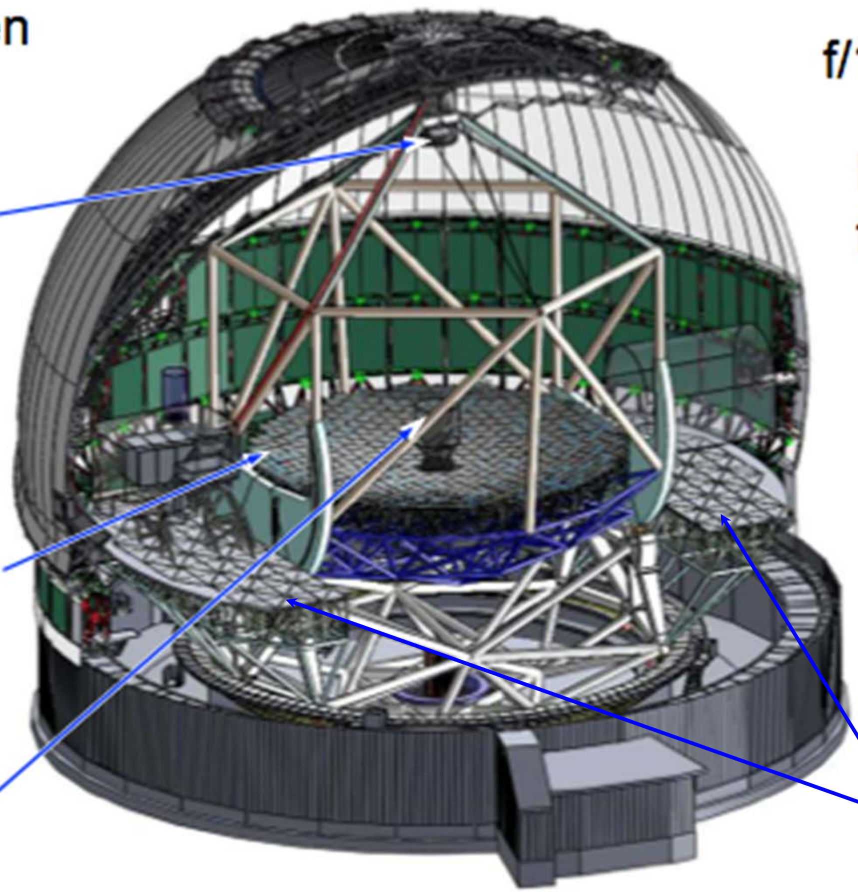
Thirty Meter Telescope Observatory Software Architecture

Kim Gillies, Corinne Boyer
Thirty Meter Telescope

THIRTY METER TELESCOPE

TMT Optical Design Key Facts



Ritchey-Chrétien optical design

3.1m convex hyperboloidal secondary mirror

30m hyperboloidal f/1 primary mirror w/ 492 segments

Flat 2.5m x 3.5m tertiary mirror

f/15 final focal ratio

Focal surface 20m from tertiary mirror

20 arcmin field of view 2.62 m diameter

Field curvature radius 3.01 m

2 Nasmyth platforms hold instruments

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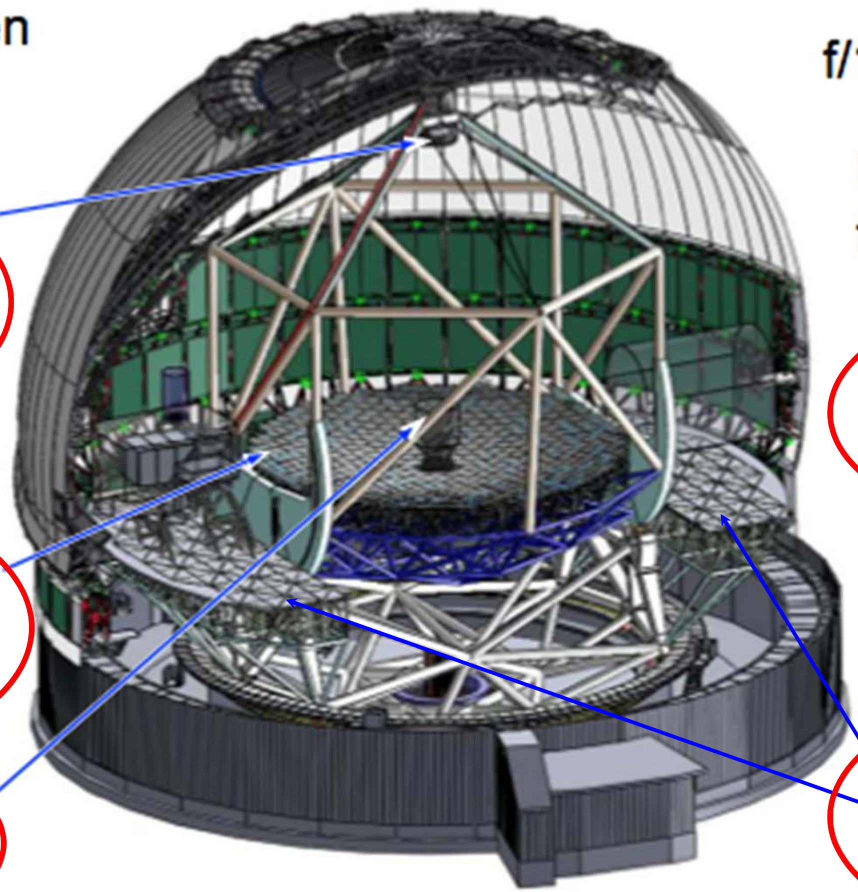

