Enabling Technology to Extend Life and Utility of Hydroacoustic Systems

L3 MariPro

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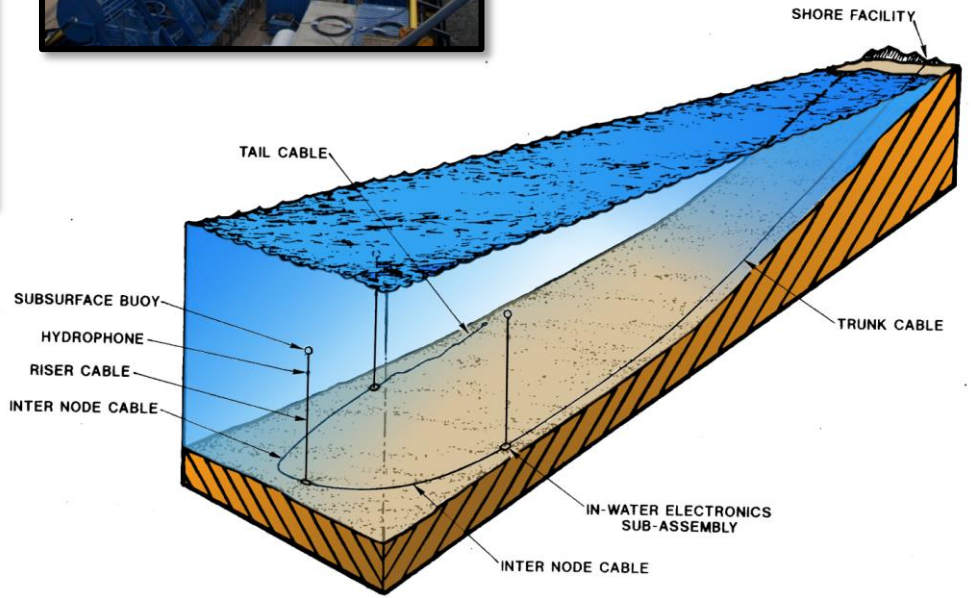
Topics

- **Application of advances in installation technology**
- **Ocean observatory expansion to existing systems**

Hydroacoustic Station



- **3 hydrophones in water column**
- **11 systems in 6 remote locations worldwide**
- **Deepwater deployments with 20 year design life, however actual in-water system life closer to 100 years**

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Application of Advances in Installation Technology

HA04 Crozet Installation

- **Installation at HA04 Crozet presented greater challenges than the previous five hydroacoustic system installations**
- **Extended the installation weather upper limit due to severe conditions common at Crozet**
  - Weather limit driven by maximum allowable vessel motion during lowering nodes
- **Beaufort scale used to quantify weather severity**
  - Previous threshold Beaufort 5
  - Crozet threshold Beaufort 6
  - Roughly doubled stern accelerations forcing motion of nodes in water during deployment

BEAUFORT WIND FORCE	WIND SPEED (KNOTS)	SIGNIFICANT WAVE HEIGHT (M)
5	18 - 20	1.9 – 2.4
6	22 - 26	3.0 – 4.6

Launching First Node S1 at HA04 Crozet

HA04 Crozet Installation - Changes to components

- **Modify node base structure for lower in-water drag and higher negative buoyancy**
- **Increase tension capability of load bearing components in node base and of the internode cable used to lower node to seafloor**
- **Add position transponders to node**
  - Update real-time deployment modeling software with live position
  - Accurate record of actual node location on seafloor

SYSTEM	VESSEL MOTION AMPLITUDE	NODE	PEAK INTERNODE DYNAMIC LOAD	MINIMUM INTERNODE CABLE YIELD	SAFETY FACTOR
Original	1.3 m	2	33,000 N	66,700 N	2.0
Crozet	2.5 m	2	55,600 N	111,200 N	2.0

