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Pathways to US Instrumentation

Scot Kleinman
Astromanager LLC

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Image courtesy of Amagi Observatory (天城天文台)

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Who am I?

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Who am I?

BASKIN-ROBBINS ICE CREAM

Skyles Electric Works

SUBARU TELESCOPE
National Astronomical Observatory of Japan

PVSD

orbisphere

HARVEY MUDD COLLEGE 1955

NASA

Kepler

GEMINI OBSERVATORY

TEXAS
The University of Texas at Austin

UNIVERSITY OF HAWAI'I AT MĀNOA
SHIDLER
COLLEGE OF BUSINESS

WET
Whole Earth Telescope

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SDSS

CFH

TMT INTERNATIONAL OBSERVATORY

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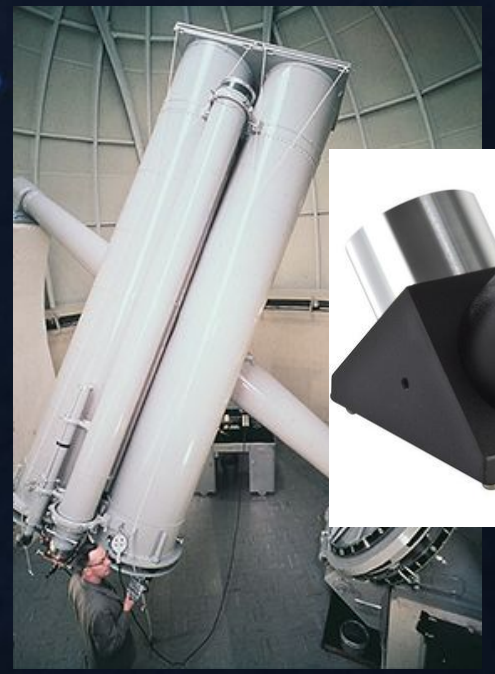
My start in astronomy instrumentation

NASA Kepler



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Phatphot

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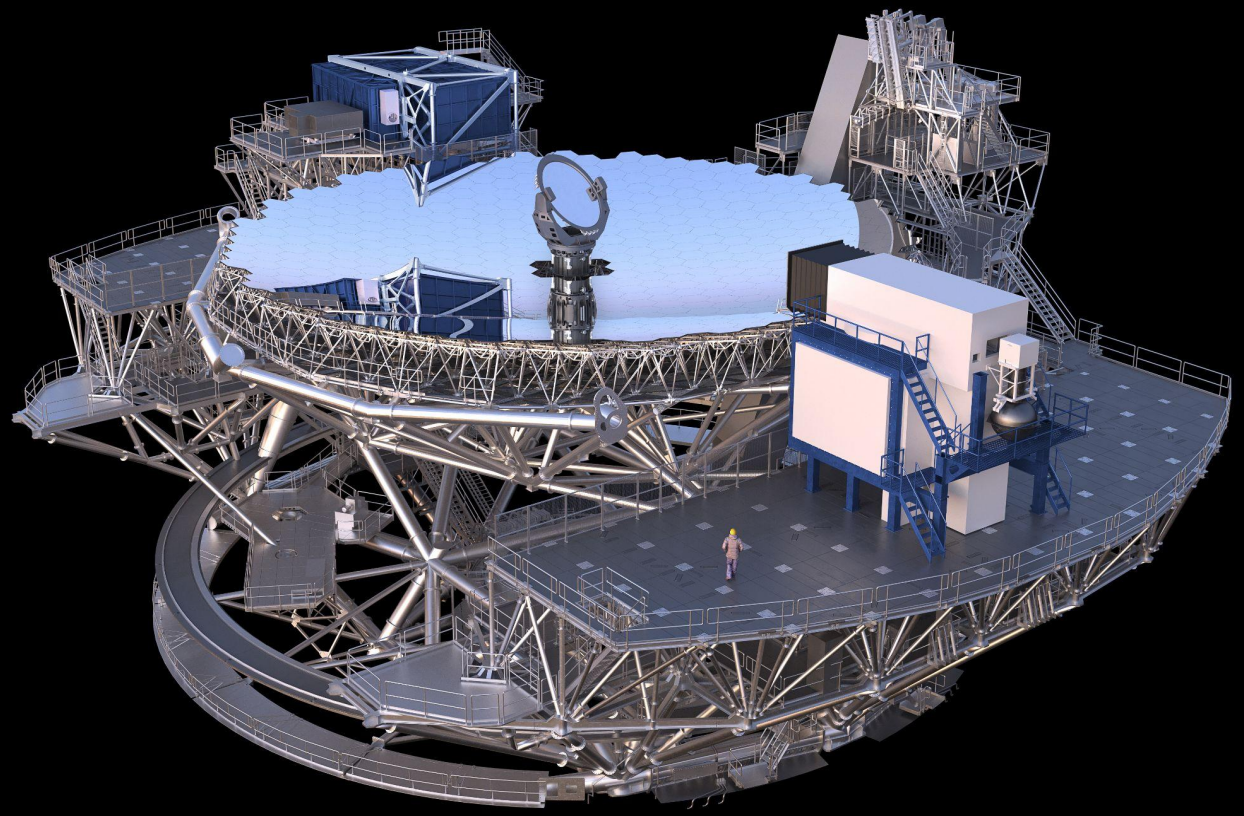
My current instrumentation

TMT WFOS



CFHT
Pathfinder-IFU
1000 fiber 31”x31” optical IFU

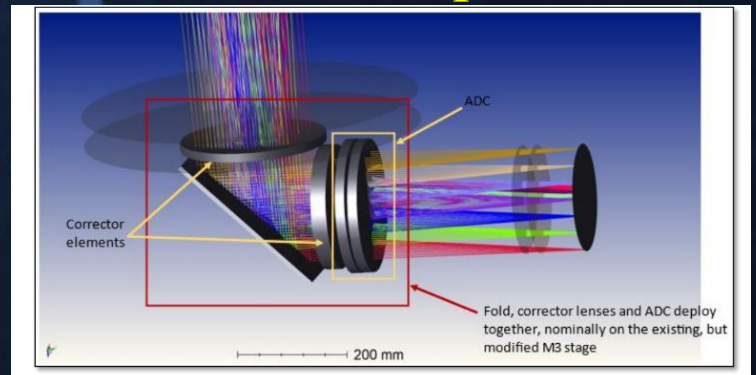
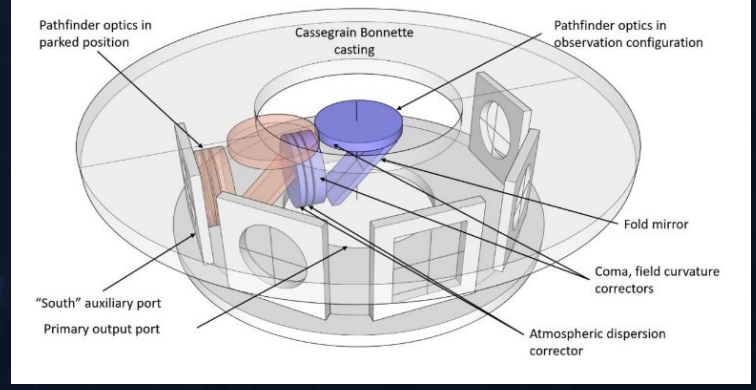


