astro technology

ADVANCED DEEPWATER MONITORING

ABOUT ASTRO TECHNOLOGY

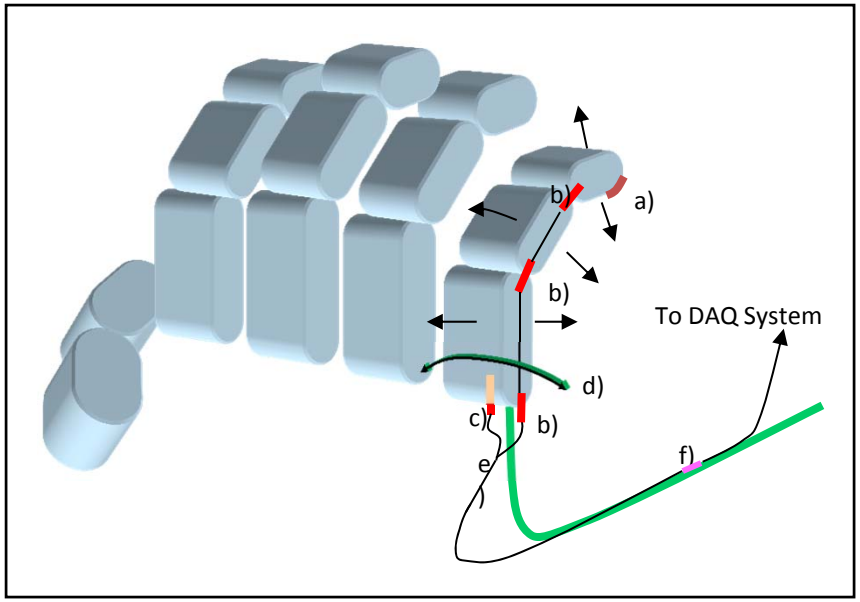
ADVANCED INSTRUMENTATION FOR:

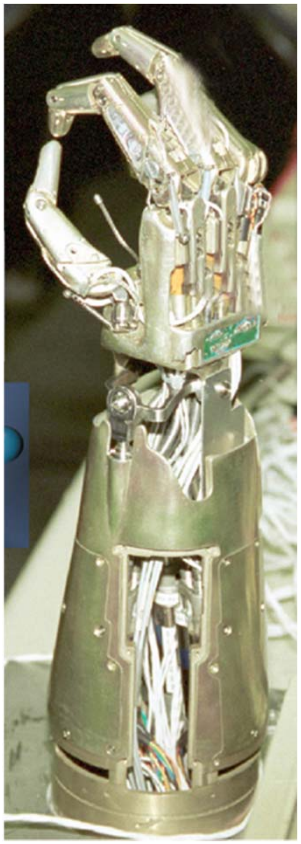
- Subsea fields
- Pipelines and risers
- Space structures
- Rocket Motors

ENGINEERING CAPABILITIES INCLUDE:

- System integration
- Real-time embedded systems
- Experimental stress analysis
- Fiber-optic sensor technology
- Conventional sensor integration
- Environmentally hardened systems
- Software development

INSTRUMENTATION OF NASA'S ROBONAUT HAND

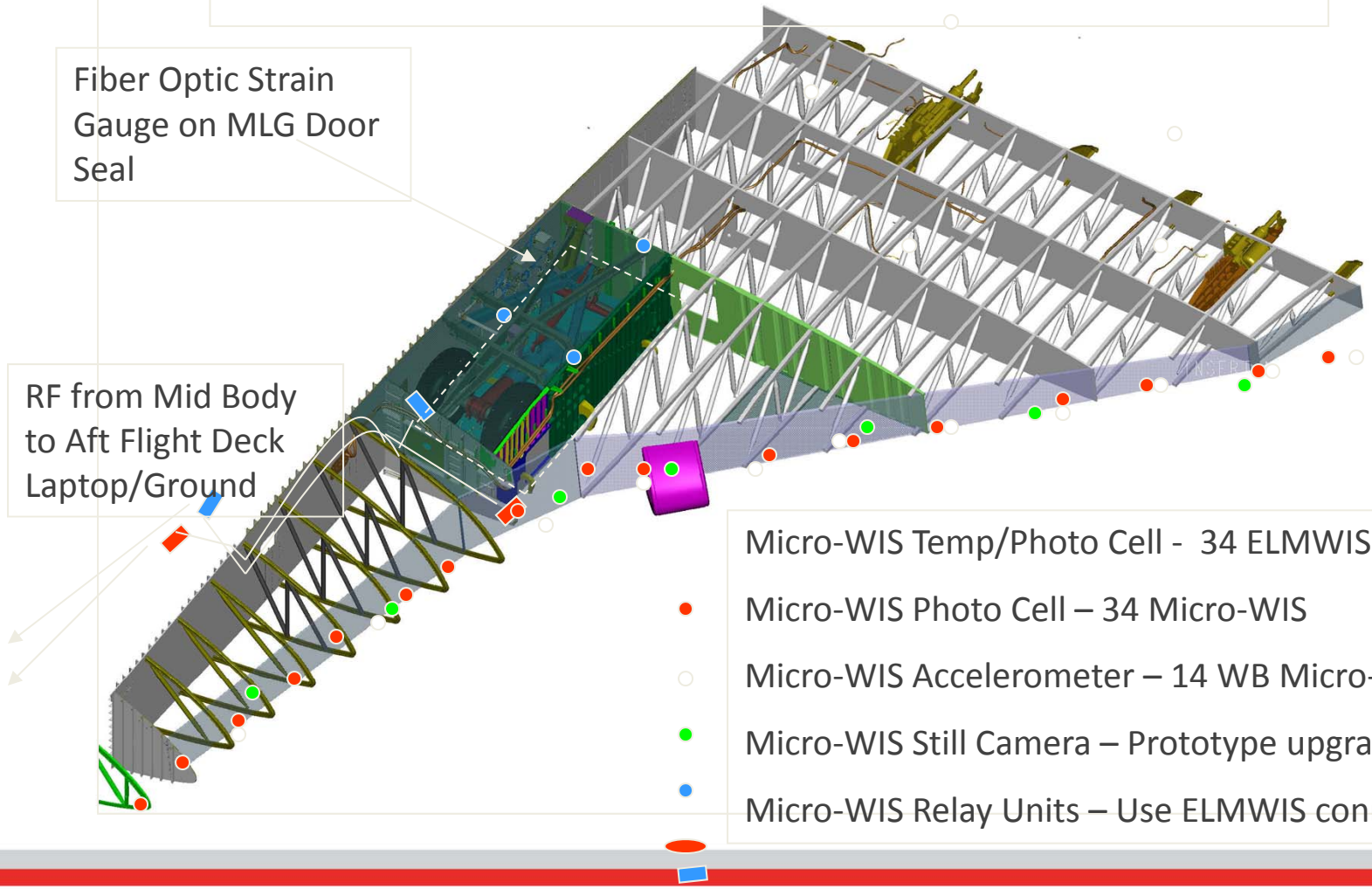




Space Shuttle Return-to-Flight

Fiber Optic Strain Gauge on MLG Door Seal

RF from Mid Body to Aft Flight Deck Laptop/Ground



Micro-WIS Temp/Photo Cell - 34 ELMWIS

Micro-WIS Photo Cell – 34 Micro-WIS

Micro-WIS Accelerometer – 14 WB Micro-TAU

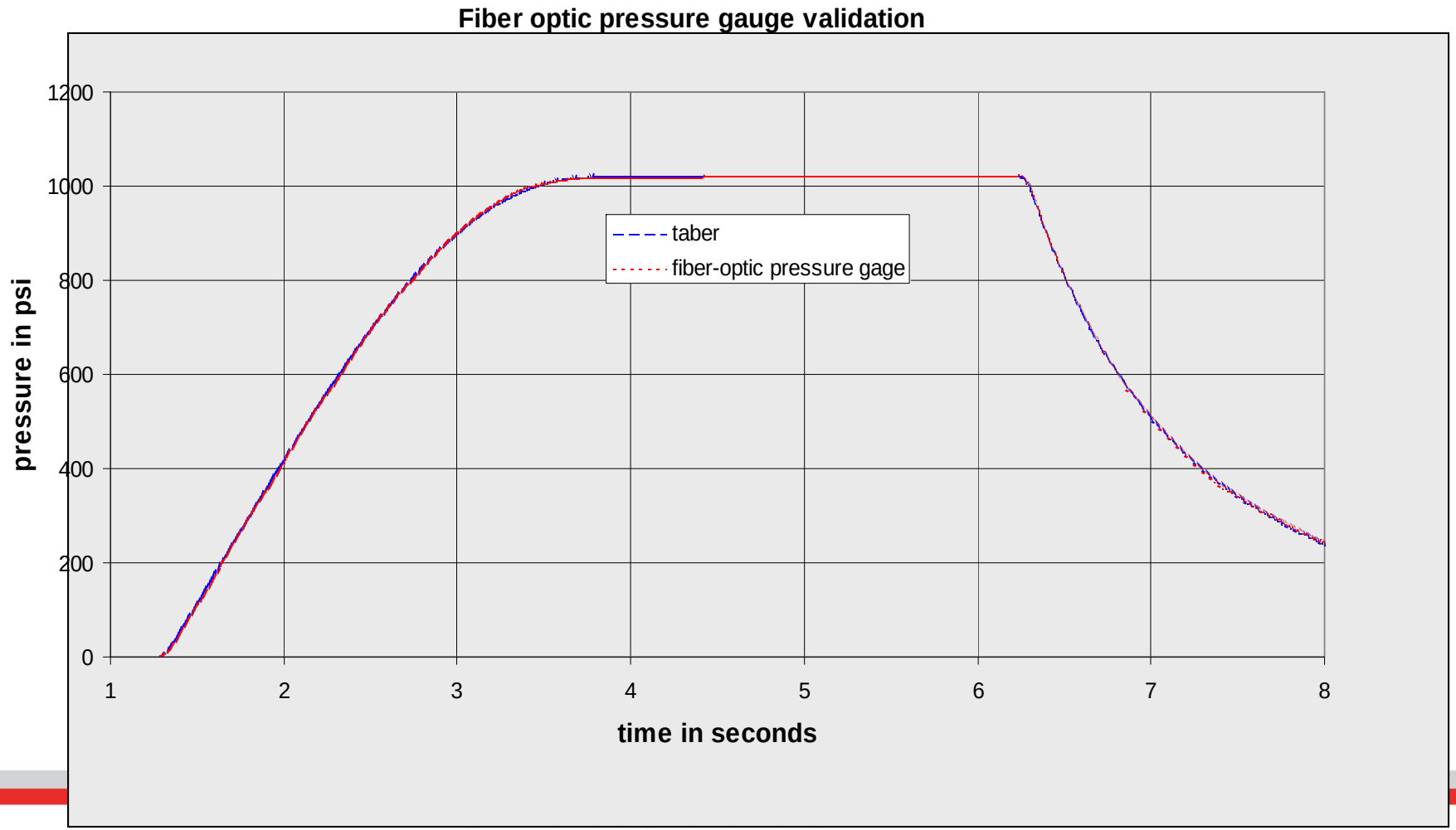
Micro-WIS Still Camera – Prototype upgrade to flight