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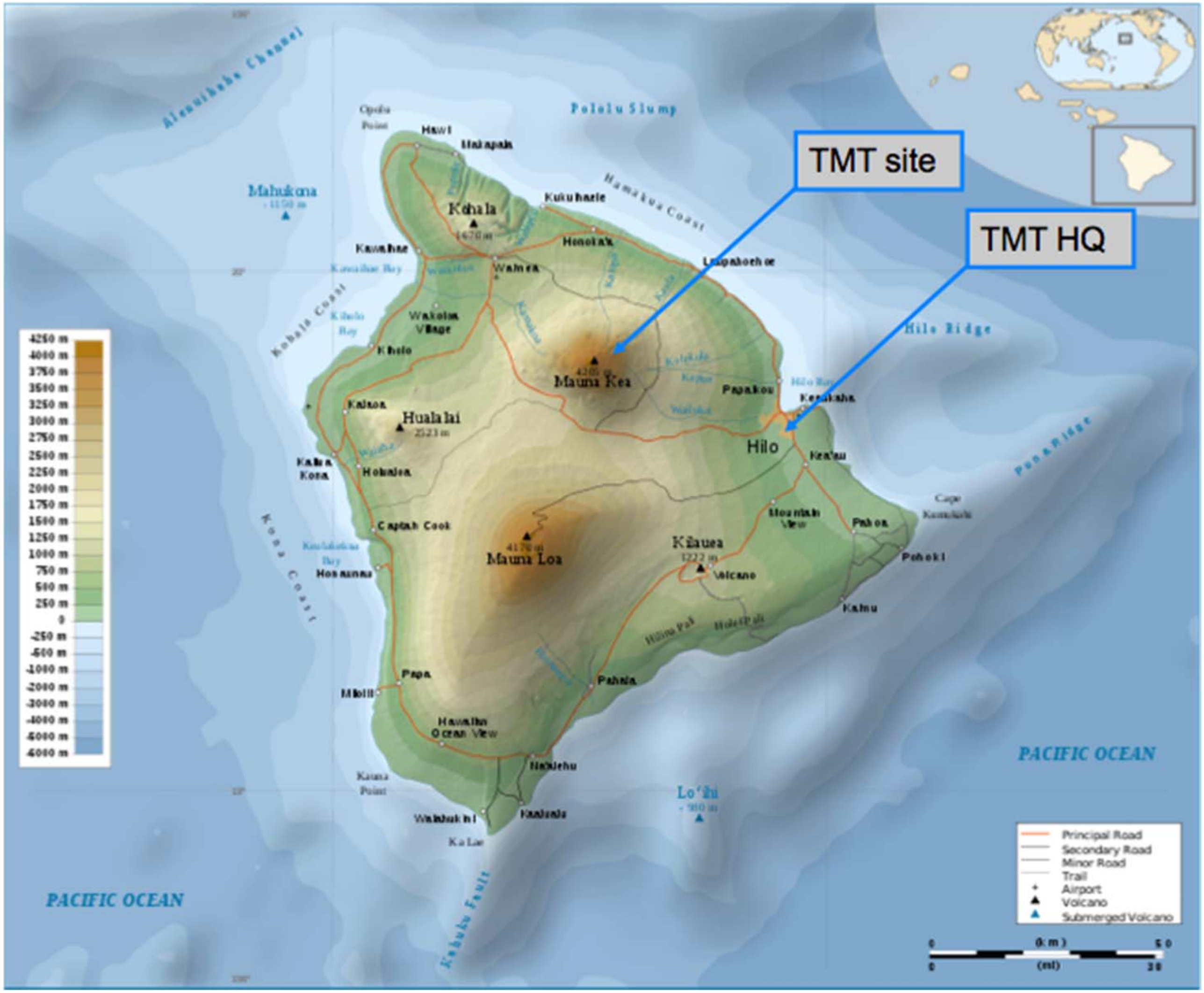
Where is TMT?



TMT site
TMT HQ
Mauna Kea
Mauna Loa
Hualalai
Kilauea
Kohala
Hilo
PACIFIC OCEAN
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Operations Plan

End-to-End Science Data Flow

The Observatory Requirements Document (PDF)

The Observatory Requirements Document (ORD) contains the highest level system requirements for the observatory. Top level requirements are defined for the telescope and instrumentation, summit and support facilities, environmental health and safety, and high level software. The ORD also defines site specific environmental parameters and constraints.

Editors: G. Angeli, S. Roberts
Last update: May, 2011

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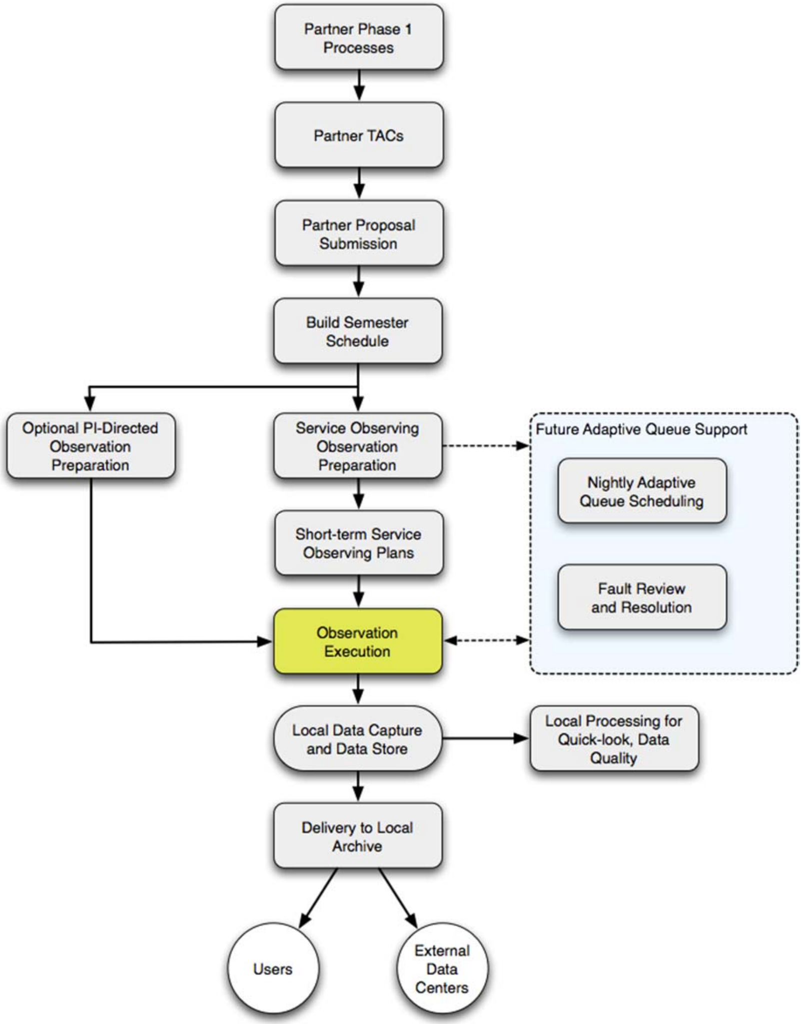

