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Revision C

DANIEL K. INOUYE SOLAR TELESCOPE

DKIST WBS Descriptions

Editor: R. Hubbard
Systems Engineering

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REVISION SUMMARY:

1. Date: September 22, 2006
   Revision: A
   Changes: Initial Document
2. Date: September 2012
   Revision: B
   Changes: Revised to update WBS changes and added details since 2006
3. Date: May 2015
   Revision: C
   Changes: Revised to update WBS changes and added details since 2012
   Conformed to new outline for PMCS documents
   Removed ‘Dictionary’ from the title to conform to PMBOK usage.
4. Date: November 2015
   Revision: C1
   Changes: Removed all WBS elements beyond 1.2.8.

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Preface

A Work Breakdown Structure (WBS) is a tool used by project management and systems engineering to decompose a project into manageable components. It is typically organized into a hierarchical tree structure with clearly defined objectives and responsibilities.

1. PLANNING

The DKIST (formerly ATST) project planned to have two versions of the WBS. The first was for tasks to be performed during the Design and Development phase (D&D). The second was for work associated with the construction phase of the DKIST facility. These two phases were funded separately.

2. DEVELOPMENT

Development of the D&D phase WBS began in October 2001 when the D&D phase was approved and started. A project manager was hired on 1 February 2002 and a working version of the D&D WBS was in place shortly thereafter.

The Construction phase WBS was developed in parallel with D&D work. An early version was included in the January 2004 Construction Phase proposal and was updated in May 2009 when DKIST submitted an updated project proposal. The WBS is still a living document. The project continues to add detail, perform restructuring, and make minor nomenclature changes.

3. MAINTENANCE

The construction-phase WBS is the only WBS currently maintained by the DKIST project.

Construction Phase Work Breakdown Structure:

1 ATST

1.1 (INTENTIONALLY BLANK)

1.2 ATST CONSTRUCTION AND COMMISSIONING

1.2.1 Project Management

The Project Management WBS element is comprised of the following major areas: WBS, schedule, budget, project infrastructure, administrative support, staffing, planning, tracking and reporting.

1.2.1.1 Project Management Control System (PMCS)

The design, development and implementation of the Project Management Control System will be used as a management tool for the project and external EVMS reporting. This includes outsourced services of Sr. PMCS Consultant. The PMCS personnel support was estimated using direct experience from other projects and comparison to other MREFC scale projects such as ALMA, IceCube, LIGO, etc.

1.2.1.2 Environmental Health and Safety (EH&S)

The Environmental Health and Safety WBS component includes a fulltime Safety Officer through the run out of the project. The Environmental Health and Safety WBS component also includes safety materials and supplies, such as hard hats, vest, first aid equipment, back boards, lanyards, etc. as well as an allowance for hiring off-duty paramedics to be on-site during identified critical construction periods. Safety Equipment: hard hats, auxiliary safety gear: loves, vests, etc., boots, safety harnesses, lanyards, self-retracting harness equipment, connection devices, safety related training, first aid equipment/support:, safety equipment kits, restock lock out tag out kits, spill prevention kits, hearing protection, rescue and retrieval system, respiratory protection, fit testing, medical evaluations, allowance for off-duty paramedics.

1.2.1.3 Quality Assurance/Quality Control (QA/QC)

The Quality Assurance/Quality Control WBS component includes an allowance for QA/QC consultants from construction start through on-site construction. The project intends to contract for QC from vendors (e.g., TMA and Enclosure) and provide QA through a combination of the project’s Systems Engineering team (lead QA), COTRs, and independent QA/QC consultants as required. The Quality Assurance/ Quality Control WBS component also includes a travel allowance for the QA/QC consultants and an allowance for independent testing – the combined total is the estimate for the QA/QC consultants contract(s). The consultants will not be part of the project team directly, but act in an independent capacity to advise the project regarding QA/QC best practices and make recommendations and conduct tests as appropriate through the vendor shop and on-site construction effort.

1.2.1.4 Travel

The travel budgets for project staff, the Science Working Group, various reviews and committees, recruitment of new hires, and costs associated with the rental house in Maui.

1.2.1.5 Computers and Supplies

The budgets for computers and supplies.

1.2.1.6 Relocation

The budgets for the relocation expenses associated with ATST team members that are relocating to Hawaii. This budget also includes re-location of new hires to any of the project office locations.

1.2.1.7 General Construction Equipment

The General Construction Equipment WBS component includes vehicles (vans, trucks), and their associated fuel, maintenance, and registration costs. The General Construction Equipment also includes an allowance for supplemental/additional crane leases during construction, scissor lift lease, off-road fork lift lease, indoor electric/propane forklift, facility tools, office equipment, and materiel and supplies to support the construction effort on-site. The General Construction Equipment WBS component also includes an allowance for temporary housing for the team and securing warehouse space.

1.2.1.8 Special Events

Special events such as Dedications, Groundbreakings or special reviews.

1.2.1.9 National Park Service Special Use Permit (SUP)

This work package is to fund the biological mitigations and monitoring required by the National Park Service for issuance of a Special Use Permit to use the historic road in Haleakala National Park.

1.2.1.10 Legal Fees

Contract for AURA's attorney fees in Hawaii to support CDUA process, project labor agreements, excise tax exemptions and other items as required. Legal fees associated with the University of Hawaii's (IFA) application for a Conservation District Use Permit (CDUP) for the project. As per sub award number C22024S and ATST Cooperative Agreement, the ATST project is committed to reimbursing all of University of Hawaii's expenses relating to the CDUP process.

1.2.1.11 Project Permitting and Environmental Compliance

Consultant services to support environmental compliance and permitting.

