GEO-CAPE Oceans
Coastal Ecosystem Dynamics

Oceans Science Working Group

presented by
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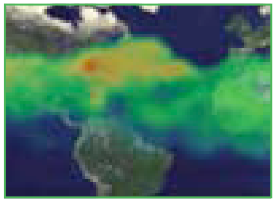
Outline

- Background/Mission Overview
- Atmospheric Science
- SWG Ocean Members
- Science Traceability Matrix
- Instrument Design Study
- GOCI

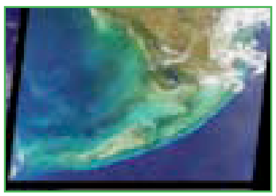
GEOSTATIONARY COASTAL AND AIR POLLUTION EVENTS (GEO-CAPE)

Launch: 2013-2016 Mission Size: Medium

Science



Identification of human versus natural sources of aerosols and ozone precursors



Dynamics of coastal ecosystems, river plumes, and tidal fronts

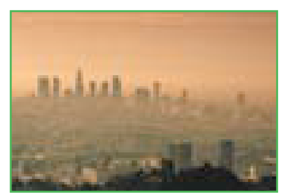
Observation of air pollution transport in North, Central, and South America

Applications Societal Benefits

Prediction of track of oil spills, fires, and releases from natural disasters

Detection and tracking of waterborne hazardous materials

Coastal health



Forecasts of air quality

credit: NRC 2007

View from Geostationary orbit

95 W & Equator

36,000 km altitude

courtesy of Janet Campbell with revisions

GEO-CAPE could track oil spill in Gulf of Mexico with sub-hourly imagery

MODIS image

Decadal Survey Summary

GEO-CAPE Coastal Waters Science Objectives from NRC Decadal Survey:

- To quantify the **response of marine ecosystems to short-term physical events**, such as passage of storms and tidal mixing.
- To assess the **importance of high temporal variability in coastal-ecosystem models**.
    - Both short-term and long-term forecasts of the coastal ocean require better understanding of critical processes and sustained observing systems.
- To **monitor biotic and abiotic material in transient surface features**, such as river plumes and tidal fronts.
- To **detect, track and predict the location of sources of hazardous materials**, such as oil spills, waste disposal, and harmful algal blooms.
- To **detect floods** from various sources, including river overflows.

Societal benefits from GEO-CAPE oceans mission

- Prediction of fisheries yield through improvement of models and model forecasting.
- Detection and tracking of hazards that relate to human health.
- Link data to models and decision-support tools and processes.
  e.g., to predict the occurrence and extent of hypoxic regions ("dead zones")

Joint Atmospheric Chemistry - Coastal Ocean Mission

Multiple Instruments (TBD)

- UV-VIS-NIR hyperspectral sensor plus SWIR bands with high spatial resolution (250 to 400 m)
    - Primarily for Coastal Ocean Ecosystem Dynamics
- UV-VIS hyperspectral sensor with coarser resolution (2 to 7 km)
- CO sensor
- Thermal Infrared sensor

Atmospheric Science Questions & Measurements

1. What are the temporal and spatial variations of **emissions of gases and aerosols** that are important for air quality and climate?
2. How do **physical, chemical, and dynamical processes** determine tropospheric compositions and air quality over scales ranging from urban to continental, diurnally to seasonally?
3. How does **air pollution drive climate forcing** and how does **climate change affect air quality** on a continental scale?
4. How do we **improve air quality forecasts** and assessments for societal benefit?
5. How do **regional and intercontinental transport** affect local and regional air quality?
6. How do **episodic events**, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

Baseline measurements

O3, NO2, CO, SO2, HCHO, CH4, NH3, CHOCHO, different sampling frequencies, 4 km horizontal spatial footprint size at nadir; and
AOD, AAOD, AI, aerosol optical centroid height (AOCH), cloud detection, hourly for SZA<70 and 1 km horizontal spatial footprint size at nadir.

Threshold measurements

CO hourly day and night, and O3, NO2, SO2, hourly for SZA<70, at 8 km horizontal spatial footprint at nadir; AOD hourly (SZA<70) at 2 km.

GEO-CAPE aerosol-atmospheres Science Traceability Matrix as approved by Science Working Group in March 2010

GEO-CAPE Oceans Science Working Group (SWG)

NASA HQ Mission Leads: Paula Bontempi & Jassim Al-Saadi (Fred Lipshultz)
Coordinator: Laura Iraci (NASA ARC)

Science Working Group:

Bob Arnone
Barney Balch*
Janet Campbell (co-lead)
Francisco Chavez
Chuanmin Hu*
Paula Coble
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Ru Morrison
Colleen Mouw*
Frank Muller-Karger*
Joe Salisbury
Heidi Sosik
Rick Stumpf
Omar Torres
Maria Tzortziou*
Menghua Wang

*** 6 New Members since 2009 OCRT Meeting**
Others are Welcome to Join

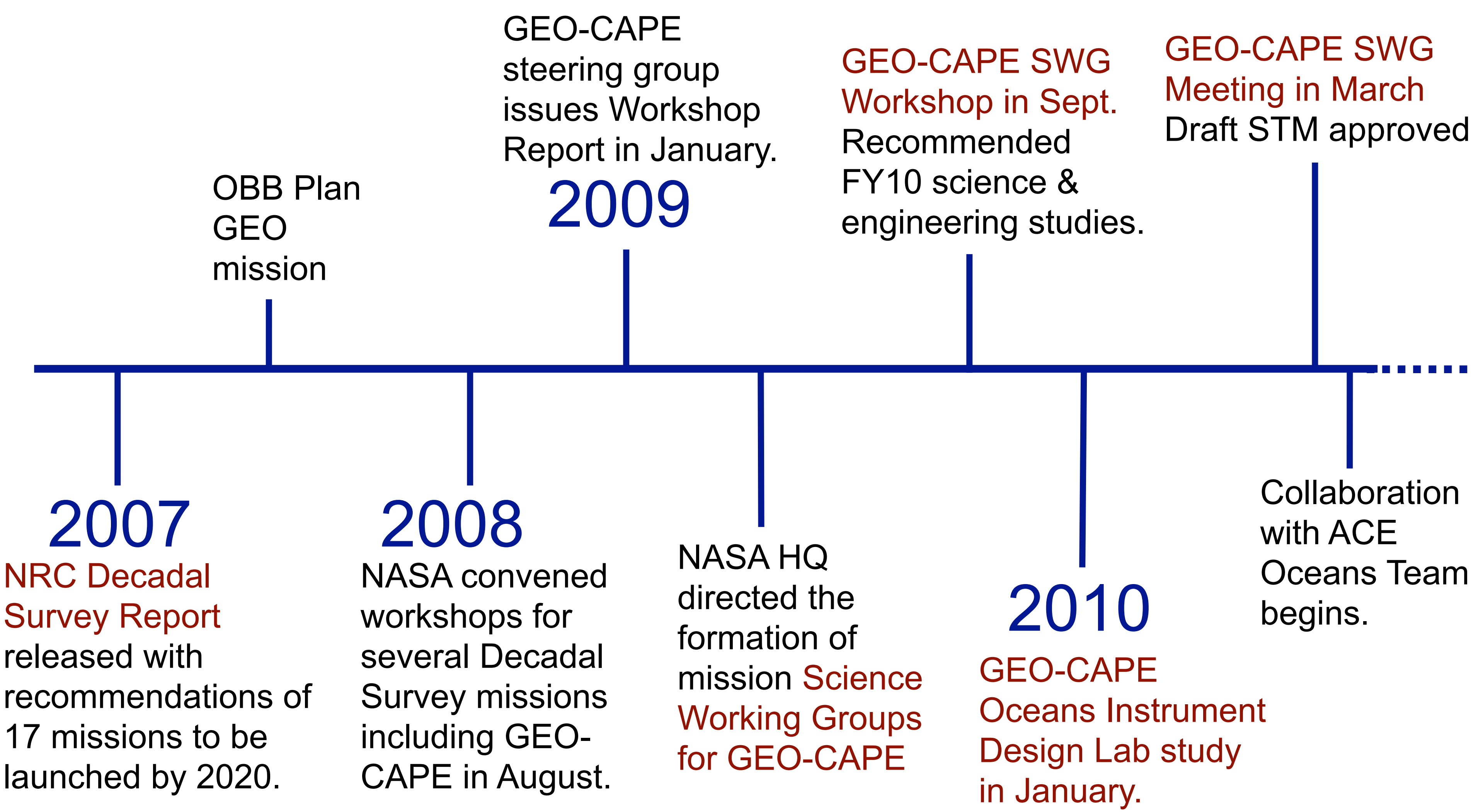
Objectives

Develop mission Science Traceability Matrix (STM) for Coastal Oceans

- Define ocean science questions for GEO-CAPE mission
- Establish measurement & instrument requirements
- Advise HQ on required scientific & engineering studies

