Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-58		OCI Functional Requirements		
OCI-59		Spatial		
OCI-128	MRD-84 MRD-81	Instantaneous Field of View (iFOV)	OCI along track and cross track iFOV, defined as full width half max of one science pixel, shall be between 0.07639 degrees and 0.09296 degrees and verified at 865nm. All other spectral bands shall have an IFOV within +/-10% of the value measured at 865nm.	PACE/OCI is a global ocean, cloud, and aerosols mission. A GSD of 1km enables global science. Req change rationale: The requirement performance is all relative to 865nm
OCI-60	MRD-84 MRD-81	Ground Sample Distance (GSD)	The OCI cross track ground sample distance (GSD), defined as the angle between the centroid of adjacent science pixels, shall be equal to the measured OCI cross IFOV within +1%, -2% The OCI along-track ground sample distance (GSD), defined as the angle subtended at the instrument by successive science pixel centers at scan center, at mission altitude and 20 degrees tilt, shall be between 94 and 98.5 % of the angular size of the measured along-track IFOV. The distance between successive pixel centers shall be the product of the maximum ground speed at mission altitude and the rotational period of the rotating telescope assembly. GSD will be verified at 865nm and shall measured or estimated for all bands.	PACE/OCI is a global ocean, cloud, and aerosols mission. A GSD of 1km enables global science. Req change rationale: The requirement performance is all relative to 865nm
OCI-61	MRD-80	Field of Regard	OCI Field of Regard shall be ±55°	2 day global coverage is to sensor zenith angles of 60 degrees. A LEO orbit between 650km and 700km drive the need for a wide field of regard. At an orbit of 675km 56.5 degrees enables 2 day global coverage to sensor zenith angles to 60 degrees and 1 day global coverage to all sensor zenith angles. The threshold requirement is ±50.0° with a tolerance of +1°,-0° .

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-62	MRD-81 MRD-2032	OCI Tilt	The OCI shall be designed to collect science data with the boresight tilted +/- 20 degrees off nadir in the along track direction and meet pointing requirements within 15 seconds after tilt motion is complete	Mission tilt function is a L1 requirement
OCI-63	MRD-84 MRD-81	Cross-Track Spatial Aggregation	OCI shall have the capability of improved spatial sampling at the edge of scan	To enable reduction of pixel stretch at the edge of scan due to edge of scan geometry
OCI-64		Spectral: UV-VIS-NIR Bands		
OCI-65	MRD-89	Visible Spectral Range	OCI shall have a visible spectral range of 342.5 nm - 887.5 nm 322.5 nm - 342.5 nm is a goal	Visible spectral range enables geophysical retrievals for PACE science products.
OCI-66	MRD-89	Visible Spectral Resolution	OCI shall have a wavelength difference of the center wavelengths for adjacent hyperspectral channels of 5nm ±0.5nm. This requirement shall be verified with 5nm bands only and not spectrally subsampled bands	5nm resolution enables geophysical retrievals for PACE science products
OCI-67	MRD-89 MRD-1993 MRD-2005 MRD-2006	Visible Spectral Resolution Accuracy	The center wavelength of each 5nm band shall be characterized with an accuracy of 0.1 nm, pre-launch. This requirement shall be verified with 5nm bands only and not spectrally subsampled bands	0.1nm accuracy needed to calculate bandwidth for calibration purposes.
OCI-68	MRD-89	Visible Spectral Range Bandwidth	OCI visible spectral range bandwidth shall be 5 nm ± 1.0 nm FWHM	The bandwidth and sampling interval should be as similar as possible, 1nm is an acceptable difference.

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-69	MRD-1993 MRD-2005 MRD-2006	Allowable Visible Relative Spectral Response, RSR (Integrated Out of Band Response)	The ratio of the sum of all integrated out of band response to the integrated in band response shall be less than XX and measured with an uncertainty of YY for each multispectral band with center wavelengths: < 600nm: XX=2.5%, YY=0.25% >600nm and < 900nm: XX=1.0%, YY=0.25% 1) In Band Response is defined by FW1P (Full Width 1%). 2) Out of Band Response (total integrated out of band energy) is defined as 1% of the In-Band peak to 300nm and 1% of the In-Band peak to 2300nm. 3) 1% of the In-band peak shall occur in 10nm or less from the 50% points of the In-Band peak	To understand the spectral radiometric response of each band with respect to all other bands. Req change rationale: Higher uncertainty allocation than original requirement is acceptable, based on results provided by global ocean color product evaluation.
