AUTOMATED METEOROLOGICAL AND OCEANOGRAPHIC SYSTEM (AMOS)

Presented by

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UNIVERSITY OF MIAMI

AT INMARTECH 2014

OREGON STATE UNIVERSITY, CORVALLIS, OREGON

OCEANSCOPE

- AMOS was designed and deployed for the OceanScope project
- Development supported by Royal Caribbean Cruises Limited, the parent company of Royal Caribbean International and Celebrity Cruises
- The automated observing system is a pilot program initiated by the formal partnership between RCCL and the University of Miami

AMOS BENEFITS

- Uses “off-the-shelf” components
- Uses National Instruments cRIO Real Time Controller
- Program and data are stored in solid-state memory, therefore eliminating rotating storage with high potential for failures
- Critical functions are executed in an FPGA, improving reliability
- Written in LabVIEW Graphical Programming Language
- Leak detection: automatic shutdown with audible and visual alarms
- Pressure monitoring: programmable over pressure level signals automatic shutdown

AMOS BENEFITS CONT'D…

- Bypass valve allows regulation of system pressure and flow
- Bio-fouling controlled through fresh water flushing and mechanical wipers
- Pump monitoring provides protection if air bound due to high sea conditions
- Exclusion zones – system turns on and off automatically based on predetermined coordinates – reducing system contamination in ports and eliminates ship's "discharge"
- Network Camera – provides real time observation of system and valve states
- Remote monitoring
  - Allows diagnosis of problems with system state
  - Permits instruction of crew members to perform tasks/maintenance on the system

RCCL – EXPLORER OF THE SEAS

FUN FACTS – Size and capacity comparison
137,308 GT 311m (1,020 ft) 3,114 passengers 1,180

- Legacy System installed in 2000
- System was manned from 2000 –2007
- Redesigned in 2008
- Included fully automated functionality

INSTRUMENTATION
- AMOS
- ADCPs (38 & 150 kHz)
- MAERI

- Decommissioning science equipment in February 2015
- Moving instrumentation to Freedom of the Seas

USS NIMITZ

FUN FACTS – Size and capacity comparison
100,020 GT 332.8m (1092 ft) 3200 Ship's company, Air wing

RCCL – FREEDOM OF THE SEAS

FUN FACTS – Size and capacity comparison
154,407 GT 339m (1,112 ft) 3,634 passengers 1,360

- Replaces EXPLORER of the SEAS science installation
- Scouting trip scheduled early November 2014
  - Meet staff – Environmental and Engineering officers and crew
  - Find potential locations for equipment
  - Discuss timeline, assistance required, potential issues
- Dry dock Jan 2015
  - Bow intake and discharge
  - Seachests for ADCPs

AMOS PARAMETERS EXPLORER OF THE SEAS

- Sea Surface Temperature
- Sea Surface Salinity
- Turner Designs C6 Fluorometer
  - Chlorophyll *a*
  - DOM
- Auxiliary system
  - pCO_2

RCCL – ALLURE OF THE SEAS

FUN Facts – Size and capacity comparisons

225,282 GT 362m (1187 ft) 6,296 passengers 2,384 c

- Installation in 2012
- AMOS MK III
- Seawater intake located mid-ship, tapped from ship's main seachest
- Met data provided by ship's sensors
- Dry dock in 2015
  - Relocate AMOS to bow thruster space
  - Install 75 kHz ADCP
  - Auxiliary pCO_2

