Contract Number: OASRTRS-14-H-UARK
Quarterly Report Progress Report Number: 1
Quarter Start and End Date: September 15, 2014 – December 31, 2014
PI Name: Richard A. Coffman
Program Manager Name: Caesar Singh

2. Table of Contents

3. Glossary of Terms

AHTD	Arkansas State Highway and Transportation Department
BAER	Burned Area Emergency Response
CDOT	Colorado Department of Transportation
Co-PI	Co-Principal Investigator
FHWA	Federal Highway Administration
GRA	Graduate Research Assistant
ITD	Idaho Transportation Department
ISU	Idaho State University
MAP-21	Moving Ahead for Progress in the 21st Century
MTU	Michigan Technological University
PI	Principal Investigator
RECOVER	Rehabilitation Capability Convergence for Ecosystem Recovery
TAC	Technical Advisory Committee
TRB	Transportation Research Board
TRC	Transportation Research Committee
UGRA	Under Graduate Research Assistant
USDOT	United States Department of Transportation
USGS	United States Geological Survey
UofA	University of Arkansas

4. Executive Summary

The Technical Status and Business Status of the OASRTRS-14-H-UARK Contract are presented herein. Specifically, the work completed during the first quarter of the federal fiscal year (October 1, 2014 through December 31, 2014) are presented and discussed. Two deliverables were scheduled for completion during this quarter. These deliverables included: 1) development of a technical advisory committee, and 2) development and maintenance of a project website. Both of the deliverables were completed. Several activities were also completed in association with the required deliverables. These activities included: 1) a kickoff meeting that was held in Denver, Colorado, on December 12, 2014 and 2) the informal launch of the project website on November 24, 2014 (the date that the website link was submitted to Caesar Singh and Vasanth Ganesan) and the formal launch of the project website on December 12, 2014 (the date that the website link was shared with the TAC).

A total of $88,464.09 of USDOT funds were expensed during the quarter. A total of $10,162.84 dollars of cost-share (UofA) were expended during this quarter. Although the project team expended time and effort, only the salaries for the graduate assistant at the UofA were encumbered. At the time of the submission of the quarterly report, the UofA has not yet received an invoice from MTU, so any costs associated with the work performed by the personnel at the Michigan Technological University, during this quarter for this project, were not included.

Orders were placed for the equipment associated with the ground-based remote sensing device (Activity 3). Several of the pieces of equipment (the ASD Field Spec 4 device and two Data Physics Quattro devices) were delivered and preliminary analyses are being performed using the equipment. Other pieces of equipment that are required to complete the ground-based remote sensing device are expected to be delivered during the second quarter of the fiscal year (January 1, 2015 through March 1, 2015).

5. SECTION I — TECHNICAL STATUS

Accomplishments by Milestones

Activity 1: Formation of TAC

The TAC was developed (as reported to Caesar Singh and Vasanth Ganesan on November 24, 2014). In accordance with Deliverable 1 that was due within the first three months of the project, the committee met on December 12, 2014 in Denver, Colorado.

Activity 2: Development of Website, Implementation Plan, and Service Provider

A website was developed for the project (https://wildfire-landslide-risk-dss.uark.edu). In accordance with Deliverable 2 (and as reported to Caesar Singh and Vasanth Ganesan on November 24, 2014), the website was posted online within the first three months of the project. The official launch of the website was at the TAC Meeting on December 12, 2014. The development of the implementation plan and service provider are underway. The "Implementation Plan, Fee Structure, and Utilization Rate" report is due within 12 moths of the project start date.

Activity 3: Development of a Ground-based Remote Sensing Device

The equipment required for the ground-based remote sensing device have been ordered. Upon arrival, the equipment will be assembled and the device will be tested. Several of the pieces of required equipment have already been received and laboratory testing, utilizing the equipment on soil samples, has already begun. The "Users Manual for Ground-based remote Sensing Devices" report is due within the first twelve months of the project. Likewise, the "Development of a Ground-based Sensing System for Collecting Data to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires" report is due within the first 12 months of the project start date.

Activity 4: Collection of Data/Creation of Databases

Based on the recommendation of Scott Anderson (FHWA) and Ty Ortiz (CODOT), and because of the close proximity to Denver, Colorado, the location of the Waldo Canyon wildfire was investigated by the PI on the Monday (December 15, 2014) following the TAC. A conference call with the members of the TAC is planned to occur during Quarter 2. This call will aid in determination of the sites that will be tested during this project. It is anticipated that the Waldo Canyon area will be one of the sites.