Prepare documentation to advance mission to Phase-A

Timeline of GEO-CAPE Activities



GEO-CAPE Oceans STM

Draft v.2.7 - March 24, 2010

Science Focus	Science Questions
Short-Term Processes	**1** How do short-term coastal and open ocean processes interact with and influence larger scale physical, biogeochemical and ecosystem dynamics? (OBB1)
Land-Ocean Exchange	**2** How are variations in exchanges across the land-ocean interface related to changes within the watershed, and how do such exchanges influence coastal and open ocean biogeochemistry and ecosystem dynamics? ‡ (OBB1 & 2)
Impacts of Climate Change & Human Activity	**3** How do natural and anthropogenic changes including climate-related forcing impact coastal ecosystem biodiversity and productivity? ‡ (OBB1, 2 & 3)
SYNERGY Impacts of Airborne-Derived Fluxes	**4** How do airborne-derived fluxes from precipitation, fog and episodic events such as fires, dust storms & volcanoes significantly affect the ecology and biogeochemistry of coastal and open ocean ecosystems? (OBB1 & 2)
Episodic Events & Hazards	**5** How do episodic hazards, contaminant loadings, and alterations of habitats impact the biology and ecology of the coastal zone? (OBB4)

Approach

PRODUCTS

Standing Stocks: Aquatic chlorophyll a, POC, DOC, PIC, DIC*, inherent & apparent optical properties, total suspended matter, phytoplankton biomass*, pigments* and key functional groups, terrigenous DOC*, & black carbon*.

Rate Measurements: Aquatic primary productivity, respiration*, air-sea CO2 fluxes*, photooxidation, phytoplankton fluorescence responses*, phytoplankton vertical migration*, net community production of DOC* and POC*, and other associated trophic responses*

Hazards: Aquatic HABs, petroleum-derived hydrocarbons, and other pollutants*.

***Products not currently derived from ocean color observations.**

Approach	Maps to Science Question
Targeted, high-frequency, episodic event-based monitoring and evaluation of tidal and diurnal variability of Standing Stocks, Rate Measurements and Hazards from river mouths to the coastal ocean (and lakes).	1 2 4 5
Routine sampling of seasonal and interannual variations in the Standing Stocks, Rate Measurements and Hazards for estuarine and continental shelf regions with linkages to open-ocean processes at appropriate spatial scales.	2 3 5
Observe coastal region at sufficient spatial scales to resolve near-shore processes, coastal fronts, eddies, and track carbon pools and pollutants.	1 2 5
Integrate GEO-CAPE observations with field measurements, models and other satellite data: 1. To derive coastal carbon budgets and determine whether coastal ecosystems are sources or sinks of carbon to the atmosphere	1 2
2. To quantify the responses of coastal ecosystems and biogeochemical cycles to river discharge, land use change, airborne-derived fluxes, hazards and climate change.	1 2 3 4 5
3. To estimate fishery yields, extent of oxygen minimum zones, and ecosystem health (including ocean acidification).	3 5

Measurement Requirements

Water-leaving radiances in the near-UV, visible & NIR for separating absorbing & scattering constituents & chlorophyll fluorescence

Product uncertainty TBD

Temporal Resolution:
Targeted Events:
- Threshold: 1 hour
- Goal: 0.5 hour

Routine Coastal U.S.:
- Threshold: ≤3 hours
- Goal: 0.5 hour

Regions of Special Interest (RSI): Threshold: 1 RSI 3 scans/day
- Goal: multiple RSI 3 scans/day

Other Coastal N. & S. America 50°N to 45°S:
- Threshold: 4 times/yr
- Goal: ≤3 hours

Spatial Resol. (nadir):
- Threshold: 375 x 375 m
- Goal: 250 x 250 m

Field of Regard for Ocean Color Retrievals:
50°N to 45°S;
162.5°W to 32.5°W

Coastal Coverage:
width from coast to ocean:
- Threshold: 375 km
- Goal: 500 km

RSI: Amazon & Orinoco River plumes, Peruvian upwelling, Cariaco Basin, Bay of Fundy, Rio Plata, etc. (TBD)

Instrument Requirements

Spectral Range:
Hyperspectral UV-VIS-NIR
- Threshold: 345-900 nm; 3 SWIR bands 1245, 1640, 2135 nm
- Goal: 340-1100 nm; 3 SWIR bands 1245, 1640, 2135 nm

•Spectral Resolution:
- Threshold: UV-VIS: 0.5 nm FWHM; NIR: 1 nm; SWIR: 20-50 nm
- Goal: UV-VIS: 0.25 nm FWHM; NIR: 0.5 nm; SWIR: 20-50 nm
  - Retrieval of NO_2 and O_2 A-band for atm. corrections? (TBD)

Signal-to-Noise Ratio (SNR):
- Threshold: 1000:1 for 10 nm FWHM (380-800 nm); 600:1 for 40 nm FWHM in NIR; 300:1 to 100:1 for SWIR bands (20-50nm FWHM)
- Goal: 1500:1 for 10 nm FWHM (380-800 nm); 600:1 for 40 nm FWHM in NIR; 300:1 to 200:1 for SWIR bands (20-50nm FWHM); 400:1 NO_2 band (TBD)

see Measurement Requirements for Temporal & Spatial Resolutions and Field of View.

Field of Regard:
- ±9° N to S & E to W imaging capability from nadir for Lunar & Solar Cals.

Jitter
- Threshold: <25% pixel size during single exposure
- Goal: TBD

Non-saturating detector array(s) at Lmax

On-board Calibration:
- Monthly Lunar Calibration at ≤7° phase angle
- Weekly to Bi-weekly Solar Calibration (TBD)

Polarization: <0.5%

Relative Radiometric Precision:
- Threshold: 1% through mission lifetime
- Goal: 0.5% through mission lifetime

Mission lifetime: Threshold: 3 years; Goal: 5 years

Intelligent Payload Module: Near Real-Time satellite data download from other sensors (GOES, etc.) for on-board autonomous decision making: (TBD)
- To bypass scanning mostly cloudy scenes; Targeting events (e.g., HABs)

Pre-launch characterization: to achieve radiometric precision above on orbit

Solar Zenith Angle Sensitivity: Threshold: ±70°; Goal: ±75°

Platform Requirem.

Geostationary orbit to permit sub-hourly observations of coastal waters adjacent to the continental U.S., Central and South America

Storage and download of full spatial data and spectral data.

Ancillary Data Requirem.

Western hemisphere data sets from models, missions, or field observations:

Measurement Requirements
(1) Ozone
(2) Total water vapor
(3) Surface wind velocity
(4) Surface barometric pressure
(5) NO2 concentration
(6) Vicarious calibration & validation - coastal
(7) Full prelaunch characterization

Science Requirements
(1) SST
(2) SSH
(3) PAR
(4) UV
(5) MLD
(6) CO2
(7) pH
(8) Ocean circulation
(9) Tidal & other coastal currents
(10) Aerosol & dust deposition
(11) run-off loading in coastal zone
(12) Wet deposition in coastal zone

Validation Requirements
Conduct high frequency field measurements and modeling to validate GEO-CAPE retrievals from river mouths to beyond the edge of the continental margin.

‡ Climate change-related science questions

GEO-CAPE Science Questions are traceable to NASA's OBB Advanced Planning Document ….

* Coverage area within field-of-view (FOV) includes major estuaries and rivers such as Chesapeake Bay & Lake Pontchartrain/Mississippi River delta, e.g., the Chesapeake Bay coverage region would span west to east from Washington D.C. to several hundred kilometers offshore (total width of 375 km threshold).

