North Atlantic Aerosols and Marine Ecosystems Study (NAAMES)

Confirmation Review

28 August 2015

http://naames.larc.nasa.gov

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Why?

The abundance and growth of the plankton is critical to ocean health, fisheries production, atmospheric carbon dioxide levels, and the human goods and services provided by the sea

'Hot Spots' of ocean production occur in many subpolar regions, but we do not yet understand how climate and ecology control their vital annual plankton cycles

These plankton 'Hot Spot' also emit aerosols into the atmosphere that impact clouds and climate

The NAAMES project will provide new insights on the function of plankton ecosystems and their connection to atmospheric aerosols, clouds, and climate

NAAMES is an interdisciplinary investigation of the annual plankton cycle and its associated atmospheric aerosols

Overarching Science Goals

Goal #1: D*efine environmental and ecological controls on plankton communities to improve predictions of their structure and function in a warmer future ocean*

Goal #2: Define linkages between ocean ecosystem properties and biogenic aerosols to improve predictions of marine aerosol-cloud-climate interactions with a warmer future ocean

Baseline Science Objectives

Objective #1: Characterize plankton ecosystem properties during primary phases of the annual cycle in the North Atlantic and their dependence on environmental forcings

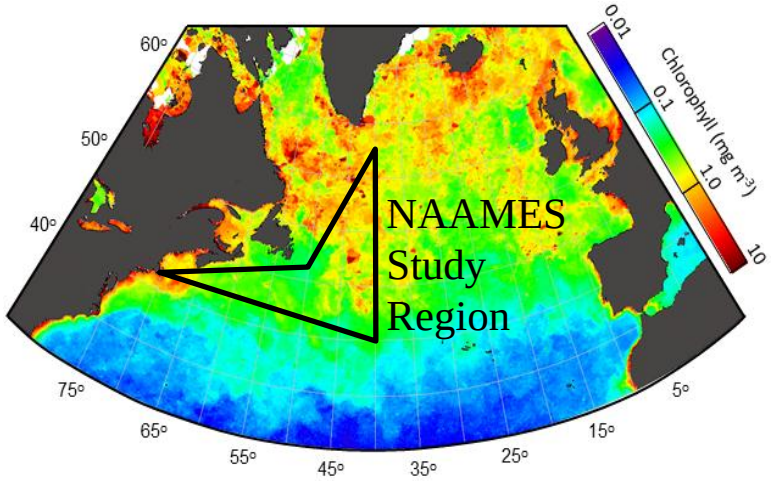
Objective #2: Determine how primary phases of the North Atlantic annual plankton cycle interact to recreate each year the conditions for an annual bloom

Objective #3: Resolve how remote marine aerosols and boundary layer clouds are influenced by plankton ecosystems in the North Atlantic

Science / Investigation Overview

- Annually repeated North Atlantic plankton bloom is the largest in global ocean
- Bloom has been associated to significant biogenic aerosol loads, with long-distance transport
- Ecological and physical processes controlling bloom development are strongly debated, but clearly linked to climate variability
- Improved understanding of bloom dynamics and associated aerosols will reduce uncertainties in projections of future change and implications to ocean productivity and climate

North Atlantic Phytoplankton Bloom



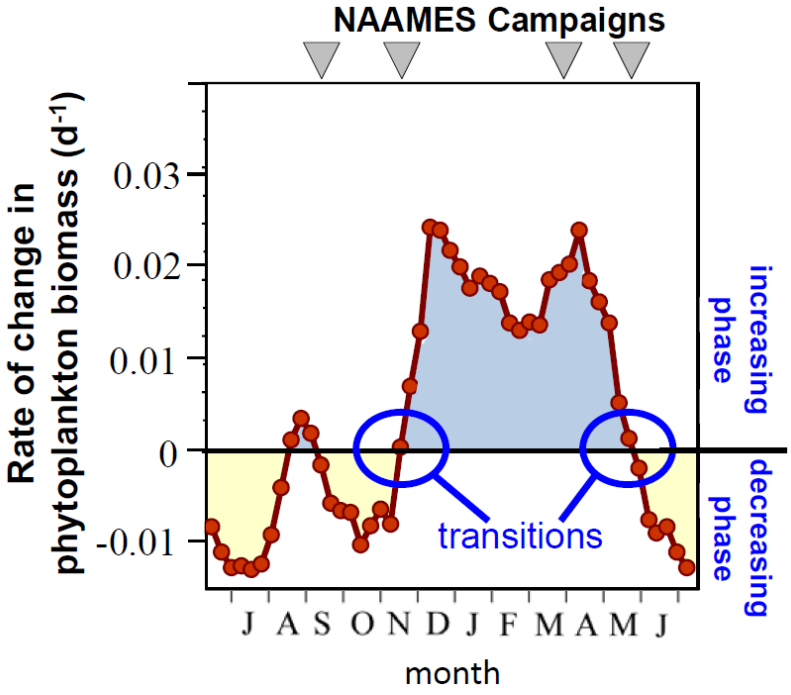
Science / Investigation Overview

- Four field campaigns
- Target contrasting 'states' of the annual plankton cycle and associated aerosols

  Bloom initiation: *November-December*
  Accumulation phase: *March-April*
  Bloom climax: *May-June*
  Deceleration phase: *September-October*

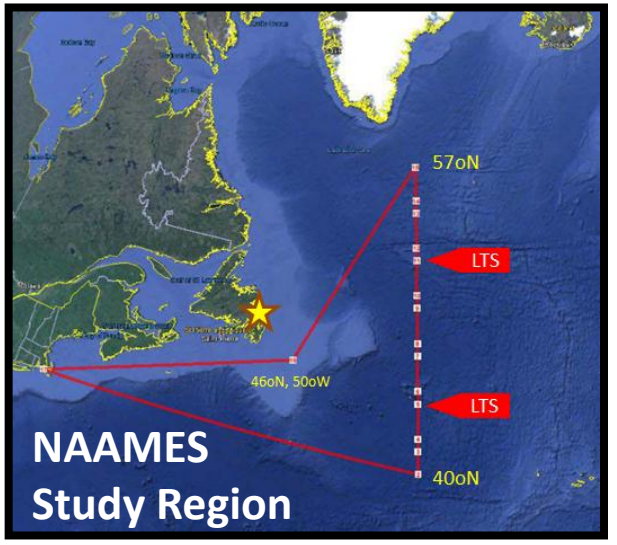
- Capitalize on natural meridional gradients to plankton 'states'

The *Contrasting States* of the Plankton Cycle



Science / Investigation Overview

- **26-day ship deployments** during each campaign
  - Campaign #1: *Bloom initiation; R/V Atlantis, Nov 5 - Dec 2, 2015*
  - Campaign #2: *Bloom climax; R/V Atlantis, May-June 2016*
  - Campaign #3: *Deceleration phase; September-October 2017*
  - Campaign #4: *Accumulation phase; March-April, 2018*
- **Common default profile:** Woods Hole - transects to/from turning points, primary science w/ daily stations (40°N - 57°N, 40°W)
- **Flexibility:** Departure/arrival port, direction of transect, latitudinal extent (particularly Deceleration and Accumulation phases)
- **Ocean Biological Measurements**: Biological composition & stocks, rates of production, accumulation, and loss processes
- **Aerosol Measurements**: Concentrations and production rates of aerosol precursors in the surface ocean, sea-air transfer rates, lower troposphere biogenic aerosol concentrations
- **Optical Measurements**: Inherent optical properties, apparent optical properties, water leaving radiance spectra - *optical measurements link in-situ data to remote sensing*



