**Task 5c Task Post Mortem document**

This document will review the accomplishments, products, performance, and lessons learned of and by the Contractor (WSI) during the 2012 DOGAMI TIR project. In order to maintain compliance with the Task 5 project close out steps set forth in the contract between the Agency (DOGAMI) and WSI.

Major Accomplishments

There are several worthy accomplishments from this thermal remote sensing project:

* The co-acquisition and processing of over 150,000 acres of broad area airborne thermal infrared (TIR) imagery and LiDAR remotely sensed data. The combination of geospatial products enables identification of geothermal surface expression and their relationship to detailed landscape morphology.
* The geospatial data (LiDAR/TIR) were successfully acquired at night, in remote terrain, and under strict environmental parameters (clear skies, cold nights, and no snow cover). This accomplishment proved that this type of data acquisition is possible over large areas.
* All deliverables met or exceeded the specifications outlined in the Statement of Work.
* The TIR imagery illustrated areas of thermal contrast suggesting geo-thermal activity (hot springs, warm ground) in several of the project sites. The TIR imagery provides the basis for follow-on interpretation and analysis.

Deliverables Produced

**General Deliverables**

Kick off meeting

Imagery & Base Deliverables for all project survey areas

TIR Measurement Processing & Analysis

Project Close-out

1. Checklist verifying completion and location of each task deliverable
2. Acceptance document verifying satisfaction of all task work
3. Task Post Mortem summarization

**TIR Deliverables**

Thermal Measurement Points (AOI Image Indices)(shapefile format)

Air Target Accuracy checkpoints (shapefile format)

TIR image mosaics (GEOTiff format)

TIR Native Frames (IMG file format)

TIR Rectified Images (GEOTiff format)

**LiDAR Deliverables**

All Return Point Cloud (LAS v1.2, Class: 1. Unclassified, 2. Ground) (1/100th USGS Quad delineation)

Ground Return Point Cloud (LAS v1.2 Class: 2. Ground) (1/100th USGS Quad delineation)

Bare Earth Digital Elevation Model (USGS Quad delineation)

Highest Hit Digital Elevation Model (USGS Quad delineation)

Intensity Images (1/100th USGS Quad delineation)

**Data Report**

Revised versions of both Delivery 1 & 2 reports (V2) incorporating agency edits (.docx & .pdf formats)

**Formal Metadata**

Metadata will be applied to all pertinent deliverable products

**Coordinate System**

All data was projected and delivered

Projection: UTM Zone 10 or 11 (Baker Pass only) North

Horizontal Datum: NAD 83 (CORS96), meters

Vertical Datum: NAVD88 Geoid 03, meters

Performance to Schedule

The original contract schedule objectives were not met due to a number of factors ultimately resulting in a 60 day extension to the contract. Overall, the image acquisition was completed in a very efficient and time sensitive manner. Data acquisition in all project areas occurred at the first opportunity that met the environmental and no snow cover requirements. Regardless, delivery schedules were ultimately impacted by the data acquisition schedule. The following timeline illustrates contributing factors to schedule performance:

* On February 9th, 2012, WSI was contracted to acquire, process, and deliver high resolution airborne thermal imagery and co-acquired LiDAR. The contract end date was set at April 30th, with preliminary delivery targeted for April 15th. A project “kick-off” between team members from DOGAMI and WSI was held in the WSI Corvallis office on the 10th of February (Task Item 1). During the Kick-off meeting, both WSI and DOGAMI recognized that the delivery schedule was ambitious with success almost entirely driven by the timing of data acquisition, which was subject to seasonal variability in the weather.
* Flight conditions required for optimal acquisition of high resolution TIR imagery requires clear skies, below freezing temperatures, and no snow. Snow conditions and weather at the project sites precluded data acquisition at any project sites until the 1st week of March. The Christmas Valley, Summer Lake, Oregon Military, and Paulina Marsh areas were flown from March 3rd through 9th resulting in the collection of 49,873 raw TIR image frames covering over 108,000 acres.
* WSI deployed a ground crew to the Baker Pass area on March 8th in preparation of data acquisition. However the ground crew found significant snow in the project area and relayed this information to WSI managers. The snow conditions in the Bakers Pass area were communicated to DOGAMI staff and a decision was made to delay acquisition until the area was snow free.
* Weather and snow conditions prohibited data acquisition in Baker’s Pass until April 6th. Baker’s Pass imagery was collected over three nights (April 6-8) comprising \*\*\* acres and 24,027 TIR frames. At the time the Baker’s Pass data acquisition (April 10), the project team recognized that the original contract end date was not realistic. The contract was extended to June 30th to allow time to process all areas and for DOGAMI’s review of deliverables.
* Summer Lake project was delivered as a priority first delivery on May 16th, 2012 to DOGAMI. The remaining datasets were processed and shipped to DOGAMI on June 15th, 2012. QAQC edits were received on June 20th for the Baker Pass project area, and on June 26th for the Paulina Marsh project area.
* Overall, the processing of deliverables for each project area took longer than originally anticipated. The increased needed for processing was the result of a combination of factors:
  + The month difference in acquisition dates of the Baker’s Pass area and the other project areas increased processing time by requiring an additional bore-sight of the TIR camera and separate processing workflow for the Baker’s Pass area.
  + The LiDAR data were produced first in order to provide a DTM for orthrectifying the TIR imagery. The LiDAR data was a very valuable addition to the deliverables, but the additional processing time was not accounted for in the original schedule.
  + The large number of TIR frames required more computing time than originally anticipated. In addition, the overall objective of the project is to retain all information contained in the TIR imagery. Consequently, some tools available for standard orthophoto production such as edge feathering, color balancing, and global tilting were not used on the TIR imagery. This required more manual interpretation and editing – especially when addressing QC edits.

Performance to Budget

WSI did not request any budget increases or modifications to complete the project. All project work was completed to specification and within the contract fixed-price budget.

Lessons Learned

*Data Acquisition:*

* While the data were ultimately collected under the desired conditions, the narrow acquisition time frame had the largest impact on delivery schedule and budget. Given the susceptibility of the project areas to snow, the optimal acquisition time frame would occur in late fall or early winter.
* WSI was careful to fly all projects areas during conditions where large blocks could be collected in single flight and the associated flight lines were flown sequentially. The late night/early morning acquisitions helped to minimize residual heat from the day and stabilize overall radiant temperature of the terrain. None-the-less, apparent temperature differences were observed between some flight lines that may reflect a combination of temporal differences in radiant temperature and changing atmospheric conditions. Future projects should seek to minimize overall acquisition time and require that lines are flown sequentially to minimize temporal differences in radiant temperatures.

*Data Processing/Analysis:*

* The co-acquisition of airborne LiDAR into the product deliverables proved very valuable in the interpretation of detailed topography associated with thermal patterns.
* The initial data processing schedule was ambitious considering the “pilot” nature of the project and the dependence of acquisition on the variability of winter weather.
* While thermographs were placed in some of the study areas to verify radiant temperature accuracy, the consistency in measured temperatures both within the study area and between flight lines is probably more important for the interpretation and mapping of terrestrial features. In this regard, the ability to cover a large area in a relatively short amount of time is important. This would suggest that covering a broader area in a single flight line (possibility at the expense of spatial resolution) is desirable for this application.

*Project Concept:*

* As hoped, the TIR image mosaic illustrated a complexity of radiant temperatures across the landscape. The presence of surface water was easily detected in the TIR imagery due to its warmer temperature compared to the surrounding terrain. The imagery was calibrated to the emissivity of water and checked against in-stream thermographs to verify accuracy. Consequently, the radiant temperature of the water should provide some indication of its origin (i.e. hot spring).
* The relatively small range of terrestrial temperatures combined with differences in emissivity for terrestrial features can make interpretation of (non-water) surface temperature s more difficult. The radiant temperature patterns are best analyzed within the context of other spatial data layers. Vegetation layers and detailed topography information are particularly useful.