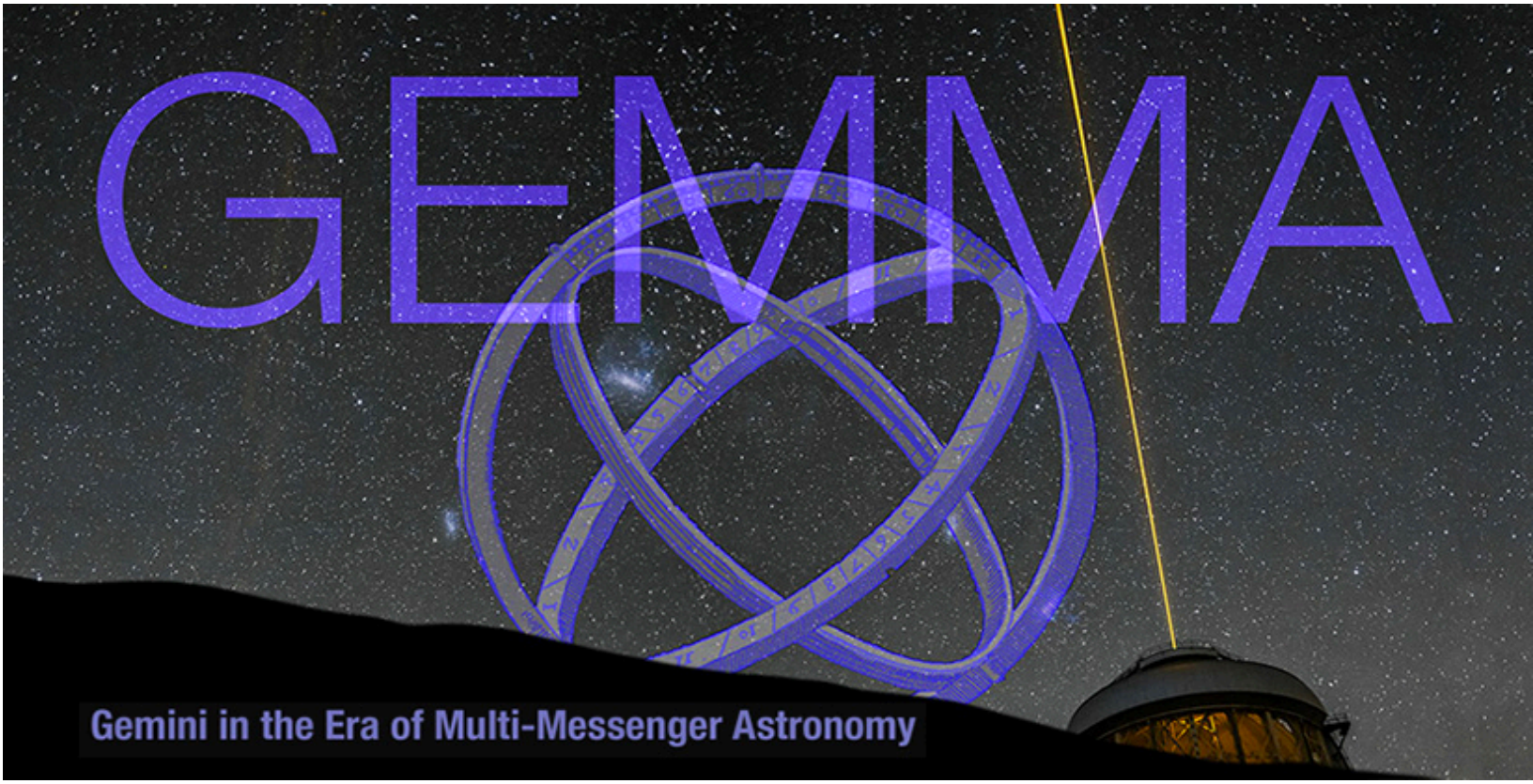

Time Domain Astronomy

Annual Report
FY2019

Cooperative Support Agreement 1839225
Submitted September 30, 2019

Summary

The TDA project will allow Gemini to take a leadership role in the era of MMA and LSST. 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

Specifically, the project 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.
- Provide software to help Gemini users work with the new APIs.
- Automate the data reduction for selected modes (e.g. GMOS long-slit) of at least one legacy instrument working within the new infrastructure to provide reduced data products in almost real-time at night.
- Improve the ingestion of reduced data products and provide for communication to and from end user tools to enable automatic download of products.