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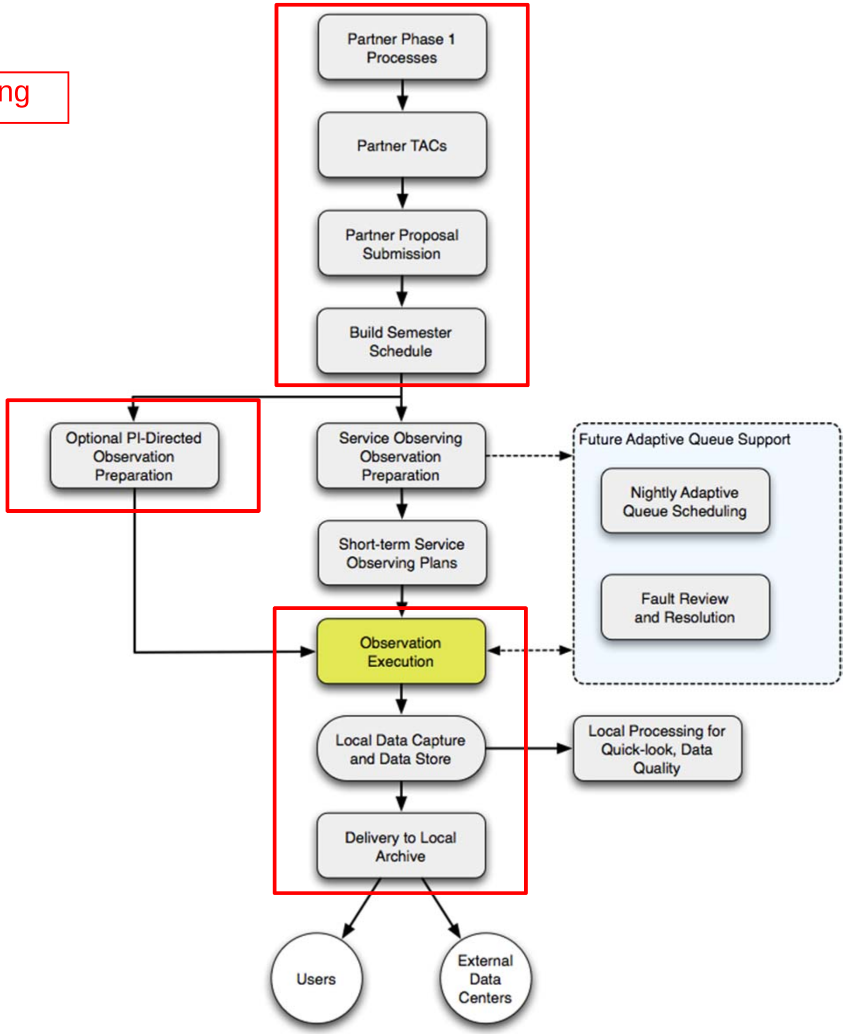
PI-Directed Observing



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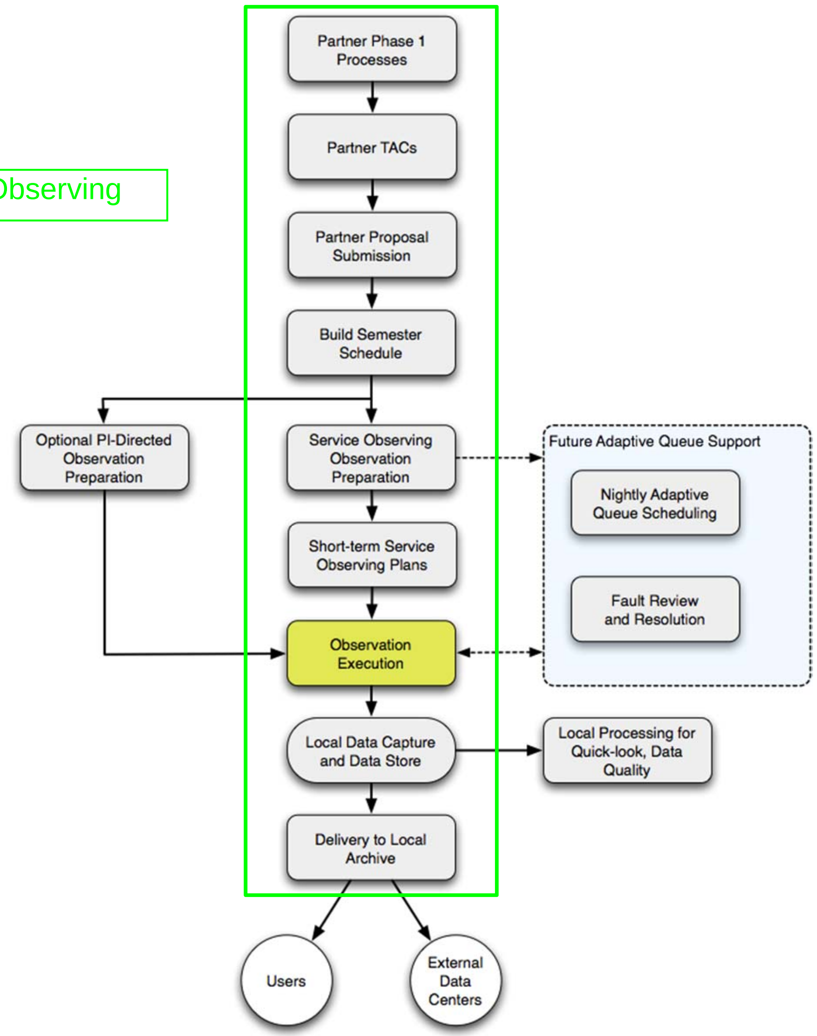
Pre-planned Service Observing



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What is TMT Observatory Software?

