ADVANCED INSTRUMENTATION and INSPECTION
FOR DEEPWATER OIL AND GAS

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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
SMALL LEAKS IN SUBSEA FIELDS
THE NEED FOR BETTER SUBSEA INSTRUMENTATION
Prevent Undesired Events from Happening

• Detect warning signs early
• Prevent potential accidents from occurring
• Improve system operations
• Automate monitoring of critical systems
• Track pressure, temperature, strain and flow
• Give critical data to key decision makers
• Eliminate production downtime
• Prevent asset damage and pipeline leaks
• Reduce safety and environmental risks
FROM AEROSPACE TO SUBSEA
Clear Gulf Study
ABOUT CLEAR GULF STUDY
Prevention of Unwanted Events, Rather than Reaction

ADVANCED INSTRUMENTATION FOR:
• Subsea fields
• Pipelines and risers
• LNG facilities

CLEAR GULF FOCUS AREAS:
• Risers and Flowlines
• Flow Assurance
• Subsea Equipment Monitoring
• Miniature Subsea Robotics
• Leak Detection
• Smart Fields (Intelli-Fields)
• Downhole Monitoring
• Mooring Line Monitoring
• Arctic Monitoring
• Service Life Extension
ADVANTAGES OF CLEAR GULF
Prevention of Anomalies

- Improve performance
- Reduce risk – environmental and safety
- Involvement in advanced technology research for oil and gas
- NASA collaboration
- Outside research institutions involvement, i.e. multiple universities
- Industry “subject-matter experts” interface
- Participation on “Technical Steering Committee”
- Access to leading-edge technology
- Significant cost benefit — pooling funding resources
- Acts as an R&D department for oil and gas companies
  - Supplements R&D efforts at large companies
  - Provides new R&D departments for smaller, independent companies
- Participate in annual meeting with U.S. Congress
FIBER-OPTIC SENSOR ROCKET MOTOR TEST

Fiber-Optic Pressure Gauge Validation

![Graph showing the results of fiber-optic pressure gauge validation against Taber's traditional method. The graph plots pressure (PSI) against time (seconds) with a distinct increase and decrease pattern.]

- **Taber**
- **Fiber-Optic Pressure Gauge**
INSTRUMENTATION OF NASA’S ROBONAUT HAND
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.
BASS LITE – DEVIL’S TOWER

- 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
FIBER-OPTIC SENSORS FOR DEEPWATER DRILLING
Ocean Clipper
PREVIOUS INSTRUMENTATION ON DEEPWATER RISERS
PREVIOUS INSTRUMENTATION ON RISERS AND FLOWLINES
OVERVIEW OF NEW DEVELOPMENTS

- New tensile strength measurements
- Quantified effects of wet and dry bonding
- Improved clamp design
- Methods for calibration of post-installed sensors
TENSION LEG MONITORING SYSTEM
SUBSEA BONDING STRENGTH ENSURED

Button Pull Testing
BONDING MAINTAINED

Four-Point Bending Test
BONDING MAINTAINED
Compression and Tension Tests
TENSILE STRENGTH MEASURED
Button Pull Testing
SUMMARY OF TENSILE STRENGTH RESULTS
## SUMMARY OF TENSILE STRENGTH RESULTS

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IMPROVED CLAMP DESIGN

Prototype Clamp Mold Created with 3D Printer
CALIBRATION OF POST-INSTALLED SENSORS

Tide Amplitude  Wave Amplitude
THERMOCLINE AT SENSOR CLAMP DEPTH
PREDICTIVE MONITORING
Foxtrot TTMS Average Load

LOAD (KIPS) vs TIME (HOURS)

- T12
- T21
- T32
- T41

- T12*
- T21*
- T32*
- T41*
PREDICTIVE MONITORING

Foxtrot TTMS Average Load
Create cutting-edge techniques for managing production

Develop safer and more environmentally sensitive systems for drilling and production

Respond to challenges faced when working in remote and harsh environments

Focus on monitoring assets including platforms, risers, flowlines, subsea equipment, deepwater wells and downhole operations