GEMMA
Time Domain Astronomy Project Execution Plan

May 8, 2019

C-TDA-003

Issued By:	Arturo Nuñez
Sponsored By:	Andy Adamson
Approved By:	Catherine Blough

Change Log

The purpose of this log is to update the material and to improve the clarity and legibility of the Project Execution Plan. A summary of the changes for this revision is given below. Footers within each section of this document indicate the last revision date of the content in that section, while all page headers in the document include the date and NSF number of the current version of the Major Facilities Guide.

1. Inserted Change Log as new material to reflect edited sections, moved material, deleted material and updated material.

2. Figure 2, was revised to clarify the two levels of oversight of the project and the single reporting point at the top of the project.

3. Section 1.1 - moved the content of original Section 1.5 to here, reducing redundancy at the same time.

4. Section 1.2 - Updated introductory paragraphs to clarify the meaning of “threshold” and “objective”, noting that the requirements are all TDA-specific (not OCS) and stating that we do not anticipate major evolution of these requirements. [addressing NSF question]

5. Section 1.3 - added a statement of the meaning of “Baseline” above the high-level requirements table. [addressing NSF question]

6. Section 1.4.3 - pointed to section 2.5 for more detail on the community input. [addressing NSF question]

7. Section 1.4.3 - Fixed typo. Said: “The TDA project will build upon these developments to meet the science goals laid out in Section 2.1”, but it is section 1.1.

8. Section 2.5 - fleshed out community involvement plan - initial paragraph and subsequent bullet list. [addressing NSF question]

9. Section 3.1 - Update milestone dates in text to match with revised plan. Updated Product Distribution Manager and Real Time Pipelines milestones based on detailed plan available now for these two work packages. Reorder summary schedule description for each TDA product, to match order in which they were introduced. Removed reference to Project Plan as all its content is now part of the main PEP.

10. Section 3.2 - Noted budget and funding source for TDA.

11. Section 3.3 - Described development schedule for TDA.

12. Section 3.4 - Moved “Planning Assumptions and External Dependencies” and “Monitoring and Control” from Project Plan to this section.

13. Section 3.4 - added/modified two paragraphs at the beginning of this section, stating the relationship between staffing in this project and that in the OCS Upgrades. [addressing NSF question].

14. Section 3.5 - Moved “Lessons Incorporated” from Project Plan to this section

15. Section 4.1 - Added summary budget and schedule, originally in reference document Project Plan. Removed product description, as it is a repetition of what was discussed in Section 3.1.

16. Section 4.3 - Revised Dictionary - in particular, added details on Real Time Pipelines (WBS 1.4.5) and Product Distribution (1.4.6).

17. Section 4.4 - Added Scope Management Plan to section 4.4 - originally in reference document.

18. Removed original Section 4.7 Cost Book, Cost Model Data Set and Basis of Estimate, as it is not applicable for TDA, as it is an addition to existing observatory operations. Renumbered following sections to match.

19. Section 4.7 - Updated baseline funding profile due to plan updates. Showing more details of labor cost per WBS up to level 4.

20. Section 4.8 - Updated baseline schedule with updated dates for different work packages. Updated Figure 5 to show updated Gantt Chart.

21. Section 4.9 - Updated Milestones

22. Added section 4.10 and 4.11 to indicate Project Milestones and Tolerances, originally in reference document Project Plan.

23. Section 4.11 - Updated reference to details about scope, as now it is covered in the main PEP and not in a reference document.

24. Section 5.1 - Updated staffing profile (figure 6) due to redistribution of work.

25. Section 5.2 - Updated with expected hiring date of High Level Software engineer.

26. Replaced section 6.1 with Risk Management Plan, so no need for external document.

27. Section 6.2 - Updated to indicate reference to Risk Register in the appendix.

28. Section 6.3 - Describe contingency management approach for TDA.

29. Section 7 - Updated Systems Engineering section to cover specific TDA issues and remove need of external document.

30. Section 8 revised content to refer to new structure for escalation.

31. Removed Section 9 - Acquisitions as TDA doesn't have any. Updated numbers for remaining sections. Section 9 become Project Management Controls

32. Section 10 - Included link to the GEMMA web page where resource documents are stored.

33. Removed Section 11 Site and Environment, as it is not relevant to TDA.

34. Section 12.2 - Updated Acceptance/Operational readiness plan.

35. Removed Section 13 Environmental Safety and Health, as it's not relevant to TDA

36. Added Appendixes in section 14.

Table of Contents

List of Acronyms

Acronym	Definition
AEON	Astronomical Event Observatory Network
ANTARES	Arizona-NOAO Temporal Analysis and Response to Events System
ALeRCE	Automatic Learning for the Rapid Classification of Events
AURA	Association of Universities for Research in Astronomy
CDR	Critical Design Review
CP	Cerro Pachón (the site of the Gemini South telescope)
CSA	Cooperative Support Agreement
DR	Data Reduction
ELT	Extremely Large Telescope
EM	Electromagnetic
ESO	European Southern Observatory
FoV	Field of View
FTE	Full-Time Equivalent
FWHM	Full-Width Half Maximum
GHOST	Gemini High-resolution Optical SpecTrograph
GMOS	Gemini Multi-Object Spectrograph (-S located at Gemini South, -N at Gemini North)
GMT	Giant Magellan Telescope
GN	Gemini North
GNIRS	Gemini Near InfraRed Spectrograph
GW	Gravitational-wave
GS	Gemini South
IRAF	Image Reduction and Analysis Facility
INTEGRAL	INTErnational Gamma-Ray Astrophysics Laboratory
ICD	Interface Control Document
IQ	Image Quality
IR	InfraRed

KPP	Key Performance Parameter
KSR	Key Science Requirement
LCO	Las Cumbres Observatory
LIGO	Laser Interferometer Gravitational-Wave Observatory
LSST	Large Synoptic Survey Telescope
MMA	Multi-messenger Astrophysics
NASA	National Aeronautics and Space Administration
NCOA	National Center for Optical-Infrared Astronomy
NIFS	Near-Infrared Integral Field Spectrometer
NOAO	National Optical Astronomy Observatory
NIR	Near InfraRed
NSF	National Science Foundation
O&M	Operations and Maintenance
OCS	Observing Control System (Gemini operations software)
OIR	Optical and Infrared
PI	Principal Investigator
PM	Project Manager
PMO	Portfolio Management Office
QAP	Quality Assurance Pipeline
rToO	Rapid Target of Opportunity
SOAR	Southern Astrophysical Research Telescope
TDA	Time Domain Astronomy
TMT	Thirty Meter Telescope
TOM	Target Observation Manager (a standard software agent used by many LC science programs)
ToO	Target of Opportunity
TFT	Transient follow-up system
VIS	Visible wavelength region
WBS	Work Breakdown Structure
ZTF	Zwicky Transient Facility

1 Introduction

1.1 Scientific Objectives

On August 17, 2017 the Advanced LIGO and Virgo detectors observed a gravitational wave signal consistent with a neutron star - neutron star merger. The Fermi gamma-ray observatory then detected a gamma-ray burst in the same part of the sky 1.7 seconds later. This led to a massive observing campaign by electromagnetic (gamma rays to radio, including Gemini) and neutrino telescopes. Although no neutrinos were observed, the electromagnetic campaign detected the remains of a "kilonova" explosion that resulted from the merger[1].

One month later, on September 22, 2017 a muon produced by a collision with a 290 TeV neutrino was detected by the IceCube Neutrino Observatory. The neutrino's origin was apparently coincident with a known gamma-ray blazar[2]. Electromagnetic follow-up observations from gamma-ray to radio frequencies were then carried out in response to the IceCube alert. These observations showed that the blazar was in a "flaring" state and showed that blazars can be a source of high-energy neutrinos.

These examples show that we are entering the era of multi-messenger astrophysics (MMA). A "messenger" is any independent form by which we can receive information from astronomical sources. Our current messengers are gravitational waves, neutrinos, high-energy particles (muons, cosmic rays, etc), and electromagnetic radiation. As in the two examples above, combining information from different messengers allows us to understand the nature of the sources and the physical processes involved. In science new technologies and capabilities always lead to new discoveries and the current era has the potential to be very exciting if the resources can be used to their full potential.

The Large Synoptic Survey Telescope (LSST) is currently under construction on Cerro Pachón near La Serena, Chile, and will take MMA and time-domain astronomy (TDA) to the next level. LSST will image the entire visible sky every few nights for ten years in order to identify variable and transient objects and make very deep stacked images[3]. LSST will produce thousands of new alerts every few minutes from variable stars, AGN, solar system bodies, and all varieties of cosmic explosions. It will not be possible to understand the nature of many of these detections from LSST photometry alone, so observations at other electromagnetic wavelengths and, and in some cases also from neutrinos and gravitational waves, will be required.

MMA is one of NSF's Ten Big Ideas. As described above, it combines the results from some of the NSF's major astrophysics facilities in order to elucidate the nature of new and rare events. In response to the NSF-sponsored report by the National Research Council on *Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System*[4] and the NOAO/LSST report on *Maximizing Science in the Era of LSST*[5], NOAO initiated a project to establish a transient follow-up network based on the Las Cumbres Observatory design and incorporating multiple facilities that will be under the forthcoming umbrella of NSF's National Center for Optical-Infrared

1 LIGO and Virgo collaborations, et al. 2017, ApJ, 848, L12 (https://doi.org/10.3847/2041-8213/aa91c9)

2 IceCube Collaboration et al., Science 361, eaat1378 (2018). DOI: 10.1126/ science.aat1378

3 Ivezić, et al. 2008, arXiv:0805.2366

4 https://www.nap.edu/catalog/21722/optimizing-the-us-ground-based-optical-and-infrared-astronomy-system

5 https://www.noao.edu/meetings/lsst-oir-study/

Astronomy (NCOA).

This work aligns Gemini Observatory squarely with NSF priorities. The TDA project will allow Gemini to take a leadership role in this era of MMA and transients. Being among the largest of the optical-infrared (OIR) telescopes, Gemini has an important role to play in the study of fainter transients. Gemini currently observes many transients under its Target-of-Opportunity (ToO) observing mode, but the process is somewhat manual and inefficient. Gemini provides data reduction software for its facility instruments, but some of the steps require manual interaction and will not run in real time. The overall objectives of the TDA project are to:

- Allow Gemini to cope with the expected massive increase in follow-up ToO requests, interrupts and the resulting rescheduling,
- Satisfy user demand for transient follow-up while preserving our ability to support non-transient observational programs
- Ensure that the observatory is efficiently utilized in a wider network of telescopes for transient science in the MMA era

In short, this project will build on and augment the OCS upgrades program and existing developments in data reduction so that Gemini can operate efficiently and provide the most useful data possible. For clarity, TDA does not:

- Provide all of the infrastructure needed by the Gemini observatory control system (OCS) including databases, observation and target models, graphical user interfaces, etc.
- Create an entire follow-up system (see Figure 1 below).
- Create the routines and algorithms needed to reduce the data from Gemini facility instruments.

1.2 Scientific Requirements

The following requirements will achieve the overall objectives listed above and allow Gemini to work within the time domain follow-up system described in Section 1.4. The requirements are based in part on initial user stories developed for the OCS Upgrades Program (see Section 1.4.3) and discussions with AEON participants. To formally succeed, the project should meet the threshold requirement in all cases. Priorities will therefore be assigned only on "Objectives" column, not on "Thresholds". All the scientific requirements listed in the table are TDA specific. The related OCS Upgrades Project provides supporting infrastructure, but nothing specific to these requirements.

We do not anticipate revising these requirements in the near future. However, some of them are dependent on the way in which the follow-up network of telescopes will ultimately function, which in turn depends on ongoing discussions with the Gemini Board and with other observatories. So some changes may be expected in the coming two years.