1.2.1.12 Habitat Conservation Plan

The Habitat Conservation Plan (HCP) is devised to address anticipated impacts to state and federal threatened, endangered, and listed species from the construction of the ATST at HO on Maui, Hawaii. The purpose of the HCP is to offset any takes on the endangered species (petrels) and is a condition of the issuance of the CDUP. Several mitigations including a conservation fence to restrict movement of the feral goats in the area, predator control and biological monitoring will be funded through the HCP which has been committed to by the National Science Foundation, approved by the Endangered Species Recovery Committee and will be presented to the Board of Land and Natural Resources for approval at their February 25, 2011 meeting. HCP will be in place for approximately 6 years.

1.2.1.13 Programmatic Agreement

The funding for the Cultural Specialist will help ensure protection of existing historic properties and their traditional cultural values at the ATST Project Site during construction of ATST on Haleakala, Maui, Hawai'i.

1.2.1.14 Remote Operations - Office Space

This is for office space on Maui for remote facilities. There is a Building line item that will either be used to continue a lease or for payment on a Building that AURA or UH would build. Lease of the remote operations office space off the mountain, currently in Pukalani. Wages to complete a design requirements document for the Remote Operations Building to be built to support off-site operations in Maui.

1.2.2 Systems Engineering

The Systems WBS element encompasses the following systems engineering activities: design requirements flow-down, error budgets, interface control, standards, design requirements documents, performance predictions, acceptance test plans, integration plans, and documentation control. The Systems Engineering WBS component includes a fulltime Systems Engineer, Optical-Systems Engineer (also lead IT&C engineer), and Documentation Coordinator through the run out of the project. The travel, computers, materials and supplies, and relocation required to support the Systems Engineering team are held in the Project Management WBS component. The Systems Engineering WBS component includes the following: Payroll and Benefits: Systems Engineer, Optical Systems Engineer (also lead IT&C engineer), and Documentation Coordinator.

1.2.3 Telescope Systems

1.2.3.1 Telescope Assembly

The Telescope Assembly WBS element encompasses the telescope mount, the heat stop, the M1 assembly, the M2 assembly, the feed optic assemblies, the system alignment equipment, and the acquisition system.

1.2.3.1.1 Telescope Mount Assembly

The Telescope Mount Assembly (TMA) WBS element encompasses the large structure that supports the optics and instruments of ATST. It includes all the various mechanical subassemblies, bearings, controllers, drives, and equipment that are used to point, track, and slew these optics and instruments during science operations.

1.2.3.1.1.1 Mount Structure

The mount structure is comprised of all the major structural elements that provide support and rotation of the mirror assemblies and related instrumentation packages in azimuth and altitude. The mount is comprised of the optics support structure assembly, the mount base assembly, the azimuth track, the azimuth and altitude bearing systems, the mount access platforms, and the light baffle tube.

1.2.3.1.1.2 Mount Drive System

The mount drive system is comprised of the drives, amplifiers, encoders, brakes, over-travel stops, servo controllers, and other equipment used to point, track, and slew the mount in azimuth and altitude rotation.

1.2.3.1.1.3 Coudé Rotator Structure

The Coudé Rotator Structure is the large, single-level steel assembly that rotates about an azimuth axis inside of the Pier. It is comprised of the structural elements that support coudé instruments and optical benches underneath the mount, the bearings that allow for rotation, and also the flooring system.

1.2.3.1.1.4 Coudé Rotator Drive System

The coudé rotator drive system is the assembly of drives, encoders and controllers that allow the coudé rotator to track and de-rotate the light feed from the mount, align slits of spectrographs, and to slew to different positions during normal telescope operations.

1.2.3.1.1.5 (Intentionally blank)

1.2.3.1.1.6 (Intentionally blank)

1.2.3.1.1.7 Ancillary Mechanical Equipment

The ancillary mechanical equipment is the collection of secondary equipment that is bolted to the mount and coudé rotator structures (e.g., mirror cover, cable wraps, etc.)

1.2.3.1.1.8 Mount Control System

The mount control system (MCS) is the system responsible for the control and coordination of the TMA, including the mount drive system, the coudé rotator drive system, and the Nasmyth rotator drive system. It also controls the ancillary mechanical equipment, and provides interfaces for all these components to the telescope control system (TCS), the observatory control system (OCS), and the global interlock system (GIS).

1.2.3.1.1.9 Telescope Mount Assembly GIS Interface

The portion of the GIS associated with the TMA is distributed in two separate local interlock controllers. These LICs communicate through the safety network which is part of the GIS. These individual LICs function as independent safety systems as well as globally communicate within the GIS, providing for equipment and personnel safety.

1.2.3.1.1.10 (Intentionally blank)

1.2.3.1.1.11 Telescope Mount Assembly Tools & Equipment

The TMA tools and equipment include specialty items required to install, align, and test the TMA in the factory and on-site. These include such things as dummy weights, precision measurement equipment, hydraulic bolt tensioners, lifting equipment, slings, come-alongs, and other "install and align" type items.

1.2.3.1.2 M1 Assembly

The M1 Assembly contains the M1 (primary) mirror and the M1 support system that controls its optical figure over the telescope operating conditions.

1.2.3.1.2.1 M1 Mirror

The M1 Mirror is the primary light-collecting mirror in ATST.

1.2.3.1.2.1.1M1 Mirror Blank

The M1 mirror blank is made of highly homogeneous low-expansion glass ceramic material with a machine-generated front and back surface ready for optical polishing and figuring.

1.2.3.1.2.1.2 M1 Mirror Grind, Polish, Ship

The contracted effort, beginning with the delivery of the M1 mirror blank, consisting of the generation, polishing and transport of the finished M1 Mirror to the site.

