Oil & Natural Gas Technology

DOE Award No.: DE- FE0013961

Quarterly Research Performance Progress Report
(Period ending 12/31/2015)

Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

Project Period (10/1/2013 to 9/30/2016)

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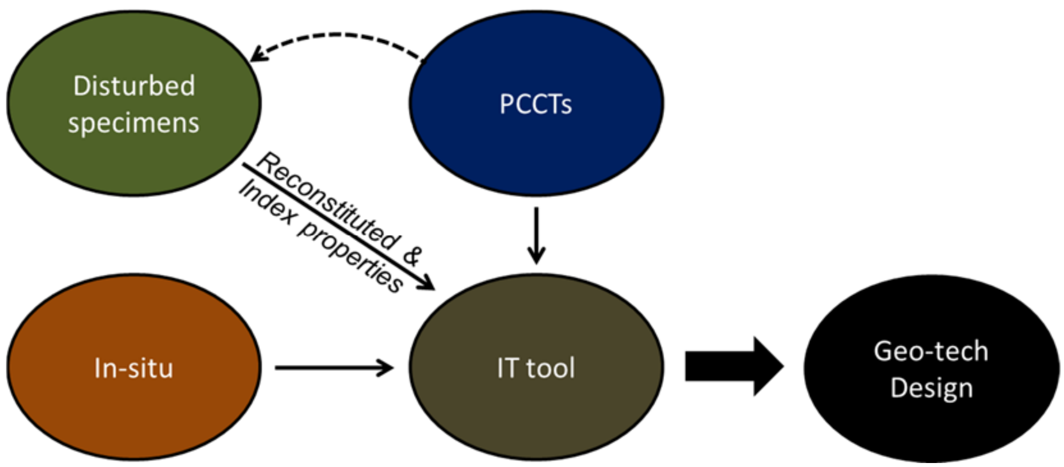
Office of Fossil Energy

DISCLAIMER:

Context – Goals.

The physical properties of hydrate bearing sediments are critical for gas production strategies, geo-hazard mitigation and its impact on gas recovery engineering. Typically, the determination of physical properties relies on correlations and experimental data recovered from conventional and pressure cores. Inherent sampling disturbance and testing difficulties add significant uncertainty. In this research, we develop a new comprehensive borehole tool for the characterization of hydrate bearing sediments, and an IT tool for the physics-bases selection of appropriate parameters.



Accomplishments

The main accomplishments for this period include:

- Borehole tool design: body (sub-task 3.4: Final design and construction)
  - Final assembly
- Borehole tool (sub-task 4.3: Final design and construction)
  - New improved strain gage resolution
- Field deployment
  - First deployment on KAUST marina

Plan - Next reporting period

Design of the coupler for the drill string, a new and compacted electronic rack, add electric resistivity measurement to the log data and a new version/generation of the camera module.

Research in Progress

Borehole Tool

The updated borehole tool is a modular design that involves multiple modules coupled in series. These modules were machined of stainless steel 316 for corrosion and mechanical resistance. Instrumentation within modules is complemented by peripheral piping and chambers for water and gas sampling, and hydraulic conductivity measurements.

The tool can be operated in three different modes. The first mode is a stand-alone device: all electronics, batteries and storage are kept inside the tool. The second mode is hard-wired to the vessel at the surface for real time data gathering and power supply. The third operating mode is a hybrid customizable/mode device to satisfy a wide range of applications.

Tool construction and assembly

Figure 1 shows the final assembly of the body (housing), sensor modules, and sediment samplers.