All of the papers containing data that have been used to develop the USGS probabilistic model have been acquired and placed into a spreadsheet. These data will serve as the preliminary data for the database of remotely sensed properties. The actual "Database of Remotely Sensed Properties" will be demonstrated and reported with 18 and 21 months, from the project start date, respectively.

Activity 5: Development of a Probabilistic Model Decision Support System

Based on the discussions of the TAC during the TAC meeting, the creation of a landslide probabilistic model for the RECOVER decision support system is much needed. The model is anticipated to mimic the model created by the USGS but will be based on remotely sensed data instead of or in addition to pointwise data. As previously mentioned, a conference call with the members of the Technical Advisory Committee is planned to occur during Quarter 2. This call will aid in finalizing the structure of the probabilistic model. "The Development of a Remote Sensing Based Decision Support System to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires" demonstration and report are due within 19 to 24 months from the project start date, respectively.

Activity 6: Development of a Probabilistic Model Decision Support System

This quarterly report is the first in a series of quarterly reports. A synopsis of the discussions of the TAC, and the results from the obtained data are reported herein. As more data become available, the results will be rapidly disseminated utilizing the website. "The Remote Sensing Assessment System for Evaluating Risk to Transportation Infrastructure Following Wildfires" report is due within 24 months from the project start date, respectively.

Problems Encountered

The cost for the modifications to the Gamma Remote Sensing device were quoted in currency of the Swiss Franc. With the volatility of the Swiss Franc value, the cost of the device may fluctuate from the initial cost estimate.

Future Plans

Although no milestones are required to be accomplished during the next quarter, the equipment that is required for the ground-based remote sensing device will continue to be purchased and assembled upon delivery. During assembly, the equipment will also be tested in the laboratory to ensure proper function. Interesting findings in the collected data will be reported.

6. SECTION II — BUSINESS STATUS

As shown in Table 1, the amount of time that was allocated for the project and the amount of time that was expended on the project are documented. Although time has been expended, the cost associated with the hours has not been charged; the academic year cost for the PI will be charged to the project during the Spring term of the 2014-2015 school year. The summer cost will be charged to the project during the Summer of 2015. The number of expended hours that are reported in Table 1 were associated with time spent: in weekly meetings (PI and the GRA); in bi-weekly meetings (PI, the GRA, the Co-PI, and the Co-PI's GRA); in the technical advisory committee meeting (including travel time); developing and maintaining the website; ordering equipment; collecting data with the new equipment; collecting data related to the probabilistic model; preparing the quarterly report.

The GRA only expended 80 hours (instead of 200 hours) on the ground-based device because several of the parts for the ground based device have still not arrived. The 80 hours that were expended were spent collecting soil spectra using the ASD Field Spec 4. The remaining 120 hours will be expended in Quarter 2. A UGRA was not selected to begin work on the project until January 1, 2015. Therefore, the allocated hours were not expended. It is anticipated that the allocated hours for Quarter 1 will be expended in Quarter 2.

Table 1. Hours allocated and expended.

Quarter 1	USDOT Allocated (Hours)	UofA Allocated (Hours)	USDOT Expended (Hours)	UofA Expended (Hours)
PI - TAC Meeting	16	16	16	16
PI -Website	20	10	20	10
PI – Ground Based Device	24	46	24	46
PI – Data Collection		10		10
PI –Quarterly Report		10		10
GRA - TAC Meeting	20	20	20	20
GRA - Website	30		30	
GRA – Ground Based Device	200		80	
GRA – Data Collection	30		30	
GRA - Quarterly Report	40		10	
UGRA - TAC Meeting	20		0	
UGRA - Website	80		0	
UGRA – Ground Based Device	20		0	
Admin - Website	21.7		21.7	

Based on the number of hours expended, the level of effort that was expended by personnel from the University of Arkansas is 100.0 percent for the PI, 53.1 percent for the GRA, 0.0 percent for the UGRA, and 100 percent for the Admin.

As shown in Table 2, the amount of funds that were allocated for the project and the amount of funds that were expended on the project are documented. Several of the funds that were allocated for equipment during Quarter 1 were not expended because the equipment has not yet been delivered. Likewise, Michigan Technological University has not yet invoiced the University of Arkansas, so these funds have not been expended. It is anticipated that these non-expended funds will be expended during Quarter 2.

Table 2. Funds allocated and expended for Year 1.