OCI-70	MRD-99	Visible Spectral Subsampling	OCI shall provide spectral subsampling at 1/2, quarter, or eighth of the visible spectral resolution	Enables details of spectral lines for species identification
OCI-71		Spectral: SWIR Bands		
OCI-72	MRD-92	SWIR Bands	OCI shall have the following SWIR bands: 940nm ± 4nm 1038nm ± 2nm 1250nm ± 4nm 1378nm ± 2nm 1615nm ± 10nm 2130nm ± 5nm 2260nm ± 10nm	SWIR spectral range enables geophysical retrievals for PACE science products
OCI-73	MRD-92	SWIR Bandwidth (FWHM)	OCI SWIR bands shall have the following bandwidths Full Width Half Max (FWHM): 940nm: FWHM 45nm ± 4nm 1038nm: FWHM 75nm ± 4nm 1250nm: FWHM 30nm ± 4nm 1378nm: FWHM 15nm ± 2nm 1615nm: FWHM 75nm ± 10nm 2130nm: FWHM 50nm ± 5nm 2260nm: FWHM 75nm ± 5nm	Bandwidth enables geophysical retrievals for PACE science products
OCI-74	MRD-92	SWIR Bandwidth (FW1P)	OCI SWIR bands shall have the following bandwidths Full Width 1% (FW1P): 940nm: FW1P = FWHM * 2 1038nm: FW1P = FWHM * 2 1250nm: FW1P = FWHM * 2 1378nm: FW1P = FWHM * 2 1615nm: FW1P = FWHM * 2 2130nm: FW1P = FWHM * 2 2260nm: FW1P = FWHM * 2	Bandwidth enables geophysical retrievals for PACE science products
OCI-75	MRD-92	SWIR Band Characterization Accuracy	The center wavelength of each SWIR band shall be characterized with an accuracy of 0.1 nm, pre-launch.	Characterization of science bands
OCI-76	MRD-92	SWIR Integrated Out of Band Response	The integrated out of band response of the SWIR bands shall be less than 0.7% for 1378nm and less than 1.0% for 940nm, 1038nm 1250nm, 1615nm, 2130nm, and 2260nm. Out of band is defined by the FW1P	Reduce the uncertainty of the measurement. 1378 is for thin cirrus clouds and requires a tighter filter requirement.
OCI-77		Radiometric Dynamic Range		

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-78	MRD-103	Dynamic Range	OCI shall operate over a dynamic range defined in table 1 that extends from the noise floor to Lmax and meet baseline radiometric precision defined in table 2 from Ltyp to Lmax	The dynamic range identifies the expected radiance that OCI will measure on orbit
OCI-79	MRD-103	Sensor Signal Clipping	OCI shall not clip the measured signal at L_{clip} or L_{max} per table 1	Oceans are a very low signal. Clouds are a very bright signal. OCI must detect both while meeting radiometric performance at Ltyp to enable mission success
OCI-80	MRD-103	Saturation Recovery, S	OCI shall be capable of meeting radiometric performance at Ltyp for all channels within a maximum of 10 seconds after the last pixel intensity of 1.3 times Lmax per table 1.	To limit loss of data for bright sciences greater than Lmax. This specification is meant to limit the impact of saturated pixels on neighboring pixels. No TOA radiances above 1.3 times Lmax are expected to occur on-orbit or when tilting through the glint
OCI-81		Systematic Error (Radiometric Accuracy)		
OCI-82	MRD-1982 MRD-1993 MRD-2005 MRD-2006	Pre Launch Absolute Gain Accuracy, K1	The pre-launch accuracy of the OCI absolute gain factor (1-sigma), K1 (see figure 2) shall be: 2.0% for bands between 340nm - 585nm 2.0% for bands between 615nm - 890nm 5.0% for bands 940nm, 1038nm, 1250nm, 1615nm, 2130nm, 2260nm 8.0% for band 1378nm over the entire operating temperature range, traceable to NIST standards, and shall be established at Ltyp for unpolarized light during prelaunch measurements.	The reason for requiring a better accuracy in this instrument is the expectation that the additional efforts spent on a more accurate prelaunch characterization will translate into a better understanding of the instrument. Note that the on-orbit calibration accuracy after vicarious calibration needs to be 0.2%, therefore it would raise serious concerns if the instrument cannot be calibrated to 2.0% prelaunch. The accuracy of the OCI absolute gain factor, K1 (see figure 3.4.1-1) is 2% threshold (one sigma) for all bands in Table 3.5-1 below 1000nm, and 4% threshold for bands above 1000nm, over the entire operating temperature range, traceable to NIST standards, and shall be established at Ltyp for unpolarized light during prelaunch measurements.

