
SST ME 19-04.04C.15.05	DM-17215	Middeware Testing Process & Infrastructure	25	17 :	28-Jan-19	19-Feb-19	31-Jan-19			46.66%	1110 31 Jan-19A	23-May-19	-66	\$0.00	Middlews	are Testing Process & Infrastructure		
SST ME 19-04.04C.15.05	DM-16917	Test AT Hexapod Algorithm	2	11	15-Feb-19	04-Mar-19	01-Feb-19			40%	1116 01-Feb-19 A	15-May-19	-62	\$0.00	Test ATH	sdepod Algorithm		
SST ME 19-04.04C.15.05	DM-17180	MTWEP Algo & SW Testing	5	6 :	28-Jan-19	04-Feb-19	01-Feb-19			46.67%	1121 01-Feb-19 A	08-May-19	-66	\$0.00	MTWEPA	ligp & SW Testing		
												_						

5 Testing of ATThermoelectricCooler SW			ac index smil	BL Project Hinish	Adual Start	Adual Finish P	20pected Finan	Pripa Call	ous Hous dust	Finish	Vatance - BL	Boogenoc materia	FY201		F #2020	1 table 1	22.2
Trains of PARA DW			21. hm 10	07.Ech 10	01-8			5	1977 OI 4mm 10.4	OR Mars 10	Project Pinish	Cost	2018-10	01	2019-10-01	2020-10-01	2021-10-
			57-341-19	07-100-10	01-04-10			40%	127 01944-184	00-14-10	-00	40.00	· =	testing of	A ThermoelectridCooler SW	1	
Testing of Destruments (AurTub PM			17-Jan-19	25-385-19 03 May 10	01-Apr-19			19.96%	1115 ULAP-19A	08-May-19	-72	\$0.00	- 2	Testing of	DIMM SW		
3 Testing of laedroniveer (Autrie) SW			28-Apr-19	03-May-19	01-Apr-19			0.2%	1122 01-Apr-19A	08-May-19	-3	\$0.00		Testing of	Electrometer (AuxTel) SW	1	
8 TestAl Pneumatics Algorithm	1	11	14-Mar-19	28-Mar-19				0%	292 01-May-19	15-May-19	-34	\$0.00	-	Test ATPs	esmatics Algorithm		
3 Testing of Align Bys Control SW	1	6	31-Jan-19	07-Peb-19				0%	1121 01-May-19	08-May-19	-63	\$0.00	•	Testing of a	Mgn Sys Control SW		
2 Testing of AT Spectrograph Algorithm	1	6	18-Apr-19	25-Apr-19				0%	1116 08-May-19	15-May-19	-14	\$0.00		Testing of	AT Spectrograph Algorithm	1	
d Testing of ATMonochromator SW	1	6	18-Apr-19	25-Apr-19				0%	1116 08-May-19	15-May-19	-14	\$0.00		Testing of	A Monochromator SW		
.7 TestATD ome Algorithm	0	11	18-Feb-19	05-Mar-19				0%	111 31-May-19	14-Jun-19	-73	\$0.00	-	Test.Al	Come Agorithm	1	
.9 TestATD omeTrajectory Agorithm	1	11	15-Feb-19	04-Mar-19				0%	1094 31-May-19	14-Jun-19	-74	\$0.00	-	TestAT	DomeTrajectoryAlgorithm		
4 TestATAOSAigorithm	1	11	15-Feb-19	04-Mar-19				0%	1094 31-May-19	14-Jun-19	-74	\$0.00	-	Test AT	AOS Algorithm	1	
.8 Testing of M1M3 New Features w' Simulator in T	x 2	22	02-Apr-19	01-May-19				0%	189 31-May-19	01-Jul-19	-43	\$0.00	_	Testin	of M1M3 New Features w/ Simula	der in Tusson	
2 Testing of MTAOS SW	1	11	02-Apr-19	16-Apr-19				0%	166 31-May-19	14-Jun-19	-43	\$0.00	-	Testing	MINOSSW		
1 TestATMCS Apolithm	8	11	14-Mar-19	28-Mar-19				0%	1076 26-Jun-19	11-34-19	-74	\$0.00	-	Test	ATMCS Algorithm	1	
79 Testing of FibreSpectrograph (AuxTel) Algorithm	2	11	13-May 19	27-Mpr-19				0%	51 26-Aug-19	10-Sep 19	-74	\$0.00		_ 0	Testing of EtraSpectrograph (Aut)	Tel Anythm	
