W. M. KECK OBSERVATORY
Maunakea, Island of Hawai'i

The W. M. Keck Observatory Data Services Initiative
Progress Report, July 2023

The W. M. Keck Observatory (WMKO) and its partners have embarked on a major strategic campaign to modernize the data flow and increase scientific yield: The Data Services Initiative (DSI). This report summarizes the project goals and the project's progress in the last year made possible by the support of our Keck Family of Supporters.

The goal of the DSI is to ensure that all data obtained at Keck is useful, discoverable, and quick. The DSI will transform the end-to-end data flow of data delivered to Keck observers and the community at large through the Keck Observatory Archive (KOA). Realizing the goals of the DSI will require significant data infrastructure changes at Keck, robust observatory supported reduction pipelines, and extensions to the KOA to support real-time ingestion of raw data followed by quick ingestion of science-ready data.

The DSI: Major Components

The DSI will require design, development, prototyping, refinement, and deployment of four major components: Prepare, Execute, Reduce, and Archive. ***Prepare*** refers to the user-facing components that result in an observation being ready to perform. ***Execute*** refers to the back-end instrument and telescope control tools driven by ***Prepare*** and results in the execution of observations and related calibrations. ***Reduce*** refers to the set of data reduction routines and their underlying framework. ***Reduce*** results in a set of quick-look or science-ready data products for the astronomer. ***Archive*** refers to the curation, storage, and retrieval of data, both in raw and post-***Reduce*** science-ready forms to the KOA. ***Archive*** results in data delivery either for the original observer in near real-time, or for the world community after the proprietary period, and will integrate with other world-wide archives to increase impact. The framework of DSI is shown in Figure 1.

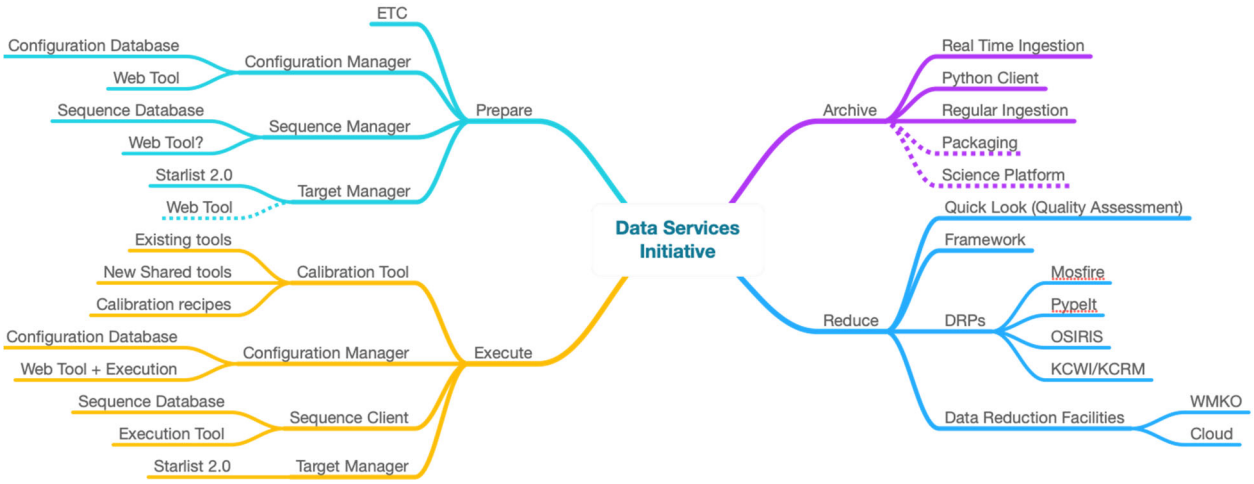

Figure 1: Top-level architecture of the DSI

Underlying both ***Prepare*** and ***Execute*** is the system of Database Driven Observing Infrastructure (DDOI). DDOI, which is already undergoing significant design work at WMKO[1] will create a single descriptive language for observations across the entire WMKO instrumentation suite, similar to systems like the Astronomer's Proposal Tool (APT) for the *Hubble Space Telescope*. The system will facilitate target management, exposure management, instrument configuration, calibration sequencing, and observation logging. The basic structure of DDOI is shown in Figure 2.