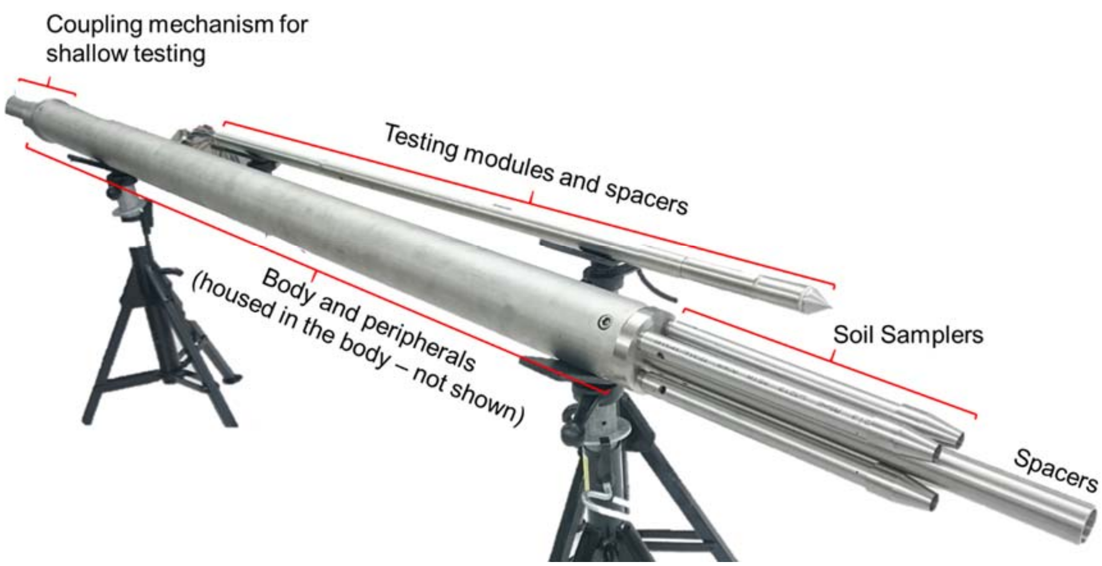
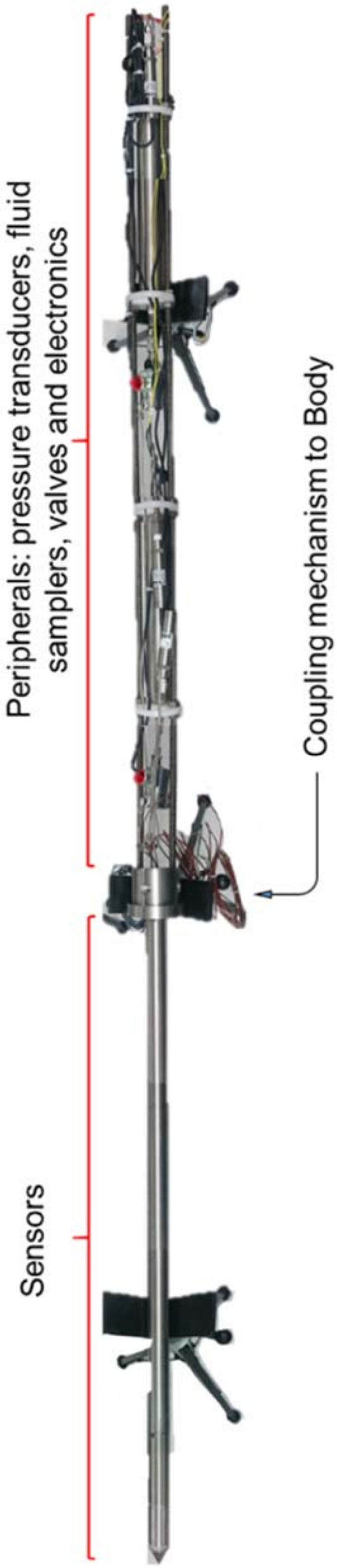


Figure 1: The tool. Note: sensor modules not shown due to space limitations

Figure 2 shows the extruded image of the peripheral components in the tool. All sensors are mounted above the coupling mechanism to the Body. Piping, pressure transducers, fluid samplers, valves and electronics are depicted in the figure as well.



Electronics: new board and circuitry.