Science / Investigation Overview

- **Autonomous Bio-Argo Floats:** 3+ deployments per campaign along primary science transect
- **Surface Drifters:** 20 deployments (10 contributed) per campaign along primary science transect; deployments targeting mesoscale eddy features
- **Autonomous Assets:**

    1) Provide sustained observations along transect during campaigns

    2) Provide 'bread crumb trail' for airborne observations

    3) Provide sustained observations post-campaign, with matchups to satellite observations

    4) Allow evaluation of predictive capacity from ship measurements ('ecological forecasting' skill)

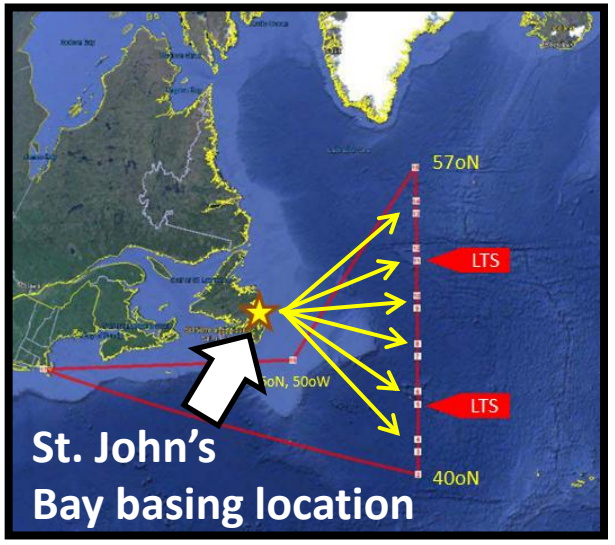
Science / Investigation Overview

- High- and low-altitude remote sensing and in-situ aerosol measurements conducted from **NASA C-130 aircraft**
- Aircraft deployments based at **St. John's Bay, Canada**
- **Deployment profile**: Departure flight toward ship location during primary science transect, measure ocean and aerosol properties at/around ship location, overfly surface drifter areas, overfly upcoming ship transect, return to base.
- **Goal**: 6 successful science flights per campaign
- **Aircraft measurements**:

    1) link ship aerosol and ocean biological observations to satellite spatial scales

    2) allow aerosol/cloud sampling upwind and downwind of the ship

    3) allow assessment of spatial variability



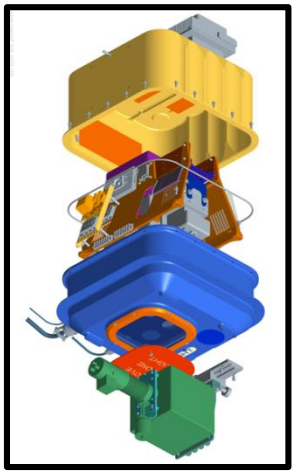
Science / Investigation Overview

- High Spectral Resolution Lidar (HSRL): Vertical profiling of clouds, aerosols and ocean plankton
- Research Scanning Polarimeter (RSP): Column-integrated cloud, aerosol, and plankton properties
- GeoCAPE Airborne Simulator (GCAS): Plankton and carbon stocks from hyperspectral ocean color measurements
- Spectrometer for Sky-Scanning Sun-Tracking Atmopheric Research (4STAR): Downwelling sunlight and atmospheric chemical composition

HSRL

RSP

GCAS



4STAR

Science / Investigation Overview

- **Satellite remotes sensing**: ocean color, lidar, and altimetry provide long-term, basin scale context of NAAMES field observations
- **Modeling**: Allows integration of NAAMES observation into system function, extension of NAAMES results to future forecasts, comparison of NAAMES-resolved processes to other ocean areas, and campaign planning

  Ocean circulation-ecosystem modeling (WHOI)
  Mesoscale processes (UW/City College of NY)
  Aerosol modeling (LaRC)
  Cloud modeling (UW)

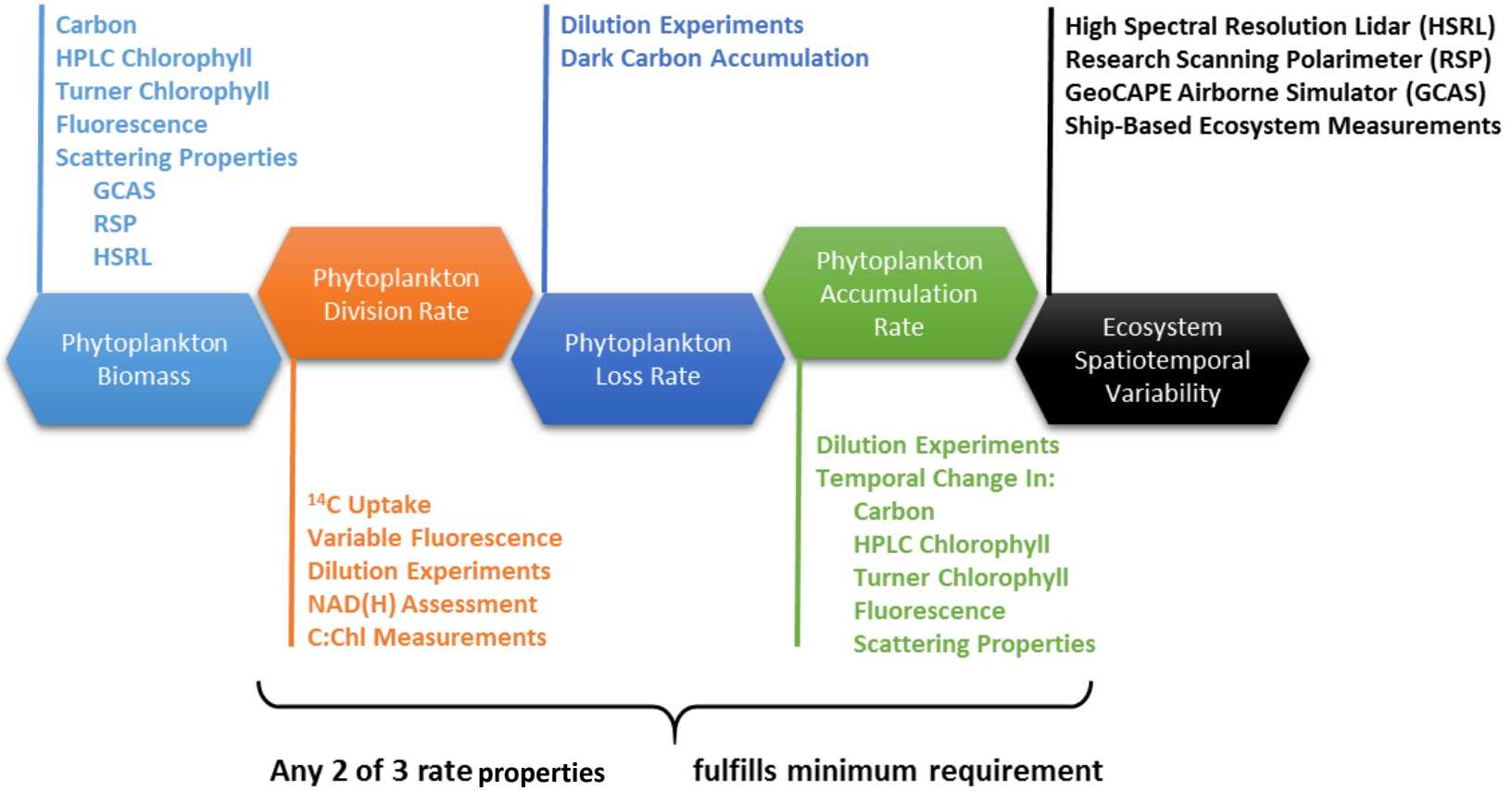
- **NAAMES Website**: http://naames.larc.nasa.gov/