Major Goals

Major Activities Accomplished Under these Goals

Operational Concept Document: The operational concept document for TDA is being written in conjunction with the development of the Operations Concept for the Observatory Control System (OCS) since the two efforts are dependent on each other. The latter required additional effort to get completed and delayed our goal to have this formally reviewed in FY2019. Despite these delays, sufficient information was documented such that progress on the other TDA work packages was possible, mitigating schedule delays. The final version of this document is ready, and a formal review is planned for October 2019.

TDA Scheduler: We have executed experiments with different scheduling solvers, including investigation of solutions adopted by Las Cumbres Observatory. There are several options available, and a choice will be made once performance requirements are fully defined. The core of this work will be in the definition of the weighting scheme that we will use to evaluate any given telescope schedule, and not the solving engine itself. With that, we launched an activity to define that scheme, and the required software model that will support the scheduler within the

Observatory Control software. This work will be the focus of this work package in the first quarter of FY2020.

TDA APIs: We prototyped an API to demonstrate how a full GMOS Nod & Shuffle observation can be specified, using the OpenAPI standard. This has been given to the Project Scientist to compare against what is possible to do with the APIs that Las Cumbres is developing in the context of the AEON project. In addition, work started on documenting the workflow and concepts we need to support in the system for these APIs. This information will be used to define the specific APIs needed for TDA.

TOM Plugins: During AAS in January 2019, the project scientist presented a prototype of how Gemini can be triggered using our existing software interfaces via a Target and Observation Manager (TOM). The project scientist has written a Gemini plugin for the TOM Toolkit, a Las Cumbres Observatory led open source software project. This allows teams using the TOM Toolkit to trigger observations on Gemini using the existing, limited API. It was used by the 2019A US LIGO follow-up program on Gemini. This effort allows users to get experience with using TOMs, an important part of the developing follow-up network, and gives Gemini some early experience with and input on the TOM toolkit initiative. Later in September, Gemini and in particular the TDA Project Scientist, will be participating in the TOM Toolkit Workshop in Pasadena, CA.

Real Time Pipelines: Work began on the data reduction software, as planned. In addition to the set-up work, the team produced initial implementation of core algorithms for wavelength calibration and for source extraction. Work is progressing on automated spectrum extraction and sky subtraction, flat fielding, quantum efficiency correction, and archive support for processed arc and wavelength solution.

Definition of interfaces from the pipelines to the rest of the Observatory Control System (OCS) is also documented and it is ready for review by the software team.

This work package was affected by resource conflicts with another observatory project. As a result, the team replanned their work to mitigate schedule delays, but the conflicting project is not yet complete, and the risk of delay is still present.

Next Reporting Period Plan

- We plan to hold a review of the Operational Concept Document for TDA and OCS in October 2019.

- The scheduler work package will be focused on defining the weighting scheme and identifying required software changes to support the scheduler within the Observatory Control Software.

- The operational requirements for TDA APIs will be baselined and the definition of these APIs for use by the TOM Toolkit will be prototyped.

- As the work on the TOM Toolkit itself is not seen at this point as a major risk item, we do not anticipate spending effort on it during the next reporting period.

- The Real Time Pipelines work package will be focused on completing algorithms for automated spectrum and sky subtraction, flat fielding, quantum efficiency correction, and archive support for processed arc and wavelength solution.

- Gemini representatives will participate in an AEON splinter session at AAS235 (Honolulu, HI, January 2020), ESA/ESO Sciops 2019 (Madrid, ES, November 2019), and Transients 2020 (Cape Town, SA, February 2020).

Project Management

Cost Management

Current overall budget, actual expenditures and open commitments as of August 31, 2019 are shown below in table 1. Payroll for September will increase the total expenditures for FY19. Carry forward of unspent funds will likely be minimal and will be finalized when FY19 is closed by CAS accounting.

