Team Astraea

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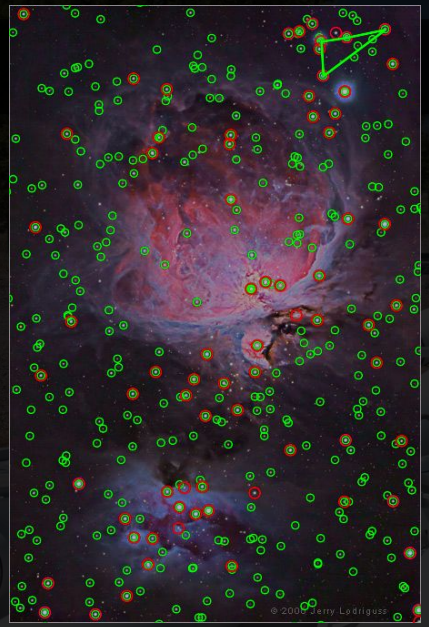
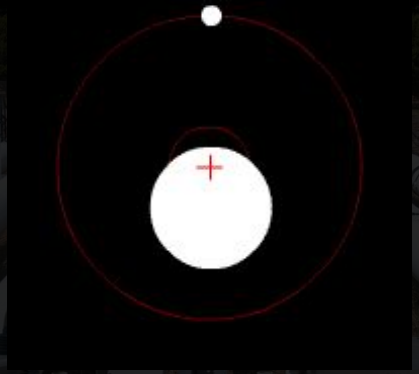
Client: Navy Precision Optical Interferometer (NPOI)
Sponsors: Jim Clark (Navy Research Laboratory), Teznie Pugh (Lowell Observatory)
Mentor: Isaac Shaffer