Description of Scope	Threshold Key Science Requirements	Objective Key Science Requirements

Gemini to automatically accept up to N% of its observing time in the form of unplanned alerts	N=20%	N <= 100%, not limited by the system implementation.
Reduce manual scheduling to simple oversight and occasional human intervention	Manual scheduling time <= 1 person-hour / day / site	Manual scheduling time = 10 min / day
Optimization of a metric	The automatic scheduling system shall create observing plans by maximizing a metric for selecting observations. The metric to be developed includes scientific ranking, matches to conditions, timing constraints, and other considerations consistent with and based on current planning practices.	
Scheduling frequency	The automatic scheduler shall be able to deliver a new schedule to the telescopes on a timescale shorter than 15 minutes, typical of weather changes.	The scheduler shall be able to deliver a new schedule to the telescopes on a timescale shorter than 5 minutes, typical of weather changes on unstable nights.
Scheduling multiple telescopes together	The scheduler shall be able to generate plans for Gemini North and South at the same time and coordinate observations between the two.	The scheduler shall be able to coordinate observations with facilities outside of Gemini
Available components	On a given night the scheduler shall only schedule observations that can be done with available instruments in their current configurations (eg. filters, masks, gratings).	
Weather conditions	At a given moment the scheduler shall only schedule observations that can be executed under the current conditions. The conditions may come from weather sensors, data reduction pipeline measurements, or operator entry.	

Calibrations	The automated scheduler shall schedule the required calibration observations along with the science observations so that the data can be fully reduced within one day.	Whenever possible and appropriate the automatic scheduler shall schedule the required calibration observations before the science observations so that the data reduction pipeline uses the best calibrations and the pipeline/PI does not have to reprocess the data once better calibrations become available.
Forward-look schedules	The scheduler shall be able to project a plan at least 7 days into the future while accounting for weather forecasts and telescope, instrument, and staff calendars.	The scheduler shall be able to project a plan at most 6 months into the future while accounting for weather forecasts and telescope, instrument, and staff calendars, to allow Gemini to simulate an entire semester. It would be desirable for the scheduler to make suggestions about when to install instrument components such as gratings and MOS masks.
Alternative scenarios	The scheduler shall allow an operator to create plans for different scenarios in the future including variations in weather (eg. forecast uncertainties), and changes in instrument configurations.	The scheduler shall allow an operator to create plans for different scenarios in the future including variations in weather (eg. forecast uncertainties), and changes in instrument configurations.
Manually adjustable observation weight	It shall be possible for a human operator to manually adjust the weight of an observation.	
Interrupting Target of Opportunity Triggers	It shall be possible for urgent or interrupting ToOs to automatically interrupt an ongoing observation by applying a set of rules (e.g. an algorithm for determining whether to abort or read out).	
Non-interruptable observations	It shall be possible to set observations with a time-critical or coordinated status that gives very high priority and prevents interrupts.	
Manual control of scheduler	It shall be possible for a human operator to turn off reception of the automated plans so that manual operation can be performed.	

Target of Opportunity Requests	It shall be possible for external users to request ToO (targets not defined in the proposal) observations using either a user interface (UI) or application programming interface (API)	It shall be possible to request ToO (targets not defined in the proposal) observations using either a user interface (UI) or application programming interface (API) that are common to all AEON members.
Telescope status API	It shall be possible for external users to request telescope open status, weather conditions, ToO status (accepting?), and instrument configurations for Gemini using an API.	It shall be possible to request telescope open status, weather conditions, ToO status (accepting?), and instrument configurations from Gemini, SOAR, and other AEON members via a common API.
Scheduler/Telescope API	There shall be APIs to receive status information (e.g. open/closed, weather conditions, execution status) and for the scheduler to send the schedule to each telescope node (e.g. Gemini sequence executors) .	The APIs shall be common to AEON in order to support multiple telescopes.
Real-time spectroscopic pipeline	There shall be a real-time longslit spectroscopic reduction pipeline for at least one of Gemini's legacy spectrographs (e.g. existing, pre-GHOST, instruments such as GMOS and GNIRS, the priority is GMOS) that will produce an extracted, wavelength calibrated spectrum within 30 minutes of the end of readout for 10 raw frames.	There shall be a real-time spectroscopic reduction pipeline for **all** of Gemini's legacy spectrographs that will produce an extracted, wavelength calibrated spectrum within 5 minutes of the end of readout for 10 raw frames.
Real-time imaging pipeline	There shall be a real-time imaging reduction pipeline for at least one of Gemini's legacy imagers that will produce a flat-fielded, stacked image and a photometry catalog within 1 hour of the end of readout for 50 raw frames.	There shall be a real-time imaging reduction pipeline for **all** of Gemini's legacy imagers that will produce a flat-fielded, stacked image and a photometry catalog within 1 hour of the end of readout for 50 raw frames.
Reduced data in the Gemini Observatory Archive	It shall be possible for external users to download raw and reduced data from the Gemini Observatory Archive using an API within 5 minutes of the end of readout (raw) or the completion of the reduction (processed).	

Target Observation Manager Plugin	Gemini shall provide a plugin for the TOM Toolkit to make it easier for external users to use the Gemini/AEON APIs to request observations, check status, and download reduced data products from the Gemini Observatory Archive.	The TOM toolkit plugin shall include a way to connect to a service that can push data and data products to the user.

1.3 High Level Requirements

The following table lists the highest-level requirements on the three fundamental systems for TDA. "Baseline" values set the minimum top-level requirement. We may exceed these statements in various ways, but we must at least meet them.

Parameter	Baseline Value
Application Program Interface	It shall be possible to send observation requests, receive status, and retrieve data via an application or script, and without the need for a manually driven interface.
Automated scheduling	An algorithm running in an application must be able to automatically generate telescope schedules that maximize a quality metric in less than 15 minutes.
Real-time data reduction	Data for at least one legacy imager and one legacy longslit spectrograph must be reduced automatically on the night in which it is taken.

1.4 Facility/Infrastructure

1.4.1 Overview

As noted above, our response to the challenge of time-domain astronomy in the LSST era is to incorporate Gemini into a wider network of telescopes (the Astronomical Event Observatory Network, or AEON), covering multiple apertures and capabilities. Figure 1 gives a schematic of the working model for the complete follow-up system, based on and around the current Las Cumbres Observatory (LCO)).

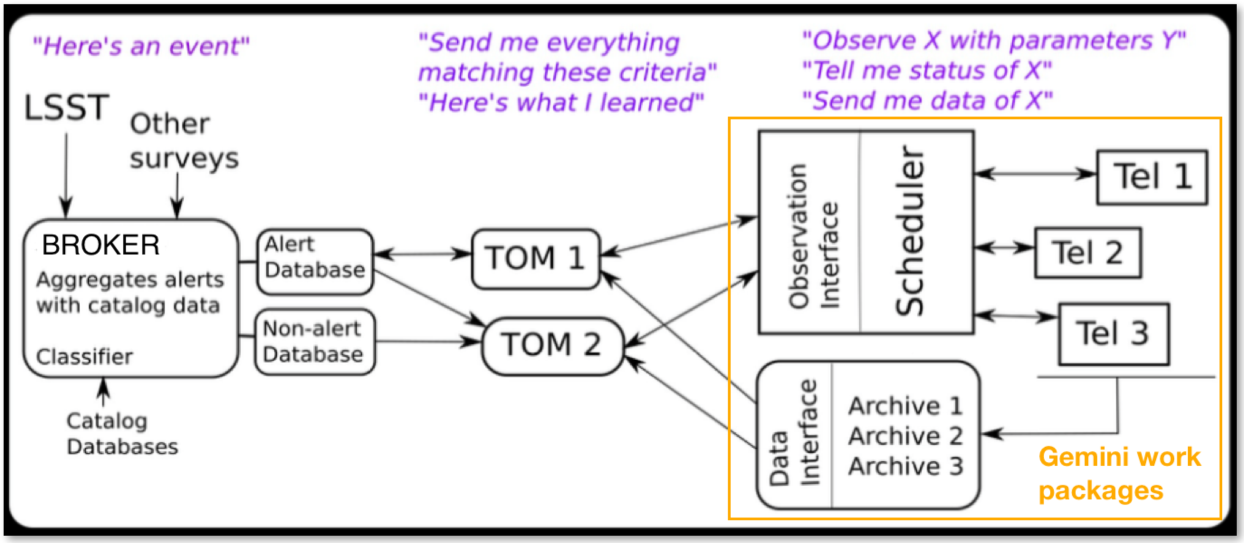


Figure 1 - Concept for the broad transient follow-up system (credit: Rachel Street, LCO). The yellow box (AEON) provides scheduling and data reduction for NCOA and LCO telescopes. The TDA work packages involve the components in this box and the interface to the TOMs (user software agents).

The main components of the overall system are:

1. **Alert Broker**: This accepts transient event alerts from one or more facilities (eg. LIGO, IceCube) or surveys (e.g. ZTF, LSST) and classifies the objects based on position, color, and light curve information and associations with existing catalogs. Research teams can configure filters in order to extract objects of interest. There are ongoing broker projects at NOAO (ANTARES[6]), in Chile (ALeRCE[7]), and in the UK (Lasair[8]). The AEON network will take alert streams from ANTARES.
2. **Target Observation Manager** (TOM): These are observation management tools for specific research projects. They collect alerts from surveys or brokers and allow the teams to review data, make decisions, and submit observations to the observatories on which the teams have observing time[9]. Las Cumbres Observatory has initiated a community TOM development effort and has produced a TOM development kit[10].
3. **Scheduler(s)**: This is an algorithm that schedules observations on the telescopes on the network. There can be a single network scheduler, or individual telescopes can have their own schedulers. The schedulers must be responsive in order to react to new events and changes in site conditions.
4. **Telescopes**: These are the individual nodes of the network. They must be able to broadcast their current observing status (closed, open, current target), receive the observation plans from a scheduler, execute the observations.
5. **Data reduction pipelines**: These reduce the data immediately after they are taken. Both raw and processed data are transferred to an archive.
6. **Data archives**: These are databases for raw and reduced data. Authenticated users

[6] https://www.noao.edu/ANTARES/
[7] http://alerce.science/
[8] https://github.com/lsst-uk/lasair
[9] https://www.noao.edu/meetings/lsst-tds/agenda.php
[10] https://tomtoolkit.github.io

(often using TOMs) can download the data as soon as it is available.

The current plan for the AEON project is to develop interfaces and scripting capabilities to execute time-domain observations from the LCO scheduler on the Southern Astrophysical Research (SOAR) telescope during dedicated nights by the end of 2019. The TDA project will incorporate Gemini into the network by 2021, in time for LSST commissioning and early operations.

The following three subsections detail current Gemini infrastructure and software, and the ways in which they will develop to enable integration into AEON.

1.4.2 Telescopes and Instrumentation

Gemini operates twin 8-m telescopes on Cerro Pachón in Chile and Maunakea in Hawai'i, providing coverage of the entire sky. Thus, while Gemini is ideally suited to observe targets detected by LSST, it is also capable of reaching any LIGO or IceCube target with an identified electromagnetic counterpart and supporting space missions like Chandra and JWST. The telescopes were designed for queue observing, so switching between facility instruments happens in less than a minute. Complementary optical and NIR instrumentation is available at both sites. The longitude difference between Gemini South and North will be increasingly useful in the era of LSST Operations, allowing 8-m followup to continue after targets have set in Chile. Thus, the geography, hardware, and software already make Gemini an ideal platform for MMA and transient follow-up. The most significant development supporting TDA will be the building of a new broad-wavelength imaging spectrograph, SCORPIO, specifically as a follow-up workhorse instrument. This will be delivered to Gemini South, and thus colocated with LSST, in time for the start of LSST survey operations.