A new microprocessor, board and circuitry have been tested to improve accuracy and resolution of the various strain gages used in the tool.

The force module integrated with the new command board were tested within a high pressure chamber (max. pressure = 35 MPa) under two power supply voltage levels: 5 and 10V. Figure 3 shows the results of this test. The 5V board delivered lower resolution data (0.5 MPa to 1.8 MPa jumps). On the other hand, the 10V supply delivered data with 0.18 MPa resolution.

The final tool assembly involves three battery packs for power supply: strain gages, microprocessor and solenoid valves.

Figure 2: Sensors and peripheral components.

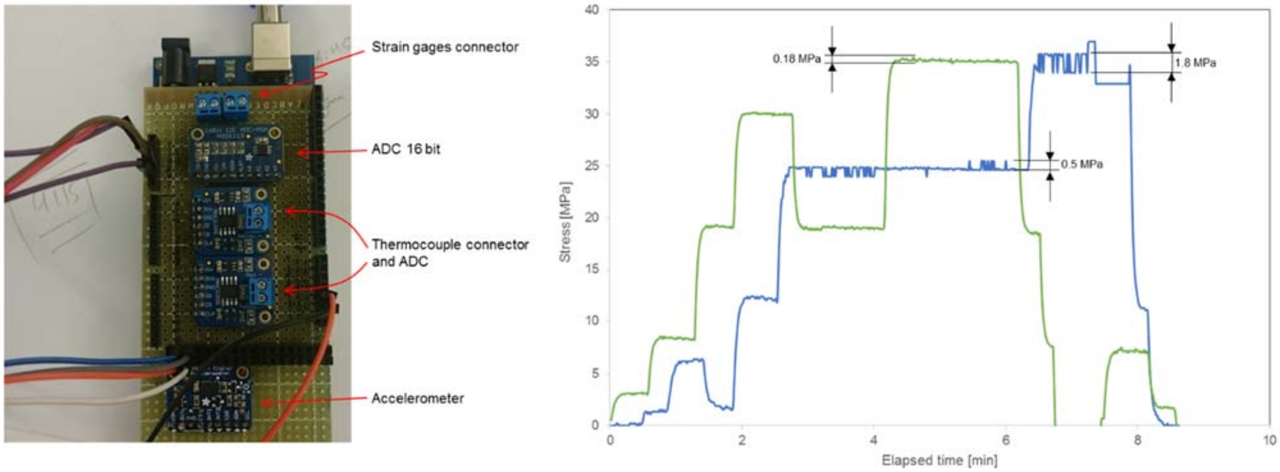


Figure 3: Electronics: Enhanced resolution attained with the new board, microprocessor and circuitry.

Borehole tool: pressure testing.

The tool was subjected to a pressure test within the high pressure vessel at the Coastal Marine Resources Core Lab at KAUST. The high pressure vessel has an internal diameter of 0.5 m. and 2.5 m. internal depth, and is able to sustain up to 100 MPa internal pressure at temperatures that range from 0 to 100°C. Figure 3 shows the pressure vessel about to be tested and the pressure history imposed during the test, including pressure steps at 10, 50, 100, 200 and 350 bars. The tool sustained the 35 MPa (350 bars) water pressure without any leakage.