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-83	MRD-2007	On-Orbit Absolute Gain Accuracy, K1 at Time = 0	The accuracy of the OCI absolute gain factor at time = 0 via on-orbit solar calibration (1-sigma), K1 (see figure 2), shall be better than 1.6% for all bands.	Solar calibration absolute gain is the reference gain at t=0. K2 tracks the change in gain over time. This requirement is part of a mission allocation to the OCI solar calibration assembly
OCI-84	MRD-2005 MRD-2006 MRD-2008	On-Orbit Stability, K2 (EOL)	OCI system gain shall vary by less than or equal to +/- 0.1% for multispectral bands over 24 hours. This independent of temperature and linearity corrections. Exception: for 1378nm, compliance is a goal.	On-Orbit Radiometric Response Trending. 15% is the allowable degradation in gain at EOL Req change rationale: Clarifying uncertainty range and band definition. Exceptions for water vapor band, challenging to measure in normal lab conditions.
OCI-85	MRD-2008	Relative On-Orbit Gain Correction, K2 at Time = n (Solar and Lunar Calibration)	The OCI on-orbit relative radiometric response (System Gain Degradation) at Lbright shall be correctable after 3 years with an accuracy of: 0.12% for bands between 340nm - 400nm 0.12% for all bands between 400nm - 890nm 0.12% for bands above 940nm For a single solar calibration measurement, the uncertainty in radiometric response shall be less than: 0.26% for bands between 340nm - 865nm 0.29% for bands above 940nm	On-Orbit Radiometric Response Trending
OCI-86	MRD-367 MRD-368 MRD-369 MRD-370 MRD-371 MRD-2008	Lunar Calibration	OCI shall be capable of viewing the Moon through its Earth-view port and not saturate with a lunar radiance, Llunar, defined in table 1	Lunar calibration is used to track the K2 gain degradation overtime
OCI-87	MRD-117 MRD-373 MRD-374 MRD-375 MRD-1990 MRD-2007 MRD-2008	Daily Bright Target Solar Calibration	OCI shall perform a daily bright target solar calibration via on on-board solar diffuser at one point in the orbit and not saturate during calibration activites	The main purpose of the primary solar diffuser is to detect short term (less than 6 months) radiometric gain sensitivity variations. It can also be used to determine SNR on-orbit. Longer term variations are to be detected with lunar measurements. The radiometric gain degradation measured by the combination of the two solar diffusers shall validate the lunar measurements.

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-88	MRD-117 MRD-373 MRD-374 MRD-375 MRD-1990 MRD-2007 MRD-2008	Monthly Bright Target Solar Calibration	OCI shall perform a monthly bright target solar calibration via on on-board solar diffuser at one point in the orbit and not saturate during calibration activites	The main purpose of the primary solar diffuser is to detect short term (less than 6 months) radiometric gain sensitivity variations. It can also be used to determine SNR on-orbit. Longer term variations are to be detected with lunar measurements. The radiometric gain degradation measured by the combination of the two solar diffusers shall validate the lunar measurements.
