Keck Next Generation Adaptive Optics

Real-time control design team - Meeting notes

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October 29, 2007

References

1. FRD Section 7.7 (RTC)
2. Wavefront Error Budget
3. NGAO System Architecture definition KAON 499

Bandwidth

Required control system bandwidth is a key specification parameter. The FRD states that the required 3db control bandwidth is 54.3 Hz and states this is derived from error budget spreadsheet v1.26. Version 1.22 is posted on the wavefront error budget page in 5 science-case versions where the bandwidth varies from 90 to 162 Hz. More guidance on the requirements flowdown is needed.

WFS Camera interface

RTC will depend on the readout interface of the WFS camera, and on the chosen geometry and layout of the sensor in its sampling of the wavefront. These are ICD item. For now we make the following assumptions:

- Assume raw pixels are streamed out of the camera.
- Assume all high-order LGS and the NGS wavefront sensor are Hartmann sensors
- Assume all LGS wavefront sensors have the same sampling geometry (#subaps across the aperture = 64) (see KAON 499)

Still, the pixel rate at the interface depends on the number of pixels per subap and the number of readout amplifiers. These are TBD. For now we assume a ~1MHz pixel rate. Since the number of pixels per subaperture will depend on final details on the design of the radial geometry WFS design but for now we assume there are sufficient readout amplifiers to maintain this pixel rate. The (average) number of pixels per Hartmann subaperture is TBD but for now we assume on average a 20x6 array for the radial CCD (LGS WFS), and up to 8x8 for the NGS WFS.

WFS Latency

It is efficient to be able to start the centroiding process on partial frame data in order to overlap in time with the readout process. The fundamental latency between start of readout and start of centroiding depends on WFS camera readout details. It will trade with camera frame rate in order to achieve the specified control bandwidth. The error budgets assume a factor 20 between bandwidth and frame rate. For now we assume 1kHz frame rate and one subaperture row readout latency.

WFS Grid, Internal Tomography Grid, Deformable Mirror Grid

We will assume the Hartmann WFS samples on the same grid as the tweeter DM, 64 across. This is finer than the woofer grid, 20 across. We will be flexible about the internal tomography grid, and consider designs for 1x, 2x, and 4x oversampling.

Woofer/Tweeter algorithm

We will need a woofer/tweeter strategy for each mode: e.g.

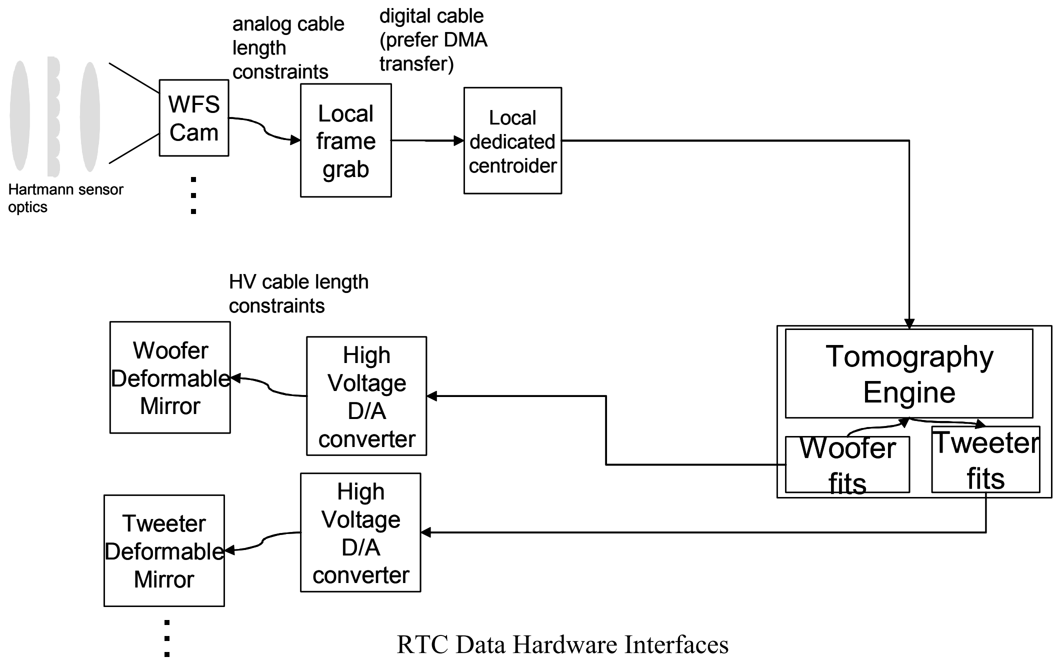
- Multi-object IFU (dNIRI): Woofer gets average wavefront over the field. Tweeters get delta wavefront specific to direction. The woofer can only control to lower order so we need a model to project out the space it is controlling. The residual average higher order wavefront needs to be added to the tweeters.