Baseline Mission Requirements

Baseline
a. Conduct ***four*** field campaigns between 2015 and 2019 in the plankton bloom-forming region of the North Atlantic.
b. Acquire science data on plankton stocks and rate processes and biogenic aerosols from ship-based and aircraft measurements during each field campaign.
c. Acquire in situ autonomous science data on plankton properties using optical instruments on profiling floats deployed during each field campaign.
d. Measure plankton properties (see Table 3-2 for a summary of the NAAMES targeted Ocean Ecosystem Measurements) during the four primary ecosystem states of the annual cycle (Fig. 1-2), with each of the four campaigns targeting a specific ecosystem state.
e. Sample above-water aerosols and in-water aerosol precursors during the four primary ecosystem states of the annual cycle (Fig. 1-2), with each of the four campaigns targeting a specific ecosystem state. (See Table 3-3 below for a summary of the NAAMES targeted Aerosol-Related Measurements).
f. Measure plankton, aerosol, and cloud properties at different locations to assess spatial variability during the four primary ecosystem states of the annual cycle (Fig. 1-2). (See Table 3-1 below for a summary of the NAAMES targeted Airborne Remote Sensing Measurements.)
g. Use satellite observations to assess spatial and temporal variability in plankton and aerosol properties across the subarctic Atlantic basin.
h. Compare contemporary ocean ecosystem and aerosol model results to NAAMES ship, aircraft, and autonomous measurement data and satellite remote sensing data.
i. Record, validate, publish, and deliver science data and calibrated geophysical data products to the science community. Archive data on NASA DAAC.

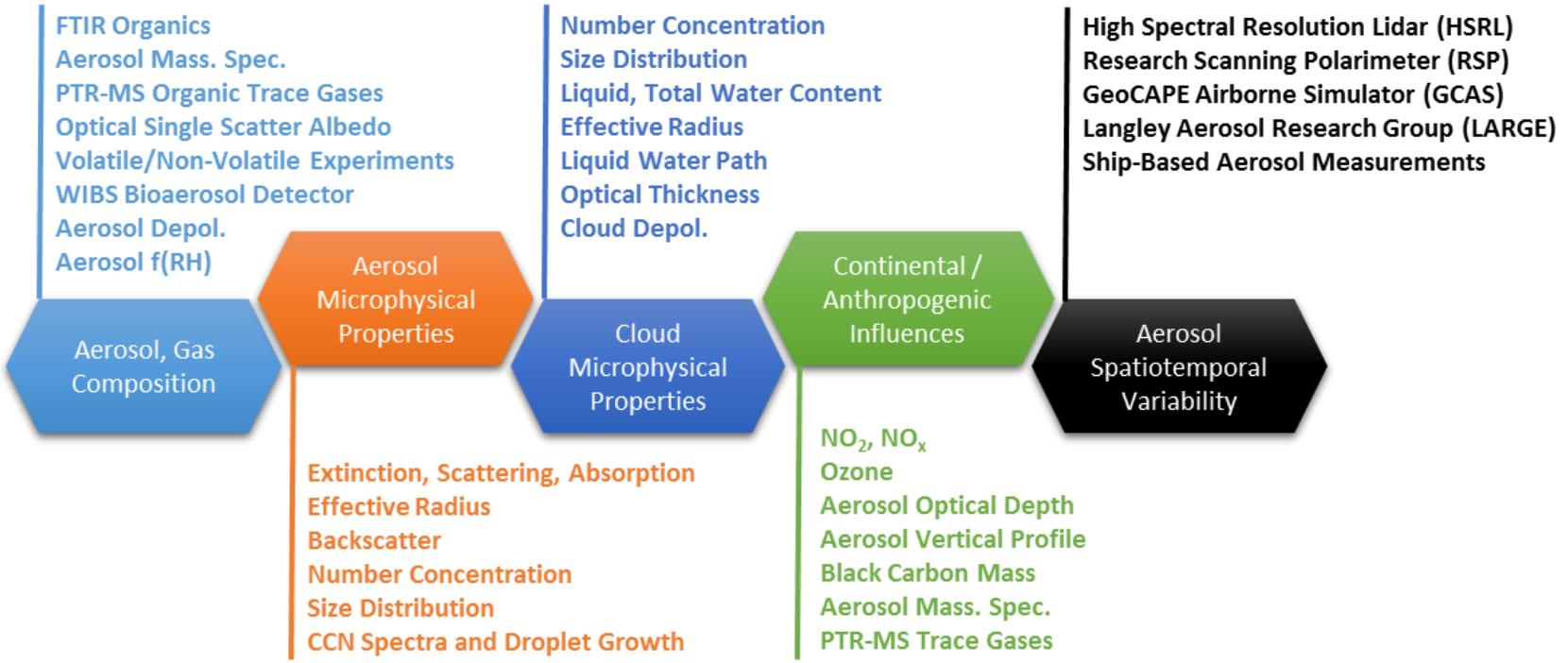
Baseline Mission Requirements

1. Redundancy in ecosystem observations - ‘property’ not ‘measurement’



Baseline Mission Requirements

2. Redundancy in aerosol observations - ‘property’ not ‘measurement’



Baseline Mission Requirements

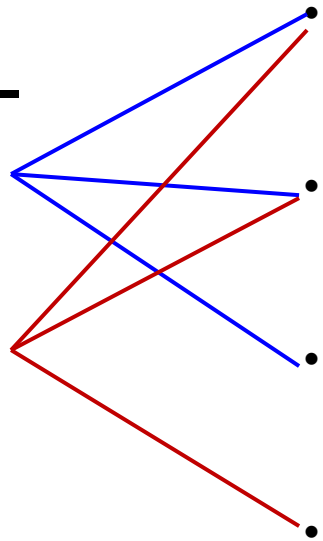
3. Redundancy in airborne observations - 'property' not 'measurement'

   "Are core ecosystem properties observed from the ship representative of properties measured at the satellite pixel level?"

