CGI/Observatory Interface Sensitivity

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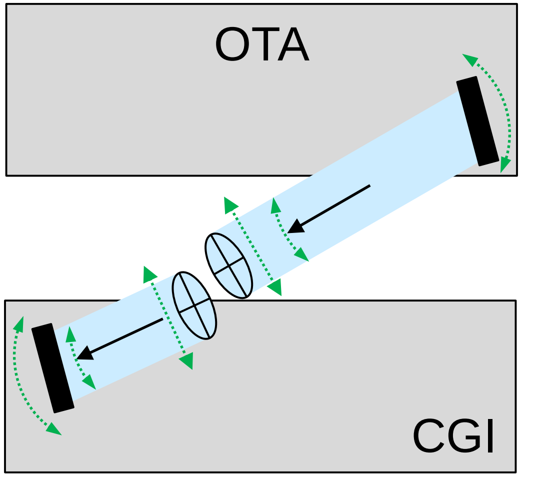
Overview

- OTA-CGI optical interface (JPL-Harris via GSFC)
  - Define hardware capability provided to support CGI science & technology
  - Static and drift
- Observatory-CGI interfaces (JPL-GSFC with flowdown to Harris *et al.*)
  - Extends beyond optical interfaces
  - Programmatically more complex
- Integrated modeling needs (JPL-GSFC)
  - Summarize CGI sensitivities to jitter and drift
  - Outline IM results needed to verify CGI meets L2 and L3 requirements
  - Highlight some areas where additional testing is likely necessary for model verification and calibration

OTA Interfaces (1)

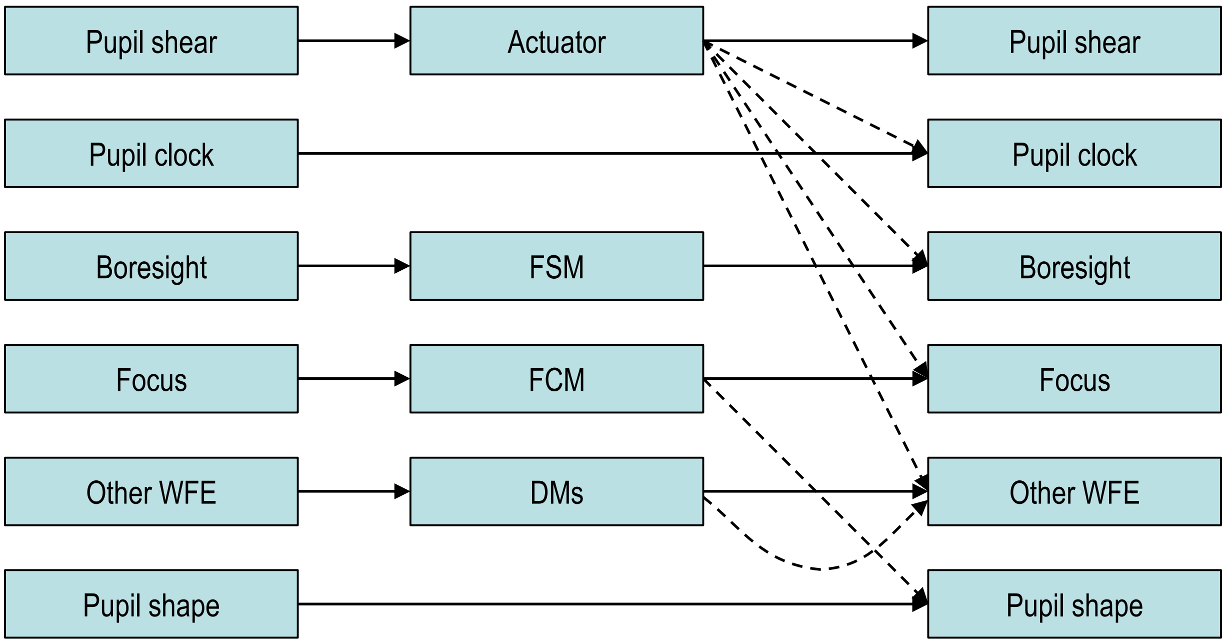
	Accuracy	Knowledge	Ground-to-orbit
OTA exit pupil shear	±1 mm	±0.15 mm	±0.3 mm
OTA exit boresight	±0.7 mr	±0.15 mr	±0.2 mr



- Exit Pupil Shear (output of OTA w.r.t. input to CGI)
  - Assumes pupil shear actuator in TCA → put OTA exit pupil at CGI entrance pupil
- OTA exit boresight
  - Expect up to ±1.5mrad change in TCA exit boresight as a result of pupil shear actuation
    → CGI boresight maps to different sky angle, 5" away (unimportant)
  - OTA WFE depends on OTA boresight
    - 13 nm RMS focus and 1 nm RMS higher WFE, for ±(1.5,1.5) mrad at TCA exit

Multiple actuators, interactions

Agreement with Observatory



Needed for CGI

OTA Interfaces (2)