1.2.3.1.2.2 M1 Cell Assembly

The assembly containing the M1 mirror, M1 support system, M1 thermal control system, cooled aperture plate and M1 control system

1.2.3.1.2.2.1 M1 Support System

The M1 Support system supports the weight of M1 and maintains nominal surface figure over operational zenith angles and thermal conditions.

1.2.3.1.2.2.2 M1 Cell Structure

The M1 Cell Structure is the base that supports the M1 Support System, M1 Thermal Control System and the cleaning and washing hardware.

1.2.3.1.2.2.3 M1 Thermal Control System

The M1 Thermal Control system maintains the temperature of the M1 surface and aperture plate close to ambient temperature to prevent self-induced seeing.

1.2.3.1.2.2.4 M1 Safety Restraint System

The M1 Safety Restraint System provides protection of M1 in the event of seismic activity.

1.2.3.1.2.2.5 M1 Control System

The M1 Control System controls application of the active forces to M1, and controls the thermal management system. It includes hardware to run the software.

1.2.3.1.2.2.6 M1 Ancillary Equipment

The M1 Ancillary Equipment includes the aperture plate, M1 lifter, and M1 handling cart.

1.2.3.1.2.3 (Intentionally blank)

1.2.3.1.2.4 (Intentionally blank)

1.2.3.1.2.5 (Intentionally blank)

1.2.3.1.2.6 (Intentionally blank)

1.2.3.1.2.7 (Intentionally blank)

1.2.3.1.2.8 M1 Tools and Equipment

The M1 tools and equipment includes any tooling whether custom or off-the-shelf that is required for the assembly and disassembly of the M1 assembly.

1.2.3.1.2.9 M1 Assembly Vendor Design

The M1 Assembly Vendor Design is the vendor deliverable during the design phase of the contract.

1.2.3.1.3 Top End Optical Assembly

The Top End Optical Assembly (TEOA) includes the M2 module, Heat Stop Assembly, Lyot Stop, M2 Support Frame and control system.

1.2.3.1.3.1 Heat Stop Assembly

The Heat Stop Assembly (HSA) is the assembly at prime focus that prevents unwanted solar disc light from heating and scattering on subsequent optics. The HSA is the first field stop, allowing approximately a 5-arcmin FOV to pass to M2.

1.2.3.1.3.1.1 Reflector Assembly

The reflector assembly reflects most of the light incident on its surface, and removes the remaining absorbed energy to allow only a minimal temperature rise within the HSA.

1.2.3.1.3.1.2 Occulter Insert

The Occulter Insert (current an upgrade path) is a small, conical device that fits into the opening in the HSA, and provides a limb-shaped occulting edge in the center of the FOV during near-limb coronal observations.

1.2.3.1.3.1.3 Heat Stop Control System

The Heat Stop Control System is responsible for the control and coordination of the HSA, including the pump speed, system pressure, coolant temperature, and the sundry sensors. This system provides software interfaces for these components to the TCS, OCS, and GIS. This includes hardware to run the software.

1.2.3.1.3.2 M2 Assembly

The M2 Assembly contains the 62 cm diameter off-axis mirror (M2) that is the second element in a chain of optics that collects and focuses the solar energy into high-resolution images. The assembly consists of M2, the M2 positioning system composed of a hexapod and fast tip-tilt mechanism, the M2 thermal control system and the M2 control system.

1.2.3.1.3.2.1 M2 Mirror

The M2 is the second mirror of the system, and, in conjunction with M1, forms an image at the Gregorian focus.

1.2.3.1.3.2.1.1 M2 Mirror Blank

The M2 mirror blank is a light-weighted silicon carbide substrate.

1.2.3.1.3.2.1.2 M2 Mirror Grind, Polish, Ship

The contracted effort beginning with the availability of the M1 mirror blank, consisting of the generation, polishing and transport of the finished M1 Mirror for integration into the TEOA.

1.2.3.1.3.2.2 M2 Positioning System

The function of the M2 positioning system is to support the weight of M2 and define its position and orientation over the operational zenith angles and thermal environments of the telescope. In addition, the positioning system provides fast tip-tilt motion of M2.

1.2.3.1.3.2.3 M2 Thermal Control System

The M2 thermal control system removes solar energy that is absorbed by the optical surface of M2 to maintain its surface temperature as close to ambient as possible.

1.2.3.1.3.2.4 M2 Control System

The M2 Control System is to control the M2 thermal management system. The system will also store and apply a 24-hour thermal profile estimation to be used in the thermal control of M2. The M2 Control System provides status information and interfaces to the TCS, GIS and OCS. It includes hardware to run the software.

1.2.3.1.3.2.5 M2 Ancillary Equipment

The M2 Ancillary Equipment consists of the mounting frame.

1.2.3.1.3.2.6 Lyot Stop

The Lyot Stop assembly is located at the first pupil image. It will become the aperture stop of the telescope during coronal observations. Its function is to mask the bright ring at the edge of the pupil image caused by diffracted sunlight at the edge of the entrance aperture above M1.

1.2.3.1.3.2.7 M2 Tools and Equipment

The M2 Tools and Equipment includes the handling fixtures and other miscellaneous fixtures used in handling the M2 mirror.

1.2.3.1.3.3 TEOA Control System

The TEOA Control System (TEOACS) commands the hexapod actuators at the direction of the WCCS, commands the tip/tilt actuators as part of the AO system, and is responsible for the control and coordination of the Heat Stop Assembly. It is commanded through the TCS. The TEOACS also controls the M2 Thermal Management System and deployable Lyot Stop. The TEOACS provides status information and interfaces to the TCS, WCCS and GIS. It includes the hardware to run the software.

1.2.3.1.3.4 TEOA Ancillary Equipment

The TEOA Ancillary Equipment includes the TEOA Shipping & Handling Rig, the M2 Lifter, and any other tools or hardware needed for maintenance and testing of the M2 assembly.

