



Retrofitting the Canada-France-Hawaii Telescope for Remote Operations

Telescopes from Afar

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Sarah Gajadhar, Tom Vermeulen, William Cruise, CFHT



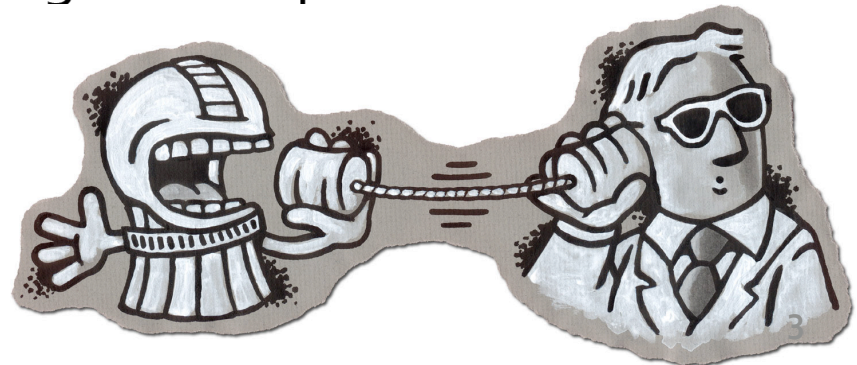
Goals

- Enable the remote control of the observatory at the summit of Mauna Kea from the control room in the Headquarters building in Waimea
- Instead of having two people operating the telescope and performing the observations from the summit, this project will allow one operator to remotely control the observatory and perform observations for the night.



Scope

- Several remote capabilities in place, including queue observing system
- Development of tools required for remote assessment, monitoring, notification, and control of observatory systems that are necessary for observing and other critical observatory functions
- Remote operations only designed for queue instruments





Constraints

- Implementation should have minimal impact on observing time
 - Modifications to systems must be accomplished during the day with a working observatory each night
- Remote operations should not impact telescope efficiency
 - Remote capabilities must be comparable to those that in the past have benefited people at the summit
 - Maintain <2% time lost to technical problems