1.4.3 Evolving the Gemini Observatory Control System

Gemini's current observation preparation and execution software (known as the Observatory Control System, OCS) has been under continuous development since about 2000. However the fundamental design has not changed greatly and has also made it very difficult to include the constraints needed for proper automated scheduling. Therefore, static nightly observing plans are still created manually, and it is cumbersome and inefficient for observers to update plans as new rapid target-of-opportunity (rToO) observations arrive or to switch plans as conditions change. A substantial increase in the rate of rToOs, as we expect, will lead to more inefficiencies.

For these reasons, Gemini has embarked on a project to modernise the entire OCS suite, and this upgraded OCS will by design support the MMA and time domain follow-up network. Currently the ability to trigger ToO observations at Gemini programmatically is rudimentary, using scripts via a very basic Application Program Interface (API). A defining concept of the new system is that all the fundamental services should be accessible both through manual user interfaces, and through APIs that define how programs interact with the systems. The OCS Upgrades Program will provide the infrastructure such as the databases and the observation and target models that will support the constraints needed by the scheduler.

The TDA project will build upon these developments to meet the science goals laid out in Section 1.1. Specifically, we will

- Provide an efficient, dynamic way to schedule large numbers (order 10-100) of transient observation requests per night.
- Provide new application programming interfaces (APIs) that comply with a set of standards that will be generally applicable across a wider network of follow-up facilities.

These will allow observations to be requested, provide the required feedback, and allow automated data access as described in a later section.
- Provide software to help Gemini users work with the new APIs

The performance and success of the system will be evaluated by tracking time use and completion statistics in a manner similar to what we do now. Some policies, such as the charging for interrupting ToOs, will be evaluated and updated if we start to notice problems or impacts on other programs. In order to make the system understandable and transparent, we will publish the quality metric (weighting algorithm) and present both the schedule history and future plans with a much detail as permitted by the privacy restrictions of the programs (e.g. don't publicly publish target information).

We will also be discussing new time allocation modes for AEON with partner observatories. We have proposed a common AEON TAC to allocate time on multiple facilities in order to reduce multiple jeopardy in the proposal process and help make the decision-making process more uniform. While outside the scope of this project, it may help promote the use of the followup network.

Finally, we will be participating in community discussions about MMA procedures, especially the coordination of observations between very different facilities (e.g. Gemini, the VLA, space observatories, IceCube, LIGO, etc). See Section 2.5 for more detail.

1.4.4 Evolving Gemini Data Reduction

Gemini currently provides data reduction software for all of its facility instruments. The purpose is to make the data amenable to scientific analysis by removing instrument, telescope, and atmospheric signatures (including sky/telluric features). For all but one instrument, this takes the form of a package of Image Reduction and Analysis Facility (IRAF) scripts or command line tools. IRAF is growing obsolete, especially its compatibility with modern operating systems and file structures. Therefore, we have begun a project to replace Gemini IRAF with a Python-based platform using and aligned with AstroPy. The first release to support all facility imagers will take place in early 2019. The next step will be GMOS long-slit spectroscopy (our most commonly used instrumental mode). This is a major undertaking that will lead to the foundation of our Python spectroscopy software suite, the bulk of which will be reusable for other spectroscopic instruments. However, neither the IRAF reduction package nor its Python-based replacement run automatically or unattended.

Gemini currently distributes raw data using the Gemini Observatory Archive[11] that runs on Amazon Web Services. PIs who receive notification of completion of observations on their science program are able to login to the archive and download the raw, proprietary data for processing using the data reduction package referred to above. The archive supports reduced data only in a rudimentary fashion.

The TDA project will enhance these data reduction and archiving efforts to close the data loop with the science teams. Specifically we will:

- Automate the data reduction for selected modes (e.g. GMOS long-slit) of at least one legacy (pre-GHOST) instrument working within the new infrastructure to provide reduced

[11] https://archive.gemini.edu/

products in almost real-time at night, so that these products may be fed back immediately to the requesting PI or software agent (TOM). New instruments such as GHOST and SCORPIO will be delivered with Gemini-compliant data reduction pipelines.

- Improve the ingestion of reduced data products and provide for communication to and from the TOMs to enable automatic download of products.

2 Organization

2.1 Internal Governance & Organization and Communication

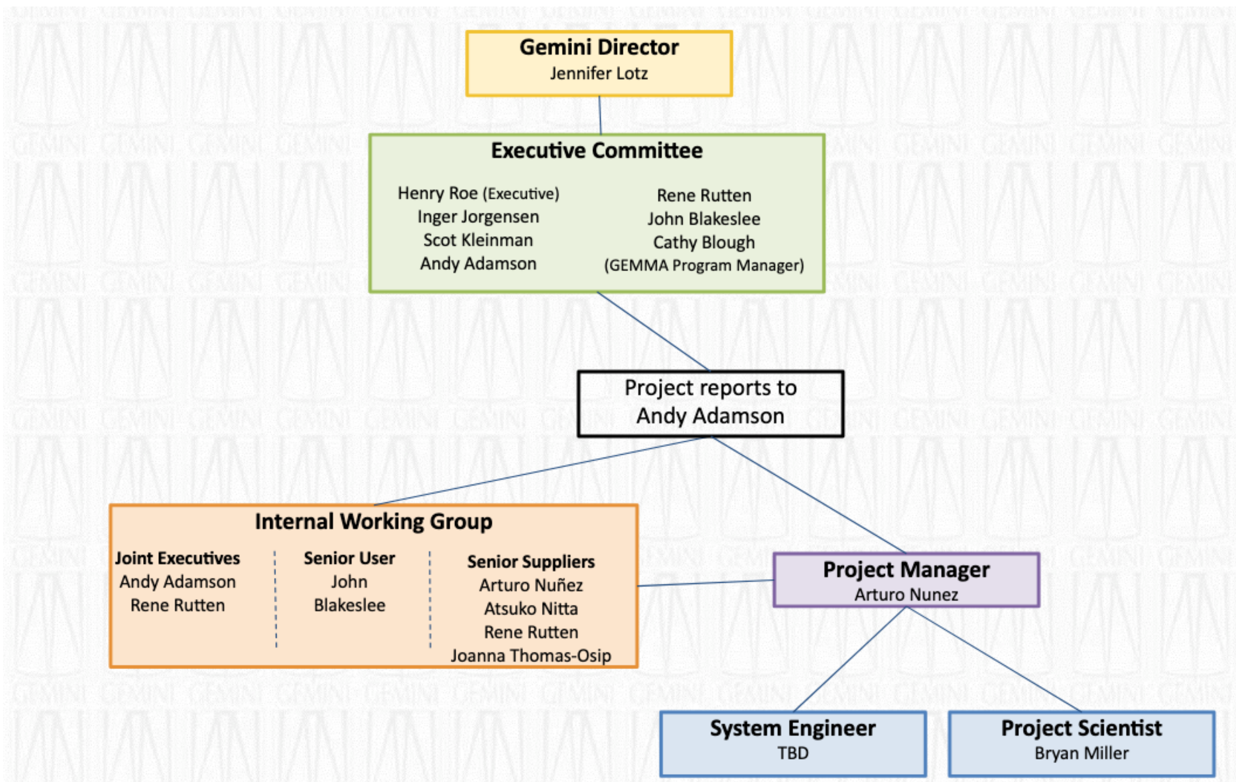


Figure 2 - Internal organization of key project staff

Project Manager: Reports to the Project Sponsor and the Program Manager. The Project Manager is accountable to the Project Sponsor for the management of the project and is accountable to the Program Manager for adherence to the program goals. Within the tolerances agreed upon with the Project Sponsor/Program Manager the Project Manager has the authority to make decisions on all aspects of the project. Decisions outside the tolerances must be approved by the Project Sponsor/Program Manager.

Project Sponsor: Reports to the GEMMA Executive Committee. The Project Sponsor is responsible for supporting the Project Manager and ensuring that the Project Manager performs the assigned tasks. The Project Sponsor functions as a link between the Executive Committee and the Project Manager and manages the escalation process outside of the purview of the

Project Manager. The Project Sponsor works with the Program Manager to make decisions outside of the Project Manager's tolerances.

Program Manager: Reports to the Executive Committee. The Program Manager is responsible for setting program and project goals and ensuring that these goals are met. The Program Manager works with the Project Sponsor to make decisions outside of the Project Manager's tolerances.

Systems Engineer: Reports to the Project Manager. Responsible for the system engineering activities pertaining to the project.

GEMMA Executive Committee, led by the Deputy Director is responsible for successful delivery of the GEMMA Program's objectives and benefits and will resolve conflicts, resource and otherwise. In all cases the Executive Committee will be consulted on major project decisions that have significant external impacts, such as design choices that impact future development options, major procurements, or major changes in deliverables by the projects.

The Executive Committee will seek consensus decisions, but the Executive has final authority on decisions when consensus cannot be expeditiously found. The Executive Committee serves as the Risk Advisory Board for the GEMMA Program. For TDA the Executive Committee will delegate day-to-day Project Sponsorship to Andy Adamson, escalating issues as needed to the full Executive Committee.

To lead project effort, we have a core team which will remain the same throughout the project's lifespan:

- Andy Adamson, Associate Director of Operations, as Project Sponsor for TDA.
- Arturo Nunez, Software Department Manager, as Project Manager for TDA.
- System Engineer, TBD.
- Bryan Miller, Tenured Astronomer GS, as Project Scientist for TDA.
- Andrea Blank as Project Coordinator for TDA.

In parallel with this, we will proceed with the four hirings described elsewhere in this document.

2.2 External Organization and Communication

Please refer to the link for the External Organization and Communication.

2.3 Partnerships

There are two significant external partners in this project to date:

1. **Las Cumbres Observatory** - already operating a network of follow-up telescopes of the 1-2 m aperture class, and currently working with the SOAR telescope to enable coordinated work for TDA observations.
2. **NOAO** - Responsible for the ANTARES event broker which will feed the TDA network, and for the project currently incorporating SOAR into LCO.

2.4 Roles and Responsibilities

Please refer to the link for organization roles and responsibilities.

2.5 Community Relations and Outreach

We anticipate taking three main approaches to acquiring adequate community input. Firstly, the community, including National Gemini Offices, is already being consulted on issues and capabilities of the new OCS, both via formal communications and at conferences and science meetings. Secondly, in consultation with the STAC we have assembled a TDA working group whose terms of reference are to advise the Observatory on its plans for the time-domain network. This working group includes members who have a direct interest in TDA, and some who undertake non-transient astronomy. The latter inclusion is consistent with the science requirement to control the impact of TDA on other Gemini science, and is a specific recommendation of the STAC. Finally, we will of course be publicizing the work at topical conferences and meetings.

The list below gives more detail on past and future community involvement in this work.

- There were community representatives on an OCS Upgrades Program working group that met during 2017-2018.
- We have been and will be discussing our plans at a variety of topical conferences and workshops. Attendance will be mainly by the project scientist. Examples include: Science in the 2020s NOAO Decadal Survey workshop, Future and Science of Gemini Observatory 2018, LSST Project and Community Workshop 2018 session on follow-up networks, AAS Division of Planetary Sciences 2018 meeting TDA follow-up session, AAS233 (various sessions), presentation at The New Era of Multi-Messenger Astrophysics conference (2019), presentations at Enabling Multi-Messenger Astrophysics in the Big Data Era Workshop (2019), TDA-follow-up network session at Hotwired VI (2019). Progress will also be shown in the various electronic publications we employ (e-newscast, Gemini Focus).
- Guided by the STAC, we have convened a TDA Working Group as mentioned above.
- OCS feedback has been sought from various committees, e.g. OpsWG, UCG, and we expect to get input from these groups on TDA-specific capabilities also.
- We will recruit beta testers from the community to provide early feedback during the development.