GEO-CAPE Oceans STM

Draft v.2.7 - March 24, 2010

Focus	Science Questions	Decadal Survey Ocean Objectives
Short-Term Processes	1 **How do short-term coastal and open ocean processes interact with and influence larger scale physical, biogeochemical and ecosystem dynamics?** (OBB1)	"To quantify the response of marine ecosystems to short-term physical events; To assess the importance of high temporal variability in coupled biological-physical coastal-ecosystem models;
Land-Ocean Exchange	2 **How are variations in exchanges across the land-ocean interface related to changes within the watershed, and how do such exchanges influence coastal and open ocean biogeochemistry and ecosystem dynamics?** (OBB1 & 2)	To monitor biotic and abiotic material in transient surface features, such as river plumes and tidal fronts;
Impacts of Climate Change & Human Activity	3 **How do natural and anthropogenic changes including climate-related forcing impact coastal ecosystem biodiversity and productivity?** (OBB1, 2 & 3)	To detect, track, and predict the location of sources of hazardous materials, such as oil spills, waste disposal, and harmful algal blooms; and to detect floods from various sources, including river overflows."
SYNERGY **Impacts of Airborne-Derived Fluxes**	4 **How do airborne-derived fluxes from precipitation, fog and episodic events such as fires, dust storms & volcanoes significantly affect the ecology and biogeochemistry of coastal and open ocean ecosystems?** (OBB1 & 2)	"A primary objective for observing coastal ocean regions is to determine the impact of climate change and anthropogenic activity on primary productivity & ecosystem variability". ***NRC DS 2007, pp. 104-105***
Episodic Events & Hazards	5 **How do episodic hazards, contaminant loadings, and alterations of habitats impact the biology and ecology of the coastal zone?** (OBB4)	

Science Questions are traceable to NASA's OBB Advanced Planning Document

GEO-CAPE Oceans STM

Draft v.2.7 - March 24, 2010

Focus	Approach	Decadal Survey
Short-Term Processes **Land-Ocean Exchange** **Impacts of Climate Change & Human Activity** **SYNERGY Impacts of Airborne-Derived Fluxes** **Episodic Events & Hazards**	**PRODUCTS** Standing Stocks: Aquatic chlorophyll a, POC, DOC, PIC, DIC*, inherent & apparent optical properties, total suspended matter, phytoplankton biomass*, pigments* and key functional groups, terrigenous DOC*, & black carbon*. Rate Measurements: Aquatic primary productivity, respiration*, air-sea CO2 fluxes*, photooxidation, phytoplankton fluorescence responses*, phytoplankton vertical migration*, net community production of DOC* and POC*, and other associated trophic responses*. Hazards: Aquatic HABs, petroleum-derived hydrocarbons, and other pollutants*. ***Products not currently derived from ocean color observations.**	"Ocean data products include measurements of chlorophyll, particulate and dissolved organic matter, turbidity, and phytoplankton growth rates. Primary productivity, particulate inorganic carbon (organic sediment), and land-ocean carbon fluxes are other target quantities detectable or inferrable from ocean spectral measurements ..." "The GEO-CAPE mission would provide observations of aerosols, organic matter, phytoplankton, and other constituents of the upper coastal ocean at multiple times in the day ..." ***NRC DS 2007, pp. 104, 208***

GEO-CAPE Oceans STM

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Focus	Approach	Maps to Science Question
Short-Term Processes	**Targeted, high-frequency, episodic event-based monitoring and evaluation of tidal and diurnal variability** of Standing Stocks, Rate Measurements and Hazards from river mouths to the coastal ocean	1 2 4 5
Land-Ocean Exchange	**Routine sampling of seasonal and interannual variations** in the Standing Stocks, Rate Measurements and Hazards for estuarine and continental shelf regions with linkages to open-ocean processes at	2 3 5
	Observe coastal region at sufficient **spatial scales to resolve near-shore processes, coastal fronts, eddies, and track carbon pools and pollutants.**	1 2 5
Impacts of Climate Change & Human Activity	**Integrate GEO-CAPE observations with field measurements, models and other satellite data:** 1. To **derive coastal carbon budgets** and determine whether coastal ecosystems are sources or sinks of carbon to the atmosphere.	1 2
SYNERGY Impacts of Airborne-Derived Fluxes	2. To **quantify the responses** of coastal ecosystems and biogeochemical cycles **to river discharge, land use change, airborne-derived fluxes, hazards and climate change.**	1 2 3 4 5
Episodic Events & Hazards	3. To **estimate fishery yields, extent of oxygen minimum zones, and ecosystem health** (including ocean acidification).	3 5

GEO-CAPE Oceans STM

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Instrument Requirements-1

		Threshold	Goal	NRC DS
Spatial Resolution	nadir (m)	375 x 375 m	250 x 250 m	250 m
Temporal Resolution	Routine U.S. Coastal Waters	≤3 hours	0.5 hour	multiple times per day
	Targeted Events	1 hour	0.5 hour	multiple times per day
	Regions of Special Interest	1 RSI 3 scans/day	multiple RSI 3 scans/day	multiple times per day
	Other Coastal N. & S. America 50°N to 45°S	4 times/yr	≤3 hours	
Coastal Coverage	width from coast to ocean	375 km	500 km	300 km
US Coastal Waters (US CW)	Includes bays, estuaries, lakes and rivers	US CW 375 km wide, Great Lakes and major rivers*	US CW 500 km wide, Great Lakes and major rivers	
Regions of Special Interest (RSI)		Amazon & Orinoco River plumes, Peruvian upwelling, etc.	All other CW from 45 S to 50 N latitude within 300 km from shore	Amazon & Orinoco River plumes, Peruvian upwelling, other E. boundary currents, etc.

* Coverage area width includes major estuaries and rivers such as Chesapeake Bay & Lake Pontchartrain/Mississippi River delta, e.g., the Chesapeake Bay coverage region would span west to east from Washington D.C. to several hundred kilometers offshore (total width of 375 km minimum).

GEO-CAPE Oceans STM

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Instrument Requirements-2

		Threshold	Goal	NRC DS
Spectral Range	Hyperspectral UV-VIS-NIR; Multispectral SWIR	345-900 nm; SWIR bands: 1245, 1640 & 2135 nm	340-1100 nm; SWIR bands: 1245, 1640 & 2135 nm	350 - 1050 nm
Spectral Resolution		UV-VIS: 0.5 nm; NIR: 1 nm; SWIR: 20-50 nm	UV-VIS: 0.25 nm; NIR: 0.5 nm; SWIR: 20-50 nm (NO_2 & O_2 A-band	
Signal-to-Noise Ratio (SNR)	For Ocean Scenes at specified Ltyp: See excel spreadsheet	- UV-VIS: 1000:1 (10nm bands); - NIR: 600:1 (40nm) - SWIR: 300 to 100:1 (20-50nm bands)	- UV-VIS: 1500:1 (10nm bands); - NIR: 600:1 (40nm); - SWIR: 300 to 200:1 (20-50nm bands)	"high signal-to-noise ratio"
Field of Regard Ocean Color		50°N to 45°S 162.5°W to 32.5°W		

"[GEO-CAPE] would have the temporal spatial resolution necessary to resolve critical processes in the coastal ocean, and it would have the sensor capabilities (signal-to noise ratio, spectral resolution, and so on) needed to de-convolve the complex atmospheric and ocean optical signals". **NRC DS 2007 p. 209**

GEO-CAPE Oceans STM

Draft v.2.7 - March 24, 2010

Instrument Requirements-3

		Threshold	Goal
Solar Zenith Angle (SZA) sensitivity		±70°	±75°
Sensitivity & Saturation		High sensitivity but non-saturating detector arrays	
Cloud Avoidance to Maximize Coverage	TBD	Intelligent Payload Module: near real time cloud avoidance with GOES data	
Field of Regard	Lunar Calibration	±9° N to S & E to W imaging capability from nadir to observe the moon at ≤7° phase angle	
	Solar Calibration	TBD - On-board solar diffuser for weekly to bi-weekly calibrations	
Polarization		<0.5%	

GEO-CAPE Oceans STM

Instrument Requirements-4

		Threshold	Goal
Jitter (pixel tracking)		<25% pixel size during single exposure	TBD (~10% pixel size during single exposure)
Relative Radiometric Precision	UV-VIS-NIR & SWIR	1% through mission lifetime	0.5% through mission lifetime
Pre-launch Characterization	Complete	to achieve relative radiometric precision on orbit	
Orbit / Location	Geostationary	95°W	
Measurements from Other Sensors	NO_2, ozone, total water vapor, surface wind velocity, Atm. pressure	Contemporaneous Atmospheric NO_2, aerosols and ozone from other GEO-CAPE sensor.	
Lifetime Design	Class B	3 years	5 years

95 W View

courtesy of Janet Campbell with revisions

GEO-CAPE
Coastal Ecosystems Dynamics Imager (CEDI)
Instrument Design Lab Study
January 25-29, 2010

GSFC IDL Team,
Scott Janz, Jay Smith, Antonio Mannino

Other Participants: Janet Campbell, Jay Al-Saadi, Richard Key,
Fred Lipshultz, Kate Hartman & Doreen Neil
with contributions from: Chuanmin Hu, Chuck McClain & Zhongping Lee