Quarter 1	USDOT Allocated Year 1 ($)	UofA Allocated Year 1 ($)	USDOT Expended ($)	UofA Expended ($)
Salaries	67,410.00	15,126.00	5,318.25	0.00
Fringes	2,470.00	3,872.00	196.78	0.00
Supplies	6,750.00	3,825.00	729.01	0.00
Travel	3,250.00	0.00	0.00	2,058.65
Other	0.00	75,000.00	0.00	0.00
Indirect	21,400.00	0.00	0.00	0.00
Tuition	0.00	8,148.00	0.00	0.00
Subcontract	54,788.00	0.00	0.00	0.00
Subcontract Indirect	25,000.00	0.00	0.00	0.00
Equipment	278,635.00	114,051.00	82,220.05	8,104.19

7. ADVISORY/STEERING COMMITTEE MEETING

The first of two in-person meetings that are scheduled for the TAC was held at the CDOT office in Denver, Colorado, on Friday, December 12, 2014. The agenda for the meeting, and the Microsoft Powerpoint® slides that were presented in the meeting are enclosed herein (on Pages 9 to 31). There was constructive discussion by the members of the TAC and the project team during the discussion portions of the meeting. Notes collected, during these discussions, are presented below.

Project Overview Discussion

Ty Ortiz, from the CDOT, discussed the corridor-based approach that is currently utilized by the CDOT. He was interested in how the proposed system would be implemented (as a corridor approach or as a site specific approach). He mentioned the rockfall hazard system that was developed by the FHWA and that is currently in use in Colorado.

The rainfall intensity threshold that is utilized by the USGS for regions that were subjected to wildfire was also discussed. This intensity threshold varies based on the region. Jason Kean, from the USGS, provided clarification that the decision makers (who makes the decision to close the road following a wildfire) are not the BAER (United States Forest Service) team members. Instead, these scientific teams are utilized to collect data to aid the decision makers in determining when the roadway needs to close. Typically, the decision is reactionary to facilitate incident management.

Scott Anderson, from the FHWA, provided/facilitated discussion on the normality basis of wildfires. Have citizens been lulled into not worrying about wildfires because of the high frequency and low hazard that has been experienced with other wildfires? Furthermore, are agencies not disseminating risk information, becasue they are afraid of being sued for information that was disseminated? Scott used the example of the Waldo Canyon fire near Manitou Springs, Colorado. The fire happened two years ago but a larger flooding event occurred last year because the fire denuded the slopes. This forced significant infrastructure to be constructed that may not be required because the slopes will eventually return to the pre-fire condition that will prevent the large flood event that necessitated the need for the infrastructure.

The main take-away from the project overview discussion was the need to monitor slopes immediately after the fire and as a function of time to determine the rainfall intensity threshold that will lead to a landslide/flood.

Discussion of Activity 2

Bill Shaw, from the ITD, requested that the “Deliverables” and “Activities” pages on the website be activated so that a user will be able to click on a deliverable and see the report or the demonstration.

Discussion of Activities 3 and 4

Scott Anderson (FHWA) was unsure of the end goal of the project. Discussion surrounded two options. Option 1 was to 1) examine the difference between utilizing the existing models (pointwise data) and new models that include remotely sensed data, 2) update existing models with remote sensing data, and 3) to investigate the difference between the results obtained from satellite-based remotely-sensed data and ground-based remotely-sensed data. Option 2 was to determine how the soil structure will return to the pre-fire condition as a function of time.

The main design parameter that the TAC was interested in was risk. How does the risk change as a function of time after the wildfire? The comment was also made that rockfall is not usually an issue with wildfires. Instead, when the natural slope fails following a wildfire, the rocks that are retained within or by the natural slope become mobilized.

The other issue that was discussed is that the wrong decision makers are usually notified when infrastructure improvements are designed to withstand a certain level of risk. Scott Anderson and Ty Ortiz (CDOT) both indicated that coordinating with other agencies and maintenance personnel is critical and of need when designing the infrastructure improvements.

Discussion of Activity 5

Scott Anderson (FHWA) mentioned the use of a "Risk Cube" to investigate the snowball effect that commonly causes remedial measures to be over designed. Scott also mentioned that other parameters (as defined in MAP-21, instead of designing based on strength alone) should be considered. Specifically safety, reliability, mobility and environmental stability should be considered.

The main discussion from Scott, Ty, and Jason focused on the idea of the consequence of a landslide event instead of the probability of a landslide. Thereby, the hazard should be considered. On Wednesday, December 17, 2014, Scott followed up the discussion from Friday, December 12, 2014, with a presentation that was recently presented by Scott about geotechnical risk.

Bill mentioned that the dissemination of the technology through the RECOVER platform is of vital importance to the project. Bill stated that he has been involved with three to four rounds of the remote sensing program and several of the projects did not achieve the outlined goals/did not provide value because the technology was not able to be disseminated.