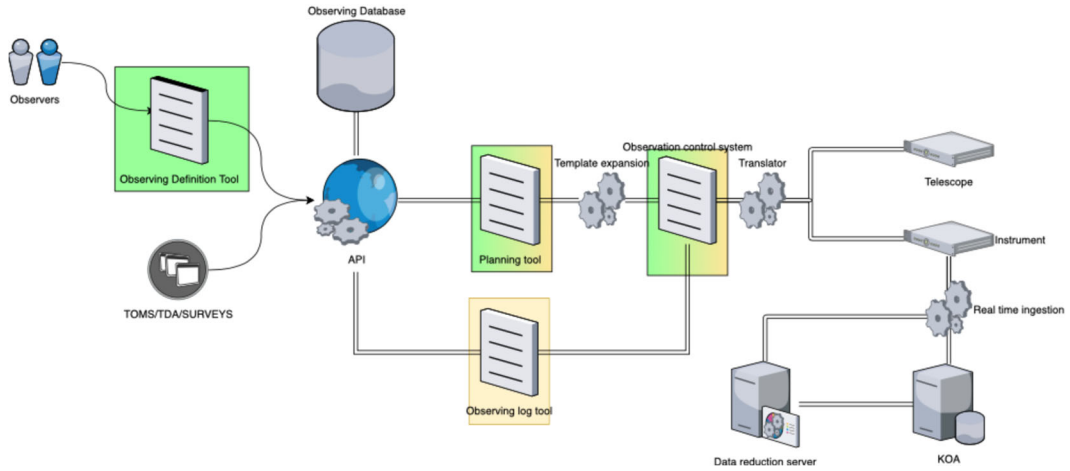

Figure 2: Architecture of the DDOI and interfaces

DDOI will contain an observing database that users can interact with through a set of APIs to create observing plans, observing logs, and observing 'templates' that can be modified in real-time to maintain the classical nature of observations at Keck. The database also manages time allocations for observations triggered as Target of Opportunity (such as gravitational wave EM follow-up observations) or as part of cadence programs (such as precision radial velocity surveys of stars for exoplanet characterization). A critical component of DDOI is automatic and dynamic scheduling of calibrations. Observers can specify the state of an instrument in the planning tool, and the calibration tool will create a set of standardized calibrations for that instrument state. Observers will maintain the flexibility to expand upon these calibrations, but the system will guarantee (within the bounds of instrument+telescope availability prior to sunset or after sunrise) that all instrument configurations used to obtain data in a night have the requisite calibrations to be pipeline processed. WMKO Staff Astronomers will work with the observing community and pipeline development teams to determine these requisite calibrations.

The DSI: Progress in the Last Year

The last year has been foundational for DSI across each of the branches. Four data reduction pipelines are now in nightly service pushing data in near real time to astronomers on the KOA. These instruments include KCWI (an optical wavelength integral field spectrograph), MOSFIRE (an infrared multi-object spectrograph), DEIMOS (an optical wavelength multi-object spectrograph), and KPF (an ultra-precise optical spectrograph for exoplanet characterization). Instead of waiting until after an observing run is complete, astronomers using these four instruments are gaining access to science-grade data during the night and can often change their observing strategy on the fly as a result. An example is shown in Figure 3, which shows the flow of data acquisition, data reduction, and archive ingestion across a night's

[1] Please see the design reference documentation for DDOI here: https://docs.google.com/document/d/1pHaW-5fe4UfkooISmUTvCrbLo0GmS2YvMicyn6dRdNE/edit

observing with KCWI. This flow has only been possible due to work on the data reduction pipelines AND the real-time ingestion software developed at WMKO under DSI in 2022.

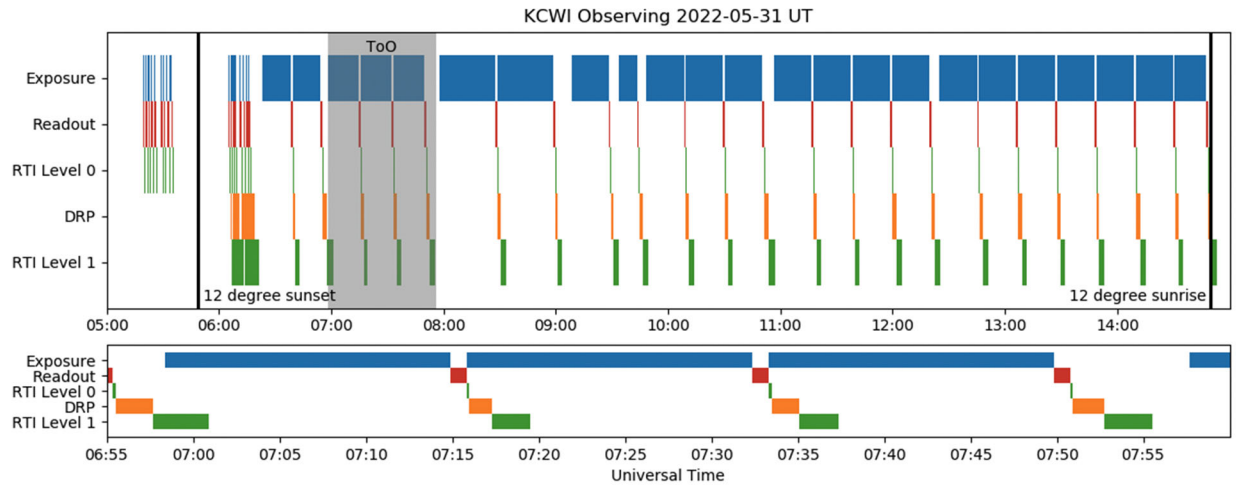

Figure 3: A night observing with KCWI showing data acquisition (blue), ingestion in real time at the archive (green) and data reduction (orange)

Additionally, significant work has been made to improve the observer portal, shown in Figure 4, and the DDOI system which underpins all DSI. In the coming months, the DDOI system, which already runs the KPF instrument at the *execute* level, will be deployed fully end-to-end on the NIRES instrument, complete with a new DRP interface for real time ingestion. This end-to-end demonstration will be a major milestone for the project and will serve as the template for other instruments under DSI at WMKO.

Figure 4: New Observer's Portal interface

Note: Report created by Keck Observatory Deputy-Director and Chief Scientist Dr. John O'Meara.