NASA OCRT Meeting - May 11-13, 2010

IDL Study Objectives & Questions

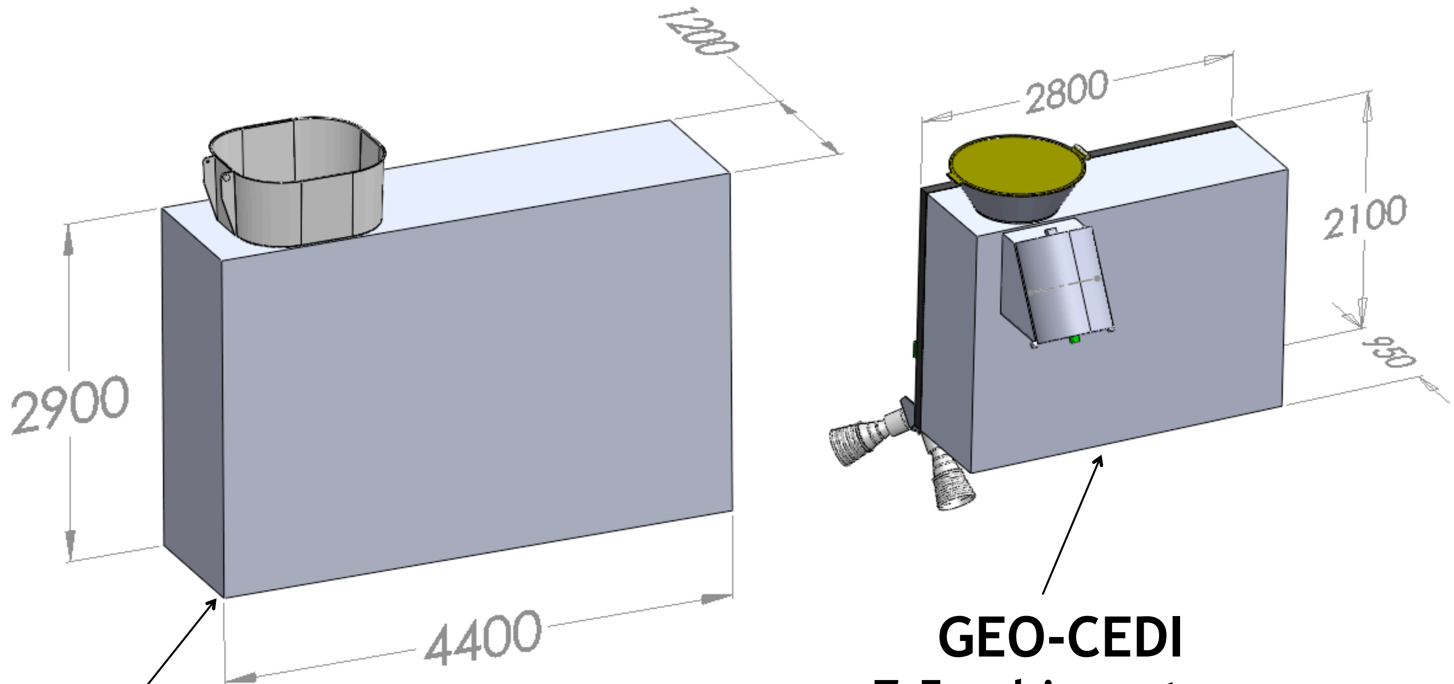
- **Primary objective:** instrument design that meets and exceeds the oceans threshold requirements.
  - reduce volume and mass of GEO-MDI (<half volume)
- Which science requirements drive size/mass/cost?
- What goal requirements can be met with minimal impact to instrument size, mass and cost?
- How frequently can we image US coastal waters and regions of special interest?
- What technological innovations are most critical to meet threshold/goal requirements?
- Provide estimates of achievable pointing knowledge, stability, and accuracy with mechanism support.

Design Discussions/ Evolution

Optics

- CEDI design is a modification of the previous IDL design of the MDI instrument in 2006 (250m spatial resolution).
- Assuming 375m spatial resolution per pixel which allowed implementation of a 0.5 m Primary and shrinking of optical layout reducing the volume.
- Telescope focal length set for 1:1 Offner Spectrograph designs
    - Effective focal length = 1717.728 mm, F/3.44 focal ratio
- UV-VIS-NIR split into 2 bands
    - 345 nm to 600 nm
    - 600 nm to 900 nm (up to 1100 nm achievable but QE of detector is very low at >1 micron)
- SWIR band - 1225 to 2160 nm
- All detectors have 18 μm pixels

Volume Comparison

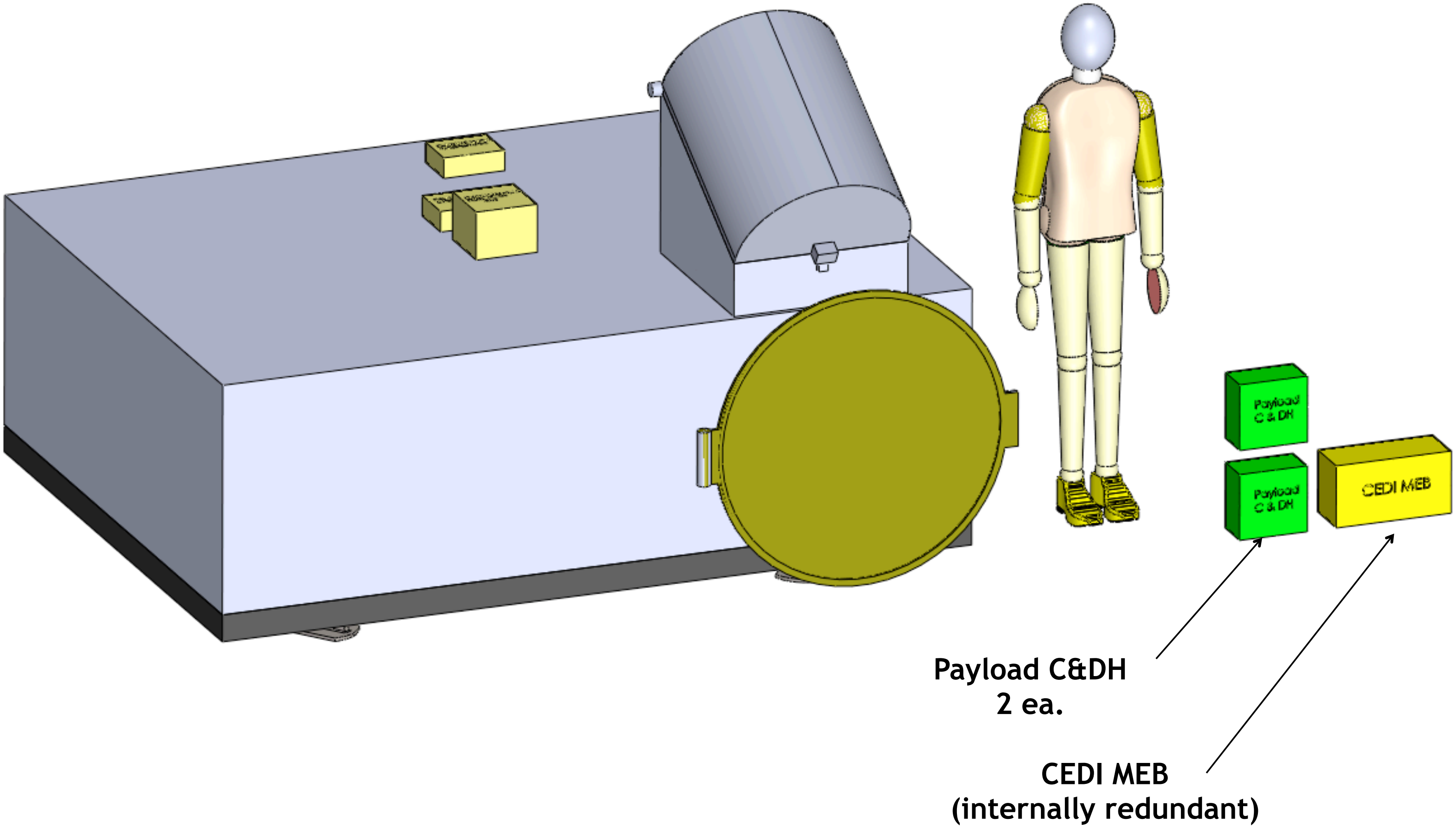


GEO-CEDI
7.5 cubic meters
(includes calibration assy. volume)

GEO-MDI
15.3 cubic meters
(includes calibration assy. Volume)