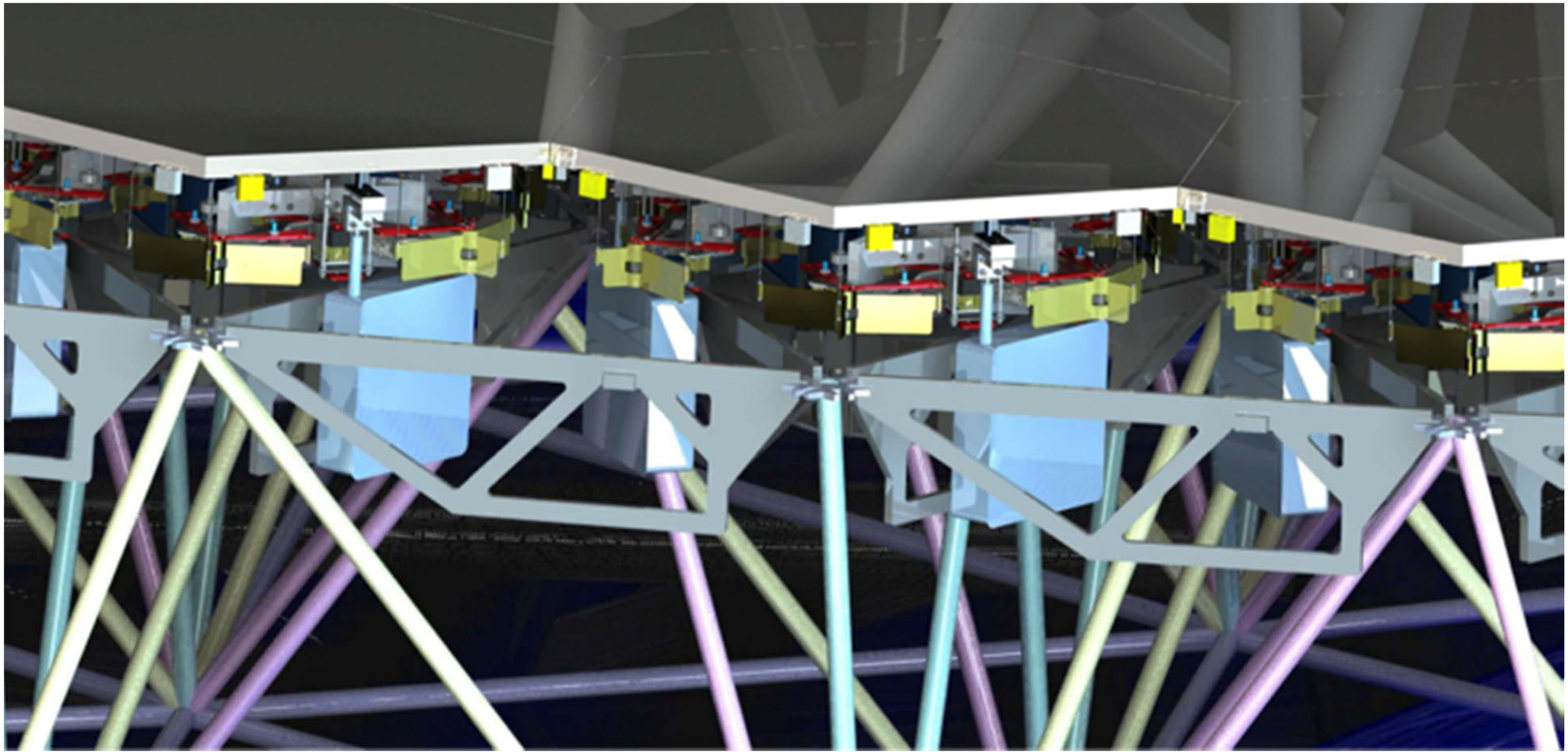
1. Software architecture for large observatories has converged around a few common ideas and solutions.

2 Reuse known solutions for the low risk areas and focus on aspects unique to TMT.

3 Improve where operations experience with solutions has shown problems or areas for improvement.

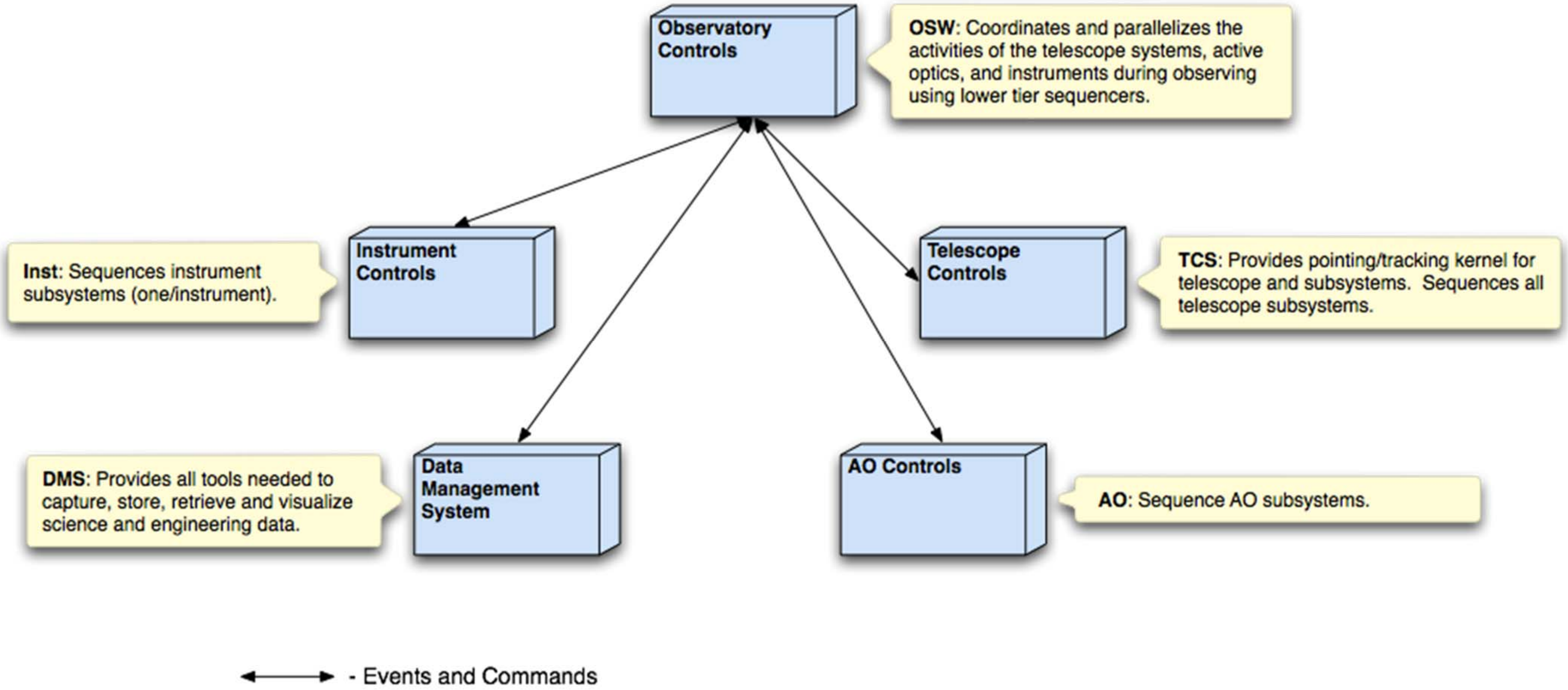
4 Some aspects of TMT software complexity scale with aperture size, but a lot of 8m software works fine.

