Become a PI of an Instrument/Mission

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About Me

- Research Scientist at University of Colorado's Laboratory for Atmospheric and Space Physics (LASP), specializing in instrumentation for Extreme Ultraviolet solar occultations, and solar irradiance.
  - PI of the Occultation Wave Limb Sounder (OWLS)
  - Lead Instrument Scientist of TSIS-2/Total Irradiance Monitor
  - Deputy PI of the MAVEN EUV Monitor
  - PI/Co-I on ~5 current NASA research grants
- Scientific interest in planetary upper atmospheres, solar corona/flares, space weather.
- First-generation college grad, Air Force veteran, and non-traditional undergrad.
- Happy to share my experience and listen to yours. Just reach out.
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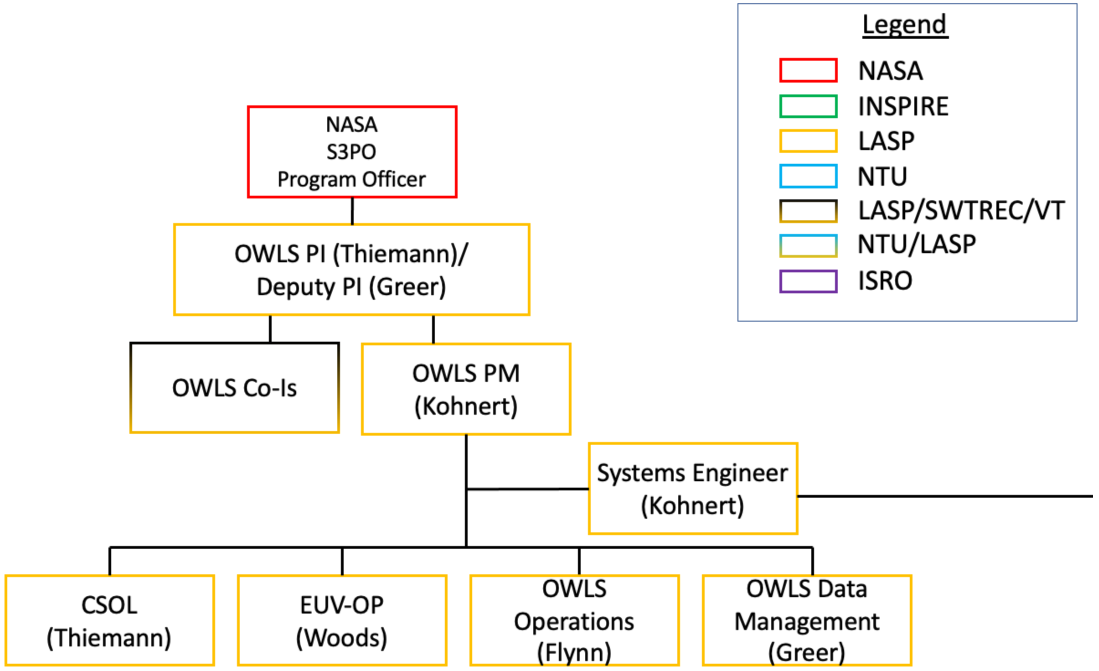
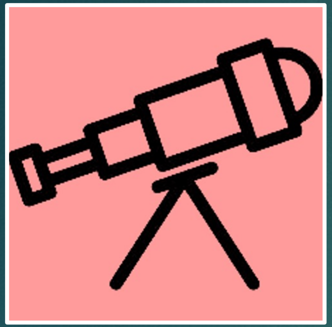
What's a PI anyways?

- A hardware Principal Investigator (PI) is the senior leader of a hardware program, ultimately responsible for the program success (or failure), day-to -day operations and budget.
- A typical org chart has the PI at the top, but a partner program manager may make most of the day-to-day decisions.
- The PI must lead the team and be knowledgeable of both the hardware and the science.



Instrument vs Mission PI



An Instrument PI is typically the lead technical expert of a spacecraft instrument/experiment and responsible for its development and operation.

- Instrument PIs are often experimentalists and hardware oriented.
- Not always the case, sometimes an instrument PI is the science leader and will partner with an instrument scientist.
- Instrument PI's may also lead small CubeSat missions because CubeSats are often considered instrument development programs.

A Mission PI typically leads a collection of instruments on a spacecraft and is responsible for the overall program.

- Not all missions are PI-led.
- The Mission PI is the responsible for both the instruments, spacecraft and science team.
- The mission team is comprised of instrumenters, modelers and science data analyst.

Instrument PI Example: Arthur Walker Jr.