CELEBRITY – EQUINOX

FUN FACTS – Size and capacity comparison

121,878 GT 317.2m (1,041ft) 2,850 passengers 1,250 c

- Latest Cruise Ship Installation
- Cadiz, Spain
  - May 2014

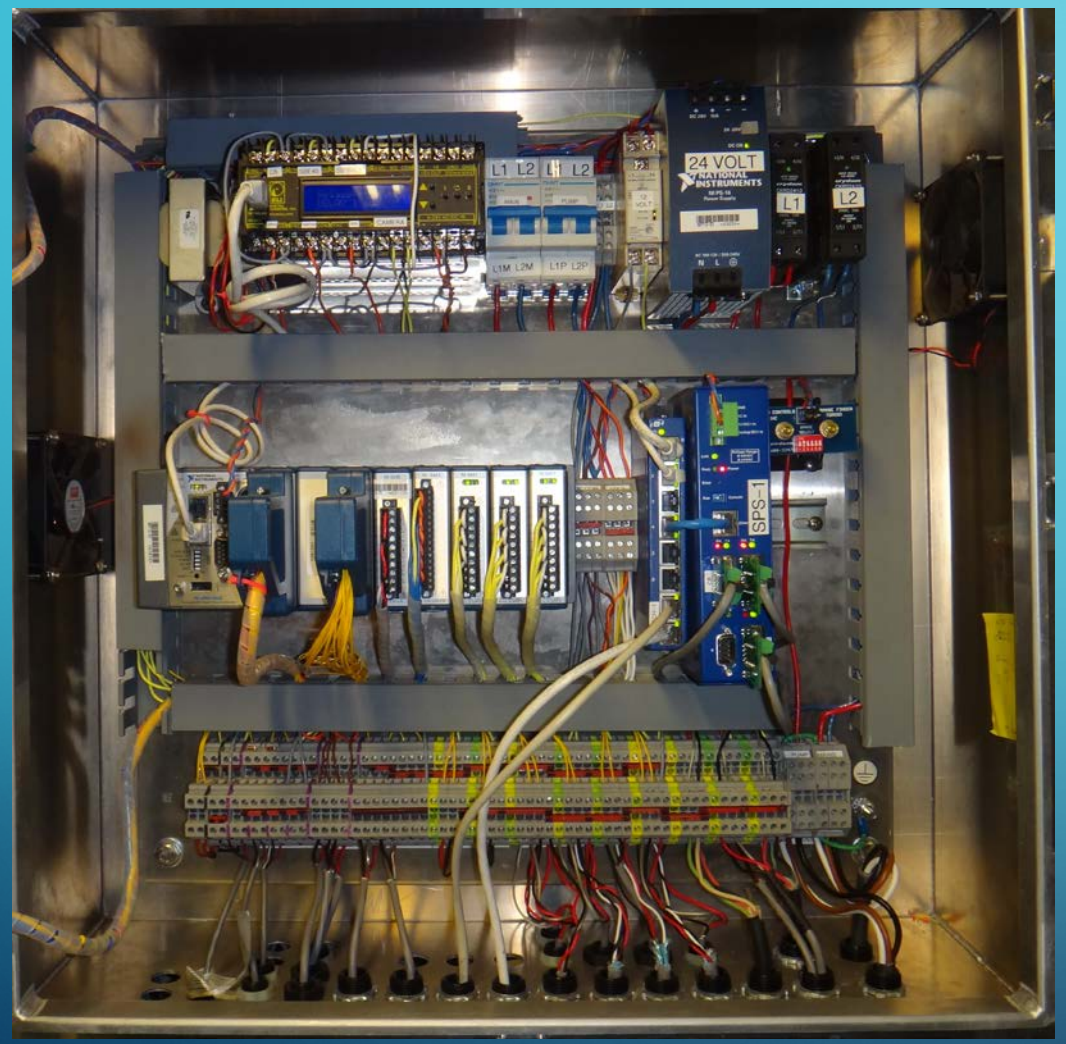
NEWEST AMOS INSTALLATION – EQUINOX

- Located in bow thruster space
- Dedicated through hull valves

PARAMETERS

- Sea Surface Temperature
- Sea Surface Salinity
- Turner Designs C6
  - DOM
  - Chlorophyll *a*
  - Turbidity
  - Phycoerythrin (Cyanobacteri
  - Crude Oil
  - Optical brighteners (detergents)
- Auxiliary System
  - pCO_2 (soon)

