# Data Acquisition & Control

**Plenary Session Notes**

1. Ongoing work right now is a trade-study document comparing different software in use on other observatories.
    a. Down select to software for use on S4
    b. Will circulate trade study at the end of the month
    c. Users should submit requests for what DAQ software needs to accomplish if any special requests
2. Scope
    a. Control of all subsystems
    b. Encompasses housekeeping systems, meta-data, timing, **non-safety** alarms
    c. Hand of data to DM, which handles storage
    d. Observing priorities passed to DAQ, converted to observing schedule
    e. Monitoring of HK systems (both live and historical)
3. Overview
    a. Scheduling - Perform actions like “move to”, “take IV curve”, “start acquisition”
    b. Interface with hardware/software agents
    c. Agents collect HK data, etc. write to disk, and provide data to live monitor
    d. Emphasize scope -- hardware and human safety not in our scope
    e. WBS breaks down to:
        i. Control system
        ii. Monitoring
        iii. Subsystem development and support - support for labs and their usage of site software for lab testing
4. Control Requirements
    a. Support remote or local high level commanding on mix of computing hardware
        i. Detector readout
        ii. Cryo
        iii. detector/HK acquisition control start/stop
        iv. other
    b. Scheduling
    c. Modular system
        i. Scale from lab with small setup to full site
    d. Same system at both sites, though unlinked
    e. Interface to the hardware should be a digital signal
    f. ‘User friendly’
        i. Users should prefer using our system over home grown systems
        ii. Expect to contribute some code to support your hardware
    g. User access control
    h. Robust
5. Baseline design
    a. Based on SO DAQ system

    b. Figure shown for SO SAT1 setup, describing control and monitoring of various hardware components
    c. Modular Agents
        i. Allows use across all test beds using that hardware
        ii. Commonly written by hardware experts close to the unique hardware in the lab
6. Monitoring + Alarms
    a. Real-time browser based monitoring of HK and diagnostic data
    b. Decimated after ~1 week
    c. Hierarchical alarm system based on HK data inputs
    d. Monitor multiple HK systems
    e. Grafana interface for monitoring for plotting timestreams
        i. Highly configurable by users
    f. Detector live monitoring with Lyrebird from SPT-3G
        i. Backend server for performing on-the-fly math, i.e. downsampling, demodulation, etc.
        ii. Envisioned for use during calibration, not constantly
    g. Current monitors aren't linked, i.e. can't plot power vs temperature, etc
7. DAQ Requirements
    a. Control
    b. Slow data acquisition
    c. Fast acquisition from readout boards (500k detectors, 32-bit sampling, ~400 Hz)
    d. No plans for sync pulse, just high precision time stamps
8. Moving from S3 to S4
    a. Order of magnitude increase in data rates
    b. Older designs have been scaled in the past, i.e SPT -> SPT-3G
    c. S3 experiments provide architectural design and resource for S4
9. DAQ Details
    a. Data gets written to L1 data aggregator computer(s)
    b. Eventually combined on a L2 data aggregation computer which merges in HK data
    c. Passed to DM after that
    d. Common hardware at sites in Chile and Pole
10. Network Design
    a. 10 Gbit Ethernet (really only need 5 Gbit, so have headroom)
    b. Synchronous Ethernet + PTP for timing
    c. 100-200 nodes per broadcast domain
    d. Segrate high-speed and low-speed DAQ
11. Timing System
    a. Baseline PTP distribution of timing through ethernet
    b. Industry standard technology, allows cheap off the shelf hardware to be used that is compatible
    c. Can provide 10 MHz, IRIG, etc.
12. Low Rate DAQ

    a. <1 kHz
    b. Broad variety of agents supplying this data
    c. Push model to get data to aggregator
    d. All DAQ users should be able to contribute a low rate DAQ Agent
13. Near Term Planning
    a. Same software for lab and the site
    b. Goal is to have the DAQ ready and waiting when you get the hardware
    c. Support your fridge/widgets/readout
    d. All off-the-shelf hardware
    e. Currently building a test stand at MSU
14. Breakout later today
    a. Discuss trade study report
    b. Lab testing
    c. Detector live monitoring
15. Questions
    a. “Is page 8 showing just a one-telescope (one-mount) diagram, or include hardware (computers) for all telescopes at the site?”
        i. That was showing just one cryostat from SO, though does include agents that will be common when at the site.
        ii. Intending on only one aggregator/influxdb/control computer per site.
    b. “When you say that there will not be a “sync” pulse, does that just mean that each readout card will have its own set of timestamps, but the timestamps between cards will not be synchronized?”
        i. Timing is distributed from a GPS locked clock either directly from the clock or from boundary clocks which are phase locked to the main clock.

**Breakout Session:**

(Note: this is primarily a discussion!)

