



**NEW ADVANCES**  
*in* **POST-INSTALLED**  
**SUBSEA**  
**MONITORING SYSTEMS**

---

for Structural and Flow Assurance Evaluation

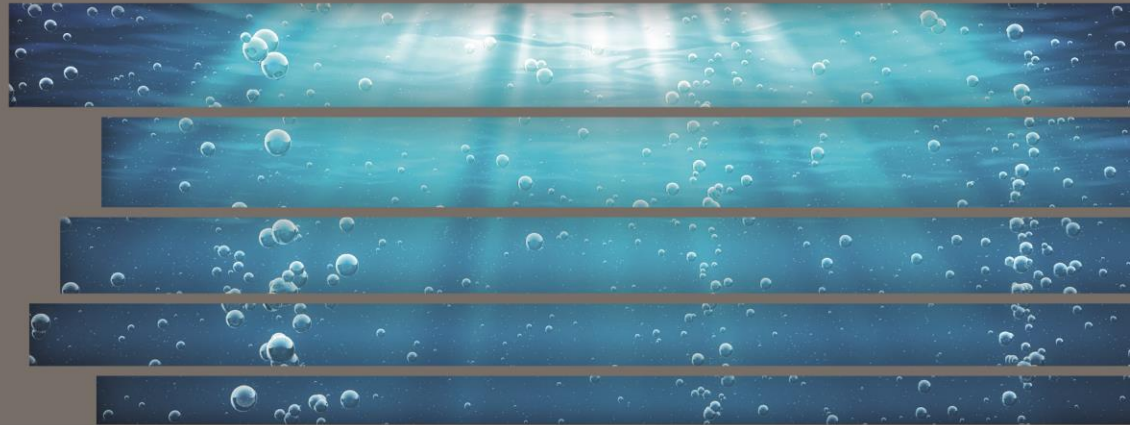
**D.V. Brower, A.D. Brower**  
*Astro Technology*

**J.D. Hedengren,**  
**R. Asgharzadeh Shishavan**  
*Brigham Young University*

# ABOUT **ASTRO TECHNOLOGY**

## ADVANCED INSTRUMENTATION FOR:

- Subsea fields
- Pipelines and risers
- LNG facilities

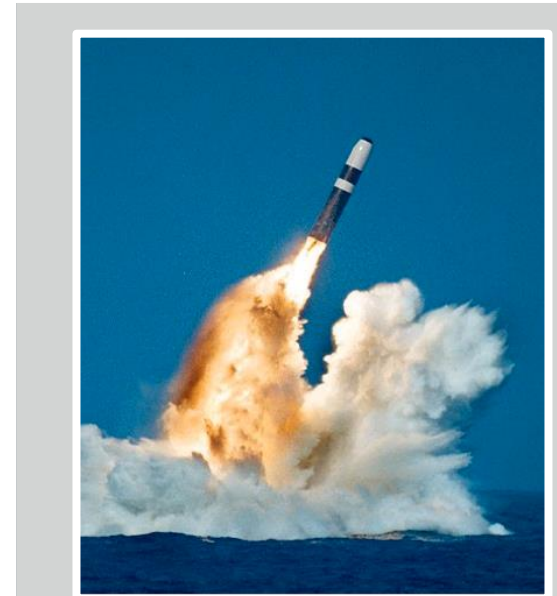
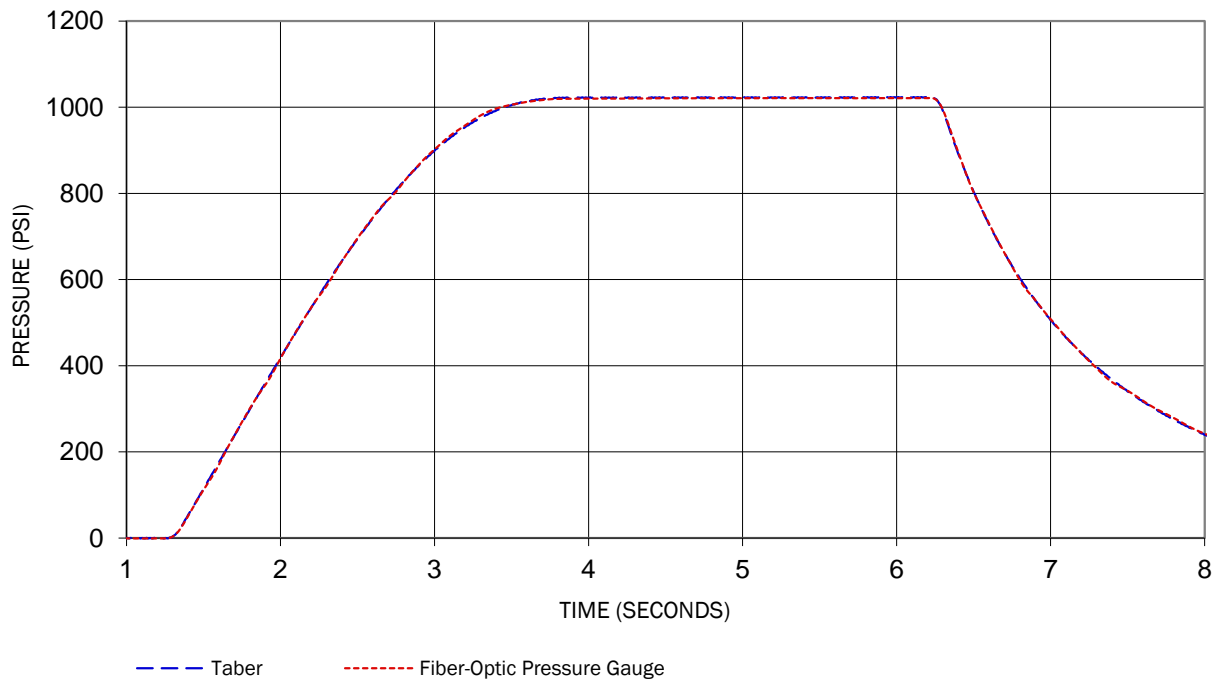