- Developed the first XUV normal incidence telescope.
  - Same multilayer technology used in modern EUV imagery of the Sun by AIA and SUVI.
- After completing his PhD, joined the Air Force and developed rocket instruments to measure the Van Allen Belts.
- As Stanford Professor, partnered with Materials Science faculty to develop multi-layer optics for normal incidence XUV imagery.
- Led multiple rocket payloads in the 1980s and 1990s.
  - First full disk image of the solar corona
  - Later rockets developed technology used on CHANDRA X-Ray observatory.
- Sally Ride’s PhD advisor.
- 1936-2001

Mission PI Example: Shannon Curry

- PI of the MAVEN mission orbiting Mars.
- After completing her B.S., worked as a systems engineer at Lockheed Martin.
- After completing her PhD, joined UC Berkeley as a post-doc on the MAVEN program.
  - Established herself as an early career expert of MAVEN science specializing in atmospheric evolution and solar wind interaction.
  - Authored/co-authored 68 papers.
  - Selected as the MAVEN PI in 2021 to replace the retiring PI.
- Guest investigator on Parker Solar Probe.
- Project Scientist on Parker Solar Probe.

Day in the Life of a PI

- **Instrument and mission lifecycles are long, so PIs rarely work on a single program.**
- 1-4 hours of instrument/mission meetings.
  - Spacecraft operations status.
  - Science planning.
  - Instrument health and safety.
  - Instrument development/engineering meeting.
- 1 hour of administrative/budget work.
- 1-2 hours of email correspondence.
- 1-3 hours of laboratory payload development work.
- 1-2 hours of instrument calibration.
- 1-3 hours of data analysis and paper/presentation writing.
- 1-3 hours of proposal development.

PI Qualities and Strengths

- Entrepreneurial: Look for the gaps in the scientific state of the art.
- Persistence: Statistically speaking, proposals are more likely to be rejected than selected.
- Flexible: Selected ideas don't always work as planned.
- Good and new ideas: Science is about discovery and probing things we do not know.
- Driven: No one should care more about the program than the PI. It's their "baby" and often their idea.
- An Advocate: If things aren't working, the PI should be involved in the solution.
- A Leader: Keep the team moving forward cohesively

Path to an Instrument PI

Instrument PI Education

- Substantial engineering coursework aids in understanding the technical details of an instrument.
  - Non-engineering majors should take engineering electives.
  - Electrical engineering is prevalent/useful.
- **Find a hardware mentor.**
  - Don’t just look at schools with large space instrumentation programs, many schools have 1-2 researchers with rocket programs.
  - Rockets are great teaching programs. Lower risk→Less QA→More student involvement.
- Apply to the NASA Mission Design Schools
  - Intent is to train early career (including students) to be future PIs
  - https://www.jpl.nasa.gov/edu/intern/apply/nasa-science-mission-design-schools/

Instrument PI Good Practices

- Become an expert in the science.
  - Hardware is often a massive time-sink and FUN to work on but if you want to be a PI or instrument scientist rather than an engineer, you need to understand the science of the measurement target.
- Look for open questions.
  - Always look for opportunities to apply your specialty within and outside of your field of interest.
- Collaborate and network.
  - Get to know others in your field with specialties that could enhance your investigation. If you have a need in a proposal, don't hesitate to cold call someone you think has the right skillset.

Getting Your First Investigation: Start with a Question

- Find a clear solvable science question.
  - Proposal get rejected all the time because they can't show a science question can be closed.
    - **This should NEVER happen since you get to choose your science question.**
  - Addressing an open scientific controversy is an easy way to convince a panel your investigation is compelling.
- Write a clear science traceability matrix (STM).
  - The STM traces the science questions to the measurements.
  - Use the template given in the proposal.