401-50 QA - FY 19 - Labor	0	49	22-34-19	30-Sep-19				0%	47 11-Sep-19	22-Nov-19	-37	\$0.00			CALEY 19. Later		
44 KOTA CMOS ARI Testino			05.Mar.10	01-800-19				0%	165 17-0-1-19	24-04-19	-146	\$0.00		_	E INTACINOS AN TIME	1	
(01.70 OA.EV.90. Labor		100	01-04-19	07-14-20				014	47 29 Nov 19	27.400.00	- 140	50.00			- Infrideoster fready		
11 Mill East discally Charle with COC Controller - 91		100	02.14.20	24-14-20				01/0	18 17.000-10	00.04.20		80.00				QA- PT 20 - Labor	
			02-30-20	24-00-20				0.0	in ironyau	00-00-20	-04	40.00				M2 Fundsonality Check with CSU	Controller + SAL -
d Site Software Build	5	364	02-Jan-19	07-Jul-20	31-Jan-19				105 31-Jan-19A	09-Jun-20	20	\$0.00	_		1	1	
8 Update TSSW CI Infrastructure	5	17	02-Jan-19	25-Jan-19	31-Jan-19	28-Feb-19		10.0%	31-Jan-19A	28-Feb-19A	-22	\$0.00	- Upo	ate TSSW C	Infrastructure	1	
31-50 Software build PY 19 - Labor	0	49	22-Jul-19	30-Sep-19				0%	102 24-Jun-19	30-Aug-19	19	\$0.00		_	Software build FY 19 - Labor	1	
.01-80 Software build PY 20 - Labor	0	186	01-Od-19	07-Jul-20				0%	102 02-Sep-19	09-Jun-20	19	\$0.00			Soft	ware build FY 20 - Labor	
or Visualization Environment (LOVE)	0	164	02-Nov-18	07-Jun-19	01-Jun-17				345 01-Jun-17A	26-Jun-19	-13	\$445,590.00			1	1	
.0 INRA Contract phase 1 - workshop 1	0	22	02-Nov-18	03-Dec-18	01-Jun-17	01-Jul-17		10.0%	01-Jun-17A	01-Jul-17 A	362	\$29,335.00	<b>FIA</b> Contr	at phase 1 -	workshop 1	1	
.0 INPEA Contract phase 1 - Interfaces Integration to	8 O	67	04-Dec-18	13-Mar-19	01-Nov-17	31-Jan-18		10.0%	01-Nov-17 A	31-Jan-18 A	282	\$28,325.00	N	RIAContract	phase 1 - interfaces integration to tell	enetry simulators	
0 INRIA Contract phase 1 - workshop 2	0	21	14-Mar-19	11-Apr-19	01-Mar-18	16-Mar-18		10.0%	01-Mar-18 A	16-Mar-18A	272	\$28,325.00	-	NRIAContra	of phase 1 - workshop 2		
INFIA Contract phase 1 - review of deliverables	0	41	12-Apr-19	07-Jun-19				0%	345 01-Mar 19	26-Jun-19	-13	\$359.605.00		NR/	Contract phase 1 - molecu of debury	where a	
ad Site Software Integration and Test	67	485	08-Feb-19	05-Nov-20	01-Mar-19				683 01-Mar-19-A	01-Feb21	-57	\$0.00			1	-	
2 Test ATD one Aborthm w/ Hardware		20	11-Mar-19	05-Apr-19	01-Mar-19			59.98%	303 01-Mar-19-A	28-May 19	-37	\$0.00	_	True ATT	Alternatives of Mandatana	1	
Test #Till express films (then an id and annea		90	05-Mar.19	01-800-19	01-Mar-19			10.00%	202 01.Mar. 19.8	28.Mm.19	-41	\$0.00		True ATL	the registration of the store		
4 Test & Descention Algorithm of Marchance		20	20-Mar-10	15 Apr 10	01-140-10			000	202 10 Mar 19	12. km-10	-14	80.00	_	Tut			
		200		20100				0.0	and cold of	12-341-10		40.00	_	C INCA	rieunaus Agonam w/ Haroware	1	
5 Teachas tel sorpei w Hardware	1	20	29-102-19	25-Mpr-19				0%	202 10-MBy-19	12-305-19	-34	\$0.00	-	Test Au	x3el Scripts w Hardware		