INSIDE THE BOXES



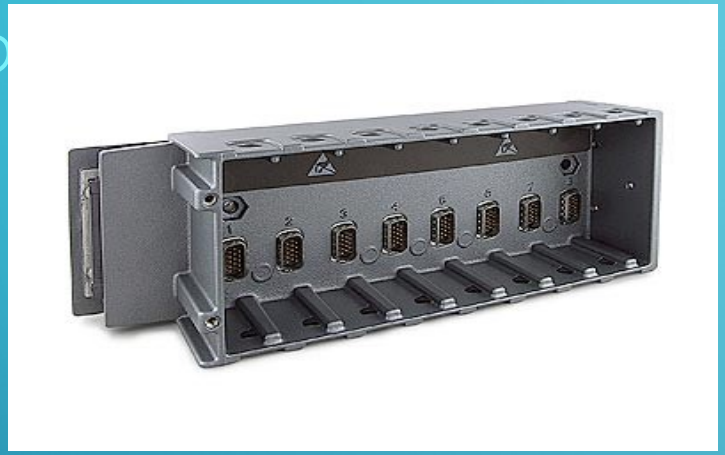
Dry Box

Wet Box

NI cRIO-9024 Real-Time Controller

- Embedded controller runs LabVIEW Real-Time for deterministic control, data logging, and analysis
- 800 MHz processor, 4 GB nonvolatile storage, 512 MB DDR2 memory
- Dual Ethernet ports with embedded Web and file servers for remote user interfacing 10/100 &10/100/1000
- Hi-Speed USB host port for connection to USB flash and memory devices
- RS232 serial port for connection to peripherals; dual 9 to 35 VDC supply inputs
- -20 to 55 °C operating temperature range
- Operating humidity
  - (IEC 60068-2-56) 10 to 90% RH, noncondensing
- Vibration
  - Random (IEC 60068-2-64) 5 grms, 10 to 500 Hz
  - Sinusoidal (IEC 60068-2-6) 5 g, 10 to 500 Hz
- Operating Shock
  - (IEC 60068-2-27) 30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations

NI cRIO-9114 RECONFIGURABLE CHASSIS



Example

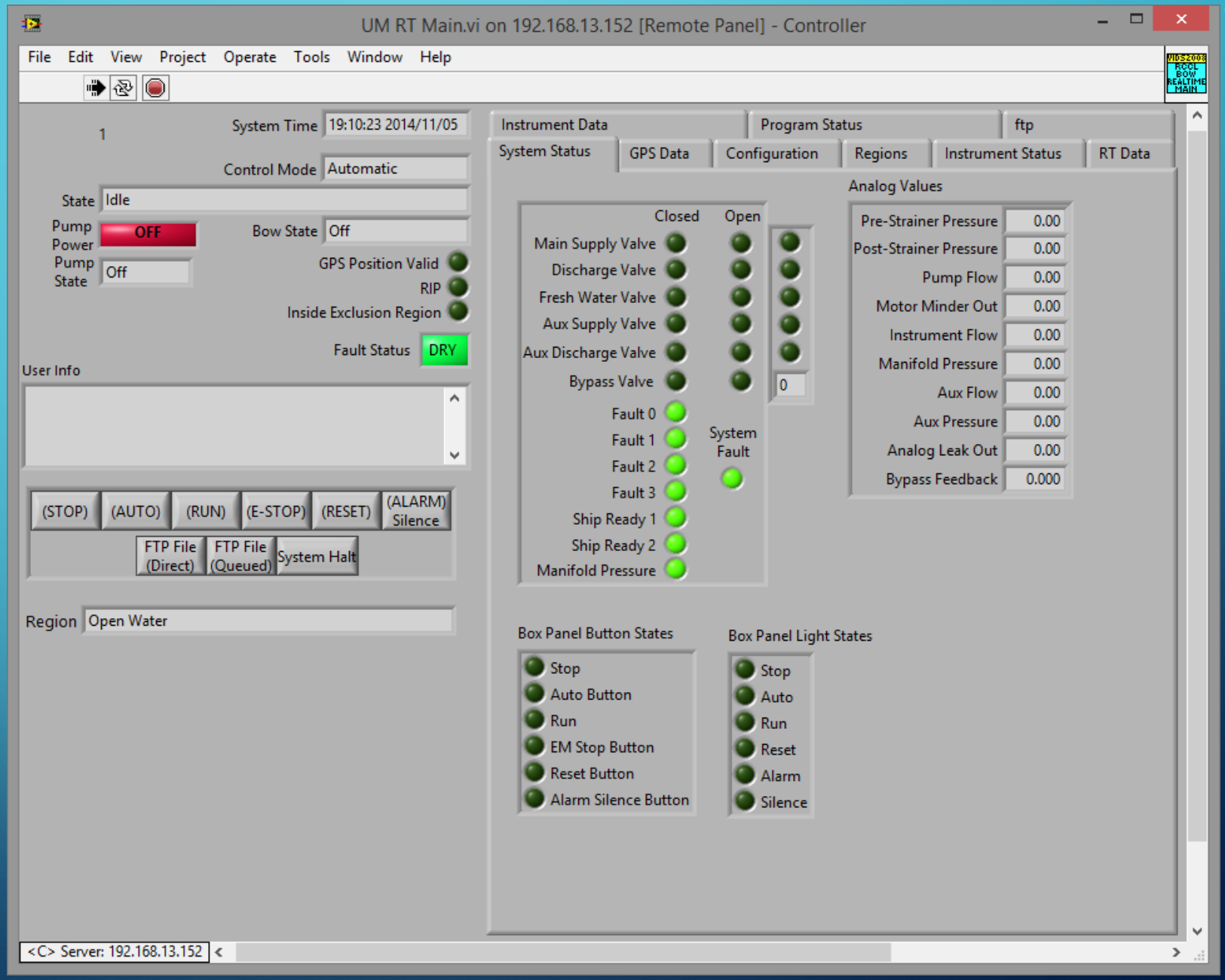
- **8-Slot, Virtex-5 LX50 cRIO Reconfigurable Chassis**
  - Number of flip-flops 51,840
  - Number of 6-input LUTs 28,800 (Look Up Tables)
  - Embedded block RAM 3,456 kbits
- LabVIEW FPGA automatically synthesizes electrical circuit implementation
- cRIO extreme industrial certifications and ratings
- cRIO FPGA core executes at default rates of 40 MHz