Essential Core Objective:

Ecosystem spatial variability

Aerosol spatial variability

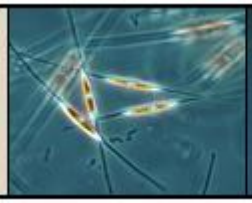


- *High Spectral Resolution Lidar* (HSRL)
  clouds, aerosols, ocean plankton
- *Research Scanning Polarimeter* (RSP)
  clouds, aerosols, ocean plankton
- *GeoCAPE Airborne Simulator* (GCAS)
  ocean plankton
- *Langley Aerosol Research Group Experiment* (LARGE)
  aerosols

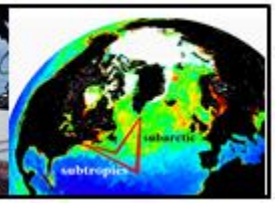
Baseline Mission Requirements

- Observational redundancies influence decision making
- Core objectives robust to specific instrument failures
- Unlikely that a ‘go - no go’ decision will be determined by instruments

NAAMES







Science Traceability Matrix

Science Objectives & Questions	Scientific Measurement Requirements	Instrument Functional Requirements	aligns with	Investigation Functional Requirements	aligns with
Science Objectives: • Characterize plankton ecosystem properties during primary states of the annual cycle in the North Atlantic and their dependence on environmental forcings • Determine how primary states of the North Atlantic annual plankton cycle interact to recreate each year conditions for an annual bloom **Question #1:** How do environmentally-driven changes in phytoplankton growth rate and seasonal changes in ecosystem interactions create the spring bloom, and what does the relative importance of these two processes imply about future change? **Question #2:** How are seasonal changes in community composition linked to bloom formation?	1 Continuous, mission-long plankton ecosystem properties from satellite ocean color data (e.g., VIIRS, MODIS, HICO, OCM-2, OCLI, SGLI) 2 Continuous, in situ mission-long plankton ecosystem properties through the water column at distributed locations in N. Atlantic 3 In situ measurements of mixed layer plankton concentrations, species composition, POC, cDOM, and phytoplankton growth, accumulation, total loss, and grazing loss rates 4 UV-to-NIR airborne radiometric measurements linking local-scale analytical data (item 3 above) to satellite remote sensing resolution 5 Field measurements in items 3 and 4 above conducted over a wide dynamic range in ecosystem properties and encompassing differences in seasonal timing of ecosystem annual cycle events 6 Field measurements in items 3 and 4 above conducted during contrasting states of the annual plankton cycle	1. Autonomous measurements of water column optical and physical properties at 5 m vertical resolution and sustained over annual cycle 2. Ship-based ecosystem and optical measurements as specified in Table 3-2 3. Ship- and aircraft-based in situ aerosol, aerosol-precursor, trace-gas, and cloud measurements as specified in Table 3-3 4. Passive airborne remote sensing of mixed layer plankton and cDOM properties as specified in Table 3-1 5. Active airborne remote sensing of subsurface particles as specified in Table 3-1 6. Passive airborne remote sensing of column-averaged aerosol properties from surface to aircraft level as specified in Table 3-1 7. Active airborne remote sensing of aerosols between surface and aircraft levels as specified in Table 3-1 8. Active and passive airborne remote sensing of clouds as specified in Table 3-1 9. Passive airborne remote sensing of spectral aerosol optical depth above the aircraft as specified in Table 3-1	2 3 1, 2, 3, 4 1, 4 5 2, 3 2 2 2	1. Field campaigns targeting biomass increasing/ decreasing states and transition states of the annual plankton cycle 2. Geographically co-located ship and airborne measurements and long-range, transport-scale airborne measurements during each field campaign . 3. Field measurements of the North Atlantic gradient in ecosystem and aerosol properties 4. Autonomous sensor deployment along latitudinal gradient to sustain in situ observations of annual cycle 5. Airborne transects including below, in, and above cloud in-situ sampling and remote sensing at high altitude during each campaign. 6. Basin-scale retrievals of aerosol and ecosystem properties from existing/upcoming satellites 7. Central data archive 8. Climate-ecosystem modeling to (1) optimize field campaign design, (2) understand mechanisms of observed ecosystem variability, (3) forecast change in ecosystem properties, with relevance to aerosols	6 1, 2, 3, 3, 4 5 2 2 5
Science Objective: • Resolve how remote marine aerosols and boundary layer clouds are influenced by plankton ecosystems in the North Atlantic **Question #3:** How do ocean-ecosystem emissions alter remote marine aerosol burden, spatial distribution, and properties? **Question #4:** How do these biogenic aerosols affect cloud condensation nuclei abundance and, in turn, cloud microphysical properties?	*Ecosystem and optical properties as in 1-4 above plus the following with spatial-temporal coverage as in 5-6:* 1 Measurements of surface air concentrations of aerosols (e.g., sea salt, POA, SOA) and trace gases (e.g., VOCs, DMS) 2 Measurements of aerosol concentration, size distribution, composition, optical properties and CCN activity below, above, and between clouds 3 In situ and remote sensing measurements of cloud droplet number density, size, and liquid water content 4 In situ measurements of seawater volatile organics and their production and consumption rates 5 Continuous, mission-long record of passive-sensor, satellite-derived aerosol and cloud properties				

	Participants	Role	Affiliation
Project Management	Behrenfeld, Mike	Principal Investigator	OSU
	Kleb, Mary	Project Manager	NASA LaRC
	Hostetler, Chris	Project Scientist	NASA LaRC
	Moore, Richard	Deputy Project Scientist	NASA LaRC
	Proctor, Christopher	Project Data Manager	NASA GSFC
	Chen, Gao	Flight Planner	NASA LaRC
	Shook, Michael	Meteorologist	LaRC/SSAI
	Ziemba, Luke	Logistics /C-130 Platform Manager	NASA LaRC
Project Science	Doney, Scott	BEC-CESM Modeling	WHOI
	Franz, Bryan	Ocean Color Analyses	NASA GSFC
	Gaube, Peter	Mesoscale Physics	WHOI
	Hu, Chuanmin	GCAS Analyses	USF
	Hu, Yongxiang	Ocean/Cloud Satellite Analyses	NASA LaRC
	Lindo, David	Mesoscale Modeling	City College, NY
	Liu, Hongyu	GEO-Chem Aerosol Modeling	NASA LaRC
	Milligan, Allen	Ocean Primary Production	OSU
	Westberry, Toby	Satellite Analysis /In Situ Optics	OSU
	Wood, Robert	Cloud modeling	UW
Ship Science & Instruments	Bates, Tim	Aerosol Flux	UW
	Boss, Emmanuel	Ocean optics, Profiling Floats	UM
	Brooks, Sarah	Aerosol and CCNuclei	TAMU
	Carlson, Craig	DOC Measurements	UCSB
	Giovannoni, Stephen	VOCs, Plankton Taxonomy	OSU
	Halsey, Kimberly	VOC precursors & processing	OSU
	Maritorena, Stephane	OC Algorithm Development	UCSB
	Menden-Deuer, Susanne	Microzooplankton Grazing	URI
	Nelson, Norman	CDOM /Bio-Optics	UCSB
	Russell, Lynn	In Situ Aerosol	UCSD
	Saltzman, Eric	In Situ Trace Gases & Aerosol	UCI
	Siegel, David	Ocean optics, Remote Sensing	UCSB

	Participants	Role	Affiliation
Airborne Science & Instruments	Anderson, Bruce	LARGE Aerosol &Trace Gases	NASA LaRC
	Cairns, Brian	RSP; Ocean-Aerosol-Cloud RS	NASA GISS
	Chowdhary, Jacek	RSP; Aerosol Analyses	NASA GISS
	Ferrare, Richard	HSRL; Aerosol Analyses	NASA LaRC
	Hair, John	HSRL; Ocean-Aerosol-Cloud RS	NASA LaRC
	Janz, Scott	GCAS; Ocean Color RS	NASA GSFC
	Moore, Richard	LARGE; Cloud Microphysics and Aerosol-Cloud Interactions Analyses	NASA LaRC
	Redemann, Jens	4STAR; Aerosol Optical Depth	NASA ARC
	Wisthaler, Armin	PTR-MS; Organic Trace Gases	Innsbruck
Support Flight Operations	Cropper, Mike	C-130 Airborne Science Mission Manager	NASA WFF
	Griffin, Kelly	C-130 Logistics and Mission Manager	NASA WFF
	Nowicki, Martin	C-130 Integration/Operations Engineer	NASA WFF

