Optical Seismic Sensor for Low-Cost Frac Monitoring

SBIR Phase II Project Number DE-SC00015781

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U.S. Department of Energy

National Energy Technology Laboratory

Mastering the Subsurface Through Technology Innovation, Partnerships and Collaboration:
Carbon Storage and Oil and Natural Gas Technologies Review Meeting

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Presentation Outline

- Overview and Goals
- Work performed
- Accomplishments to date
- Further work

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Industry Need

- Accurate geophysical data with reliable, transparent analysis are essential for profitable, safe reservoir operation
- DOE pushing for better understanding of well dynamics in fractured wells to improve safety and efficiency.
- State of the art seismic wireline tools are bulky and require maintenance, so downhole sensor deployments are temporary, labor intensive, and disrupt production operations.
- DEPLOYMENT COST > HARDWARE COST

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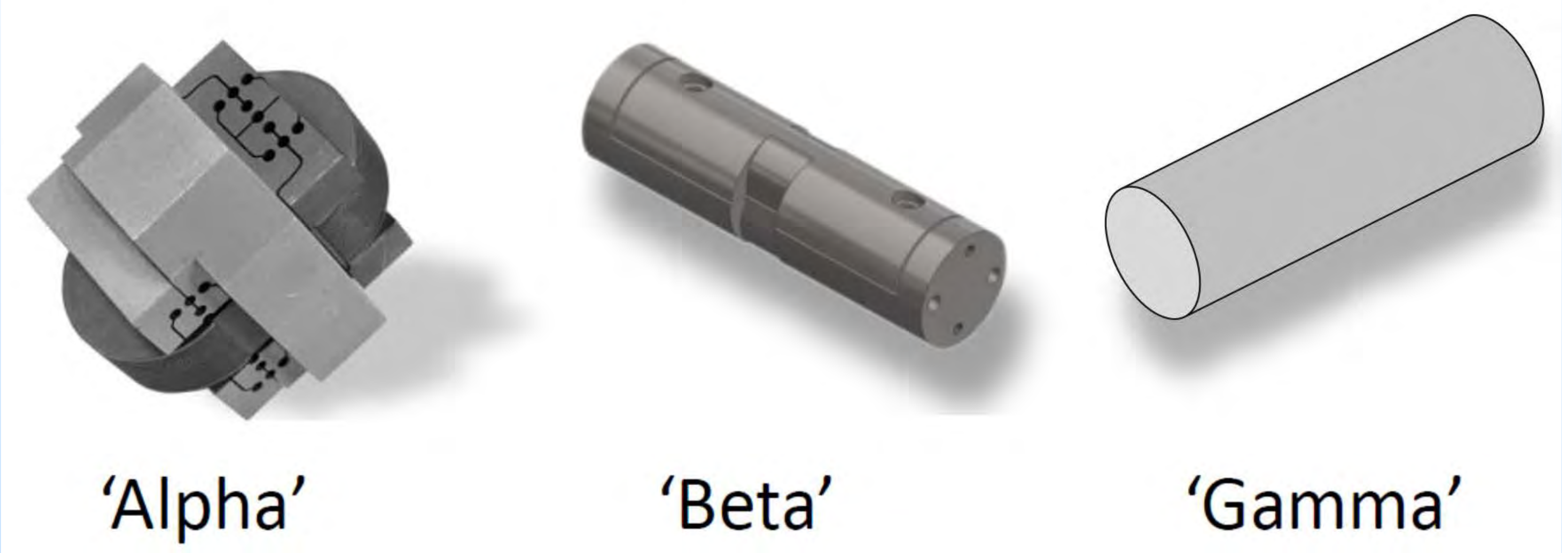
Technical Status

- We've optimized our designs for narrow diameter, high performance optical seismic sensors



2.5" diameter, proved concept	0.85" diameter, 4 pieces	0.85" diameter, cost reduced
Developed with DOE SBIR from Geothermal Tech. Office	Developed privately	Developed during this program

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Technical Status

- Based on prior deployment experience and feedback from industry, we are adding features to simplify deployment and reduce cost



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Technical Status

Sensor Assembly

- 3C sensor assembly is a fluid filled, sealed, testable unit.
- Fiber passes out a high pressure feedthrough, splices to trunk lines.
- OD = 0.97in, length is 25 in
- Enclosed in tube of corrosion resistant alloy.
- Proprietary features allow deployment with less labor, less downtime, and in narrower (cheaper) wells

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Technical Status

- We've completed and tested a full assembly in the lab.
- Field test planned for 2019 will involve a small array with multiple 3C sensor assemblies
- Proprietary interrogation system (previously used in field tests), is configured and tested; undergoing integration.