I/O MODULES INSTALLED

- NI 9208 +/- 21.5 mA, Current Analog Input, 500 S/s. 16 Ch Module
- NI 9425 24 V, Sinking Digital Input, 32 Ch Module
- NI 9265 0 to 20 mA, Analog Output, 100 kS/s/ch, 4 Ch Module
- NI 9485 SSR Relay, 60 VDC/30 Vrms, 750 mA, 8 Ch Module
- NI 9481 (3) 4-Channel Relay [30 VDC (2 A), 60 VDC (1 A), 250 VAC (2 A)]

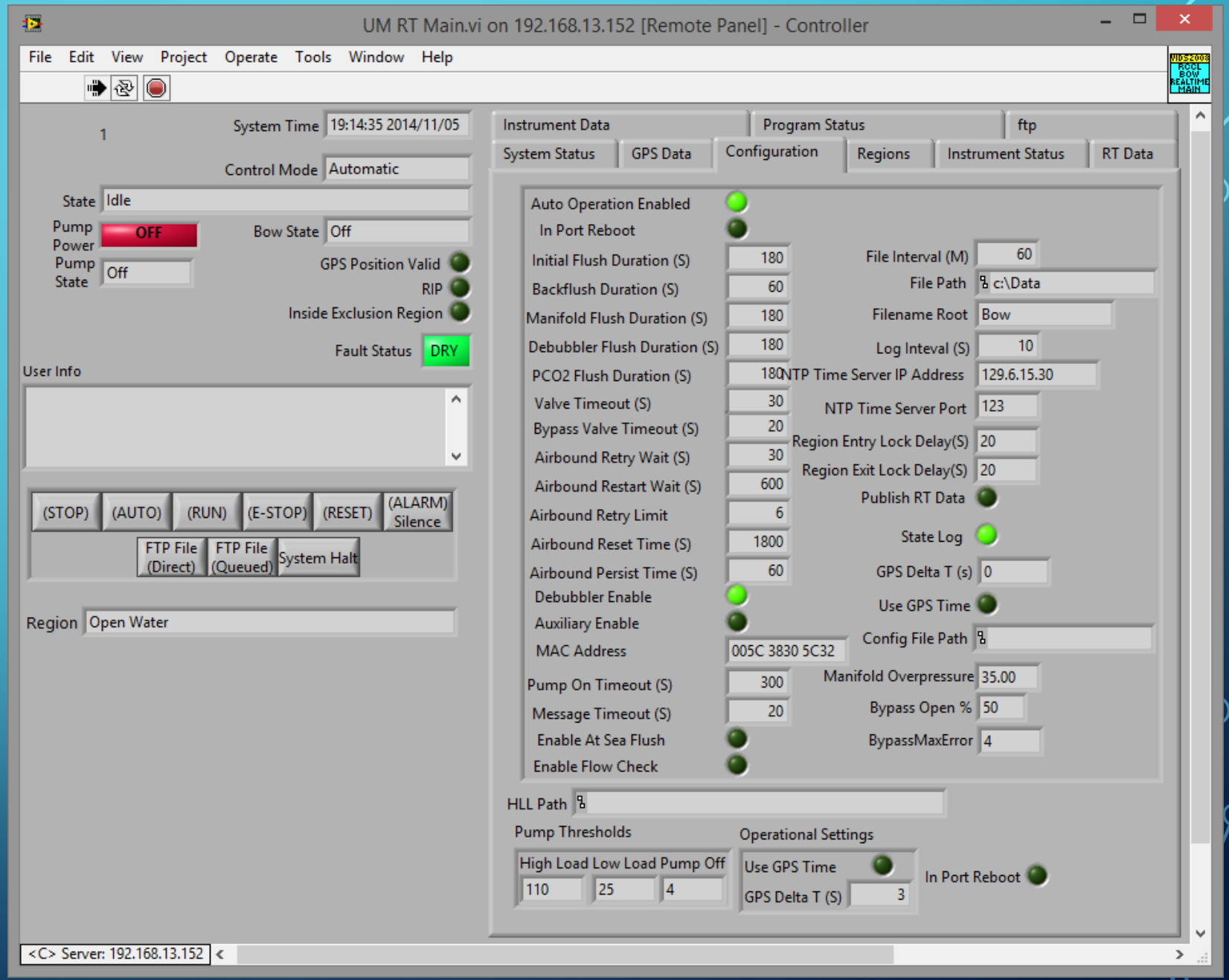
REMOTE PANEL

SYSTEM STATUS