M1 Control System Complexity Scales with Aperture Size

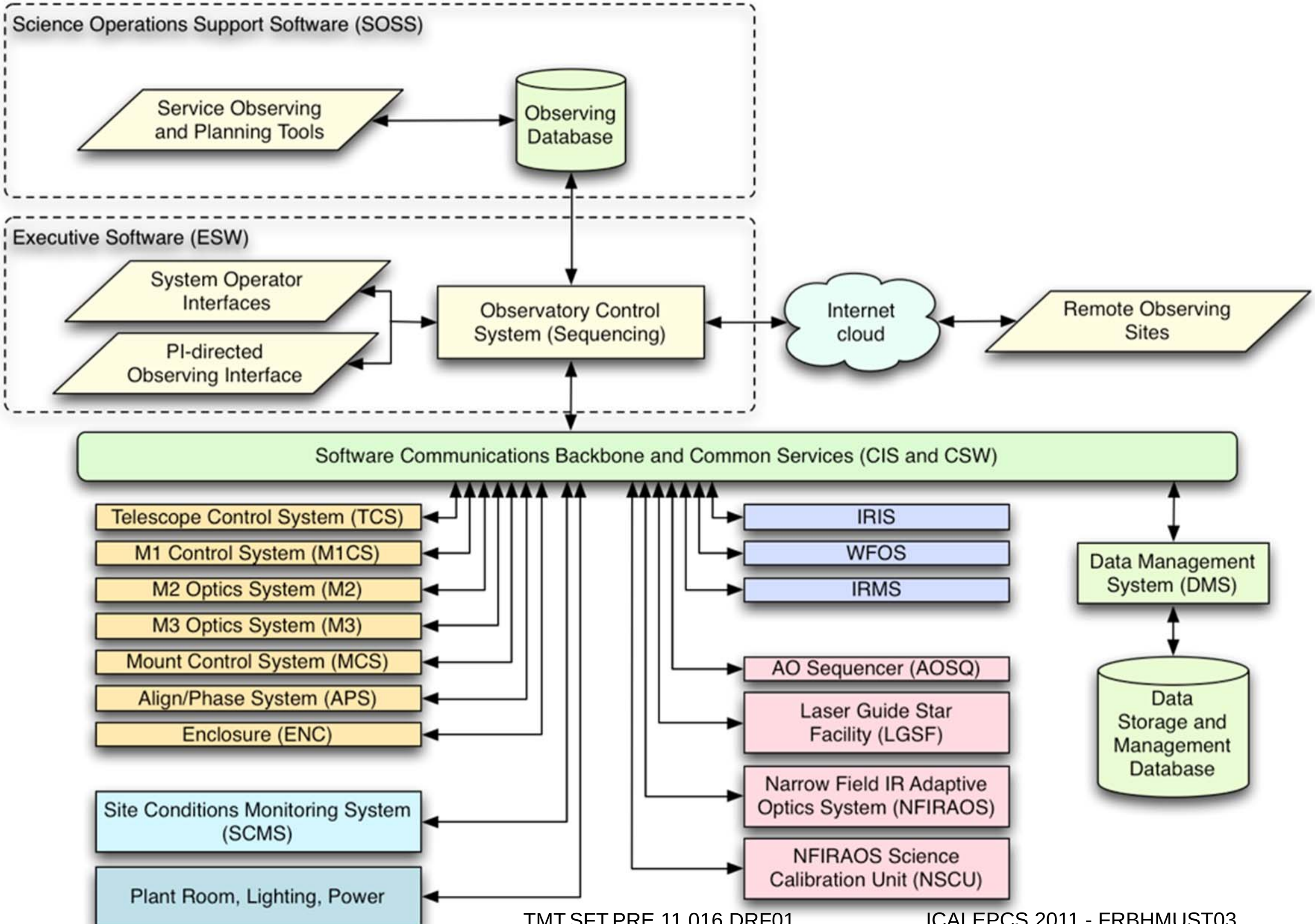


Courtesy: M. Sirota - See M0MK5023

Principal Software Systems



Decomposing into TMT Subsystems



Areas for Improvement

Table 1: Architecture Challenges

Challenge	Description
Acquisition	There are demanding requirements on the system performance and coordination for target acquisition and observation setup.
Composition challenges	Some components must be used in a variety of situations or composed in different ways to support different applications. For instance, the MOBIE wavefront sensors must act as part of MOBIE but also work as part of the phasing system.
Wavefront measurement	Wavefront measurement functionality and hardware is potentially spread throughout telescope systems and instruments making it a challenge to cleanly decompose the system and software. This was a problem with 8m class telescopes as well.
Distributed development	Multiple, distributed, international partners provides a new level of software construction and management complexity.
Operations maintenance	The long lifetime of TMT requires an architecture that can be enhanced and modified without impacting the operations system.

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Architecture must allow flexible integration and construction of components

software qualities

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Observing Mode Oriented Architecture (OMO)

An observing mode is a well-defined observing task and an associated set of owned resources, procedures, and capabilities.

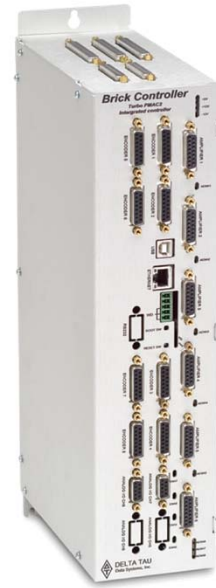
Observing Mode Example: infra-red diffraction-limited multi-filter integral field spectroscopy

Run as little software as is necessary to execute an observation using a single observing mode.

Eliminate waste code associated with subsystem implementation integration.

Hardware Trends

- The last decade has seen more and more hardware device controllers migrate to network.
- Industrial Ethernet-based fieldbus has become common and well-supported.
- More and more power and capabilities exist in PLC and PAC systems and their programming.