Micro-WIS Relay Units – Use ELMWIS connected by wire

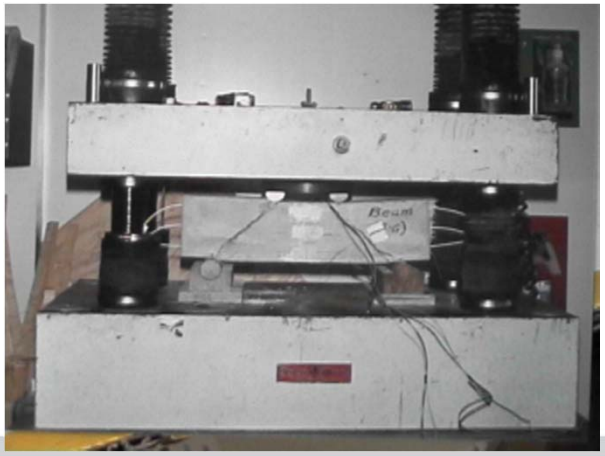
Solid Rocket Motor Test

- Apply fiber-optic sensor technology to solid rocket motors
  - In-situ sensors on new motors
  - Sensors bonded to the interior of existing motors
    - Fiber Bragg-gratings
    - Fabry Perot
- Measure mechanical and chemical properties during handling, storage, long-term aging, motor firing, case burst and damage assessment
- Provide tool for service life evaluation
- Early detection of possible structural failure

FIBER-OPTIC SENSOR ROCKET MOTOR TEST



FIBER-OPTIC SENSORS FOR CIVIL STRUCTURES



FAILURES TO MONITOR AND PREDICT

- Detect early warning signs
- Automate monitoring of critical systems
- Give critical data to key decision makers

Deepwater Horizon
2010

Thunder Horse
2005

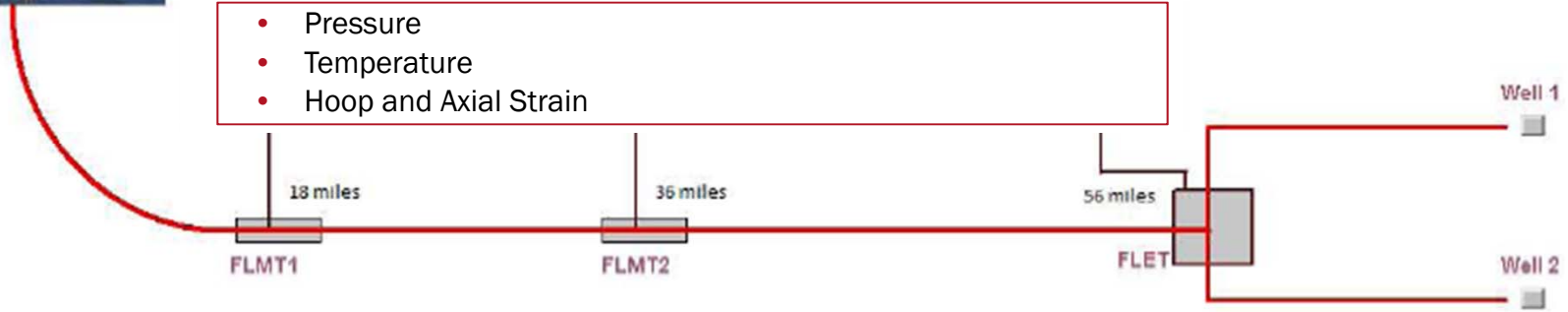
Texas City Refinery
2005

DEVIL'S TOWER BASS LITE (OMAE 2012)

- Located in Atwater Valley Block 426
- Utilizes 20.3-cm (8-in) diameter flowline
- 90-km (56-mi) length
- Ties to Devil's Tower in Mississippi Canyon
- Production — Up to 130 million cubic feet per day
- Water depth — 2,050 m (6,750 feet)
- Commenced operation in February 2008

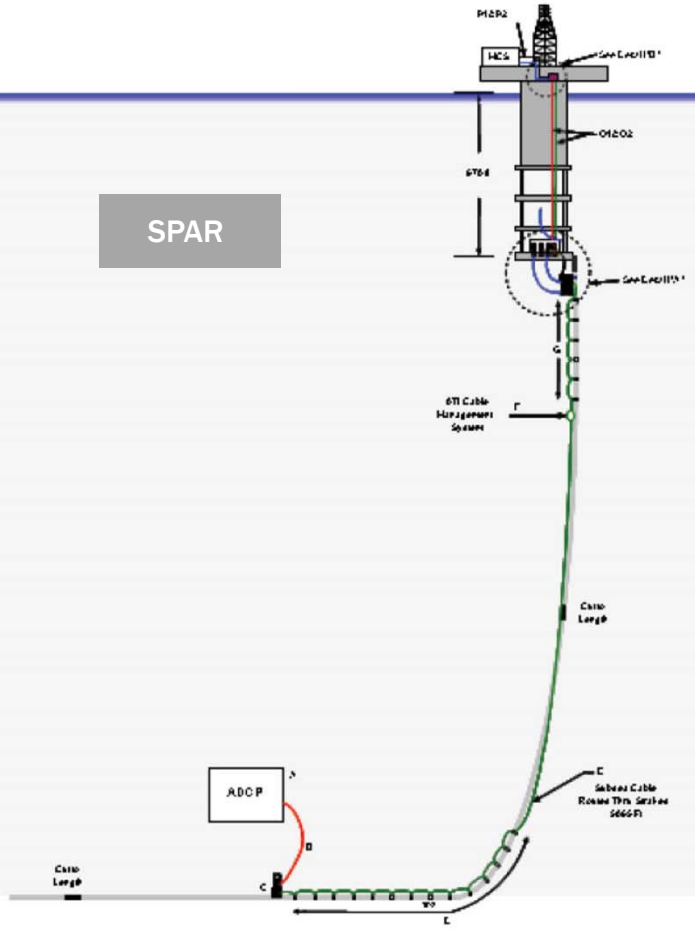
MONITORING:

- Pressure
- Temperature
- Hoop and Axial Strain

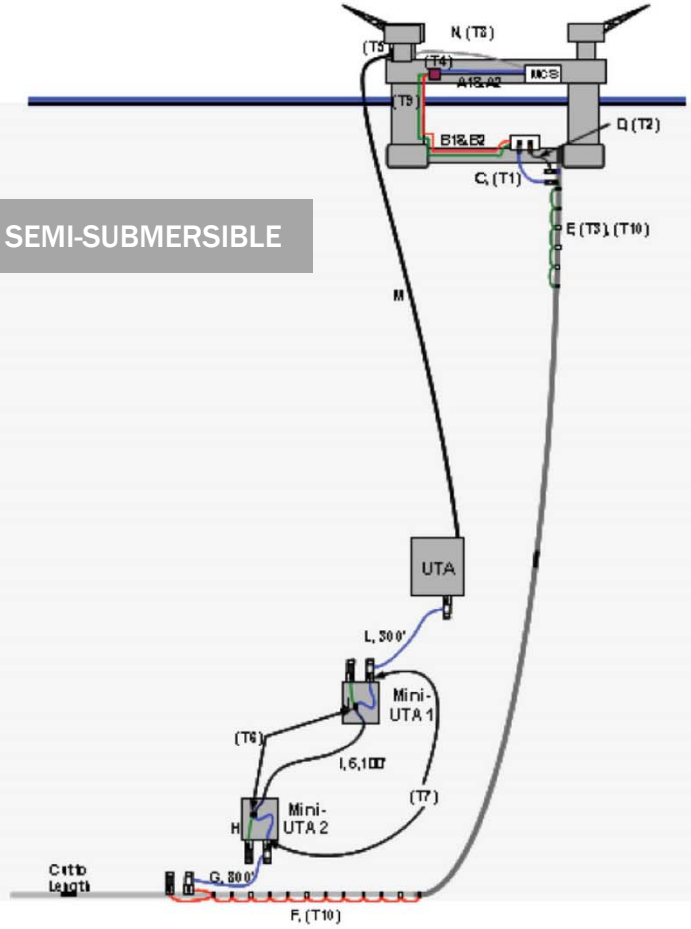


PREVIOUS INSTRUMENTATION ON DEEPWATER RISERS

SPAR

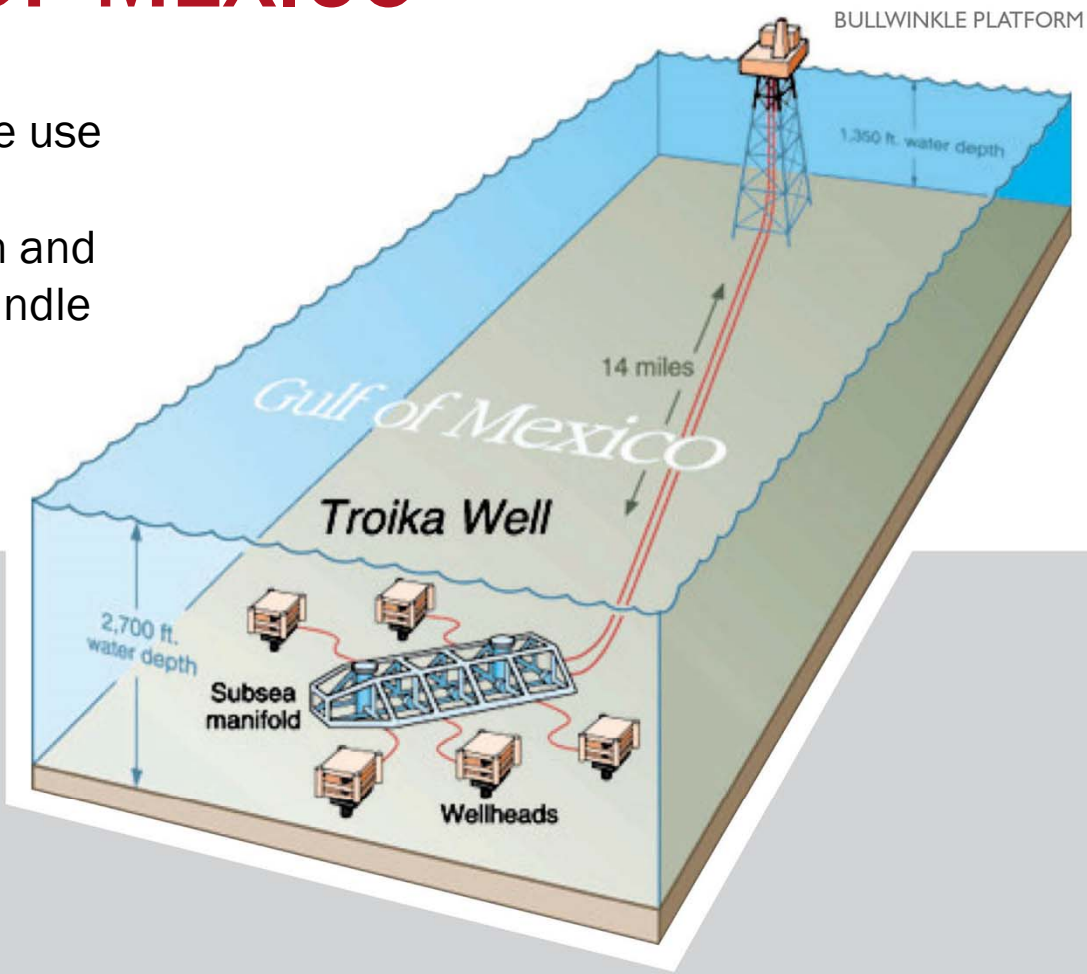


SEMI-SUBMERSIBLE



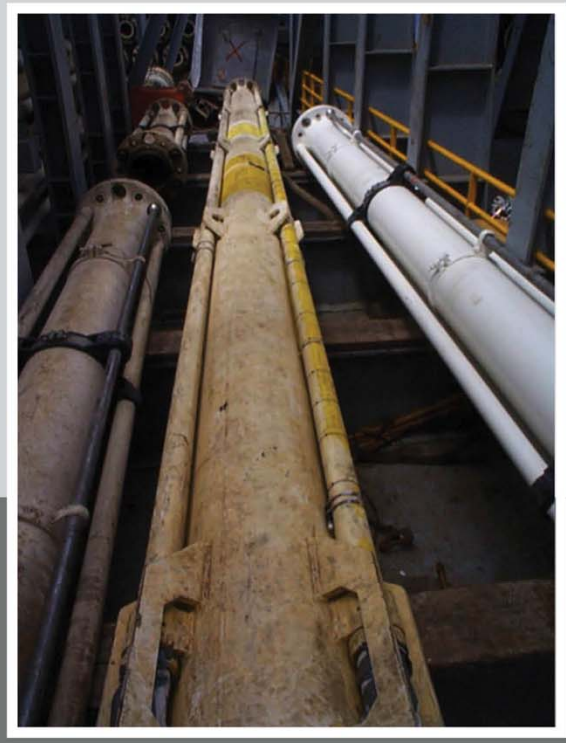
TROIKA — GULF OF MEXICO

ASTRO TECHNOLOGY pioneered the use of fiber-optic sensors on a subsea pipeline to monitor pressure, strain and vibration in external casing pipe bundle during fabrication.



FIBER-OPTIC SENSORS FOR DEEPWATER DRILLING

OCEAN CLIPPER



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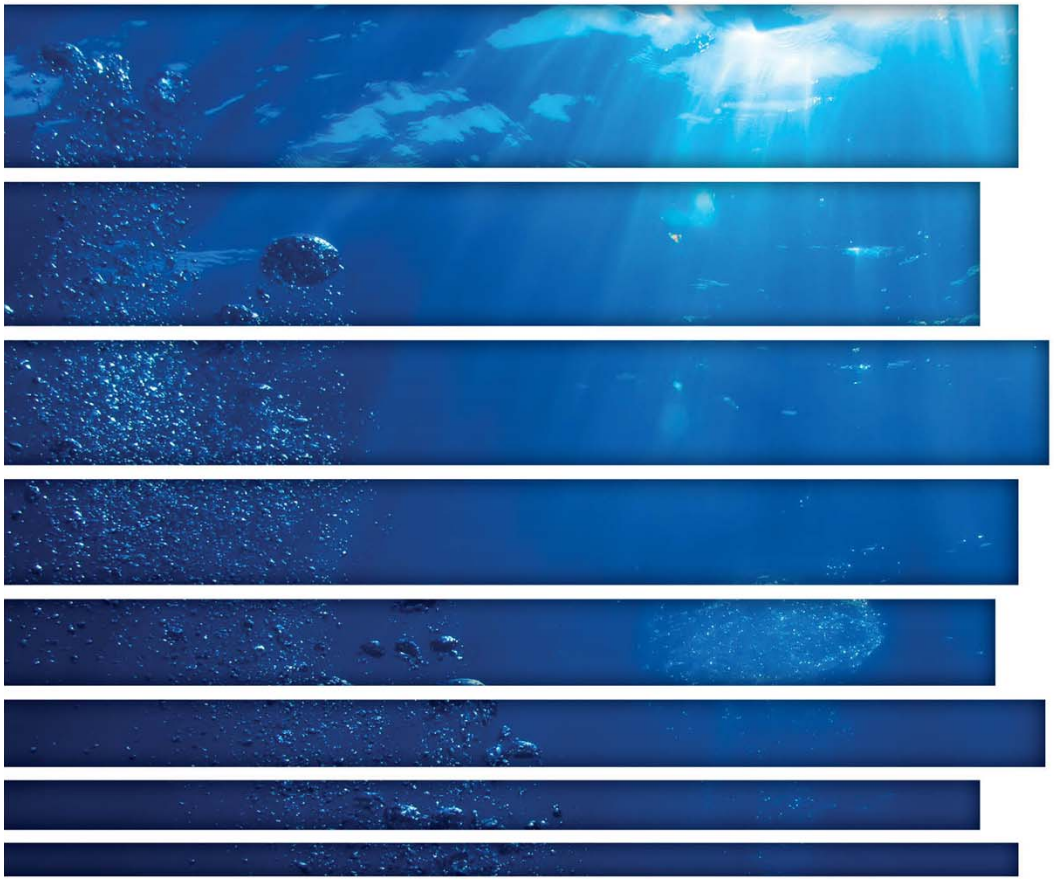

OVERVIEW *of* INSTRUMENTATION METHODS

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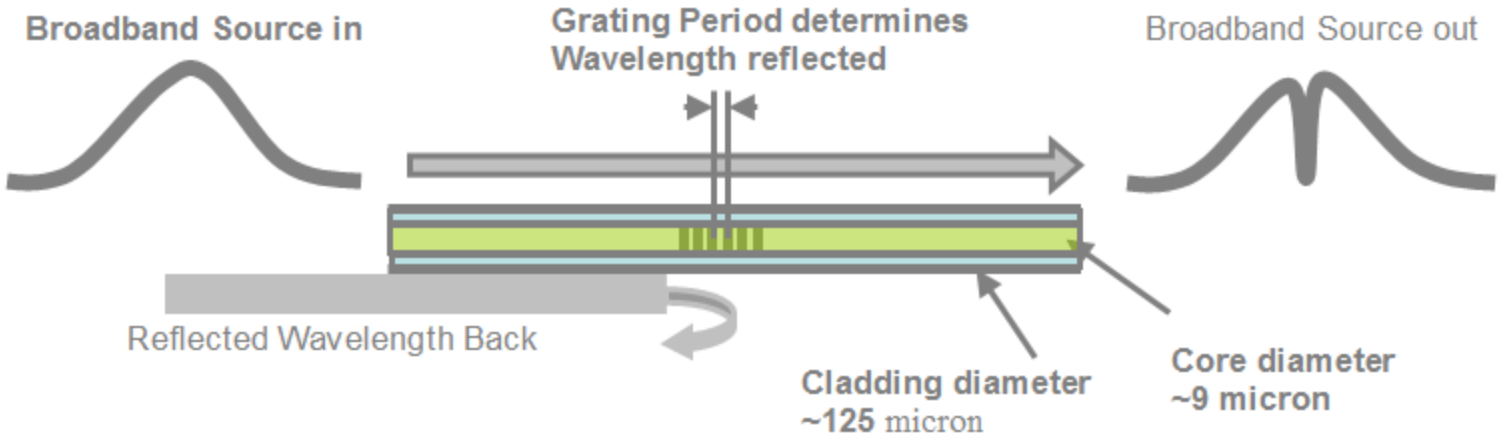
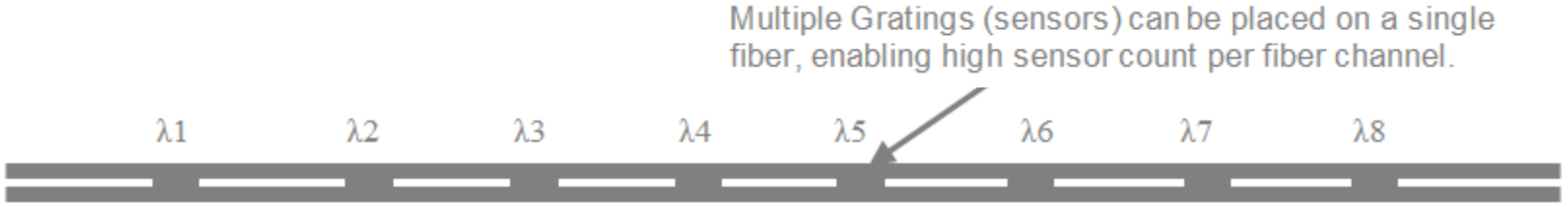
SUBSEA SYSTEMS
ASTRO TECHNOLOGY
DEEPER INSIGHT.

