Project Documentation
Document PMCS-0100
Revision C

DKIST Project Execution Plan

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	Name	*Date*
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REVISION SUMMARY:

1. Date: May 19, 2015
   Revision: A
   Changes: We adopt the PMI PMBOK 5th edition standard for the project management plan content. This document provides the pointers/mapping to the suite of project documents that describe these areas.

   We note that this is the successor to the PEP Overview (PMCS-0001) which pre-dated the project funding.

2. Date: October 1, 2015
   Revision: B
   Changes: We adopt the Large Facilities Manual: NSF15-xxx, May 2015 draft as a structural template.

3. Date: December 2, 2015
   Revision: C
   Changes: Added Physical Security to Section 12. Added links to AURA policies in Section 11.

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Preface

We adopt the Large Facilities Manual (NSF 15-xxx, May 2015) standard for the project execution plan content. This document provides the content as well as pointers/mappings to the suite of project documents that together describe these areas and processes.

The project maintains a set of historical documents which together encompass the components of a PMI PMBOK standard Project Management Plan. At this stage in the project (more than half completed), we have attempted to more succinctly describe the realization of the Project Management Plan and the processes by which we will deliver the project scope within budget and schedule. The core documentation representation of this would be:

- PMCS-0100 Project Execution Plan (this document)
- PMCS-0101 Project WBS Dictionary
- PMCS-0102 Systems Engineering
- PMCS-0103 Project Management Control Systems

We provide a broader mapping of the Large Facilities Manual Project Execution Plan components in Section 1.

1. INTRODUCTION

1.1 DOCUMENT PURPOSE

The project execution plan describes how the project will be executed, monitored and controlled. For the DKIST Construction Project, this content is contained in a confederation of separate documents, which evolve at different rates. This document is therefore a means of navigating/discovering the mapping of the project documentation consistent to the project execution plan framework laid out in the NSF's Large Facilities Manual (draft May 2015).

Large Facilities Manual Component	*DKIST Project Document Location*
Introduction	PMCS-0100 (This Document) SPEC-0001 ATST Science Requirements Document
Organization	PMCS-0100 (This Document)
Design and Development	PMCS-0100 (This Document)
Construction Project Definition	PMCS-0100 (This Document) PMCS-0101 WBS Dictionary PMCS-0008 PMB Cost Book (September 2013) Project Integrated Project Schedule (August 2015)
Staffing	PMCS-0100 (This Document)
Risk and Opportunity Management	PMCS-0103 Project Management Control System
System Engineering	PMCS-0102 Systems Engineering Plan
Configuration Control	PMCS-0103 Project Management Control System SPEC-0002 Document and Drawing Control Plan
Acquisitions	PMCS-0109 Procurement Management Plan
Project Management Controls	PMCS-0103 Project Management Controls System PMCS-0038 Financial and Business Controls Plan
Site and Environment	PMCS-0100 (This Document)
Cyber Infrastructure	PMCS-0100 (This Document)
Health and Safety	SPEC-0086
Review and Reporting	PMCS-0100 (This Document)
Integration and Commissioning	PMCS-0102 Systems Engineering Plan
Project Close-out	PMCS-0100 (This Document)
Facility Termination	PMCS-0100 (This Document)

1.2 PROJECT RESEARCH OBJECTIVES

The DKIST (Daniel K. Inouye Solar Telescope, formerly the Advanced Technology Solar Telescope, ATST) research objectives are elaborated in the proposal submission to the NSF (http://dkist.nso.edu/conprop).

Section II ("Science Goals of the DKIST") of the proposal summarizes:

The astronomical object most relevant to humanity and life on earth is the Sun. Amongst the many reasons for the intense, continuing interest in observing the Sun are:

- *The Sun sustains life on Earth; it controls our environment and impacts our technological civilization. Understanding and predicting the influences of the Sun on the Earth's climate and on space weather in the near-Earth environment is a major challenge for science. Understanding the Sun and Sun-Earth connection is crucial for understanding planetary systems (solar and extra-solar) in general.*
- *The Sun is the nearest and most readily studied astronomical object. Many physical processes that form the foundations of our current understanding of the universe are most accurately observed on the Sun.*
- *The Sun is a unique plasma physics laboratory. Its magnetic field configurations and environment provide conditions unattainable in terrestrial laboratories and are close enough to study with precision.*
- *The Sun presents us with many important unsolved mysteries and unexplored domains that challenge science.*

Nowhere in the universe is there a better place to explore and understand how magnetism directs astrophysical and terrestrial change. The DKIST is the first telescope the astronomical community has designed in all its aspects as a tool for magnetic remote sensing. Its collecting area, diffraction limit, wavelength performance and integral instrumentation are all targeted for understanding how magnetic fields affect the dynamics of the Sun and the solar-terrestrial environment. DKIST will replace the aging national facilities (built in the 50s and 60s) that are now beginning to lose their competitive edge to moderately sized new solar telescopes such as the 1m New Swedish Solar Telescope. The 4m aperture DKIST will be the largest solar telescope ever built and with its unique and unprecedented capabilities will be at the forefront of international solar research and astronomy.

The Sun sustains life on Earth and is our main source of energy. Although we are confident that the Sun's total radiative output will not change over times relevant to human society, it is the subtle variation in the spectral composition of this output that profoundly influences Earth climate and our more and more technology driven society that we have to worry about. These variations occur on much shorter time scales and are modulated by the evolution of the magnetic field in the solar interior in ways we do not yet understand, but need to be able to predict. The detailed study of the structure and dynamics of the solar magnetic field on all its relevant scales, which is required to develop such predictive capabilities, is the main objective for building the DKIST. DKIST is not only a telescope of unique design but also provides a set of state-of-the-art instruments that in many cases will be operated simultaneously to obtain the maximum amount of information about the dynamic solar atmosphere.

Our vantage point on Earth allows us to study the Sun in more detail than any other star. We would never have been able to extract the physical intricacies of all the processes we see on its surface if we had to go by the spatially averaged light we receive from other stars. Although, with the prospect of 30-100 m telescopes resolving distant stars will become feasible and the observations of the sun that DKIST will deliver will be essential for the correct interpretation of the data coming from the giant aperture telescopes. Currently, we are not yet able to observe these processes at their natural scale, even in the case of the Sun. With DKIST we will have the ability to zoom in on these scales and finally gain an understanding of the role magnetic field and its interaction with the embedding plasma plays in the Sun and many other astrophysical objects. With the new spatial scales that DKIST will allow us to resolve, and the new spectral windows it will make available to us we will also have new opportunities for discoveries of processes we had no idea existed.

To achieve the goals we have set for DKIST we require an instrument with a large aperture, not only to reach sufficient spatial resolution, but also to collect enough photons for accurate polarimetry. We also require the ability to observe the Sun at many wavelengths simultaneously, including in the near ultraviolet and in the infrared, to resolve the three-dimensional structure of the solar atmosphere, and at high temporal resolution to resolve the highly dynamic nature of the atmosphere. With these requirements the DKIST will be the ideal tool for magnetic remote sensing.

Much progress in our understanding of the behavior of the solar magnetic field and its direct influence on the near Earth environment has been made with space missions like Yohkoh, SoHO, TRACE, and most recently RHESSI. These missions have reinforced our perception that the Sun's atmosphere is highly dynamic and changes in its magnetic field lead to strong variations in its UV and X-ray, and particle flux. Changes in the solar magnetic field produce solar flares, coronal mass ejections, and cause variations the solar wind. All of these processes have profound impacts on human society, driving terrestrial climate, determining the state of the Earth's atmosphere and magnetosphere, affecting communication, power transmission and other activities on the Earth's surface, and presenting hazards to humans in space. Unfortunately, our understanding of these phenomena is still very limited. We do not know how the highly intermittent magnetic fields observed at the solar surface are generated by dynamo processes and how are they dissipated. We do not know what magnetic configurations and evolutionary paths lead to flares and coronal mass ejections, or which mechanisms are responsible for variations in the spectral and total irradiance of the Sun and solar-type stars.

Over the last two decades a remarkable change has taken place in solar physics. The increasing power of numerical simulations, both in hardware performance and through development of new techniques, has transformed the field from a more phenomenological science, describing the appearance of the wide variety of magnetic phenomena, to a real physical science that investigates their nature and connections between them. Unfortunately, the spatial, spectral, and temporal resolution of solar observations has not been able to keep up with the predictions the simulations produce. As a result, many simple questions remain unanswered. The DKIST is needed to constrain and guide the modeling efforts to the point where we not only understand the behavior of the solar magnetic field and plasma, but also are able to predict its behavior.

There is a great incentive for DKIST to work at infrared wavelengths. Maximum sensitivity to magnetic field is achieved with infrared lines. Earth's sky is also darker in the infrared than the visible, resulting in much reduced background levels and improved signal-to-noise levels. For accurate determination of the magnetic field parameters from the photosphere to the corona, DKIST will provide access to infrared wavelengths at high spatial resolution in a way that cannot be achieved economically from space due to the required large telescope aperture. The unique ability of DKIST to measure coronal magnetic fields using infrared lines is needed to solve the mystery of flares and coronal mass ejections (CMEs). No existing instrument can provide these crucial measurements. Coronal magnetic field observations are starved for photons. DKIST constitutes an improvement in sensitivity by nearly a factor of 50 from one of the world's current largest coronagraphs (0.4m). This sensitivity improvement will allow fields as low as the equipartition field strength to be measured for the first time. This is a unique capability, which DKIST provides because, except for occasional point-like observations of background radio sources, we have never had the capability to detect and measure such coronal magnetic fields.

It should be emphasized that exploration of the Sun at infrared wavelength is a relatively new field and is an area with the potential for new discoveries. The history of science is full of examples where measurements of the Sun, stimulated by basic questions and using new observational capabilities (often first applied to the Sun), led to revolutions in our deepest understanding of nature. A recent example is the neutrino problem (Bahcall et al. 2000), i.e., the disagreement between the measured and predicted

solar neutrino fluxes. Helioseismology has proven the standard solar model to an accuracy of better than 0.1%. The conclusion from this is that the origin of the problem was an incomplete understanding of neutrinos ñ a result recently confirmed by experiments far more expensive than the DKIST. The DKIST is such a large qualitative and quantitative step forward that it offers a good chance of continuing this tradition of revolutionary discoveries with impacts far beyond solar physics. Based on the history of major solar telescopes, we emphasize that a main scientific contribution of the DKIST is likely to be one or more discoveries that we cannot foresee.

The 0.022 arcsec (at 430nm, g-band, 16km on the surface of the Sun) diffraction limited resolution of DKIST will finally allow detailed comparison with models of physical processes on their natural scales. The DKIST will easily resolve the fundamental scale of the photon mean free path in the photosphere, which probably restricts the spatial extent of thermal variations. DKIST will be the only solar telescope that can resolve these fundamental scales at near infrared wavelengths such as 1.6 microns, which have become an indispensable diagnostics tool for magnetic field measurements. DKIST will be the only solar telescope that can resolve these fundamental scales in the corresponding important parts of the spectrum. DKIST's large aperture is also needed to achieve a high photon flux for accurate measurement of physical parameters like magnetic strength and direction, temperature and velocity through polarimetry and spectroscopy at high spectral and temporal resolution. A large field of view is needed to study the evolution of magnetic active regions, the prime manifestation of solar magnetic fields on larger scales. The flexible post-focus instrument package of the DKIST will allow the observer to optimize the relevant observing parameters such as spatial and spectral resolution and polarimetric sensitivity and accuracy to a specific problem. Such optimization is hardly ever possible for space missions.

During the past decade, solar astronomers have presented strong scientific arguments for a large-aperture solar telescope. These arguments are presented in the latest NSF/NASA Astronomy & Astrophysics Survey Committee (AASC) Decadal Survey (2000) and the NAS/NRC report on Ground-Based Solar Research: An Assessment and Strategy for the Future(1999). The close synergism between DKIST and NASA's 'Living with a Star' program and its space missions such as the Solar Dynamic Observatory (SDO) was stressed by the Solar and Space Physics Decadal Survey (Lanzerotti, 2003). Combining the individual strengths of the ground-based DKIST and space missions will lead to the desired scientific breakthroughs. These reports make a strong and persuasive case that high-resolution studies of the Sun's magnetic fields will lead to a better understanding of cosmic magnetic fields and the fundamental processes responsible for solar activity and variability. The latest Decadal Survey of Astronomy has given the DKIST a high ranking within the Nation's astronomy program. The DKIST is a community-wide program. The recent NAS/NRC panel study on Ground-Based Solar Research and its recommendation that the DKIST be the next major solar project, as well as the broad participation of university and other national and international partners, reflect the communities' support.