3 Design and Development

3.1 Project Development Plan

In order to satisfy the scientific objectives and requirements for this project, we have identified five major products that need to be developed:

- Gemini TDA APIs: A new set of application programming interfaces (APIs) that will allow observations to be requested, provide the required feedback, and allow automated data access.
- Gemini Plugins for Target and Observation Managers (TOMs): Provide software to help Gemini users work with these new APIs

- Scheduler: Provide an efficient, dynamic way to schedule large numbers (order 10-100) of transient observation requests per night.
- Real Time Pipelines: Provide a mechanism to automatically reduce imaging and long slit spectroscopic data in real-time for rapid characterization of transient sources and more responsive decision-making during night operations.
- Product Distribution Manager: Updates the Gemini Observatory Archive to be able to deliver reduced data to users.

These TDA software products are built on top of existing software infrastructure that support telescope operations as shown in the next figure:

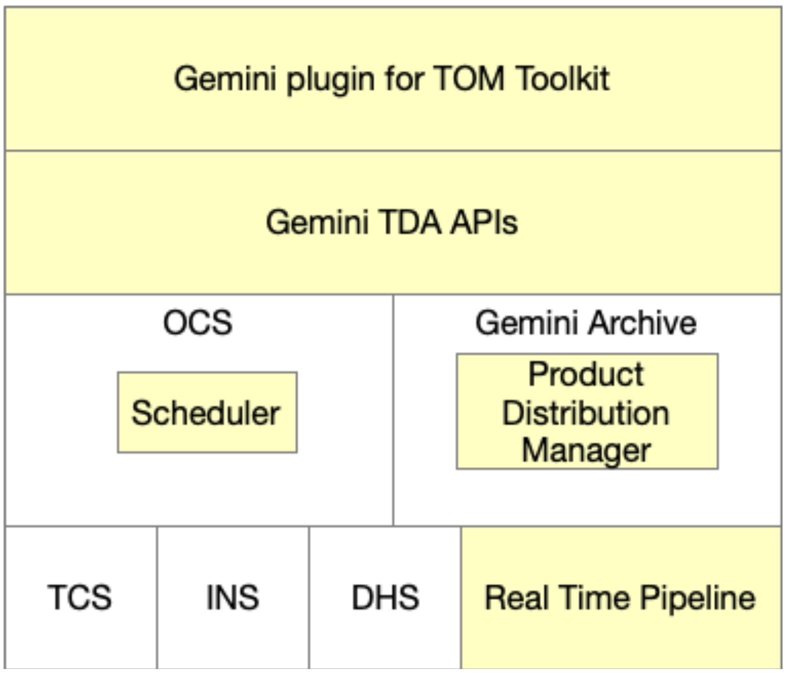


Figure 4 - (Yellow) the work on GEMMA-TDA as it fits into other systems.

The TDA software products, shown in yellow in Figure 7, have interfaces with existing software components of the Gemini Software infrastructure. In particular, the Gemini plugin for the TOM Toolkit uses the Gemini TDA APIs to access the observatory. The Gemini TDA APIs connect to both the Observatory Control System (OCS) and the Gemini Archive. These two systems, in turn, need to be modified and updated to incorporate the Scheduler (in the OCS) and the Product Distribution Manager (in the Archive). OCS will continue using the existing interfaces to the Telescope Control Software (TCS), Instruments (INS) and the Data Handling System (DHS). The Real Time Pipeline produces reduced data from the DHS, and delivers that to the Gemini Archive. These interfaces and dependencies will be documented in corresponding Interface Control Documents.

All the elements depicted in white in Figure 7 must be in place and remain in place for the TDA software plan to be successfully completed.

The following is an overall schedule description for each one of the core TDA products:

Gemini TDA APIs. In order to implement the Gemini TDA APIs, the following are the main activities and milestones we plan to follow:

- Operational requirements baselined: July 2019
- TOM Interface implementation: November 2019
- Scheduler Interfaces implementation: March 2020
- API testing and verification: May 2020

Gemini Plugin for TOM Toolkit. With both operational requirements of the Gemini TDA APIs and Scheduler, the work on the Gemini Plugin for the TOM toolkit can begin. The following are the main milestones in that work package:

- TOM plugin requirements and interfaces baselined: July 2019
- TOM plugin and User Interface implementation: October 2020
- TOM testing and verification: December 2020

Scheduler. In order to implement the Gemini Scheduler in support of TDA, the following are the main activities and milestones we plan to follow:

- Requirements and initial prototype: October 2019
- Final Architecture definition: February 2020
- OCS Support infrastructure completed: December 2020
- Implementation completed: October 2020
- Verification and Testing: April 2021

Real Time Pipelines. In order to implement the Real Time Pipelines, the following are the main activities and milestones we plan to follow:

- Pipeline interfaces baselined: October 2019
- Operational modification to support automation: June 2020
- GMOS Long Slit Spectroscopy data reduction implemented: October 2020
- Deployment of Quicklook mode: January 2021

Product Distribution Manager. In order to implement the Product Distribution Manager in the Gemini Archive, the following are the main activities and milestones we plan to follow:

- Updates to Gemini data reduction software: November 2019
- Updates to Gemini archive software : February 2020
- Product Distribution work ready: August 2020

3.2 Development Budget and Funding Sources

The budget for this project is 14.2 FTE, plus $120,000 for travel covered by GEMMA Cooperative Service Agreement.

3.3 Development Schedule

The schedule of this project is October 1 2018, June 30, 2022. Details are described in the next section.

3.4 Planning Assumptions & External Dependencies

The Observatory Control System is going through a major upgrade, so that effort must be coordinated with this project. There is significant cross-membership between the teams, though they are not identical (e.g. there is no data reduction component in the OCS Upgrades). Cross-membership is a strength, as the systems are clearly strongly dependent upon one another. The Project Manager, A. Nuñez is common to both and also line manages the majority of the resources. The Project Scientist (B. Miller) is also common to both projects, ensuring that the operations concepts and requirements are consistent and complementary.

The great majority of staff in GEMMA-TDA are in the Software Department, the Science User Support Department, and the two Science Operations Departments. The projects will proceed in parallel by using the existing Gemini resource allocation and planning processes. This was used in previous major projects such as the various Transition Software Projects, Base Facility Operations, and the Real-Time Upgrades, all of which were successfully completed.

It is expected that the work on the APIs and the scheduler will be done in some form of collaboration with Las Cumbres Observatory, NOAO, and SOAR. Project scientists currently meet bi weekly to discuss activities. Communication channels between project scientists and project managers and developers must remain in place to avoid unexpected changes in requirements.

Gemini and NOAO will be restructuring into the National Center for Optical/IR Astronomy (NCOA) starting in 2019. It is assumed that the project structure and personnel will be retained during this transition. We assume also that a similar process for resource allocation and portfolio management will continue, so this project will be able to continue without adding significant management overheads.

There are several efforts ongoing in the community to replace core IRAF spectroscopic reduction tasks with python equivalents. Gemini has been in communication with the astropy group, STScI, and SOAR about such efforts. It is assumed that Gemini will be able to take advantage of such efforts and that unexpected changes will not cause additional work on the Gemini reduction tools.

For this plan to be successful, four new fixed-term software engineers will be hired. It is assumed that these positions will be sufficiently attractive, and filled in a timely manner.

The software needs to be ready and in operations by the time LSST starts its operations. It is assumed that that takes place in 2022.

3.5 Lessons Incorporated

In this project we will be using a similar approach to other Gemini software projects that we have successfully completed in the last years, improving specific aspects based on our experience. In particular:

- We will use the principles of goal-aided design[12] to develop the functional requirements. This is a similar process to that used during the Phase I/II (UX) project. We will conduct interviews of representative people in all the roles that use the tools (e.g. community users, NGO staff, and Gemini staff with different roles). This information will be used to construct "personas" that will be used to define the operations or use concepts and the requirements.

[12] Cooper, A. Reiman, R, Cronin, D., & Noessel, C. 2014, About Face: The Essentials of Interaction Design, John Wiley & Sons, Inc.

- We will use an Agile software development methodology, in which developers and users will work as a team to deliver the product, in all stages of the development, from definition to deployment using an iterative approach. This was also used in the UX, Queue Visualization, OCS Advanced Features, Laser Clearance House Target Tracking System and Sequence Executor projects at Gemini, successfully from 2011 to 2018.
- The software will be open-source, hosted in GitHub and subject to the peer code review process currently in place for all high-level software at Gemini. This has been useful not only as an effective revision control system but also as a mechanism to increase software quality through continuous peer code reviews. We assume that the Gemini Plugin for the TOM Toolkit - that will be implemented on top of existing software frameworks done by other observatories - can be developed the same way.
- We plan to build the system such that it will support automatic testing and continuous integration/deployment from the outset. This has been extremely useful not only in recent projects like the Sequence Executor, but also for our existing codebase supporting the Observatory Control System.

3.6 Monitoring & Control

The plan is developed using PMO methodology, with Agile concepts for software development. We will have specific milestones in the project plan that will be used to assess progress and adjust plans. Highlight reports will be submitted monthly to the project sponsor, and necessary escalations will be provided. As a PMO based project, we plan to manage this by exception.

4 Construction Project Definition

4.1 Summary of Total Project Definition

The following is a summary of the budget and schedule of this project - details are discussed in section 4.8 and 4.9:

Investment in **non-labor** (K$):	$120,000
Investment in Gemini labor (FTE[13]):	14.2 FTE
Investment in external labor (FTE and K$):	$0
Other Costs in Operations/ Maintenance (K$):	We estimate a total effort of 0.05 FTE/year per product dedicated to ongoing maintenance and support once the system is handed over to operations, for a total of 0.25FTE total. Out of this, 0.1FTE are scientific programmer effort and 0.15FTE are high-level software support.
Project Duration:	Jan 1, 2019 to Jun 30, 2022

[13] Full-Time Equivalent. 1 FTE = 1720 hours

Benefits Realization:	Full Benefit realization is expected at project completion.

4.2 Work Breakdown Structure (WBS)

WBS #	WBS Title	Deliverable	Responsible Organization
1.4.1	Operational Concept Definition	Concept of Operation for TDA Software	Gemini Observatory
1.4.2	Scheduler	Automated Queue Scheduler	Gemini Observatory
1.4.3	TDA APIs	TDA APIs	Gemini Observatory
1.4.4	Gemini Plugin for TOM Toolkit	Gemini Plugin for TOM Toolkit	Gemini Observatory
1.4.5	Real Time Pipelines	Automation of GMOS and NIR Long Slit Spectroscopy	Gemini Observatory
1.4.6	Product Distribution Manager	Improvements to Data Archive to support distribution of reduced data	Gemini Observatory
1.4.7	Integration and Commissioning	Verification, Validation, Integration, and Commissioning Tests Complete	Gemini Observatory
1.4.8	Documentation, training and Handover to operations	Handover of TDA products to operations	Gemini Observatory

4.3 WBS Dictionary

WBS #	WBS Title	WBS Description
1.4.2	**Scheduler**	
1.4.2.1	Requirements and initial prototype	Defines the Key Science Requirements and Key Performance Parameters of adaptive queue scheduling for Gemini in the context of the anticipated TDA network of telescopes,

		and generates software for testing of concepts (not anticipated to be the same architecture as the final version). Also, defines Interface Control Documents to other software systems.
1.4.2.2	Initial Prototype and Architecture definition	Final software architecture defined, and prototype software created based on that
1.4.2.3	Implementation	Scheduler moved from prototype to facility and integrated with the OCS / Observing database
1.4.2.4	OCS Support infrastructure	Database infrastructure in support of the automated scheduler, in particular AND and OR logic
1.4.2.5	Scheduler Testing	Testing the scheduler against KSRs defined in 1.4.2.1, including its ability to match (or better) existing queue planning methods.
1.4.3	**TDA APIs**	
1.4.3.1	Operational Requirements	Generate requirements on the APIs to satisfy the KSRs, and user stories in the Concept of Operations.
1.4.3.2	TOM APIs Implementation	Coding of APIs in AGILE “Sprints”, with close interaction with project scientist and other relevant staff.
1.4.3.3	Scheduler Interfaces implementation	Coding of interfaces involved in automated scheduling. Limited to interfaces with elements of the OCS.
1.4.3.4	API testing	Testing the APIs against KSRs defined in 1.4.3.1.
1.4.4	**Gemini Plugin for TOM Toolkit**	
1.4.4.1	TOM Plugin UI and Implementation	Provides users with the ability to interact with the Gemini observing system, database and archive directly from their TOMs.
1.4.4.2	TOM Testing	End-to-end testing of the interaction between users’ TOMs and the Gemini observing system, database and archive. Verification that all User Stories and Key Science Requirements have been met.