FIBER BRAGG GRATINGS



Relationship between Strain (ε) and Change in Wavelength ($\Delta\lambda_b$)

$\Delta\lambda_b / \lambda_b = (1-p_e)\varepsilon$, where p_e is the photoelastic constant for glass and λ_b is the base wavelength



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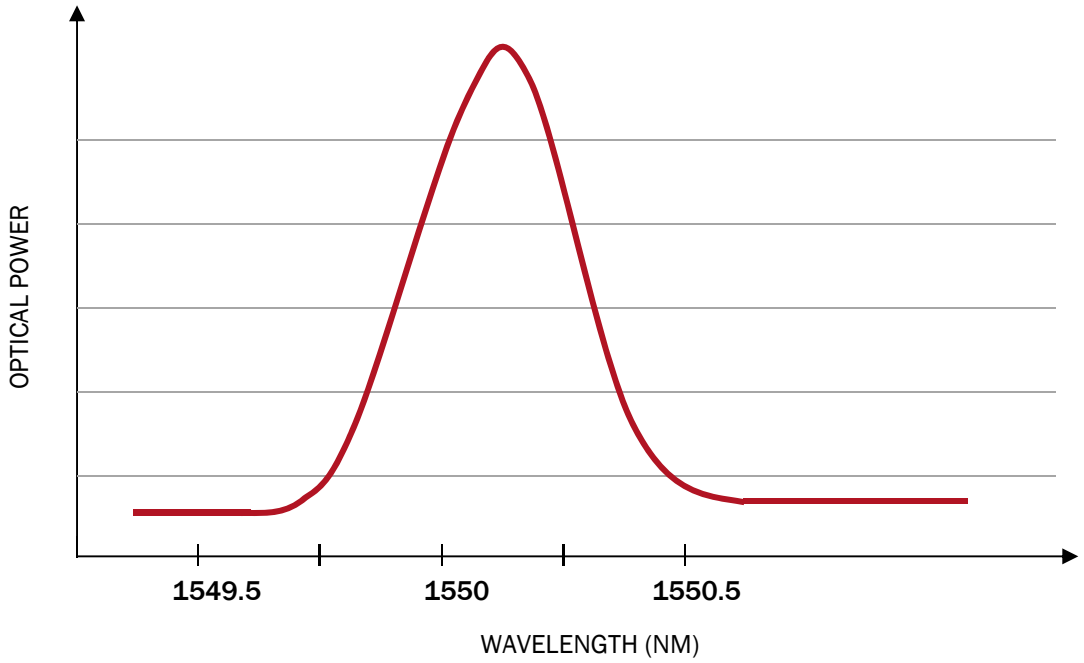
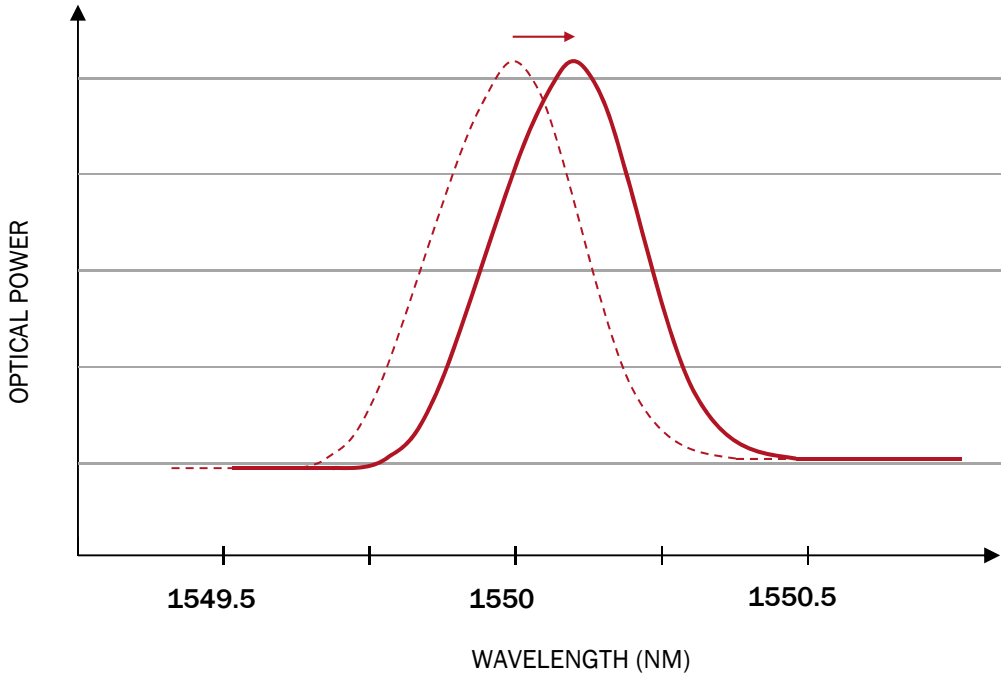
RELATIONSHIP BETWEEN WAVELENGTH & STRAIN

EXAMPLE BASE WAVELENGTH FOR A SINGLE FBG



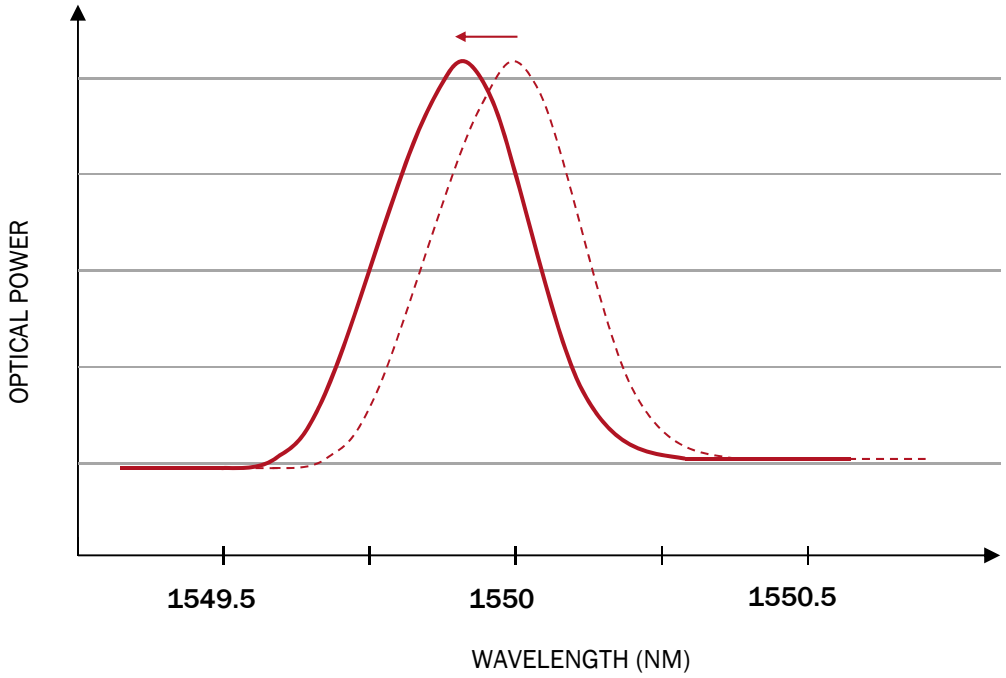
RELATIONSHIP BETWEEN WAVELENGTH & STRAIN — TENSION