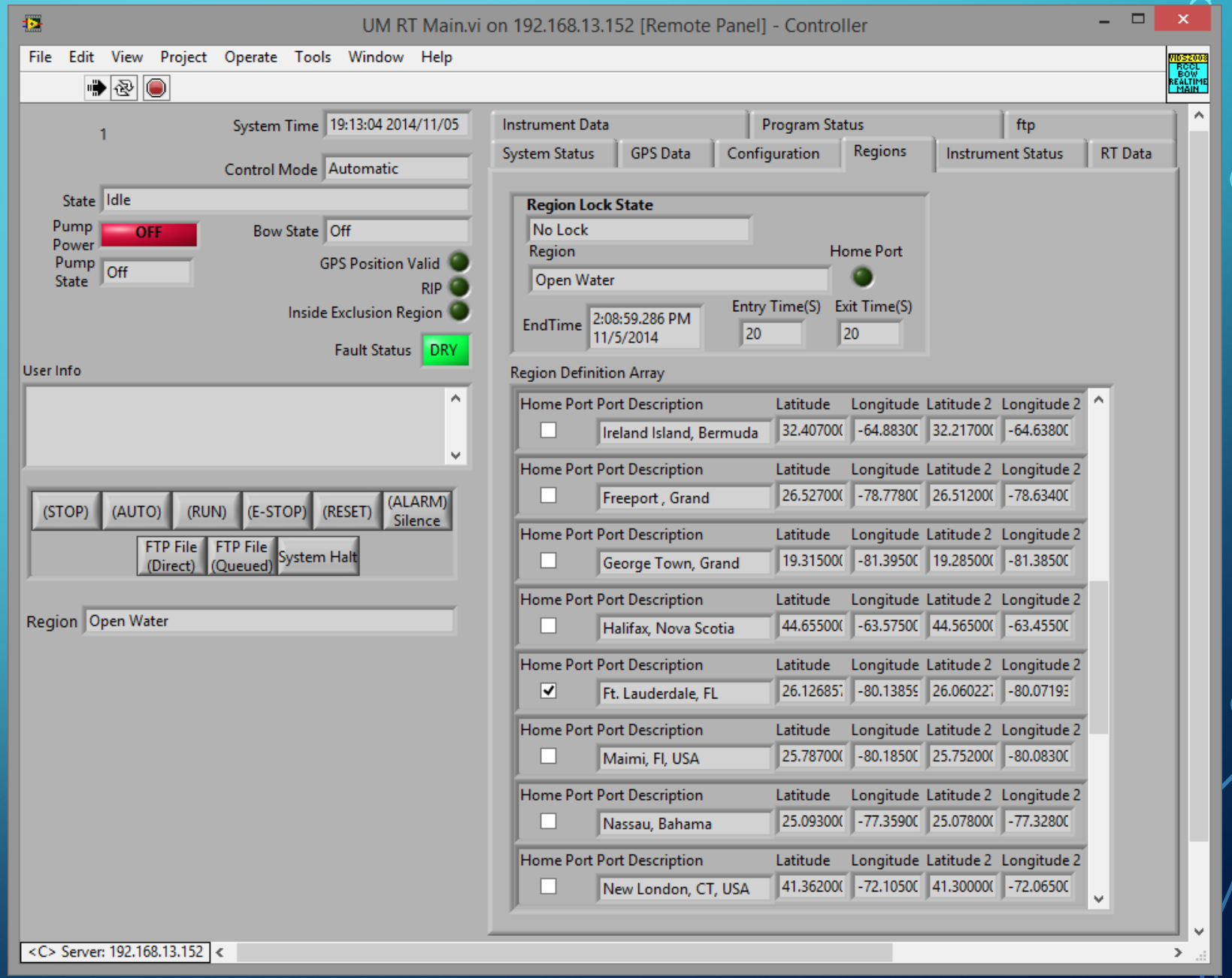
REMOTE PANEL

CONFIGURATION DISPLAY



REMOTE PANEL

EXCLUSION ZONES



SEA-BIRD SBE 38 DIGITAL OCEANOGRAPHIC THERMOMETER

- **Range:** −5 to +35 °C
- **Initial Accuracy** [1]: ± 0.001 °C (1 mK)
- **Resolution:** 0.00025 °C (0.25 mK)
- **Stability:** 0.001 °C (1 mK) in six months, certified
- **Response Time** [2]: 500 milliseconds
- **Self-heating Error:** less than 200 µK