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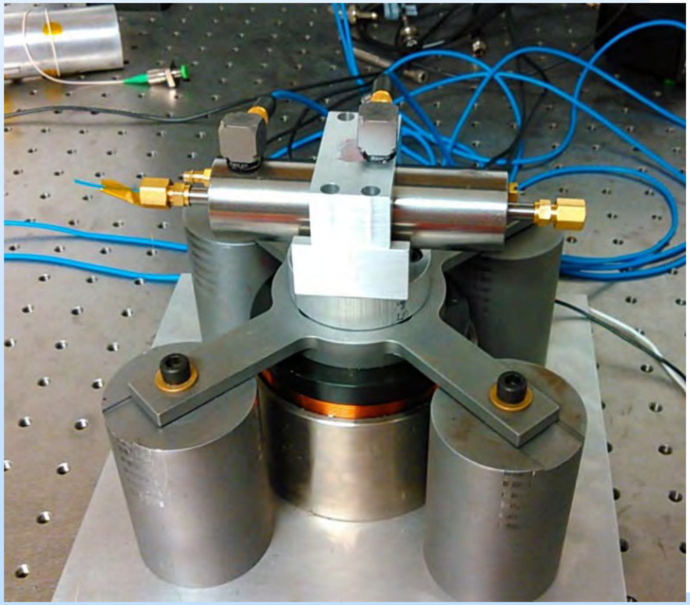
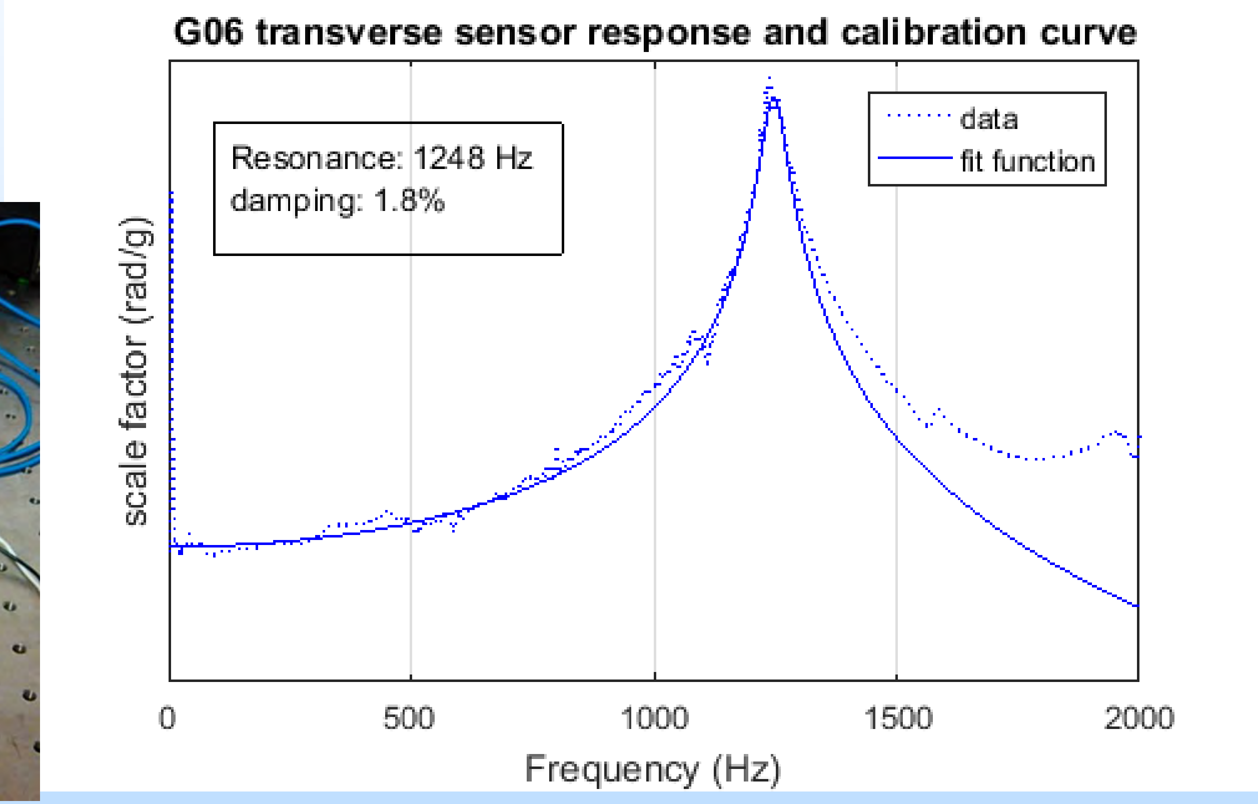
Accomplishments to Date