OCI-89	MRD-1993 MRD-2005 MRD-2006	Monthly Dim Target Solar Calibration	OCI shall perform a monthly dim target solar calibration via on on-board solar diffuser at one point in the orbit and not saturate during calibration activities	To track instrument response curve changes between Llow and Lbright
OCI-90	MRD-1993 MRD-2005 MRD-2006	Allowable Radiometric Temperature Sensitivity, K3	For a constant radiance source, the variation of dn with temperature over the entire on on-orbit thermal environment shall be less than 2% from Lbright to Lmax	To understand and characterize the radiometric response of the instrument over full expected temperature range on orbit. These characterizations will be used in the final calibration of the data product Req change rationale: The calibration uncertainty is the driving requirement. The allowable change L3 helped bound the FPA design. OCI not compliant in a few cases to the original L3.
OCI-91	MRD-1993 MRD-2005 MRD-2006	Radiometric Temperature Sensitivity Correction, K3	Pre-Launch, OCI temperature sensitivity of the multispectra bands, defined as change in dn with temperature, shall be characterized and correctable to: 340nm - 400nm: 0.15% 400nm - 585nm: 0.12% 615nm - 890nm: 0.13% >940nm: 0.19%	Knowledge of temperature sensitivity makes up part of the artifact budget (square summation limit) Req change rationale: Use unallocated margin to bring requirement to compliance
OCI-92	MRD-1993 MRD-2005 MRD-2006	Allowable Response vs. Scan Angle, K4	For bands between 340nm – 585nm & 615nm – 2260nm the response of OCI to a constant radiance source shall vary with scan angle by less than: 7.0% for the whole scan angle range. 0.5% for scan angles that differ by less than 1degree.	To understand the change in radiometric performance of the telescope as a function on scan angle Req change rationale: The calibration uncertainty is the driving requirement. The allowable change L3 helped bound the optical design. OCI not compliant in a few cases to the original L3.

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-93	MRD-1993 MRD-2005 MRD-2006	Response vs. Scan Angle Correction, K4	The OCI response vs scan angle shall be characterized and correctable with an accuracy of: 0.17% for bands between 340nm - 400nm 0.11% for all bands between 400nm - 585nm 0.11% for all bands between 615nm - 885nm 0.16% for all bands between 940nm – 1378nm 1.00% for all bands between 1615nm -2260nm for all scan angles within the earth view range.	Knowledge of response vs scan angle makes up part of the artifact budget (square summation limit) Req change rationale: Low RVS uncertainty is needed for earth view scan angle range only. The required RVS uncertainty at the solar diffuser scan angle is bound by OCI-83
OCI-94	MRD-1993 MRD-2005 MRD-2006	Instrument Response Curve Shape, K5 (Linearity)	The OCI response curve for dn versus radiance shall be monotonic from Llow to Lmax (or Lclip, whichever is smaller), and, the OCI response (dn) shall not fall below its value at Lmax (or Lclip, whichever is smaller) for radiances from Lmax (or Lclip, whichever is smaller) to 1.3 times Lmax.	To understand the linearity and associated uncertainty of the radiometric response due to radiance levels that span Ltyp - Lmax
OCI-95	MRD-1993 MRD-2005 MRD-2006	Allowable Instrument Response Curve Shape, K5 (Linearity)	The OCI response curve deviation (Max Non-Linearity) shall be less than 6% (K5) from L_{min} to L_{max} or all multispectral bands.	To understand the linearity and associated uncertainty of the radiometric response due to radiance levels that span Lmin/Ltyp - Lmax Req change rationale: OCI-96 is the driving requirement; The calibration uncertainty is the driving requirement. The allowable change L3 helped bound the FPA design. OCI not compliant in a few cases to the original L3.