Figure 7-14 Optical path through the Cassegrain fold mirror to the IFU



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Astromanager Instrument scales…

Phatphot

- Motivated by a specific observational challenge
- One graduate student; one machinist
- Prior experience: rebuilding a VW engine
- Requirements: Schnock
- Review process: Thesis adviser
- No budget, no schedule, no plan
- Cost: ~$15k USD

SCORPIO

- Motivated to fill a strategic, scientific mandate
- Involves 6+ institutions
- Prior experience: many ground-based and spaced-based instruments
- Extensive requirements flowdown
- 6 formal reviews + numerous internal and peer reviews
- 292 pages of contract documents
- Fixed schedule: Working by start of LSST
- $15M contract + ~20% “complexity”

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WFOS ~$95M

Astromanager Instrument motivation

The standard model

1. Start with a scientific question
2. Figure out what observations you need to answer it
3. Derive requirements for an instrument to make those observations
4. See if one already exists you have access to
5. If not, build one

Reality

1. Identify some cool new technology
2. Figure out a way to use it for your science
3. Identify the specs for the major accompanying technology and calculate what the instrument can do
4. Figure out what part of your science you can do with such an instrument
5. Find someone willing to fund your instrument
6. Derive requirements consistent with the funder's requests, your science, and the technology you found

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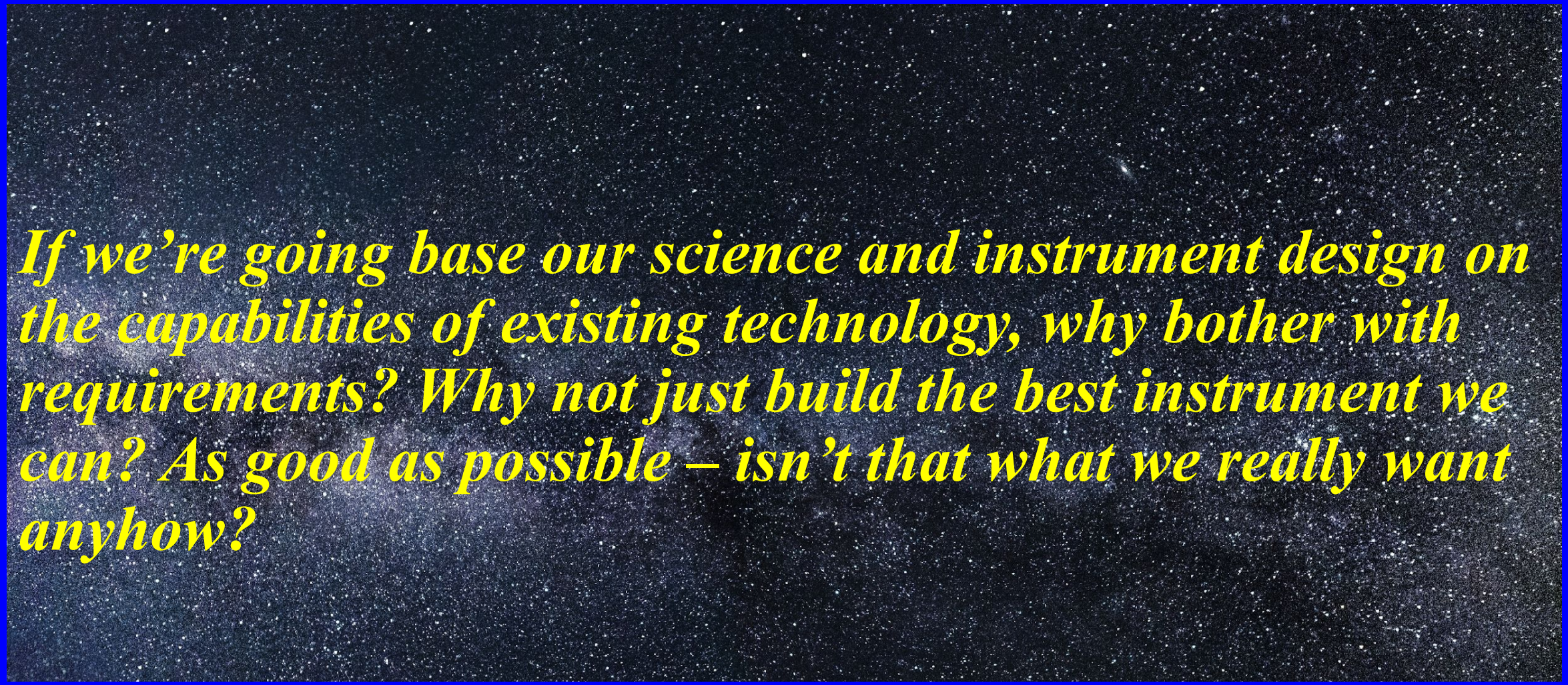
Why not just build the best you can?



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Why not just build the best you can?

- How do you know when you're done?
- Impossible to control cost and schedule.
- What if as good as possible in one area means a little less than possible in another? How do you decide?
- There are always trades to be made in one capability versus another. If you don't have a consistent way to make those trades, you end up with an instrument that does nothing well.

*An instrument designed to do **something** well, usually does something **else** well, too.*

An instrument designed to do nothing well, usually ends up doing nothing well.

Astromanager Requirements

- A requirement is a statement of one thing a product must do or a quality it must have.
- Requirements flow from higher and to lower-level requirements.
- Requirements are testable.