Fluid fillable test fixture allows testing sensors in isolation





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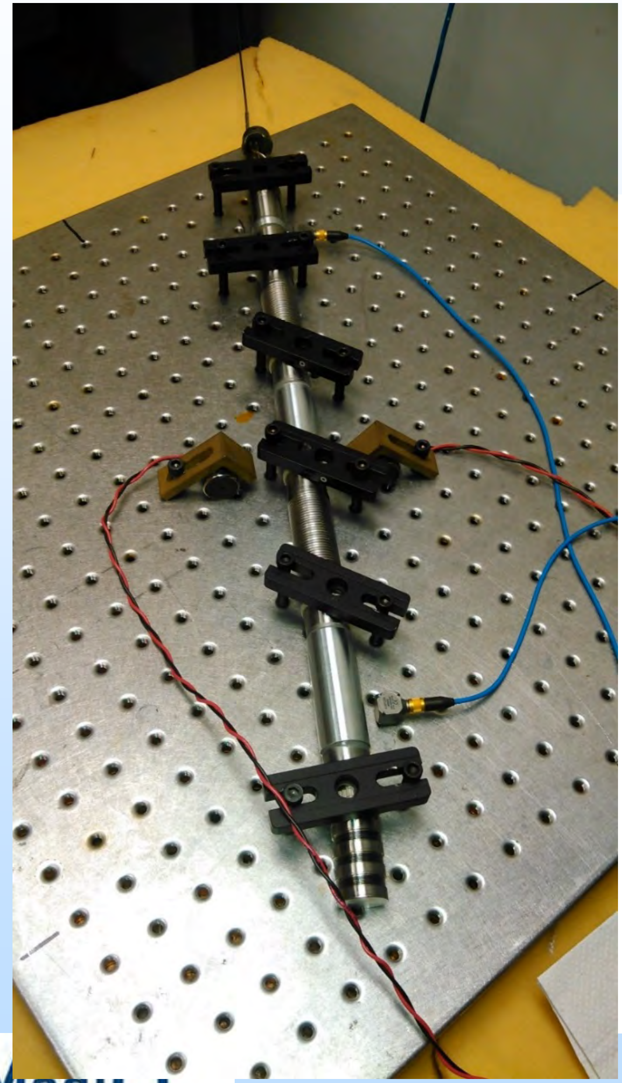
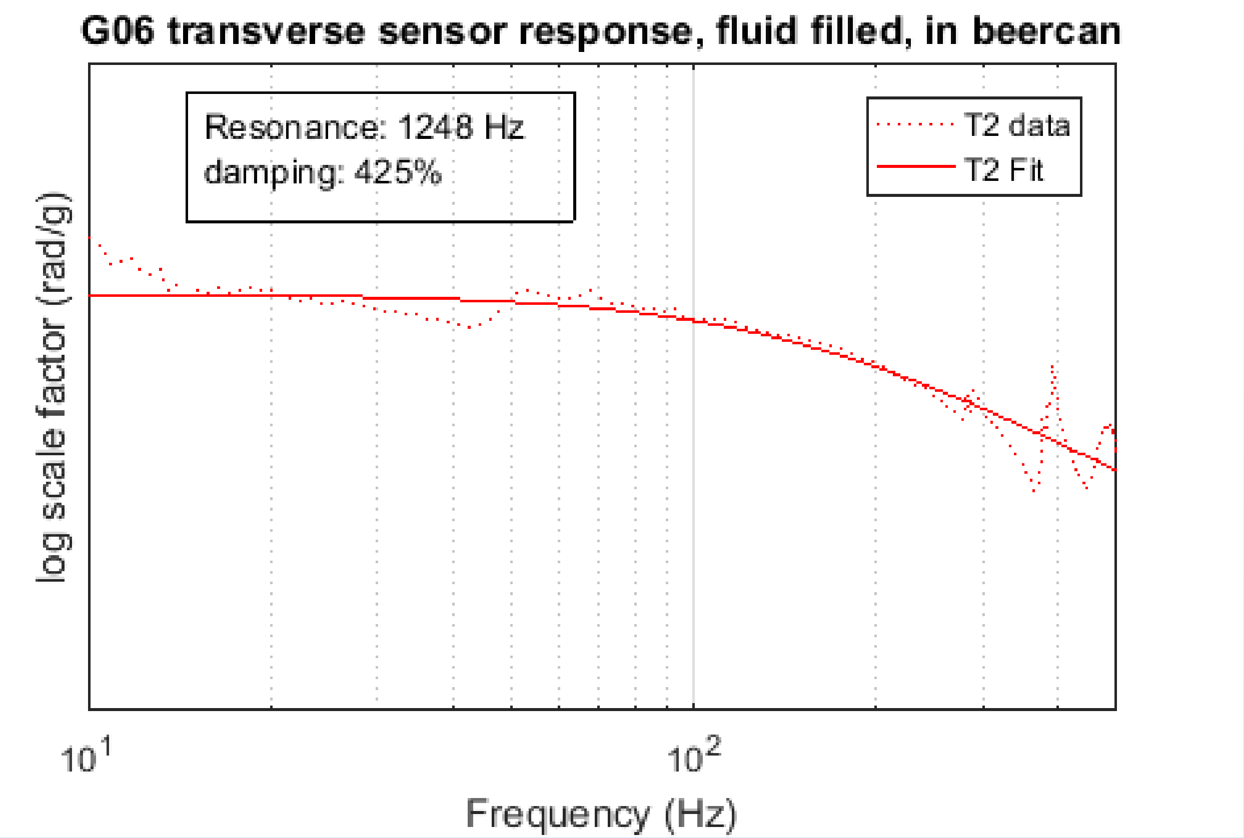
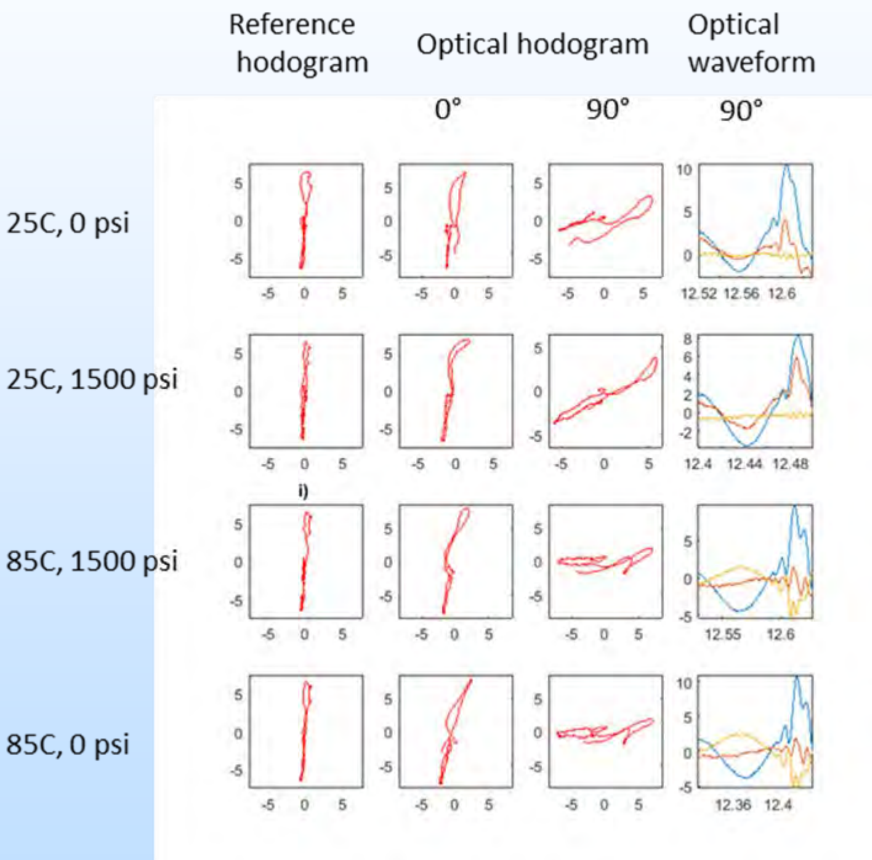
Accomplishments to Date