Table 1 Budget and Expenditures

TDA Software Upgrade					
	Approved Budget	**Total Expense FYTD**	**Current Open Commits**	**-Spend Remaining**	**-% Remaining**
TOTAL WAGE & BENEFITS	**119,334**	**104,724**	**0**	**14,611**	**12.24%**
TOTAL TRAVEL	**9,754**	**2,410**	**5,689**	**1,655**	**16.97%**
TOTAL OTHER DIRECT COSTS	**0**	**410**	**0**	**(410)**	**0.00%**
TOTAL EXPENSE	**129,088**	**107,544**	**5,689**	**15,855**	**12.28%**
GRAND TOTAL	**129,088**	**107,544**	**5,689**	**15,855**	**12.28%**

Milestones and Schedule

Table 2 Milestones and Schedule

TDA	Finish Date	Completion or Revised Date
Project Plan submitted to NSF	12/31/18	Completed
Concept of Operations Completed	5/15/19	Completed
Scheduler Work Package Milestones		
Scheduler Work Started	5/16/19	Completed
Gemini TDA APIs Work Package Milestones		
TDA APIs Work Started	7/15/19	Completed
Operational Requirements Baselined	7/29/19	Revised: 25-Oct-2019
Interface Control Documents		
Pipeline Interfaces defined	10/1/19	Completed
Gemini APIs for TDA baselined	7/29/19	Revised: 25-Oct-2019
Real Time Pipelines Work Package Milestones		
Real Time Pipelines Work begun	4/1/19	Completed
Reviews		
Conceptual Review	7/10/19	Revised: 25-Oct-2019

Resource Management

One of the main issues in the project has been securing the required software effort. Towards this goal, we have:

- Identified the required high-level software engineering effort from Gemini Operations that will work on this project, and made them available.
- Started process to backfill these operations positions, to ensure the continued availability of these engineers.
- Offers have been extended to two new software engineers to help with data reduction software and archive, and they will begin their work in October 2019.

With these actions, we expect that the issues we had in 2019 related to resource conflicts will be mitigated.

The project was also affected by delays in completing the Operational Concept document for the Observatory Control Software (OCS) upgrade, impacting the corresponding documentation for TDA - since TDA and OCS efforts are dependent on each other. That document and its corresponding review are now in good shape and should get completed in October 2019. Despite these delays, sufficient information was documented such as progress on the other TDA work packages was possible, mitigating schedule delays. The project plan was updated to account for these changes.

Staffing plans based on the work breakdown structure for the project were created in May and submitted with revised PEPS in Q3. Due to continued underspending NSF requested a revised budget and WBS submitted in August. The revised WBS is the current baseline in the GEMMA Resource Allocation Spreadsheet, a tool to monitor staff effort. The project manager receives monthly reports from the Portfolio Management Office allowing them to compare planned staff effort against actuals.

Risk

Table 3 Risk Summary

Issue/Risk	Risk Level	Mitigation
Science Effort not available	Medium	Working with upper management to secure required science effort for this project.
Software Resources not available	Low	Lowering risk as software engineer has been hired.
OCS Upgrades Dependencies	Medium	As the new OCS cannot be fully released before the end of 2021, final integration might need to be delayed.
Integration with AEON network	Medium	Interface definition ongoing, expect to finalize details in FY2020, Q1

Engagement with communities of interest:
In FY19 we have presented the GEMMA TDA plans and solicited feedback at the following workshops and conferences: the 50th meeting of the AAS Division of Planetary Sciences (Knoxville, TN, October 2018), the 233rd meeting of the AAS (Seattle, WA, January 2019), The New Era of Multi-Messenger Astrophysics (Groningen, NL, March 2019), LSST Chile IV (La Serena, CL, March 2019), Enabling Multi-Messenger Astrophysics in the Big Data Era (Baltimore, MD, April 2019), LSST Project and Community Workshop 2019 (Tucson, AZ, August 2019), and Hot-wiring the Transient Universe VI (Evanston, IL, August 2019).

The Project Scientist presented an invited LIneA webinar to a group of Brazilian astronomers on the new infrastructure for alert follow-up, including GEMMA TDA plans, in July 2019.

The Project Scientist led an Astro2020 Decadal Survey Activities, Projects, or State of the Profession Consideration (APC) white paper on community efforts and needs related to creating an alert follow-up network. GEMMA TDA plans were included in the discussion.

Gemini organized a TDA Advisory Committee that includes representatives of the Gemini partnership. The committee is discussing high-level issues on TDA. Their report to the Gemini Science and Technology Advisory Committee (STAC) is expected in November, 2019 and their advice will be considered in future planning.

Conference Presentations / Papers:

The following conference presentations and papers related to this project have been produced in FY2020.