## **ENGINEERING CAPABILITIES INCLUDE:**

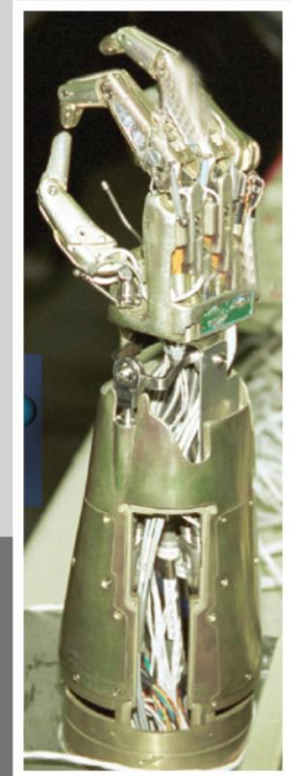
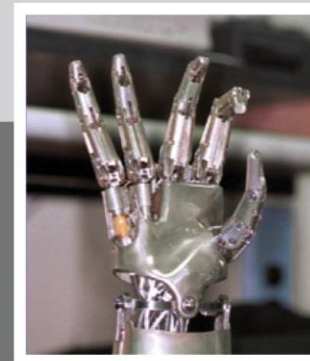
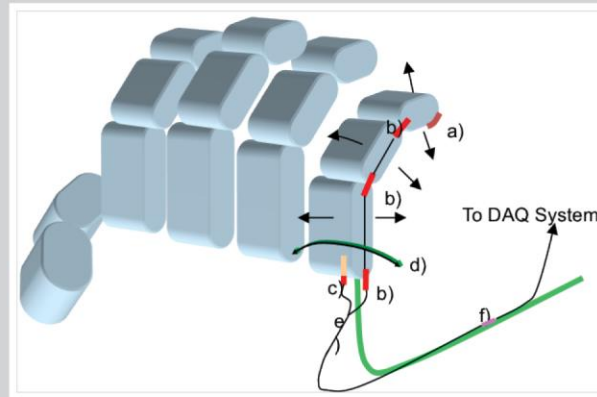
- System integration
- Real-time embedded systems
- Experimental stress analysis
- Fiber-optic sensor technology
- Conventional sensor integration
- Environmentally hardened systems
- Software development

# FIBER-OPTIC SENSOR ROCKET MOTOR TEST

## Fiber-Optic Pressure Gauge Validation



# INSTRUMENTATION OF NASA'S ROBONAUT HAND

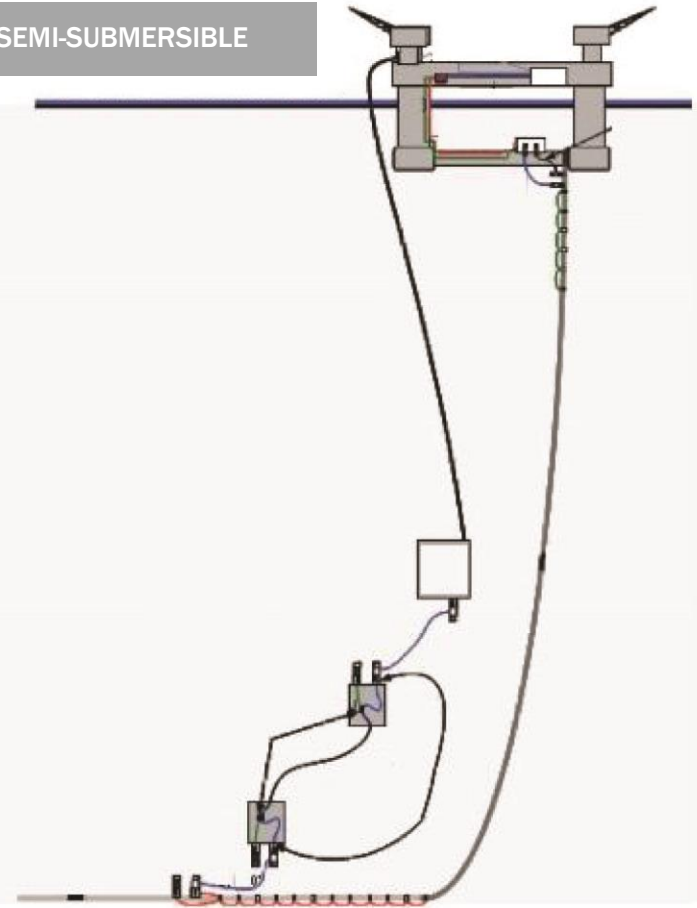


# PREVIOUS INSTRUMENTATION ON DEEPWATER RISERS

SPAR



SEMI-SUBMERSIBLE





## PREVIOUS INSTRUMENTATION ON RISERS AND FLOWLINES



# THE NEED FOR BETTER SUBSEA INSTRUMENTATION

- Detect early warning signs
- 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