NAAMES Science Team Members

* New additions reflect proposal panel review suggestions

Changes Based on Proposal-Phase TMLC Panel Comments (PIP Appendix A)

1. Science team additions to bolster expertise in anthropogenic pollution transport, anthropogenic trace gases, and linkages to clouds and climate:
   - T. Bates (sea-air aerosols transfer)
   - H. Liu (aerosol modeling)
   - A. Wisthaler (in situ airborne aerosols)
   - R. Wood (collaborator on cloud-climate interactions)

2. Augmented the in situ LARGE payload to include filter samples for both bioaerosol collection as well as for offline analyses of sea salt aerosols

3. Add the role of Deputy Project Scientist to assist the PI, PM, and PS given the numerous non-NAAMES commitments of the PS

4. Post-Selection flight planning activities and thinking incorporate stacked cloud legs and bow-tie flight patterns upwind and downwind of the ship as per the panel comments

Platforms

Platforms Are Suitable to Meet Project Goals

NASA Wallops Flight Facility C-130

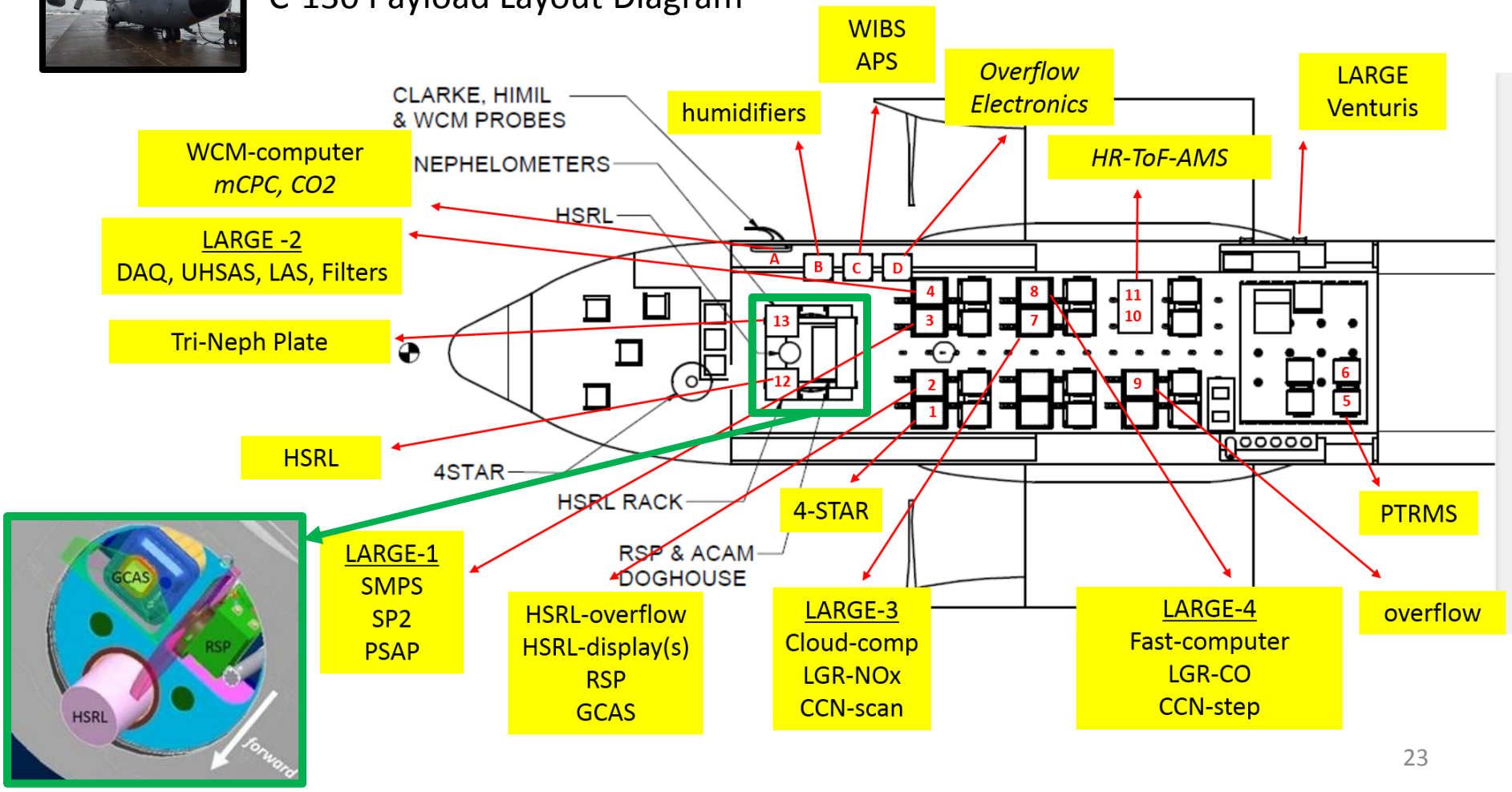
- Availability guaranteed for all deployments
- Payload capability and 5,500 km minimum range meet NAAMES requirements
- Modifications to the aircraft to accommodate in situ sampling probes, wing-mounted cloud probes, and nadir-viewing remote sensors are underway and on schedule.

UNOLS/WHOI *Research Vessel Atlantis*

- Anticipated to support all NAAMES deployments,
- Cruising speed, duration, laboratory space, berths, and home port make the *Atlantis* ideal for NAAMES
- *Atlantis* has extensive experience with wintertime operations in the North Atlantic
- Alternatives: *Revelle* (Scripps), *Thompson* (Univ. Washington), *James Clark Ross* (UK), L'Atlante (France)
- Trigger for seeking alternative: 18 months

Measurements/Instruments/Payload

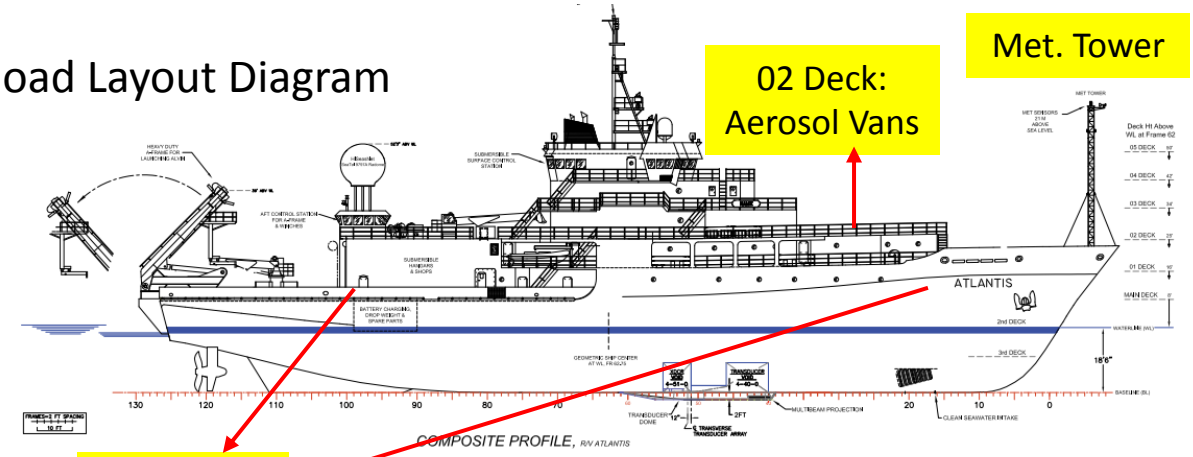
C-130 Payload Layout Diagram



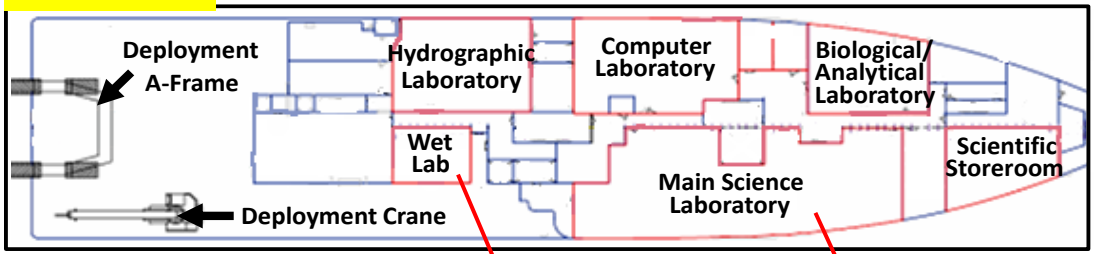
Measurements/Instruments/Payload – *Continued*