1.4.5	**Real Time Pipelines**	**Automation of the pipeline reduction for Gemini long-slit spectrometers in advance of the delivery of SCORPIO**
1.4.5.1	Data Reduction Software	Data reduction software modifications
1.4.5.1.1	Initial Steps	Creation and storage of bad pixel mask, algorithms for linearization of 1D spectra, storage and usage of world coordinate system information.
1.4.5.1.2	Quantum efficiency and flatfield	Algorithms to correct for quantum efficiency variation and for creating and applying the spectroscopic flat field correction. Tests.
1.4.5.1.3	Automated Wavelength Calibration	Without human intervention identify arc lines against a line list and calculate the wavelength solution. Apply the wavelength solution to the data. Reduce and store arc lamp data. Tests and documentation.
1.4.5.1.4	Automated spectrum extraction and sky subtraction	Without human intervention find spectra on a 2D image, select appropriate apertures, trace and extract 1D spectra from those. Remove sky emission from the spectra. Tests and documentation.
1.4.5.1.5	Automatic Spectrophotometric Flux Calibration	Process standard observations. Calculate the spectrophotometric flux calibration and store the response function. Apply the calibration to the science data. Tests and documentation.
1.4.5.1.6	Quicklook reduction software integration	Once all the pieces of the long slit reduction have been implemented, integrate them and ensure that they work as intended together. "quicklook" is defined a reduction that is complete but not necessarily optimized for science publication. the data is wavelength calibrated, sky subtracted, and extracted to 1D. Spectrophotometric calibration is applied if a flux calibrator is available.
1.4.5.1.7	Optimization for reliable automation	Once integrated and shown to work in standard cases, some elements like wavelength calibration and extraction will require optimization to ensure the robustness and reliability of the automation for a wider variety of observations. Eg. faint sources,

		semi-blended sources, a wider selection of grating and central wavelength configurations, etc.
1.4.5.2	Operations Tools for Automation	Required updates to operational tools to support automation
1.4.5.2.1	Calibration tool	Automatically or semi-automatically generate fully reduce calibrations, biases, flats, arcs etc. imaging and long slit, from data obtained from the archive. The raw inputs are selected based on some predefined rules that ensures uniformity. Those processed calibrations will be used to reduce follow-up data at night.
1.4.5.2.2	Quicklook reduction dispatcher	The dispatcher receives information from the OCS regarding the progress of an observation sequence. From that information, the dispatcher decides when to trigger a reduction of the data. For example, in most case, it will wait for the completion of the sequence, once all the data is available, to trigger the reduction of that sequence.
1.4.5.2.3	Quality Assessment Reduction	Nighttime quick reduction for quality assessment purposes and queue decision making. Measurement of sky condition metrics. Tests and deployment.
1.4.6	**Data Products Management**	**Required changes to the Gemini Observatory Archive and its interfaces to enable ingestion and automatic distribution of reduced data products from the Pipeline**
1.4.6.1	Updates to DRAGONS software	New routines to store data reduction information in the product's header. New routine to upload the data to the local data storage database, Fitsstore. From there the data will be uploaded to the public archive. Any additions to the tagging and bookkeeping system in DRAGONS to support reduced products.
1.4.6.2	Updates to Fitsstore (archive) software	Add support of reduced products to the Fitsstore software, which is also the public Archive software (GOA). Implement a system to differentiate reduced "quicklook"

		data from reduced "science quality" data. Modify the API and search from to allow search of quicklook data. Provide information about the reduced product, like provenance, and how was reduced. Provide a thumbnail of the spectrum.
1.4.6.3	Test and deployment	Deploy internally and test the Archive software in house with Fitsstore. When considered successful and stable, deploy to the public Gemini Archive.
1.4.7	**Integration and commissioning**	**Producing a working overall system from the products of the previous five work breakdown items. Detailed plan to be produced.**
1.4.8	**Documentation and Training**	**Documentation and Training necessary to hand over TDA software products to operations**
1.4.9	**Project Management and Administration**	**Overall project management effort in support of this project**

4.4 Scope Management Plan and Scope Contingency

4.4.1 Scope Boundary Conditions

These are the scope boundary conditions for each product in TDA Software:

1. Gemini Plugin for TOM Toolkit: This product will be developed using the TOM Toolkit provided by Las Cumbres Global Telescope Network (LCGTN). This is a Python-based system. This plugin has interfaces to the rest of the LCGTN TOM Toolkit and to the Gemini API Interfaces as shown in Figure 1.
2. Gemini TDA APIs: These APIs will be modeled after similar APIs provided by LCGTN for access to their system, but tailored to Gemini's needs. To facilitate access from TOMs they must be web APIs.
3. Scheduler: The scheduler runs as part of the OCS and is exposed to the outside world only through APIs. As such, its interfaces are internal and the implementation is not constrained.
4. Product Distribution Manager: The Gemini Archive is written in Python, and this product will add the necessary capabilities to the Archive to be able to characterize and retrieve reduced data. The Product Distribution Manager is an internal service in the Archive, and it's used by external products through the Archive API.
5. Real Time Pipelines: This product provides Python data reduction recipes for GMOS Long Slit spectroscopy automation, including documentation and tests. This will also include, as a goal, Near Infrared (F2 and/or GNIRS) Long Slit spectroscopy.

4.4.2 Scope Details

In Scope
Gemini TDA APIs to support TDA astronomy that will allow observations to be requested, provide the required feedback, and allow automated data access.
Gemini Plugin for TOM Toolkit.
Automatic Scheduler for Gemini. Defines mechanisms and the specification of a merit function to optimize observing schedules.
Updates to the Gemini Archive to improve handling of reduced data including API changes
Data reduction recipes for GMOS Long Slit spectroscopy automation, including documentation and tests

Out of Scope
Any additional APIs that are needed for the Observatory Control Software normal operations. This is assumed to be provided by Gemini Operational software.
Any software to implement the TOM toolkit framework itself. This is assumed to be provided by LCGTN.
Algorithms to optimize the schedule. We will use existing tools that perform this work.
All infrastructure needed by the Gemini observatory control system (OCS) including databases, observation and target models, graphical user interfaces, etc.
Creation of the routines and algorithms needed to reduce the data from Gemini facility instruments.
Creation of an entire follow-up system.
Development of Imaging Pipelines. These are being done outside the scope of this project.

4.4.3 Change Management

All changes to the project are requested through a Change Request Form and submitted to the Project Manager. The Project Manager will assess the benefit of the change and the impact on cost, timeline and resources available and decides if the change can be implemented. If the scope of the change is outside of the tolerances for the Project Manager, the Project Sponsor will be asked to approve.

4.5 Cost Estimating Plan, Cost Reports and Baseline Budget

Please refer to the link for https://www.gemini.edu/gemma/documents

4.6 Complexity Factor

Please refer to the link for the Cost Estimating Plan which describes the Complexity Factor. https://www.gemini.edu/gemma/documents

4.7 Baseline Funding Profile

Baseline Funding Profile per WBS - Labor (US$)

WBS Id	Title	FY2019	FY2020	FY2021	FY2022	TOTALS
1.4.1	**Operational Concept Definition**	$15,062				**$15,062**
1.4.2	**Scheduler**	$41,239	$285,102	$257,744	$89,518	**$673,602**
1.4.3	**TDA APIs**	$75,696	$123,886			**$199,582**
1.4.4	**Gemini Plugin for TOM Toolkit**		$77,015	$22,612		**$99,627**
1.4.5	**Real Time Pipelines**	$149,273	$210,844	$135,688	$89,931	**$585,736**
1.4.6	**Product Distribution**		$99,003			**$99,003**
1.4.7	**Integration and commissioning**			$154,804	$20,885	**$175,689**
1.4.8	**Documentation, Training and Ops Handover**			$64,574		**$64,574**
1.4.9	**Project Management and Administration**	$21,610	$29,073	$28,962	$3,440	**$83,085**
	TOTALS	**$302,880**	**$824,922**	**$664,384**	**$203,774**	**$1,995,961**

Detailed budget profile per each WBS is shown in the next figure.

WBS Code	Title	Expected Costs	2018	2019				2020				2021				2022	
			Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
1.4.	▼ **Time Domain Software Plan**	**$1,995,961.12**	**$5,492.11**	**$12,602.62**	**$97,423.81**	**$187,361.71**	**$220,895.21**	**$212,530.70**	**$211,512.81**	**$179,983.70**	**$184,304.61**	**$61,699.16**	**$205,578.04**	**$212,802.51**	**$146,635.52**	**$31,798.88**	**$25,339.73**
1.4.1	▷ Operational Concept Definition	$15,062.20	$3,183.88	$7,837.24	$4,041.08												
1.4.2	▼ **Scheduler**	**$673,602.08**			**$34,446.36**	**$6,792.24**	**$57,574.29**	**$81,882.71**	**$72,266.48**	**$73,378.27**	**$53,746.24**	**$17,651.09**	**$86,207.16**	**$100,139.01**	**$89,518.21**		
1.4.2.1	▶ **Requirements and initial prototype**	**$41,238.60**			**$34,446.36**	**$6,792.24**											
1.4.2.2	▷ Inital Prototype and Architecture definition	$77,171.20					$42,444.16	$34,727.04									
1.4.2.3	▷ Implementation	$115,416.00						$18,594.80	$41,678.00	$42,319.20	$12,824.00						
1.4.2.4	▶ **OCS Support Infrastructure**	**$133,574.08**					**$15,130.13**	**$28,560.87**	**$30,588.48**	**$31,059.07**	**$28,235.52**						
1.4.2.5	▷ Scheduler Testing	$33,095.80									$12,686.72	$17,651.09	$2,757.98				
1.4.2.6	▷ OCS Contingency	$273,106.40											$83,449.18	$100,139.01	$89,518.21		
1.4.3	▼ **TDA APIs**	**$199,582.34**				**$75,696.38**	**$72,961.64**	**$39,523.06**	**$11,401.26**								
1.4.3.1	▷ Operational Requirements	$6,468.80				$6,468.80											
1.4.3.2	▷ TOM APIs Implementation	$121,718.82				$69,227.58	$52,491.24										
1.4.3.3	▷ Scheduler Interfaces Implementation	$51,988.32					$20,470.40	$31,517.92									
1.4.3.4	▷ API testing	$19,406.40						$8,005.14	$11,401.26								
1.4.4	▼ **Gemini Plugin for TOM Toolkit**	**$99,627.40**							**$34,695.80**	**$42,319.20**	**$22,612.40**						
1.4.4.1	▷ TOM Plugin and UI Implementation	$80,221.00							$34,695.80	$42,319.20	$3,206.00						
1.4.4.2	▷ TOM Testing	$19,406.40									$19,406.40						
1.4.5	▼ **Real Time Pipelines**	**$585,736.20**			**$51,723.63**	**$97,549.39**	**$65,910.22**	**$55,242.58**	**$46,968.19**	**$42,722.92**	**$38,800.87**	**$31,798.88**	**$32,295.74**	**$32,792.59**	**$32,792.59**	**$31,798.88**	**$25,339.73**
1.4.5.1	▶ **Data Reduction Software**	**$520,975.00**			**$47,143.63**	**$78,650.15**	**$38,709.97**	**$45,911.72**	**$42,217.33**	**$42,722.92**	**$38,800.87**	**$31,798.88**	**$32,295.74**	**$32,792.59**	**$32,792.59**	**$31,798.88**	**$25,339.73**
1.4.5.2	▶ **Operations Tools for Automation**	**$64,761.20**			**$4,580.00**	**$18,899.24**	**$27,200.24**	**$9,330.86**	**$4,750.86**								
1.4.6	▼ **Product Distribution**	**$99,002.90**					**$17,125.35**	**$28,669.61**	**$38,968.34**	**$14,239.60**							
1.4.6.1	▷ Updates to DRAGONS software	$10,730.20					$10,730.20										
1.4.6.2	▷ Updates to Fitsstore (archive) software	$16,951.00					$6,395.15	$10,555.85									
1.4.6.3	▷ Test and deployment	$42,020.00						$18,113.76	$23,906.24								
1.4.6.5	▷ Contingency	$29,301.70							$15,062.10	$14,239.60							
1.4.7	▶ **Integration and commissioning**	**$175,688.80**									**$16,653.39**	**$5,147.41**	**$60,456.00**	**$72,547.20**	**$20,884.80**		
1.4.8	▶ **Documentation, Training and Ops Handover**	**$64,574.40**									**$45,168.00**		**$19,406.40**				
1.4.9	▷ Project Management and Administration	$83,084.80	$2,308.23	$4,765.37	$7,212.74	$7,323.71	$7,323.71	$7,212.74	$7,212.74	$7,323.71	$7,323.71	$7,101.78	$7,212.74	$7,323.71	$3,439.92		