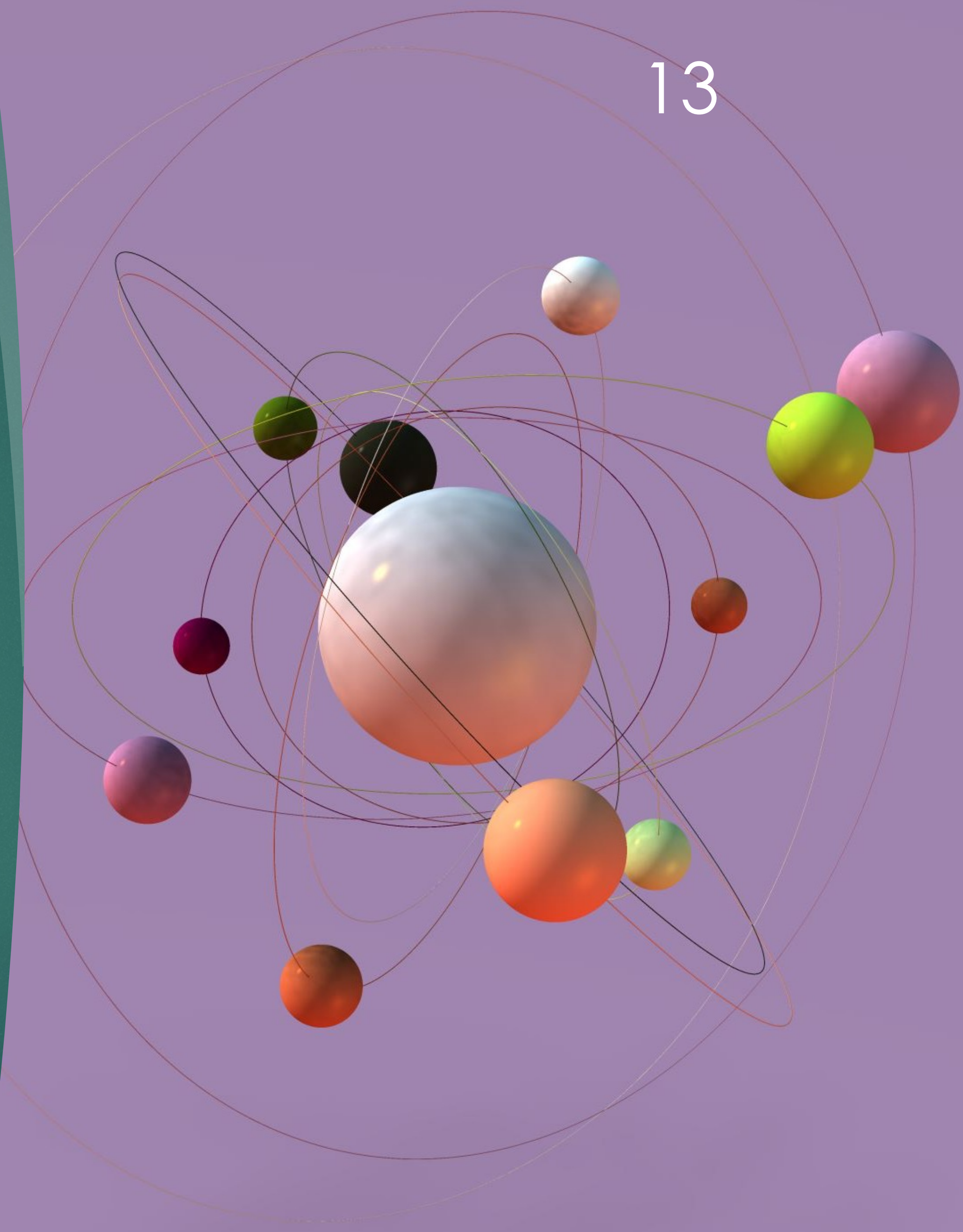
The OWLS Science Traceability Matrix

Table 1. OWLS Science Traceability Matrix for the Key Science Question

Science Question	Science Objective	Science Requirement	OWLS Channel	Functional Requirement	Projected Performance
Science Question 1: Are regions of high gravity wave potential energy in the high latitude thermosphere (as measured by delta Ep) positively correlated with regions of temperature increase or decrease?	Measure GW activity in the LMT via E_p.	Measure GWs from 100-200 km with λ_z>20 km and Δn >3% from mid-to-high Southern latitudes at both Summer and Winter.	CSOL	O_2 Density Variance Alt. (km):100-200 Precision: 3% Resolution:10km Cadence: 6/day	90-250 1% 2km 15/day
	Measure temperature changes in the MUT.	Measure changes in neutral temperature from 175-300 km at 4% accuracy.	EUV-OP	Δ Temperature Species: N_2 Alt. (km):175-300 Accuracy:4% Resolution:25km Cadence: 6/day	N_2 150-350 <2% <20km 15/day
Science Question 2: Is there a change in dominant λz of GWs seen in the middle thermosphere from that reported in the MLT region, and does this vary with season and local time?	Measure GW activity in the LMT via E_p.	Measure GWs from 100-200 km with λ_z>20 km and Δn>3% from mid-to-high Southern latitudes at both Summer and Winter.	CSOL	O_2 Density Variance Alt. (km):100-200 Precision: 3% Resolution:10km Cadence: 6/day	90-250 2% 3km 15/day

Getting Your First Investigation: Find the Right AO

- Find the right proposal opportunity. Start small if necessary.
  - H-FOS funds concepts.
  - H-TIDeS ITD funds instrument tech development.
  - LCAS funds balloons and rockets.
  - H-FORT funds CubeSats and Hosted Payloads.
  - These are the training ground for larger explorer-class PI-led missions.
  - Planetary science overlaps with CEDAR Science: PICASSO and MATISSE
- **Learn from your rejected proposals. Fix the weaknesses, get clarity from the Program Officer and repropose, again and again.**
  - In the case of a "fatal" flaw, move on.



Path to a Mission PI

- More nebulous and may take a career to realize.
- Should be an expert in the field and in analyzing measurements and observations.
- Does not have to be hardware oriented but needs to have contacts.
  - Networking and Collaboration with Instrumenters
- Must be a good program manager and leader.

My Own Path

Enlisted in the Air Force after High School	
B.S. in Engineering Physics (2007)	• 3 years working as intern on mission operations and a sounding rocket
M.S. in Physics	
Worked as an Instrument Engineer on the EXIS Space Weather Instruments.	
PhD in Electrical Engineering (2016)	• Developed EUV irradiance models for MAVEN and EXIS
Began working on EUV solar occultations	• Applied knowledge of solar spectroscopy to measure thermospheric density
Proposed OWLS to measure gravity wave effects on the thermosphere via solar occultations.	• Rejected twice, won on the third cycle (2020).

Questions?