Some of the major scientific questions addressed by the DKIST, and the requirements these science goals place on the telescope and its instrumentation, are outlined in detail below.

DKIST will allow us to study the fundamental physical processes underlying solar magnetic activity at the spatial and temporal scales at which they naturally occur. Relating these measurements to the global magnetic variability of the Sun is a critical component of the science that the DKIST will enable. The Sun's magnetic machine involves the processes of flux generation, transport, dissipation, instability and ejection; the DKIST is critical for our understanding of all of these. For example, in Section 2.1 we discuss how DKIST observations of the small-scale processes at the solar surface may play a critical role in understanding the overall dynamo process ñ the generation of the magnetic fields themselves and their cyclic behavior. This leads naturally to Section 2.1.3, a discussion of flux tubes, which are generally believed to be the fundamental building blocks of magnetic structure in the atmosphere and the

progenitors of solar activity. The DKIST will for the first time reveal the nature of solar magnetic flux concentrations. With the DKIST will be able to observe the interaction of the magnetic field with convective motions and waves (Section 2.1.4) and determine how energy is transferred to the magnetic field. By exploiting the broad spectral coverage planned for the DKIST, especially the IR spectrum, we can observe these processes with height and measure their role in determining the structure, dynamics, and heating of the chromosphere and the corona (Section 2.3). The unique IR capabilities of the DKIST will be used to measure the cool chromospheric component and provide critically needed measurements of coronal magnetic fields. The dynamics and heating of these outer layers of the solar atmosphere in turn results in the violent flux expulsions we see as flares and mass ejections (Section 2.2.1) and variations in the solar radiative output (Section 2.4). All of these processes are tied together by the behavior of magnetic flux in the dynamic plasma at the solar surface. In Section 3 we discuss the significant impact of the DKIST on other areas of astrophysics, space science, and plasma physics and how the results from the DKIST will be crucial for building and refining space weather models. The synergism between the DKIST and other ground- and space-based assets and the crucial interplay of DKIST observations and models and simulations are described in the same section. DKIST's large photon collecting area, high angular resolution, infrared sensitivity, low scattered light and high polarimetric sensitivity and accuracy provide the tools we need to trace the origin, transport and evolution, and dissipation of magnetic fields in the Sun. This new ability to observe the life-cycle of magnetic flux is essential to resolve many longstanding solar problems.

The science focus of DKIST will undoubtedly evolve with time as the results from DKIST observations and joint DKIST-space mission observations drive the field of solar physics. DKIST has been designed in a way that will allow it to adapt to new scientific frontiers.

1.3 SCIENCE REQUIREMENTS

The Science Requirements are summarized in SPEC-0001 (ATST Science Requirements Document).

The approach taken in the document was to review a spectrum of observational use cases and choose from them the most demanding observational requirements (as envisaged at that time) and from these derive the most stringent technical requirements for telescope and instruments.

2. ORGANIZATION

The Daniel K. Inouye Solar Telescope (DKIST) project was established within the National Solar Observatory. NSO formed a dedicated project to provide central management in leading the DKIST Construction. The relationship of the DKIST project to NSO, AURA and the NSF is shown in Figure 2.1.

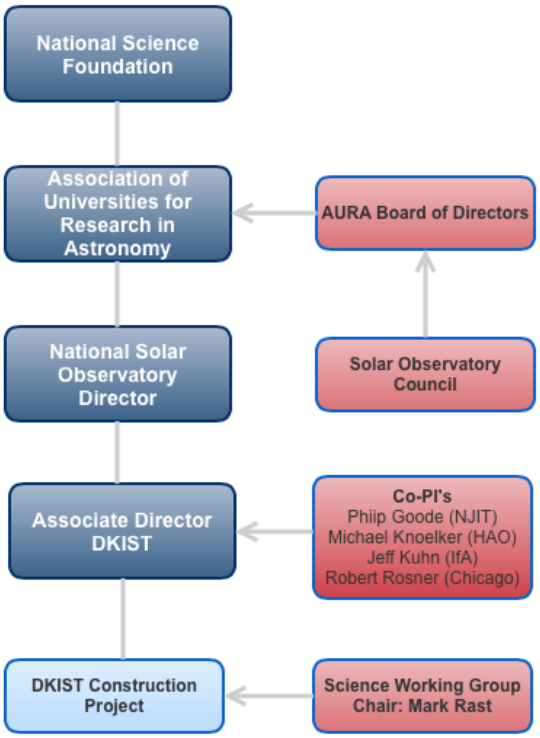


Figure 2.1 DKIST relationship to NSO, AURA and the NSF. Relationships with oversight and advisory groups are also shown.

The NSF provides the funding agency oversight for DKIST. Annual funding and contractual obligations flow from the NSF to AURA as specified in the Cooperative Agreement for the National Solar Observatory and to DKIST as specified in the pair of Cooperative Support Agreements (one for each flavor of funding: ARRA (Award 0415302), MREFC (Award 1011851)).

AURA, through the NSO, is accountable for the performance of the DKIST. NSO has responsibility for staffing the project, providing institutional support to the project, coordinating any contributions from partners, and ensuring adequate oversight of the execution and performance of the project. The Co-I team provides regular advice to the DKIST Director to review overall direction and major decisions.

The DKIST is a broad-based community project that exploits the strengths of its partner organizations. Advisory groups at each level provide oversight of the DKIST project. The AURA President and Board of Directors regularly receive advice from the Solar Observatory Council (SOC), which oversees NSO's management of its programs. The SOC includes community members from the U.S. and international groups. The DKIST Director formed the DKIST Science Working Group (SWG) who collaborated on the development of the science requirements and provides input, advice and support of scientific considerations, including assessing the impact of design trades with consideration of the scientific goals of the DKIST. The Project Manager leads the Construction Project and forms design review committees for formal design review assessment during construction; these same groups are involved in the fabrication, integration, and commissioning review. The Project Manager also uses a Change Control Board, which supports the change control function in assessing the impact of proposed changes.

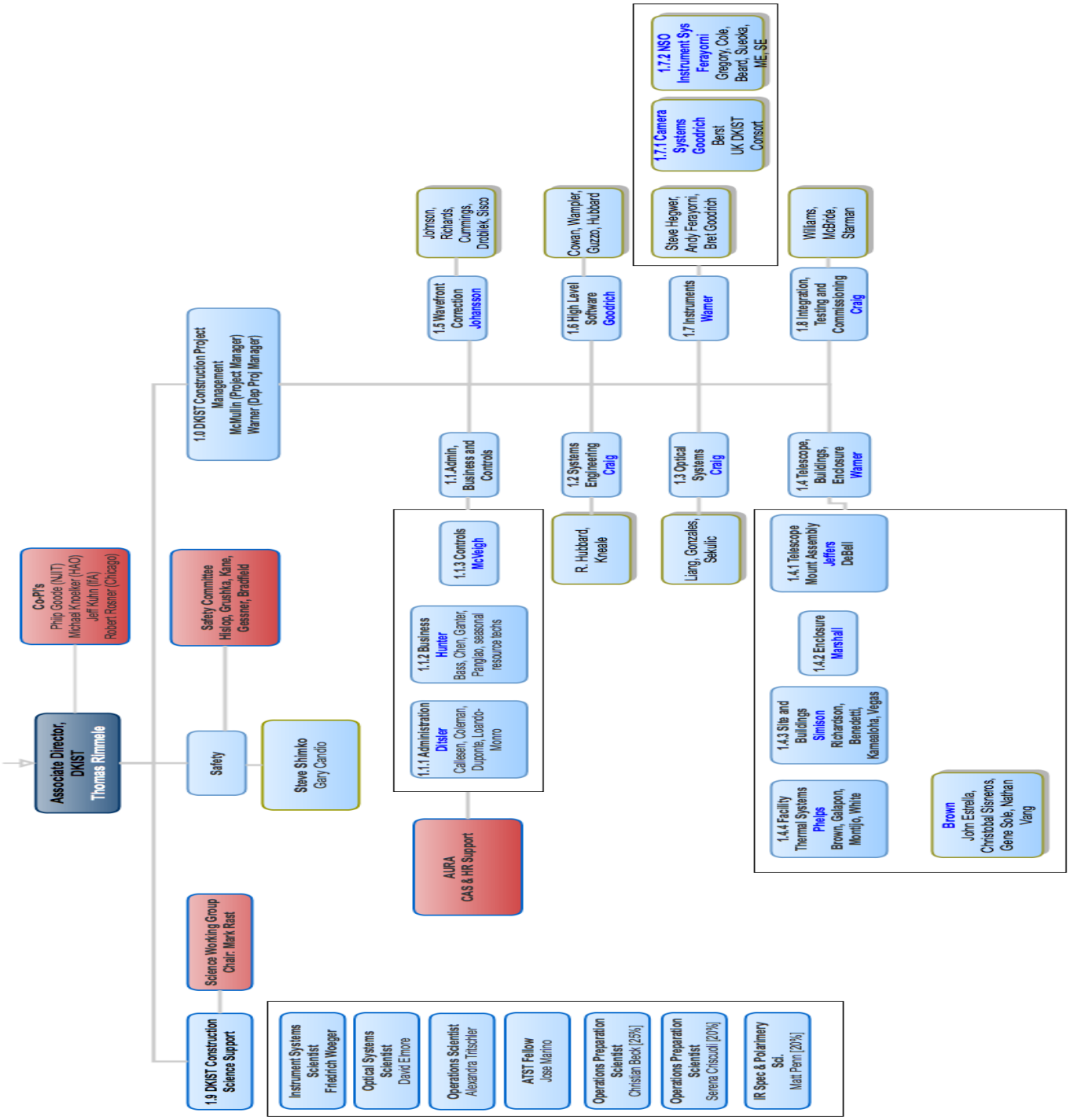


Figure 2.2 DKIST Project Team Organizational Chart (May 2015).

The Project maintains staff in four locations:

1. Tucson, Arizona; project management and main engineering group
2. Sunspot, New Mexico (Re-locating to Boulder, CO by 2017)
3. Boulder, CO (NSO Headquarters); science and instrumentation groups
4. Pukalani, Maui, HI; site construction management

The Project Manager is responsible for completing the project scope within the budget, schedule, and reporting constraints established by the Cooperative Support Agreements. The DKIST Director resolves issues where management and scientific objectives may be in conflict. Team/sub-system leads have been assigned to drive major elements of the project. Engineering leads meet bi-weekly, covering the performance, cost, schedule and risk breakdowns.

3. DESIGN AND DEVELOPMENT

The National Solar Observatory received an award (AST-0939959) for the Design and Development Phase of the (then) Advanced Technology Solar Telescope (ATST). The funding of this effort began in late 2001 with a total NSF cost of approximately $14M.

This phase included technology development and trade studies as well as detailed designs and accurate cost estimates for construction and operation of both the telescope and its first light instrumentation. In particular, the funding was used for key staff to complete design efforts and prepare for the construction start; it also supported recommended risk reductions and vendor contractor preparation needed to move into construction. The completion with industry of the site architectural and engineering (A&E) work and the foundation design was the highest priority item of risk reduction within the vendor contracting package. The A&E work and foundation design were drivers for the start of work on site and needed for the site construction critical path. Other work included adaptive optics deformable mirror prototyping and wavefront sensor camera development and further instrument and software controls development. The risk reduction efforts with industry flowed directly from recommendations made by design and cost review committees.

Construction planning milestones were completed during this phase along with the design development needed for the conceptual, preliminary and critical design reviews of the project.