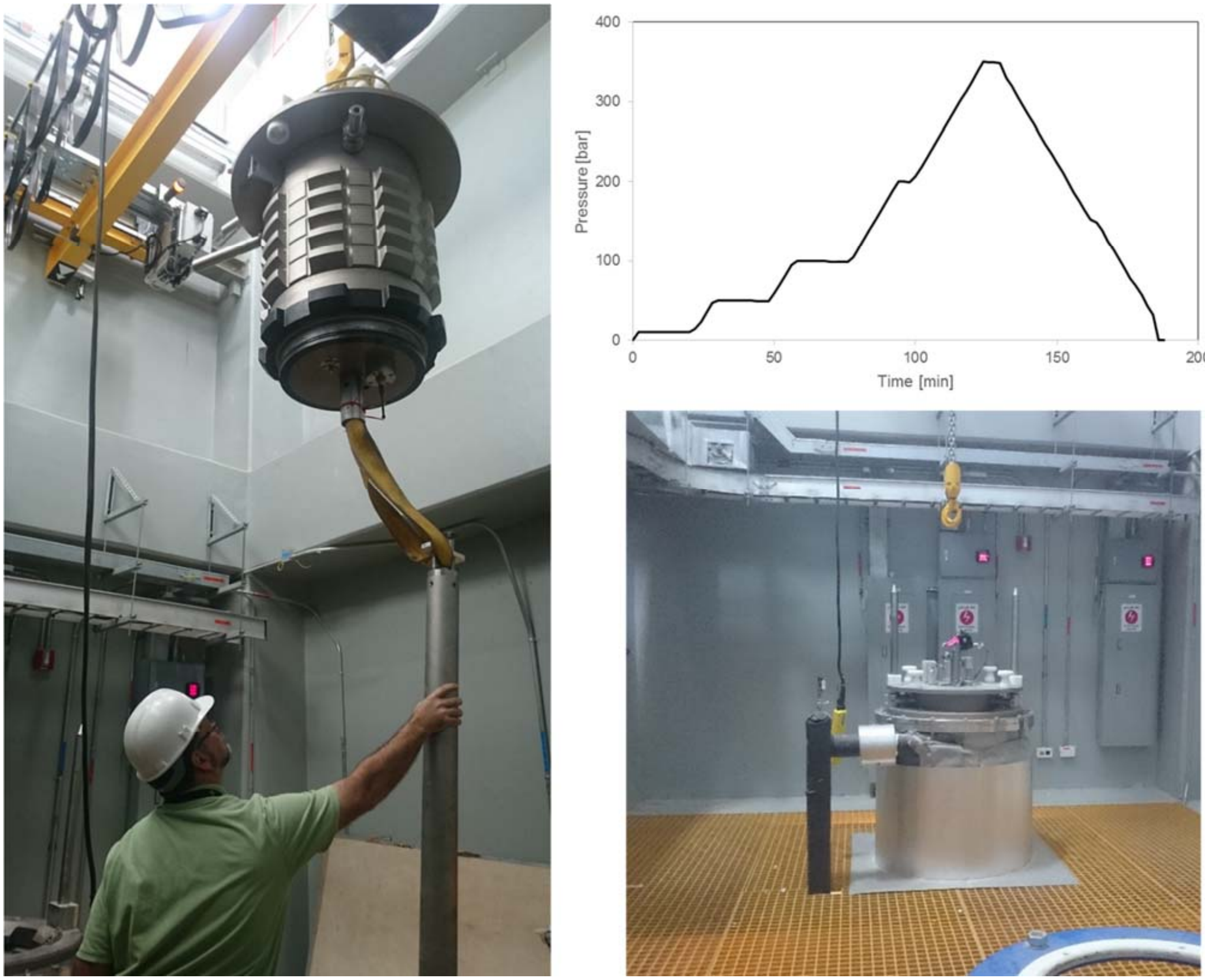


Figure 3: High pressure vessel and pressure test.

Field test.

The first field test was performed at the KAUST marina (CMOR). Figure 4 capture various part of the test. The tool was lowered vertically into shallow sediments beneath the water using a portable crane. The seafloor was ~5 meter deep and included very loose silt on top of compacted gravel and corals. Only partial penetration into the hard base was achieved.