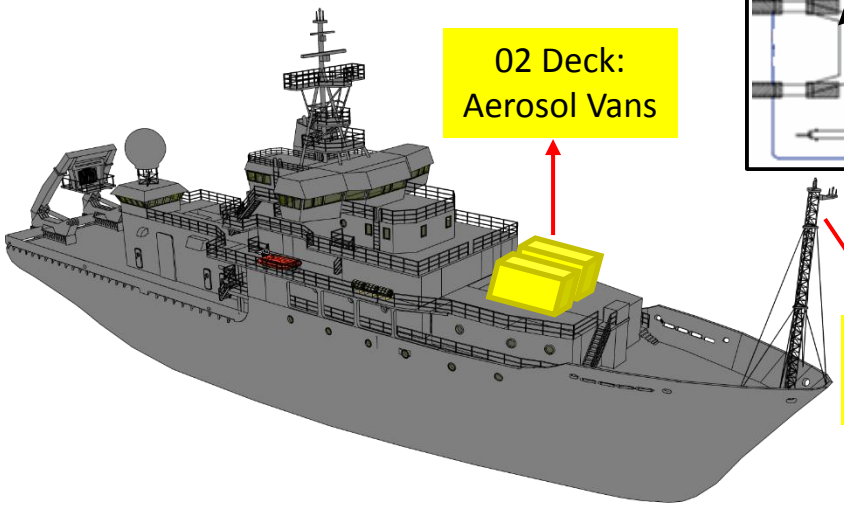
R/V Atlantis Payload Layout Diagram

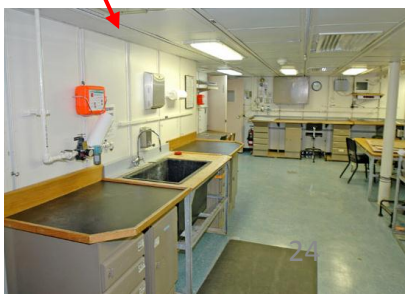
- Ocean measurements carried out on the main deck
- Aerosol measurements on the 02 Deck (to minimize sea spray)



Main Deck:



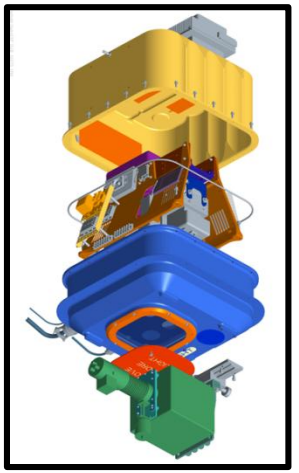




Measurements/Instruments/Payload – *Continued*

HSRL

GCAS



Airborne Remote Sensing Instruments and Measurements

Instrument and Relation to Objectives	Geophysical Products
GCAS • Hyperspectral ocean color products • Atmospheric trace gas measurements • Relate ship-scale to satellite-scale measurement • GeoCAPE prototype satellite instrument	Chlorophyll-a concentration CDOM absorption (440nm) Particulate backscatter coeff. (440nm) Diffuse attenuation coeff. (Kd490) Euphotic depth Slant column atmospheric NO_2 Slant column atmospheric O_3
HSRL-1 • Aerosol and cloud properties • Ocean properties • Relate ship-scale to satellite-scale measurements • ACE prototype satellite instrument	Aerosol backscatter (532/1064nm) Aerosol extinction (532nm) Aerosol & cloud depolarization (532/1064nm) Ocean diffuse attenuation coeff. (532nm) Ocean particulate backscatter coeff. (532nm)
RSP • Aerosol and cloud properties • Ocean properties • Relate ship-scale to satellite-scale measurements • ACE prototype satellite instrument	Aerosol optical depth for each mode of a bimodal distribution Aerosol size: effective radius Aerosol size: effective variance Aerosol Single Scatter Albedo Cloud top effective radius Cloud top effective variance Cloud mean effective radius Cloud optical depth Liquid Water Path Cloud Thickness Cloud droplet number concentration Water Leaving Radiance Chlorophyll concentration CDOM absorption (410nm) Ocean particulate backscatter coeff.
4STAR • Facilitate RSP and GCAS retrievals	Spectrally resolved aerosol optical depth (350 to 1000nm) above the aircraft for constraining nadir-viewing RSP and GCAS retrievals.

RSP

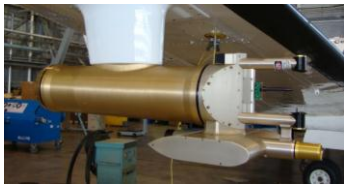
4STAR

Measurements/Instruments/Payload – *Continued*

Ship-Based Ecosystem Measurements

Geophysical Property	Instrument / Measurement
Spectral absorption and scattering	WetLabs AC-S
Spectral backscattering	WetLabs bb-3, WetLabs ECO BBFL
Spectral water-leaving radiance, up/downwelling irradiance	C-OPS, Satlantic PAR
Phytoplankton pigments	Turner 10AU fluorometer, HPLC, WetLabs ECO BBFL
Phytoplankton biomass	BD Influx, Shimadzu TOCN
Particle size distributions	BD Influx, Coulter Counter
Colored dissolved organics	2m liquid waveguide spectrophotometer, WetLabs ECO-cDOM, Wetlabs AC-S
Total particulate carbon	Exeter Analytical 440 CHN Analyzer
Phytoplankton taxonomy	HPLC/CHEMTAX, BD Influx, TAG 16S/18S rRNA, UVP/ IFCB
Zooplankton abundance	UVP/ IFCB
Heterotrophic bacterial taxonomy	TAG 16S/18S rRNA
Phytoplankton growth rates	Dilution experiments, NPP/biomass
Net primary production	^{14}C uptake, Biomass*division
Phytoplankton accumulation rate	Temporal change in chlorophyll, biomass
Phytoplankton loss rate	Dilution experiments