Requirement flow is important:

1. To understand the impact of changing one thing here on something over there (and on your top-level objectives and science cases)
2. To provide a series of tests to catch problems at their earliest catchable time (ex. when a lens comes back from a vendor versus when the camera is assembled into the instrument and tested on sky)

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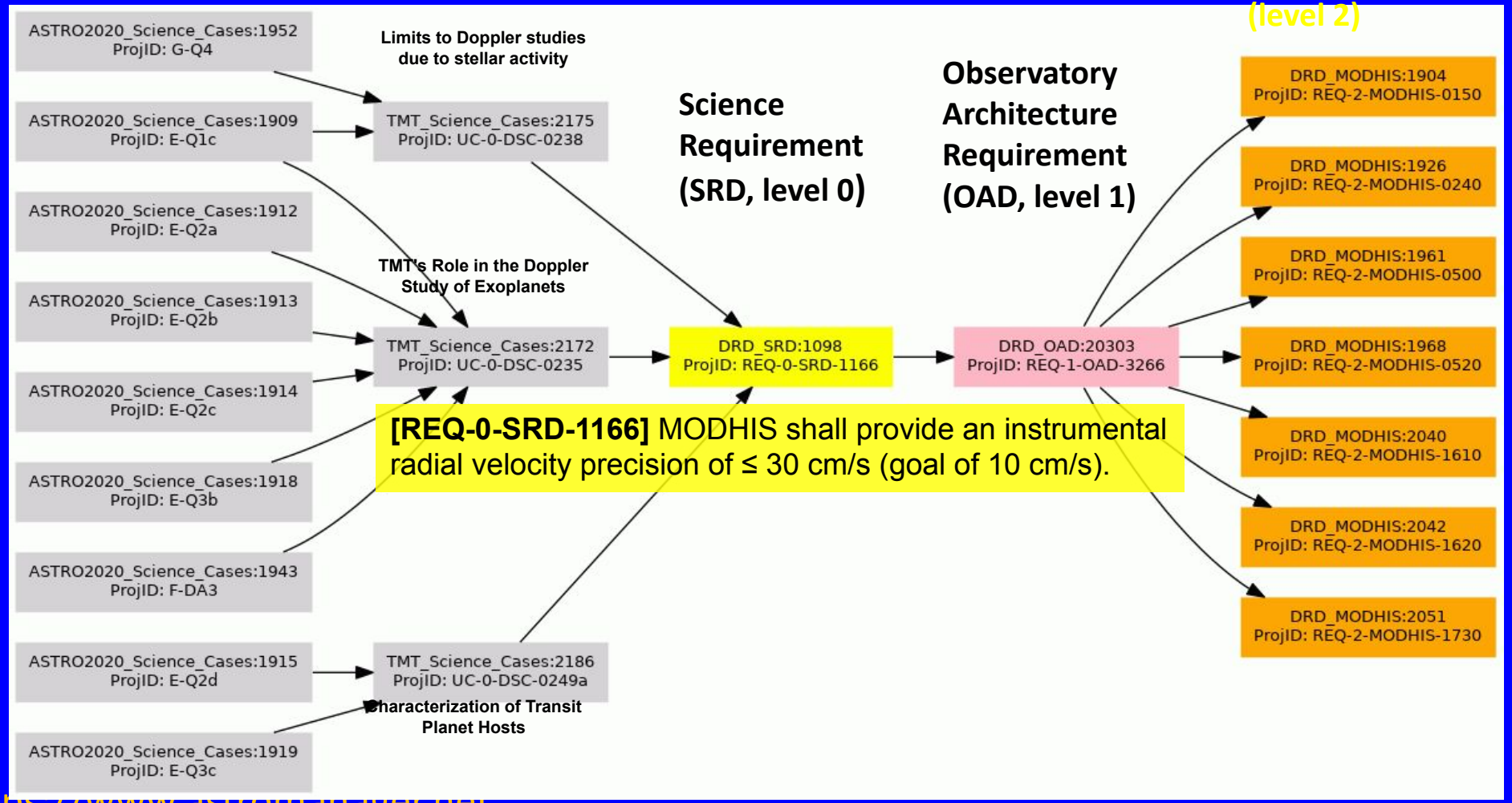
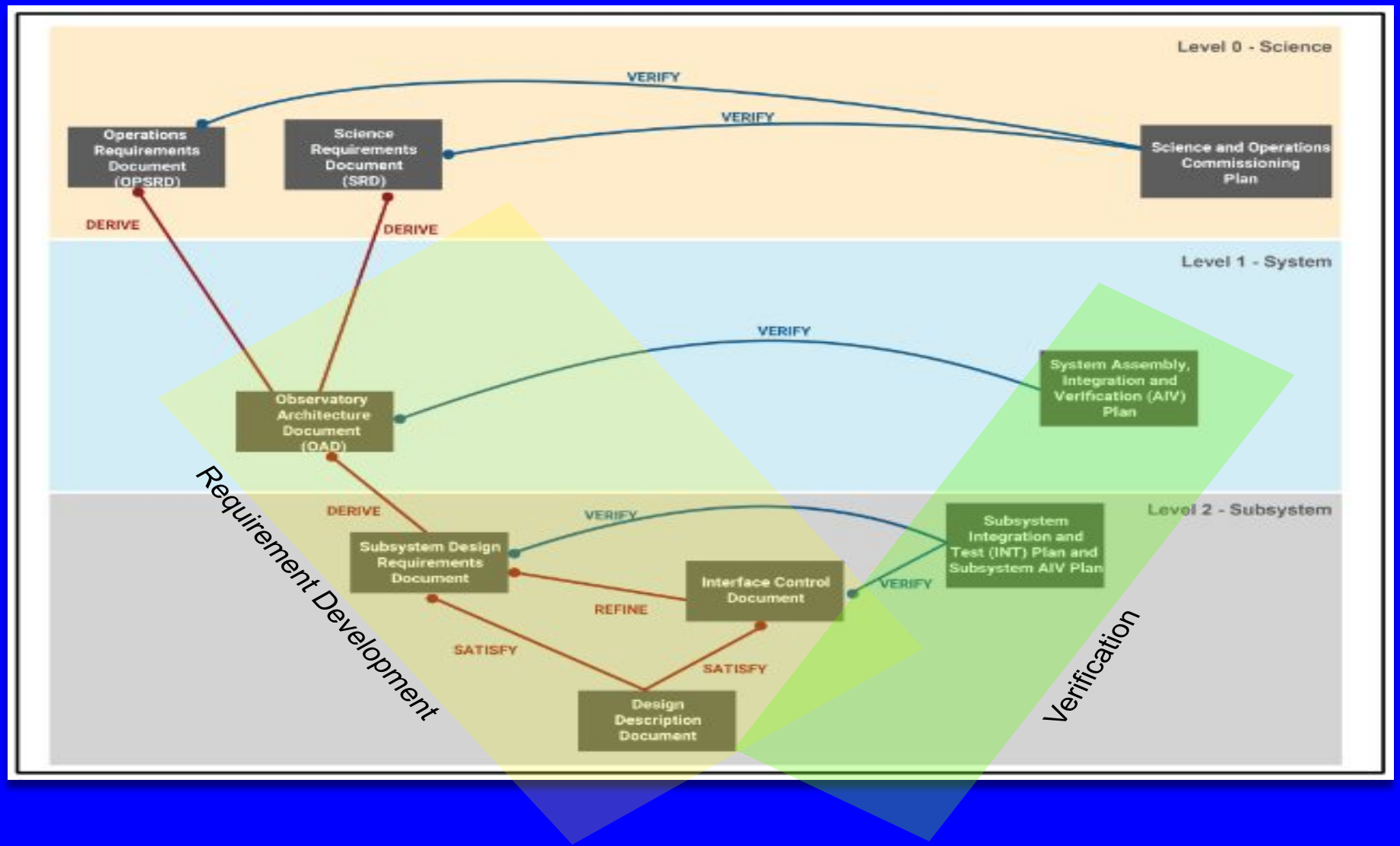
TMT MODHIS: Requirement Traceability Example