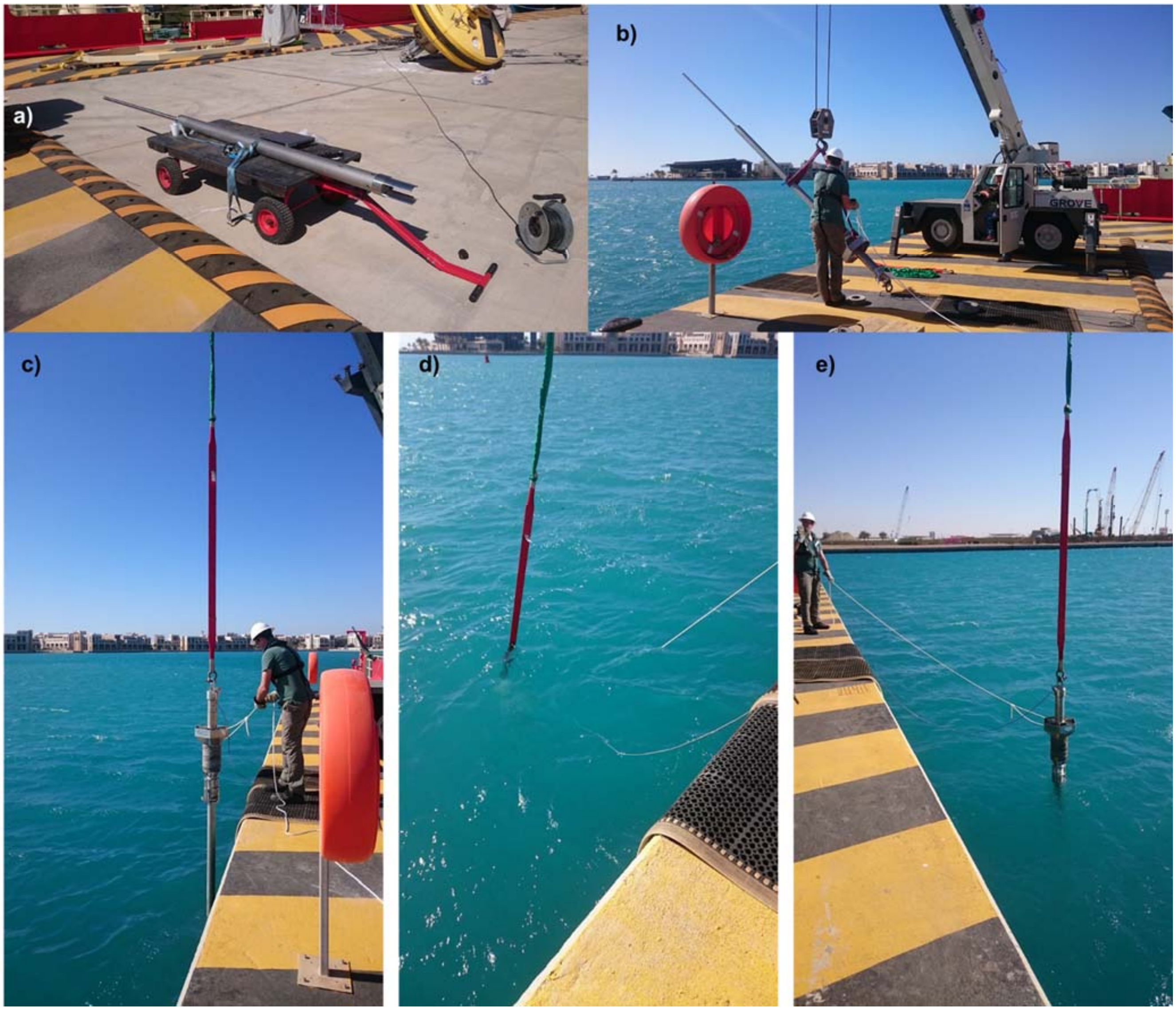


Figure 4: First field testing: deployment. a) Tool waiting to be coupled; b) lifting and approach to the water; c) decoupling to the hoist; d) lowering the tool to start the test; e) retrieving the tool.