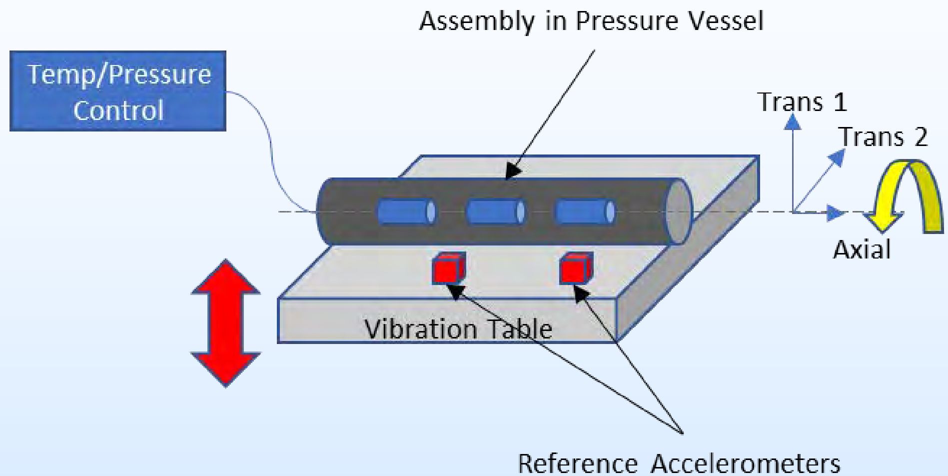


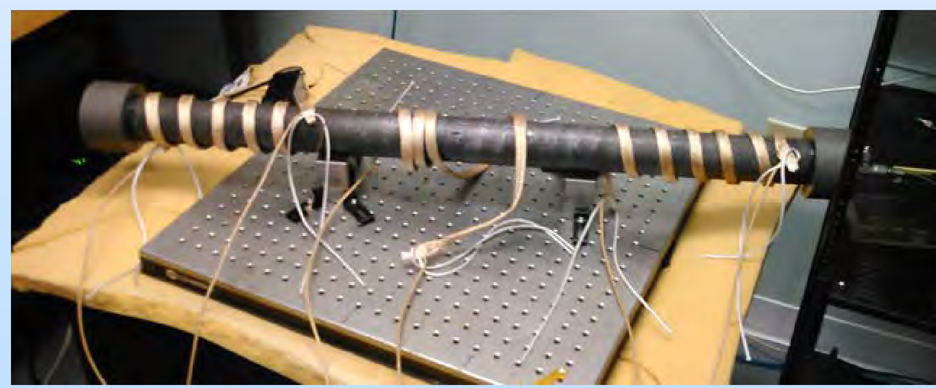
Testing assemblies in the lab



Accomplishments to Date







Accomplishments to Date

SBIR Phase II objectives

- Produce multiple transverse and axial sensors with optimized, consistent response. - Completed
- Design and fabricate assemblies, and test them for strength. Completed.
- Test a full assembly with 3 sensor components for seismic response. - Completed.
- Integrate and test a prototype sensor array, both in the lab and in the field. - Underway.
- Minimize costs of component fabrication, assembly, and quality control. – Ongoing.

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Lessons Learned

- Some elements of assembly can be surprisingly expensive, but we've identified cost effective alternatives
- Prototype assembly had some tolerancing issues, which are being worked on.
- The initial development costs of cabling and deployment hardware will be large, and will require collaboration with experienced partners.

Synergy Opportunities

– Other government programs, (carbon capture and sequestration, ocean monitoring, defense) could benefit from the technology.

– DOE field laboratories would benefit (cheaper and more comprehensive seismic monitoring, especially for long term studies)

– Other types of sensors (DAS/DTS, pressure, electronic tools, etc.) could be incorporated into our designs

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Project Summary

- Key Findings
  - We've produced sensors with consistent, optimized response
  - We've assembled and tested an assembly prototype at high temp and pressure
  - Portable interrogator performance verified and undergoing integration

- Next Steps.
  - Modify assembly design based on results from first test
  - Plan for field test: identify locations and partners, produce small array

Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Benefit to the Program

- DOE Unconventional resources program goals addressed:
- Identify and accelerate development of economically-viable technologies to more effectively locate, characterize, and produce natural gas and oil resources, in an environmentally acceptable manner
- Catalyze the development and demonstration of new technologies and methodologies for limiting the environmental impacts of unconventional oil and natural gas development activities