- Spectral pixel sampling.
- PRV mode.
- Systematic errors.
- Spectral stability.
- Temperature control.
- Vibration isolation.
- CAL Source brightness.

Astromanager Requirements & Verification



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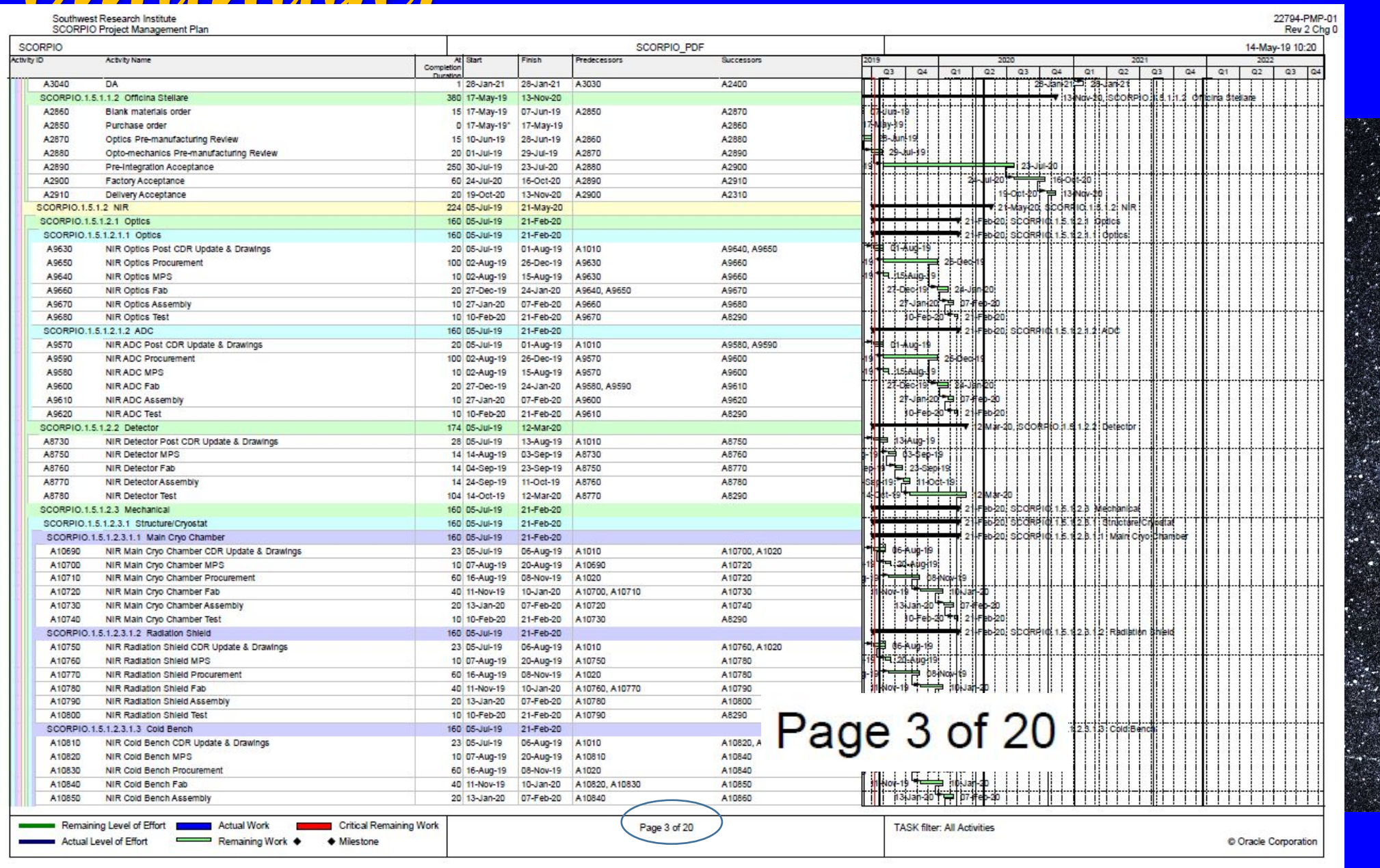
Astromanager This is not project management