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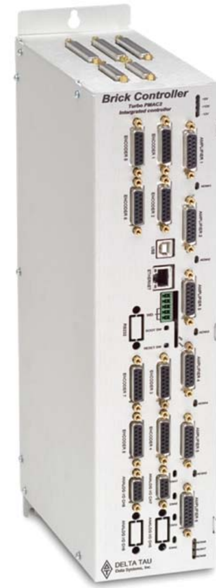
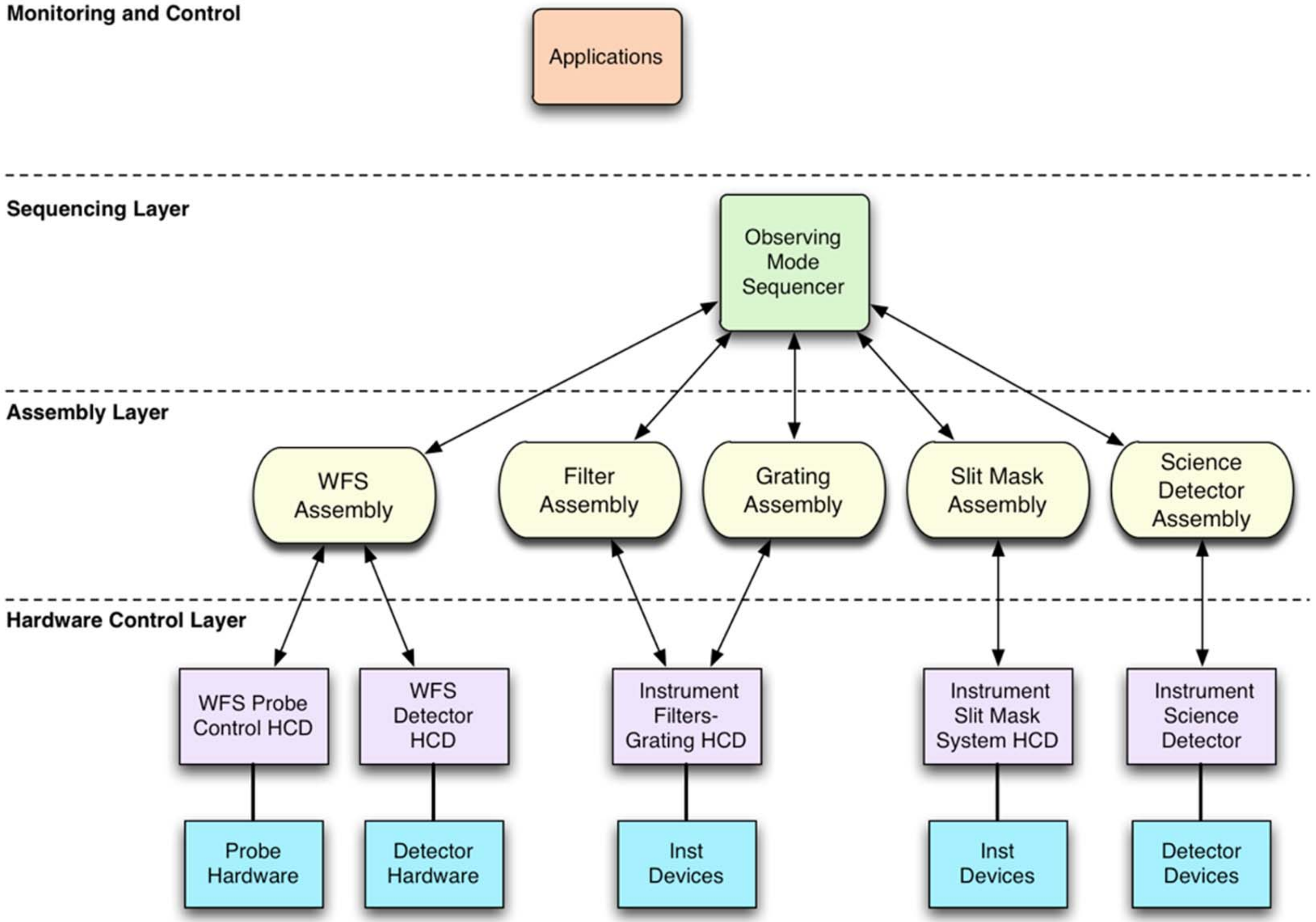


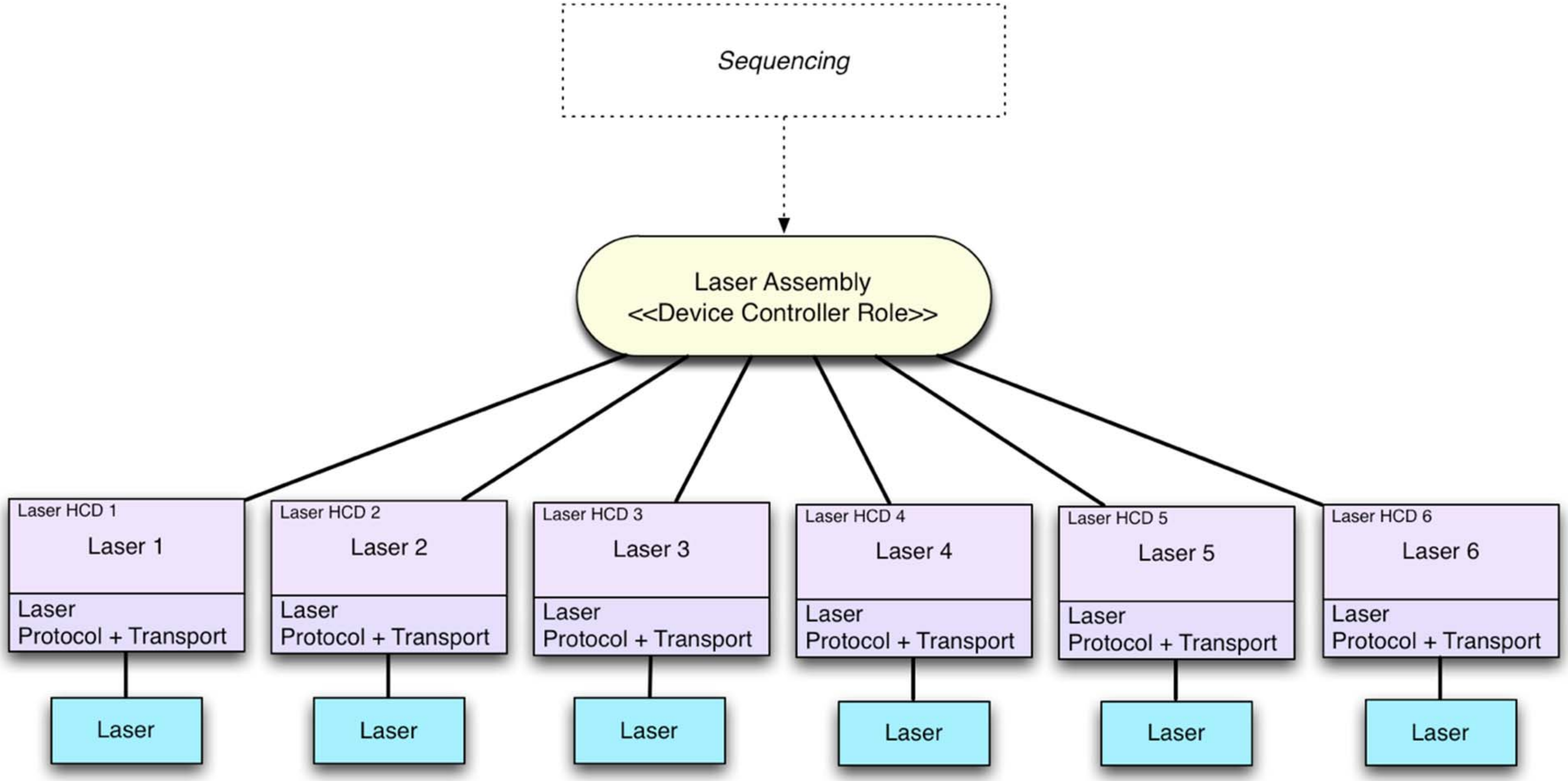
TMT will support networked device control via dedicated controllers or PAC/PLC.