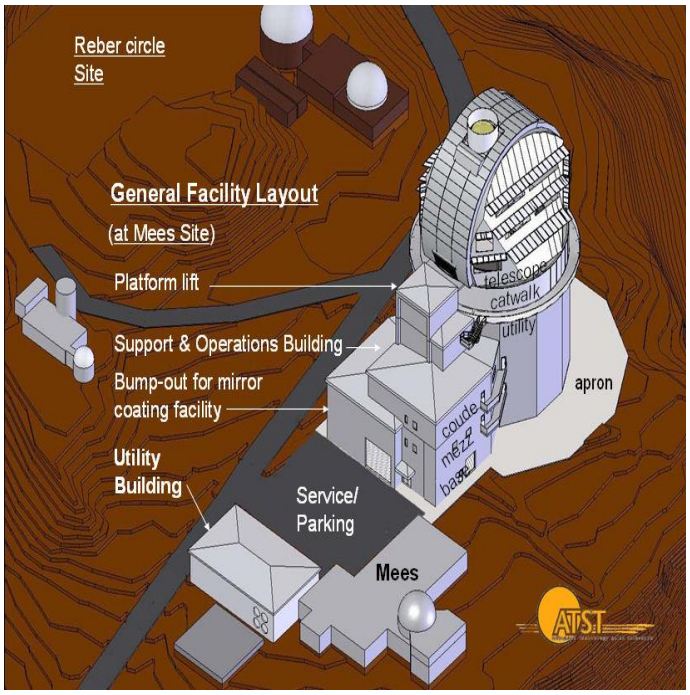
4. CONSTRUCTION PROJECT DEFINITION

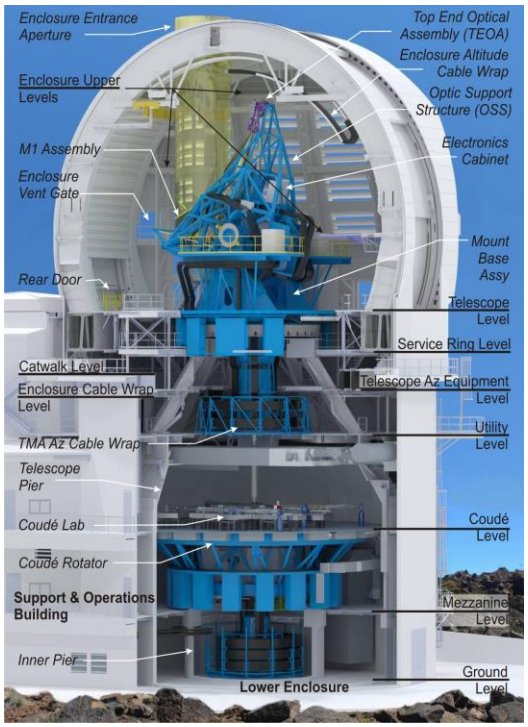
4.1 SUMMARY OF TOTAL PROJECT DEFINITION

The Daniel K. Inouye Solar Telescope will be the most powerful solar telescope and the world's leading ground-based resource for studying solar magnetism that controls the solar wind, flares, coronal mass ejections and variability in the Sun's output.

The construction project funding supports the development of a four-meter, off-axis, Gregorian telescope capable of operating over a broad range (350 to 28000 nm), integrated adaptive optics systems to achieve diffraction limited imaging, and a suite of first light instruments for performing spectropolarimetry from 380-5000 nm. It is being built within a 0.86 acre parcel on the summit of Haleakala, Maui, HI within the University of Hawai'i Institute for Astronomy's 18.166 acre Haleakala Observatory (3050 AMSL). The project was first funded in January 2010 and anticipates a start of operations in late 2019. The project is led by the National Solar Observatory (PI) with co-investigators from the UCAR High Altitude Observatory, New Jersey Institute for Technology, University of Hawai'i and the University of Chicago. It currently has two additional collaborators in the Kiepenheuer Institute for Solar Physics (contributing the Visible Tunable Filter first light instrument) and a consortium of UK universities, led by Queen's University, Belfast (contributing the visible cameras).

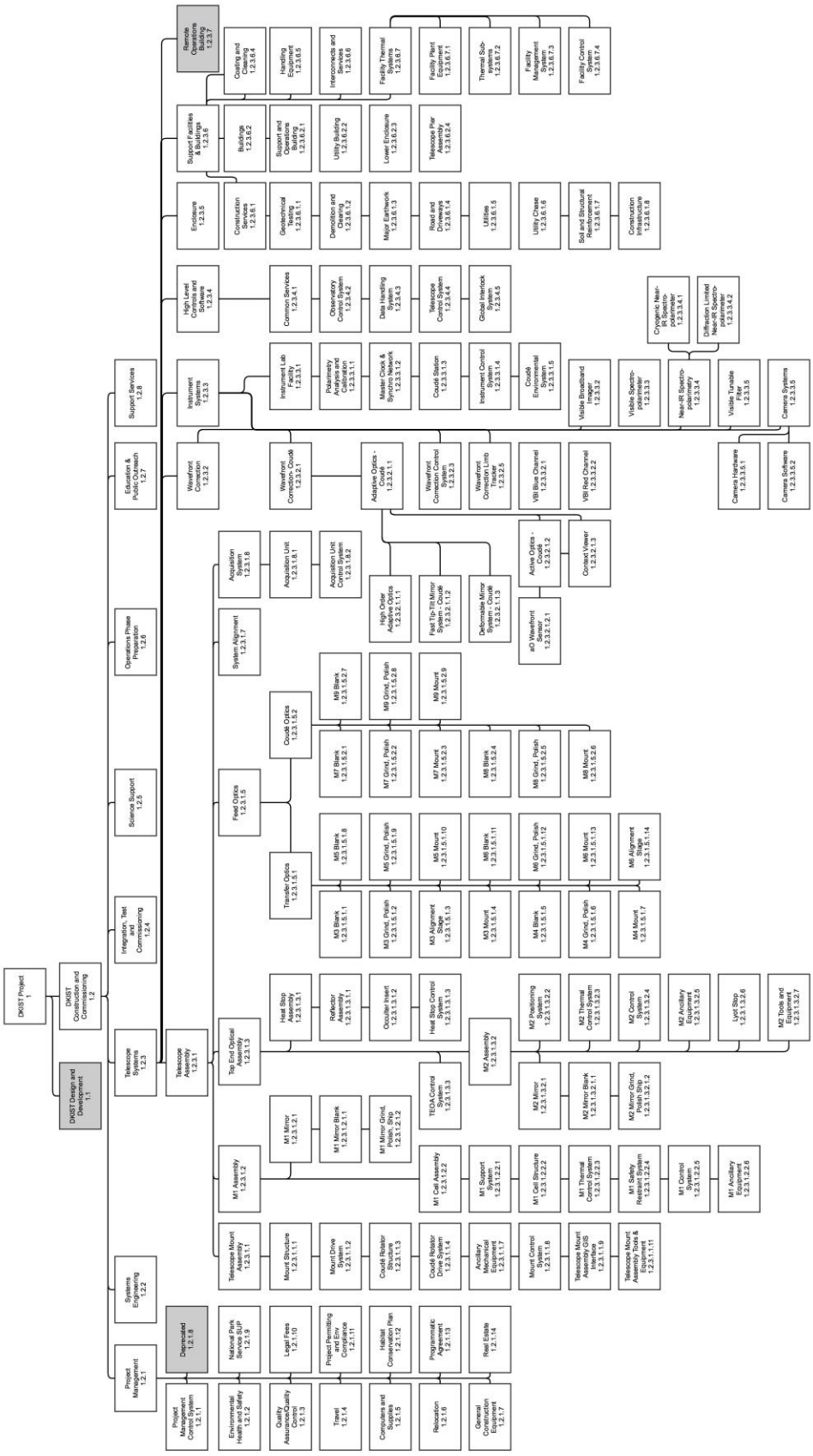
The Project Performance Measurement Baseline was established in September 2013 following the approval of the National Science Board's approval. is tracking to this schedule based on an overall budget of $344,129K, comprised of $296,772K in budget and $47,357K in contingency funds.





4.1.1 Work Breakdown Structure

Systems Engineering provided the decomposition of the project scope into the WBS elements. These are represented graphically below and described in detail in the WBS dictionary (PMCS-0101).


DKIST Project 1
DKIST Design and Development 1.1
DKIST Construction and Commissioning 1.2
Project Management 1.2.1
Systems Engineering 1.2.2
Telescope Subsystem 1.2.3
Integration, Test and Commissioning 1.2.4
Science Support 1.2.5
Operations Phase Preparation 1.2.6
Education & Public Outreach 1.2.7
Support Services 1.2.8
Project Management Control System 1.2.1.1
Environmental Health and Safety 1.2.1.2
Quality Assurance/Quality Control 1.2.1.3
Travel 1.2.1.4
Computers and Supplies 1.2.1.5
Relocation 1.2.1.6
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Deprecated 1.2.1.8
National Park Service SUP 1.2.1.9
Legal Fees 1.2.1.10
Project Permitting and Env Compliance 1.2.1.11
Habitat Conservation Plan 1.2.1.12
Programmatic Agreement 1.2.1.13
Real Estate 1.2.1.14
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Telescope Mount Assembly 1.2.3.1.1
Mount Structure 1.2.3.1.1.1
Mount Drive System 1.2.3.1.1.2
Coudé Rotator Structure 1.2.3.1.1.3
Coudé Rotator Drive System 1.2.3.1.1.4
Ancillary Mechanical Equipment 1.2.3.1.1.7
Mount Control System 1.2.3.1.1.8
Telescope Mount Assembly GIS Interface 1.2.3.1.1.9
Telescope Mount Assembly Tools & Equipment 1.2.3.1.1.11
M1 Assembly 1.2.3.1.2
M1 Mirror 1.2.3.1.2.1
M1 Mirror Blank 1.2.3.1.2.1.1
M1 Mirror Grind, Polish, Strip 1.2.3.1.2.1.2
M1 Cell Assembly 1.2.3.1.2.2
M1 Support System 1.2.3.1.2.2.1
M1 Cell Structure 1.2.3.1.2.2.2
M1 Thermal Control System 1.2.3.1.2.2.3
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TEOA Control System 1.2.3.1.3.3
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M2 Thermal Control System 1.2.3.1.3.2.3
M2 Control System 1.2.3.1.3.2.4
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M3 Blank 1.2.3.1.5.1.1
M3 Grind, Polish 1.2.3.1.5.1.2
M3 Alignment Stage 1.2.3.1.5.1.3
M3 Mount 1.2.3.1.5.1.4
M4 Blank 1.2.3.1.5.1.5
M4 Grind, Polish 1.2.3.1.5.1.6
M4 Mount 1.2.3.1.5.1.7
M5 Blank 1.2.3.1.5.1.8
M5 Grind, Polish 1.2.3.1.5.1.9
M5 Mount 1.2.3.1.5.1.10
M6 Blank 1.2.3.1.5.1.11
M6 Grind, Polish 1.2.3.1.5.1.12
M6 Mount 1.2.3.1.5.1.13
M6 Alignment Stage 1.2.3.1.5.1.14
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M7 Blank 1.2.3.1.5.2.1
M7 Grind, Polish 1.2.3.1.5.2.2
M7 Mount 1.2.3.1.5.2.3
M8 Blank 1.2.3.1.5.2.4
M8 Grind, Polish 1.2.3.1.5.2.5
M8 Mount 1.2.3.1.5.2.6
M9 Blank 1.2.3.1.5.2.7
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M9 Mount 1.2.3.1.5.2.9
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Adaptive Optics - Coudé 1.2.3.2.1.1
High Order Adaptive Optics 1.2.3.2.1.1.1
Fast Tip-Tilt Mirror System - Coudé 1.2.3.2.1.1.2
Deformable Mirror System - Coudé 1.2.3.2.1.1.3
Wavefront Correction Control System 1.2.3.2.3
Wavefront Correction Limb Tracker 1.2.3.2.5
VBI Blue Channel 1.2.3.2.1
VBI Red Channel 1.2.3.2.2
Active Optics - Coudé 1.2.3.2.1.2
Context Viewer 1.2.3.2.1.3
aO Wavefront Sensor 1.2.3.2.1.2.1
Instrument Systems 1.2.3
Instrument Lab Facility 1.2.3.3.1
Polarimetry Analysis and Calibration 1.2.3.3.1.1
Master Clock & Synchro Network 1.2.3.3.1.2
Coudé Station 1.2.3.3.1.3
Instrument Control System 1.2.3.3.1.4
Coudé Environmental Sensors 1.2.3.3.1.5
Visible Broadband Imager 1.2.3.3.2
Visible Spectro-polarimeter 1.2.3.3.3
Near-IR Spectro-polarimeter 1.2.3.3.4
Cryogenic Near-IR Spectro-polarimeter 1.2.3.3.4.1
Diffraction Limited Near-IR Spectro-polarimeter 1.2.3.3.4.2
Visible Tunable Filter 1.2.3.3.5
Camera Systems 1.2.3.3.6
Camera Hardware 1.2.3.3.6.1
Camera Software 1.2.3.3.6.2
High Level Control Hardware and Software 1.2.3.4
Common Services 1.2.3.4.1
Observatory Control System 1.2.3.4.2
Data Handling System 1.2.3.4.3
Telescope Control System 1.2.3.4.4
Global Interlock System 1.2.3.4.5
Enclosure 1.2.3.5
Construction Services 1.2.3.5.1
Geotechnical Testing 1.2.3.5.1.1
Demolition and Disposal 1.2.3.5.1.2
Major Earthwork 1.2.3.5.1.3
Road and Driveways 1.2.3.5.1.4
Utilities 1.2.3.5.1.5
Utility Chase 1.2.3.5.1.6
Soil and Structural Assessment 1.2.3.5.1.7
Construction Infrastructure 1.2.3.5.1.8
Support Facilities & Buildings 1.2.3.6
Buildings 1.2.3.6.2
Support and Operations Building 1.2.3.6.2.1
Utility Building 1.2.3.6.2.2
Lower Enclosure 1.2.3.6.2.3
Telescope Pier Assembly 1.2.3.6.2.4
Coating and Cleaning 1.2.3.6.4
Handling Equipment 1.2.3.6.5
Interconnects and Subsystems 1.2.3.6.6
Facility Thermal Systems 1.2.3.6.7
Facility Plant Equipment 1.2.3.6.7.1
Thermal Sub-systems 1.2.3.6.7.2
Facility Management System 1.2.3.6.7.3
Facility Control System 1.2.3.6.7.4
Remote Observatory Building 1.2.3.7

4.1.2 WBS dictionary

The project WBS Dictionary is contained in PMCS-0101.