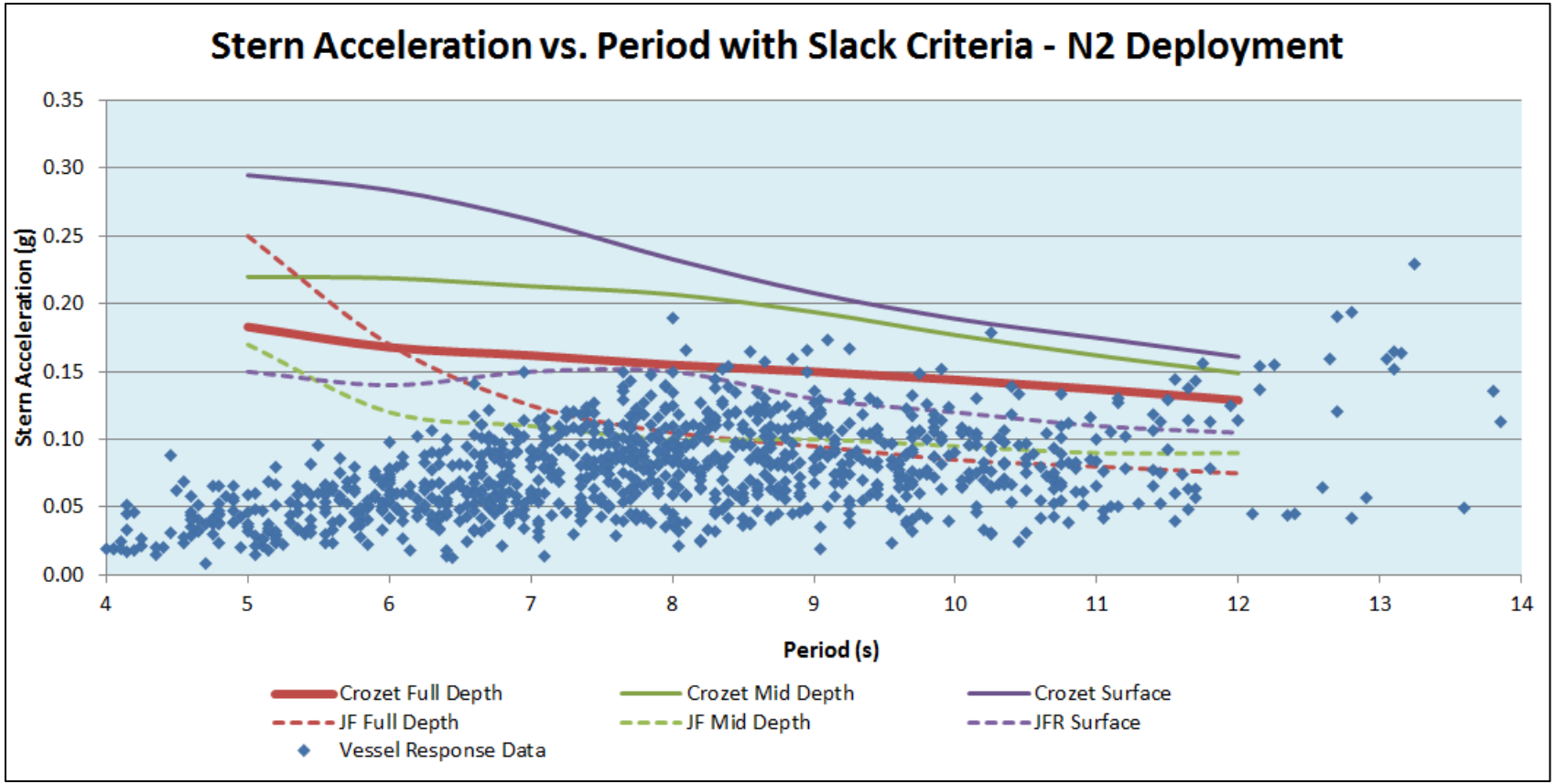
Transponder on Node S3

HA04 Crozet Installation - Deployment Model and Data

- **Developed installation models for original and new systems**
  - Predict when slack of lowering cable may occur for given stern accelerations and periods during deployment
  - Slack line leads to snap loading where tension can instantaneously increase beyond cable limits
  - Nodes lowered from stern; vessel stern motion is driving function
  - Node shape and cable properties for original and new system fed into model for comparison to previously recorded installation tension data for model validation
  - Plotted various forcing functions since vessel stern motion is variable in both amplitude and period
- **Monitored pre-deployment vessel stern acceleration to ensure driving motion was below threshold for deployment**
- **Monitored tension during deployment to compare actual tensions to modelled values for given node depth**