- Static on-orbit WFE excluding focus is 74 nm RMS
  - Typical specs are RMS at all spatial frequencies, while CGI driving requirement is peak-peak up to 24 cycles/aperture;
    Conversion Is Uncertain
  - CGI team is exploring ability to dig dark holes with some fraction of actuators stroke-limited; this helps define robustness to OTA WFE peaks beyond stroke limits
  - WFE varies with Boresight direction, so pupil shear actuator also changes WFE

	Focus	Other WFE
Pupil shear actuator @ 0	~0	74 nm
Pupil shear actuator @ max	770 nm	95 nm

- Focus stability <10 nm over 100 hr
  - Sets stroke of CGI focus control actuator,
  - Affects magnification slightly
- Low order WFE change excluding focus < 2 nm over 100 hr
  - Astigmatism, coma, trefoil, spherical drift are corrected with DMs, causing some high-order WFE due to actuator gain uncertainties
- Specified distribution of wavefront error vs. spatial frequency
  - Affects sensitivity to beamwalk
- Mirror coating reflectivity vs. wavelength:

430 nm	89%
500 nm	96%
550-980 nm	97%

Interfaces in Negotiation, Converging

- Exit pupil clocking ±4 mrad
  - Combines uncertainty in pupil alignment in AI&T and ground-orbit shift
  - No actuator to correct clocking, but the actuator for pupil shear also causes clocking
- Exit pupil shape accuracy ±0.04 mm
  - As-built OTA exit pupil perimeter matches CGI masks
  - Size of outer perimeter, size and centering of inner obscuration, SM strut width and alignment
- Throughput variation across pupil < 3% pk-pk (TBR) for <24 cyc/aperture
- Polarization retardance across exit pupil

Interfaces to Payload or Observatory

- Elevated in scope because they apply to systems beyond OTA
- To be dispositioned at higher level to make balanced decisions about cost drivers that help deliver L2 science
- Not resolved yet

- Line-of-sight (LOS) jitter < 0.5 mas above 10 Hz → Observatory
  - Directly drives instrument contrast near IWA
  - CGI FSM loop only controls to 10 Hz
  - Considering operational solution via limits on reaction wheel speeds
- Beam walk during 100 hr → Payload
  - Generates high-order WFE due to drift beam motion across each mirror
  - JPL to propose a formulation of requirement
- Pupil shear drift <1 micron for 2 hr (TBR) → Payload

CGI Requirements to be verified by IM

	Quasi-static Wavefront Error terms (DM stroke budget)
⊕Δ	Ground-to-orbit: Cool-down, gravity sag, and moisture desorption.
⊕Δ	*As-built OTA and TCA WFE is captured in Optical V&V (Sept 2017)*
	LOS stability
✓	LOS jitter (12 mas → 0.5 mas)
✓⊕	Slow body pointing or optical misalignment (8 mas → 0.1 mas)
	WFE stability
✓ Δ	Thermal distortion of optics (esp. PM) and of OTA structure as corrected by LOWFSC (focus 10nm, coma/astig 2 nm → 0.02 nm)
✓ Δ	OTA body pointing or optical misalignment (8 mas ⊕ 12 mas)
	WFE Jitter (0.01 – 0.05 nm passive)
	Pupil shear
⊕Δ	Ground-to-orbit
⊕	On-orbit variations (daily or annual drift)

✓ Affected by CGI controls performance
⊕ Affected by OTA-to-WFI alignment
Δ Drives an on-orbit actuator range budget

IM Deliverables to CGI

- Ground-to-orbit: Cool-down, gravity sag, and moisture desorption
- Thermal distortion (long term), material aging (months-years)
- Thermal distortion of optics (esp. PM) and of OTA structure (days)
  - Beam walk (footprint shear across mirror surface mid-SF WFE)
  - Pupil shear on-orbit variations
  - LOWFSC performance
- OTA body pointing or optical misalignment
  - WFE drift
  - Beam walk
  - Pupil shear
  - LOWFSC performance
- LOS and WFE jitter (variation of 100-sec RMS samples)

- IM results will also be used for on-orbit actuator range budget

CGI Performance Requirements that are addressed by IM

Observatory performance is critical to CGI performance
We rely on IM to demonstrate that capability

		Need From Observatory	CGI Control	CGI Reqt (TBR)
Pupil shear error post-launch		0.5 mm	TOMA-F2	0.03 mm
Pupil shear drift during observation		0.001 mm	—	0.001 mm
LoS drift (RMS per axis, equiv on sky)		8 mas	FSM	0.2 mas
LoS jitter (RMS per axis, equiv on sky)		12 mas	FSM	0.4 mas
RMS WFE drift	Focus	10 nm	FCM	0.07 nm
	Astigmatism	1.2 nm	DM	0.05 nm
	Coma	1.2 nm	DM	0.01 nm
	Spherical	1 nm	DM	0.01 nm
RMS WFE jitter	Focus	0.07 nm	—	0.07 nm
	Astigmatism	0.05 nm	—	0.05 nm
	Coma	0.01 nm	—	0.01 nm
	Spherical	0.01 nm	—	0.01 nm