4.1.3 WBS Status (End of FY2015)

Component	Company	Location	Status
Telescope Mount Assembly	Ingersoll Tools	Rockford, IL	Coude Rotator: Accepted July 2014 Mount: Accepted May 2015
Enclosure	AEC IDOM	Bilbao, Spain	Accepted Feb 2014; SAT ongoing
M1	Schott AG (blank) UA COS (polish)	Mainz, Germany Tucson, AZ	Accepted @60nm rms ; FAT ongoing
M2 (TEOA)	L3	Pittsburgh, PA	Factory Testing (heat stop)
M3, M4, M6	L3	Pittsburgh, PA	Factory Testing
M5	Physik Instrumente	Auburn, MA	Accepted
M7, M8, M9	Arizona Optical Systems, LLC	Tucson, AZ	In Fabrication
M10	Xinetics	Devens, MA	Accepted May 2015
M1 Cell Assembly	AMOS	Liege, Belgium	Factory Testing
HLS	NSO, OSL	*	FDR Sep 2015
Site – Excavation Site – Concrete Site – Steel Erection Site – Electrical Site – FTS/Plumbing	Tom's Backhoe & Exc Reef, Rojac Trucking Inc SteelTech Inc Du-Watts Electric Inc NSO*	Kula, HI Wailuku, HI Lahaina, HI Wailuku, HI Pukalani, Maui, HI	Complete Complete Ongoing (Enclosure, S&O Building) Ongoing FTS ongoing
Instruments – WFC Instruments – PA&C Instruments – Cameras* Instruments – VBI Instruments – ViSP Instruments – VTF Instruments – Cryo-NIRSP Instruments – DL-NIRSP	NSO NSO UK Consortium (QUB lead) NSO HAO KIS UH/IfA UH/IfA	Boulder, CO* Boulder CO* Belfast, N. Ireland UK Boulder, CO Boulder, CO Freiburg, Germany Pukalani, Maui, HI Pukalani, Maui, HI	CDR 2015 July PDR 2016 Fabrication Lab Testing & Integration Fabrication Contract Approvals pDR June 2015 In Fabrication In Fabrication

4.2 BASELINE BUDGET

Funding Profile Table (August 2015)

	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Total
ARRA	**$4,240,970**	**$13,000,190**	**$22,155,203**	**$42,535,491**	**$49,997,571**	**$14,070,574**	**$ -**	**$ -**	**$ -**	**$ -**	**$146,000,000**
Budget	$4,240,970	$13,000,190	$22,155,203	$42,535,491	$49,997,571	$14,070,549	$ -	$ -	$ -	$ -	$145,999,975
CONTINGENCY	$ -	$ -	$ -	$ -	$ -	$ 25	$ -	$ -	$ -	$ -	$ 25
MREFC	**$ 195,431**	**$ 2,908,069**	**$ 6,589,599**	**$ 6,360,700**	**$ 7,135,226**	**$38,171,134**	**$46,227,589**	**$37,156,861**	**$29,100,275**	**$24,284,117**	**$198,129,000**
Budget	$ 195,431	$ 2,908,069	$ 6,589,599	$ 6,360,700	$ 7,135,226	$34,590,987	$41,721,646	$31,313,688	$17,050,132	$13,326,196	$161,191,674
CONTINGENCY				$ -	$ -	$ 3,580,147	$ 4,505,943	$ 5,843,173	$12,050,143	$10,957,921	$ 36,937,326
Grand Total	**$4,436,402**	**$15,908,259**	**$28,744,801**	**$48,896,191**	**$57,132,797**	**$52,241,708**	**$46,227,589**	**$37,156,861**	**$29,100,275**	**$24,284,117**	**$344,129,000**

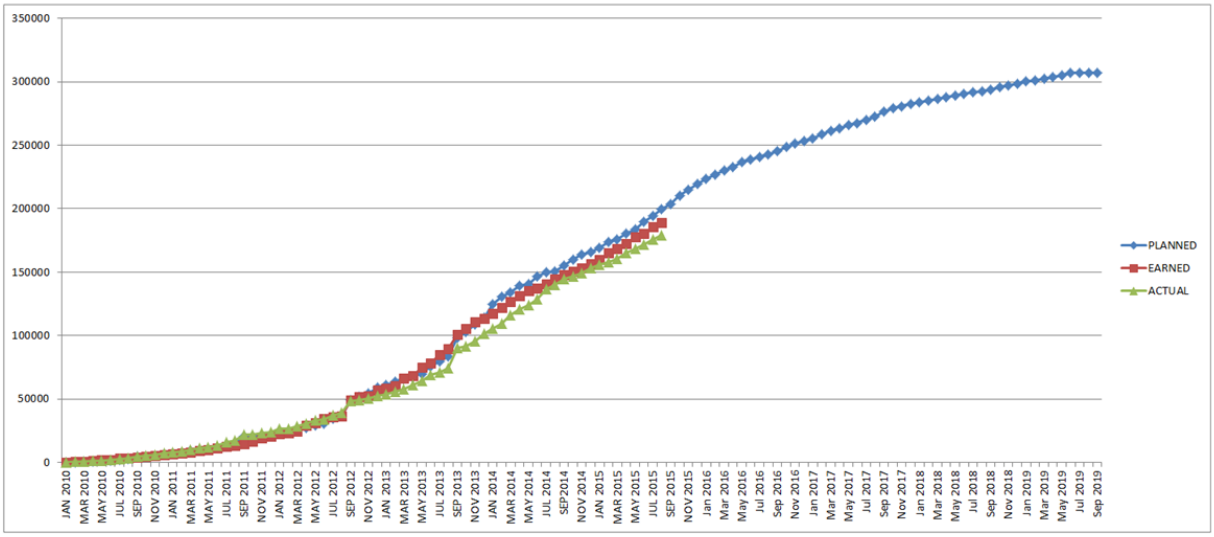
The budget break down by WBS elements is:

WBS	*AREA*	*BAC (August 2015)*
1.2.1	Project Management (including all permitting/compliance)	$46.0M
1.2.2	Systems Engineering	$4.1M
1.2.3	Telescope Systems – (TA Management)	$1.1M
1.2.3.1	Telescope Assembly (including Optical Systems)	$76.6M
1.2.3.2	Wavefront Correction	$10.9M
1.2.3.3	Instrument Systems	$32.5M
1.2.3.4	High Level Software and Controls	$7.5M
1.2.3.5	Enclosure	$29.7M
1.2.3.6	Support Facilities and Buildings	$61.0M
1.2.4	Integration, Testing and Commissioning	$18.5M
1.2.5	Science Support	$5.3M
1.2.8	Support Services	$13.8M

To date (as of end of FY2015), the NSF Funding Authorization is:

NSF Award	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total Funding To Date
ARRA	$ 146,000,000						$ 146,000,000
MREFC	$ 20,000,000	$ 5,000,000	$ 10,000,000	$ 24,976,329	$ 36,880,000	$ 25,120,000	$ 121,976,329
Total Funding	$ 166,000,000	$ 5,000,000	$ 10,000,000	$ 24,976,329	$ 36,880,000		$ 267,976,329

As of August 2015, the project progress is illustrated below:



	BUDGET	PERFORMED	ACTUAL	SV	CV	TOTAL BUDGET	SPI	CPI	SCHEDULE % COMPLETE	ACTUALS % COMPLETE
PREVIOUS	194,284	185,656	175,692	-8,628	9,963	306,347	0.96	1.06	61%	57%
CURRENT PERIOD	5,226	3,345	3,148	-1,881	197		0.64	1.06		
CUMULATIVE TO DATE	199,510	189,001	178,841	-10,509	10,161	307,192	0.95	1.06	62%	58%

4.2.1 Cost Book and Basis of Estimate

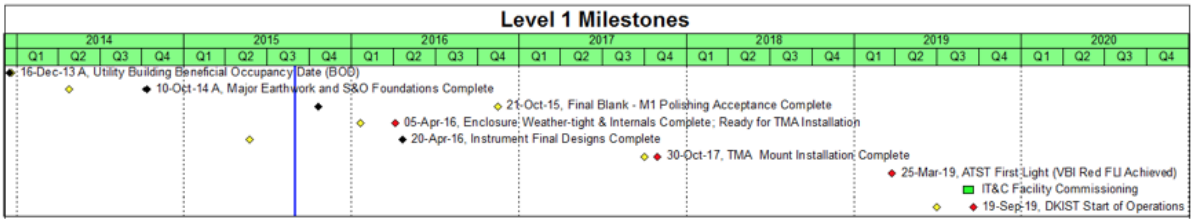
The Project Cost Book (PMCS-0008) provides the detailed budgeting information down to the work package level. PMCS-0103 (Project Management Controls System provides the details on the project processes, measurements and metrics for monitoring and controlling the project during its execution.

4.3 BASELINE SCHEDULE

The baseline schedule completion date for the construction phase is July 1, 2019.