Overboarding Node N2

HA04 Crozet Installation - Deployment Model and Data



Applying Additional Technological Advances

- **Route Working Group used to plan system location, trunk cable route, and cable armoring type for longer system life**
  - Higher resolution bathymetry and improved deployment modeling software allows planning installation to avoid seafloor features that may cause premature cable failure
  - Increased emphasis on cable armoring schedule puts proper armor where needed
- **Improved vessel positioning and control systems reduces value of vessel position and speed variables so actual cable route matches planned route**
- **Shore electronics updated and maintained to ensure compatibility with data center infrastructure and latest software security**

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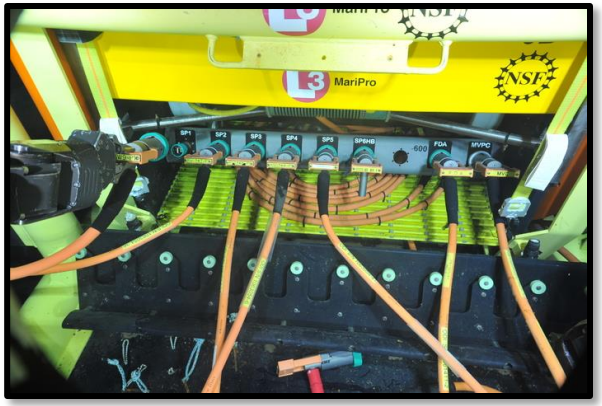
Ocean Observatory Expansion