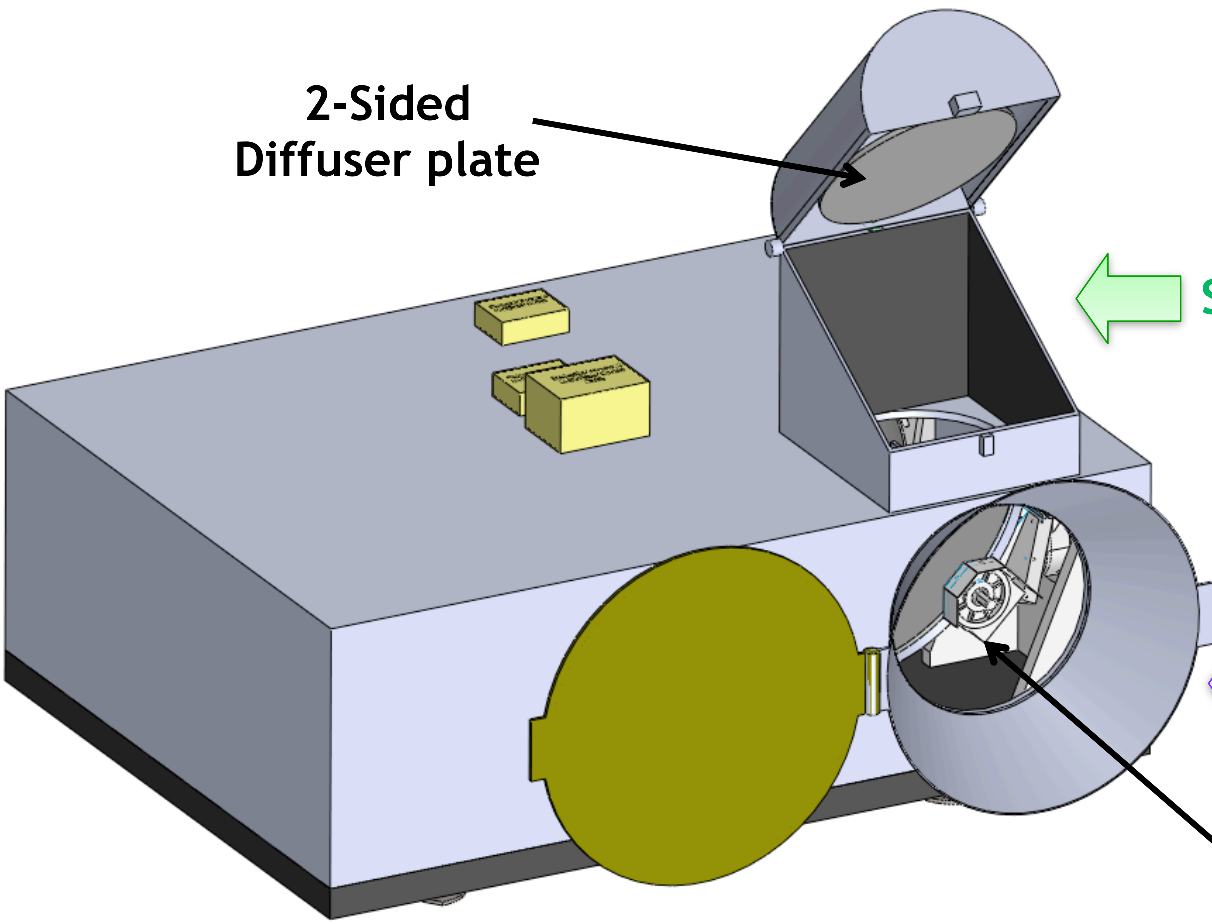
Note: dimensions in millimeters

Relative Size

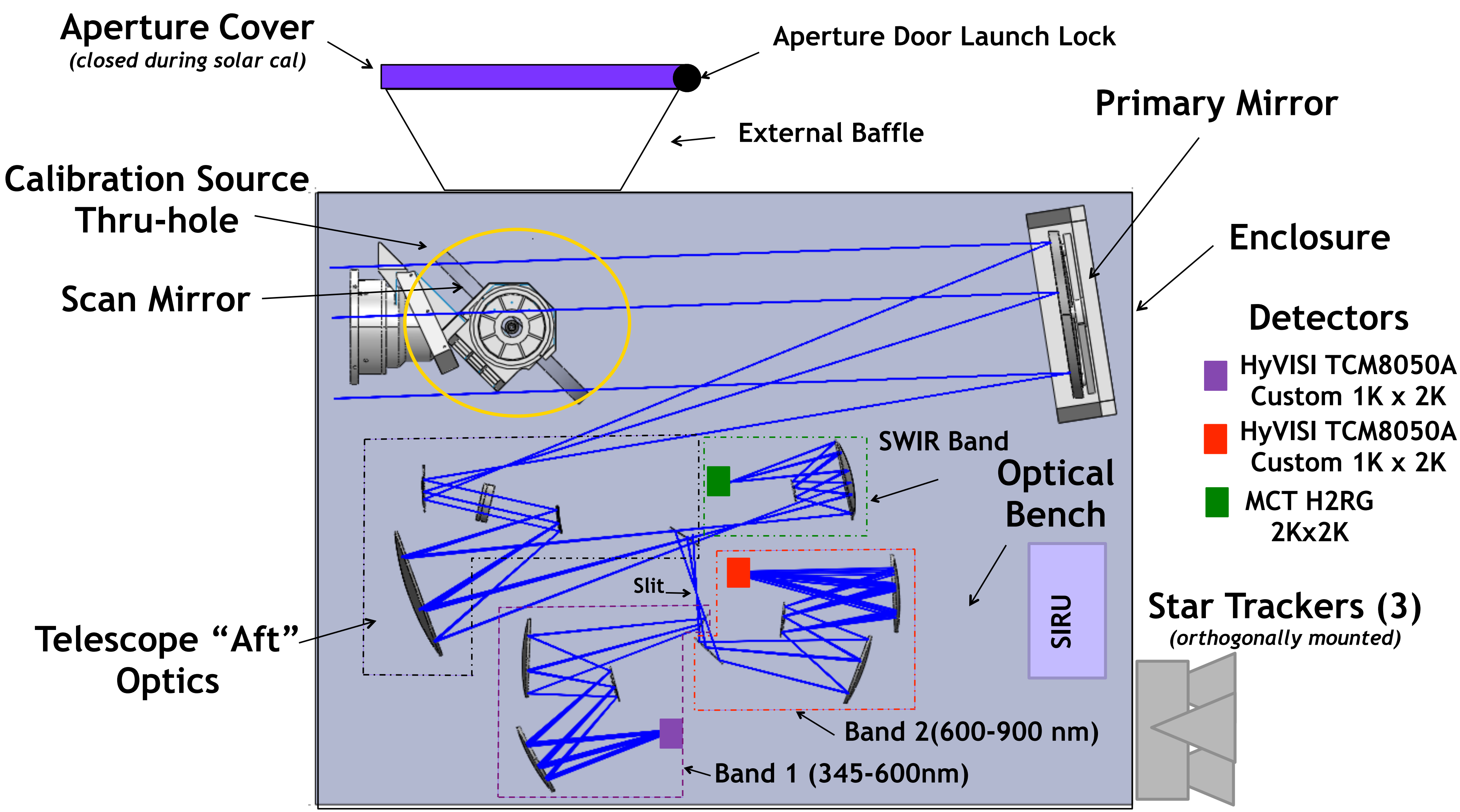


Aperture & Calibration Covers Opened

Integrated Design Capability / Instrument Design Laboratory



Coastal Ecosystem Dynamics Imager (CEDI) Block Diagram



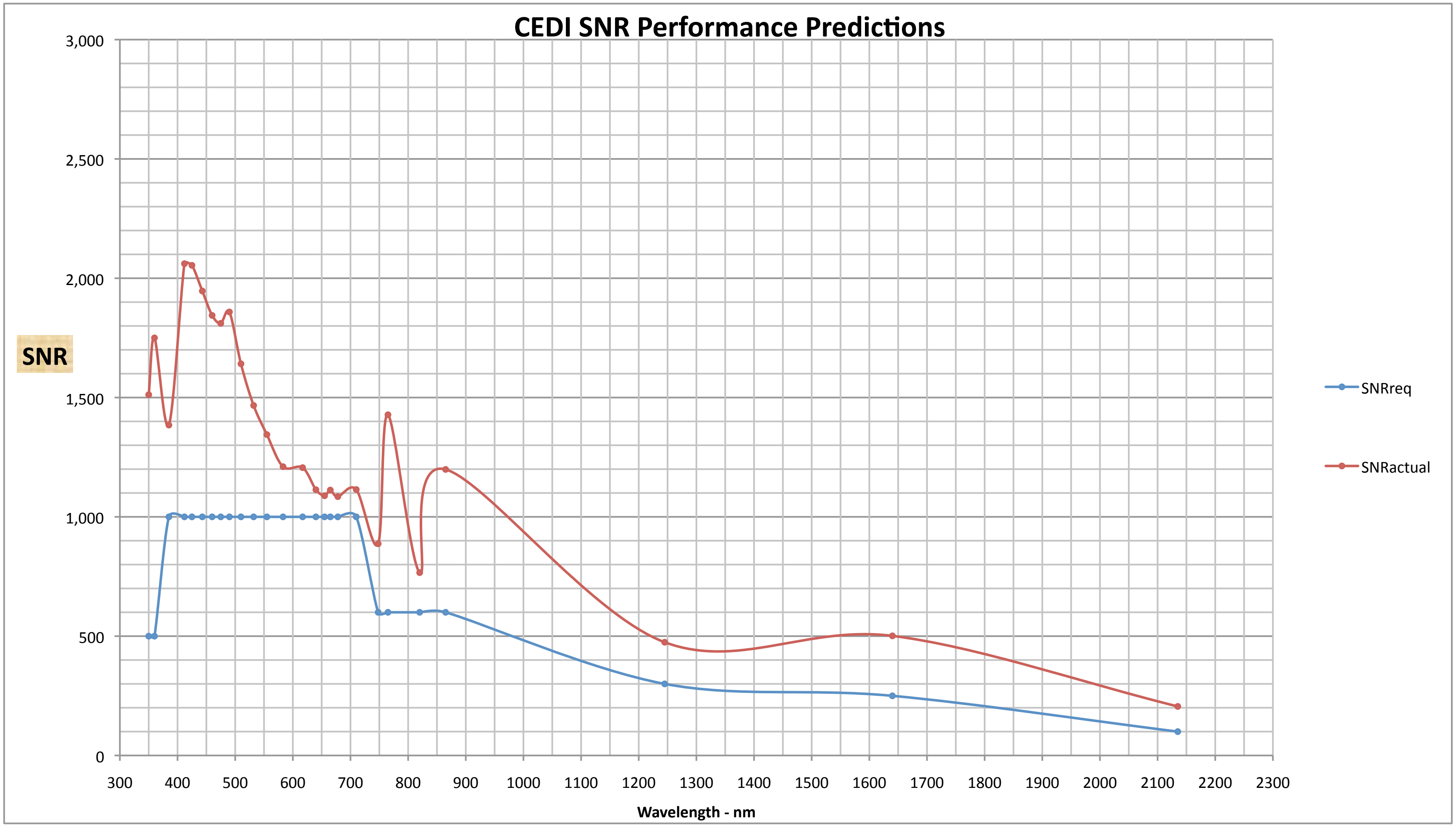
Radiometry Requirements & Results 70° SZA case

Integrated Design Capability / Instrument Design Laboratory

λ_o - Bands	FWHM	W/m^2-$\Delta\lambda$-um-ster		Req'd	Well_Capacity	Averages	Ltyp	Lmax	eff		Req'd	Ltyp
nm	$\Delta\lambda$ – nm	Ltyp	Lmax	Dynamic Range	Dynamic Range	$\Delta\lambda$	Well_Volume	Well_Volume	Opt. Tx	Det. QE	SNR_{req}	SNR_{actual}
350	15	39.26	117.5	2.99	21.49	60.00	46,538	139,247	0.24	0.65	500	1512
360	15	38.00	124.1	3.27	16.71	60.00	59,840	195,393	0.31	0.65	500	1750
385	10	32.16	125.7	3.91	17.65	40.00	56,656	221,513	0.31	0.68	1000	1385
412	10	41.77	198.7	4.76	8.65	40.00	115,662	550,095	0.43	0.72	1000	2061
425	10	40.63	193.1	4.75	8.70	40.00	114,935	546,085	0.42	0.73	1000	2054
443	10	37.51	219.1	5.84	9.61	40.00	104,106	608,151	0.39	0.74	1000	1947
460	10	33.14	238.9	7.21	10.60	40.00	94,319	679,962	0.38	0.75	1000	1844
475	10	30.25	238.3	7.88	10.96	40.00	91,250	718,621	0.39	0.75	1000	1811
490	10	29.25	226.4	7.74	10.45	40.00	95,675	740,472	0.41	0.75	1000	1859
510	10	24.23	218.8	9.03	13.08	40.00	76,441	690,354	0.38	0.75	1000	1641