Plan is to set standards.

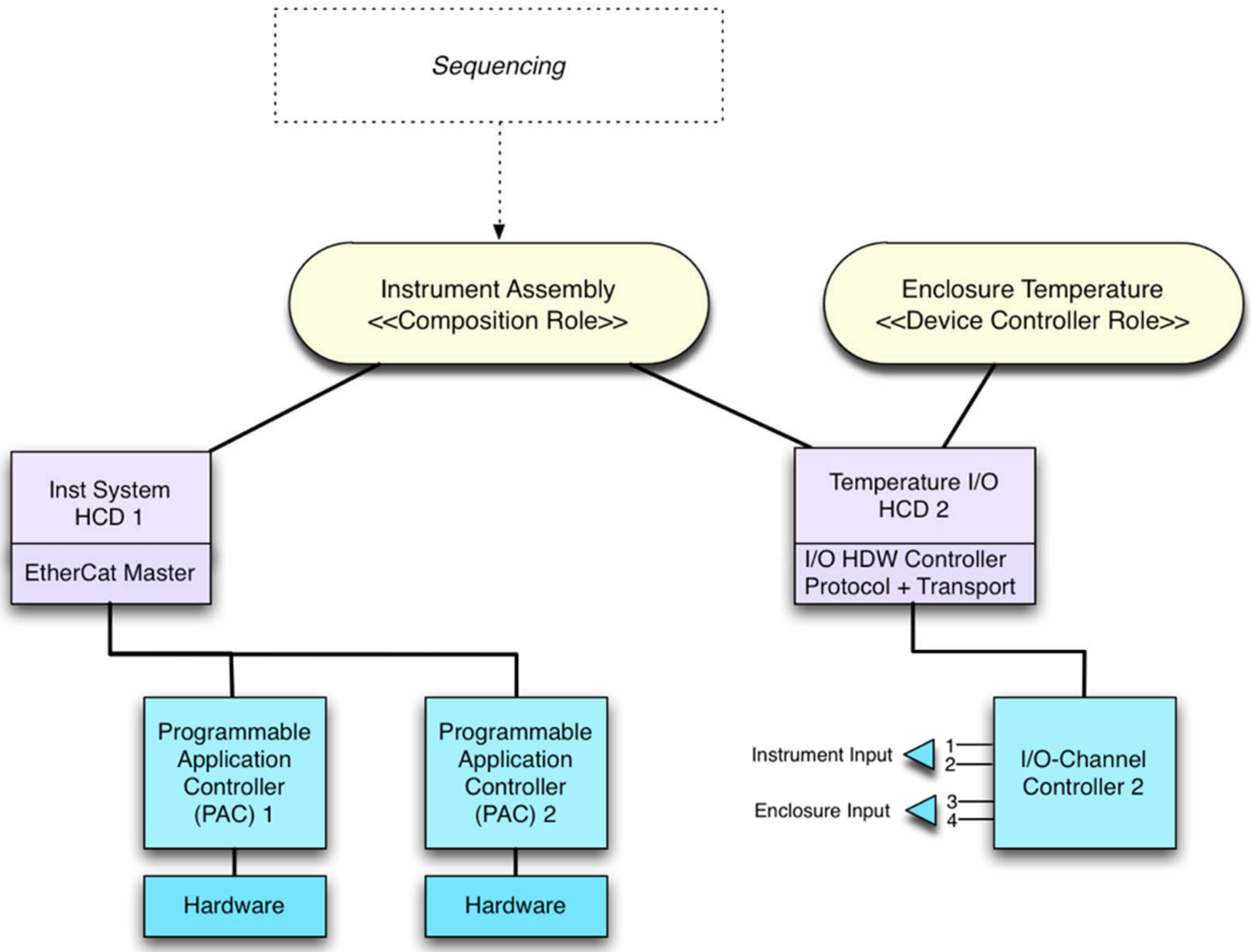
OMOA Structure View



Assembly Example: Device Controller Role

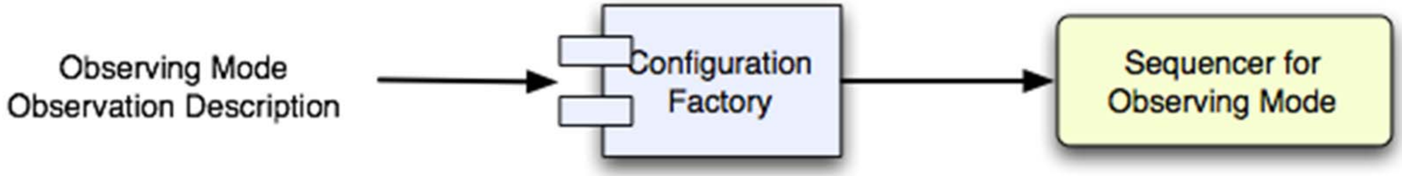


Assembly Example: Composition



Sequence Layer

- Sequencer is dynamically created for each observing mode



- Software and hardware can be optimally grouped and controlled for each observing mode
- Overall sequencer can consist of multiple focused component sequencers for reuse

Technical and Functional Architecture*

Technical and Functional Architecture*

Technical Architecture and Design → Software concepts and infrastructure that provide the foundation for the software system and enables the functional architecture

Functional Architecture and Design → Software concepts, components, and applications that enable the activities of the Observatory from the point of view of the users.