Astrometry



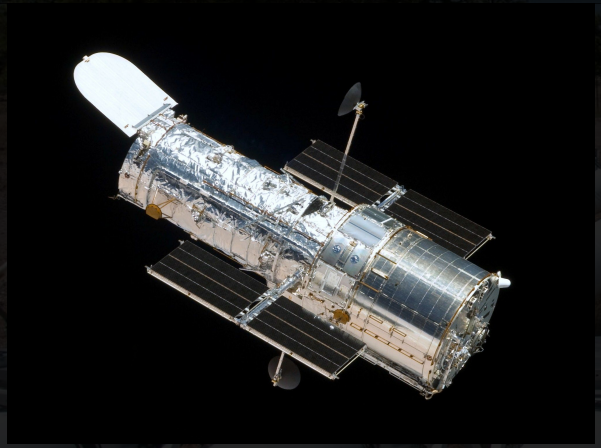
Measurements of Stars



Exoplanet Detection

Positioning of Satellites

Recent Innovations

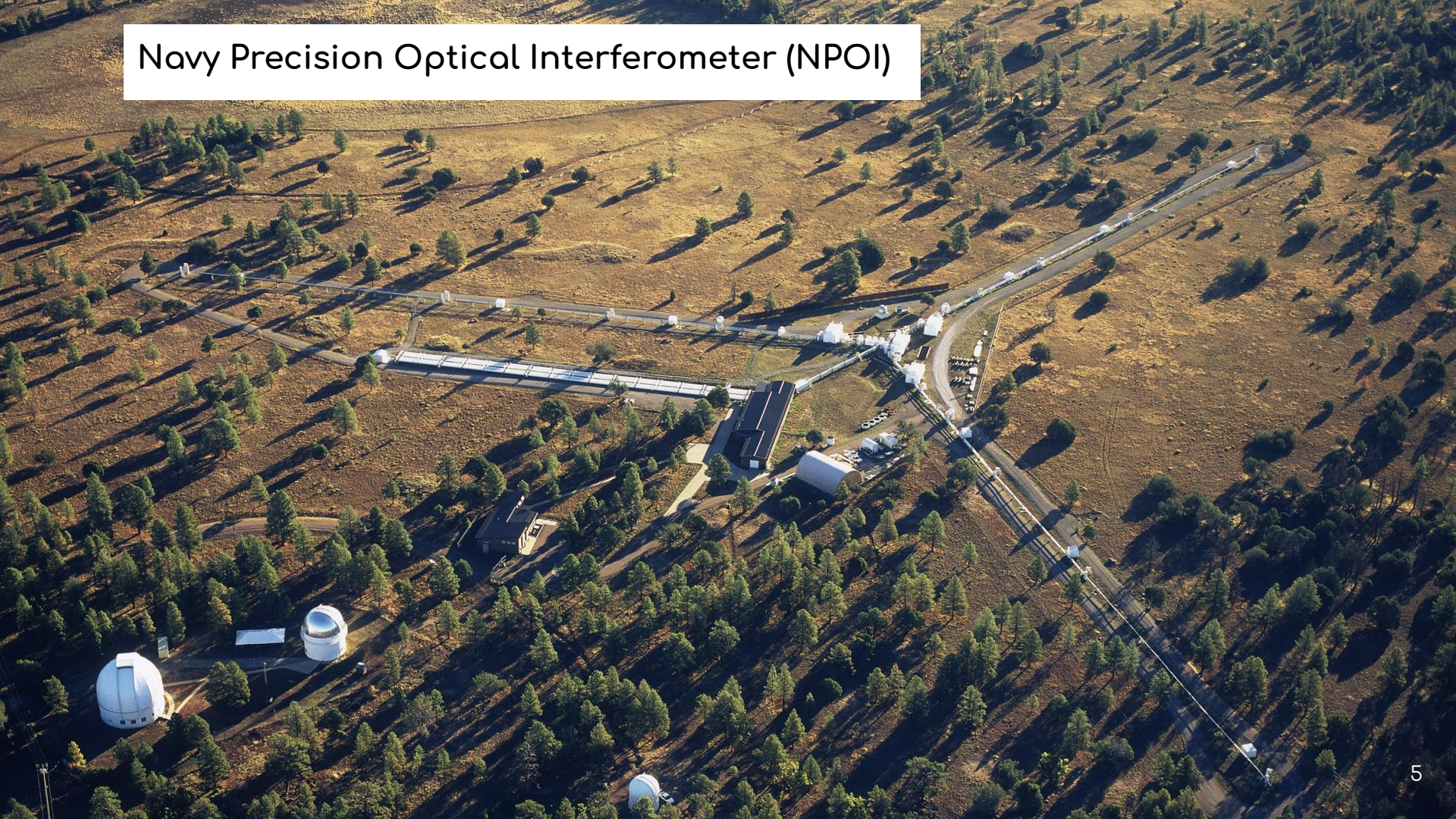


Hubble Space Telescope

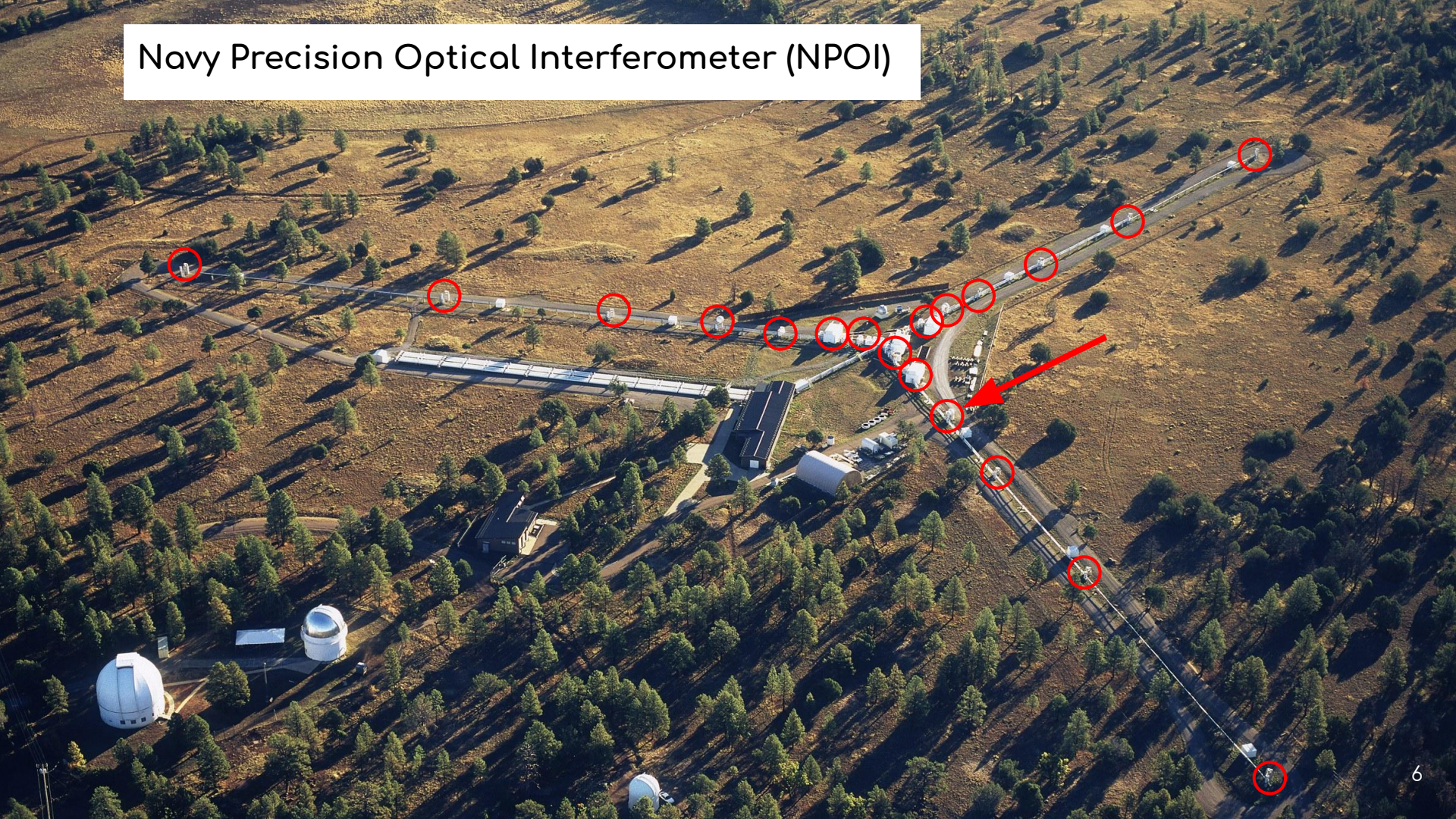
Keck Observatory

Very Large Array

Navy Precision Optical Interferometer (NPOI)



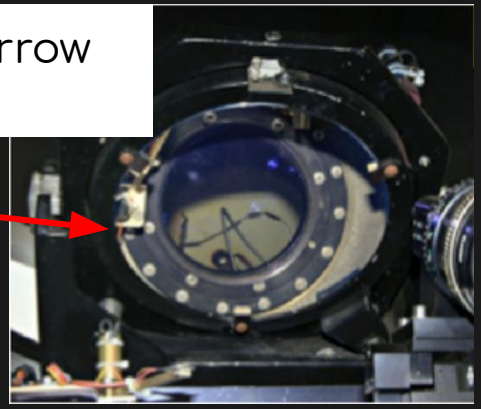
Navy Precision Optical Interferometer (NPOI)



Mirror Systems

Light path

NAT (Narrow Angle Tracker)