Activity ID	Activity Name	At Completion Duration	Start	Finish	Predecessors	Successors
A3040	DA	1	28-Jan-21	28-Jan-21	A3030	A2400
SCORPIO.1.5.1.1.2	Officina Stellare	380	17-May-19	13-Nov-20		
A2860	Blank materials order	15	17-May-19	07-Jun-19	A2850	A2870
A2850	Purchase order	0	17-May-19*	17-May-19		A2860
A2870	Optics Pre-manufacturing Review	15	10-Jun-19	28-Jun-19	A2860	A2880
A2880	Opto-mechanics Pre-manufacturing Review	20	01-Jul-19	29-Jul-19	A2870	A2890
A2890	Pre-Integration Acceptance	250	30-Jul-19	23-Jul-20	A2880	A2900
A2900	Factory Acceptance	60	24-Jul-20	16-Oct-20	A2890	A2910
A2910	Delivery Acceptance	20	19-Oct-20	13-Nov-20	A2900	A2310
SCORPIO.1.5.1.2	NIR	224	05-Jul-19	21-May-20		
SCORPIO.1.5.1.2.1	Optics	160	05-Jul-19	21-Feb-20		
SCORPIO.1.5.1.2.1.1	Optics	160	05-Jul-19	21-Feb-20		
A9630	NIR Optics Post CDR Update & Drawings	20	05-Jul-19	01-Aug-19	A1010	A9640, A9650
A9650	NIR Optics Procurement	100	02-Aug-19	26-Dec-19	A9630	A9660
A9640	NIR Optics MPS	10	02-Aug-19	15-Aug-19	A9630	A9660
A9660	NIR Optics Fab	20	27-Dec-19	24-Jan-20	A9640, A9650	A9670
A9670	NIR Optics Assembly	10	27-Jan-20	07-Feb-20	A9660	A9680
A9680	NIR Optics Test	10	10-Feb-20	21-Feb-20	A9670	A8290
SCORPIO.1.5.1.2.1.2	ADC	160	05-Jul-19	21-Feb-20		
A9570	NIR ADC Post CDR Update & Drawings	20	05-Jul-19	01-Aug-19	A1010	A9580, A9590
A9590	NIR ADC Procurement	100	02-Aug-19	26-Dec-19	A9570	A9600
A9580	NIR ADC MPS	10	02-Aug-19	15-Aug-19	A9570	A9600
A9600	NIR ADC Fab	20	27-Dec-19	24-Jan-20	A9580, A9590	A9610
A9610	NIR ADC Assembly	10	27-Jan-20	07-Feb-20	A9600	A9620
A9620	NIR ADC Test	10	10-Feb-20	21-Feb-20	A9610	A8290
SCORPIO.1.5.1.2.2	Detector	174	05-Jul-19	12-Mar-20		
A8730	NIR Detector Post CDR Update & Drawings	28	05-Jul-19	13-Aug-19	A1010	A8750
A8750	NIR Detector MPS	14	14-Aug-19	03-Sep-19	A8730	A8760
A8760	NIR Detector Fab	14	04-Sep-19	23-Sep-19	A8750	A8770
A8770	NIR Detector Assembly	14	24-Sep-19	11-Oct-19	A8760	A8780
A8780	NIR Detector Test	104	14-Oct-19	12-Mar-20	A8770	A8290
SCORPIO.1.5.1.2.3	Mechanical	160	05-Jul-19	21-Feb-20		
SCORPIO.1.5.1.2.3.1	Structure/Cryostat	160	05-Jul-19	21-Feb-20		
SCORPIO.1.5.1.2.3.1.1	Main Cryo Chamber	160	05-Jul-19	21-Feb-20		
A10690	NIR Main Cryo Chamber CDR Update & Drawings	23	05-Jul-19	06-Aug-19	A1010	A10700, A1020
A10700	NIR Main Cryo Chamber MPS	10	07-Aug-19	20-Aug-19	A10690	A10720
A10710	NIR Main Cryo Chamber Procurement	60	16-Aug-19	08-Nov-19	A1020	A10720
A10720	NIR Main Cryo Chamber Fab	40	11-Nov-19	10-Jan-20	A10700, A10710	A10730
A10730	NIR Main Cryo Chamber Assembly	20	13-Jan-20	07-Feb-20	A10720	A10740
A10740	NIR Main Cryo Chamber Test	10	10-Feb-20	21-Feb-20	A10730	A8290
SCORPIO.1.5.1.2.3.1.2	Radiation Shield	160	05-Jul-19	21-Feb-20		
A10750	NIR Radiation Shield CDR Update & Drawings	23	05-Jul-19	06-Aug-19	A1010	A10760, A1020
A10760	NIR Radiation Shield MPS	10	07-Aug-19	20-Aug-19	A10750	A10780
A10770	NIR Radiation Shield Procurement	60	16-Aug-19	08-Nov-19	A1020	A10780
A10780	NIR Radiation Shield Fab	40	11-Nov-19	10-Jan-20	A10760, A10770	A10790
A10790	NIR Radiation Shield Assembly	20	13-Jan-20	07-Feb-20	A10780	A10800
A10800	NIR Radiation Shield Test	10	10-Feb-20	21-Feb-20	A10790	A8290
SCORPIO.1.5.1.2.3.1.3	Cold Bench	160	05-Jul-19	21-Feb-20		
A10810	NIR Cold Bench CDR Update & Drawings	23	05-Jul-19	06-Aug-19	A1010	A10820, A
A10820	NIR Cold Bench MPS	10	07-Aug-19	20-Aug-19	A10810	A10840
A10830	NIR Cold Bench Procurement	60	16-Aug-19	08-Nov-19	A1020	A10840
A10840	NIR Cold Bench Fab	40	11-Nov-19	10-Jan-20	A10820, A10830	A10850
A10850	NIR Cold Bench Assembly	20	13-Jan-20	07-Feb-20	A10840	A10860

Astromanager Project management

Cost
Schedule
Scope

For most real projects, it is essentially impossible to fix all three of these.
→ You need priorities and contingencies.
Ability to use scope contingency decreases as the instrument progresses.
→ You should descope early, even when you may have cost contingency available.

Team
Stakeholders

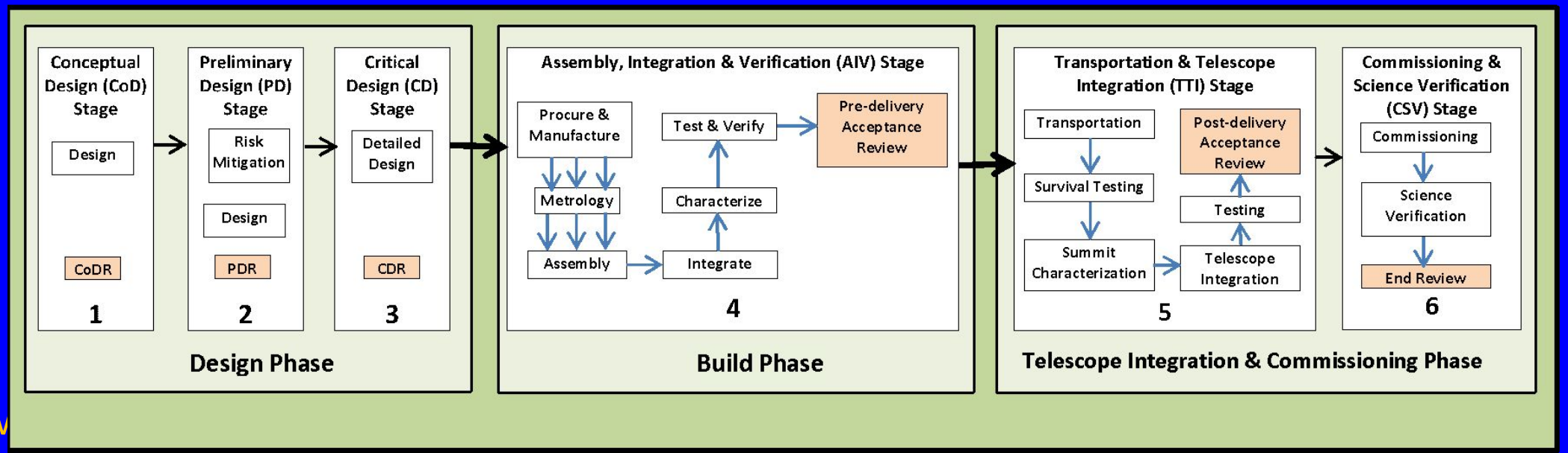
Stakeholders: team, users, funders, vendors, contractors, governance, line management, customers: facility director and support staff, …