532	10	20.09	214.8	10.69	15.96	40.00	62,645	669,884	0.36	0.75	1000	1467
555	10	16.11	212.2	13.17	18.57	40.00	53,862	709,431	0.37	0.75	1000	1345
583	10	14.56	205.9	14.14	22.22	40.00	45,007	636,418	0.33	0.74	1000	1210
617	10	11.25	192.1	17.07	22.34	40.00	44,758	764,026	0.33	0.9	1000	1206
640	10	9.39	186.1	19.82	25.53	40.00	39,177	776,529	0.33	0.91	1000	1114
655	10	8.33	176.6	21.20	26.51	40.00	37,718	799,554	0.35	0.91	1000	1088
665	10	7.83	176.9	22.59	25.58	40.00	39,087	882,988	0.38	0.91	1000	1112
678	10	7.37	171.3	23.24	26.66	40.00	37,510	871,697	0.38	0.91	1000	1085
710	15	5.36	161.4	30.10	35.39	60.00	28,256	850,622	0.38	0.9	1000	1114
748	10	4.89	147.5	30.17	36.82	40.00	27,156	819,179	0.38	0.9	600	887
765	40	3.62	141.9	39.18	51.32	160.00	19,486	763,516	0.36	0.9	600	1428
820	15	2.82	129.7	46.04	62.24	60.00	16,067	739,677	0.36	0.89	600	766
865	40	4.50	139.0	30.89	37.36	160.00	26,770	826,886	0.36	0.88	600	1758
1245	20	0.88	59.5	67.61	67.72	368.00	1,477	99,843	0.336	0.85	300	637
1640	40	0.29	17.6	60.69	156.00	736.00	641	38,903	0.336	0.85	250	514
2135	50	0.08	4.7	58.75	424.41	920.00	236	13,843	0.336	0.87	100	263

Challenge to overcome ocean requirements of high sensitivity (SNR) without saturating the detectors.

Ltyp = ~TOA Radiances at 70° SZA*

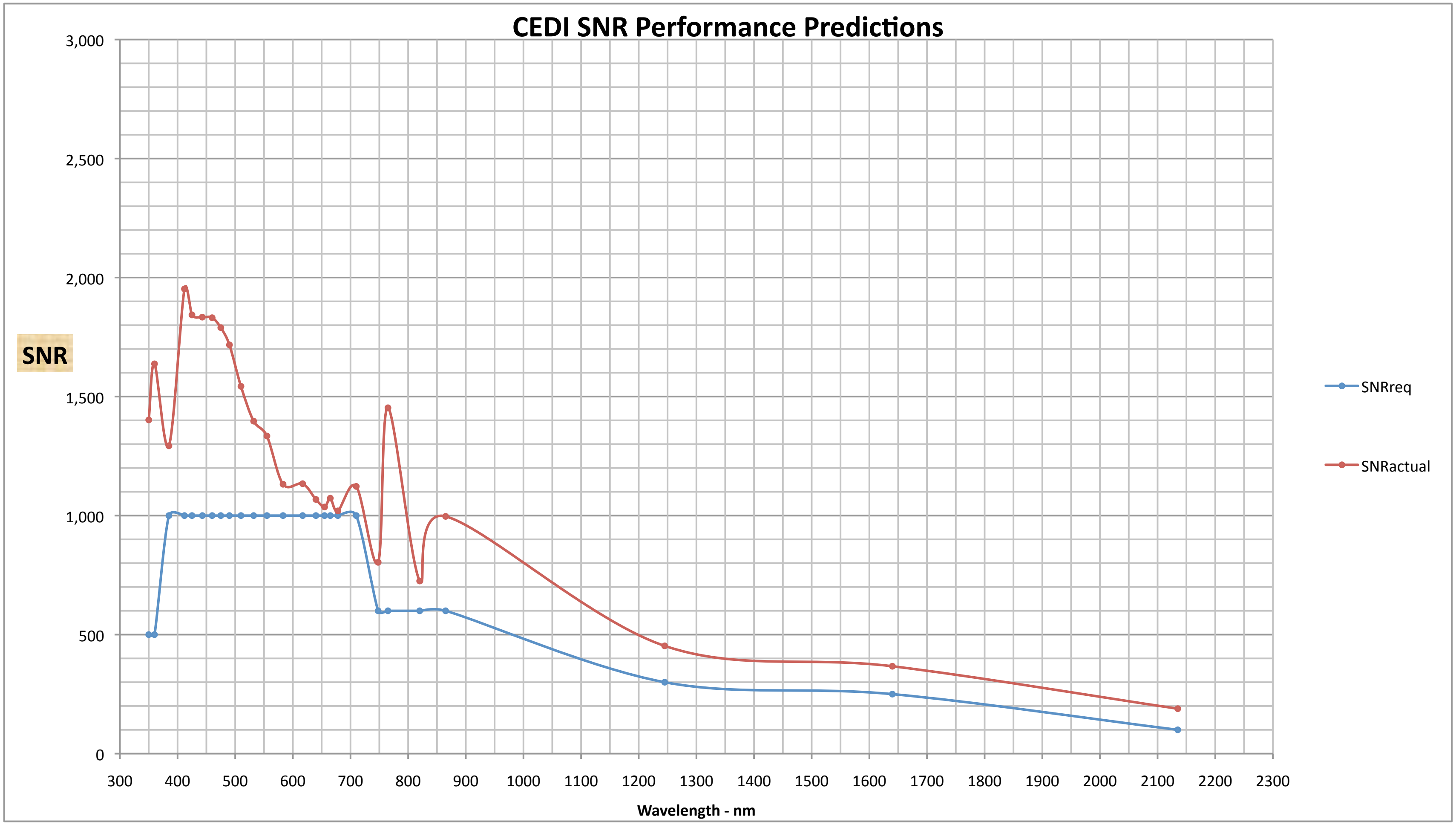


Total integration time = ~17.1 min per scene
0.8 sec integration time per scan line
Co-add 2 frames for UV-VIS-NIR & 46 for SWIR