Baseline Funding Profile per WBS - Non-Labor (US$)						
WBS Id	**WBS Title**	**FY2019**	**FY2020**	**FY2021**	**FY2022**	**TOTALS**
1.4.1	Operational Concept Definition	$9,168				**$9,168**
1.4.2	Scheduler		$26,747	$17,227		**$43,974**
1.4.3	TDA APIs	$3,274	$25,926			**$29,200**
1.4.4	Gemini Plugin for TOM Toolkit			$12,661		**$12,661**
1.4.5	Real Time Pipelines					**$0**
1.4.6	Product Distribution Manager					**$0**
1.4.7	Integration and Commissioning			$10,837		**$10,837**
1.4.8	Documentation, training and Handover to operations				$13,614	**$13,614**
1.4.9	Project Management and Admin					**$0**
	TOTAL	**$12,443**	**$52,674**	**$40,725**	**$13,614**	**$119,456**

4.8 Baseline Schedule Estimating Plan and Integrated Schedule

The Baseline Schedule is shown below:

WBS	**Description**	**Begin**	**End**
1.4	Time Domain Astronomy Software	Nov 19, 2018	Jun 10, 2022
1.4.1	Operational Concept Definition	Nov 26, 2018	May 15, 2019
1.4.2	Scheduler	May 16, 2019	Apr 14, 2021
1.4.3	TDA APIs	July 15, 2019	May 4, 2020
1.4.4	Gemini Plugin for TOM Toolkit	May 4, 2020	Dec 2, 2020
1.4.5	Real Time Pipelines	Apr 1, 2019	Oct 15, 2020
1.4.6	Product Distribution Manager	Nov 15, 2019	Aug 3, 2020
1.4.7	Integration and Commissioning	Oct 16, 2020	Oct 27, 2021
1.4.8	Documentation, Training and Operations Handover	Dec 3, 2020	Dec 5, 2021

The integrated schedule is shown in the next figure:

WBS Code	#	Title	Expected Start	Expected End
1.4.	**0**	**▼ Time Domain Software Plan**	**Nov 19, 2018**	**Jun 10, 2022**
1.4.1	1	▷ Operational Concept Definition	Nov 26, 2018	May 15, 2019
1.4.2	**2**	**▼ Scheduler**	**May 16, 2019**	**Apr 14, 2021**
1.4.2.1	**3**	**▶ Requirements and initial prototype**	**May 16, 2019**	**Oct 30, 2019**
1.4.2.2	6	▷ Inital Prototype and Architecture definition	Oct 31, 2019	Feb 19, 2020
1.4.2.3	7	▷ Implementation	Feb 20, 2020	Oct 28, 2020
1.4.2.4	**8**	**▶ OCS Support Infrastructure**	**Oct 31, 2019**	**Dec 23, 2020**
1.4.2.5	13	▷ Scheduler Testing	Oct 29, 2020	Apr 14, 2021
1.4.3	**14**	**▼ TDA APIs**	**July 15, 2019**	**May 4, 2020**
1.4.3.1	15	▷ Operational Requirements	July 15, 2019	July 29, 2019
1.4.3.2	16	▷ TOM APIs Implementation	July 29, 2019	Nov 18, 2019
1.4.3.3	17	▷ Scheduler Interfaces Implementation	Nov 18, 2019	Mar 9, 2020
1.4.3.4	18	▷ API testing	3/9/20, 1:00 PM	May 4, 2020
1.4.4	**19**	**▼ Gemini Plugin for TOM Toolkit**	**May 4, 2020**	**Dec 2, 2020**
1.4.4.1	20	▷ TOM Plugin and UI Implementation	5/4/20, 1:00 PM	Oct 7, 2020
1.4.4.2	21	▷ TOM Testing	October 8, 2020	Dec 2, 2020
1.4.5	**22**	**▼ Real Time Pipelines**	**April 1, 2019**	**Oct 15, 2020**
1.4.5.1	**23**	**▼ Data Reduction Software**	**April 1, 2019**	**Oct 15, 2020**
1.4.5....	24	▷ Initial steps	4/8/19, 8:00 AM	July 30, 2019
1.4.5....	25	▷ Quantum efficiency and flatfield	July 12, 2019	May 6, 2020
1.4.5....	26	▷ Automated Wavelength Calibration	4/1/19, 8:00 AM	Sep 23, 2019
1.4.5....	27	▷ Automated spectrum and sky substraction	June 25, 2019	Dec 5, 2019
1.4.5....	28	▷ Automatic Spectrophotometric Flux Calibration	Feb 27, 2020	May 8, 2020
1.4.5....	29	▷ Quicklook reduction software integration	8/3/20, 8:00 AM	Oct 15, 2020
1.4.5....	30	▷ Optimization for reliable automation	8/3/20, 8:00 AM	Sep 22, 2020
1.4.5.2	**31**	**▼ Operations Tools for Automation**	**April 8, 2019**	**Jun 30, 2020**
1.4.5....	32	▷ Calibration Tool	October 4, 2019	Jun 30, 2020
1.4.5....	33	▷ Quicklook reduction dispatcher	4/8/19, 8:00 AM	Mar 24, 2020
1.4.5....	34	▷ Quality Assessment Reduction	July 30, 2019	Dec 18, 2019
1.4.6	**35**	**▼ Product Distribution**	**Nov 15, 2019**	**Aug 3, 2020**
1.4.6.1	36	▷ Updates to DRAGONS software	Nov 15, 2019	Dec 16, 2019
1.4.6.2	37	▷ Updates to Fitsstore (archive) software	Dec 3, 2019	Feb 18, 2020
1.4.6.3	38	▷ Test and deployment	Feb 18, 2020	May 27, 2020
1.4.6.5	39	▷ Contingency	May 27, 2020	Aug 3, 2020
1.4.7	**40**	**▶ Integration and commissioning**	**Oct 16, 2020**	**Oct 27, 2021**
1.4.8	**43**	**▶ Documentation, Training and Ops Handover**	**Dec 3, 2020**	**5/12/21**
1.4.9	48	▷ Project Management and Administration	Nov 19, 2018	Nov 12, 2021

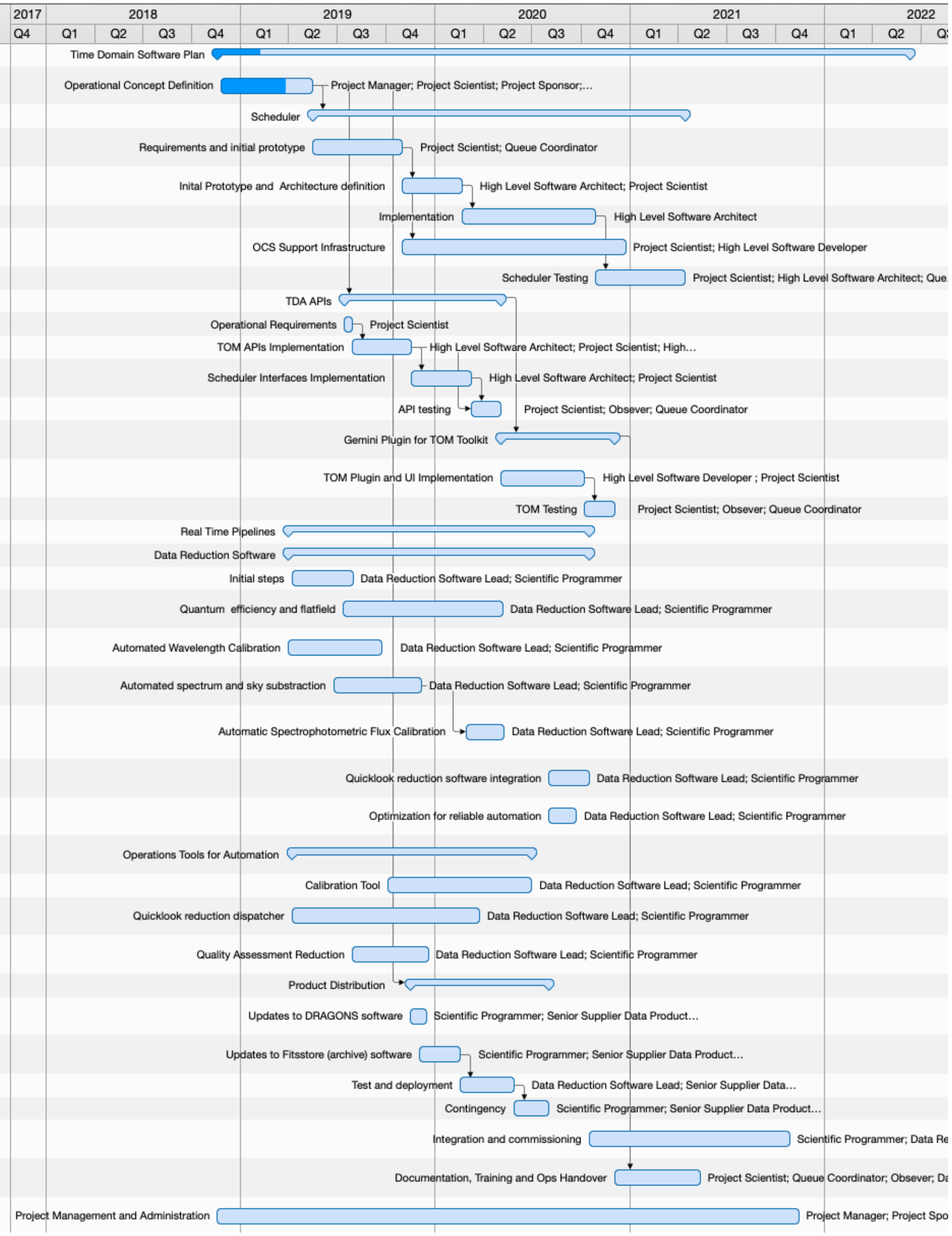
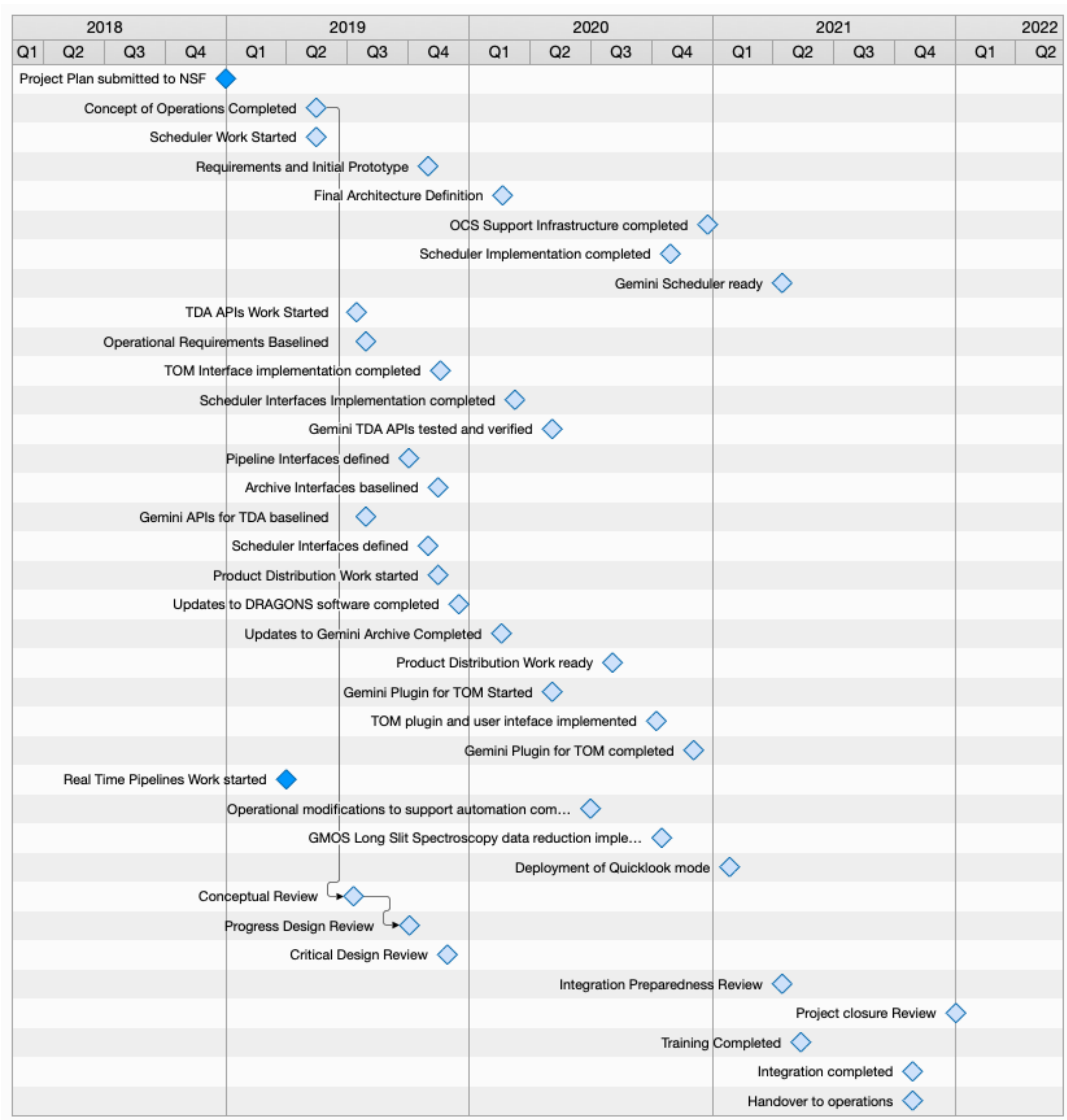