Measurements/Instruments/Payload – *Continued*



Airborne and Ship-Based Aerosol and Trace Gas Measurements

Geophysical Property	Instrument	Platform
CO	LGR CRD	Aircraft
NOx	LGR CRD	Aircraft
Ultrafine CN, Total, Nonvolatile CN	TSI 3025, (2) TSI 3772	Aircraft
Aerosol Particle Size	TSI SMPS, DMT UHSAS, TSI 3321	Aircraft
Nonvolatile Particle Size	TSI SMPS	Aircraft
CCN spectra	DMT-CCN	Aircraft
Scattering (450, 550, 700nm λ)	TSI 3563	Aircraft
Scattering humidity dependence, f(RH)	TSI 3563	Aircraft
Absorption (467, 530, 660nm λ)	PSAP	Aircraft
Black carbon mass and size	DMT SP2	Aircraft
Water Soluble Organics	Filter Sampling - TOC	Aircraft
Non-Refractory Aerosol Composition	HR-ToF-AMS	Aircraft
Bio-Aerosol Number, Size	DMT WIBS-IV	Aircraft
Cloud Particle Size	DMT CAPS	Aircraft
Ultrafine CN	GRIMM 5.400	Ship
Aerosol Particle Size	BMI SEMS, TSI APS (3321), GRIMM 1.1.08	Ship
Nonvolatile Particle Size	BMI SEMS	Ship
Scattering (450, 550, 700nm λ)	TSI 3563	Ship
Absorption (467, 530, 660nm λ)	PSAP	Ship
CCN Spectra	DMT CCN	Ship
Black carbon mass	DMT SP2	Ship
Non-refractory Composition	HR-ToF-AMS	Ship
Organic composition	Filter/FTIR, PILS/ESI/MS	Ship
Gas-phase organics	PTR/MS	Ship
Gas-phase DMS Seawater volatile organics	CIM Sequil./PTR/MS	Ship
Volatile carbon production/ consumption rates	PTR/MS	Ship

Management, Schedule, Budget

Management Structure

- Oregon State University
- NASA LaRC
- NASA GSFC
- UNOLS
- Science, Instruments, Data Analysis & Modeling, Ground Systems Teams

NAAMES
PI: Michael Behrenfeld, OSU

1.0 Project Management
Project Manager: Mary Kleb, LaRC
Project Scientist: Chris Hostetler, LaRC
Deputy Project Scientist, Richard Moore, LaRC

- **2.0 Systems Engineering**
- **3.0 Safety and Mission Assurance**
  - **3.2 Flight Safety** — Joe Posinski, WFF/GSFC
  - **3.3 Ship-Borne Safety** — Eric Benway, UNOLS
- **4.0 Science**
- **5.0 Payload - Instruments**
  - **5.1 Airborne Instrument Team**
  - **5.2 Ship-Borne Instrument Team**
- **7.0 Investigation Operations** — Payload and Logistics Manager Luke Ziemba, LaRC
  - **7.2 Aircraft Operations** — Aircraft Platform Manager, WFF/GSFC
  - **7.3 Ship Operations** — Ship Platform Manager, UNOLS
- **9.0 Ground Systems**
  - **9.1 Ocean Data** — Science Data Manager, Christopher Proctor, GSFC
  - **9.2 Airborne Data** — Science Data Manager, Gao Chen, LaRC

Data Management

	Ship Measurements / Ocean Properties	Aircraft Measurements / Aerosol Properties
Data manager	Christopher Proctor	Gao Chen
DAAC	Ocean Biology DAAC (GSFC)	Atm. Sci. Data Center (LaRC)
Project Data Repository	Ocean Bio. Processing Group site (OBPG @ GSFC)	Airborne Sci. Data for Atm. Composition site (ASD-AC @ LaRC)
Preliminary data latency	6 months	1 month
Final data latency	12 months after field experiment ends	12 months after field experiment ends

Waivers have been granted for 12 month latency for final data and data format (SeaBASS)

Schedule

	NAAMES Schedule	Year 1												Year 2												Year 3												Year 4												Year 5											
		2015												2016												2017												2018												2019											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
	Reviews:																																																											
✓	NAAMES Start																																																											
✓	Kickoff																																																											
✓	PIP Table Top Review																																																											
✓	PIP Assessment																																																											
	Confirmation Review																																																												
	Annual Science Review																																																											
	KDP-F (Closeout)																																																											
	EPTR																																																											
	ESSP Project Status Reviews																																																											
	FRR																																																											
	Ship Safety Review																																																											
	Mission Preparation Activities																																																											
	C-130 55" Nadir Port																																																											
	C-130 Mods																																																												
✓	Site Survey - SJB																																																										
	Ship Integration & Set-up																																																											
	C-130 Integration																																																												
	Mission Coordination Meeting																																																											
	Deployments: Blue = optimal; Yellow = good;																																																											
	Aircaft Deployment																																																											
	Ship Cruise																																																											
	Post-Deployment Activities:																																																										
	Data Archival																																																											
	Science Team Meetings																																																											

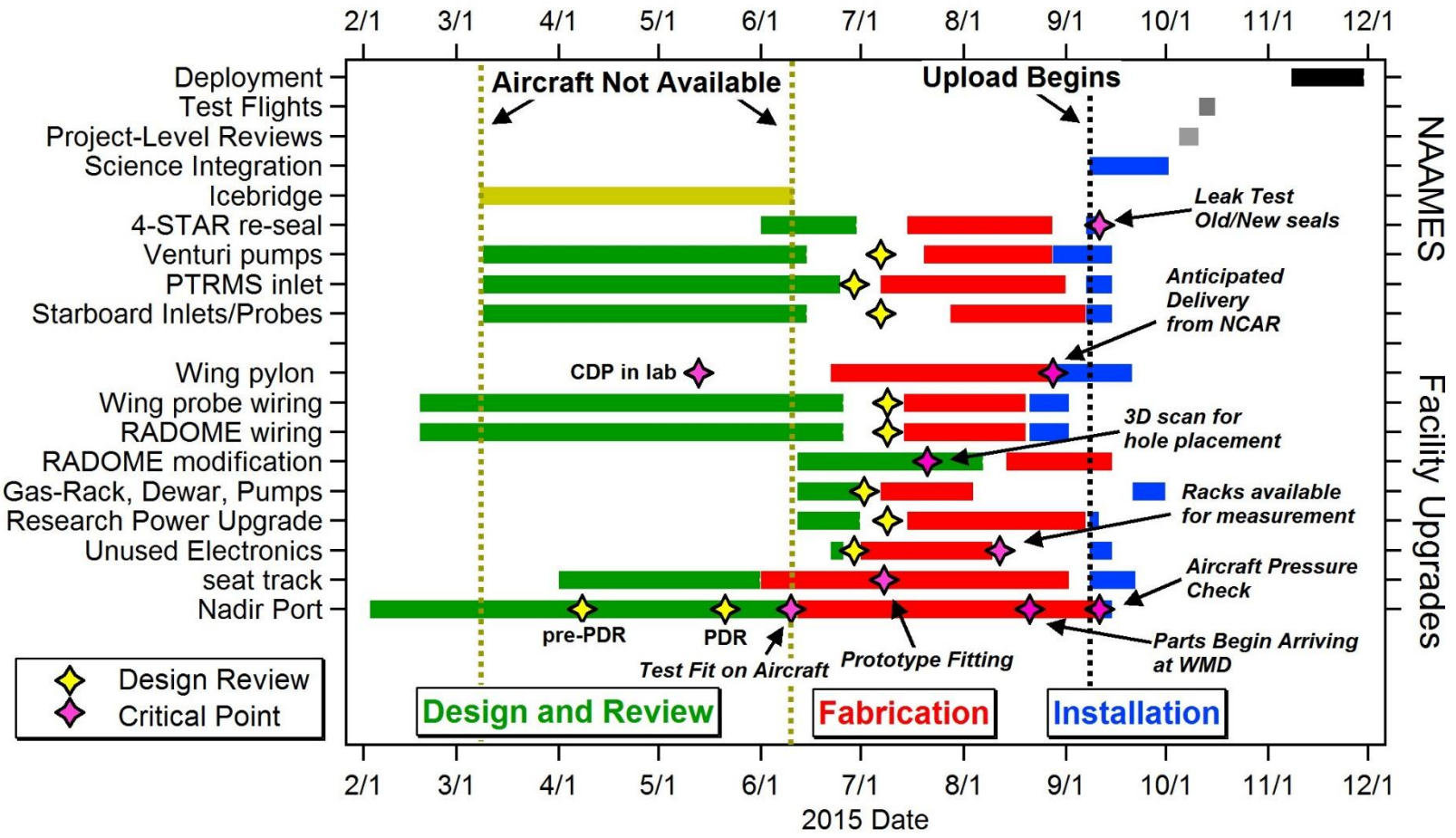
Green = Milestone, Light blue lines = optimal deployment, Yellow = acceptable deployment

