Integration of Full Tensor Gravity and ZTEM Passive Low Frequency EM Instruments for Simultaneous Data Acquisition

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Bell Geospace, Inc.

Project Officer: Ava Coy
Total Project Funding: $1.8M
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This presentation does not contain any proprietary confidential, or otherwise restricted information.
Relevance/Impact of Research

• Objectives
  – Combine Air-FTG® and ZTEM™ onto One Platform for Simultaneous Acquisition
  – Test Applicability of Technologies for Geothermal Exploration

• Challenges
  – Integration of ZTEM System onto New Platform
  – Survey Parameters Compatibility between Systems
  – Imaging Geologic Structure Sufficiently to Aid Geothermal Exploration
Relevance/Impact of Research

• Innovations
  – Combining Two of the Most Advanced Airborne Geophysical Methods onto One Platform

• Geothermal Technologies Program’s Goal(s) Impact
  – Reduce Risk for Exploration
    – Provide a Better Model of Subsurface Geology
  – Reduce Cost for Exploration
    – Increase Efficiency of Data Acquisition
Scientific/Technical Approach

• Survey Platform Systems Integration
  – Utilized Previously Certified Designs to Expedite Installation
  – Winch Hydraulic System, Winch and Latching Mechanism, Winch Control Console, Camera, and ZTEM Bird

• Data Acquisition
  – Survey a Well-Characterized Geothermal Deposit to Test Viability of Each Survey System and the Combination
  – Perform Commercial Test Survey over a Greenfield Site Using the Methods Developed at Initial Test Site

• Data Integration and Interpretation
  – Joint Interpretation of Density and Electrical Properties for Geologic Model Development
  – Release Final Integrated Interpretation Report
Accomplishments, Results and Progress

• **System Integration**
  – Winch, Camera, and ZTEM System All Installed, Flight tested, and Operators Trained
  – Highest Integration Risk - Identified
    • ZTEM Antenna Interaction with Aircraft

• **Data Acquisition**
  – Planned Date for First Survey - 04/01/2012
  – Aircraft Arrived On Location at First Survey Area - 03/25/2012
  – FTG Only Acquisition of Test Area and Most of Phase II Area
  – Combined FTG & ZTEM Acquisition Delayed

• **Technical Performance Issue**
  – ZTEM Tow Cable Wiring Failed During Calibration Flights on Survey Location
Accomplishments, Results and Progress

• Resolution
  – 1st Redesigned Tow Cable Iteration
    • Changed Rope Weave, Cable Assembly, and Integration
    • Changed Wire Construction – Fillers Added to Smooth Surface
    • Enlarged Directional Pulleys 3” to 5”
  – 2nd Redesigned Tow Cable Iteration
    • Modified Wire Composition – Higher Tensile Strength
    • Modified Wire Construction – Loosened Outer Jacket
    • Enlarged Exit Guide Pulley 3” to 5”
  – 3rd Redesigned Tow Cable Iteration
    • Maintained Wire Composition From Previous
    • Modified Tow Rope – Added Internal Load Member

• Current Tow Cable Test Results (3rd Iteration)
  – Tow Rope Aerodynamically Unstable
  – Unable to Retrieve ZTEM Antenna
## Accomplishments, Results and Progress

<table>
<thead>
<tr>
<th>Original Planned Milestone/Technical Accomplishment</th>
<th>Actual Milestone/Technical Accomplishment</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTG &amp; ZTEM System Integration</td>
<td>System Installations Complete</td>
<td>03/15/2012</td>
</tr>
<tr>
<td>Dynamic Flight Tests</td>
<td>Flight Dynamic Testing Complete</td>
<td>03/19/2012</td>
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<tr>
<td>Test Survey Acquisition</td>
<td>Completed FTG Only Portion</td>
<td>04/07/2012</td>
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<tr>
<td>Production Survey (Go – No Go)</td>
<td></td>
<td></td>
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<tr>
<td>Final Report</td>
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Future Directions

• **Immediate**
  - Complete Redesign and Testing of Replacement Tow Cable
  - Complete Rebuild of ZTEM Antenna

• **Project Milestone Risks**
  - Tow Cable Performance
  - ZTEM Noise due to Aircraft and Flight Direction
  - FTG Performance due to Increased Altitude and Flight Direction

• **Long Term Research & Development**
  - Integrated Interpretation Methods
    • Thermal Forward Model
    • Simultaneous and/or joint Inversion Methods
    • Noise Reduction Methods

<table>
<thead>
<tr>
<th>Milestone or Go/No-Go</th>
<th>Status &amp; Expected Completion Date</th>
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<tbody>
<tr>
<td>Combined FTG &amp; ZTEM, and Individual System Acquisition of Test Survey Area</td>
<td>FTG &amp; ZTEM Individual – Completed FTG Only ZTEM Only, FTG &amp; ZTEM – Q4 2013</td>
</tr>
</tbody>
</table>
• Integration of Two Advanced Geophysical Survey
  – Air-FTG® & ZTEM™ Integrated On Aircraft Completed
  – Dynamic Flight Tests Completed with No Flight Issues

• Acquisition of the Test Survey has Started
  – Completed FTG Only Portion Ahead Of Schedule
  – Preliminary Modeling of FTG Data is Continuing

• Tow Cable Issues Can Be Resolved
Project Management

Timeline:

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<tr>
<th>Planned Start Date</th>
<th>Planned End Date</th>
<th>Actual Start Date</th>
<th>Current End Date</th>
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<td>03/08/2011</td>
<td>01/01/2012</td>
<td>07/10/2013</td>
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Budget:

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<tr>
<th>Federal Share</th>
<th>Cost Share</th>
<th>Planned Expenses to Date</th>
<th>Actual Expenses to Date</th>
<th>Value of Work Completed to Date</th>
<th>Funding needed to Complete Work</th>
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<tbody>
<tr>
<td>$1M</td>
<td>$800K</td>
<td>$1.8M</td>
<td>$1.4M</td>
<td>$1.173M</td>
<td>$400K</td>
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</tbody>
</table>

- Hardware Funding Moved From Phase II into Phase I
- Project On Track to Finish within Schedule Extension
- Primary Schedule Delays Result from Redesign Time and Production Schedule Slots Available for Retests