4.3.1 Level 1 Milestones and Critical Path

Level 1 Milestones

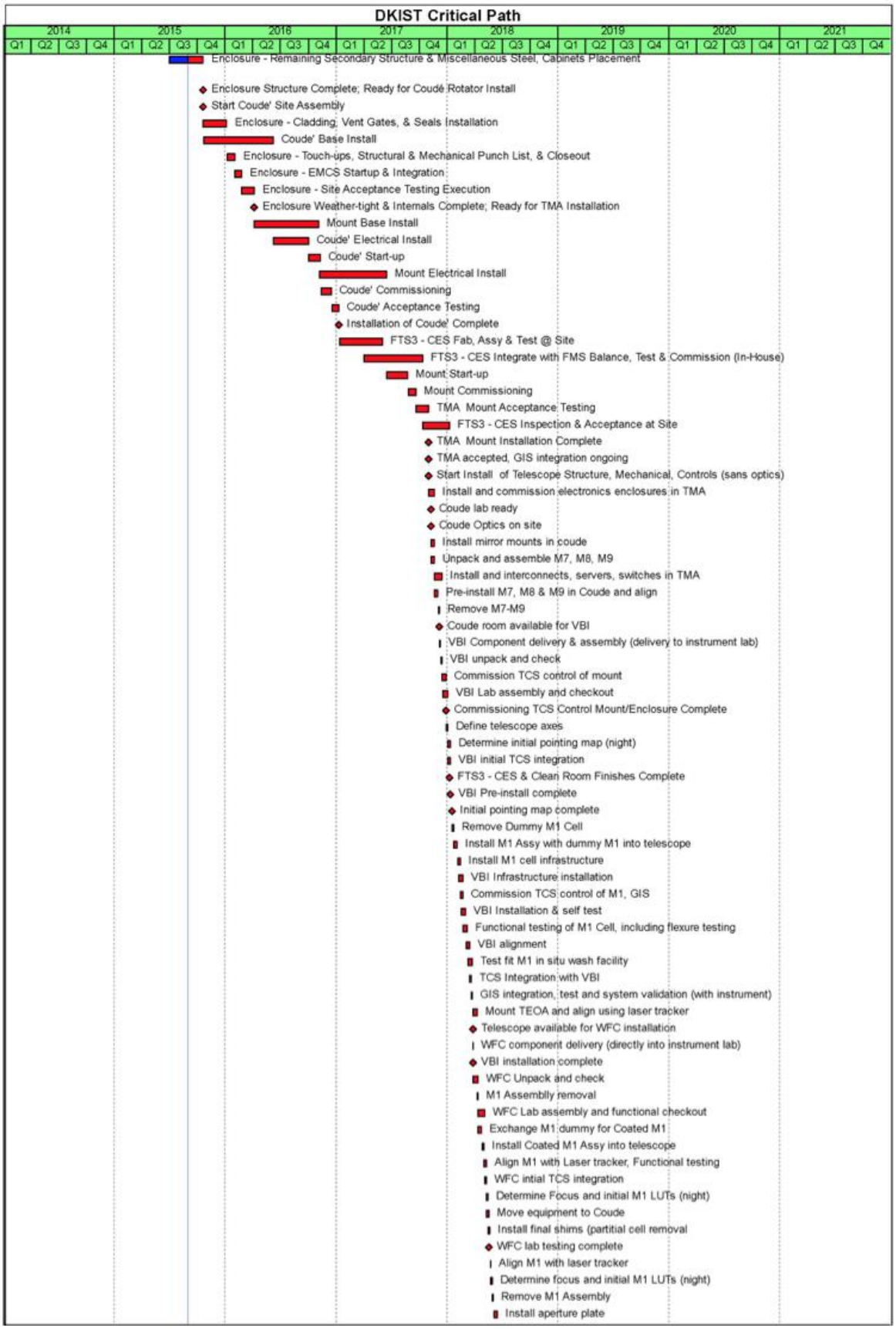


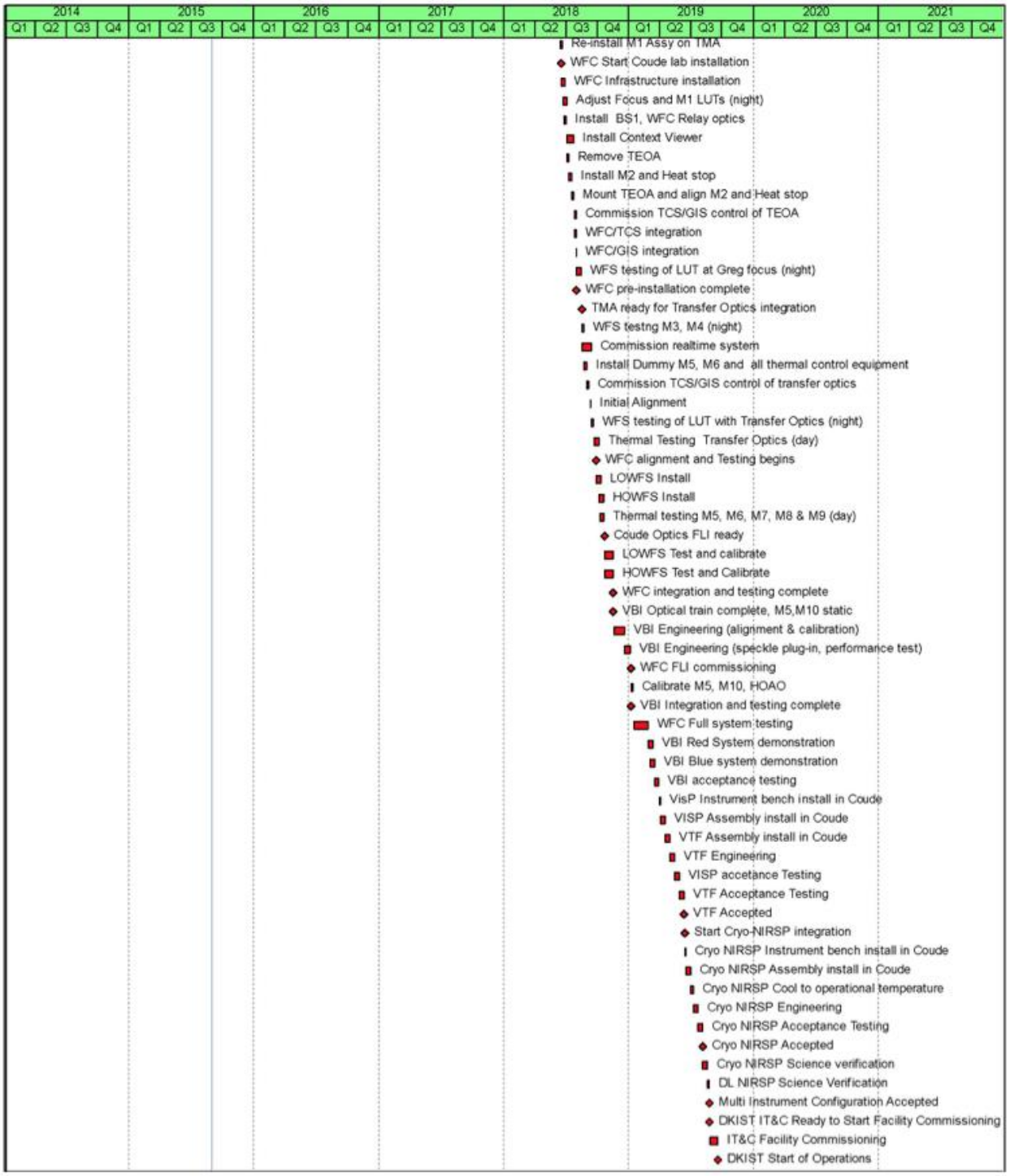
◇ Baseline Milestone

◆ Critical Milestone

◆ Milestone

Activity Name	History - NSF Re-baseline FINISH	Previous Month Finish	Finish	Delta from Baseline	Delta from Previous Month
Utility Building Beneficial Occupancy Date (BOD)	19-Dec-13	16-Dec-13	16-Dec-13	3	0
Major Earthwork and S&O Foundations Complete	24-Apr-14	10-Oct-14	10-Oct-14	-169	0
Final Blank - M1 Polishing Acceptance Complete	15-Nov-16	30-Sep-15	21-Oct-15	391	-21
Enclosure Weather-tight & Internals Complete; Ready for TMA Installation	20-Jan-16	5-Apr-16	5-Apr-16	-76	0
Instrument Final Designs Complete	22-May-15	20-Apr-16	20-Apr-16	-334	0
TMA Mount Installation Complete	2-Oct-17	30-Oct-17	30-Oct-17	-28	0
ATST First Light (VBI Red FLI Achieved)	15-Jan-19	25-Mar-19	25-Mar-19	-69	0
DKIST Start of Operations	1-Jul-19	17-Sep-19	19-Sep-19	-80	-2


DKIST Critical Path
2014
2015
2016
2017
2018
2019
2020
2021
Q1 Q2 Q3 Q4
Enclosure - Remaining Secondary Structure & Miscellaneous Steel, Cabinets Placement
Enclosure Structure Complete; Ready for Coudé Rotator Install
Start Coude' Site Assembly
Enclosure - Cladding, Vent Gates, & Seals Installation
Coude' Base Install
Enclosure - Touch-ups, Structural & Mechanical Punch List, & Closeout
Enclosure - EMCS Startup & Integration
Enclosure - Site Acceptance Testing Execution
Enclosure Weather-tight & Internals Complete; Ready for TMA Installation
Mount Base Install
Coude' Electrical Install
Coude' Start-up
Mount Electrical Install
Coude' Commissioning
Coude' Acceptance Testing
Installation of Coude' Complete
FTS3 - CES Fab, Assy & Test @ Site
FTS3 - CES Integrate with FMS Balance, Test & Commission (In-House)
Mount Start-up
Mount Commissioning
TMA Mount Acceptance Testing
FTS3 - CES Inspection & Acceptance at Site
TMA Mount Installation Complete
TMA accepted, GIS integration ongoing
Start Install of Telescope Structure, Mechanical, Controls (sans optics)
Install and commission electronics enclosures in TMA
Coude lab ready
Coude Optics on site
Install mirror mounts in coude
Unpack and assemble M7, M8, M9
Install and interconnects, servers, switches in TMA
Pre-install M7, M8 & M9 in Coude and align
Remove M7-M9
Coude room available for VBI
VBI Component delivery & assembly (delivery to instrument lab)
VBI unpack and check
Commission TCS control of mount
VBI Lab assembly and checkout
Commissioning TCS Control Mount/Enclosure Complete
Define telescope axes
Determine initial pointing map (night)
VBI initial TCS integration
FTS3 - CES & Clean Room Finishes Complete
VBI Pre-install complete
Initial pointing map complete
Remove Dummy M1 Cell
Install M1 Assy with dummy M1 into telescope
Install M1 cell infrastructure
VBI Infrastructure installation
Commission TCS control of M1, GIS
VBI Installation & self test
Functional testing of M1 Cell, including flexure testing
VBI alignment
Test fit M1 in situ wash facility
TCS Integration with VBI
GIS integration, test and system validation (with instrument)
Mount TEOA and align using laser tracker
Telescope available for WFC installation
WFC component delivery (directly into instrument lab)
VBI installation complete
WFC Unpack and check
M1 Assembly removal
WFC Lab assembly and functional checkout
Exchange M1 dummy for Coated M1
Install Coated M1 Assy into telescope
Align M1 with Laser tracker, Functional testing
WFC intial TCS integration
Determine Focus and initial M1 LUTs (night)
Move equipment to Coude
Install final shims (partitial cell removal
WFC lab testing complete
Align M1 with laser tracker
Determine focus and initial M1 LUTs (night)
Remove M1 Assembly
Install aperture plate



4.3.2 Integrated Project Schedule

The Integrated Project Schedule is maintained in Primavera (see PMCS-0103 Project Management Control System).

4.4 CONTINGENCY

Reference Risk Management Plan

4.4.1 Scope Contingency

There is no project scope contingency. Any issues that arise that are beyond our ability to handle through risk management must be handled through de-scopes.

4.4.2 Budget Contingency

The initial budget contingency was developed using a standardized risk analysis algorithm applied to each individual work package/activity. The cost estimators evaluate technical, cost, and schedule risk for each element. The initial framework is based on established values used by similar projects (LIGO, SSC, ICECube, LSST, ALMA, etc) and derives from GAO Cost Estimating Guidelines. This technique was used at the DKIST (then ATST) Final Design Review to set the initial contingency levels and updated at the time of the project's re-baseline review. The risk factoring details employed are described in PMCS-0103 (Project Management Controls System). The risk factoring provides the initial contingency pool to allow the project to manage the represented uncertainties and still deliver the project scope within budget.

The contingency funds developed by this risk assessment process are held by the Project Manager and lose their identification with the WBS component that was used in the estimating process. Contingency is held by the Project Manager to provide flexibility to manage within the established Performance Measurement Baseline. If a project is estimated properly, one hundred percent completion of a project will use one hundred percent of the direct estimate plus one hundred percent of the contingency. As the project progresses, the direct cost estimate will typically be exceeded and contingency funds will be used. The project tracks the amount of contingency available versus the percent of the project completed and the exposure from identified risks. PMCS-0103 describes the development of the risk register for management of the budget contingency during the project execution.

4.4.3 Schedule Contingency

Schedule contingency, as with budget contingency, represents the known unknowns in task duration for the various WBS components that will contribute to the overall duration of the project but that are not deterministic at the outset of the project.

At the project re-baseline, each work package had an assessed best-case and worst-case schedule scenario for completion. A Monte Carlo simulation of the project with these ranges indicated a 12 month schedule contingency was required for the 80% likelihood of success. The project accommodated this risk through a split of near-term (2013-2016) budgeted schedule contingency and late-term (post-2016) risk for contingency liens due to schedule. The budgeted schedule contingency in the near-term provides flexibility in planning to assure major milestones for the construction of the major facilities are as close to on-time as possible and will not impact the late term integration activities. The choice for unbudgeted, but identified risk for late-term schedule delays reflects the ability to monitor, accept and minimize potential delays for the sub-system integration activities and verification.

- The project included 20% funded schedule contingency into the IPS for the critical path activities from 2013-2015 (24 months duration for 20 months of activities – 4 months of funded schedule contingency). As noted in the schedule section, we are currently tracking approximately 9 weeks behind schedule; due to the anomalous weather, compliance issues, etc., we have been burning at more than the 20% planned contingency availability during this period. We are exploring means to recover this time in the coming years (2015-2016).
- In addition, a further 3 months of funded, schedule contingency are allocated for the enclosure site assembly and test (12 months duration for 9 months of activities – 3 months of schedule contingency). This schedule contingency is currently at risk due to a dispute on the Project Labor Agreement which potentially excludes the enclosure from these commitments.