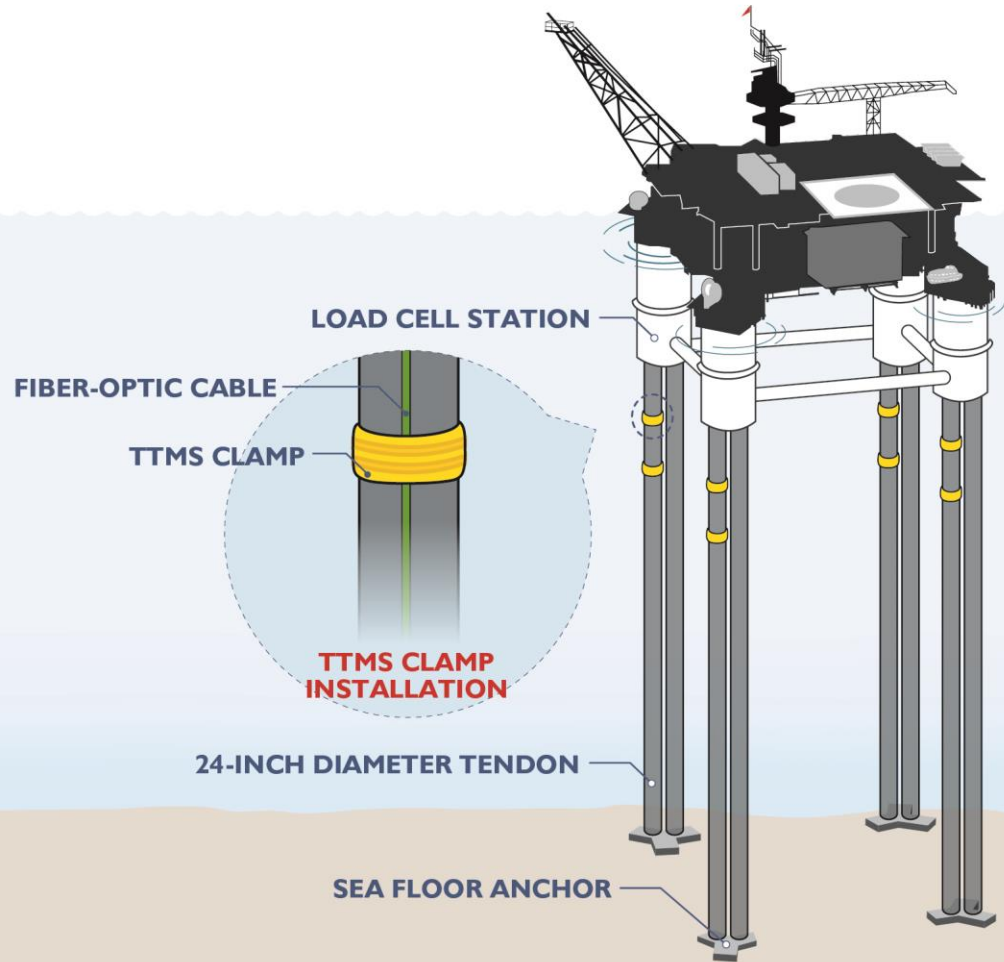
# NEW DEVELOPMENTS



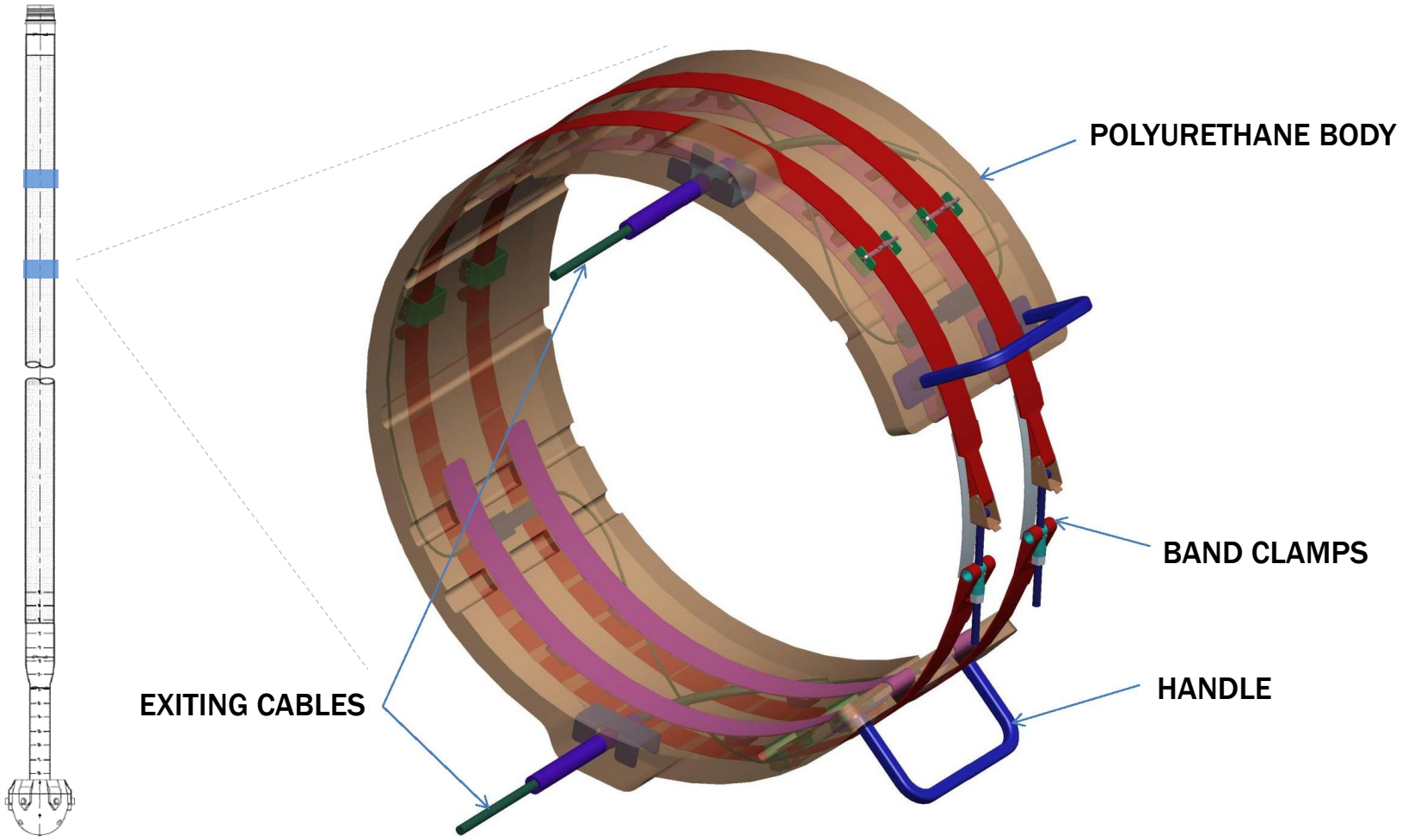
## OVERVIEW OF NEW DEVELOPMENTS

- 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

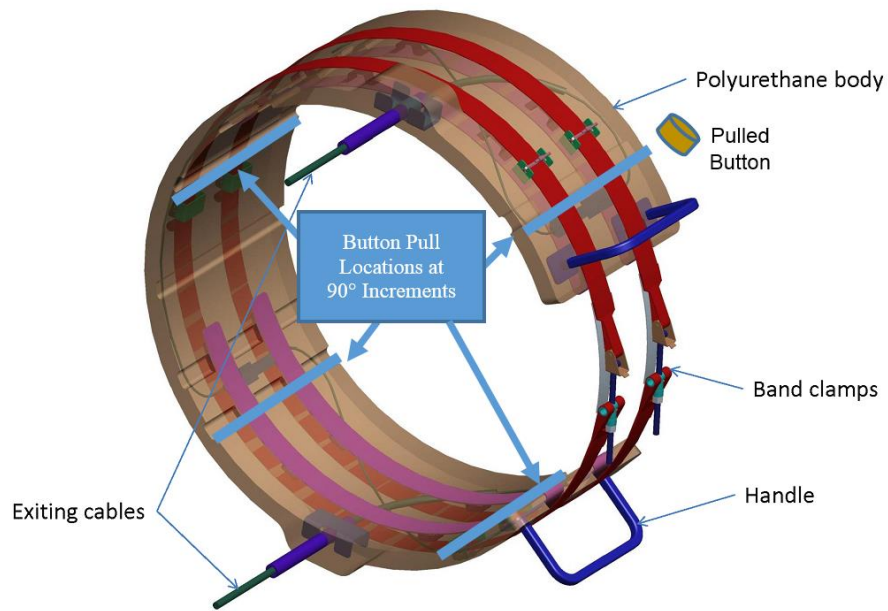


# TTMS CLAMP



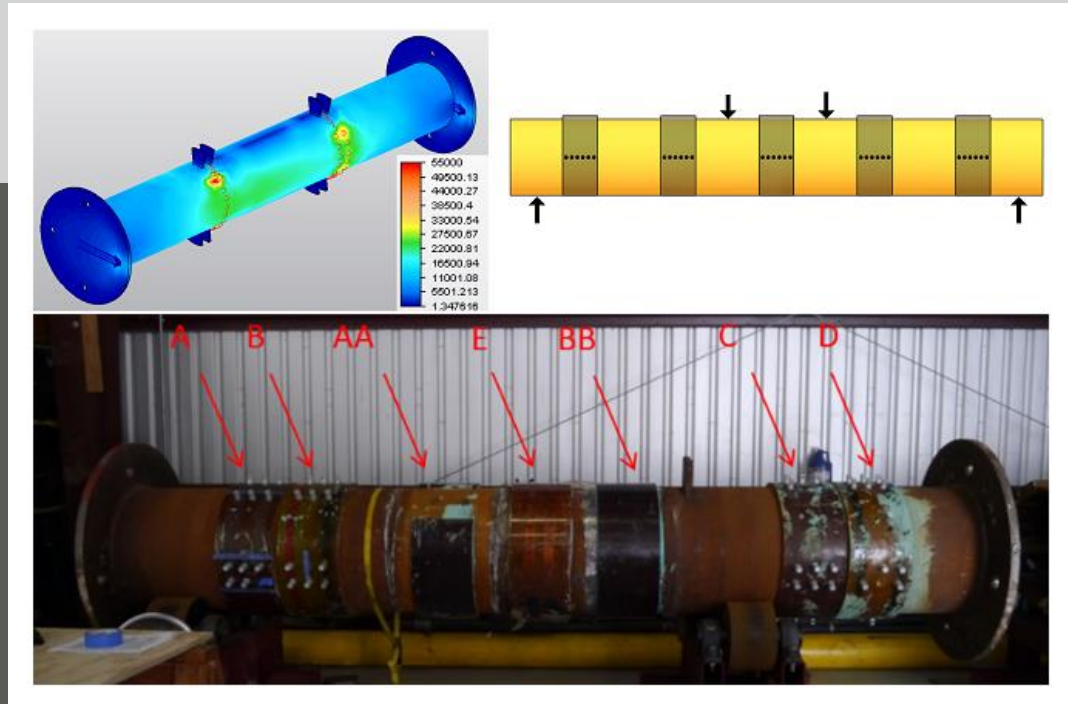
# SUBSEA BONDING STRENGTH ENSURED

## Button Pull Testing



# BONDING