1.2.3.1.4 (Intentionally blank)

1.2.3.1.5 Feed Optics

The Feed Optics consist of a number of thermally controlled optical components that function to relay the Gregorian image produced by M1 and M2 to Coudé mounted instruments.

1.2.3.1.5.1 Transfer Optics

The Transfer Optics includes M3, M4, and M6 assemblies. (M5 is part of the Wavefront Correction System as it serves as the fast tip-tilt mirror.) These mirrors transfer the beam across both altitude and azimuth axes of the telescope. The assemblies include the cooled mirrors, mounts, and positioning systems. Each Transfer Optic Mirror is a liquid cooled optical substrate fabricated from optical grade Silicon with integrated coolant manifolds and coolant supply interfaces. All Transfer Optics are mounted on the telescope OSS or mount base.

1.2.3.1.5.1.1 M3 Blank

The M3 silicon mirror blank with integrated coolant manifolds.

1.2.3.1.5.1.2 M3 Grind, Polish

The contracted activity to grind and polish M3 to a flat surface shape.

1.2.3.1.5.1.3 M3 Alignment Stage

M3 is close to the Gregorian focus, so this mirror is utilized as an actively controlled pupil steering mirror under the command of the quasi-static alignment system, which is part of the adaptive optics subsystem of the wavefront correction system.

1.2.3.1.5.1.4 M3 Mount

The M3 mount holds the mirror and alignment stage.

1.2.3.1.5.1.5 M4 Blank

The M4 silicon mirror blank with integrated coolant manifolds.

1.2.3.1.5.1.6 M4 Grind, Polish

The contracted activity to grind and polish M3 to its required off-axis ellipsoidal shape.

1.2.3.1.5.1.7 M4 Mount

The mount that holds and allows for fine positioning of the M4 mirror.

1.2.3.1.5.1.8 M5 Blank

The M5 blank is an identical version of the M6 silicon mirror blank with integrated coolant manifolds. It serves as a spare M6 and a potential stand-in mirror to replace the M5 fast tip-tilt mirror early in IT&C before delivery of the fast tip-tilt assembly.

1.2.3.1.5.1.9 M5 Grind, Polish

The contracted activity to grind a polish M5 to its required flat surface shape.

1.2.3.1.5.1.10 M5 Mount

The mount that holds and allows for fine positioning of the static M5 stand-in mirror.

1.2.3.1.5.1.11 M6 Blank

The M6 silicon mirror blank with integrated coolant manifolds.

1.2.3.1.5.1.12 M6 Grind, Polish

The contracted activity to grind and polish M6 to its required flat surface shape.

1.2.3.1.5.1.13 M6 Mount

The mount that holds and allows for fine positioning of M6.

1.2.3.1.5.1.14 M6 Alignment Stage

M6 is close to a pupil, so this mirror is utilized as an actively controlled image-steering mirror under the command of the quasi-static alignment system, which is part of the adaptive optics subsystem of the wavefront correction system.

1.2.3.1.5.2 Coudé Optics

The Coudé Feed Optics includes the three mirrors (M7, M8, and M9) in front of the deformable mirror (M10) and the wavefront-correction beam splitter. They fold and condition the beam, rendering it collimated. The M8 mirror also forms a pupil image at the location of M10, the deformable mirror. Each coudé optic assembly consists of a low-expansion substrate, mirror support system, and thermal control system.

1.2.3.1.5.2.1 M7 Blank

The low-expansion substrate for the M7 fold mirror.

1.2.3.1.5.2.2 M7 Grind, Polish

The contracted activity to grind and polish the M7 mirror to its required flat surface shape.

1.2.3.1.5.2.3 M7 Mount

The mount that holds and allows for fine positioning of M7.

1.2.3.1.5.2.4 M8 Blank

The low-expansion substrate for the M8 fold mirror.

1.2.3.1.5.2.5 M8 Grind, Polish

The contracted activity to grind and polish the M8 mirror to its required concave surface shape.

1.2.3.1.5.2.6 M8 Mount

The mount that holds and allows for fine positioning of M8.

1.2.3.1.5.2.7 M9 Blank

The low-expansion substrate for the M9 fold mirror.

1.2.3.1.5.2.8 M9 Grind, Polish

The contracted activity to grind and polish the M8 mirror to its required shape.

1.2.3.1.5.29 M9 Mount

The mount that holds and allows for fine positioning of M9.

1.2.3.1.5.3 Feed Optics Thermal Control System

The Feed Optics Thermal Control System includes hardware common to the cooling of all feed mirrors.

1.2.3.1.5.4 Feed Optics Control System

The Feed Optics Control System is the software that controls both position and temperature of the feed optics and the hardware to run it.

1.2.3.1.5.5 Feed Optics Tools and Equipment

Lifting, handling and coating fixtures.

1.2.3.1.6 (Intentionally blank)

1.2.3.1.7 System Alignment

System Alignment & Calibration components are provided to facilitate initial rough alignment of the telescope, and realignment after optical elements are removed and reinstalled. It includes centering targets at various locations, and alignment telescopes and fixtures.

1.2.3.1.8 Acquisition System

The Acquisition System provides a full-disk image of the sun that can be used by the observer to select and acquire solar features. It also provides the most basic level of guiding feedback (limb guiding) to the tracking system.

1.2.3.1.8.1 Acquisition Unit

The project has identified a small off-the-shelf telescope equipped with an H-α filter that mounts on the OSS.

1.2.3.1.8.2 Acquisition Unit Control System

The Acquisition Control System is the software and hardware responsible for controlling the collection and storage of real-time, full-disk solar images.