- We are also carrying a total of 6 months of contingency as liens in the risk registry for schedule delays for a total of 13 months of schedule contingency.

5. STAFFING

5.1 STAFFING FTE PLAN

The project staffing plans can be represented in several ways.

5.1.1 Recruitment and Termination

AURA Human Resources supports the construction project in all staffing needs (job description development, advertising, salary market surveys, COLA calculations, interviews, retention, POC for offers/offer approvals, etc).

In general, the timeline for a standard recruitment looks like:

- 5 days: Group lead/HR: Identifies resource need. If a planned resource, lead submits a job description for review to HR for review and comment. HR review includes ensuring the title and job duties are reasonable as well as confirmation of the job requirements (education, physical requirements, etc.). If the need is not a planned resource, the manager must first submit a change request for review (see PMCS-0103 Section on Change Management); if the change request is approved, process continues for an unspecified number of days.
- 1 days: Group lead: Prepares an advertisement based upon the job description and submits final job description and advertisement to administrative staff. Other information required is the composition and chair of the search committee (if required, see alternate process below), funding account, line management, position location, estimated start date and position status (FT/PT, seasonal, permanent, etc.).
- 1 - 5 days: Administration: Administrative staff prepares a Personnel Requisition and circulates it with the job description for appropriate approvals (e.g. Project Manager, Director, etc.). Once approvals are prepared, all documents are submitted to HR.
- 5 days: HR enters the position into UltiPro and prepares advertisements.
- 5-15 days: Advertisements: Depending upon the position, there may be a 5-day internal-only advertisement prior to any external postings. All positions are advertised a minimum of 5 days.
- 5 -15 days: Group lead reviews the applicants and selects the most qualified candidate(s); the group lead submits the grading system for the applicant to HR. If a panel is not required, HR and the lead will decide how to proceed with the interview process. HR will also check candidate references, as necessary. If panel is required, next step is skipped and alternate process (below) is followed.
- 5 days: Once a candidate has been selected, HR prepares an offer letter, which is circulated to the appropriate management staff for review. HR contacts the selected candidate to finalize the offer.
- **Total estimated time: 27-45 days**

Search Committee Alternate

- 5-10 days: Group lead and search committee review the applicants and selects a short list for follow-up interviews. These interviews are coordinated through HR.
- 5-20 days: Interviews: HR and administration coordinate the interview schedule and candidate travel, as needed.
- 1-5 days: Panel decision: The panel will meet to discuss the list of candidates and prepare a prioritized list for HR.
- 1-10 days: Once a candidate has been selected, HR prepares an offer letter, which is circulated to the appropriate management staff for review. HR contacts the selected candidate to finalize the offer.
- **Total estimated time with search committee: 33-81 days**

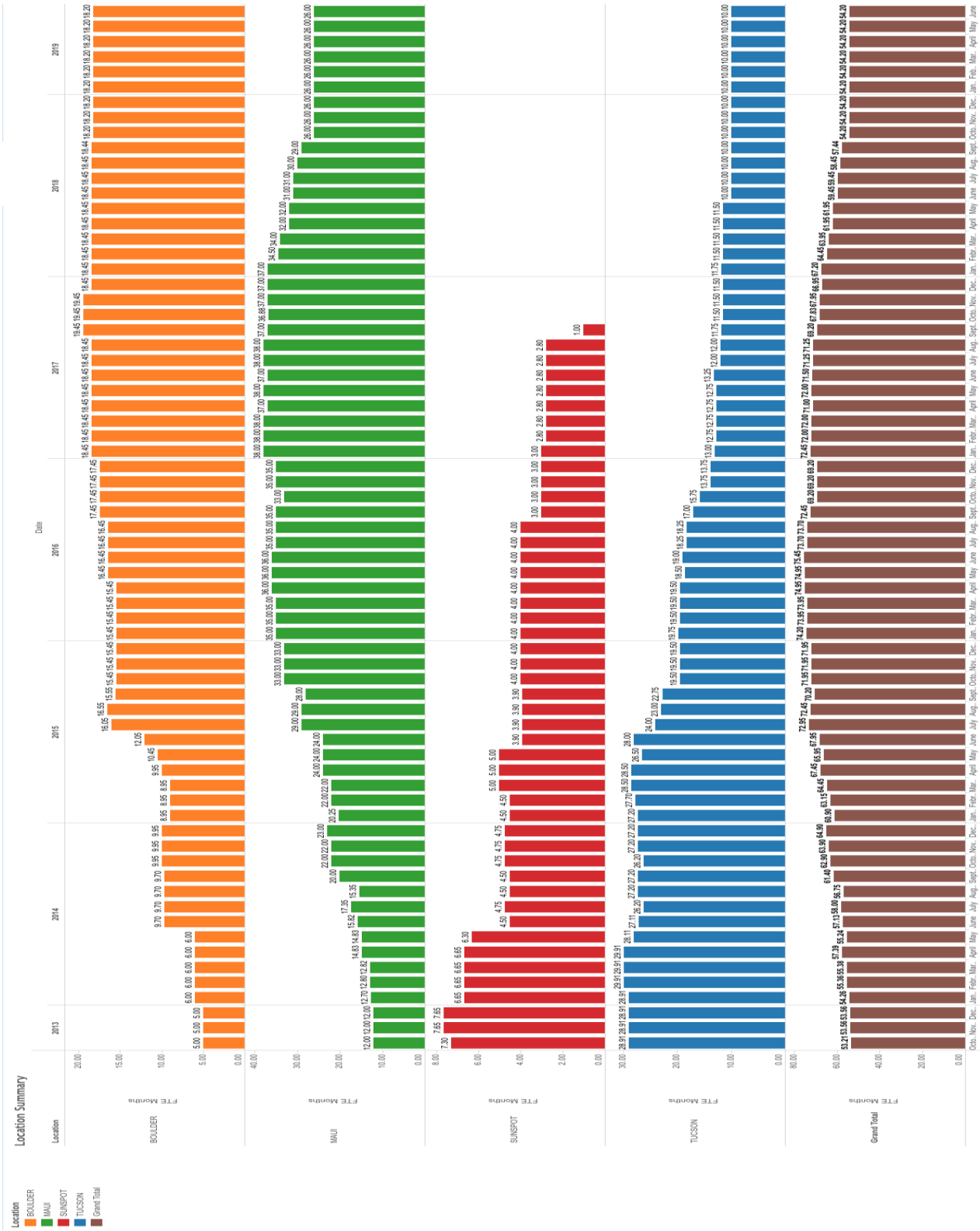
These timelines are approximate but are considered in planning for the recruitment process. Days represented only include business days. In some cases, expedited review/negotiation are required if the hiring process is driven by a loss in project staff. Number of days does not include any necessary time between the offer and start date including relocation.

AURA Human Resource guidelines/policies (including those guiding its role as an equal opportunity and affirmative action employer) are posted at: http://hr.aura-astronomy.org

Employee Termination of Employment

The DKIST Project may from time to time be required to dismiss an employee involuntarily. If that occasion arises, AURA policy and procedures will be followed including the involvement of AURA's Human Resources department. Reference AURA Personnel Policy and Procedures Section B.V.II

As employees complete their tenure with Project and/or the Project is completed, those that do not transfer into operations will be dismissed under the terms of AURA Personnel Policy and Procedures Section B.V.III, B.V.IV and B.V.V. These procedures include payment for accrued vacation and notice and/or separation pay based on their length of tenure.


Location Summary
Location
BOULDER
MAUI
SUNSPOT
TUCSON
Grand Total
Date
2013
2014
2015
2016
2017
2018
2019
FTE Months

6. RISK AND OPPORTUNITY MANAGEMENT

Risk factoring, identification, and monitor/control processes are discussed in PMCS-0103 Project Management Controls System. These topics are tightly coupled with the change management process which is also discussed in that document.

7. SYSTEMS ENGINEERING

PMCS-0102 Project Systems Engineering provides an overview of DKIST Systems Engineering processes. It has been cast in the context of the V-Diagram, a common visualization tool used within the Systems Engineering discipline. As such, it covers the topics of scope management, requirements development and management, and quality management.

8. CONFIGURATION CONTROL

The change management process is elaborated in PMCS-0103 Project Management Control System.

9. ACQUISITIONS

9.1 PROCUREMENT MANAGEMENT PLAN

Historically, the project document SPEC-0050 contained information on the early project planning for procurement strongly predicated on the Project Management Institute PMBOK edition at that time (4th edition).

A current representation of the acquisition history, plans and processes is contained in PMCS-0109 DKIST Procurement Management Plan. These processes are supported by the Financial and Business Controls Plan (PMCS-0038) which is essentially a pointer to the AURA Central Administrative Services policies and guidelines.

10. PROJECT MANAGEMENT CONTROLS

The Project Management Controls System (PMCS-0103) provides an overview of the Daniel K. Inouye Solar Telescope's (DKIST) Project Management Controls Systems (PMCS), and the details associated with the methodology for assembling the data, roles of contributors, tools infrastructure, reports, and how the systems have been implemented and are used on DKIST to inform decisions.

The design, implementation and maintenance of the DKIST PMCS are guided by the desire to satisfy its stakeholders and their respective requirements. The stakeholders include the National Science Foundation (NSF), Association of Universities for Research in Astronomy (AURA), the National Solar Observatory (NSO) and the community of Solar Physicists who will perform research with DKIST.

The Project PMCS provides information on:

- Cost Estimation and Budgeting
- Schedule Management
- Budget and Earned Value Management
- Reporting
- Risk Management
- Change Control Management

11. SITE AND ENVIRONMENT

11.1 SITE SELECTION CRITERIA

The DKIST (then ATST) site survey goal was to locate a site that would maximize the scientific productivity of the telescope. The general daytime characteristics of such a site are frequently clear skies, excellent seeing, low humidity, few aircraft contrails, and low dust levels. 72 potential sites were identified. The project identified six candidate sites for more extensive study, developing instrumentation to measure the relevant atmospheric characteristics at these sites:

- Big Bear Solar Observatory (California, US)
- La Palma, Canary Islands (Spain)
- Sacramento Peak (New Mexico, US)
- Haleakala, Maui, HI; Mauna Loa, HI; Mauna Kea, HI, US
- Panguitch Lake (Utah, US)
- San Pedro Martir (Mexico)

Details of the site survey are posted on DKIST's public pages: http://dkist.nso.edu/site

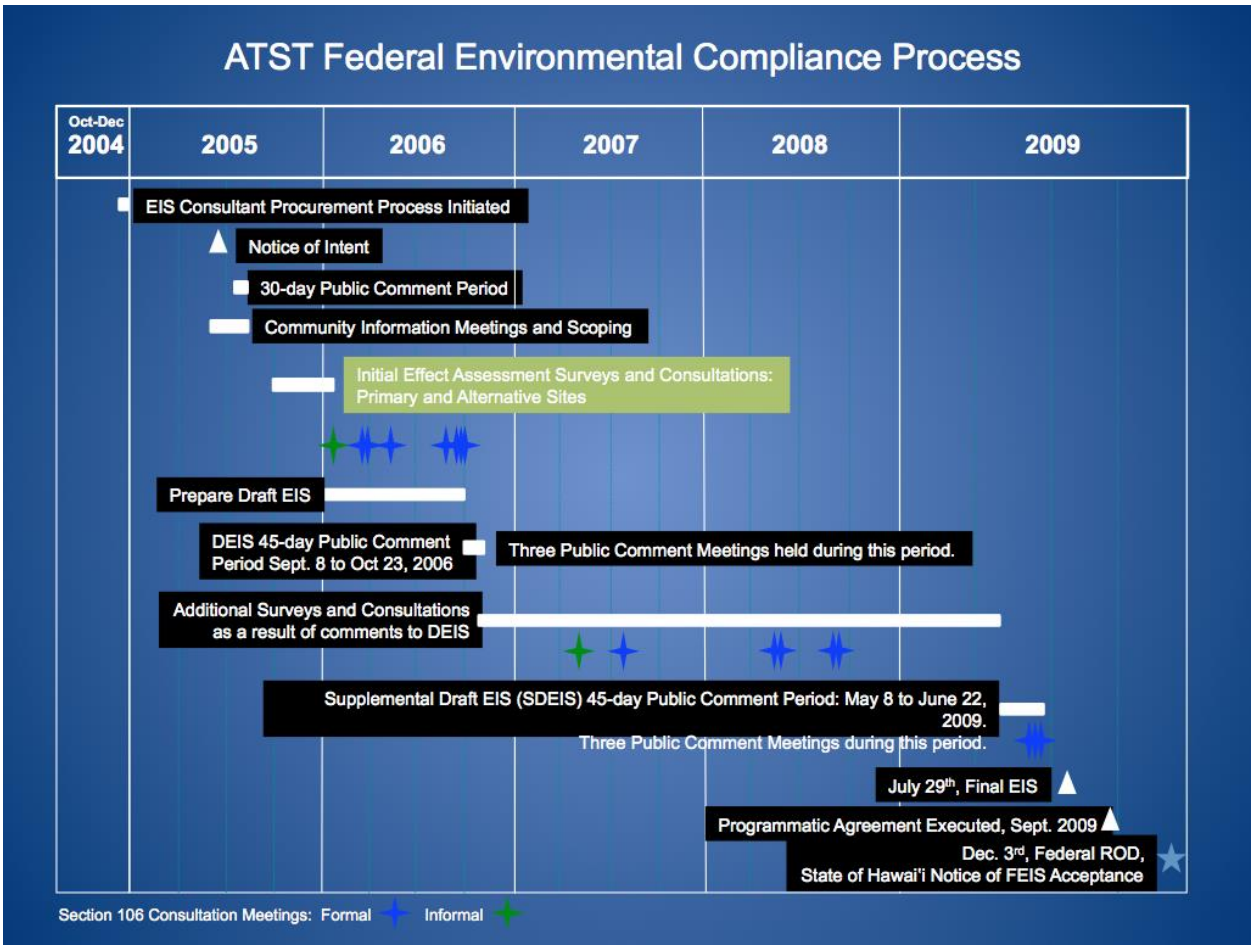
In addition, the analysis of the seeing data was published in the Publications of the Astronomical Society of the Pacific (PASP, 2005, 117, 1296).