REFLECTED SIGNAL FROM THE PREVIOUS FBG IN TENSION

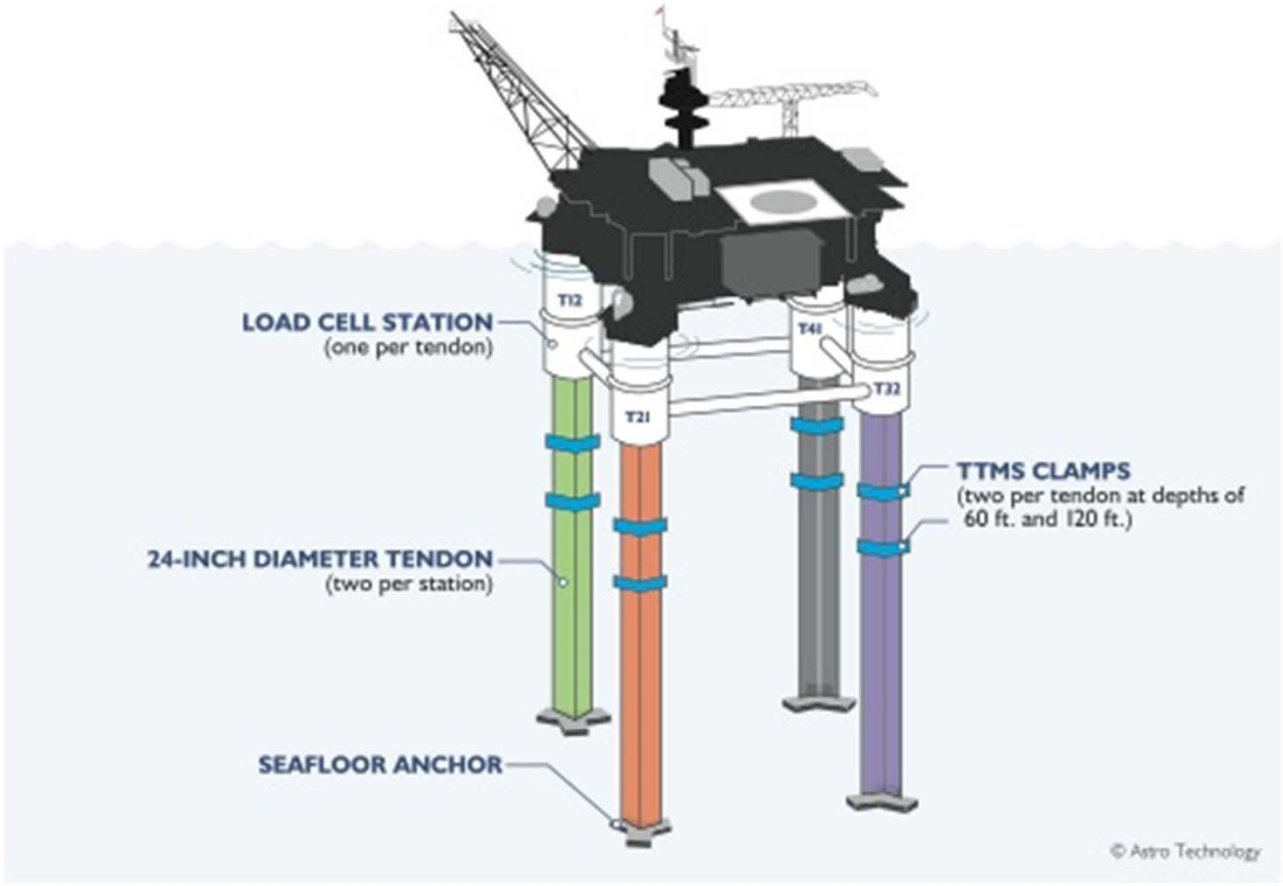


RELATIONSHIP BETWEEN WAVELENGTH & STRAIN — COMPRESSION

REFLECTED SIGNAL FROM THE PREVIOUS FBG IN COMPRESSION



TENSION LEG PLATFORM SENSORS



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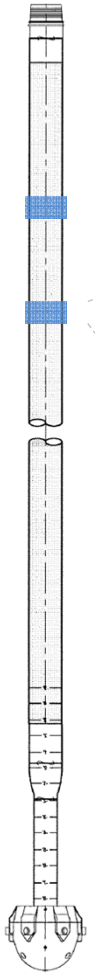
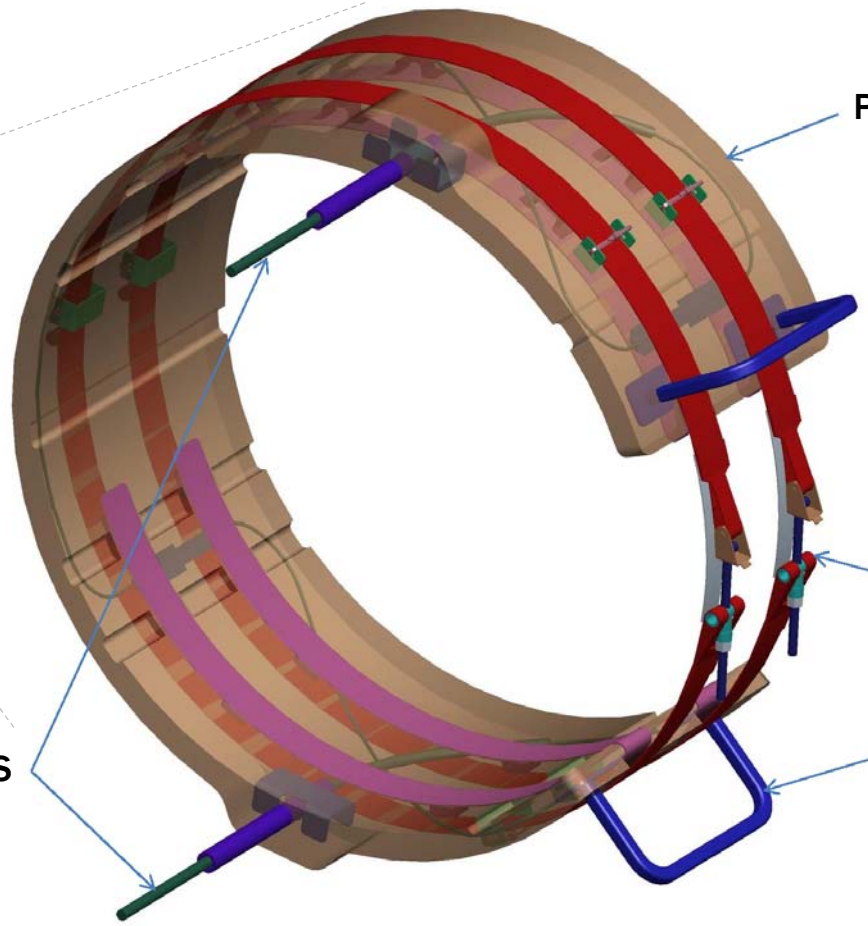
TENDON TENSION MONITORING SYSTEM





POLYURETHANE BODY

BAND CLAMPS

HANDLE

EXITING CABLES

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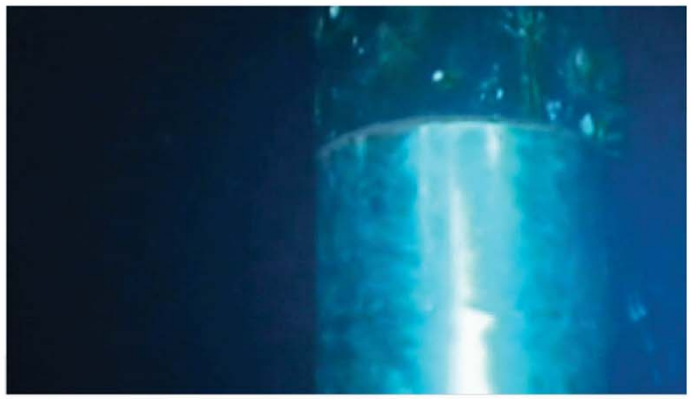
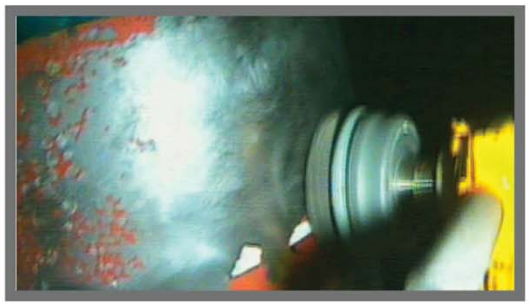
TENDON BAND PREPARATION

Marine Growth
(BEFORE)



Clean Band
(AFTER)

Cleaning with Water Jet



Polishing to Bare Metal

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DIVER INSTALLATION

Diver with Clamp

Riser Preparation

Clamp Installation

Clamp Inspection

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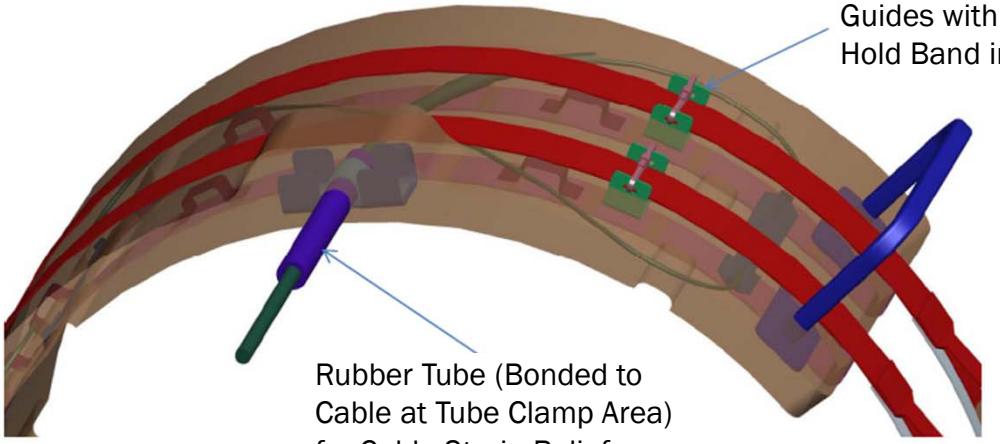
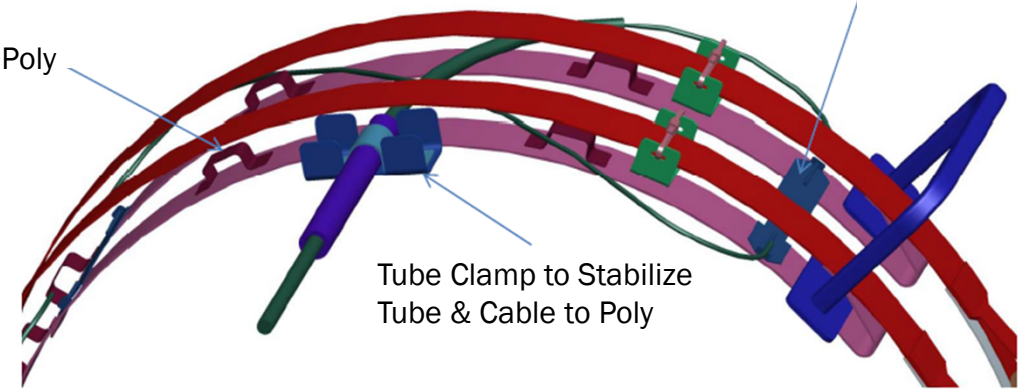
HARDENED SENSOR STATIONS