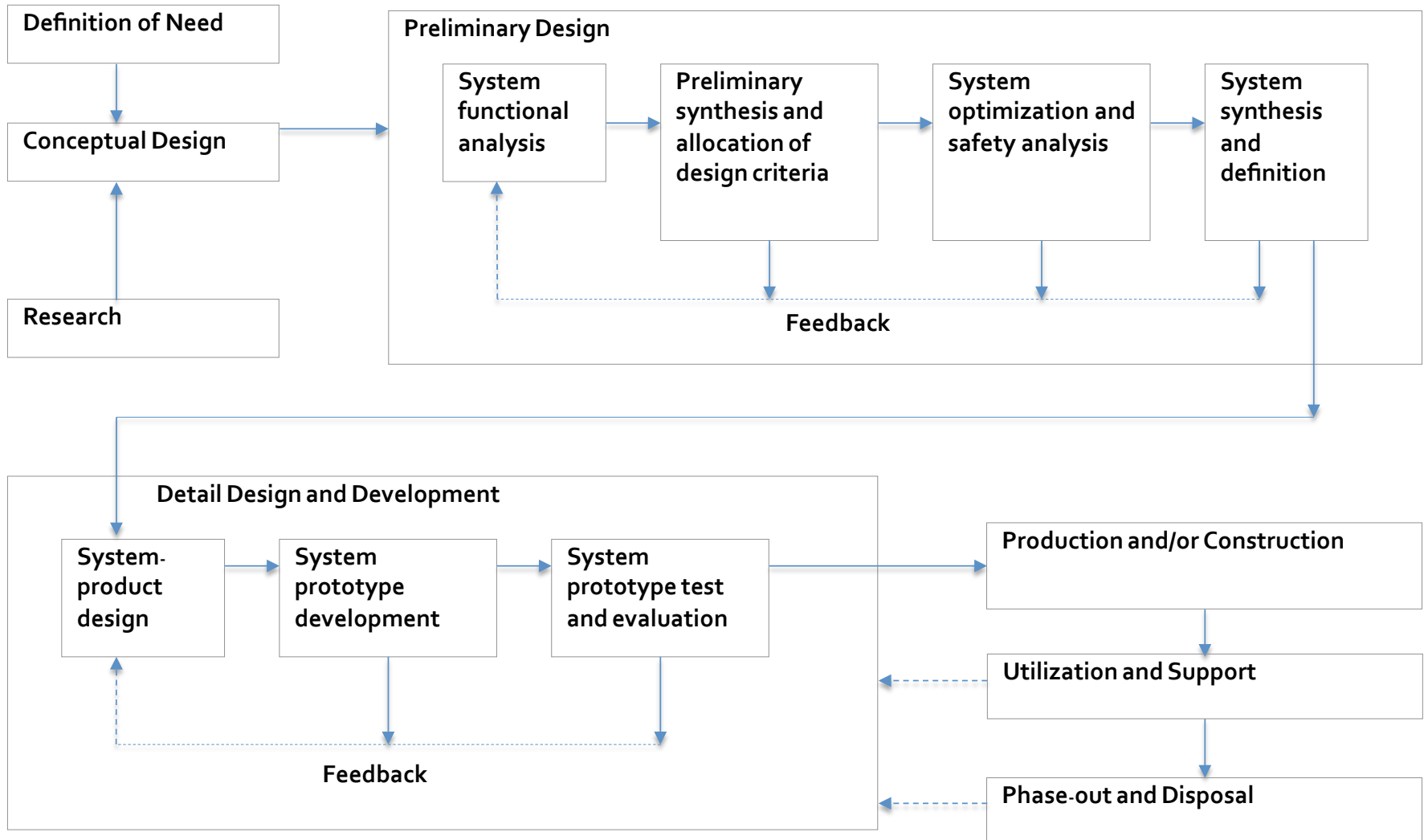


Subprojects

Phase 1	Phase 2
Mirror Covers	Dry Air System
Software Infrastructure	Dome Louvers
Remote TCS	F8 Secondary Control
Panel F Replacement	Primary Mirror Support
Remote Observing Environments	Windscreen
Dome Shutter	5 th Floor Entry
Audio and Video Monitoring	Fire Alarm Systems
PLC Infrastructure	Remote Control of Lights
Weather Sensing	Mirror Chilling
Telescope Hydraulics	
Dome Drive System	
Standard Operating Procedures	