Z Auter Caloration System Integration Tests In Chil	3 2	22	19-301-19	22-30-19				0%	100 23-May-19	24-301-19	19	\$0.00		Au Au	the Calbration System Integration Te	sts in Chile	
3 Aux tel & (Closed) Dome Pointing Control test in	1 2	11	28-May-19	11-Jun-19				0%	163 31-May-19	14-Jun-19	-3	\$0.00		AuxTel	4 (Closed) Dome Pointing Control 3	et in chile	
3 Aux Tel Pneumatics & Pointing Configuration Integ	4 2	20	28-May-19	24-Jun-19				0%	292 13-Jun-19	11-348-19	-12	\$0.00		- Aux	Fel Pneumatics & Pointing Configurat	tion Integration in Chile	
.0 AuxTel Mount Control & Pointing Integration in Ch	k 2	20	08-Feb-19	08-Mar-19				0%	1067 26-Jun-19	24-33-19	-97	\$0.00	-	Au Au	Kel Mount Control & Pointing Integra	ation in Chile	
A MainTel Calibration System Integration Tests in C	<b>d</b> 2	22	08-Apr-19	07-May-19				0%	235 09-Jul-19	07-Aug-19	-65	\$0.00	-	. • .	IninTel Calibration System Integration	rifects in Chile	
2 Support EAS instrument Site Testing	2	90	27-May-20	30-Sep-20				0%	206 06-Sep-19	16-Jan-20	181	\$0.00				Support EAS instrument Site Test	9
3 Support M1M3 cell and surrogate mirror test with	p 2	19	03-Feb (20	27-Feb-20				0%	84 11-Oct-19	06-Nov-19	75	\$0.00			Support M1M3 ce	and surrogate mirror test with coatin	g chamber
9 Testing of M1M3 New Features w/ Hardware in (	h 2	15	23-Mar-20	10-Apr-20				0%	84 02-Dec 19	20-Dec-19	75	\$0.00			Testing of M11	M3 New Features w/ Hardware in Ch	
2 Spectro graph On-Sky Commissioning	2	22	18-Dec-19	23-Jan-20				0%	862 18-Mar-20	16-Apr-20	-60	\$0.00			- Spectrograph	Dry Sky Commissioning	
AuxTel On-Sky w/ Spectrograph + Scheduler Cor	. 2	22	25-Feb-20	27-Mar-20				0%	839 20-May-20	18-Jun-20	-60	\$0.00			- Autor	On-Sky w/ Spectrograph + Schedule	Commissioning
17 Support for M2 Hexapod System Ready for Integ	a 3	13	30-Sep-19	16-Oct-19				0%	15 01-Jun-20	17-Jun-20	-168	\$0.00			Support	tion M2 Herapod System Ready for	retorration
A Support M1M3 Cell w/Surro gate Mirror on TMA?	e 2	30	17-Apr-20	01-Jun 20				0%	-49 07-34-20	17-Aup20	-54	\$0.00				amount M1M3 Cell w Surrorate Minu	on TMA Testing
All Support for M2 Hexapod installation and test on "	N 2	5	16-Jun-20	22-Jun-20				0%	-33 01-Sep-20	08-Sep 20	-55	\$0.00				Exercise for M2 bisecon ordinat adjustion	AMT on test bos
AuxTel 1st Light Commissioning	2	22	24-Jun-20	24-Jul-20				0%	754 17-Sep-20	16-Oct-20	-60	\$0.00				August 1 at Links Commissioning	and tool on these
Parter in ope commonly		10	10 Aug 20	04 Aut 00				01/0	55 00 cr 00	H Mar 20		60.00				Auxie te Light Commissioning	
11 Support MIM 2 Thermal Testing on TMA		60	14-Aug (0)	02 Alore 20				014	-55 19.Nov.20	97. he-21	-67	\$0.00			-		Testing on This
apport MINIS Informal losing on TWA	2		24-7403-20	021100420				0.26	1000 1000 000000	27-397-21	· 2/	90.00			. –	Support M1M3 Therm	In the second s second second seco
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Latest Revision 2019-06-19