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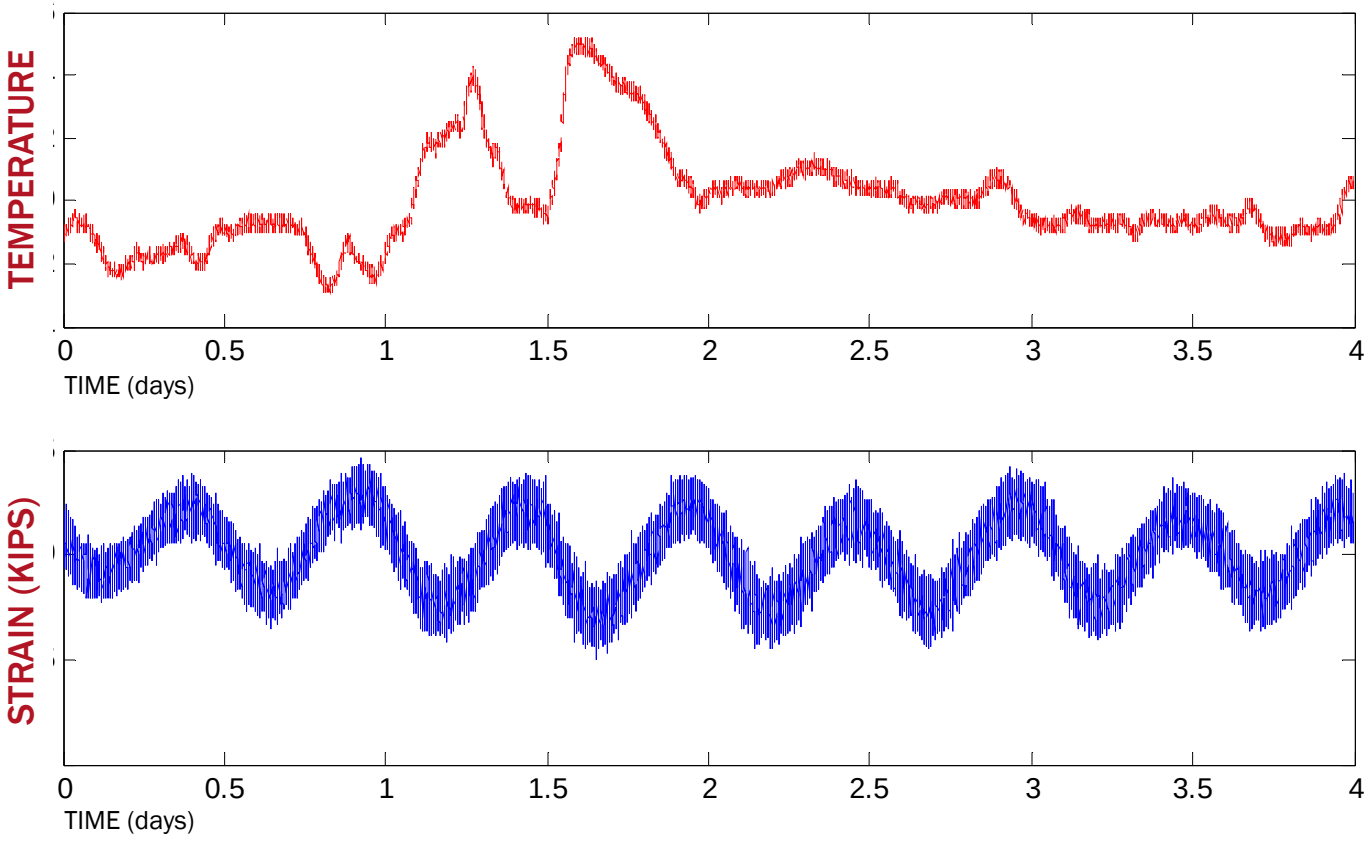
TEMPERATURE & STRAIN GAUGES



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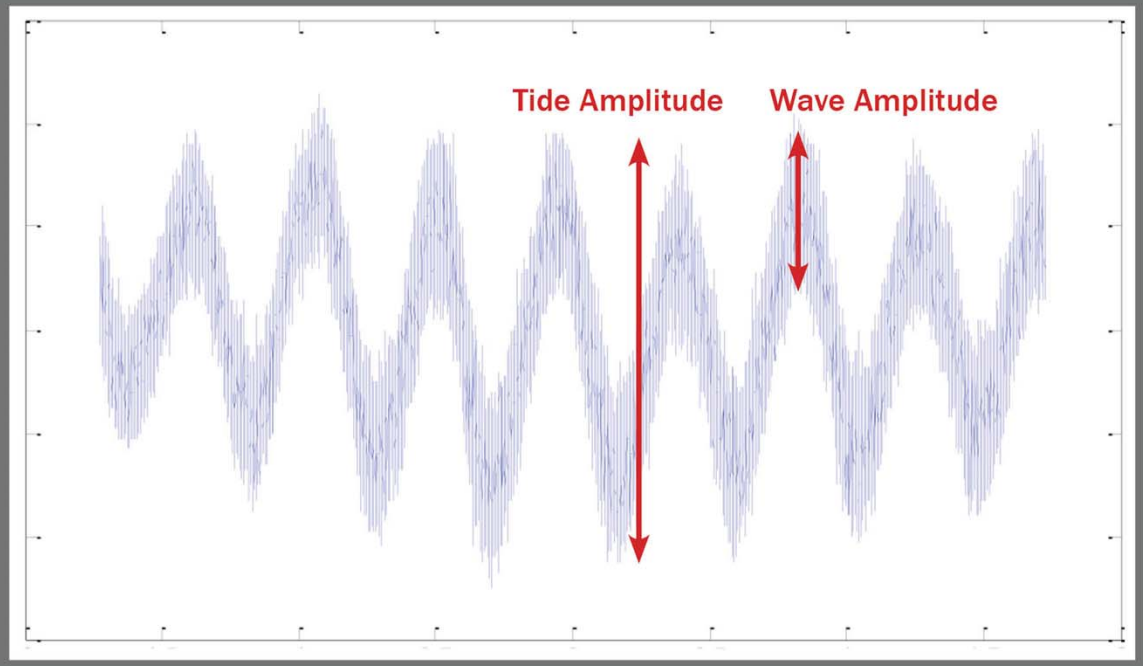
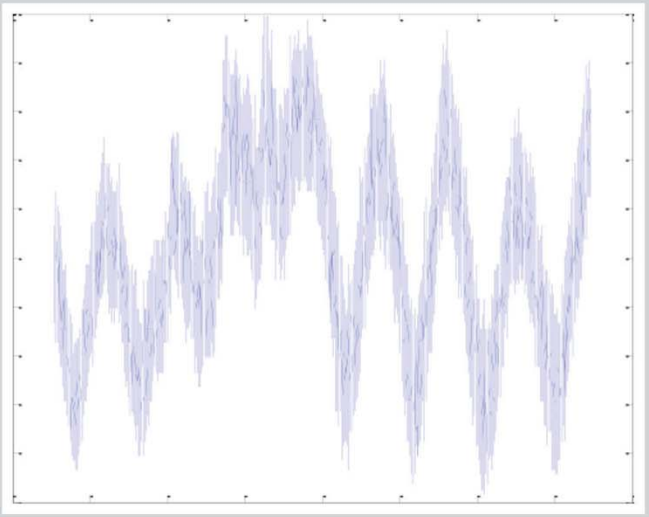
OBSERVING TIDE CYCLES

WITH TEMPERATURE COMPENSATION



WITHOUT TEMPERATURE COMPENSATION



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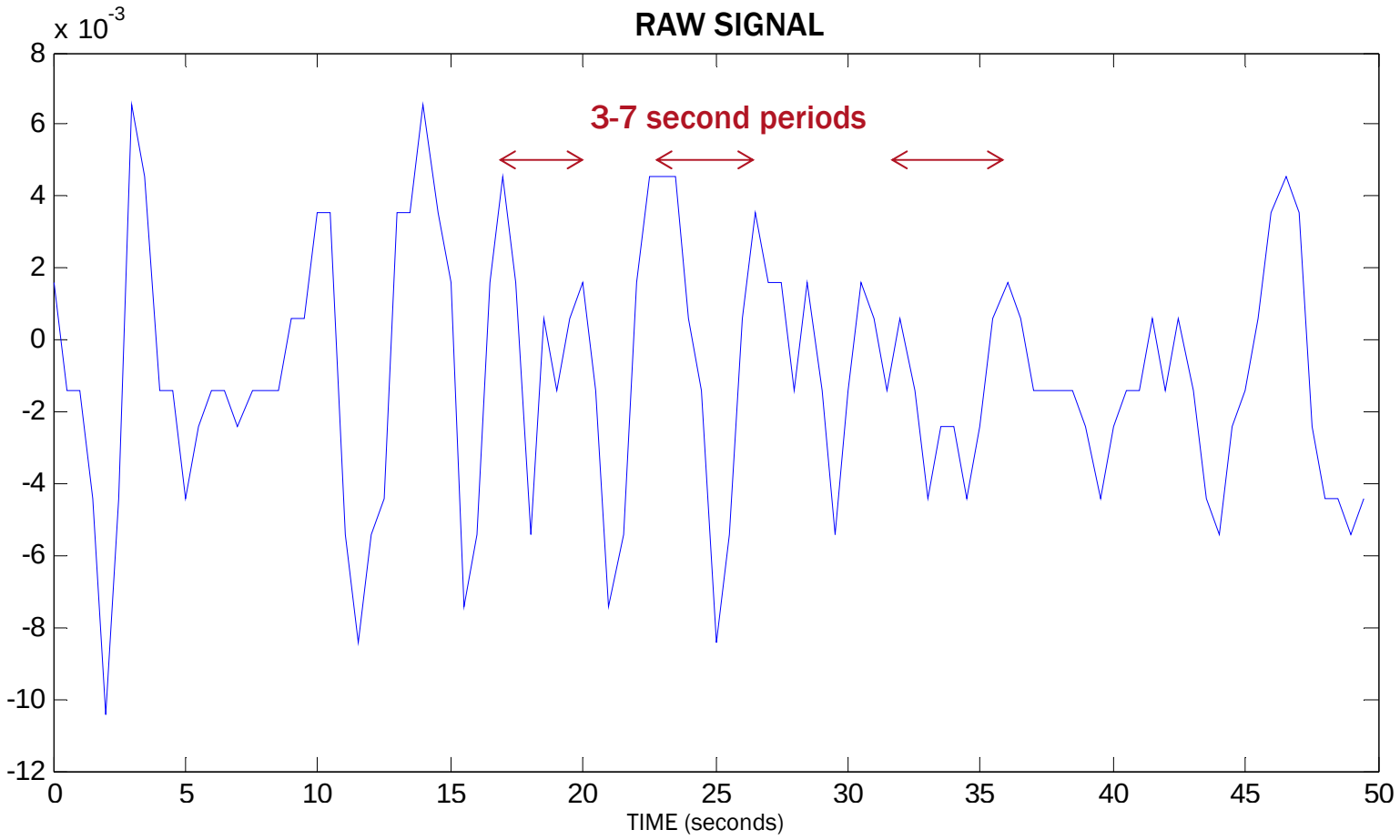
OBSERVING WAVE ACTION