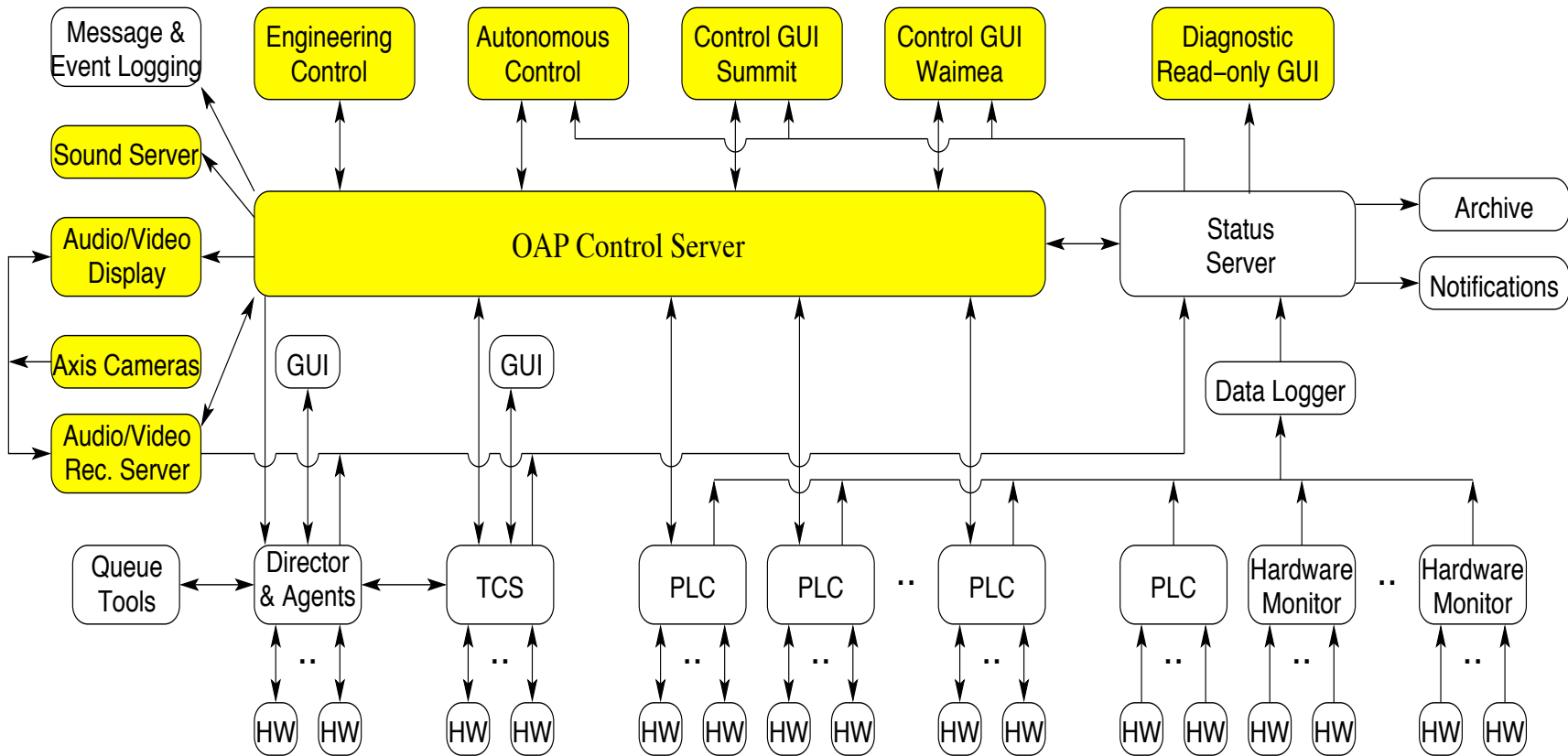


Subsystem Lifecycle





Software Architecture





Software Architecture

- Centralized control into single software component simplifies business rules and interactions between systems
- Control modes (Summit, Standby, Waimea) help moderate execution of commands and ensure actions cannot be “accidentally” initiated remotely



Autonomous control

- Autonomous closing (telescope is parked, telescope hydraulics are turned off, mirror covers are closed, and the dome shutter is closed) initiated when trigger conditions met
 - High humidity
 - Precipitation
 - Wind
 - Daytime
- When control state is set to either "Waimea" or "Standby", if network connection to high-level software is lost or summit power is lost, dome is closed automatically



Control GUI

Waimea Control GUI - Version 1.29

Summit Control | hydraulics | shutter | mirror covers | louvers | windscreen | f8 | shutdown | lights | 5 status | weather | security | fire | maint | monitor | 5 popup

- ESPaDON5
- On OK
- Closed OK
- Closed OK
- Opened OK
- Stored OK
- F8 OK
- Lights On
- Door Open
- System OK
- See Status 5

Status

- Elevator Door Open
- Freight Elevator Door Closed
- Stairwell Door Open
- Visitors Gallery Door Closed

Time	Type	Subsystem	Message
Feb-23 18:37:06	STATUS	CONTROL_SERVER	Control Server state changed from STANDBY to WAIMEA_REMOTE by Waimea Ctrl GUI
Feb-23 18:52:10	STATUS	F8_SECONDARY	F8 secondary status query initiated by Waimea Ctrl GUI
Feb-23 18:52:28	STATUS	F8_SECONDARY	F8 secondary status query completed successfully
Feb-23 18:55:13	STATUS	HYDRAULICS	Telescope hydraulics ON operation initiated by Waimea Ctrl GUI
Feb-23 18:55:53	STATUS	HYDRAULICS	Telescope hydraulics ON operation completed successfully
Feb-23 22:11:50	STATUS	HYDRAULICS	Telescope hydraulics OFF operation initiated by Waimea Ctrl GUI
Feb-23 22:11:52	STATUS	HYDRAULICS	Telescope hydraulics OFF operation completed successfully
Feb-23 22:13:59	STATUS	CONTROL_SERVER	Control Server state changed from WAIMEA_REMOTE to STANDBY by Waimea Ctrl GUI
Feb-24 07:18:15	STATUS	CONTROL_SERVER	Control Server state changed from STANDBY to SUMMIT_LOCAL by Summit Ctrl GUI
Feb-24 07:18:39	STATUS	HYDRAULICS	Telescope hydraulics ON operation initiated by Summit Ctrl GUI
Feb-24 07:19:19	STATUS	HYDRAULICS	Telescope hydraulics ON operation completed successfully