SEA-BIRD SBE 45 MICROTHERMOSALINOGRAPH

	Conductivity	Temperature (°C) *	Salinity (PSU), typical
Measurement Range	0–7 S/m (0–70 mS/cm)	-5 to 35	-
Initial Accuracy	± 0.0003 S/m (0.003 mS/cm)	± 0.002	± 0.005
Typical Stability (per month)	0.0003 S/m (0.003 mS/cm)	0.0002	0.003
Resolution	0.00001 S/m (0.0001 mS/cm)	0.0001	0.0002
Calibration Range	0–6 S/m (60 mS/cm), physical calibration over the range 2.6 to 6 S/m (26–60 mS/cm), plus zero conductivity (air)	+1 to +32 °C	

SBE 360 CAROUSEL SAMPLER ABOARD ALLURE OF THE SEAS

TURNER DESIGNS C6 MULTI-SENSOR PLATFORM
WITH MECHANICAL WIPER

- The C6™ Multi-Sensor Platform integrates up to six Cyclops-7™ fluorescence and turbidity sensors for extended or short-term deployments. The C6™ provides individual automatic gain control, calibration, and digital data reporting for each Cyclops-7™ sensor. Each C6 comes with factory-installed temperature and pressure sensors.

TURNER DESIGNS SENSORS AVAILABLE

Application	Minimum Detection Limit	Dynamic Range
CDOM/FDOM	0.15 ppb 0.5 ppb	0-1250 ppb 0-5000 ppb
Chlorophyll *in vivo* Blue Excitation Red Excitation	0.025 µg/L 0.5 µg/L	0-500 µg/L >500 µg/L
Fluorescein Dye	0.01 ppb	0-500 ppb
Oil - Crude	0.2 ppb	0-2700 ppb
Oil - Fine	10 ppb 10 ppm	>10,000 ppb >100 ppm
Optical Brighteners	0.6 ppb	0-15,000 ppb
Phycocyanin (Freshwater Cyanobacteria)	2 ppb	0-40,000 ppb
Phycoerythrin (Marine Cyanobacteria)	0.15 ppb	0-750 ppb
PTSA Dye	0.1 ppb	0-650 ppb
Rhodamine Dye	0.01 ppb	0-1000 ppb
Tryptophan	3 ppb	>20,000 ppb
Turbidity	0.05 NTU	0-3000 NTU

MSRC VDB-1 VORTEX DEBUBBLER

- Developed at Stony Brook University's Marine Sciences Research Center (MSRC)
- 2 inch diameter, internal volume approximately 0.5 liter. Suggested flow rate 9 to 12 liters per minute (2.4 – 3.2 gallons/min).
- Contact:

  Thomas.Wilson@stonybrook.edu

DIGITAL LOGGERS INC – WEB CONTROLLED, 8 CHANNEL DIN RELAY

Allows remote power cycling of individual instrumentation

- cRIO
- SBE 38 Remote Temperature Sensor
- SBE 45 MicroTSG
- Turner Designs C6

LOAD CONTROLS PMP-25

- Monitors Load on Pump
  - Dry Running
  - Overload
  - Cavitation
  - Bearing Failure

PRESSURE AND FLOW

Omega Absolute Pressure Gauge

- Monitors pressure at multiple points
  - Pre-strainer
  - Post-strainer
  - Instrument Manifold
- 316 Stainless S
- 4-20 mA outp
- Loop Powered