Figure 5 shows data gathered with the three pressure transducers, two thermocouples and the accelerometer (3 axis). The pressure transducer 1 captures three penetration events (others are for flow tests and remain inactive). The accelerometer signature shows spikes and plateaus reflecting different stages during tool manipulation.

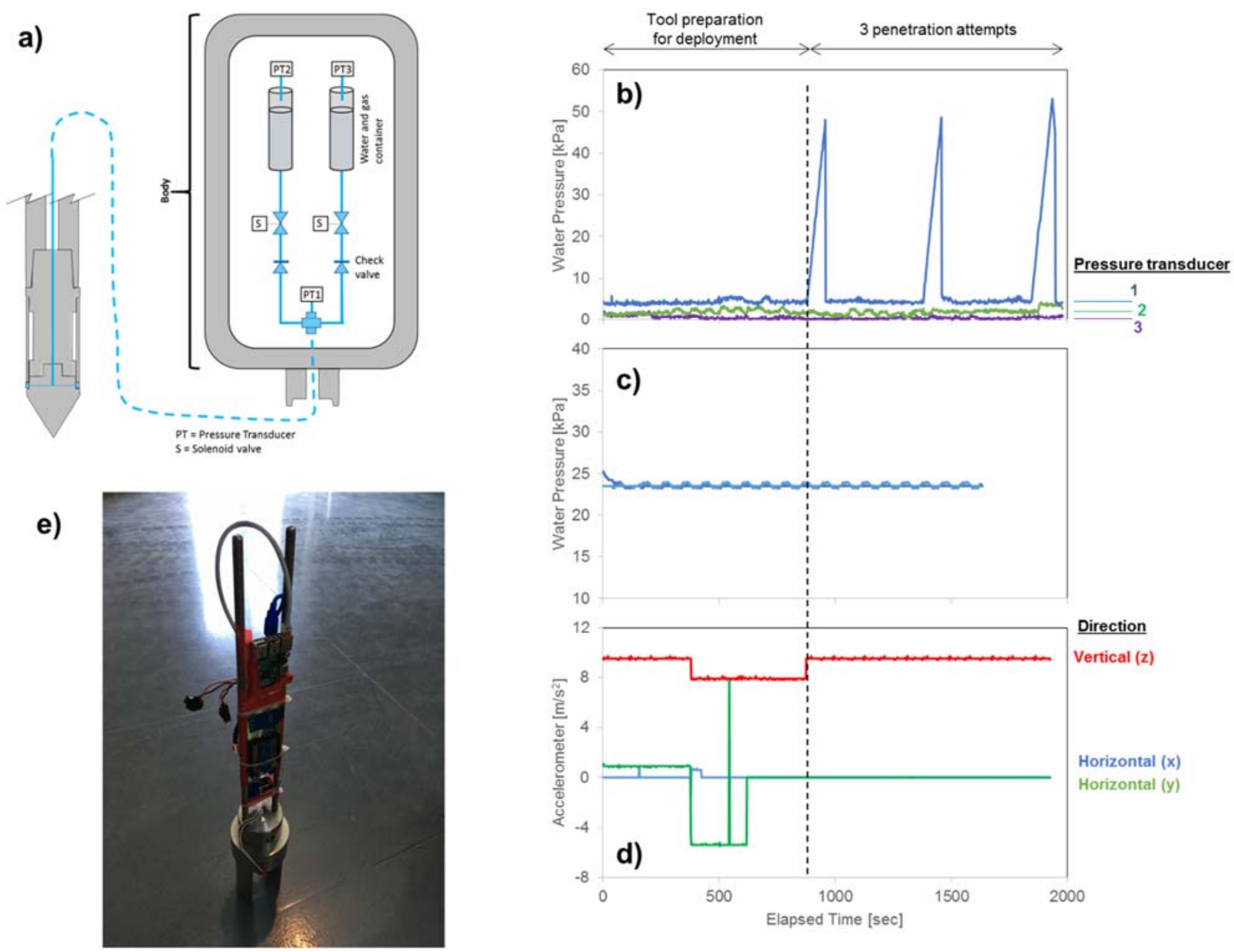


Figure 5: First field testing: sensor readings. a) pressure transducers location; b) pressure transducers readings showing the three tool insertions; c) temperature readings at the tip; d) accelerations for the three principals directions; e) assembly of electronics in the rack ready to be connected and inserted in the tool body.