MAINTAINED

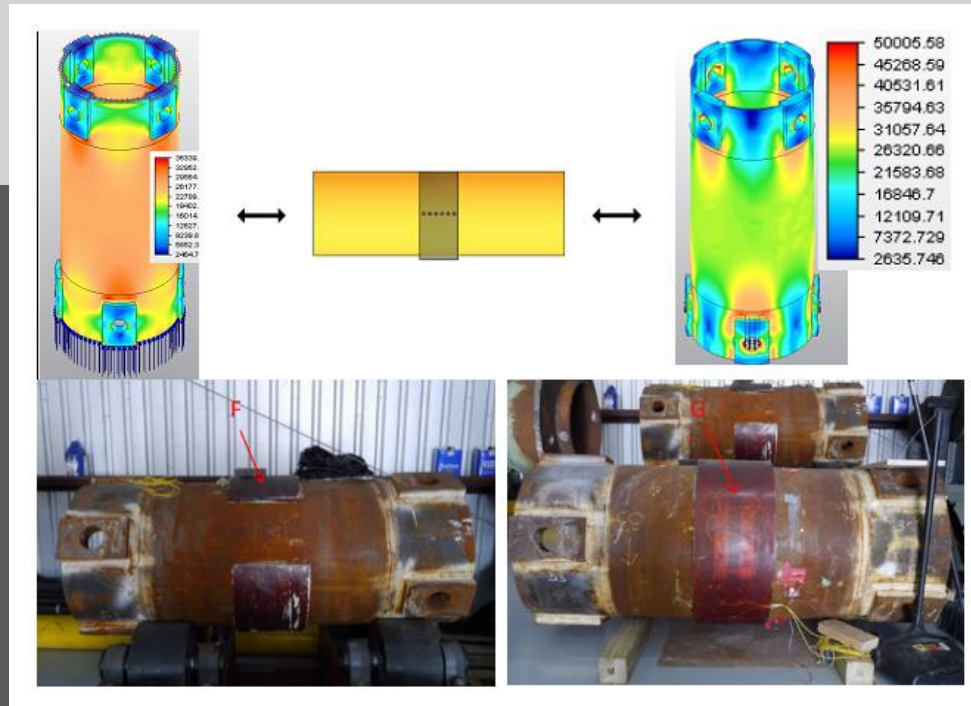
## Four-Point Bending Test





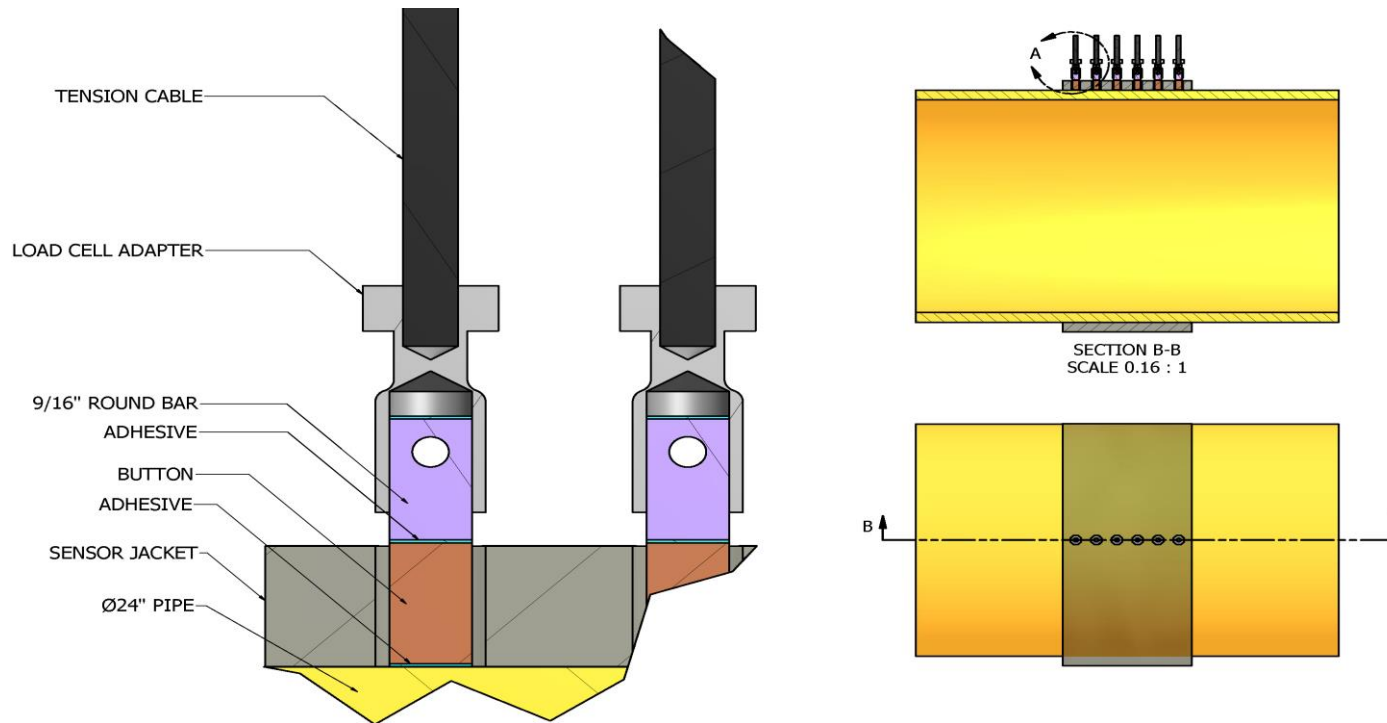
# BONDING MAINTAINED

## Compression and Tension Tests

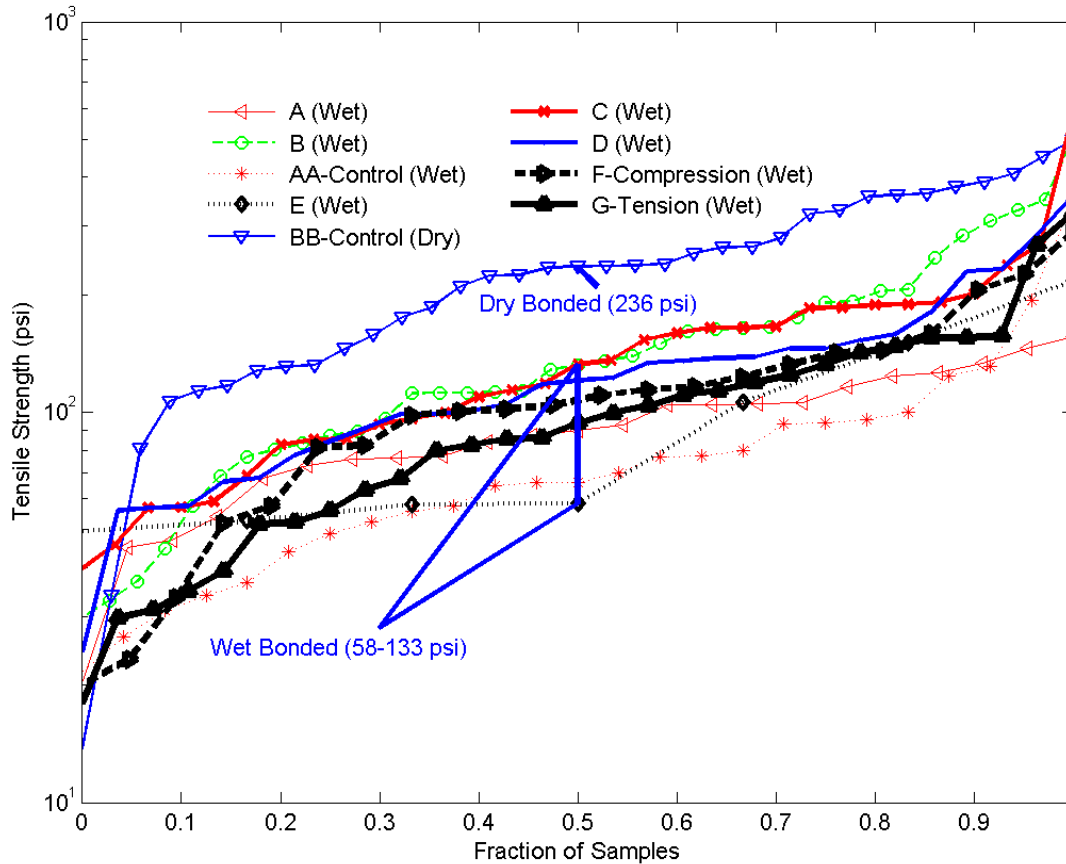


# TENSILE STRENGTH MEASURED

## Button Pull Testing



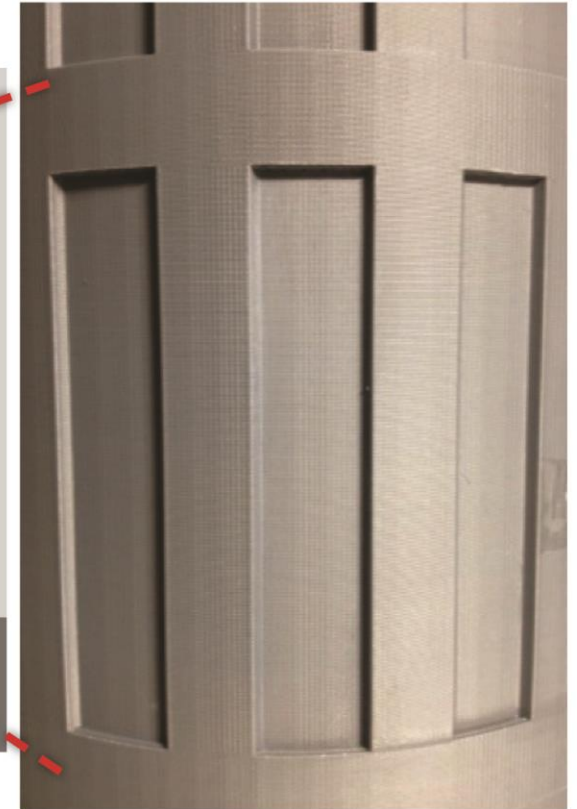
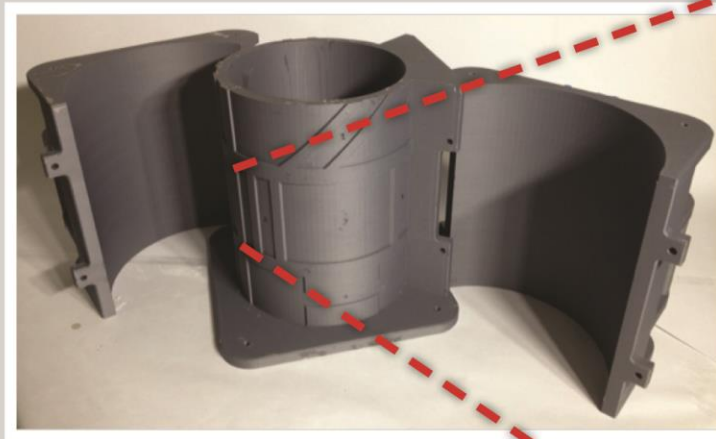