Risk

The risk register is a primary tool to convince stakeholders of the need to take action and to ensure you meet the triple constraints.

Astromanager Gemini: The SCORPIO Process

1. Gemini governance wants next instrument to be strategically complementary to LSST +
2. Gemini Science and Technology Advisory Council have their own view on how best to do this
3. Gemini issues RfP for funded feasibility studies for instruments that support #1, stating #2 as a known viable option
4. Gemini receives multiple proposals all supporting #2 and selects 4 to fund
5. Gemini takes results of the 4 studies and issues an RfP for a specific instrument with broad bandwidth imaging and spectroscopy (i.e., #2)
6. After a complicated review process, Gemini selects one team to award the design and build contract
7. After CoD, team trouble reaches a peak and the management structure changes
8. We began PD with a new PI and name



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US Instrumentation options: Universities

Universities with their own telescopes:

- University of Texas
- University of California
- Caltech

- Build instruments for your own use based on scientific interests
- Internal and external funding
- Hard or soft funding

Universities with instrument programs:

- Johns Hopkins
- Princeton
- Texas A&M

- Scientific interest
- Exchange for telescope time
- Response to observatory calls
- Mostly external funding
- Positions generally soft funding

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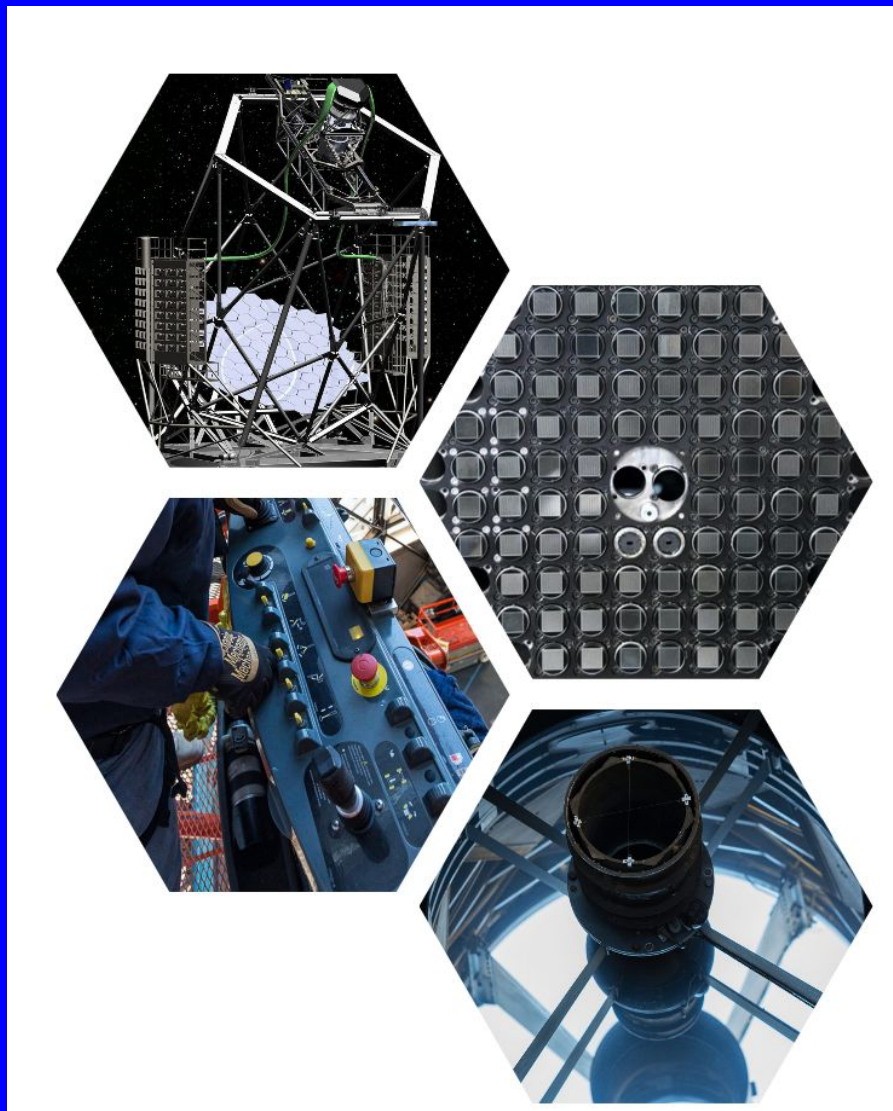
HETDEX

Hobby-Eberly Telescope Dark Energy Experiment



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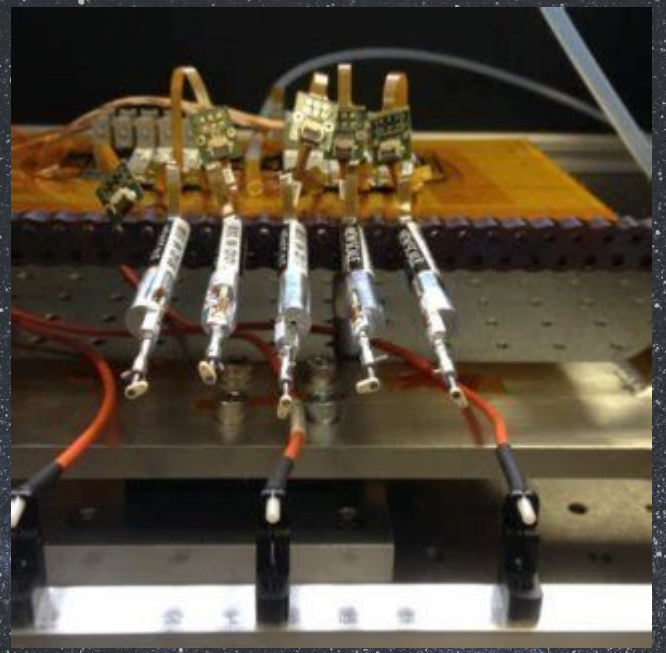
US Instrumentation options: Labs