**A) Trade Study Report**

a) https://docs.google.com/document/d/1AxTbMk9Qh4Gam6lTaia7tMxnipeMO3DbICzi09ROr6Y/edit#
b) Not the downselect document
c) Added spots for Requests from S4 Users
    i) Q) Is level of reuse part of your study? (i.e., proof that it's reusable because it has been)
    ii) Suggestion: Likelihood of becoming obsolete or planned obsolescence of components
d) Requirements (from directors review)
    i) If find new requirements, we should add them!
    ii) Some requirements are common (not relevant for trade study)
        (1) Requirements for control/daq/alarms & monitoring
    iii)
e) Simons Observatory OCS
    i) Relatively easy to use compared to alternatives (but partly because different life stage).
    ii) Had issues running on Centos8 (docker-related, fixed).
f) ALMA
    i) Difficult to set up, VM simplest solution. A lot of docs outdated.
    ii) Choices made long ago that might not be made today (e.g. CORBA)
    iii) 2 FTE for support
    iv) Planned on to be used for CTA
    v) Will be filled out in next several days!
g) CLASS
    i) Rolled their own thing
    ii) Not open source, but open to do that and document
    iii) Dirfile storage (lots of files in discovery), all data written to shared file system (sort of a misuse of Dirfiles…)
    iv) Nice web interface, alarms go to Slack
    v) Rely on KST for live monitoring. Question about level of support here.
    vi) Question about scalability at S4 scale.
    vii) Impression is that they're happy to let S4 take it over, but requires a lot of changes since hard-coded things.
    viii) Comment (Ryan Herbst): PYRO4 doesn't scale well , requires a lot of network connections.
h) GCP
    i) To be filled out by Nathan
i) LSST
    i) Not much public documentation

ii) Heavily java based
iii) Will be filled out by Brian

j) EPICS
   i) 3 technologies: Display technology (e.g. pyDM), data interconnect layer (pV), “core” layer
   ii) Main concern is high barrier of entry to understanding, and lots of different ways of doing things, which requires picking components.
   iii) Comment: pvData is really good, other parts not so much
   iv) Comment: **Don’t want to mix control layer with data acquisition layer**
   v) Lots of display options, pyDM (QT5 based) is the default now, which is very flexible/easy to use. React interface available (unclear how mature). Might be other options for QT5 to be used on web (e.g. cutelyst).

k) Commercial
   i) We’re bad at finding them!
   ii) Portions of LZ use something called “Ignition”
   iii) National Labs folks will ask around

**B) Lab Testing Discussion**

a) There’s a chance we might get some boards this year.
b) Emulator would be helpful!

**C) Detector Live Monitoring Discussion**

a) Historical detector monitoring is “data management”’s problem
b) But live monitoring is our problem (maybe?).
   i) Maybe just need to help data management people with how to display data they provide (since analysis will exist).
   ii) Sounds like data management might just take it over!
c) Expect to want to be able to plot detector properties vs. timestream.
d) What about individual labs? They don’t have real cosmology data.
   i) Priority for developing tools.
e) How live do you need the data (vs. 1 minute old).
   i) For calibration, useful to get faster feedback (but maybe not necessary)
   ii) What about alarms? Usually this is a much simpler threshold problem than looking at the data. Most complicated things need processing anyway…
f) Discussion with calibrator people and a few people from data management to figure out what we need to do.

Other discussion:

- PBDR todo: add requirements paragraph in introduction (for Cosmin)
- Q: What’s plan for trade study results?
  - Summarize what meets requirements, requests. Make sure we write down what we learned from looking at different options. Summarize pros and cons for various options. Open up for requests.

    - Scheduled design review is May 25. We will have all information for downselect by then. Can use review panels feedback to bolster a recommendation.

**Report-back plenary:**

- Trade Study information complete for Simons, CLASS, EPICS
    - Complete by end of March for ALMA, GCP, LSST
    - Will get input from John J. /Ryan H. will get input for commercial options
    - Then: synthesize information, add requirements learned from learning about packages, gather feedback from people who may have used some of these packages. Goal is inform DAQ review in May.
    - After that, downselect document.
- Live data exploration
    - Pinning down the boundary between data management (quicklook) and DAQ (livelook)
    - Add data viewing wishes to DAQ trade study document, even if it becomes part of DM (so that the needs are tracked).
    - If plotting HK variable vs detector response using analysis pipeline this should be in DM scope
        - But this must be “ready” for lab testing
        - Possibly a lag
- Q: lag for quicklook or livelook? For quicklook.
- Comment from DM: Haven’t thought about lab use, but scripts for quicklook can be quick to run with fast turnaround.
- Q: Did you consider labview as an option? No. Partially due to licensing.
- Q: where is the trade study? https://docs.google.com/document/d/1AxTbMk9Qh4Gam6lTaia7tMxnipeMO3DbICzi09ROr6Y/edit#

Chat log from report-back:

- Bobby Besuner (he/him) to Everyone (10:43 AM) How do we find the Trade Study Document?
- Nathan Whitehorn to Everyone (10:43 AM) It's in progress, but the in-progress version is in the DAQ section of the S4 google drive
- Bobby Besuner (he/him) to Everyone (10:44 AM) Got it. I had not looked in the "management" folder. https://docs.google.com/document/d/1AxTbMk9Qh4Gam6lTaia7tMxnipeMO3DbICzi09ROr6Y/edit

- Antony Stark to Everyone (10:49 AM) That was an important point:  the software for a large, long-duration project like this should not depend on proprietary software from any vendor.  In principle, everything should be compiled from source.