*Adopted from ALMA/ACS and ATST, others

TMT Common Software

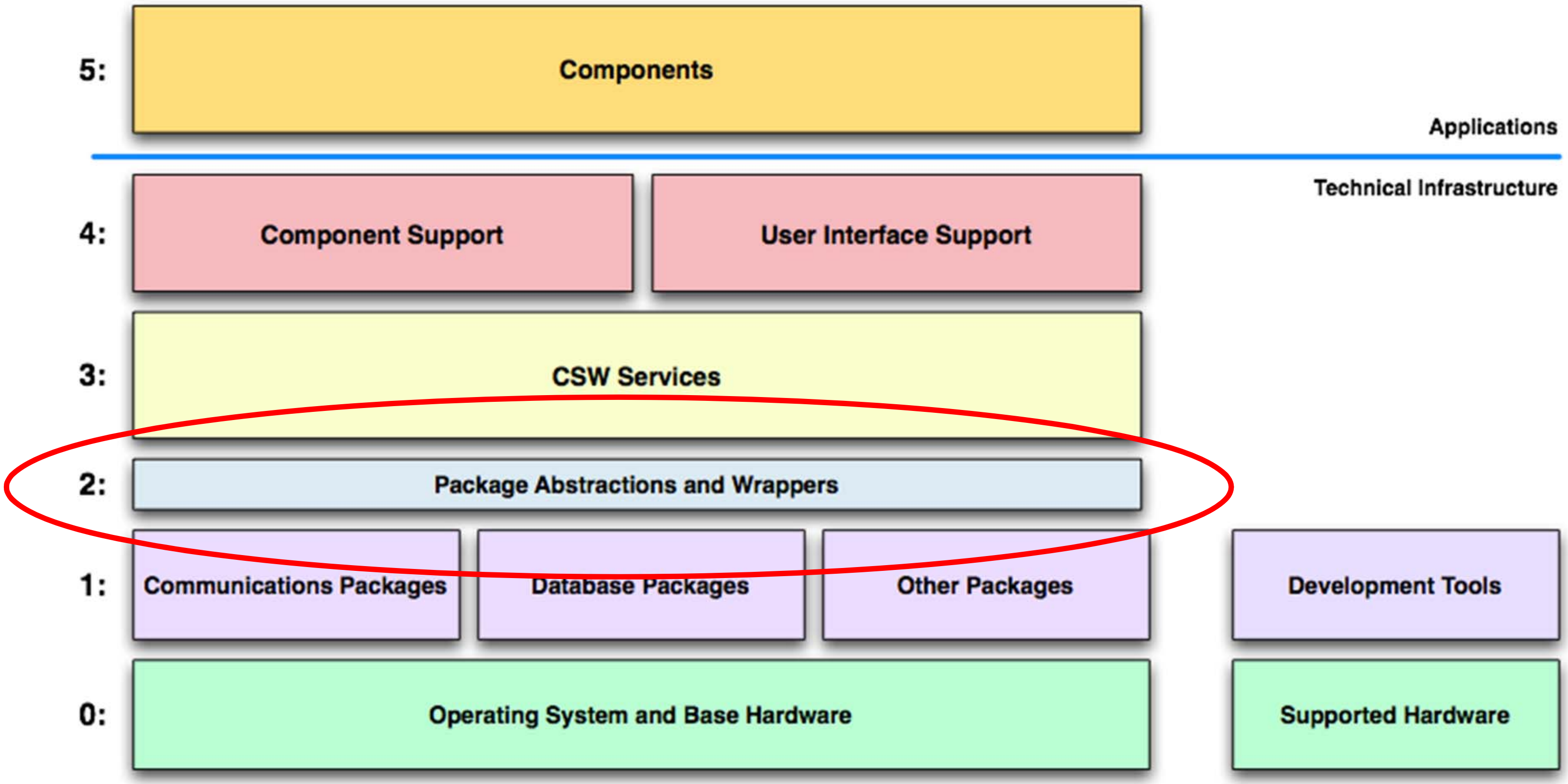
- The integration of these software components requires software infrastructure that is outside the scope of the individual components themselves.
- TMT Common Software is the implementation of the technical architecture.
- Common Software is a collection of software and services.
- A service is a set of related software functionality together with behavior and the policies that control its usage.
- The idea of shared software infrastructure based on a set of services and associated software focused on integration is a successful strategy in large observatory software architecture

Common Software Integration Services

Service	Task
User single sign on	Centrally manage user authentication/access control
Commands	Support for subscribing to, receiving, sending, and completing commands in the form of configurations
Location/connection	Locate and connect to components within the distributed system
Events/Telemetry	Enable telemetry/event publishing/subscription
Alarm/Health	Support monitoring and publishing component alarm and health signals
Configuration	Manage system and component configuration changes
Logging	Capture/store logging information
ODB Access	Common access to Observing Database(s)
Time	Standards-based, precision time access

A shared software common infrastructure can potentially reduce cost of development, integration, and long-term maintenance.

TMT Software Stack



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Event Service Options

- Base on COTS or Open Source Products and Standards.
- 100K or more events/second.

Product	Description
XMMP	Extensible Messaging and Presence Protocol (http://xmpp.org). Basis of instant messaging. IETF Standards. Many open-source and commercial implementations.
Apache Kafka	High-throughput distributed publish-subscribe messaging system. http://incubator.apache.org/kafka/index.html
AKKA	Scala-based platform for next generation event-driven, scalable, fault-tolerant architectures on the JVM. http://akka.io
DDS	Open Management Group DDS standard (http://www.omg.org/spec/DDS/1.2). RTI company sells this product. In use or proposed for similar role in VLT, EELT, ATST, and LSST. http://rti.com
AMPQ	Advanced Message Queuing Protocol (http://www.ampq.org). RabbitMQ is one open source implementation (http://www.rabbitmq.com/). Several other open and COTS products exist.
0mq	High-performance, low-level messaging library supporting a variety of message patterns (http://www.zeromq.org). Multi-language support.

- Starting partner project to evaluate event service options.

More Choices and Options

Product	Description
Time Service	Selected IEEE-1588-2008 - Precision Time Protocol - many vendors
Configuration Service	Front-end to git or subversion or other version control system for configuration file history and initial values.
Logging Service	Numerous logging systems are available
Single sign-on Service	Atlassian Crowd or plain ol'LDAP.
Commands	Configuration-based, command-action, HTTP, akka, others.
Container	OSGi

- Plan is to use Scala and JVM-based languages.
- Reviewing ATST CS and EPICS for use in TMT.
- Linux is inevitable, version is TBD.

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Conclusion

- TMT construction is scheduled to start in 2014.
- First light with 492 segments is scheduled for 2021.
- TMT technical architecture is to be set by next year.

Thank-you for listening!

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