US Labs with instrumentation:

- JPL
- FermiLab
- Lawrence Berkeley
- SwRI



- NASA originated and funded
- Response to observatory call
- Collaborations with universities and observatories
- Positions often depend on ability to bring in contracts

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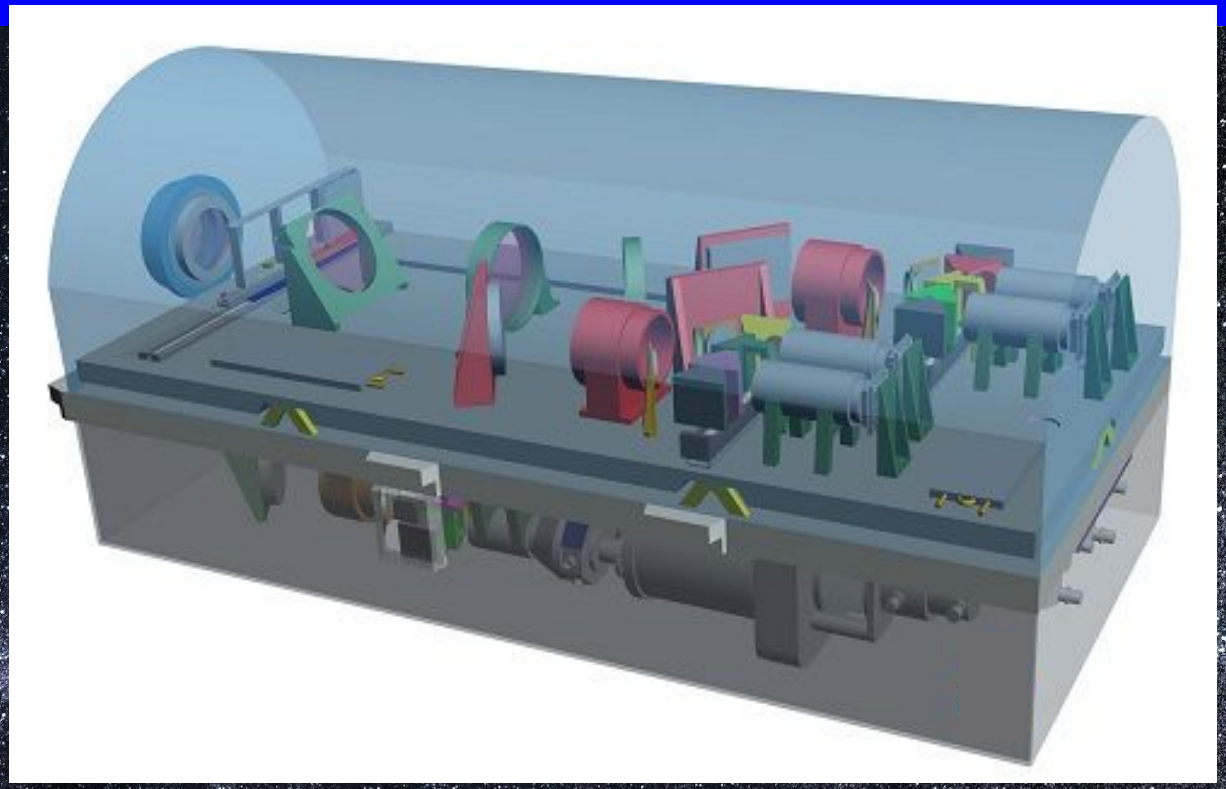
Observatory/Lab/University /Industry Consortium

SCORPIO:

- Initiated by Gemini to be responsive to LSST …
- Stated preference for “wide” field optical to IR imager and spectrograph
- Competitively selected
- Built by a consortium of universities and labs



GEMINI OBSERVATORY

STScI

SwRI

THE GEORGE WASHINGTON UNIVERSITY

Fractal

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US Instrumentation options: Observatories

NOIRLab/Gemini/Kitt Peak/CTIO

Keck, CFHT. LBT, …

GMT, TMT

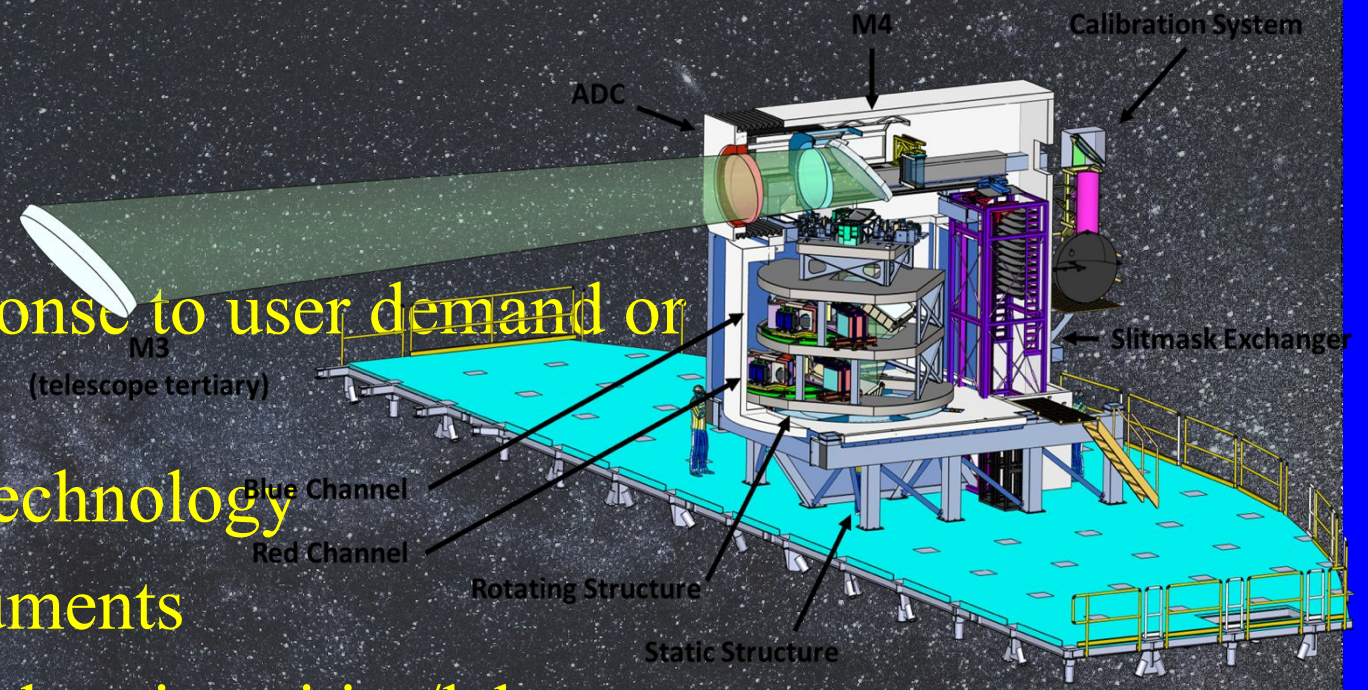
Commission instruments in response to user demand or science case