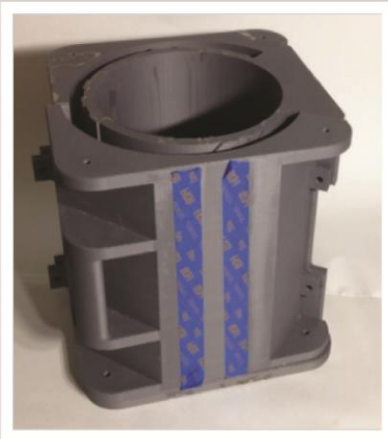
# SUMMARY OF TENSILE STRENGTH RESULTS



# SUMMARY OF TENSILE STRENGTH RESULTS

Clamp	Avg (psi)	StDev (psi)	Min (psi)	Max (psi)	Description
<b>BB</b>	<b>292.0</b>	108.9	113.6	498.6	<b>Dry Bonded Control</b>
<b>AA</b>	<b>81.4</b>	47.2	31.1	193.5	<b>Wet Bonded Control</b>
<b>A</b>	94.0	30.4	45.0	155.8	Four Point Bending (Left)
<b>B</b>	174.1	112.4	29.8	503.3	Four Point Bending (Left)
<b>E</b>	<b>91.1</b>	46.9	49.5	150.8	<b>Four Point Bending (Center)</b>
<b>C</b>	142.5	65.6	45.8	267.9	Four Point Bending (Right)
<b>D</b>	136.3	73.6	57.5	358.7	Four Point Bending (Right)
<b>F</b>	<b>114.0</b>	53.7	33.6	225.7	<b>Tension</b>
<b>G</b>	<b>105.3</b>	59.8	29.7	268.8	<b>Compression</b>