- On-axis high-Strehl: Woofer gets low order components, which are projected out of the solution and the residual put on the tweeter.

WFS Interfaces

The RTC interfaces are depicted in the figure below. The implementation will greatly benefit from parallelization of hardware and software so that independent calculations can occur simultaneously to reduce overall latency and cost. There is an advantage to putting dedicated units near the WFS cameras which contain 1) a frame grabber that captures the analog pixel data and 2) a dedicated processor to convert pixels into centroid data. The centroid data is then sent over the long link from the camera to the tomography engine. All cameras and corresponding units run in parallel.

ICD issue: the WFS optomechanical designs should allow space for these on-board units, and cabling for data, power, and cooling



RTC Data Hardware Interfaces

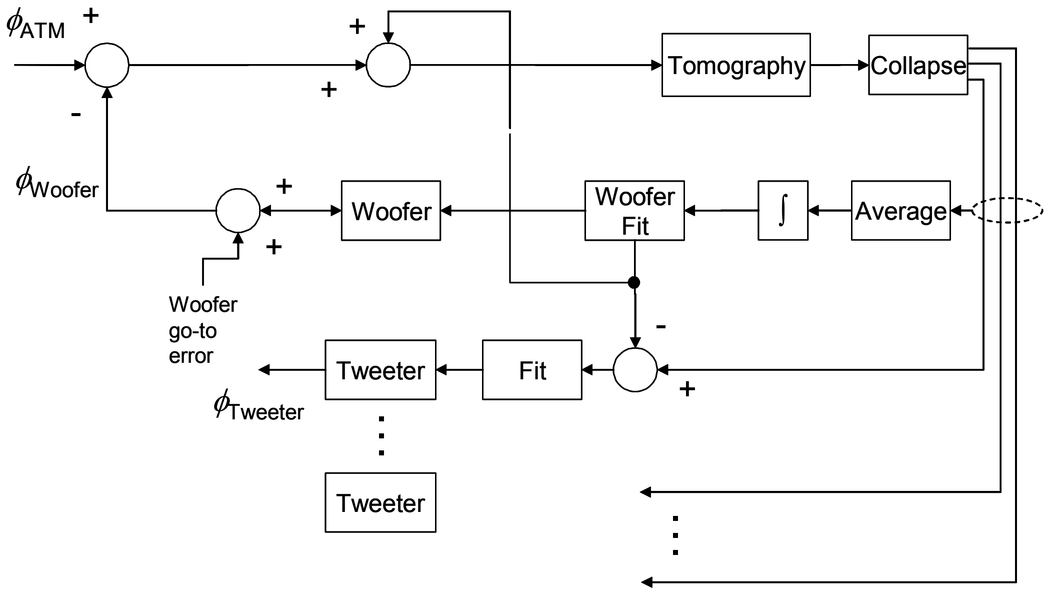
Diagnostic and Telemetry Data

Diagnostic data is defined as high-speed data taken at the full controller frame rate and recorded to disk for later analysis.

Telemetry data is defined as low-speed data, 1 to 5 Hz say, that is used for on-line monitoring of system status by humans.

One scenario is to capture every frame of every WFS, every reconstructed volume estimate in the tomography engine, and every DM command, and record this data to disk over some TBD burst of time. The WFS units contain the raw pixel data so they will need separate interfaces for this, while the tomography unit contains all the rest.

Telemetry data also needs to stream from both the WFS units and the tomography engine.



RTC Software Flow