The final recommendation in December 2004 was Haleakala, Hawai'i was the best site for DKIST. Haleakala Observatories (HO) already encompassed a number of astronomy, atmospheric science, and space situational awareness facilities. It is managed by the University of Hawai'I's Institute for Astronomy. The land use is designated for astronomical research. HO was the only site that satisfied the requirements for atmospheric turbulence, sky brightness, precipitable water vapor established a priori.

11.2 PERMITTING

The selection of Haleakala does come with consequences with regard to permitting. Haleakala Observatories is at an elevation of 10,000 feet, near the summit of an extinct volcano, and abutting Haleakala National Park. Access to the site is exclusively via a road through the National Park. The site is within a State of Hawaii Conservation District so special permitting is required for construction and operation. The site is home to endangered species of flora and fauna. The summit of Haleakala is a place of historic, cultural and spiritual importance to native Hawaiians.

An illustration of the project's Federal Environmental Compliance Process is noted below:



The broad project milestones with regard to permitting (and incorporating the key project gates):

May 2009: Final Design Review established project baseline

Aug 2006: Awards were authorized (NSB-09-57)

Dec 2009: Federal environmental compliance was completed

Jan 2010: Construction funding was awarded (ARRA and MREFC)

Jun 2010: Anticipated access to Haleakala construction site (!)

Dec 2010: Conservation District Use Permit (CDUP) granted by BLNR

Dec 2010: CDUP challenged by Kilakila o Haleakala

Jul 2011: Contested case hearing

Sep 2012: Final arguments presented to BLNR

Nov 2012: BLNR issues final decision affirming CDUP

Nov (30) 2012: Final access to site granted

Dec (1) 2012: Groundbreaking on site

12. CYBER INFRASTRUCTURE

12.1 CYBER-SECURITY

The DKIST project adheres to the AURA policies for password security (http://dkist.nso.edu/sites/atst.nso.edu/files/AURAPasswordPolicy.pdf). In addition, DKIST maintains and enforces a broader cyber-security plan for the summit facility during both construction and operations. Primarily, the plan and associated procedures protect personnel and equipment from harm by outside entities. In addition, the plan includes establishment of access and use policies, control of workflow, interactions with external systems, and requirements from funding agencies and partners.

The general behavior of the DKIST security model provides active, hardened interdiction for remote access, and a more modest detection and intervention policy for internal access. The essential security components are restriction of remote access physical access to the DKIST site network. DKIST limits remote access to the site by allowing connections only from NSO facilities and requiring additional DMZ login. DKIST also ensures additional physical restrictions to computer systems (e.g., locks on the computer room, observing room, and all control system racks on the telescope and instruments).

12.1.1 Use Cases

There are several general usage patterns for interactions between the DKIST facility and off-site users or resources. The connection between DKIST and NSO may be considered as an offsite transaction if that connection is not secured through an acceptable security policy (e.g., VPN connections).

Accessing off-site resources

In the normal course of construction and operations, DKIST staff may require access to resources outside of the control of DKIST IT systems. These transactions occur on standard Internet protocols (HTTP, FTP, RSH, SIP, etc.) and are initiated locally by DKIST personnel. Typical operational transactions include retrieving current or archived solar images from other observatories, accessing Internet sites for news, weather, or other information, logging into remote facilities to access mail and file systems, and uploading software programs and patches. Additionally, SIP telephone communications may also occur from the summit through the IT system. Each of these transactions exposes the facility to potential security violations, and are addressed through the NSO/DKIST security plan. This plan cannot prohibit or make unduly difficult the process of accessing offsite resources. However, it does institute a specific procedure for each type of access that is fully enforced.

Transmitting data

DKIST construction and operations include the transmission of data to NSO for archive and distribution through the Virtual Solar Observatory and NSO Digital Library. The data stream from the facility to the repository is allowed to go offsite with little or no hindrance or bandwidth reduction.

Remote observing

DKIST operations allow for observers to partially interact with the facility through an Internet connection. The remote observer is not allowed to directly control the telescope, instrumentation, or any other DKIST system. The observer is allowed to communicate with the local operator and observer, monitor a best-effort bandwidth version of the quick look display, and download samples of the data from the ongoing observations. The security policies for the facility accommodate these activities.

Engineering access

Troubleshooting during construction and operations often requires remote access to specific DKIST computers and software resources that are not exposed directly to outside networks. The DKIST security policy for remote access allows access of this nature while continuing to protect the facility from malicious attack. Engineering access is reserved only for troubleshooting or other non-routine maintenance activities; it is not a part of routine operations or general remote access.

12.1.2 POLICY

The DKIST security plan is comprised of a series of policies, each discussing one aspect of the security plan. These policies cover all aspects of IT security, both offsite and internal access.

DMZ and firewalls

The DKIST security plan utilizes a demilitarized zone (DMZ) to separate the local area networks crucial to operations from the outside networks. The DMZ acts as a buffer to the internal networks, allowing authentication and providing limited access to any unauthorized access. The DMZ provides servers for the public web site, login, email, network address translation (NAT), telephone, and other proxy services needed to implement the security plan.

The DKIST security plan also includes firewalls as part of the DMZ. All firewalls are proactively monitored and upgraded on a planned and regular basis as provided by the security policy.

Off-site access

Off-site access, both incoming requests and outgoing traffic, is supported only through a NSO VPN connection. Procedures are in place to restrict incoming access to DMZ machines for authorized users on the secured channels. Best efforts are implemented to prevent loss of service or external security attacks (e.g., denial of service, password testing, man-in-the-middle, etc.) from unauthorized users. Authorization is the responsibility of the DKIST administration and implemented by the IT personnel.

On-site access control

Access control within the site is a less stringent need than external access. The general policy of internal IT security is control of physical access through the use of locks, key cards, and other physical means.

On-site user security during construction and operations may be noticeably lax due to the need by observatory personnel to perform a variety of roles. Operators may be called up to act on behalf of the Resident Astronomer, Instrument Scientist, or other NSO/DKIST actor. However, security procedures do prevent other personnel from accessing these accounts or restricted programs. Engineers and IT personnel may need global or super-user access during operations; these actions are be logged as part of operations.

On-site data access control

Authorized visitors to the facility— Investigators—are given a different, more stringent access permission for use only with the DKIST data storage and processing facility. The DKIST data storage may contain data from multiple users; it is not required that DKIST prohibit investigators from accessing other investigators' data. If in the future NSO implements a data embargo or restriction requirement, the security policy is able to provide protection of observer's data from non-DKIST personnel.

Malicious and errant components

Components of the telescope and instrument control systems may become security or safety risks, either errantly or intentionally. DKIST personnel are able to detect components that are non-responsive, incorrectly operating, becoming an equipment or safety risk, accessing other components outside of its normal communications, or spoofing other components. It is not a DKIST requirement to proactively prevent such behavior, only to quickly detect them and disable the suspect component.

Malicious and errant users

Users of the telescope and instrument control systems also may become security or safety risks, either errantly or intentionally. The DKIST security policy prevents non-DKIST users from remotely accessing areas of DKIST software that involve operations and moving mechanisms. Internal users are actively restricted through standard operating systems login and password mechanisms. DKIST IT security provides continuous training and enforcement on strong passwords, social engineering attacks, and other typical illicit access strategies.

12.2 CODE DEVELOPMENT

The DKIST software created during construction uses a suite of processes for standard development, version management, configuration control, quality control, and problem tracking.

12.2.1 Development Processes

The DKIST software is developed using a standard waterfall process, used by all DKIST packages. Using this process, DKIST has developed requirements and interfaces for the software systems. DKIST has then developed the software designs through a cycle of conceptual, preliminary, and final design stages, each culminating in an external design review. The final software designs are then approved for construction.

The final design documentation includes the design documentation, interfaces, program management, acceptance tests, and operations and maintenance manuals. Each of these documents is reviewed, approved, and released; each document is also updated and re-released during the software construction as the design, interfaces, or requirements are refined.

As part of the software design development, the DKIST software teams have developed a significant amount of code used for design verification, requirement testing, and simulation. This body of software has been moved into the software construction phase to expedite the final delivery of the software packages.

All DKIST software is developed using a rapid prototyping methodology. Software requirements are introduced into the development cycle in small increments, each increment consisting of a design-build-test phase. Further requirements are added during each cycle and all requirements are tested before moving on to the next cycle. This methodology also gives the software developers and users time during each cycle to understand the impact of each requirement and to potentially improve the requirement and the design.

12.2.2 Version and Configuration Control

DKIST software teams use CVS (“Concurrent Versions System”) to maintain version control for all software written in Java, C++, and Python, along with all configuration and build information. The version control system maintains a repository of all current and past versions of every software file. The repository is stored on a RAID-5 data server that is backed up nightly and is accessed from outside the project by authorized vendors or partners.

The version control provides a separate repository for each software system under development.

The configuration control provides a “trunk” and a “release” branch for each software system. The trunk branch is used only by developers to work on the latest code; it is by definition unstable and prone to crash, however it contains the latest features and fixes. The release branch provides a stable, tested version of the software system for general users and developers of other software systems. It contains a major release (i.e., version 3) and tagged releases, known as “point” releases (as in version 3.0, or 3.1). The latest major release does change if bugs are discovered and are back-ported off the trunk onto the latest release. Older major releases are not patched.

12.2.3 Quality Control

DKIST software systems include test procedures for each requirement. The software quality assurance plan (PROC-0017, PROC-0015) defines how software is to be tested and verified.

Unit Testing

Unit testing involves the testing of individual units of work to ensure they are fit for use. A new or changed component is unit tested. This testing is performed before proceeding to component level testing. The tasks that must be completed as part of unit testing are as follows:

- Prepare new and/or changed unit tests and related documentation;
- Ensure traceability of new and/or changed tests to requirements;
- Execute new, changed, and existing unit tests upon build of component; and
- Document unit test results.

Unit testing will be performed by the work package engineer responsible for the change or his/her designee.

Integration Testing

Integration testing involves testing an intended release to ensure it integrates correctly with all other DKIST systems for which it interfaces. Integration testing is performed in a qualified DKIST test environment that uses mechanical, hardware, and software systems equivalent to the production systems. Integration testing is performed before proceeding to user acceptance level testing. The following tasks are specific to integration testing for software releases.

- Any software defects (bugs) identified in testing will be logged in JIRA tracking system;
- All test cases impacted by the defect must be re-tested once the defect is resolved;
- Any un-resolved software defects must be approved by the review team before proceeding to User Acceptance Testing; and
- Upon successful completion of integration testing the software source code will be tagged in CVS to indicate it is part of a release. Test documentation will include reference to this release number.