* TOA Radiances from Chuanmin Hu
Spreadsheet for SNR calculations from Jay Smith (NASA GSFC)

GEO-CAPE CEDI analysis Feb. 16, 2010

Ltyp & Lmax equivalent to ACE values



Total integration time = ~10.3 min per scene

0.4 sec integration per scan line

Co-add 3 frames for UV-VIS-NIR & 23 for SWIR

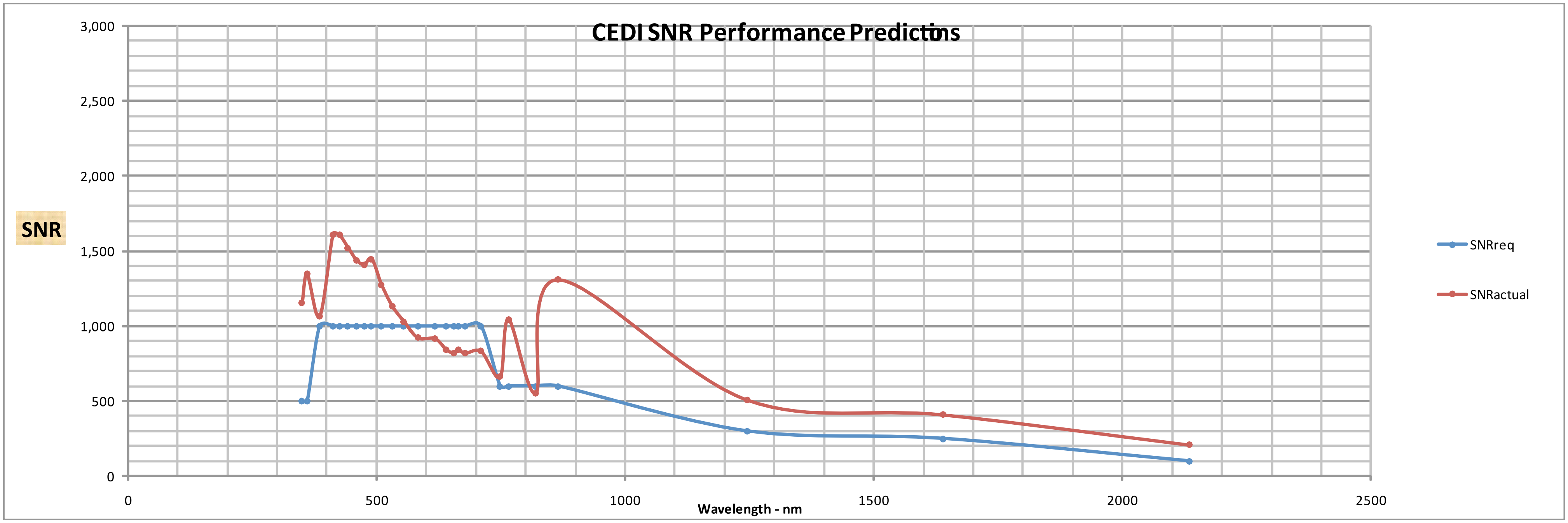
Saturation of 1245 and 1640nm bands possible for extremely bright scenes.

Lmax(Barnes) based on SeaWiFS data, only 0.2% of pixels saturated

GEO-CAPE CEDI analysis Feb. 16, 2010

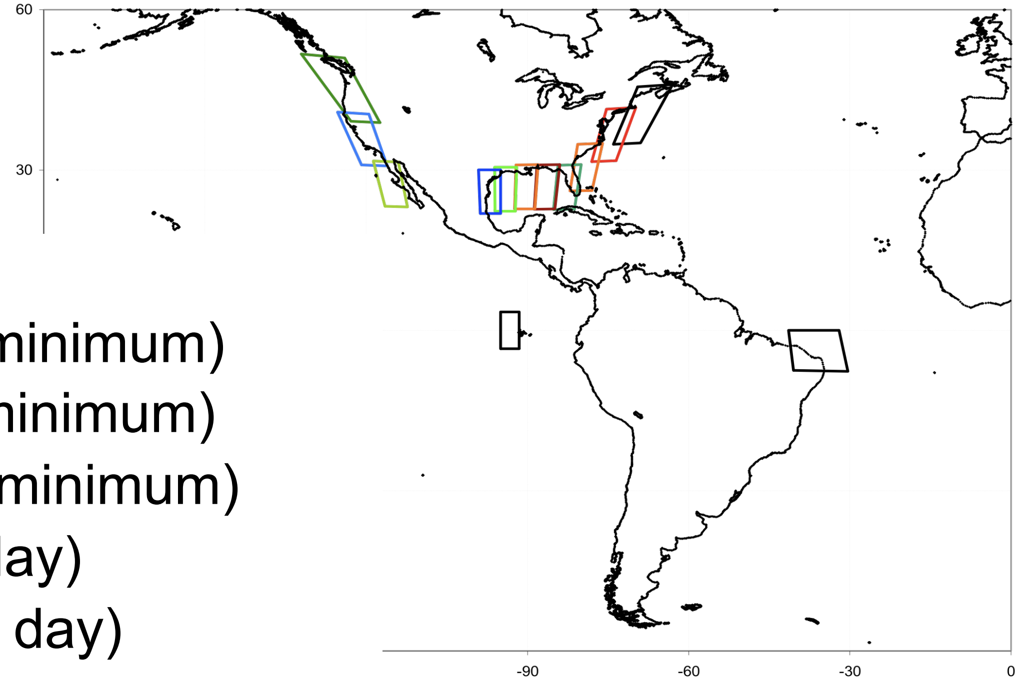
Conclusions on Spatial Resolution

- Current baseline requirements have been met with Aperture = 0.5m
- Minimum footprint - 350m
  - SNR at 678nm = 997 vs. 1000 required
- SNR performance with footprint = 300m with same spec's as above (chart below)



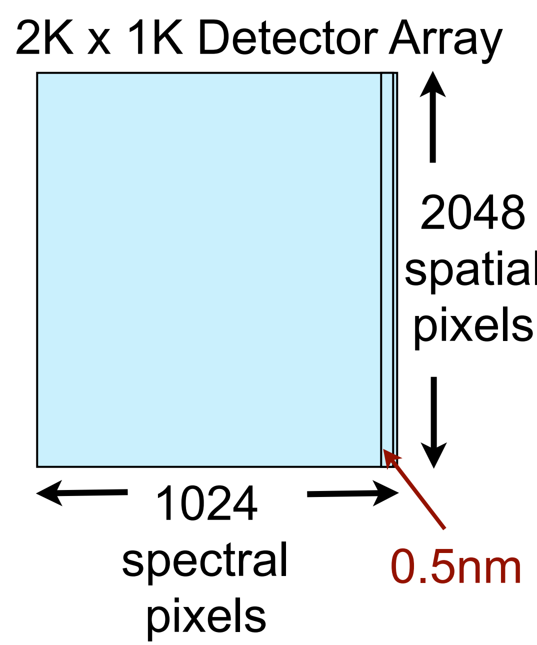
- With footprint = 300m, the aperture would need to increase to 0.585m to preserve SNR performance & radiance dynamic range (Ltyp to Lmax).