1. “Gemini Solar System Follow-up in the LSST Era” at the 50th meeting of the AAS Division of Planetary Sciences (Knoxville, TN, October 2018) link
2. “Observing with Gemini in the LSST/SCORPIO Era” at the 233rd meeting of the AAS (Seattle, WA, January 2019) link
3. “Gemini Operations for Multi-Messenger Astronomy” at The New Era of Multi-Messenger Astrophysics (Groningen, NL, March 2019) talk proceedings
4. “Gemini Operations in the LSST Era” at LSST Chile IV (La Serena, CL, March 2019) link
5. “GEMMA” and “Gemini in LSST/SCORPIO Era” at Enabling Multi-Messenger Astrophysics in the Big Data Era (Baltimore, MD, April 2019) link
6. “New Infrastructure and Processes for Time-Domain Follow-up”, LIne A Webinar (July 25, 2019) link
7. “Advances on an Alert Follow-up System” and “AEON” in a breakout session organized by the Project Scientist at the LSST Project and Community Workshop 2019 (Tucson, AZ, August 2019) link
8. “Gemini in AEON” at Hot-wiring the Transient Universe VI (Evanston, IL, August 2019) link

Other Publications:

Miller, B. W. et al. 2019, “Infrastructure and Strategies for Time Domain and MMA and Follow-Up”, Astro2020 Decadal Survey APC White Paper, arXiv:1908.11417

Part I. Risk Identification						Part II. Risk Analysis for Existing Controls			Part III. Risk Response				
Name	**Project Risk Category**	**Risk Description (ignoring controls)**	**Impact 1-5 (ignoring controls)**	**Likelihood 1-5 (ignoring controls)**	**Total Risk Score** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**What Controls (if any) are currently in place?**	**Control Effectiveness 1-5**	**Residual Risk Score** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**Control or Risk Mitigation Strategy**	**Control effectiveness based on mitigation strategy 1-5**	**Residual Mitigated Risk** Low = 1 - 8 Med = 9 - 16 High = 17 - 25	**Contingency Plan**	**Cost of contingency plan**
Software Resources	Resources	If the software effort is not	4	4	16	Hiring process to hire 3 new SW	3	8	Use Internal resources	2	4	If suitable	
Science Effort not	Resources	If the science effort is not	4	4	16	Working with upper	4	12					
Integration with AEON	Scope	Integration with AEON is	3	4	12	Escalation to project sponsor to	4	9					
Technology	Technical	If project team is not aligned on	3	2	6	Regular technical meetings with	2	2					
Missed external	Scope	If a dependency between TDA	4	3	12	Project with sufficient Systems	3	6	Regular	3	6		
Key personnel	Resources	If key personnel aren't available	4	3	12	Maintain project priority and	3	6					
Scheduler complexity	Technical	If scheduling Gemini	4	2	8	Investigation of strategies to	3	4	Consider simplifying	3	4		
Automation Flexibility	Technical	If automation cannot be made to	3	2	6	Tasks requiring flexibility are	3	3	Consider simplifying	3	3		
Scheduler performance	Technical	If the scheduler cannot run fast	4	2	8	Prototyping to assess	3	4	Early testing at full load	2	2		
Internet connectivity	Technical	If the internet connections	4	3	12	Work with internet providers and	3	6	Develop contingencies	3	6		
Changed external	Technical	If Astropy dependencies change	3	3	9	Participate in Astropy	4	7	Fork a previous version	2	2		
OCS3 Dependencies	Scope	TDA presupposes an OCS that	5	4	20	OCS Ugrades made a high	4	15	Preparing OCS	3	10		
Environmental	Technical	TDA presupposes reliable	4	3	12	Requirements for TDA will be	2	3					
Deployment Strategy		TDA requires joint telescope	4	2	8	Deployment strategy is part of	2	2					
TAC Changes		TDA may require changes to the	4	2	8	This is being addressed as part	3	4			#N/A		
Operations Changes		TDA will require changes in	4	3	12	This is part of the TDA plan to	3	6					
Long-Term Scheduling		TDA requires precise short-term	3	3	9	Topic included in the TDA	3	5					

Owner	Last Review	Status
PM	August 2019	
	August 2019	Final iteration
PM	August 2019	
PM	August 2019	Lowered
PM	May 2019	Ongoing
PM	May 2019	Ongoing.
PM	May 2019	Lowered
DR Senior	May 2019	Ongoing. DR
PM	August 2019	Scheduler work
PM	August 2019	Ongoing.
DR Senior	May 2019	Ongoing. Intent
PM	July 2019	Increased
PM	August 2019	Ongoing.
	August 2019	Risk Retired.
PM	August 2019	Low Risk. TAC
PM	August 2019	Ongoing. Part
PM	August 2019	Ongoing. Topic