Camera Electronics Systems

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Large Synoptic Survey Telescope

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Outline

• Camera Electronic Systems
  – Science Electronics (including corner rafts)
  – Power regulation and distribution
  – Cabling
  – Controllers / sensors
  – Safety / Alarm system

• In-Cryostat Electronics
  – Quick overview

• Utility Trunk Electronics
  – Location(s)
  – Cabling challenges
  – Box utilization
  – Repair scenarios
  – Installation scenarios

• Cabling from camera to elsewhere
• Off Camera Electronics
Science Electronics

- 21 Science rafts
- 4 Corner rafts
- Each with
  - Front End Electronics
  - Back End Electronics
  - Cables from sensors to FE
  - Cables from FE to BE
  - Cables from BE to Flange
- Each needing
  - DC power
  - Cooling
  - Control
- Each a source of
  - Data
Power Regulation & Distribution

- Input AC Power from Observatory
  - 1 or 3 Phase?
  - Input filter
  - AC→DC conversion
- DC-DC conversion for science loads
  - +7; +5; +18; +35; -70; ….
- DC-DC conversion for UT loads
  - +5; +12; +24; ….
- DC-DC conversion for other loads
  - ????
- Any AC loads in camera?

- Power supplies generally less reliable than most other electronics – therefore place active components in the “Electronics Boxes” in the UT where access is at least possible.
- Implies wiring from power input to those boxes and more complex wiring from that box or boxes to the various loads.
Utility Trunk ¾ Section

Three “Crates”
Nominally:
Power
Controllers
Fiber Drivers

Actually - ??
Cabling and Harnesses

• **Cabling to Boxes From:**
  - **Cryostat**
    • Power – about 10 wires per raft
    • Controls – about 10 wires per raft
    • Data – 4 coax per raft
    • In cryostat temp measuring
    • In cryostat other stuff
  - **Filter Changer**
    • 20 (?) wires
  - **Shutter**
    • 10 (?) wires
  - **Body temperature sensors / heaters**
    • Many wires
  - **Vacuum System(s)**
    • ???
  - **Cryo System(s)**
    • ???

• **Cabling from Boxes to Outside World:**
  - **AC Power from Observatory**
    • 1 quad
  - **Data Fibers to SDS**
    • 29+ pairs
  - **Ethernet (fiber?) to/from CCS**
    • A few pairs
  - **Safety System?**
    • ???
Controllers

• Controller Logic
  – TCM – Brandeis
  – Fiber Interface – Ohio State
  – Shutter - ?
  – Filter Changer - ?
  – X-Ray Calibration - ?
  – Vacuum - ?
  – Temperature (Cryostat) - ?
  – Temperature (Body) - ?

• Sensors
  – TCM – Temp + ?
  – Fiber Interface – Temp + ?
  – Shutter – limit switches, encoders, other?
  – Filter changer - limit switches, encoders, other?
  – X-Ray Calibration - limit switches, encoders, other?
  – Temperature (both) – RTD, NTC?

• Actuators
  – TCM – none
  – Fiber Interface – none
  – Shutter – motors, solenoids
  – Filter Changer – motors, solenoids
  – X-Ray Calibration – motors, solenoids
  – Vacuum – pump(s), valves?
  – Temperature (Cryostat) - heaters
  – Temperature (Body) – heaters, valves?, other?

(Custom construction)
Safety and Alarm System

- Undefined except that “software does not protect hardware”
- Need to protect:
  - **Sensors**
    - Overvoltage
    - Deposition
    - Heat
    - Warping
    - ???
  - **Grid & mechanics**
    - Heat
    - Warping
    - ???
  - **Cryostat**
    - Loss of vacuum
    - Loss of coolant
    - ???
- Simple hardware based protection
  - Discrete logic
  - PLC
  - Other??
- Need to monitor:
  - Temps
  - Pressures
  - Flows
  - Voltages
  - Other??
- Need to control:
  - Power supplies
  - Coolers
  - Pumps
  - Other??
Data, Control, & Power Feedthroughs

- **Two types of connection:**
  - Coax for high speed data (4 coax per raft) – straight through coax, SMA connectors on Raft and Fiber ends.
  - Wire for power and control – wires to connector on Raft side, MS connector on UT side.