Figure 5 - baseline project Gantt chart

4.9 Milestone/Product Plan

The following are the top level project milestones in this project (calendar years).



4.10 Project Tolerances

Project Resource	Baseline value	Proposed Project Tolerance
Software Engineering - High Level	5 FTE	1 FTE
Software Engineering - Scientific Programmers	6 FTE	NIR modes pipelines will be descoped if needed.
Scientist	1 FTE	0.2 FTE
Queue Coordinator	0.3 FTE	0.05 FTE
Observer	0.2 FTE	0.05 FTE
Project Management and Systems Engineering	0.3 FTE	0.1 FTE
Travel and training	$100,000	$20,000
Benefit: ability to automatically accept up to N% of observations in one night from the TDA network	N=20% (minimum)	5% (see section 1.2)
Benefit: minimization of staff effort in generating and re-generating schedules as new alerts come in	Manual scheduling time<=1h/day Experience with using a prototype automated scheduler suggests that manual oversight of the scheduler should be less than one hour a day.	+120m. At a minimum manual planning during the day should not take longer, on average, than currently. This effort should decrease with time as the tools are refined.

Whenever the tolerance for one of these baseline values is exceeded (or expected to be exceeded), the Executive will be alerted of the exception.

4.11 Schedule Contingency

This schedule in this project is fixed and therefore contingency will be managed via scope adjustments. Initial scope is described in section 4.4 above.

5 Staffing

5.1 Staffing Plan

The following resources are required to complete this project during the period of performance:

Core management team
- Project Sponsor: 0.05 FTE
- Project Manager: 0.1 FTE
- Project Scientists: 1.4 FTE

- Systems Engineer: 0.2 FTE

Software Engineering effort

- High Level Software Engineers: 6 FTE
- Scientific Programmers: 6 FTE

Science effort

- Observers: 0.2 FTE
- Queue Coordinators: 0.3 FTE

.

The initial staffing plan for this project is shown in the following diagram.

Assignments > Work Distribution

Status	Title	2018	2019	2020	2021	2022
	No resources assigned					
	Project Scientist	14.54 hours	886.58 hours	922.57 hours	558.31 hours	
	Project Manager	10.06 hours	74.81 hours	67.18 hours	57.95 hours	
	Project Sponsor	6.21 hours	32.5 hours	16.79 hours	14.49 hours	
	System Engineer	12.18 hours	82.7 hours	67.18 hours	137.95 hours	
	High Level Software Architect	4.23 hours	1170.57 hours	2107.87 hours	1879.33 hours	
	Senior Supplier Data Reduction	4.23 hours	41.77 hours			
	Senior Supplier Data Product Management	2.11 hours	41.43 hours	301.12 hours		
	Scientific Programmer		1421.2 hours	1625.93 hours	1321.09 hours	356.45 hours
	Data Reduction Software Lead		1473.2 hours	1700.99 hours	1424.03 hours	356.45 hours
	Queue Coordinator		170 hours	270.67 hours	339.33 hours	
	High Level Software Developer		940.4 hours	2205.6 hours	1830 hours	
	Obsever			305.17 hours	184.83 hours	

Figure 6 - Staff-effort profile over the lifetime of the project

5.2 Hiring and Staff Transition Plan

The effort in this project is heavily focused on software development. We need approximately 12 software FTE for the duration of this project (3 years) covered by 4 positions, indicated as High-Level Software Architect, High Level Software Engineer, Data Reduction Software Lead and

Scientific Programmer in Figure 6. These positions will be covered by new hires and existing Gemini staff, as follows:

- High Level Software Architect: Covered by existing Gemini Staff
- High Level Software Engineer: New Hire, expected to be in place by August 2019
- Data Reduction Software Lead: 50% Covered by existing Gemini Staff and 50% by new hire to be in place by April-June 2019
- Scientific Programmer: Covered by existing Gemini Staff.

6 Risk and Opportunity Management

6.1 Risk Management Plan

6.1.1 Project Risk Process

The GEMMA TDA Risk Management process includes identifying, assessing, monitoring, mitigating, contingency planning, and closing risks. The first source of risk identification will be from our project kickoff pre-work and meeting. Attendees of the project kickoff will review this risk management plan prior to the project kickoff and email a list of potential risks to the project manager. The project manager will create a risk register for review and risk dispositioning at the project kickoff. The risk register will follow the template provided on the Project Management Knowledge Base. The project manager owns the monitoring, mitigation, and contingency planning of these risks.

Another source for risk identification will be the interviews performed by the project manager at the beginning of the project and during the life of the project. The project manager will interview project team members from different functional areas and document the resulting risks. The project manager will review those risks with the project team. The project manager owns the assessment, mitigation, and contingency planning of these risks.

Finally, the project manager will review the risks on a weekly basis to ensure mitigation is occurring and is effective. The project manager will also review the risks with the project team members at the project status meetings, as needed. The project manager will make necessary changes to the risk register at the project status meetings, including changes to impact and likelihood, mitigation strategy, contingency plans, and close risks as required.

Once the project is completed, the project manager will close all risks and the risk register. The risk register and plan will then be archived with the project documents.

6.1.2 Other Roles and Responsibilities

The project manager will request input from functional area managers on project risks. The functional area managers or leads are responsible for defining, evaluating, and mitigating the risks in his or her area and reporting status to the project manager. All project team members are responsible for identifying and escalating all area specific risks to their team lead.

6.1.3 Timing

The project manager will write the risk management plan prior to the project kick-off.

The project manager and project team will complete the risk register at the project kick-off.

New risks will be added to the risk register within one business day of being identified, and assessed during the next project team meeting.

The project manager will lead a discussion on project risks at each project team meeting, where the project team will discuss mitigation and contingency plans and make adjustments to the risk register as needed.

6.1.4 Risk Register Scoring and Interpretation

Risks will be scored on a scale of 1-5 in two areas, impact and likelihood. The impact score reflects the impact to the project schedule, cost, scope, quality, or user acceptance if the risk is realized. Likelihood reflects the probability that the risk will be realized. This project will use the following tolerances for rating impact and likelihood of risks.

6.1.4.1 Impact

4-5 (High)
Schedule slip > 20%
Budget overrun by > 10%
Resource shortage >10%
User acceptance unlikely
Quality guidelines will not be met > 90%

3 (Moderate)
Schedule slip > 10%
Budget overrun by > 5%
Resource shortage >5%
User acceptance questionable
Quality guidelines will not be met > 50%

1-2 (Low)
Schedule slip <= 10%
Budget overrun by <= 5%
Resource shortage <= 5%
User acceptance is likely with some negotiating
Quality guidelines will be met > 90%

6.1.4.2 Likelihood

4-5 (High)
Risk mitigation is weak; there is minimal to no effective contingency plan. Realization of this risk is inevitable.
3-4 (Moderate)

Risk mitigation does not cover all areas of the risk; contingency plan is inadequate. Realization of the risk is likely.
1-2 (Low)
Mitigation plan is strong, contingency plan is effective. Realization of the risk is unlikely but still possible.

6.1.4.3 Reporting Formats

The project manager will create the risk register and ensure that the register is available on the project team site found in the Project Management Knowledge Base. The project manager will include the status of the medium and high risks on the project status report. During the initiation phase of the project, the project sponsor or project manager will include risk items of yellow or red status in the project mandate when the project sponsor or manager requests execution phase approval.

6.1.4.4 Tracking

The risk register will be kept on the Project Management Knowledge Base in the project site and kept up to date by the project manager. All team members and sponsor will have access to the register. All stakeholders with comments and concerns should forward them to the team leads and the project manager.

6.2 Risk Register

Please refer to the link for https://www.gemini.edu/gemma/documents

Part I - Risk Identification
1. Categorization & Description
2. Impact, Likelihood & Total risk scores

Part II - Existing controls, per risk
1. Effectiveness
2. Residual risk score

Part III - Risk Response, per mitigation strategy
1. Effectiveness
2. Residual risk score
3. Contingency Plan
    a. Cost
    b. Owner
    c. Review schedule
    d. Status

6.3 Contingency Management Plan

For risks that have a high impact and likelihood, a mitigation plan will be developed and documented in the Risk Register, Part III as indicated in the previous section. These risks are reviewed monthly and plans are adjusted accordingly.

7 Systems Engineering

The TDA project will use a team approach for Systems Engineering (SE). This approach is a recognition that TDA at Gemini requires a complex software system with many internal and external interfaces, which in turn requires specialized knowledge in a number of areas. The team will include experts from areas including astronomy and software engineering. Overall SE team organization is provided by a Lead Systems Engineer, who works closely with the Software Engineers and Project Scientist, and reports to the TDA Project Manager.