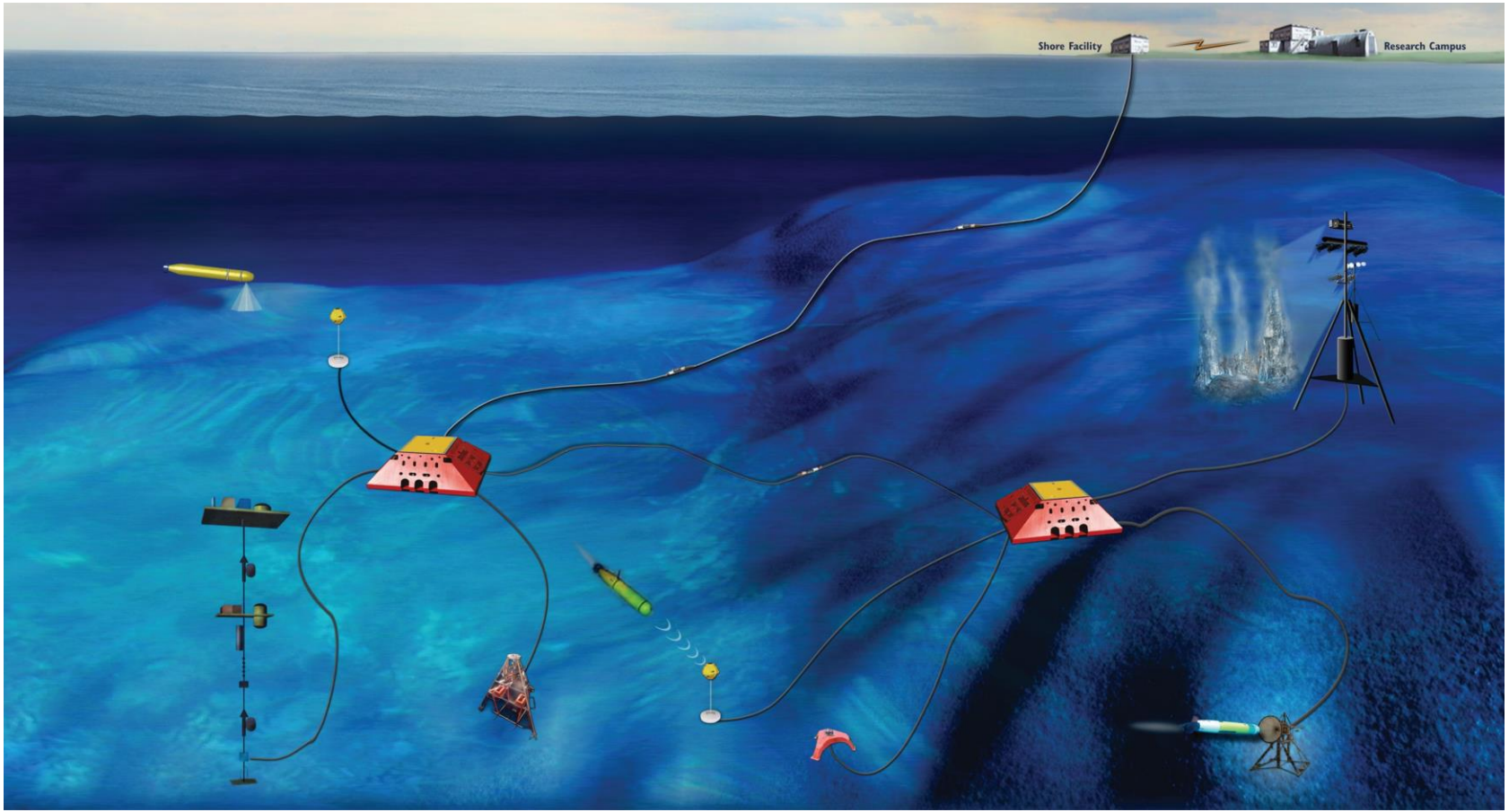
Ocean Science – What is an Ocean Observatory?

- **An ocean observatory is a power and data hub on the seafloor providing real-time data collection and long-term observation**
  - Single node to multiple nodes with regional coverage
- **Observatory has the advantage of expanding its utility as science interest and technology changes**
  - Wet-mate connectors allow flexibility of instrument types and connection of secondary infrastructure for expansion
  - Enabling science to meet new and unforeseen interests by allowing evolution in subsea science over life of the system
  - Persistent presence on the seafloor for long-term data acquisition
- **Similar architecture to existing hydroacoustic systems**
  - Shore station, trunk cable, sensors (node)



ROV Mating Wet-Mate Connector to OOI/RSN Node

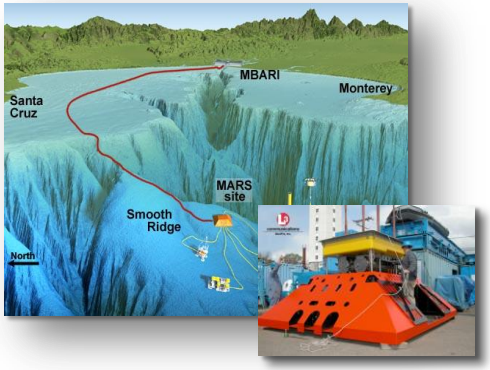
Ocean Science – Ocean Observatory



Ocean Science - Infrastructure

- **L3 MariPro has over 15 years of experience providing the largest cabled ocean observing systems deployed to date**
- **Systems successfully installed with over 1,500 km of cable with capacity of up to 10 Gbps, 10 kV operating voltage, and shore facilities that support over 150 kW of power for science**

Monterey Accelerated Research System (MARS)