1.2.3.2 Wavefront Correction

The wavefront correction system is comprised of two major elements: the adaptive optics (AO) system, and the active optics (aO) systems.

1.2.3.2.1 Wavefront Correction - Coudé (WFC-C)

Wavefront Correction at Coudé includes an Adaptive Optics System and an Active Optics System to correct the light fed to the Coudé instruments and to measure telescope alignment and M1 figure.

1.2.3.2.1.1 Adaptive Optics - Coudé (AO-C)

The AO-C corrects components of atmospheric and local seeing under moderate to good seeing conditions and telescope optical errors for coudé instruments. It also provides M1 figure information.

1.2.3.2.1.1.1 High Order Adaptive Optics

This system includes the sensors and actuators need to correct atmospheric image distortion. It includes both the deformable mirror (DM, M10), the fast tip-tilt mirror (M5), and also controls the fast tip-tilt components of M2 that are used to stabilize the sun's image when observing the corona or near-limb solar disk features.

1.2.3.2.1.1.1.1 AO Wavefront Sensor System – Coudé

The AO Wavefront Sensor is the optical system and camera that generates the digitized images used to sample the wavefront error.

1.2.3.2.1.1.1.2 Real Time System – Coudé

The Real Time System is the hardware and software needed to compute the wavefront error as a function of pupil position from the digitized images provided by the wavefront sensor. The output of the real-time system is error signals fed to the fast tip-tilt mirror (M5) and the deformable mirror (M10).

1.2.3.2.1.1.2 Fast Tip-Tilt Mirror System – Coudé

The fast tip-tilt system is the flat mirror (M5 in the ATST optical train) and associated hardware that corrects for tip-tilt components of wavefront error, as observed by the AO wavefront sensor and computed by the AO real-time system. It also includes the tip-tilt driver the powers the tip-tilt platform.

1.2.3.2.1.1.2.1 Mirror

The fast tip-tilt mirror (M5) is a light-weighted silicon-carbide flat located at a pupil conjugate of M1.

1.2.3.2.1.1.2.2 Tip-Tilt platform

The tip-tilt platform consists of the actuators that tip and tilt M5based on error signals computed by the AO real-time system.

1.2.3.2.1.1.2.3 Cooling system

The M5 cooling system removes the approximately 13 watts of power absorbed by the mirror due to beam insolation.

1.2.3.2.1.1.2.4 Tip-tilt mount to tower

The tip-tilt mount is the interface between the tip-tilt mirror and platform to the tower that supports the assembly.

1.2.3.2.1.1.2.5 Cable from driver to tip-tilt platform

This is the cable that delivers signals from the drivers to the tip-tilt platform.

1.2.3.2.1.1.2.6 Rack, cooled for Driver, cooling system

This is a cooled rack located on the mount-base assembly that provides the supporting electronics for the tip-tilt mirror assembly, including the tip-tilt drivers and cooling controllers.

1.2.3.2.1.1.3Deformable Mirror System – Coudé

The Deformable Mirror System includes all components of the deformable mirror (M10) used for high-order wavefront correction.

1.2.3.2.1.1.3.1 Deformable Mirror (DM)

The deformable mirror (M10 in the ATST optical train) is a highly reflective, nominally flat mirror that can be deformed by 1900 embedded actuators to correct for atmospheric distortion.

1.2.3.2.1.1.3.2 DM Mount

This is the mount assembly for the deformable mirror.

1.2.3.2.1.1.3.3 DM Monitor Computer

The DM Monitor Computer monitors performance and configuration of the DM.

1.2.3.2.1.1.3.4 Spare DM and Driver Cards

Because of the critical nature of the deformable mirror to the functioning of ATST, a spare system is provided.

1.2.3.2.1.1.3.5 Test flat with mount

During development, integration, test, and commissioning a test flat is available as a stand-in M10.

1.2.3.2.1.2 Active Optics (aO) - Coudé

The Active Optics (aO) system provides information to actively track targets, provides any adjustment to the shape of the M1 mirror, and it calculates the corrections for the position of M2, M3, and M6 mirrors. The last function is also referred to as Quasi-Static Alignment (QSA).

1.2.3.2.1.2.1 *aO Wavefront Sensor – Coudé*

The aO wavefront sensor includes the optics and camera that provides digital images as input to the aO real-time system.

1.2.3.2.1.2.2 *Real Time System*

The aO real-time system includes the hardware and software necessary to convert the digital images provided by the aO wavefront sensor into error signals suitable for use by M1, M2, M3, and M6 aO actuators.

1.2.3.2.1.3 Context Viewer

The Context Viewer is a video rate camera used to monitor the image being fed to the coudé instruments.

1.2.3.2.1.4 Common Items

These items are common to both AO and aO in the coudé room (such as) Coudé controller, racks, misc. items.

1.2.3.2.1.5 Coudé Tools and Equipment

1.2.3.2.2 (Intentionally blank)

1.2.3.2.3 Wavefront Correction Control System

The WCCS operates the underlying active and adaptive optics control systems. It manages the interface to the TCS for all wavefront issues. It controls the blending of Zernike values from the aO/AO systems and distributes them to the relevant telescope subsystems.

1.2.3.2.4 (Intentionally blank)

1.2.3.2.5 Wavefront Correction Limb Tracker

The wavefront Correction subsystem also has responsibility for sensing limb position during near-limb observations, and providing image stabilization via the M2 fast tip-tilt system.

1.2.3.3 Instrument Systems

The instrumentation construction costs include two distinct areas: the instrument lab facility and the focal-plane science instruments. The Instrument Lab Facility is the set of common components that directly support science instruments and observers. The science instruments are those that were selected to best meet the science requirements detailed in the SRD.