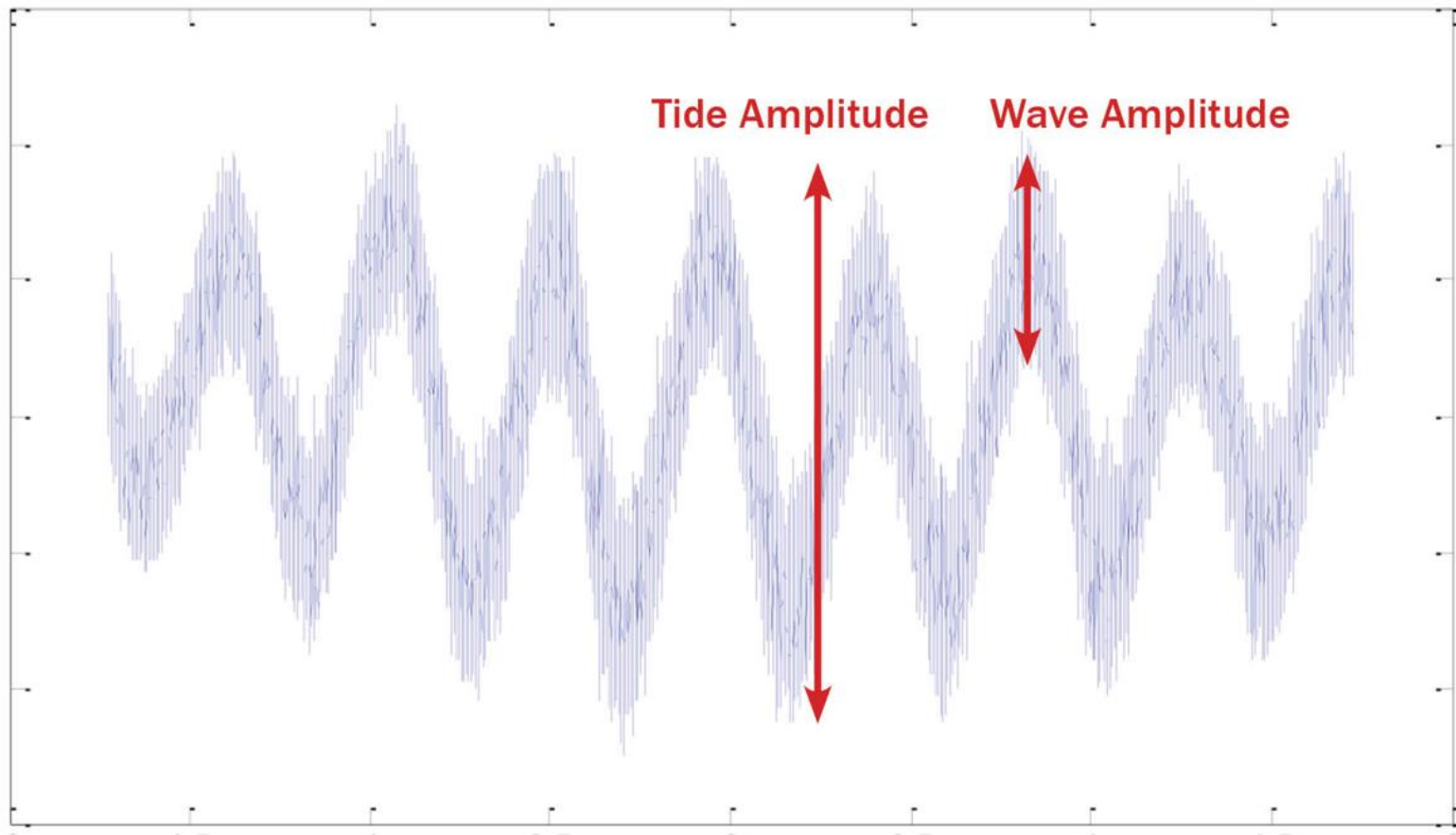
## IMPROVED CLAMP DESIGN



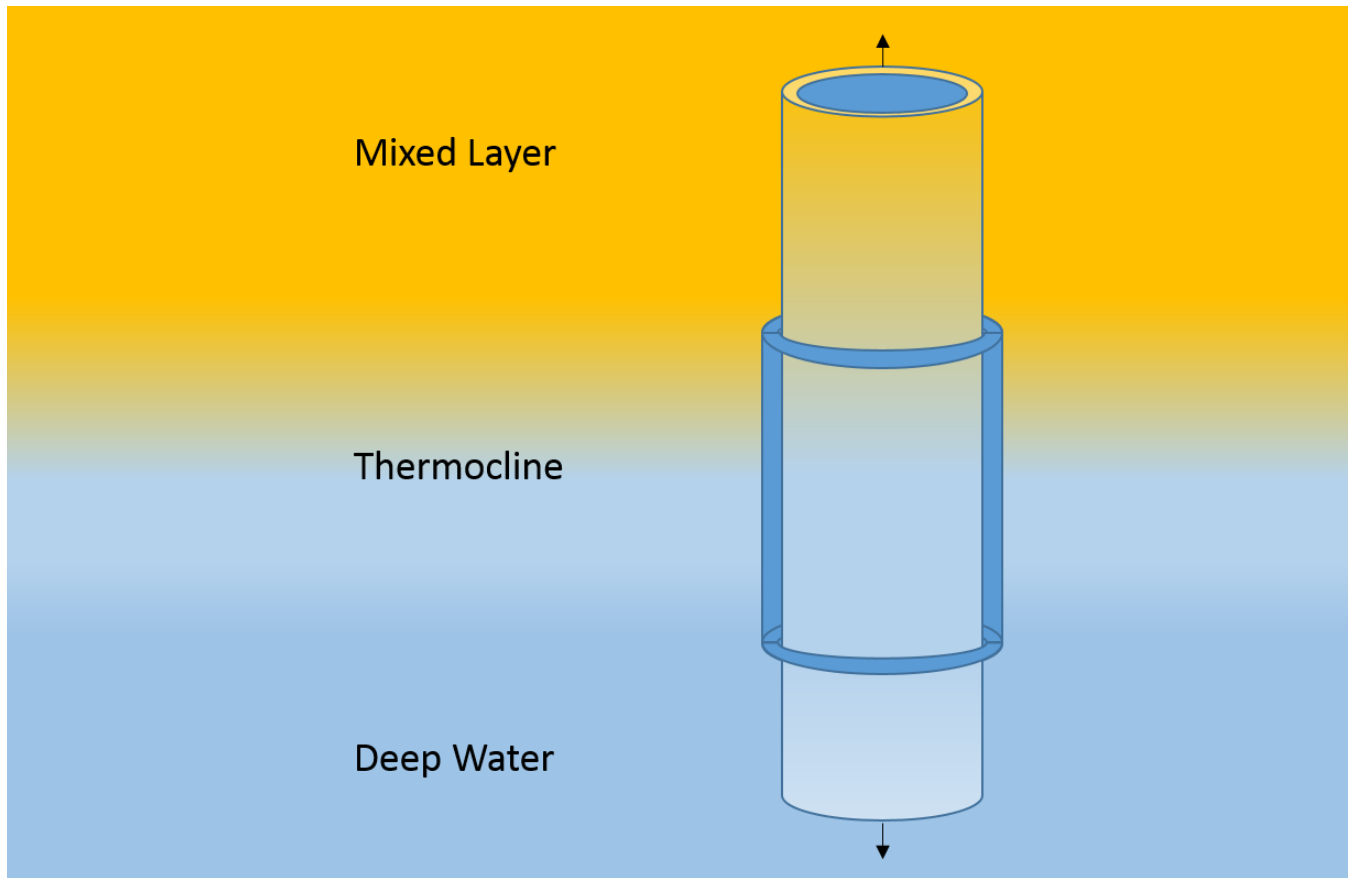
Prototype Clamp Mold Created with 3D Printer