Scanning Summary

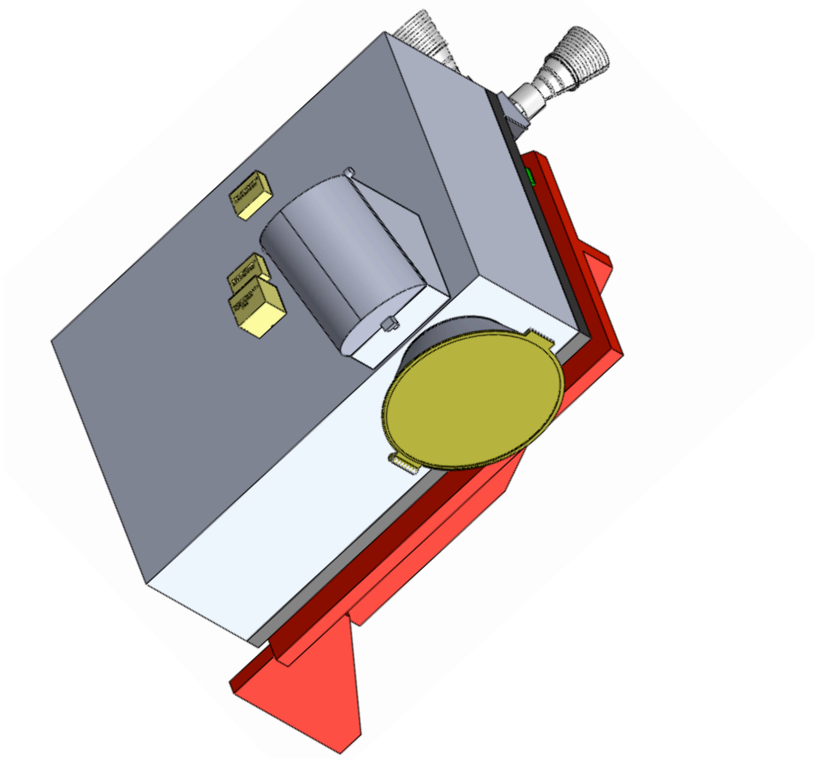


courtesy of Janet Campbell

- **U.S. Coastal Waters**
  - East Coast – 4 scenes (3x / day minimum)
  - Gulf Coast – 4 scenes (3x / day minimum)
  - West Coast – 3 scenes (3x / day minimum)
  - Puerto Rico – 1 scene (1 to 3x / day)
  - Great Lakes – 4 scenes (1 to 3x / day)
  - Hawaii - 1 scene (3x / day)
- **Regions of Interest**
  - North, Central and South America
  - Anywhere within Field of Regard (50N / 45S Lat; ~165W / ~30 W Long)
- **72 scenes per day (~750 x 375 km at nadir)**
  - Approximately 18 hours of operation per day
  - Approximately 4 scenes per hour (15 minutes)
  - 1024 iFOV scans per scene



Summary of GEO-CEDI



Instrument Concept

- Enables scientific objectives of coastal ocean and atmospheric retrievals.
- Capable of pointing anywhere on Full Disk.
- Spatial Resolution: 375 m x 375 m (nadir)
- Employs three focal planes
  - (1) 345-600 nm, (2) 600-1100 nm
    - Two Teledyne custom HyViSi ROIC: 1k (spectral) x 2k (spatial) detectors (UV-A or NIR coating)
  - (3) 1225-2160 nm
    - One HgCdTe Hawaii-2RG ROIC: 2k x 2k detector (SWIR)
- Spectral Resol: 0.5 nm (UV-NIR) and 2.5 nm (SWIR)

Instrument Characteristics

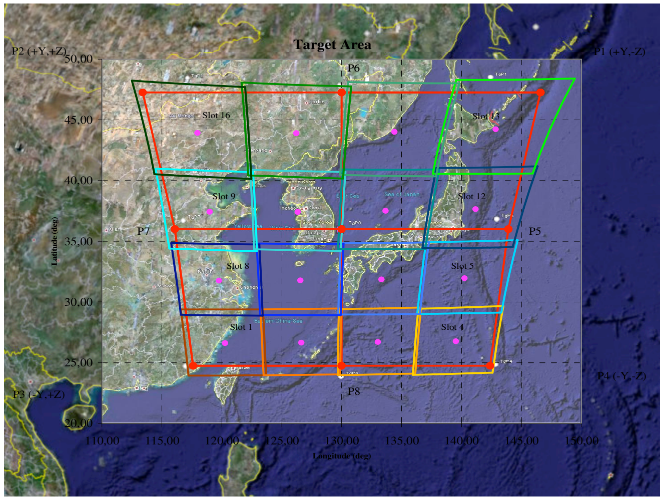
- Volume - 7.5 m^3
- Mass - 621.4 kg
- Power - 392 W
- Data Rate - 88.4 Mbps
- Scene: 750 km N-S x variable E-W
- Scene Integration Time: 10-17 min
- Pointing - ~0.5 arc-sec
- Lifetime - 3 yr (design); 5 yr (goal)

Technology Development Needs

- **Scan Mirror mechanism is on the edge of what is achievable.** Another study should be performed to determine feasibility.
- Dedicated effort required to investigate, characterize, and mitigate all sources of disturbances to scan mirror.
- 100Hz Attitude Determination may exceed existing proven technologies (133MHz BAE Rad750).

Instrument Cost - $294M

Korean Geostationary Ocean Color Imager (GOCI)

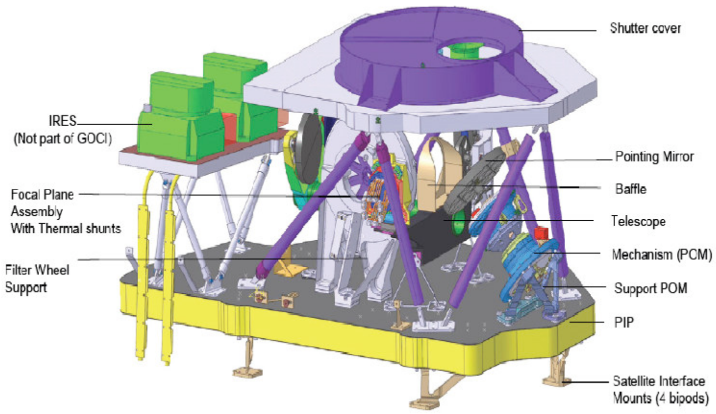


Launch: June 23, 2010

Local area coverage: 2500km x 2500 km
Center Position: 130°E Longitude, 36°N Latitude

	SeaWiFS	GOCI
Altitude	700-800 km	36,000 km
Scanning type	1-axis scanning	Staring-frame capture
Spatial resolution	1000 m	500 m
Spectral range	400-900 nm	400-900 nm
Temporal resolution	1 day	1 hour
Sun-Satellite position	stable	variable
Coverage	global	Local
Previous algorithms	Case-1 (Case-2)	No previous result

from Yu-Hwan Ahn (KORDI)



GOCI Spectral bands

Central wavelength (nm)	SeaWiFS (bandwidth, nm)	GOCI (bandwidth, nm)	Primary Use
412	1(20)	1(20)	Yellow substance and turbidity
443	2(20)	2(20)	Chlorophyll absorption maximum
490	3(20)	3(20)	Chlorophyll and other pigments absorption, K(490)
510	4(20)		Chlorophyll absorption
555	5(20)	4(20)	Suspended sediment
660		5(20)	Fluorescence base 1, chlorophyll, suspended sediment
670	6(20)		Atmospheric correction
680		6(10)	Fluorescence signal, atmospheric correction
745		7(20)	Atmospheric correction, Fluorescence base 2
765	7(40)		Atmospheric correction, aerosol radiance
865	8(40)	8(40)	Aerosol optical thickness, vegetation, Water vapor reference over the ocean

from Yu-Hwan Ahn (KORDI)

We welcome comments & suggestions!

GEO-CAPE
Discussion, Q&A
Wednesday - 1 to 1:30 pm
Southdown (4th floor)
(during lunch break)

Changes from last 2006 MDI Study

- Ground scene IFOV resolution from (250m x 250m) to (375m x 375m)
- Instrument swath FOV was 500km and is now 750km
- FOR probably the same as before or larger to accommodate the solar and lunar observations.
- Most UV – NIR FWHM bandwidths went from 12nm to ~~15nm~~ [10nm]
- Entrance aperture reduced from 0.66m dia. to 0.5m dia.
- UV to NIR sampling Δλ (FWHM) went from 0.8nm to 0.5nm
- SWIR sampling Δλ (FWHM) went from fixed filters with full width to 2.5nm
  - Grating dispersion for all there bands
- Revised Ltyp and Lmax values
- Revised Dynamic range for unsaturated operation
- Maximum well capacities were 'refined' (as well as read noise, dark signal, …)
  - Silicon = 1 million pe's
  - MCT = 100k pe's
- Balanced SNR performance with saturation avoidance at full Dynamic range