✓ = Completed

Team telecons between deployments 1&2, 3&4

Potential instrument/team conflicts: 4STAR (ORACLES, September 2017)

C-130 Modifications Schedule



Full modification schedule allows 3.5-week slip to test flights while still deploying ON-SCHEDULE

September

1

6

LARGE

NADIR PORT

PORT

HSRL

LARGE

LARGE + HSRL

RSP + GCAS

27

PTRMS

4STAR

November

1

Truck to SJB

Science Flights From SJB

30

October

PTRMS

4STAR

4

Airworthiness Reviews

11

Test Flights

18

25

31

December

Truck to WFF

download

6

13

AGU Fall Meeting

20

27

31

R/V Atlantis Integration and Set-Up

Sunday	Monday	Tuesday	Wed	Thursday	Friday	Saturday
				1 **Oct**	2	3
				Shipment to WHOI		
4	5	6	7	8	9	10
Shipment to WHOI						
11	12	13	14	15	16	17
Shipment to WHOI						
18	19	20	21	22	23	24
Shipment to WHOI						
25	26	27	28	29	30 **Science Van Loading**	31 **Van Setup**
Shipment to WHOI						

Sunday	Monday	Tuesday	Wed	Thursday	Friday	Saturday
1 **Nov** **Van Setup**	2	3	4	5	6 **Depart**	7
	Science Team Upload, Integration, Test				Deploy	
				Ship Safety Review		
8	9	10	11	12	13	14
Deployment						
15	16	17	18	19	20	21
Deployment						
22	23	24	25	26	27	28
Deployment						
29	30	1 **Dec**	2			
Deployment		**Return**	DMOB			

Safety Review Requirements

(no later than dates)

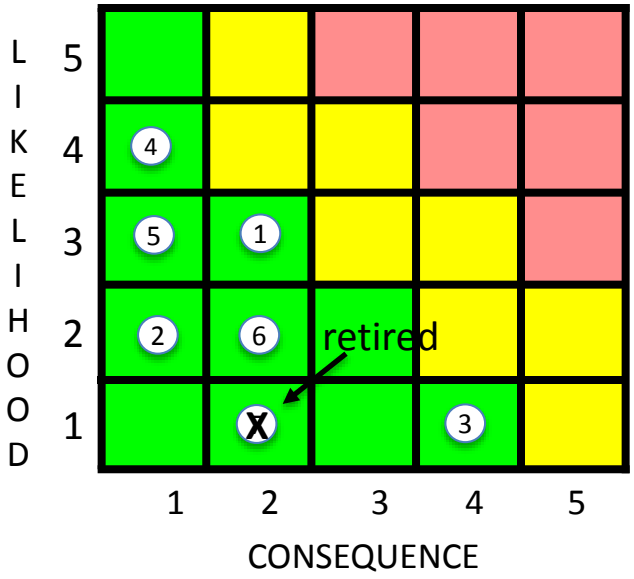
R/V Atlantis (UNOLS/WHOI)

- Safety manual distributed to all ship science teams - March 31
- HazMat Inventory submitted to Atlantis - April 14
- Departure Safety Inspection - Nov 5
- Science Team Safety Briefing - Nov 6
- Emergency Response Drills - Nov 6 - Dec 1 / weekly

C-130 (ASP/WFF)

- Sub-System Airworthiness Reviews Conducted for Applicable Aircraft Modifications Prior to Integration
- Final Installation and Inspection Review (FIIR) – Oct 23
- Flight Readiness Review (FRR) – Oct 27
- Authority to Proceed (ATP) – Oct 28
- Airworthiness Check Flight – Oct 29
- Science Test Flight – Nov 4

Risks



Legend

- Decreasing (Improving)
- Increasing (Worsening)
- Unchanged
- Action: R,A,W,M (research, accept, watch, mitigate)
- Timeframe: N, M,F
- ▲ Project Office Risk
- ◆ Top Project Risk (TProjR)

ID	Trend	Title	Risk Owner	Likelihood	Consequence				Action	Timeframe
					Safety	Technical	Schedule	Cost		
1	→	◆Aircraft mod schedule delays	PI	3	1	2	2	2	W	N
2	→	▲Foreign Deployment – ship	PI	2	1	1	1	1	R	F
3	→	▲Foreign deployment – aircraft – dip clearances	PI	1	1	4	3	3	M	N
4	→	▲Increase in aircraft fuel costs	PI	4	1	1	1	1	W	M
5	→	▲Poor observing conditions (sea state & atmosphere)	PI	3	1	1	1	1	W	M
6	→	▲ Instrument reliability	PI	2	1	2	2	2	W	M
~~7~~	~~→~~	~~▲Readiness of autonomous~~ sensors	~~PI~~	1	1	2	1	1	W	M
~~8~~	~~↓~~	~~▲Availability of aircraft~~ platform (P-3B)	~~PI~~							

Mitigation Strategies for Pre-Deployment Risks

Risk: Aircraft Mod Schedule Delays

Actions: Currently, all aircraft mods are on schedule. NAAMES is actively monitoring through frequent conversations/telecons. Upload is likely to begin on time. Integration schedule contains 3.5 weeks of schedule reserve.

Risk: Foreign Deployment Aircraft – Dip Clearances

Actions: NAAMES project does not currently have diplomatic clearance to operate out of St. John's Newfoundland. A new process is in place. WFF has submitted application to obtain clearance and is checking weekly for requests for additional information.

Risk: Readiness of Autonomous Sensors

Actions: An adequate supply of sensors are already in hand for the first deployment. Additional sensors have been ordered to replenish stock and for future deployments. **Risk retired.**

Principal Investigator Assessment: Ready to Proceed

- **NAAMES continues to be on course for a successful first deployment in November**
- **Design is robust to weather and instrument issues**
- **Instruments are all mature, with extensive field deployment histories**
- **Investigators have extensive field experience, including ship-aircraft coordinated studies with many parallels to NAAMES**
- **Adequate reserves in budget and potential for significant descopes**
- **Actively Watching and Engaged:**
  1. **Diplomatic clearances are submitted and awaiting approval**
  2. **Flight clearances are submitted and awaiting approval and coordination between project, pilots, and FAA.**
  3. **C-130 Modification Schedule - With 3.5 weeks of schedule margin, we expect an on-time deployment.**

Conclusion: NAAMES is ready to proceed to implementation

North Atlantic Aerosols and Marine Ecosystems Study (NAAMES)

Confirmation Review

28 August 2015

http://naames.larc.nasa.gov