# CALIBRATION OF POST-INSTALLED SENSORS

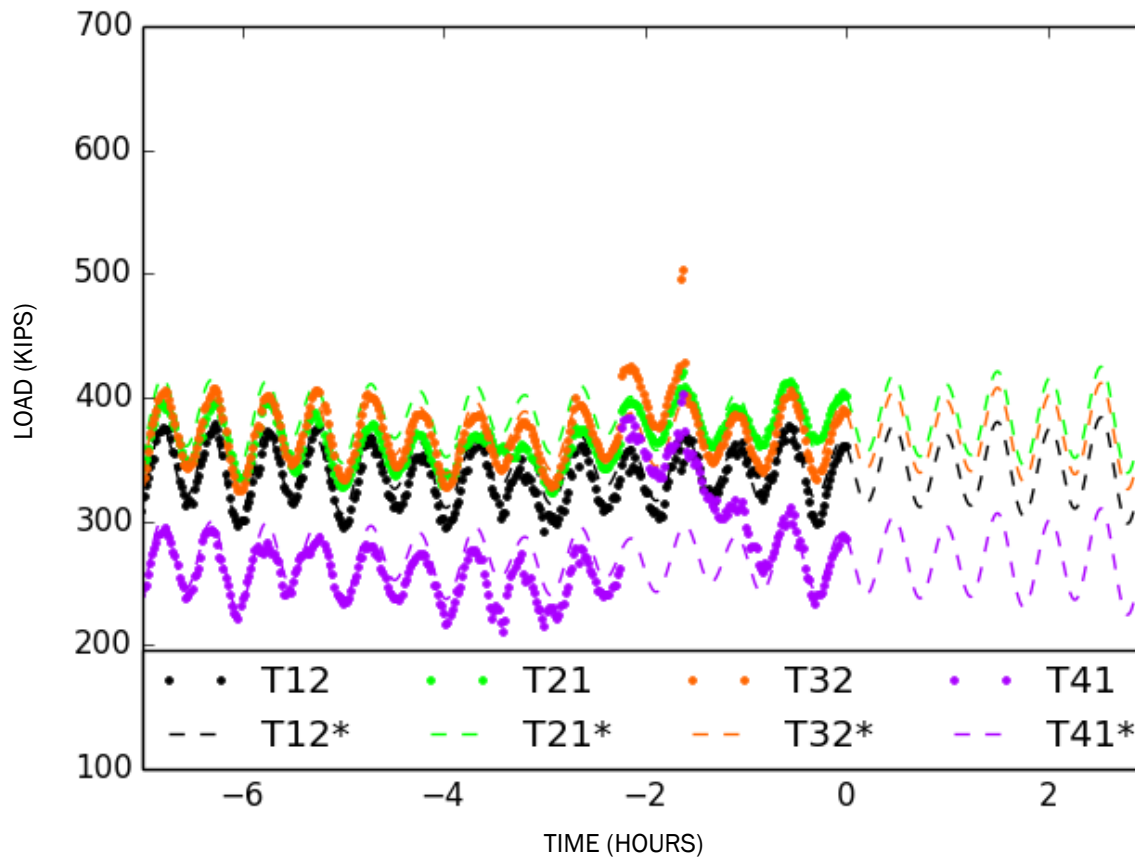


# THERMOCLINE AT **SENSOR CLAMP** DEPTH



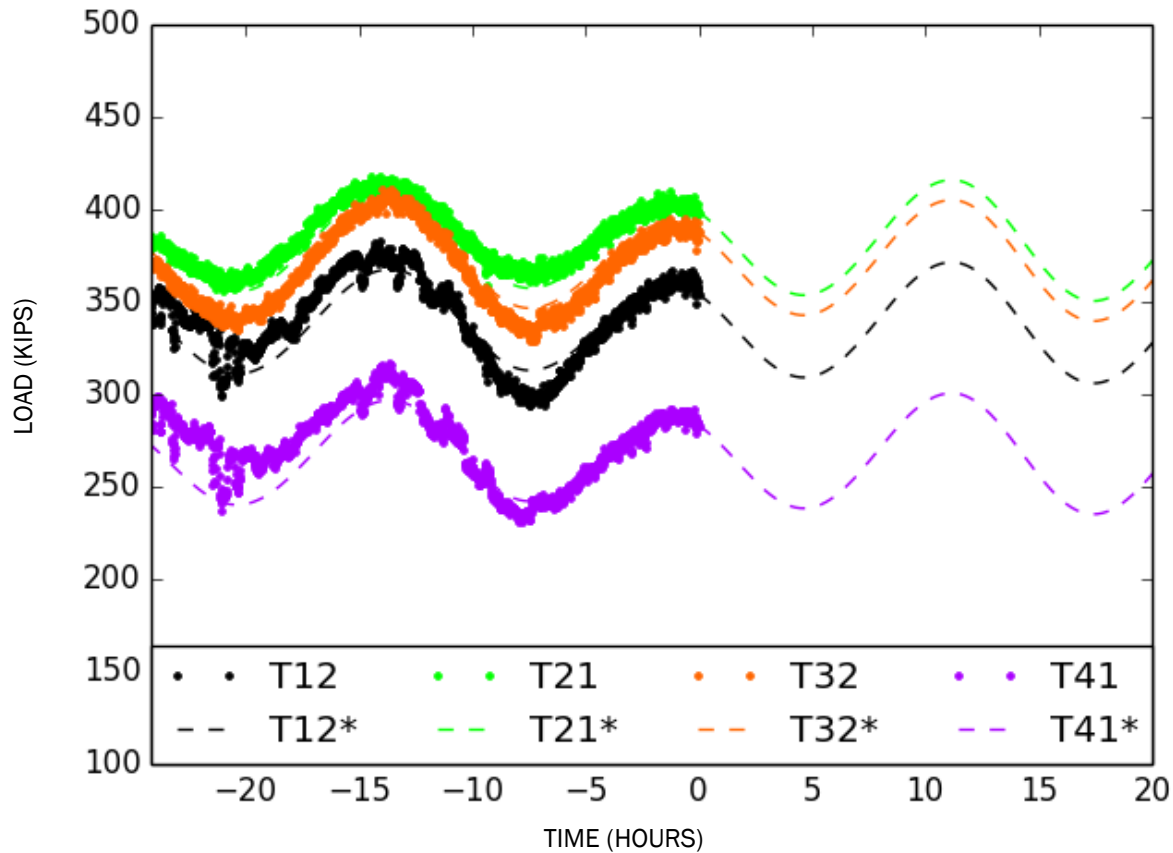
# PREDICTIVE MONITORING

## Foxtrot TTMS Average Load



# PREDICTIVE MONITORING

## Foxtrot TTMS Average Load



# CLEAR GULF

**A COLLABORATION BETWEEN**  
the Oil and Gas Industry,  
NASA and Astro Technology

ExxonMobil

Apache  
CORPORATION

ConocoPhillips



HESS



woodside

Anadarko  
Petroleum Corporation

MarathonOil

PEMEX

BR  
PETROBRAS

Eni



TOTAL

Statoil

PROPOSED PARTNERS

- 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



astro  
technology  
INNOVATION AT EVERY LEVEL