Dynasonics Clamp-On Transit Time Ultrasonic Flow

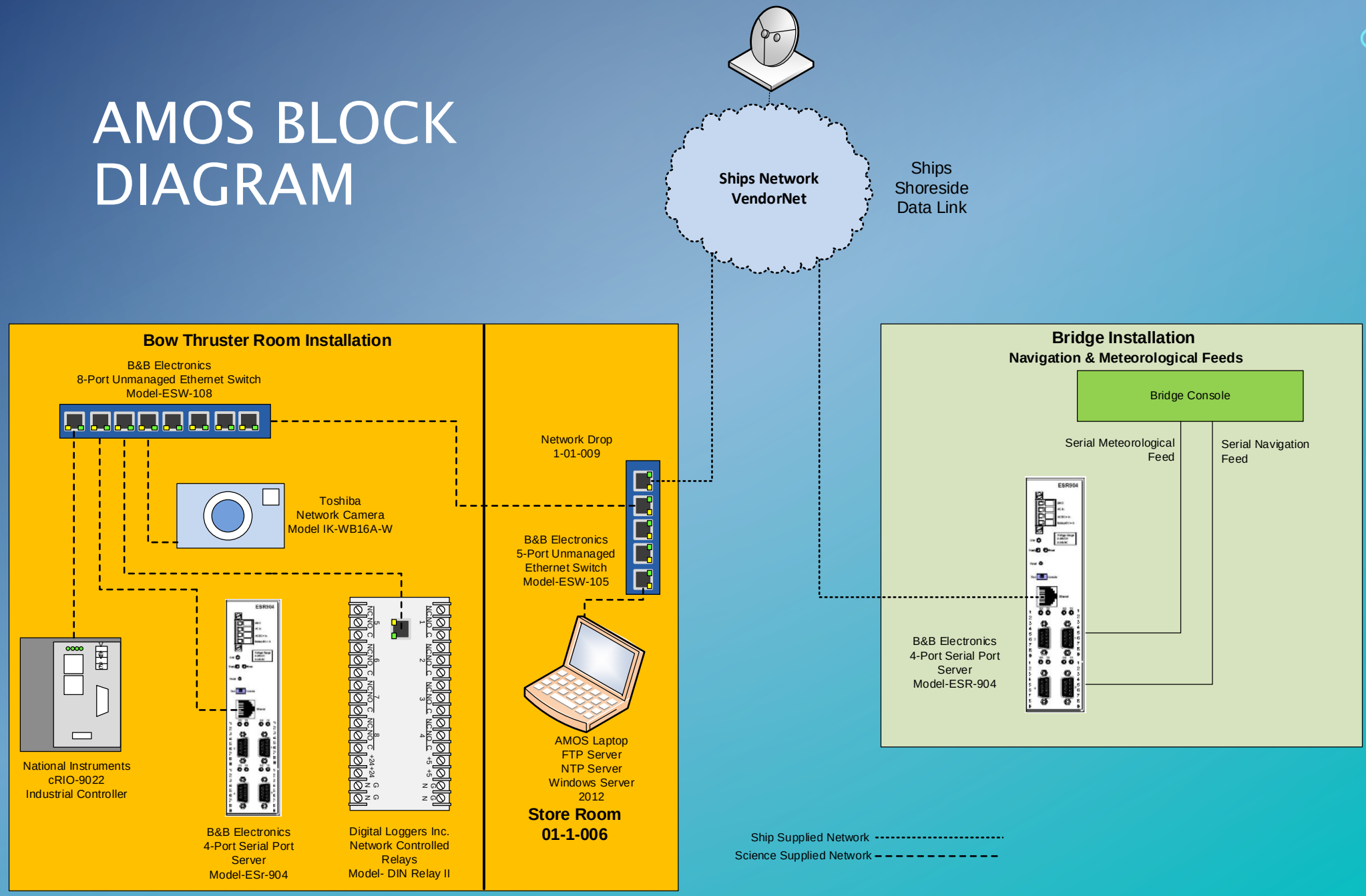
- Monitors pump and sensor flow externally
- No wet or moving parts (no fouling)
- Outputs
  - Serial

B&B ELECTRONICS ESR904 ETHERNET TO SERIAL CONVERTER

- Supports either UDP or TCP protocols
- Allows transmitting to and receiving from multiple IP addresses

- Used to interface ship's bridge sensors (GPS, Gyro & Meteorological) to AMOS
- Internal AMOS interface
    - SBE 38 Remote Temperature Sensor
    - SBE 45 Microthermosalinograph
    - Turner C6

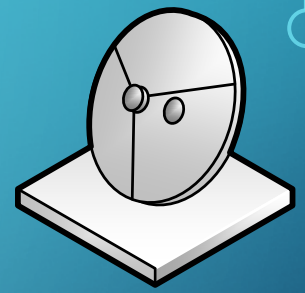
AMOS BLOCK DIAGRAM



DATA FLOW

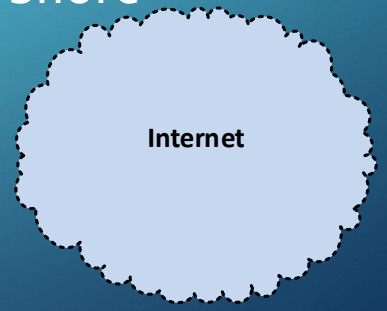
Data stored locally on cRIO, transferred hourly by FTP to AMOS laptop