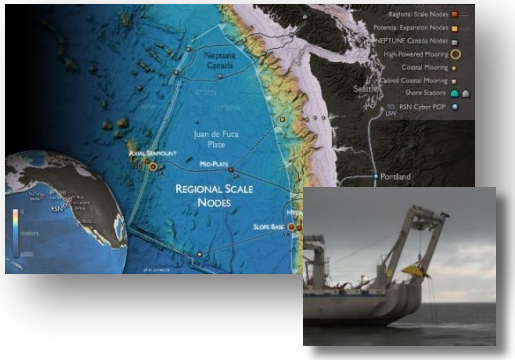


http://www.mbari.org/mars/

Ocean Networks Canada – NorthEast Pacific Time-Series Undersea Network Experiments (ONC-NEPTUNE)

http://www.oceannetworks.ca/

NSF Ocean Observatories Initiative Cabled Array (OOI- Cabled Array or RSN)



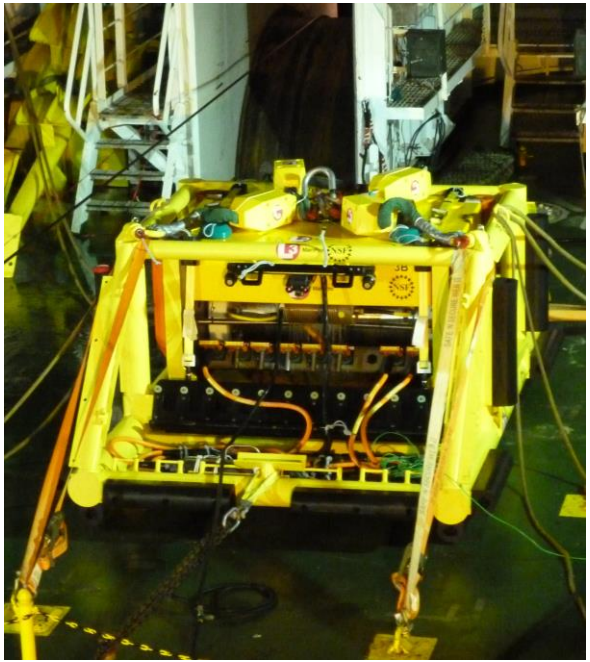
http://oceanobservatories.org/array/cabled-array/

Ocean Observatory Expansion

- **Capabilities of hydroacoustic systems can be enhanced through addition of observatory nodes along trunk cable**
- **Observatory infrastructure will support many instrument types**
  - Video and still cameras
  - Seismic sensors
  - Salinity, temperature, pressure, conductivity, turbidity
  - Current speed and direction (seafloor and vertical profilers)
  - Rovers or dock for Autonomous Underwater Vehicle (AUV)
- **Trunk cable damage is the most likely hydroacoustic system failure mechanism**
  - A cable repair mission allows opportunity to add observatory components to the system
  - Vessel is single highest-cost operation of hydroacoustic system installation and maintenance
- **Observatory infrastructure allows faster connection of a new or next generation hydroacoustic system without need to lay new trunk cable**
- **The addition of an observatory must not lower availability of hydroacoustic system**

Ocean Observatory Expansion

- **Primary limitation of an observatory added to the hydroacoustic system trunk cable is power availability and data transmission rates at remote shore sites**
  - Mostly isolated islands
- **Technology developed by L3 MariPro for the OOI/RSN observatory can be used for an observatory at hydroacoustic system locations**
- **Additional partnering with science community may enhance interest and investment in hydroacoustic systems**



Deep Water OOI/RSN Node
Just Prior to Deployment

Ocean Observatory Expansion - Conclusions

- **Improved installation methods allow better trunk cable routing and installation of hydroacoustic systems in more severe weather**
- **Capabilities of cabled hydroacoustic systems can be enhanced through addition of data and power connections along trunk cable**
- **Observatory design based on shore station capabilities**
- **Observatory infrastructure facilitates easier and faster hydroacoustic system replacement with next generations**

NEPTUNE Canada Node

Thank you!

ROV Test of Mating Connectors to RSN/OOI Node