The systems engineering team roles are defined and include the following:

- Systems Design and Analysis
  - Design and analysis of systems that cross over functional areas, subsystems or organizations (eg, end-to-end design user interface to science performance).
  - Formation and analysis of trade studies, to inform design choices management of up-scope and de-scope options
- Requirements Management
  - Identification, development, decomposition and linking of project requirements
  - Guide the translation of science cases into software technical requirements, incorporating the operational concepts
  - Flow-down the system requirements to lower-levels (subsystems, then components) until requirements are independently testable
  - Communicate requirements to owners within the development team
- Interface Management
  - Define and document where interfaces exist within the system (internal interfaces).
  - Manage interface control documents (ICD's) with the observatory
- Configuration Management
  - Maintain consistency and visibility of current project documentation and data
  - Manage changes to project documents over the lifecycle of the project
- Quality Management
  - Define a set of policies, procedures, tools and training to ensure that quality is maintained
  - Verify that Quality Assurance procedures are followed during development
  - Verify that the deliverables meet quality standards
- Verification Management
  - Identify verification method for each requirement (design, inspection, analysis, test, etc).
  - Identify at what project stage verification takes place
  - Write or manage the creation of verification test plans and procedures
  - Oversee requirements verification activities, and sign-off on results
  - Track open verification issues and develop a burn-down plan
  - Manage the Acceptance Test Review processes

7.1 Concept of Operations

The Concept of Operations (ConOps) is an important component in capturing stakeholder expectations, driving system requirements, and driving the architecture of a project. It will serve as the basis for subsequent definition documents such as the operations plan and operations handbook and provides the foundation for the long-range operational planning activities such as operational facilities and staffing. We will generate a Concept of Operations as a first step in the Conceptual Design Phase, and will use it as a basis for requirements and interface definition.

7.2 System Design

To date, we have made considerable strides in developing the conceptual design for time-domain astronomy software at Gemini. Once the conceptual design is complete and successfully passes Conceptual Design Review (CoDR), the system enters the preliminary design phase. A successful Preliminary Design Review (PDR) will demonstrate that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. The next milestone, Critical Design Review (CDR), will demonstrate that the maturity of the design is appropriate to continue its software implementation, integration, and test, and that the technical effort is on track to meet system performance requirements within the identified cost and schedule constraints.

7.3 Interface Management

The objective of the interface management is to achieve functional and physical compatibility among all interrelated system elements. Early in the design phase, we will define external, internal, functional, and physical interfaces. In this project, most of these interfaces are software interfaces that will be specified through Application Programming Interface (API) documentation. We plan to use software standards APIs to document these, like the Open API Specification (OAS) - (https://github.com/OAI/OpenAPI-Specification).

7.4 Quality Assurance and Quality Control

Quality Assurance (QA) provides an independent assessment to the project manager and systems engineer of the items produced and processes used during the project life cycle. The project manager and systems engineer will manage quality risks and enforce adherence to procedures and specifications throughout the system development and system integration.

7.5 Validation & Verification

Once the system development is complete, verification and validation processes on the realized products and system will be implemented to ensure they meet applicable life-cycle phase success criteria. Realization is the act of verifying, validating, and transitioning the realized product for use at the next level up of the system structure. This verification process will generate evidence necessary to confirm that end products, from the lowest level of the system structure to the highest, conform to the specified requirements (specifications and descriptive documents). For lower level products, this process may be conducted by the software developers.

Planning to conduct the product verification is a key first step that will occur in conjunction with the requirements definition process. From relevant specifications, the type of verification (e.g., analysis, demonstration, inspection, or test) will be established based on the life-cycle phase, cost, schedule, resources, and the position of the end product within the system structure. The verification plan will specify any specific procedures, constraints, and success criteria.

When verification of the end product is conducted, the responsible engineer will ensure that the procedures were followed and performed as planned, and the data were collected and recorded for required verification measures. The Systems Engineer will analyze the verification results and ensure the following:

- End-product variations, anomalies, and out-of-compliance conditions have been identified
- Appropriate re-planning, redefinition of requirements, design and reverification have been accomplished for resolution for anomalies, variations, or out-of-compliance conditions (for problems not caused by poor verification conduct)
- Variances, discrepancies, or waiver conditions have been accepted or dispositioned
- Discrepancy and corrective action reports have been generated as needed
- The verification report is completed.

Once all of the lower level requirements and products are verified, system level verification and validation will be performed. System level verification could include a roll-up of children requirement verification reports or a system level analysis or test. System validation will also be performed to ensure compliance with the Concept of Operations. Validation testing is conducted under realistic conditions (or simulated conditions) on the system to determine the effectiveness and suitability for operations by typical users and to evaluate the results of such tests.

8 Configuration Control

8.1 Configuration Control Plan

The end product, as well as all previous product iterations, will be under Configuration Control. This means that all changes made to requirements, technical, cost and schedule are tracked and are subject to the approval of the Sponsor. This process adheres to the document control policies with all decisions and documents stored in the project team drive. This process is monitored by the project coordinator. The team sites will be the repository for all changes not under change control.

8.2 Change Control Plan

All changes to the project are requested through a Change Request Form and submitted by the individual Project Managers to the Project Sponsor. The sponsor will assess the benefit of the change and the impact on cost, timeline and resources available based on program impact and project need and decide if the change can be implemented. If the scope of the change is outside of the tolerances for the Sponsor, the Executive Committee will be asked to consult.

A Change Request Form is a PMO template to be use for change control.

8.3 Documentation Control Plan

Gemini currently has a Document Control procedure in place that describes how documents are tracked and retrieved. For this, a Xerox supplied DocuShare application called Document

Management Tool (DMT) is used. Released documents are stored in DMT and subsequent updates are uploaded while the old version is kept. Version change information is stored with each version. The tool complies with:
1. Security
2. Alerts/Notifications
3. Back-up
4. Version Control
5. Review/Approval
6. Use of different file types
7. Index/Searching (tags)
8. Reports

In addition, DMT has a secured area required for ITAR related documents.

9 Project Management Controls

9.1 Project Management Control Plan

The project management team has defined a detailed WBS with associated cost, scope and schedule, and this will be used as a roadmap to plan detailed software development effort. The software development will be done using Agile software methodologies, ensuring frequent communication across all stakeholders and regular reporting and monitoring, on a week by week basis. These techniques have been used successfully in the past by Gemini in similar software intensive projects.

In addition, formal monthly updates and monitoring using Gemini's project management processes will assist the PM in closely controlling this project.

Gemini has a Portfolio Management Office which provides guidance to the project management process by providing:

- Methodology for the Project Life Cycle
- Project Management and Systems Engineering Templates in the Portfolio Management Toolkit.
- Reporting and resource allocation tools
- Training

9.2 Earned Value Management System (EVMS)

This is covered in the GEMMA Program Plan.

9.3 Financial and Business Controls

This is covered in the GEMMA Program Plan.

10 Cyber Infrastructure

10.1 Cyber-Security Plan

Resource Document

10.2 Code Development Plan

Resource Document

10.3 Data Management Plan

Resource Document

11 Review and Reporting

11.1 Reporting Requirements

Gemini is required by the CSA to provide quarterly financial reports and semi annual reports in throughout the life of the award. The reports are to coincide with other observatory reports required for the governance committees and Board.

11.2 Audits and Reviews

Expected reviews for this project: Conceptual Design Review, Preliminary Design Review, Critical Design Review, Integration Preparedness Review and Project Closure Review.

12 Integration and Commissioning

12.1 Integration and Commissioning Plan

When the project nears the final product delivery an Integration and Commissioning plan will be developed. The following items will be addressed as applicable:

- Integration
- Verification and Validation
- Installation plan
- Manuals
- Commissioning plan

For software the V&V step needs to include:

- Developing test cases to confirm that interfaces (e.g. APIs) are receiving and transmitting the correct data
- Running performance tests to confirm that performance and reliability specs are met

12.2 Acceptance / Operational Readiness Plan

A TDA Acceptance Test Plan will be developed prior to final acceptance of the TDA products in operations. This plan will have the following structure:

- Verification Methods Matrix and results
- Software Requirements
- Other Requirements
- External Interfaces
- Summary of Test Equipment and Test Software

13 Project Close-out

13.1 Project Close-out Plan

When the project nears the final product delivery a Project Close-out plan will be developed.

13.2 Transition to Operations Plan

Once the project passes its Integration and Commissioning plans, we will use Gemini standard Change Request processes to deploy the system in regular operations.

14 Appendix A

14.1 NSF Review Comment - Document Mapping

Page	Section	Comment
7	1.2	The table of scientific requirements is very clear and very useful. However, what constitutes success for the project as a whole – achieving all of the “threshold key science requirements”? Will these tasks be prioritized, or revised in the near future, and are all within the scope of this GEMMA funded project? **REVISED SECTION:**

		Section 1.2, introductory paragraphs above the table.
10	1.3	For the high-level requirements [note - posted in a short table below the science requirements], what is meant by a "Baseline Value"? **REVISED SECTION:** **Section 1.3** - added a statement above the table, clarifying the meaning of "Baseline"
13	1.3.3	What are Gemini's plans for soliciting community input on the TDA project? Perhaps expand on the "community discussions" mentioned on pg. 13. **REVISED SECTIONS:** **Section 1.4.3,** pointing to 2.5 (where some of this was addressed) and **Section 2.5** (adding a list of past and anticipated community contacts and a small change to the introductory paragraph).
3	3	As noted in the Project Plan, the OCS is already undergoing a major upgrade. Is the same team working on both projects? How will the two projects be executed in parallel? Does one person have overall responsibility for the OCS upgrades? **REVISED SECTIONS:** **Section 2** - New organizational chart addresses the question about overall responsibility. **Section 3.4** - At the start - added two paragraphs (one new, one attached to the original opening paragraph) derived from the "Team" and "Parallel" bullets above.

14.2 TDA Budget 1030 Form

GEMMA - Gemini in the Era of Multi-Messenger Astronomy: High Image Quality and Rapid Response					
Time Domain Astronomy					
	FYE19	**FYE20**	**FYE21**	**FYE22**	**TOTAL**
Senior Personnel	0	0	0	0	0
Other Personnel	193,907	528,245	425,433	130,484	1,278,069

Total Salaries and Wages	**193,907**	**528,245**	**425,433**	**130,484**	**1,278,069**
Fringe Benefits	108,917	296,715	238,966	73,293	717,892
Total Salaries/Wages/Benefits	**302,824**	**824,961**	**664,399**	**203,777**	**1,995,961**
Equipment	0	0	0	0	0
Domestic Travel		2,777	5,722	2,777	11,277
Foreign Travel	12,443	49,896	35,004	10,837	108,180
Total Travel	**12,443**	**52,674**	**40,725**	**13,614**	**119,457**
Participant Support	0	0	0	0	0
Other Direct Costs: Materials and Supplies	0	0	0	0	0
Other Direct Costs: Publication/Documentation/Dissemination	0	0	0	0	0
Other Direct Costs: Consultant Services	0	0	0	0	0
Other Direct Costs: Computer Services	0	0	0	0	0
Other Direct Costs: Subawards	0	0	0	0	0
Other Direct Costs: Other	0	0	0	0	0
Total Other Direct Costs	**0**	**0**	**0**	**0**	**0**
Total Direct Costs	**315,267**	**877,634**	**705,124**	**217,392**	**2,115,417**
Indirect Costs - ***Calculated on Total Project in IDC Account***	0	0	0	0	0
Total Direct and Indirect Costs	**315,267**	**877,634**	**705,124**	**217,392**	**2,115,417**
CSA Period of Performance Start:	*10/1/18*				
CSA Period of Performance End:	*9/30/24*				