MILESTONE LOG

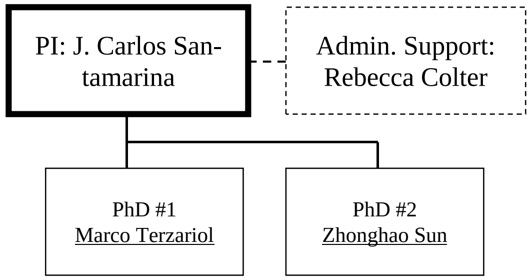
	Milestone	Completion Date	Comments
Title Planned Date Verification method	Completion PMP November 2013 Report	11/2013	
Title Planned Date Verification method	Insertion – Tool design September 2014 Report	9/2014	
Title Planned Date Verification method	Database and IT tool September 2014 Report	9/2014	Paper in preparation
Title Planned Date Verification method	Electronics in operation January 2015 Report	9/2015	
Title Planned Date Verification method	Lab testing of prototype September 2015 Report	9/2015	
Title Planned Date Verification method	Tool deployment Before September 2016 Report	In progress	

PRODUCTS

- **Website:** Publications and key presentations are included in http://egel.kaust.edu.sa (for academic purposes only)
- **Inventions, patent applications, and/or licenses:** None at this point.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Research Team: The current team is shown next. We anticipate including external collaborators as the project advances



IMPACT

None at this point.

CHANGES/PROBLEMS:

None at this point.

SPECIAL REPORTING REQUIREMENTS:

We are progressing towards all goals for this project.

BUDGETARY INFORMATION:

As of the end of this research period, expenditures are summarized in the following table (Note: in our academic cycle, higher expenditures typically take place during the summer quarter):

Baseline Reporting Quarter DE-FE0013961	Budget Period 2								Budget Period 3							
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4	
	10/1/14 - 12/31/14		1/1/15 - 3/31/15		4/1/15 - 6/30/15		7/1/15 - 9/30/15		10/1/15 - 12/31/15		1/1/16 - 3/31/16		4/1/16 - 6/30/16		7/1/16 - 9/30/16	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan																
Federal Share	30,000	168,944	30,000	198,944	30,000	228,944	86,571	315,515	30,000	345,515	30,000	375,515	30,000	405,515	71,510	477,025
Non-Federal Share	10,495	50,475	10,495	60,970	10,495	71,465	10,945	82,410	14,693	97,103	14,692	111,795	14,693	126,488	-	126,488
Total Planned	40,495	219,419	40,495	259,914	40,495	300,409	97,516	397,925	44,693	442,618	44,692	487,310	44,693	532,003	71,510	603,513
Actual Incurred Cost																
Federal Share	64,746	186,648	38,605	225,253	19,041	244,294	-	244,294	19,140	263,434		263,434		263,434		263,434
Non-Federal Share	10,601	50,580	27,525	78,105	-	78,105	-	78,105	19,133	97,239		97,239		97,239		97,239
Total Incurred Costs	75,347	237,228	66,130	303,358	19,041	322,399	-	322,399	38,273	360,672	-	360,672	-	360,672	-	360,672
Variance																
Federal Share	34,746	17,704	8,605	26,309	-10,959	15,350	-86,571	-71,221	-10,860	-82,081						
Non-Federal Share	106	105	17,030	17,135	-10,495	6,640	-10,945	-4,305	4,440	136						
Total Variance	34,852	17,809	25,635	43,444	-21,454	21,990	-97,516	-75,526	-6,420	-81,946						

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