1.2.3.3.1 Instrument Lab Facility

The Instrument Lab Facility is a set of components that directly support science instruments and observers.

1.2.3.3.1.1 Polarimetry Analysis and Calibration

The Polarimetry Analysis and Calibration system is used both to modulate the beam for determining the polarization state of solar features, and to determine telescope polarization. The system includes the Gregorian Optics Station, polarization modulators, calibration optics, and Nasmyth and coudé analyzers. It also includes control software and the hardware it runs on.

1.2.3.3.1.2 Master Clock & Synchro Network

Develop and construct the timing system for the ATST software and instrument systems. Build and integrate the timing network (IEEE-1588) into the observatory and deliver the time standard to the instruments.

1.2.3.3.1.3 Coudé Station

The Coudé Station includes the optical benches and beam splitters that divide the ATST beam amongst the various instruments in the coudé lab. This does not include the imaging optics, their supports, nor the optical benches under each instrument. These are considered part of the individual instruments.

1.2.3.3.1.3.1 *Imaging Optics*

The ATST optical system ends after BS1 beam splitter that divides the wavefront correction beam and the science beam. The beam at this point is collimated. Each instrument provides its own imaging optics to suit the specific needs of that instrument.

1.2.3.3.1.3.2 *(Intentionally blank)*

1.2.3.3.1.3.3 *Optical Benches*

The optical benches are also considered part of each instrument.

1.2.3.3.1.3.4 *Additional Lab Items*

1.2.3.3.1.4 Instrument Control System

The Instrument Control System provides a standard interface between the ATST instrument systems and the telescope support facilities (TCS, data handling, user interfaces). It supports instrument developers by providing hardware and software standards for instrument components, and services for connections to the telescope.

1.2.3.3.1.5 Coudé Environmental System

The Coudé Environmental System is the equipment responsible for maintaining a thermal environment in the coudé lab compatible with the seeing requirements, and also providing air filtration for dust control. In addition to the HVAC equipment, it includes the coudé lab ceiling system with integrated filtration and lighting, the wall finishes, and the air knife assembly.

1.2.3.3.2 Visible Broadband Imager (VBI)

The Visible Broadband imager is an imaging filtergraph that is operated between 393.4 nm and 656.3. It is located in the coudé lab.

1.2.3.3.2.1 VBI Blue Channel

The VBI is separated into two distinct components (blue and red) because each has its own optical bench and each picks off its share of the beam at different locations along the science beam. The blue channel operates between 393.4 nm and 486.1 nm.

1.2.3.3.2 2 VBI Red Channel

The VBI is separated into two distinct components (blue and red) because each has its own optical bench and each picks off its share of the beam at different locations along the science beam. The red channel operates from 600 to 860 nm and is optimized for 656.3 nm.

1.2.3.3.3 Visible Spectro-polarimeter (ViSP)

The ViSP is a grating-based slit spectrograph that provides polarimetric data in all four Stokes vectors, I, Q, U, and V. By scanning the sun's image perpendicular to the slit orientation it can produce IQUV images. It is located in the coudé lab.

1.2.3.3.4 Near-IR Spectro-polarimetry (NIRSP)

Similar to the ViSP, Near-IR Spectro-polarimetry is accomplished using two distinct instrument packages, both located in the coudé lab.

1.2.3.3.4.1 Diffraction Limited Near-IR Spectro-polarimeter (DL-NIRSP)

The DL-NIRSP is operated and room temperature and uses the deformable mirror and Coudé bench light distribution following the DM. The wavelength range is 900nm to 2300nm.

1.2.3.3.4.2 Cryogenic Near-IR Spectro-polarimeter (Cryo-NIRSP)

The Cryo-NIRSP is cryogenically cooled. This is the primary coronal instrument, capable of high signal-to noise coronal spectro-polarimetry.

1.2.3.3.5 Visible Tunable Filter (VTF)

The Visible Tunable Filter is a narrow-band filtergraph that operates between 500 and 900 nm. It provides diffraction-limited images as narrow as 3 pm and can perform full Stokes vector polarimetry. It is located in the coudé lab.

1.2.3.3.6 Camera Systems

The Cameras WBS component includes the initial facility cameras required for commissioning of the VBI, ViSP, NIRSP-N, and VTF instruments. These cameras will be available to be used at the coudé and Nasmyth instruments as well as two context viewers. Spare cameras of each type are also included.

ATST provides cameras for all facility instruments to allow for a high level of standardization.

1.2.3.3.6.1 Camera Hardware

Camera hardware includes the camera heads, camera control computers, camera controllers, and camera cooling systems. Note that the x-y-z stage that the camera mounts is provided by the individual instruments.

1.2.3.3.6.2 Camera Software

The camera software, also known as the virtual camera, produces frames that are derived from individual exposures from a physical camera or cameras. These virtual images are, in general, fewer in number than the exposures coming from the camera thereby reducing the total data rate. The frames are sometimes sums of exposures, or a selected subset of the exposures. They may also be bursts of exposures taken at a cadence faster than can be handled by the bulk data transport and read out at a rate that can be handled.

1.2.3.4 High-Level Controls and Software

The High Level Controls and Software WBS element encompasses the means to control and coordinate observations performed with the telescope and instruments. This includes the lowest level servo or logic controller to the highest-level queue and scheduling processes.

1.2.3.4.1 Common Services

The Common Services provides software infrastructure required by all ATST software systems.

1.2.3.4.2 Observatory Control System (OCS)

The OCS operates the observatory by creating and coordinating observations sent to the other systems. The OCS provides user interfaces, planning and scheduling, and observation management tools.

1.2.3.4.3 Data Handling System (DHS)

The DHS manages input data streams from the instruments. It provides the data flow mechanisms, data storage, archival, and retrieval, and data display.