Temp (WT): -4.3

Temp (DT): -3.0

Humidity (WT): 97.8

Humidity (DT): 92.0

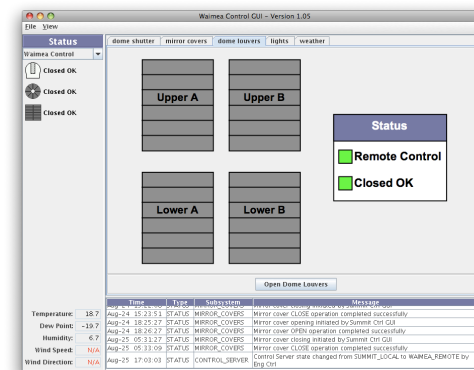
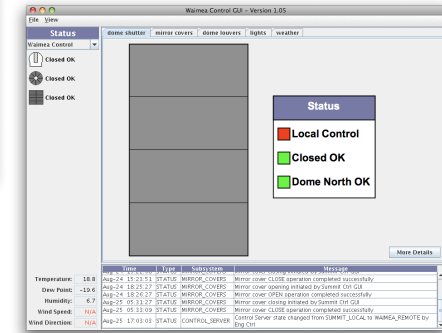
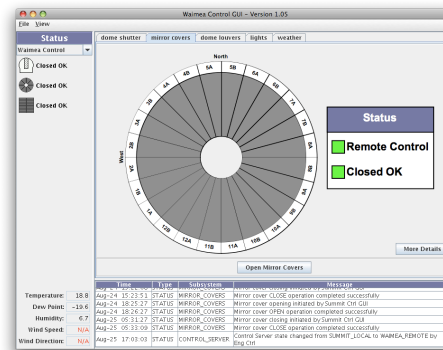
Precipitation: NO

Wind Speed: 4.4

Wind Direction: 264.0



Consistent look and feel for legacy equipment





Overall Status

Status Information

✓ Air Compressors & Dryers PLC	✓ Remote Lights
✓ Basement Chiller PLC	✓ SkyProbe Computers/Network
✓ 3rd Floor Chiller Room PLC	✗ Solar Sail Deployed
✗ Control Server not in STANDBY mode (SUMMIT_LOCAL)	✓ Summit Computers/Network
✓ DataLogger	✓ Summit Video Cameras
✓ DIMM Computer/Network	✓ TCS Computers/Network
✗ Dome Control in Local Mode	✗ Telescope Locked Out
✓ Dome Louvers	✗ TCS Servo Power - COMM FAIL on all PS -- probably locked out
✓ Dome Security	✓ Telescope Hydraulics
✓ Dome Shutter	✓ Weather Systems
✓ Humidifier PLC	✓ Windscreen
✓ Mirror Cooling Duct/Stand	✓ ESPaDOaS Instrument Computers/Network
✓ Mirror Covers	

Summit



Control Rooms

Waimea





Audio and video monitoring





Environmental monitoring

- Additional environmental sensors added to ensure that the remote observer had enough information available to be able to confidently make decisions without being able to walk out on the catwalk
- Sensing humidity, wind, precipitation, temperatures
- Low light cameras to replace the night vision goggles
- Infrared camera to detect cloud cover
- Skyprobe



Technical benefits

- More remote diagnostic tools and status information available to engineers in the event of a problem
- iPhones allow monitoring and control from anywhere
- Constant monitoring of systems and automatic notification when conditions are outside of limits
 - Alerts and warnings sent by email and text



Technical benefits

- Improved control systems have increased reliability of several systems
- Improved understanding of operating conditions of equipment and trends informs maintenance plans



Implementation of remote operations

- Remote operations is now our normal mode of operating
- Remote monitoring and control of many observatory systems have been implemented with almost zero impact on observing time
- Incremental integration of changes to observatory systems while we were still operating at the summit eased the transition to remote operations
- Impacts policy, logistics, and operating procedures



Results

- On time and budget
 - ~1 year brainstorming and planning
 - 2 years design -> implementation
 - Existing staff
- No downtime
- Reduced nighttime staff, working in a more comfortable environment



Conclusions

- CFHT is now remotely operated at night with no one at the summit
- Successful modification of the observatory systems
- Same quality data – fewer resources
- Improved reliability, maintainability, and remote diagnostics of observatory systems