The work package engineer responsible for the change and the designated test engineer for each interfacing DKIST system will perform integration testing.

User Acceptance (Verification) Testing

User acceptance testing involves performing tests for which the user will validate the output of the system to determine pass/fail status. User acceptance testing shall be performed in a production environment, or a qualified test environment that is approved by the user. User acceptance testing shall be performed before a release can be made operational for production use. The following tasks are specific to user acceptance testing for software releases.

- Only software source code from the CVS tag that matches the release number identified in the integration test documentation may be used for user acceptance testing;
- Any software defects identified during testing will be logged in JIRA tracking system;
- All test cases impacted by the defect must be re-tested once the defect is resolved;
- Any un-resolved software defects must be approved by the review team before proceeding to production release; and
- Test documentation should include reference to the CVS tag for this release.

User acceptance testing will be performed by the user, with the support of the work package engineer responsible for the release, and test engineers from other interfacing systems.

12.2.4 Release and Distribution

Each DKIST software system is released on a schedule defined in the project schedule. All releases are noted as either a major or minor release. In general, software systems provide an alpha-1 major release for basic functionality and interfaces, an alpha-2 release for additional functionality and user support, a beta release for preliminary design and user testing, and a final release upon the completion of construction.

12.2.5 Problem Tracking

The DKIST project maintains a JIRA problem tracking system to identify and resolve all issues associated with software systems. Each software system has its own JIRA area. New issues are tracked as problems or feature requests and are given priorities. Significant issues are discussed and addressed in weekly software meetings.

12.3 DATA MANAGEMENT

DKIST construction data management is under development by the Data Handling System (DHS). Data collected by the summit telescope is delivered to NSO Operations for final disposition and policy control.

12.3.1 Infrastructure

Data collected by instruments at the summit telescope are stored in one of five DHS camera lines, each containing 32 Terabytes of temporary storage. The storage is sufficient to keep 3 days of data on the summit in case daily export to NSO is unavailable.

Data are transferred from instruments to the DHS on a 56Gbps InfiniBand network. Data are displayed and export off the summit on 10Gbps Ethernet networks.

12.3.2 Archiving and Transport

Instrument data archives on the summit are temporary, with permanent storage performed by NSO Operations. Engineering data archives, comprised of logs, events, properties, headers, and other databases, are kept on the summit for up to 6 months, with daily copies made and exported to NSO Operations.

There are three mechanisms for data transport from the summit to the NSO Remote Operations Building (ROB), where NSO Operations assumes control of the data. The preferred mechanism is the external 10Gbps Ethernet connection off the summit to the ROB. If the external network is not operationally, the DHS will write data to 32TB portable disk arrays that are transported off the summit to the ROB for data ingestion. Alternatively, personnel in the ROB may manually search the DHS data archive and download individual sets of files for analysis and diagnostics.

13. HEALTH AND SAFETY

The document "ATST Safety, Health, and Environmental Program Plan" (SPEC-0086) describes the safety management philosophy, defines safety-related roles within the project team, and describes top-level policies governing safety, health, and environmental issues. In addition, the following documents chart further details of the health and safety execution:

- "System Safety Plan" (SPEC-0060): The DKIST project has adopted MIL-STD-882D as the primary source of guidance for our safety plan. This document provides an overview of the detailed documentation relevant to systems safety planning.
- "ATST Hazard Analysis Plan" (SPEC-0061): This document provides a summary of our approach to hazard analysis (based on MIL-STD-882D).
- "ATST Hazardous Materials and Hazardous Waste Management Program" (SPEC-0035): This document provides the procedure guidelines on the EAP&DOT standards.
- "Conditions for Working at the ATST Project Site and Safety and Health Specification" (SPEC-0030): This document describes the special Haleakala environmental, cultural, security and safety requirements and a set of minimum requirements for all contractors per OSHA.
- Assessment of Life-Safety and Other Code Requirements for the ATST Facility Design: This document references codes relevant to occupancy, egress, electrical and mechanical equipment, structural, seismic, energy conservation and other code-defined requirements that bear on the architectural and engineering contracts.

The Project maintains (and continues to develop) an online Safety Manual at http://dkist.nso.edu/safety/manual. This document covers the construction and IT&C activities at the DKIST Summit Facility.

The safety program processes continue to evolve and are detailed in site specific documents like the Construction Safety Implementation (SAF-0003) Manual, Confined Space Program (SAF-0004), Safety and Health Training Plan (SAF-0005), Spill Response Plan (SAF-0006), Respiratory Protection Program (SAF-0007), Hazard Communication Standard (SAF-0008), Lockout-Tagout (SAF-0009), Bloodborne Pathogens Policy (SAF-0010), Expanded Work Hours (SAF-0011) and Personal Protective Equipment program (SAF-0012) and more to come. These are all linked through the on-line safety manual.

13.1 SECURITY

The DKIST construction project is maintained across several sites each with distinct physical security. The physical security measures are intended to address vulnerabilities to project staff, resources and information, in particular handling the threats of:

- Theft
- Physical damage
- Interruption of services/utilities
- Unauthorized disclosure of information

This is distinct from the safety arena which addresses the protection of life and assets against accidents, natural disasters, fire, etc. Physical security encompasses principally vandalism, theft and attacks by individuals while cyber security addresses aspects of electronic interference and theft (covered in Section 11).

For the Project sites:

- Pukalani Office: Leased office space in the Pukalani census-designated place in Maui County, Hawai'i. The office is a shared building with other tenants with businesses (church, yoga studio, optometrist). The high traffic area is a general deterrent to theft and vandalism. The office

maintains lockable exterior and interior doors. Power protection is done through standard UPS systems for the computers. Critical materials/information are backed up centrally to off-site servers (DKIST vault, JIRA). Fire prevention is handled through fire detection devices (Simplex fire alarm system with visual/audible alarms, pull stations and ceiling/duct smoke detectors) and fire suppression devices (hand held 3A:40B: C Badger 5 pound multipurpose dry chemical fire extinguishers). These offices are used only as offices and no special environmental handling is employed (standard HVAC).

- Haleakala Summit: Leased 0.86 acres on the Haleakala Observatories (HO) land (from University of Hawai'i). The HO area is fenced and gated and is not open to the public (just the other observatory tenants on the site). During normal operating hours, the project staff and contractors are monitoring the site areas. During off-hours, the project employs the G4 Security agency to monitor and patrol the site. In addition, a visible wavelength webcam monitors the site continuously. Each of the Project buildings (Utility, Support and Operations) is currently securable through locked doors. Project/contractor vehicles on site have their keys removed at night and are under the monitoring of the site security. Power will be maintained through Project Generators and UPS units. Fire prevention is maintained separately in different buildings (fire alarm systems and 5/10 pound multi-purpose dry chemical extinguishers; clean agent hand held fire extinguishers will be used in optical/clean rooms). The construction is fire-resistant-rated construction. The Enclosure maintains unique environmental handling (Facility Thermal Systems, Coude Environmental Systems) to maintain the solar observing imaging integrity.
- Central Maui Baseyard: Leased storage area in Kahalui, Maui. The area has a coded gate security (for after hour entry) as well as individually fenced regions for each lessee. The Project maintains the Deltek security firm for monitoring assets stored in the area. There are no powered components stored. Fire prevention is handled through the security alerts. The storage area is outdoors and there is no special environmental handling.

14. REVIEW AND REPORTING

The Cooperative Support Agreement (CSA Award AST-1011851) has several obligations for project reporting:

- The CSA incorporates by reference the NSF Cooperative Agreement Financial & Administrative Terms and Conditions which have the following reporting/notification/approval obligations:
    - Article 1: Notification – any allegation of research misconduct that it concludes has substance and requires investigation in accordance with NSF research misconduct regulations published at 45 CFR Part 689; any significant problems relating to the administrative or financial aspects of the award.
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    - Article 3: Approval: Significant Project Changes (e.g., transfer of the project effort, change in objectives or scope, absence or change in PI, etc); rearrangements/alterations aggregating $25,000 or over; no cost extensions (IAW AAG Chapter I.D.3c.(ii)).
    - Article 6: Inventory
    - Article 8: Pre-Approval - Significant Project Changes (transfer of the project effort, change in objectives or scope, absence or change of Principal Investigator).
    - Article 11: Pre-Approval - Rearrangements and Alterations (aggregating $25,000 or over)
    - Article 15: Report
        - Annual Project Reports submitted via FastLane 90 days prior to the end of the current budget period
        - Final Project Report within 90 days following the expiration date of the award.
        - Special Reports as the NSF may reasonably require or the awardee deems appropriate.
        - Project Outcomes Report for the General Public submitted via FastLane within 90 days following the expiration date of the award
    - Article 16: Expenditure Reports: This reporting obligation was removed in a subsequent FATC update as it is extracted from the Award Cash Management System directly.
- The CSA Award specific Financial & Administrative Terms and Conditions for reporting/notifications/approvals are:
    - Article 3: Labor Standards requires a weekly copy of payrolls for union/trade employees.
- The CSA Award specific Programmatic Terms and Conditions
    - Article 3: Submit reports monthly
        - 25th of each month; includes budget information with expenditures in the current period, milestone schedule status report, earned value management reports including variances and their causes, A full explanation for negative variances in excess of $50,000 with recovery plans, risk management activities.
    - Article 3: Submit reports annually
        - 3 months prior to the end of the 12 month period; provides a comprehensive analysis of the project over the reporting period
    - Article 4: All proposed changes or proposed use of contingency will be made known to the NSF (posted via a change control database or similar) prior to authorization
        - Prior approval of the NSF Program Officer is required for:
            - Configuration changes increasing the overall program baselines for cost or schedule
            - Reallocation of funds among subawardees exceeding $250,000 at the Level 2 WBS
            - Requests for use of cost contingency exceeding $150,000 and/or use of schedule contingency for milestones exceeding 45 days.

The Cooperative Agreement (CA Award AST-0946422) also has several obligations.

- The CA Award specific Financial & Administrative Terms and Conditions for reporting/notifications/approval are:
    - Article 1.4: Contractual agreements greater than $250,000 require prior approval of the NSF Program Officer and the Grants & Agreements Officer
    - Article 1.10: News releases; prior notice will be given before issuing news releases.
    - Article 1.17: Master Site Plan; a new plan must be provided each October 1, or a statement that no changes have been made.
- The CA Award specific Programmatic Terms and Conditions for reporting/notifications/approval are:
    - Article 2.6: NSF Program Oversight:
        - A comprehensive review will occur midway through the cooperative agreement using FAR 35.017.1 as the guide.
        - Business systems reviews will be conducted as deemed necessary
        - A program review will be done annually
        - Other reviews may be called as needed.

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15. INTEGRATION AND COMMISSIONING

The planning for systems integration, testing and commissioning, including acceptance procedures, is covered under “Systems Engineering Plan” (PMCS-0102).

16. PROJECT CLOSE OUT

The project close-out will occur in three areas:

- Administrative
    - Historical information and lessons learned are transferred to the NSO for use by future projects.
    - Project files from construction activities are turned over to the observatory.
    - The project completion is documented through the compliance with the hierarchical requirements (see PMCS-0102 Project Systems Engineering). All requirements must be met or have approved waivers. Documented receipt of all deliverables is generated. If the project is terminated prior to completion, documentation on the cause of termination is needed, along with documentation on the transfer of finished and unfinished deliverables.
- Contractual
    - The project contract officer identifies any open contracts and contacts remaining contractors for any relevant actions necessary to close the contract, as designated in the associated contract clauses and per AURA's procedures and policies.
- Acceptance
    - Acceptance is complete with the receipt of a formal statement that the terms of the project have been met.

17. FACILITY TERMINATION

The National Science Foundation, the National Park Service, the Advisory Council on Historic Preservation, the Hawai'i State Historic Preservation Officer, the Association of Universities for Research in Astronomy and the University of Hawai'i signed a Programmatic Agreement to document the commitment of these organizations to the Section 106 of the National Historic Preservation Act (NHPA; 54 U.S.C. 306108).

In Section II of that document ("NSF Area of Responsibility"), the NSF assumes the following responsibility:

E. Decommissioning of the ATST

In all cooperative agreements governing the operation of the ATST Project entered into between NSF and AURA/NSO (or any successor entity), NSF shall include a provision requiring NSF to decommission and deconstruct the ATST Project within fifty (50) years from the date operations commence, unless, after consultation by NSF with NHOs, NSF decides otherwise, in which case NSF shall notify the ACHP, the SHPO, and the NPS.