1.2.3.4.4 Telescope Control System (TCS)

The TCS is responsible for the control of the telescope positioning and image quality. It operates associated subsystems, including the enclosure, mount, M1, M2, acquisition and guiding, and adaptive/active optics.

1.2.3.4.5 Global Interlock System (GIS)

The GIS provides a redundant, stand-alone safety mechanism for personnel and equipment.

1.2.3.5 Enclosure

The Enclosure is the large structure that surrounds and provides protection for the Telescope Assembly. It includes a variety of mechanical subassemblies, bogies, controllers, drives, and equipment that are used to point, track, and slew it in synch with the Telescope during science observations.

1.2.3.6 Support Facilities and Buildings

The Support Facilities and Buildings include the buildings, facility equipment and site infrastructure.

1.2.3.6.1 Construction Services

1.2.3.6.1.1 Geotechnical Testing

After leveling the site or after excavation for the telescope pier, it may be considered necessary to do additional testing such as: borings & lab testing of samples at critical foundation areas; ground penetrating radar to find potential voids; or inspection and recommended treatment of the exposed rock substrate.

1.2.3.6.1.2 Demolition and Clearing

Removal of the following items that are in the area where the ATST enclosure and S&O building will be constructed: the existing ATST test tower and its foundations; the existing Mees cesspool; existing IfA weather station; Mees generator, existing low rock walls and walks extending out from the Mees facility.

1.2.3.6.1.3 Major Earthwork

Creation of a level pad for placement the ATST facility and excavating pits for foundations. This work will consist of: removal of rock and soil using bulldozer, backhoe, trenchers and other standard large excavating equipment; breaking up of large rocks as required using jackhammers, hoe-ram, and other non-explosive means; auger drilling holes for caissons; transporting and depositing removed soil and rock to designated soil placement areas at Haleakala Observatory.

1.2.3.6.1.4 Roads and Driveways

Minor modification of the existing main access road north of the site. Construction of a paved service yard/parking area between the ATST S&O Building the Utility Building and, the existing Mees facility.

1.2.3.6.1.5 Utilities

Connection from existing exterior utility infrastructure to new ATST facility including: new primary electric feed from utility company substation; connection to existing fiber optic and telephone lines; connection to existing Mees domestic water cistern. Installation of new exterior utility systems including: wastewater treatment plant to serve ATST and Mees facility and electrical grounding system. Also included are the trenching and materials necessary for the earth-electrode subsystem.

1.2.3.6.1.6 Utility Chase

An underground accessible trench to run power, water, data and other facility interconnects and services between the Utility Building and the S&O Building.

1.2.3.6.1.7 Soil and Structural Reinforcement

Special measures necessary due to subsoil conditions including: over-excavation and re-compaction at previous cesspool area; and installation of concrete caissons down to solid rock strata under pier and enclosure foundations.

1.2.3.6.1.8 Construction Infrastructure

Temporary on-site facilities necessary for construction including: contractors' trailers, temporary utilities, construction crane(s), dumpsters, portable toilets, and special construction signage.

1.2.3.6.2 Buildings

1.2.3.6.2.1 Support and Operations Building

The multi-story structure attached to the telescope enclosure that houses the control room, instrument preparation lab, mirror coating facility, mechanical equipment room and other support spaces that benefit from proximity to the telescope and coudé instrument lab.

1.2.3.6.2.2 Utility Building

The single-story building located remotely from the telescope enclosure that houses equipment that, for reasons of heat and vibration, are required to be separated from the telescope and scientific instruments.

1.2.3.6.2.3 Lower Enclosure

The Lower Enclosure includes the structure and wall system that interfaces to the ground and provides support to the enclosure azimuth track.

1.2.3.6.2.4 Telescope Pier Assembly

The telescope pier is a monolithic concrete foundation poured in place at the site. It includes interfaces to the coudé rotator and the mount via their respective azimuth track assemblies. The pier also includes the steel flooring and the LULA observatory lift.

1.2.3.6.3 Facility Equipment

1.2.3.6.3.1 General Outfitting and Furnishings

This cost for furnishing the facility includes control room consoles (not including hardware), office equipment, furniture, shelving & cabinet work, shop equipment, break room equipment, appliances and other general building outfitting items.

1.2.3.6.3.2 Environmental Monitoring

This includes a weather station and GPS antenna to provide appropriate environmental data to the various observatory control systems.

1.2.3.6.3.3 Generator

A dedicated on-site generator and automatic transfer switch for soft shutdown and maintaining power to critical systems in the event of a primary power outage. The anticipated capacity of the generator would be ~300KVA, which would cover all UPS loads, keeping instruments cool or warm, stowing the telescope, closing the dome, lighting, and all safety critical systems, but would not allow for the uninterrupted continuation of full observing operations.

1.2.3.6.3.4 Uninterruptible Power Supplies (2)

Two units to provide a total of ~100KVA of UPS power.

1.2.3.6.3.5 Special Mechanical Equipment

The cost for this special purpose equipment includes cryogenic cooling systems; glycol chillers for cooling the telescope, optics, heat stop, and enclosure; pumps and glycol systems; vacuum pump and air compressor.

1.2.3.6.3.6 Tools and Special Equipment

The cost for this item includes machine tools (e.g., mill, lathe), power tools (e.g. drills, grinders), welding tools (e.g. TIG and MIG welders), electronic/electrical tools (e.g. oscilloscopes, ESD equipment), hand tools (metric & SAE), and various cabinets, tool boxes and work benches.

1.2.3.6.4 Coating and Cleaning Facilities

1.2.3.6.4.1 Cleaning Station, Fixtures, Tooling

This cost includes: a fixture for securing the M1 mirror in a tilted orientation, cleaning and stripping equipment, drainage system and holding tank for stripping fluids, compressed air delivery, rack of gas cylinders, handling trolleys, and miscellaneous specialized tools.