- Project Benefits Statement:

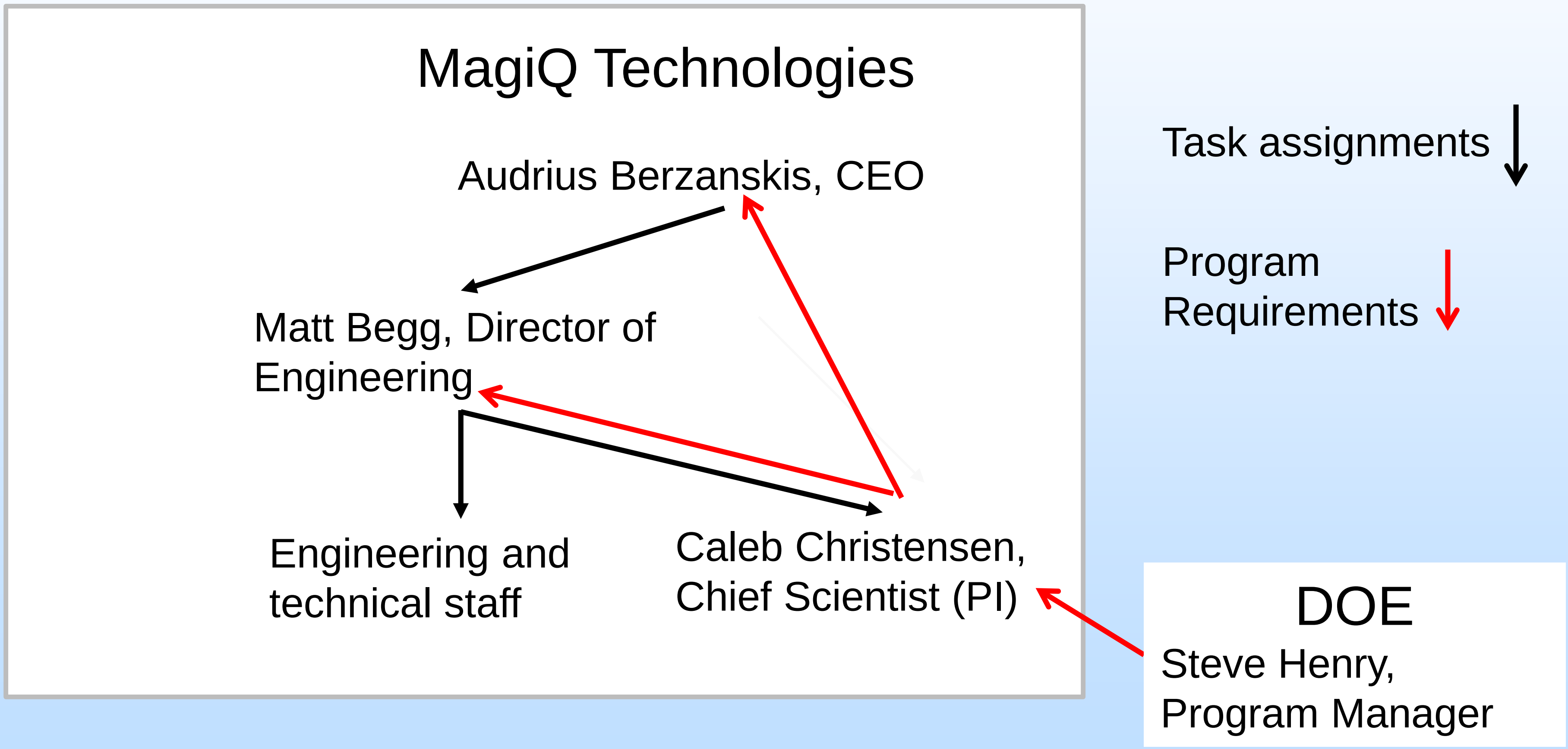
This program is developing a harsh environment, narrow diameter optical seismic sensing system to reduce costs of downhole seismic imaging and monitoring of unconventional resources. Compared to existing seismic tools, the form factor will be faster and safer to deploy with less labor in a wider variety of well configurations. The technology, when successfully deployed, will acquire seismic data with high sensitivity and bandwidth in locations where it was previously impossible or cost-prohibitive, allowing for better modeling, analysis and recommendations to ultimately improve extraction efficiency, safety, and productivity.