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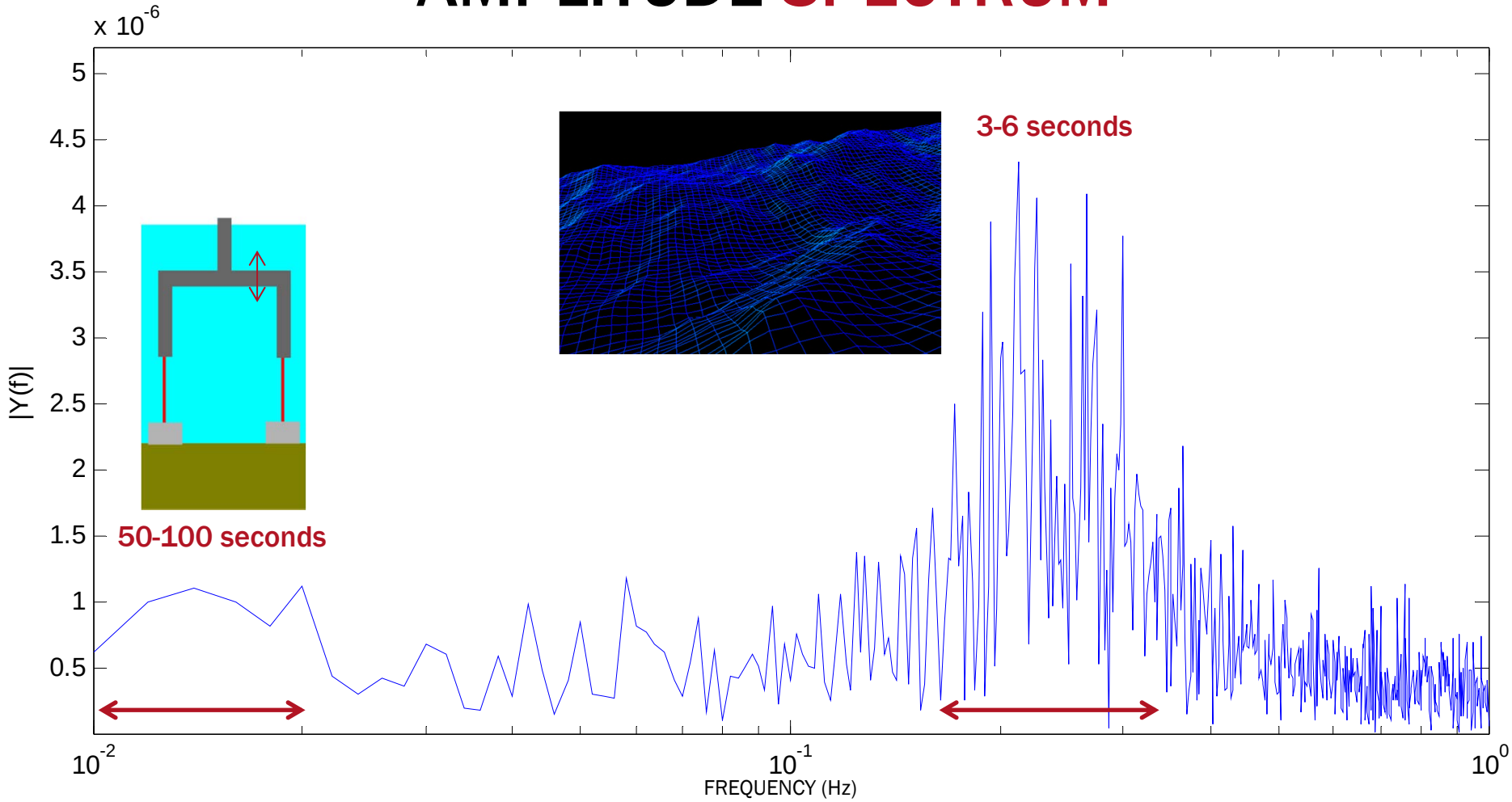
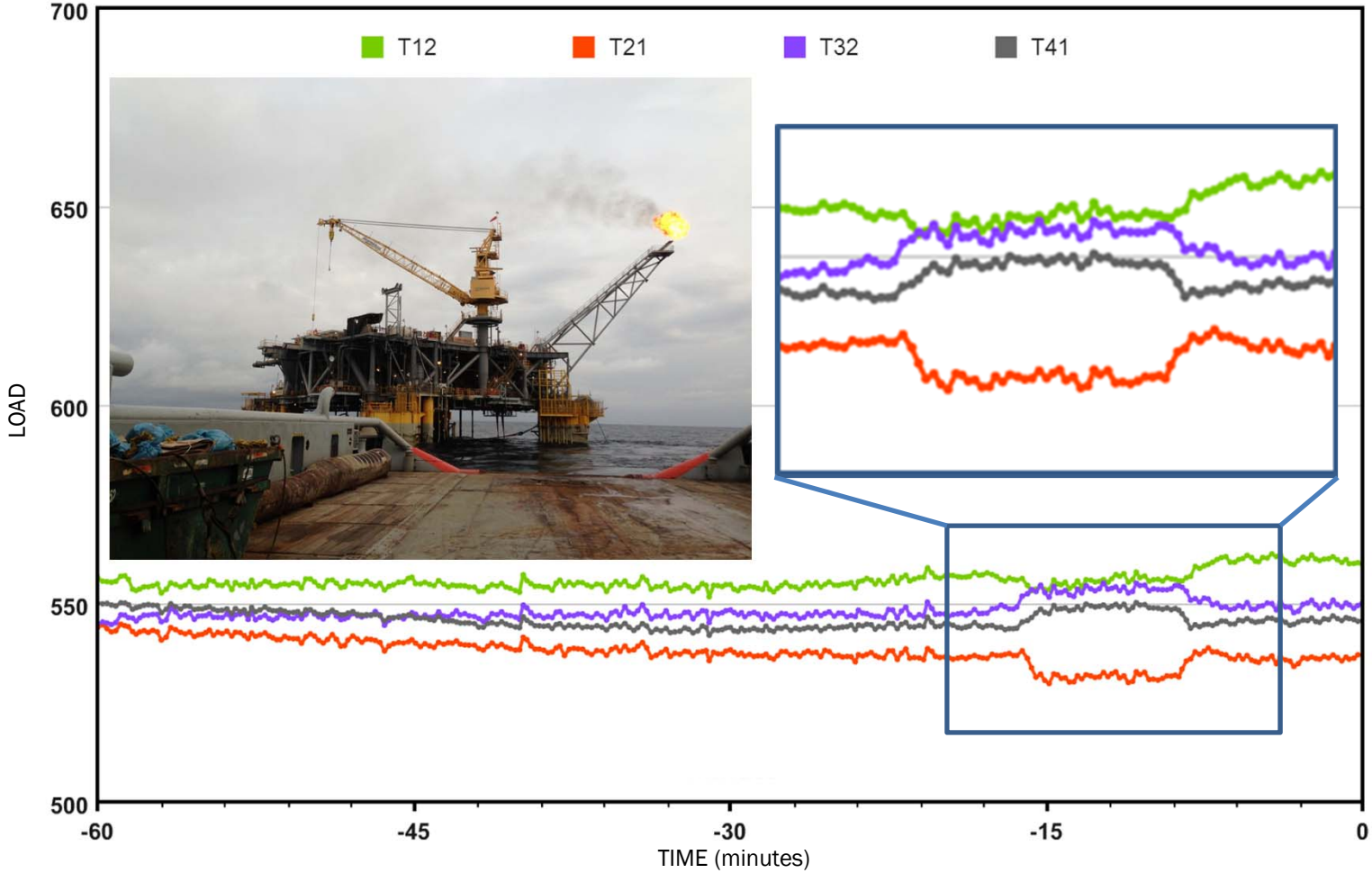
AMPLITUDE SPECTRUM