OCI-96	MRD-1993 MRD-2005 MRD-2006	Instrument Response Curve Correction, K5 (Linearity)	Pre-launch, the OCI response curve shall be characterized and correctable over the instrument temperature range during pre-launch calibration to: Multispectral Bands Between 350nm - 748nm 0.3% from Llow to Lhigh 0.4% from Lhigh to Lbright 2.0% from Lbright to Lmax Multispectral Bands 820nm and 865nm 0.5% from Llow to Lbright 2.0% from Lbright to Lmax Bands Between 940nm - 1378nm 0.25% from Llow to Lbright 2.0% from Lbright to Lmax Bands Between 1615nm - 2260nm 2.0% from Llow to Lmax The Lbright-Lmax specification in OCI-96 shall only apply to bands that do not saturate below Lmax.	Knowledge of linearity makes up part of the artifact budget (square summation limit) Req change rationale: Some bands saturate below Lmax (e.g. the high gain bands), and they do not meet the spec as written(they are very nonlinear from Lbright to Lmax). Use unallocated margin to bring requirement to compliance

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-97	MRD-1993 MRD-2005 MRD-2006	Instrument Response Curve Stability, K5 (Linearity) (EOL)	EOL On-Orbit, uncertainty due to the shape of the response curve from linear shall be less than (this does not include fixed gain and offset): Multispectral Bands Between 350nm - 748nm 0.3% from Llow to Lhigh 0.4% from Lhigh to Lbright 3.0% from Lbright to Lmax Multispectral Bands 820nm and 865nm 0.5% from Llow to Lbright 3.0% from Lbright to Lmax	End of life instrument response curve Req change rationale: Update match the linearity requirement in OCI-96
OCI-98	MRD-1993 MRD-2005 MRD-2006	Allowable Polarization, P	The radiometric response of OCI shall vary by less than 1% for wavelengths between 345nm - 890nm and 2% for wavelengths above 900nm for all linear polarization angles and view angles of a radiance source between Ltyp and Lmax for all science bands except for the spectrograph transition region. (P) Spectrograph Transition Region: 590.5nm - 609.5nm	To understand the radiometric response due to different light polarization Req change rationale: 340nm is not a critical ocean color wavelength. Higher polarization is acceptable, as long as 345nm meets the requirement
OCI-99	MRD-1993 MRD-2005 MRD-2006	Polarization Correction, P	OCI linear polarization sensitivity shall be characterized and correctable to: 0.17% for bands between 340nm - 400nm 0.11% for all bands between 400nm - 890nm Bands above 940nm will be characterized pre-launch but are not correctable.	Knowledge of polarization makes up part of the artifact budget
OCI-100	MRD-1993 MRD-2005 MRD-2006	High Contrast & Spatial Crosstalk (Straylight Requirement)	For a global top-of-atmosphere radiances based on measured MODIS radiances, the global average residual contamination shall be less than 0.4% for 350nm, 360nm, 385nm, 555nm, 583nm, 820nm and 865nm and less than 0.20% for all other multispectral bands. For OCI pre-launch verification, the goal PSF is shown in Figure 3. See OCI-SCI-TN-0120 for detailed explanation	Accurate resolution of high contrast in TOA radiance images is important to estimate stray light contamination due to clouds, and for studying small scale features like ocean fronts and for working in coastal and estuarine areas where the scales are 1km. This occurs in all wavelengths in the spatial direction. Knowledge of high contrast resolution makes up part of the artifact budget. The PSF provided by OCI PDR Design meets the requirement as do any PSFs with smaller values. Even multiplying the PSF by a factor 4 (except for the central (receiver) value) meets the above specification. Req change rationale: Higher uncertainty allocation than original requirement is acceptable based on results provided by global ocean color product evaluation.
OCI-105	MRD-1993 MRD-2005 MRD-2006	Uniform Scene Artifacts Correction, U (Striping)	There shall be no discontinuities greater than 0.1% after correction in the measured radiance in one band as a function of scan angle or in track direction. (Striping)	Knowledge of striping makes up part of the artifact budget

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-106	MRD-1993 MRD-2005 MRD-2006	Offset, DNo (Dark Scan, Gain Offset Calibration)	OCI shall perform a dark calibration once per scan	To bias out dark noise of the instrument radiometric response
OCI-107	MRD-1993 MRD-2005 MRD-2006	Offset, DNo Gain Offset Correction	OCI system offset contribution to radiometric uncertainty at Ltyp shall be known to: 0.15% Relative to Ltyp, Pre-Launch	Required number of samples to remove bias Req change rationale: Measured bias at 2260nm between OCI drum and cold TVAC shroud slightly above allocation.