Data stored on AMOS laptop on a RAID drive



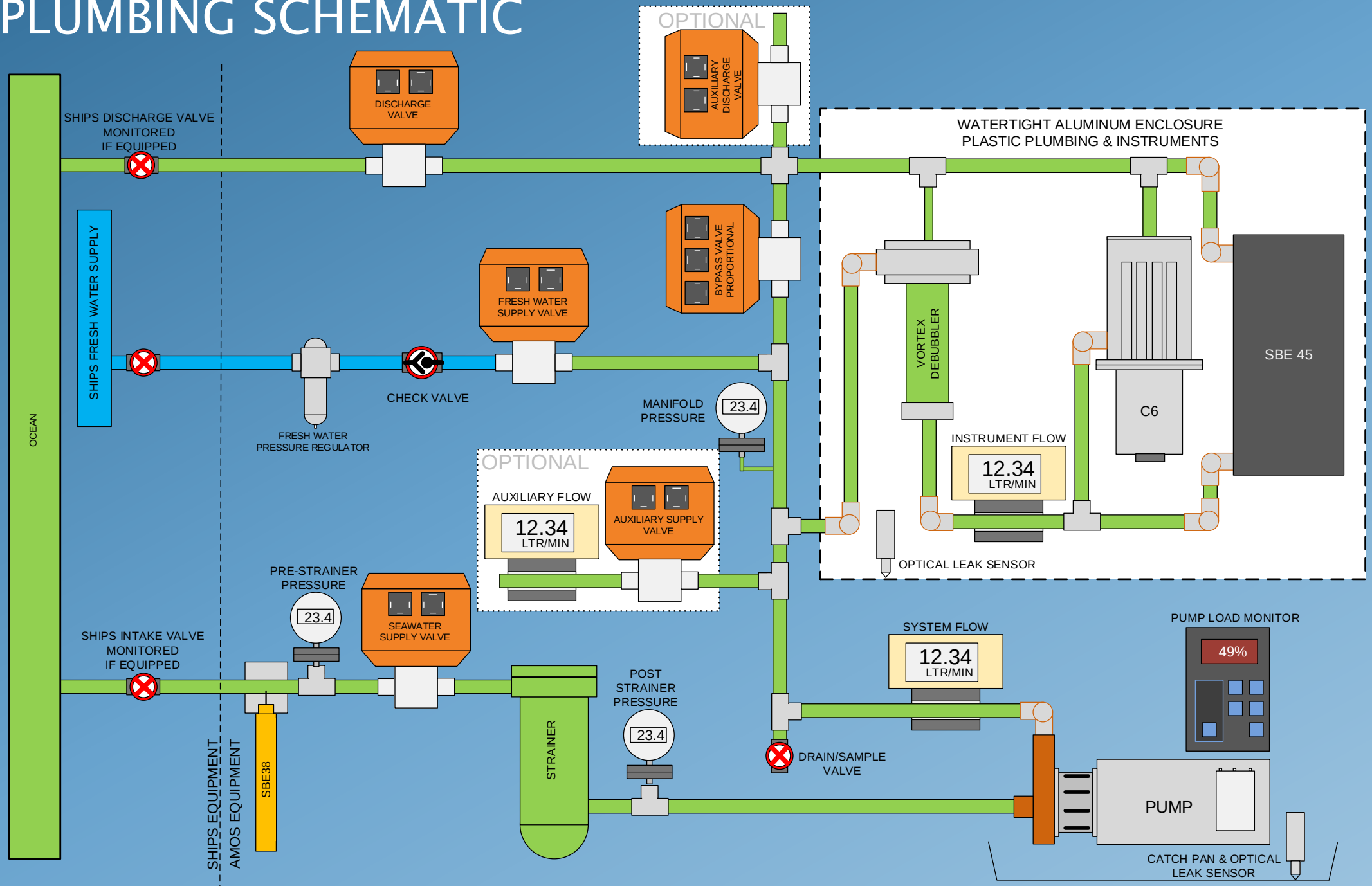
Satellite Connection – Ship to Shore

Data pulled by FTP from AMOS laptop to RSMAS Server



Data made available to registered science users

PLUMBING SCHEMATIC



THANK YOU

- Royal Caribbean/Celebrity Cruise Lines
- Crew of:
  - Explorer of the Seas
  - Allure of the Seas
  - Equinox
  - Freedom of the Seas
- NOAA
- NSF
- NASA

CONTACTS

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