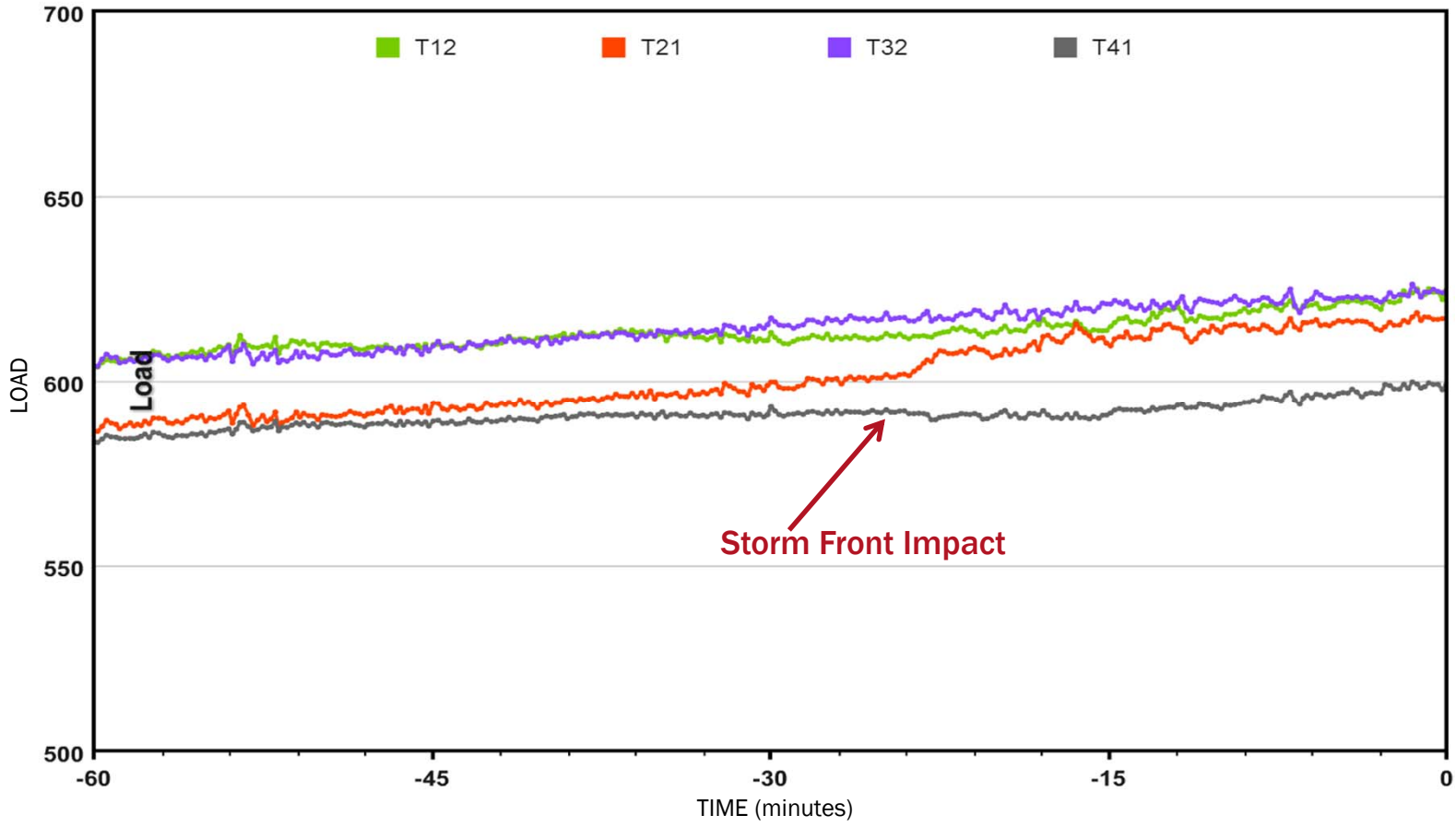


BOAT DOCKING

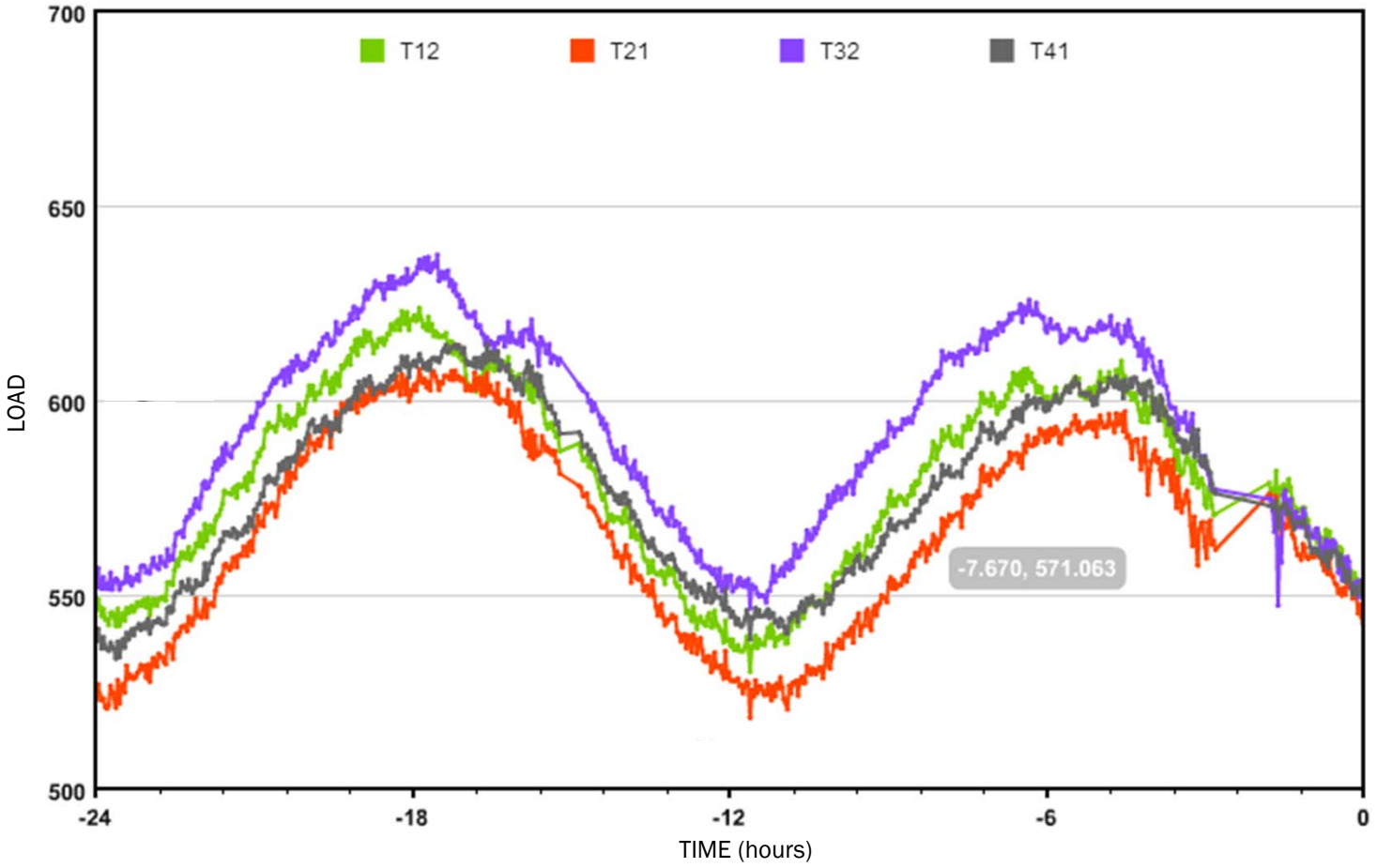


WEST AFRICAN ENVIRONMENT:

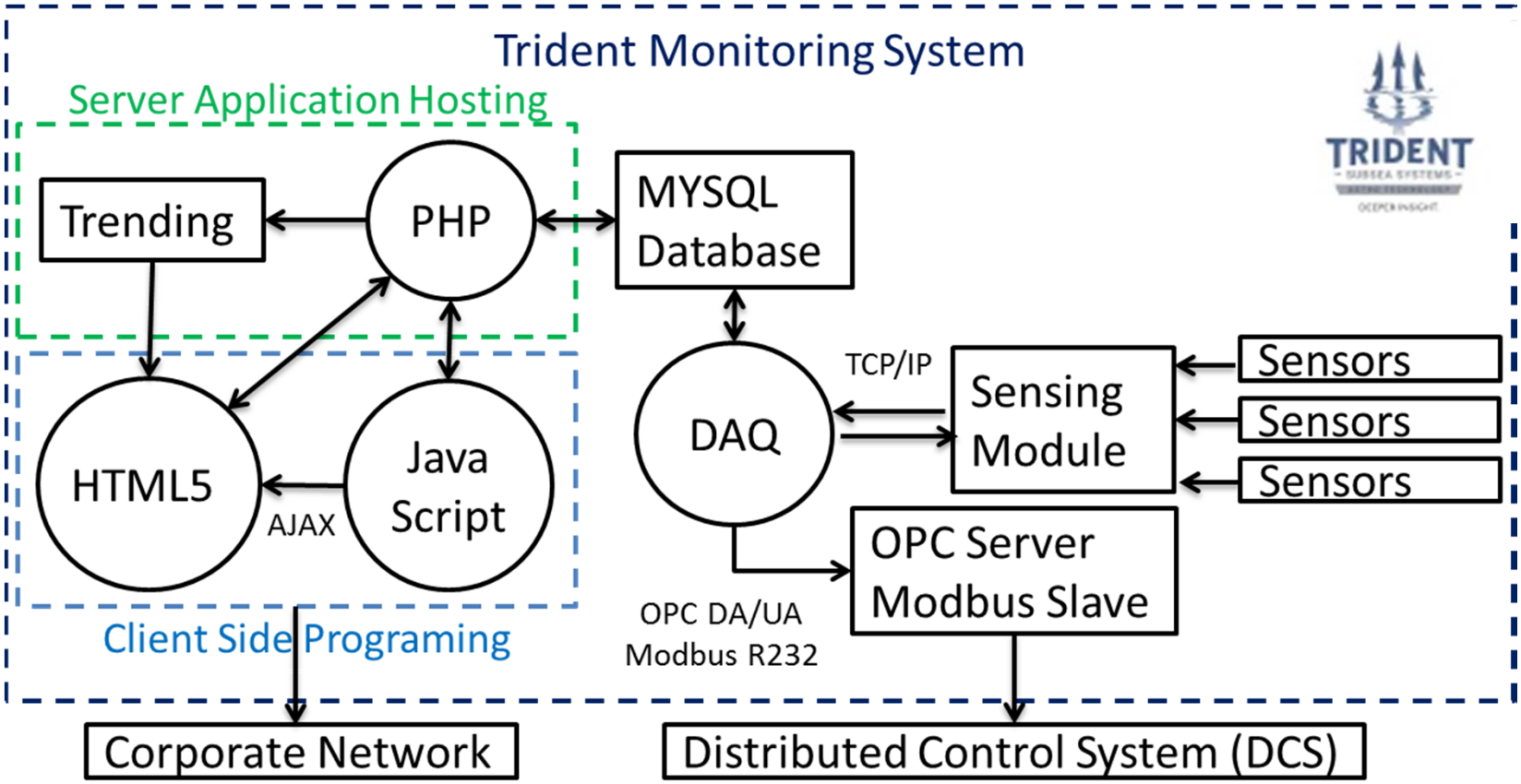
SUDDEN AND POTENTIALLY VIOLENT SQUALLS



SENSOR CALIBRATION WITH TIDE CYCLES



TRIDENT MONITORING SYSTEM



ADVANCED DEEPWATER MONITORING SUMMARY

- Flow Lines (Temperature, Pressure, Hydrates)
- Risers, Tendons (Strain, Fatigue, Vibration)
- New Data Acquisition Overview
  - Calibration on Post-Installed Systems
  - Key Software Architecture Elements
- Observing Unique and Interesting Events
- Synthesizing Data into Actionable Information
  - Delivered to Key Decision Makers
- Future Activities Include Automation of Load Balancing and Abnormal Event Detection

CLEAR GULF JOINT INDUSTRY PROJECT (JIP)

- Collaboration between oil and gas industry, NASA and Astro Technology

PROPOSED PARTNERS INCLUDE:

- Create cutting-edge techniques for managing production
- Develop environmental and safety systems for drilling and production
- Respond to challenges faced when working in remote and harsh environments
- 7 specific deliverables for Phase-I on post-installed monitoring systems