Upgrade instruments with new technology

Receive/support user-built instruments

Often built via collaborations with universities/labs

Typically hard money positions



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TMT: WFOS

Project Leads

- PI **Chuck Steidel** (CIT)
- PS **Eric Peng** (NOIRLab)
- PM **Scot Kleinman** (TIO)→ **Alastair Heptonstall** (TIO)
- SE **John Miles** (TIO)
- Optical **Jason Fucik** (CIT)
- Mechanical **Reston Nash** (CIT)

(Current) Teams: A well-developed. representative partnership

- Caltech – SSTR, RSTR, SE, PI
- India TMT Coordination Center – Software, Electronics, CAL, GRX, FX, Camera rotator: **Ramya Sethuram, Sivarani Thirupathi**
- National Astronomical Observatories of Japan – SMX, grating development, IFU concept: **Shinobu Ozaki**
- *Xi'an Institute of Optics and Precision Mechanics* – ADC: **Tao LV**
- *National Astronomical Observatories of China* – ADC coating, Collimator: **Hangzin Ji**

There may be opportunities soon to get involved in WFOS: ADC, electronics, software, CSU?

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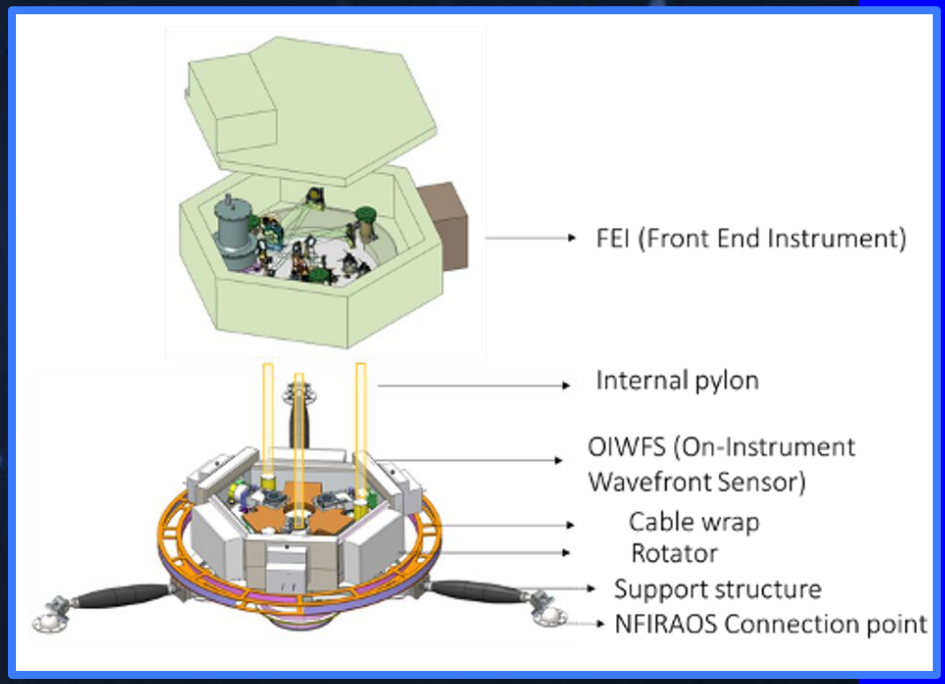
TMT: MODHIS

- The driving science case for MODHIS is the study of **exoplanets**, but it is capable of a broad range of science.
- **Near-Infrared** (from y-band to K-band; **0.98—2.46um**) wavelength region
- *Stable* and *high-throughput* **High-Dispersion** (**R>100,000**) spectroscopy
- MODHIS will be mounted on the top port of NFIRAOS
- Light from diffraction-limited images provided by NFIRAOS will be injected into **Single-mode fibers**
- Two spectrographs (y-J and H-K bands) will be located in a stable environment off of NFIRAOS and will include no moving parts

Project Manager: **Hiroshi Terada**



Above: MODHIS top-end instrument is fed by NFIRAOS. Below: The MODHIS spectrographs

The MODHIS team is interested in bringing in new partners.

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Astromanager Instrument expertise needed

- Science – determine and assess ability to do driving science cases
- Observations/Operations – translate science objectives and approach to operating scenarios
- Systems Engineering – build requirements flow from science cases to instrument/systems/sub-systems/…; oversee multi-level requirement testing
- Engineering – machining, optics, mechanics, cryogenics, electronics, software, computing, ….
- Legalese – read and respond to RfPs; negotiate work contracts; purchasing
- Finance – budget estimation; deliver to a fixed cost
- Project management – develop and deliver to a fixed schedule
- General management – manage stakeholders, write reports, document, …

What's missing?

Astromanager *What's missing?*

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Problem Solving

1 - Identifying a problem:	*There's something wrong here.*
2 - Who needs to be involved:	*We need X-san involved in this.*
3 - Brainstorms solutions:	*Here are 5 ways we could solve this.*
4 - Emotional responses:	*That's a great/terrible idea.*
5 - Technical analysis:	*Here are the pros and cons.*
6 - How could it go wrong?	*This approach is the least risky.*
7 - Get buy-in:	*Rally the troops!*
8 - Do it already!	*Let's do this.*
9 - Did we solve the problem?	*Is this working for you?*