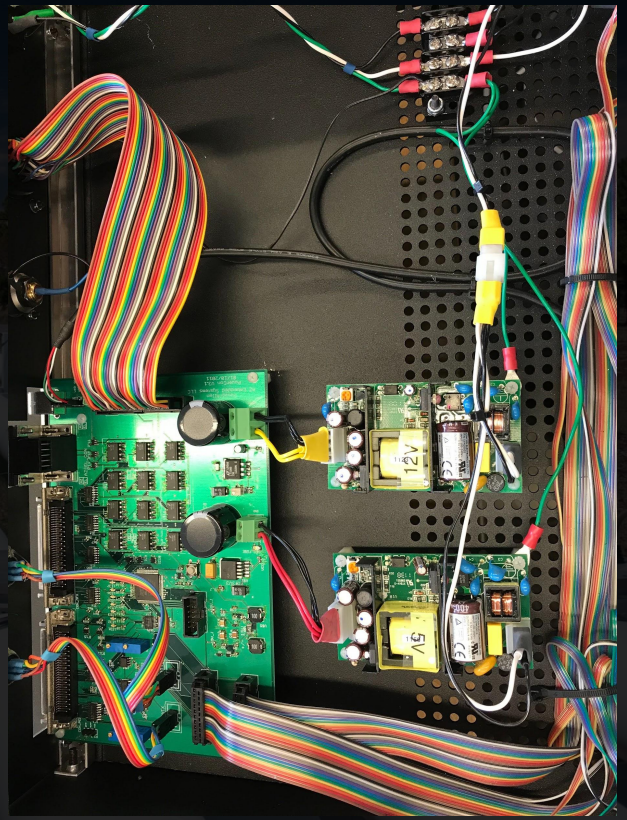
Siderostat

Problem: Overview

- Redundant Racks
  - Multiple Computers
- Overcomplicated Connections

Problem: Overview

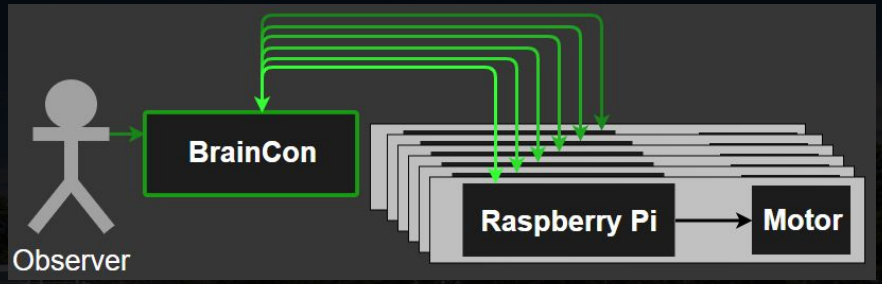
- Failing Hardware
  - 20 years old
  - Custom Hardware
  - Insulation Issues
- Software Complications
  - Multiple OS's
  - Bloated Files
  - Redundant



Problem: Overview

- Failing Hardware
  - 20 years old
  - Custom Hardware
  - Insulation Issues
- Software Complications
  - Multiple OS's
  - Bloated Files
  - Redundant

Solution: Vision



- Hardware
  - Centralized computer: BrainCon
  - Microprocessor (Raspberry Pi) at each station
- Software
  - BrainCon handles networking to each station and data processing
  - Raspberry Pi handles driving the stepper motors.

Solution: Justification

- Replace failing custom hardware
- Reduce points of failure
- Alleviate software redundancy
- Finer control over the system

Requirements: Overview

- BrainCon (Dell server rack)
- Raspberry Pi

BrainCon (Dell server rack)

Raspberry Pi

Requirements: Functional

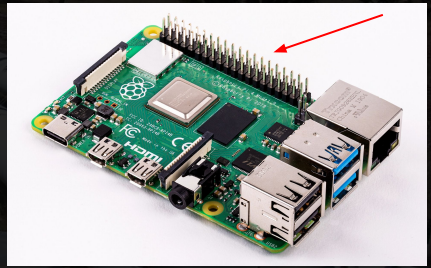
Raspberry Pi:

- Drive the NAT and Siderostat
  - Drive stepper motor
  - Drive piezoelectric motor
- Send feedback across network to BrainCon
  - Motor step counts
  - Limit switch feedback
- Electronic insulation

Requirements: Environmental Constraints

Raspberry Pi:

- Interface with existing hardware
  - Existing network
  - Limit switch wiring
  - Output to stepper motor
  - Output to piezo motor
- Temp tolerance -20 to 115 °F (-28 to 46 °C)



Requirements: Performance

Implemented System:

- Maintain precision of the system
- Send/receive signals at above 2400 Hz.
- Communicate with 6 stations
- Control 2 stepper and 2 piezo motors per station.

Requirements: Acquisition

- Weekly meeting with client
- Frequent visits to NPOI
- Analyzation of hardware
- Review of relevant documentation
- Meeting with observer

Requirements: Moving Forward

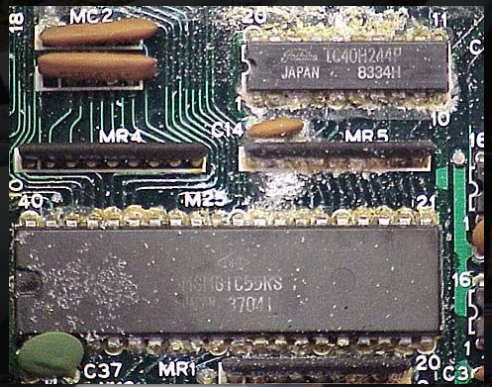
- Requirements will evolve alongside the project
- Only constant in software is change