OCI-108	MRD-1993 MRD-2005 MRD-2006	Fiber Optics, SWIR, K6	EOL Radiometric uncertainty of bands >940nm due to fiber optics implementation shall be less than 0.25%	SWIR fiber optics implementation adds radiometric uncertainty to the SWIR bands
OCI-109		Random Error (Radiometric Precision)		
OCI-110	MRD-1993 MRD-2005 MRD-2006	SNR (Flat Field)	OCI shall meet the Signal-to-Noise ratios with a uniform spectral radiance in all science pixels (flat field) at Ltyp at the bandwidth as defined in Table 2 for all bands.	To enable required precision to meet PACE geophysical science products
OCI-111		Spectral Stability		
OCI-113	MRD-1993 MRD-2005 MRD-2006	Spectral Temperature Sensitivity (Stability)	The maximum variation of the center wavelength over the whole range of expected on-orbit instrument temperatures shall be less than 0.5nm during science and calibration data collection	Spectral shifts reduce the radiometric accuracy and long tern calibration trending curves
OCI-114	MRD-1993 MRD-2005 MRD-2006	Spectral Temperature Sensitivity Accuracy	Spectral temperature sensitivity measurements shall be made with an accuracy of 0.1nm per degree Kelvin over the whole range of expected on-orbit instrument temperatures during science and calibration data collection	Spectral shifts reduce the radiometric accuracy and long term calibration trending curves
OCI-116	MRD-113 MRD-114 MRD-115 MRD-1983	On-Orbit Allowable Spectral Stability	On-Orbit, After Launch, OCI spectral stability shall change no more than 0.5nm per year and no more than 1nm after 3 years.	On-Orbit Radiometric Response Trending

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-117	MRD-113 MRD-114 MRD-115 MRD-1983	On-Orbit Spectral Stability Correction	On-Orbit, After Launch, OCI shall characterize the spectral accuracy to 0.5 nm.	On-Orbit Radiometric Response Trending
OCI-118		Navigation and Registration		
OCI-119	MRD-85 MRD-1990	Pointing Knowledge	OCI pointing knowledge allocation shall be per the TAR PACE-REQ-SYS-0020.	Geolocation is needed to geophysical products and mapping
OCI-121	MRD-87 MRD-1990	Pointing Stability	OCI pointing stability allocation shall be per the TAR PACE-REQ-SYS-0020.	The IFOVs of adjacent pixels in scan and track direction shall not have gaps greater than 5m in spatial coverage, whereas overlap is acceptable. The spacing of the pixel center ground locations for adjacent scan lines will be within 10% of the along-track IFOV.. To ensure global coverage and data is not missed

Req ID	Parent	Requirement Title	Requirement Statement	Rationale
OCI-122	MRD-1968	Band-to-Band Registration	Spatial band-to-band registration between any two bands shall be greater than 80% of one IFOV.	It is desired for each band to be taken at the same time on the same place on earth
OCI-123	MRD-1967	Simultaneity	Temporal measurement (simultaneity) of all bands within one IFOV shall be less than 0.02 seconds (20 milliseconds).	To enable an accurate account of all spectral content in time at a particular ground scene
OCI-124	MRD-346	International Atomic Time	OCI shall use International Atomic Time (TAI) as the time reference on-board	Heritage FSW is baselined
OCI-126		Image Quality		
OCI-127	MRD-84 MRD-1965	Modulation Transfer Function (MTF)	Design Requirement: The MTF in both track and scan direction shall equal or exceed: Fraction of Nyquist GSD Sample Frequency (MTF Req) 0.00 (1.0), 0.25 (0.9), 0.50 (0.7), 0.75 (0.5), 1.00 (0.3) Test Requirement: This requirement will be verified in the lab during the LSF measurement. See OCI-SCI-ANYS-0072 for description	The sensor Line Spread Function (LSF) in the along-track (cross-track) direction is defined as the response to a line slit test pattern oriented in the cross-track (along-track) direction. The Modulation Transfer Function (MTF) in the along-track (cross-track) direction is defined as the magnitude of the normalized Fourier Transform of the sensor LSF in the along-track(cross-track) direction. The MTF is a function of spatial frequency, and it is equal to one at the origin by virtue of the normalization condition of the LSF. As used here, MTF applies to the on-orbit sensor performance and includes contributions from diffraction, optical aberrations, detector field-of-view, integration drag, aggregation, TDI, crosstalk, electronic response, jitter disturbances, and charge transfer efficiency.