1.2.3.6.4.2 Coating Chamber

[No longer relevant; ATST will recoat M1 primary at the Air Force facility AEOS.]

1.2.3.6.5 Handling Equipment

The Handling Equipment includes a jib crane and lift.

1.2.3.6.5.1 Platform Lift

A lift suitable for conveying the M1 assembly and large instruments to the various levels. It is assumed to be a non-personnel-rated, electric, 20-ton capacity, 19 ft. square platform lift, generally described by industry as a vertical reciprocating conveyor. The contract for this lift would include the platform, guide rails, power unit, controls and all necessary hardware. It would not include construction of the shaft-way, gates at each level, or excavation for the pit. These costs are incorporated into the S&O Building estimate.

1.2.3.6.5.2 Handling Cranes

This is for the interior building cranes that are used for various operational tasks, including the high-bay shipping and receiving area (e.g,. M1 handling), the instrument lab (e.g., instrumentation handling), and the coudé lab access monorail crane.

This cost includes 2 cranes: a 20-ton bridge crane in the receiving and mirror handling area and a 5-ton monorail crane in the instrument lab. Both are assumed to be electric and include the trolleys, hoist, controls, and other necessary hardware. The cost for the primary support beams is incorporated into the S&O Building estimate.

1.2.3.6.5.3 Personnel Access Equipment

This is for the interior man lift that is used to access the interior of the enclosure, as well as the TMA mount, and other miscellaneous areas of the ATST Observatory.

1.2.3.6.6 Interconnects and Services

1.2.3.6.6.1 System Interconnects

System Interconnects are sets of pipes, hoses, cables, and other means of conveying utilities (e.g., power, chilled fluids, vacuum), network services, and the system time base from their source to any subsystem that requires them.

Specialty system connects to facility services. Examples are networks, additional power for instruments, control signals for sensors, compressed air, and vacuum lines.

1.2.3.6.6.2 IT Infrastructure

IT Infrastructure includes the computer network, computers, telephone and videoconferencing.

1.2.3.6.6.3 Grounding and Lightning Protection System

This includes all grounding and transient/surge suppression devices, building and facilities grounding system tie-in to the earth electrode subsystem.

1.2.3.6.7 Facility Thermal Systems

1.2.3.6.7.1 Facility Plant Equipment

The cost for this special purpose equipment includes cryogenic cooling systems; chillers to cool heat transfer fluids for cooling the telescope, optics, heat stop, and enclosure; pumps and heat transfer fluid systems; vacuum pump and air compressor. It covers the installation of the mechanical equipment and Primary Distribution piping in the Utility Building and to the standard HVAC in the S&O Building which is also included.

1.2.3.6.7.2 Thermal Sub-Systems

This includes major components of the FTS Secondary Distribution & Enclosure Thermal Systems, and the FTS Tertiary Distribution & TMA Thermal Systems.

1.2.3.6.7.3 Facility Management System

The Facility Management System (FMS) is the control software and hardware, instrumentation, monitoring devices, control elements, and distributed controls required to safely and economically monitor and operate facility special mechanical equipment and control site power demand. This work package includes the procurement, fabrication, installation, and integration of the FMS.

1.2.3.6.7.4 Facility Control System

The FCS is the high-level control system that interprets and converts control commands from the OCS into commands for the low-level thermal control and status system.

1.2.3.7 Remote Operations Building (ROB)

A project operational headquarters facility somewhere in the Up-Country area of Maui in the approximate vicinity of the IfA Advanced Technology Research Center (ATRC) and their Waikoa lab facility.

1.2.3.7.1 Building (Lease)

Assumes a separate building next to the ATRC with space to accommodate the ATST ROB requirements as projected in the Construction Proposal.

1.2.3.7.2 Building Outfitting

All necessary furnishings and equipment necessary for operating out of the ROB that are not provided as part of the lease.

The funding for the ROB construction was not funded in the Project scope, requiring the construction phase to acquire rental office space for the duration of the construction. This WBS element was deprecated and the projected leasing costs moved under the Project Management WBS (1.2.1) for Real Estate (1.2.1.14).

1.2.4 Integration, Test, and Commissioning

The Integration, Test & Commissioning WBS element encompasses the assembly of the various telescope components after fabrication is complete (integration). Then evaluation can proceed as the various subsystems are integrated (test). Finally the systems are used together to obtain system level performance measurements to verify that requirements are being met (commissioning). Towards the end of commissioning the transition to initial operations will occur.

1.2.5 Science Support

The Science Support WBS element encompasses the activities of the ATST Science Working Group and its interactions with the Project Scientist. These activities include ASWG meetings and workshops.

1.2.6 Operations Phase Preparation

Support is provided throughout IT&C in preparation for the handoff to the operations phase. It includes, for example, manuals, maintenance procedures, and training of operations staff as construction ramps down and operations ramps up.

1.2.7 Education & Public Outreach

A public outreach employee was paid out of this WBS element during the project's design phase, but that was discontinued at the start of construction. No public outreach is planned until the operations phase.

1.2.8 Support Services

The Support Services WBS element is comprised of overhead areas such as purchased support services from NOAO (e.g., accounting, purchasing, and facilities maintenance) as well as the AURA management fee. Business Services Fees are paid to AURA/NOAO for all business services in support of the project. These include accounting, payroll, human resources, and procurement. A Facilities Use Fee is paid to AURA/NOAO to support employees housed in Tucson for all expenses related to office space including space, maintenance, network, phone, etc. The AURA Fee is the financial and administrative rates charge by the AURA Corporate Office for providing fiscal and management oversight.