- **Three rafts per feedthrough plate (corner rafts a bit special):**
  - Need ~9 for science + corners
  - Need others (all wire??) for other cryostat functions plus calibration fiber feed throughs – cost not a strong function of volume at this level so specials are ok
Harness Routing - Boxes to Cryostat and Shutter
Box Design Considerations

• Total Volume
  – Guess 3 cubic feet total
  – Need to itemize objects to get better estimate
  – That needs designs for power, fiber, TCM, controllers – some time to go

• Shape / Design
  – Objects natural size / shape
  – Cabling
  – Cooling
  – Access through hexapod
  – No obvious standards to use but for regular parallelepiped can use Eurocard parts with custom side plates

• Cabling
  – Better for servicing of object to have no permanent cabling out front (large r)
  – Implies rear connectors that have object inputs and outputs – e.g. bulk power in, power to rafts out
  – May not be so easy for Fiber Interface??
  – May imply some “backplanes” to mount connectors, not to bus data (but maybe to bus power?)
  – Easy connect/disconnect of box harness would ease installation and servicing (or do we swing boxes out of UT volume using final harnesses?)

• Cooling
  – Conduction or do we have a fan or fans in the UT??
Installation, Access, Repair

- Installation on tooling fixture, relatively unconstrained.
- Fast repair scenarios imply reaching through hexapod, removing a cover, removing a board or sub-box and then replacing with a spare.
- How much real access space is there?
- How wide / large can we make a removable panel (a card or sub-box is, presumably much smaller)?
To the Outside.....

- Cabling plant (electro-optic only) is pretty small
  - AC Quad ~ 1cm dia.
  - 100 Fibers ~ 1-2 cm dia.
  - Safety / Alarm ??
- Plumbing is much larger

- Off-Camera “Electronics” –
  - Safety / Alarm System
  - AC power conditioning (filtering, UPS, ??)
  - Parts of cooling and vacuum systems but not really part of “Electronics”
Utility Trunk Contents

• Until recently, we have just been holding the utility trunk volume open, knowing that we would have some camera hardware to put there

• We now have the start of a real design
  – Support electronics requirements
    • 3 crates, each about 1 ft³ (per Rick Van Berg e-mail)
    • Try to make the crates accessible through the support hexapod, so boards can be replaced on the telescope
    • Crates need provision for cooling
  – Valve box requirements
    • Valves must remain roughly vertical during normal operations
    • Valves should be remotely actuated, both for system safety and to speed up cooldown/warm-up cycles
    • Remote actuation means that valves do NOT need to be accessible for hand operation while on the telescope
    • Large, heavy, bulky cryogenic transfer lines must be accessible so they can be disconnected when the camera is being removed from the integrating structure (ground operation only)
  – Interface with telescope
    • Telescope rotator inside diameter is not negotiable, which means our Utility Trunk max diameter must get smaller → 940 mm is the max diameter allowed (CoDR trunk diameter is 1005 mm)
    • Access is essentially not possible while on the telescope EXCEPT by reaching through the hexapod support structure → this access is limited, but is the only way to get into the electronics crates
Utility Trunk Re-Design

- Camera back flange and interface to rotator
- Vacuum valve and turbo-pumps
- Support electronic crates
- Cryogenic valve box (vacuum vessel)
- Telescope Integrating Structure end ring
- Cryogenic transfer lines (vacuum insulated)

Support frame—this is a basic concept, showing clear accesses. Final design will include removable covers
Utility Trunk Side Elevation

- Cryostat support tube
- Support electronic crates
- Valve panel
- Valve Box
- Valve pneumatic actuators
- Open access to Feedthrough Flange and pumps
Utility Trunk Inside the Telescope Structure

- Support tube—this runs through the bore of M2 and its stiffening structure
- Hexapod—this is just a notional concept with much hardware missing
- Rotator
- Camera back flange mounted to Rotator
- Front end of telescope Integrating Structure
Access to Support Electronics Crates

- Access to front of crates through the hexapod legs
- Crates arrayed with front facing radially outward
- Center volume clear for cable/fiber routing and cooling for crates
- The camera rotates with respect to the hexapod, so if needed we can rotate the camera to align a crate with an opening in the hexapod
- Additional volume is available, but the access is much more limited
Questions

• What is the preferred crate type?
  – It looks like we have a comfortable amount of room, so we don’t need to miniaturize these crates
  – What standard crate type do you want to use? What are the standard shapes and sizes?
  – Once we have a crate type, we can lay out real crates and give you a much better idea of the total number of boards that will fit

• How do cables and fibers connect to crates?
  – The layout assumes that connections would be on the back side → these would be relatively inaccessible, but allow free access to the boards
  – Cables and fibers would likely be routed up cable ways mounted to the support structure

• Test crates
  – One problem with this (or any other) design is that the support electronics block direct access to the back end of the cryostat
  – This means that the crates cannot be there while we are integrating, but test crates will be needed
  – The test crates will need to be off to one side, meaning that all of our custom cable and fiber lengths won’t reach the test crates
  – We could use pigtails or test cables → any timing issues?

• Other issues to work
  – We are also starting to firm up our N2, air, and vacuum plumbing needs → these can take up quite a bit of room, so we will be laying out volume for those systems, as well