Risks and Feasibility

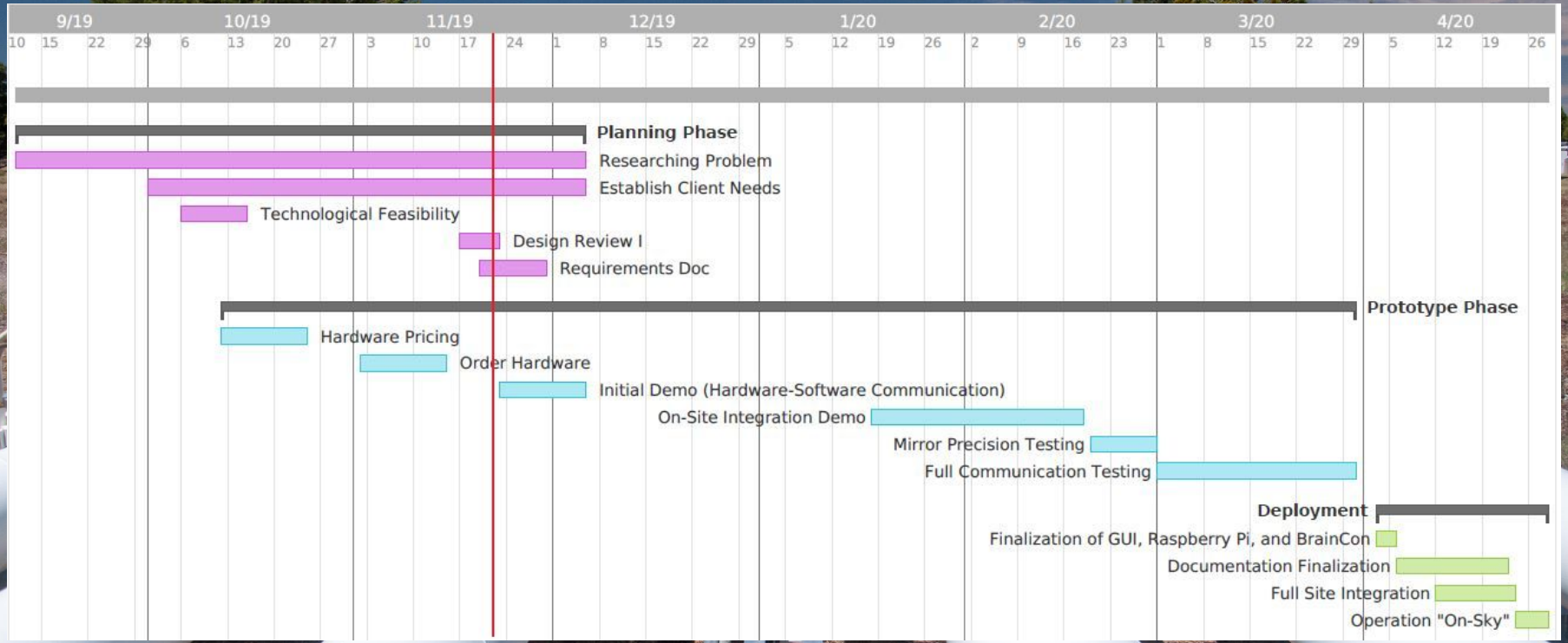
- New/overlooked requirements | medium impact (25% chance)
  - Mitigation: prototype feedback
- Raspberry Pi communicating over local network to BrainCon | medium impact (5% chance)
  - Mitigation: client communication

Environmental Risks

- Lightning strikes | high impact (0.001% chance)
- Humidity | high impact (0.1% chance)
  - Mitigation: Insulated Raspberry Pi



Development



Conclusion

- Astrometry, precise mirror control is important to client
- Problem: antiquated system, failing hardware
- Solution: redesign mirror control system
  - Remove redundancy
  - Centralize data processing
  - Create off-the-shelf solution

Conclusion

- Requirements
  - Acquisition: Meeting with client weekly, traveling to site
  - Environmental: Interfacing with existing hardware
  - Functional: Drive NAT, Sid, communicate w/ feedback loops
  - Performance: Maintain precision of the system
- Risks/Feasibility:
  - New requirements, network complications, lightning/humidity
- Next Steps: Demo
  - BrainCon - Raspberry Pi - Stepper Motor - Limit switch


Questions?