Project Overview

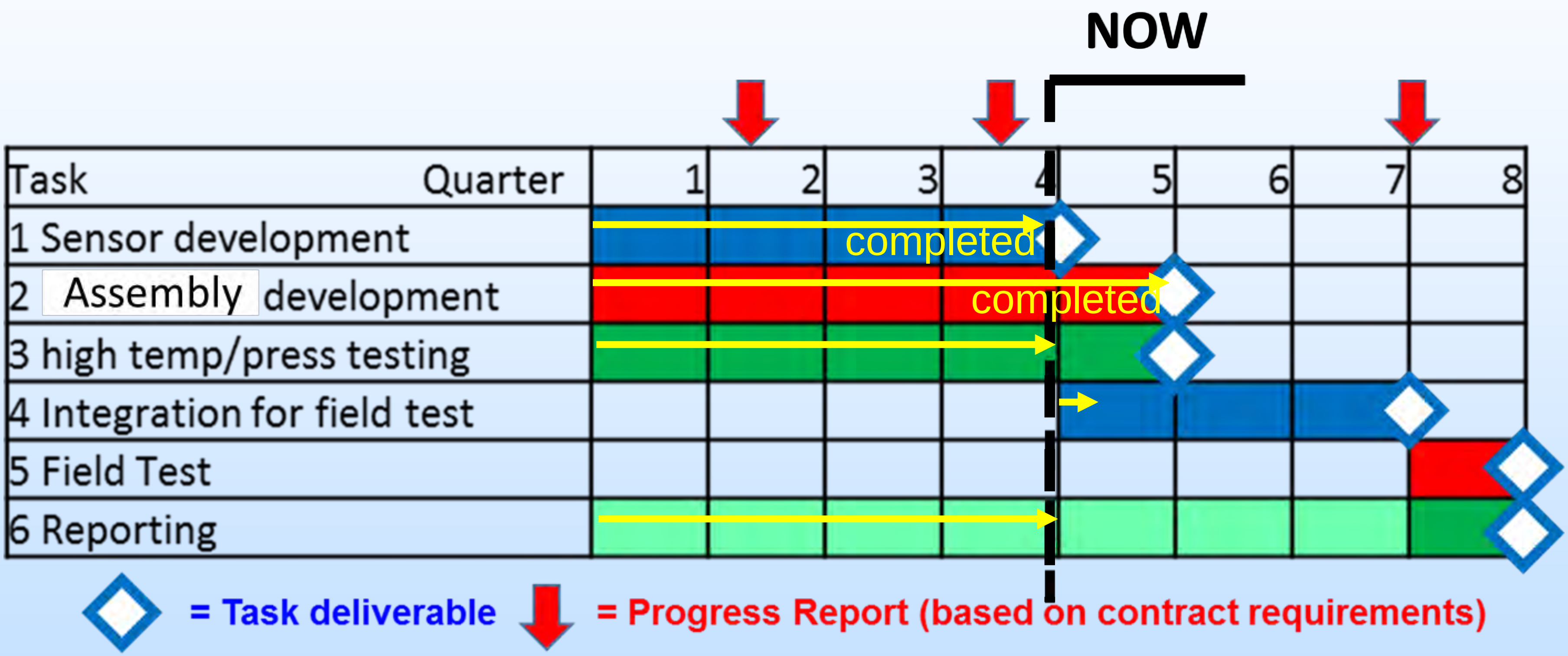
Goals and Objectives

- Produce multiple transverse and axial sensors with optimized, consistent seismic response.
  - Required for good data quality and analysis, success is consistent (+/- 10%) DC response and resonance frequency
- Design and fabricate assemblies, and test them for strength and flexibility
  - Required for manufacturing, ruggedness and survival in target environment, success is 500 lbs tensile strength while strained
- Test a full assembly with 3 sensor components for seismic response
  - Verify that it hits required performance metrics for quality data and analysis
- Integrate and test a prototype sensor array, both in the lab and in the field.
  - Required to demonstrate successful operation and understand operational requirements. Success is completed field test.
- Minimize costs of component fabrication, assembly, and quality control.
  - Required to meet the economic viability goals, success will be producing an accurate cost estimate.

Organization Chart



Gantt Chart



Yellow lines indicate degree of completion of each task

Bibliography

– No peer reviewed publications generated