TENTATIVE AGENDA

Meeting of the Technical Advisory Committee
December 12, 2014

Project Title: Remote Sensing Based Assessment for Evaluating Risk to Transportation Infrastructure Following Wildfires

Project Sponsor: United States Department of Transportation Office of the Assistant Secretary for Research and Technology (USDOT/OST-R)

Location: Turnpike Conference Room
Colorado Department of Transportation Headquarters
4670 Holly St. Unit A, Denver, CO 80216

0800 – 0830	Badge Pickup and Breakfast
0830 – 0845	Welcome and Introductions
0845 – 0900	Project Overview – Richard Coffman
0900 – 0920	Discussion of Project Overview
0920 – 0930	Detailed Overview of Activity 2 – Richard Coffman/Sean Salazar
0930 – 0950	Discussion of Activity 2
0950 – 1000	Break
1000 – 1020	Detailed Overview of Activity 3 – Richard Coffman
1020 – 1030	Discussion of Activity 3
1030 – 1040	Detailed Overview of Activity 4 – Richard Coffman
1040 – 1050	Discussion of Activity 4
1050 – 1120	Detailed Overview of Activity 5 – Thomas Oommen
1120 – 1150	Detailed Overview of the RECOVER DSS – Keith Weber
1150 – 1210	Discussion of Activity 5 and the RECOVER DSS
1210 – 1220	Break
1220 – 1300	Working Lunch (Discussion and Summarization of Salient Points)

Project Website: https://wildfire-landslide-risk-dss.uark.edu/

Conference Dial-in Number: (605) 475-4700
Participant Access Code: 659010#

Technical Advisory Committee Members

Jason Kean
Chief, Post Wildfire Debris Flow
U.S. Geological Survey
Geologic Hazards Science Center
Box 25046, DFC
Mail Stop 966
Denver, CO 80225
303-272-8608
jwkean@usgs.gov

Scott Anderson
Geotechnical Technical Service Team Manager
U.S. Department of Transportation Federal Highway Administration
12300 West Dakota Avenue, Suite 340
Lakewood, CO 80228
720-963-3244
scott.anderson@dot.gov

Ty Ortiz
Geotechnical Engineer
Colorado Department of Transportation
4670 Holly Street
Denver, CO 80216
303-398-6601
ty.ortiz@state.co.us

Bill Shaw
Planning and Public Involvement Supervisor
Idaho Transportation Department
206 N. Yellowstone Ave.
P.O. Box 97
Rigby, ID 83442
208-745-7781
bill.shaw@itd.idaho.gov

Herby Lissade
Chief, Office of Emergency Management
California Department of Transportation
1120 N Street
Sacramento, California 95814
916-417-6994
herby.lissade@dot.ca.gov

December 12, 2014 Meeting Participants

Scott Anderson, USDOT Federal Highway Administration (TAC Member)

Richard Coffman, University of Arkansas (PI)

Vasanth Ganesan, USDOT/OST-R (University Grants Programs) [via phone, if available]

Rene Garcia, CalTRANS (on behalf of Herby Lissade, TAC Member) [via phone]

Jason Kean, United States Geological Survey (TAC Member)

Thomas Oommen, Michigan Technological University (Co-PI)

Ty Ortiz, Colorado Department of Transportation (TAC Member)

Sean Salazar, University of Arkansas (Graduate Student)

Bill Shaw, Idaho Transportation Department (TAC Member)

Caesar Singh, USDOT/OST-R (Director, University Grants Programs) [via phone, if available]

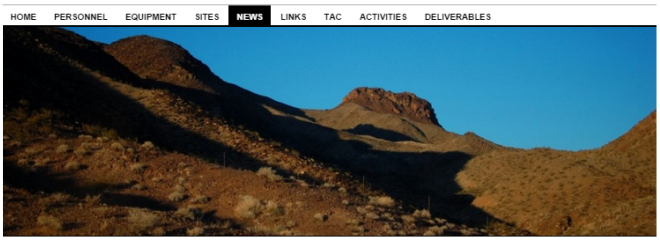
Keith Weber, Idaho State University (Team Member)

Project Website

- Walkthrough: https://wildfire-landslide-risk-dss.uark.edu
- Contains content of interest to stakeholders, including links to progress reports, updates, pictures and other deliverables.

Remote Sensing for Evaluating Hazard Following Wildfires

HOME PERSONNEL EQUIPMENT SITES **NEWS** LINKS TAC ACTIVITIES DELIVERABLES



News

Civil Engineering magazine, December 2014:

Device Could Detect Probability of Postwildfire Landslides

University of Arkansas Newswire headlines, October 22, 2014:

Grant Will Help Researchers Develop System to Assess Risk of Mudslides, Rock Falls

United Nations Platform for Space-based Information for Disaster Management and Emergency Response, October 22, 2014:

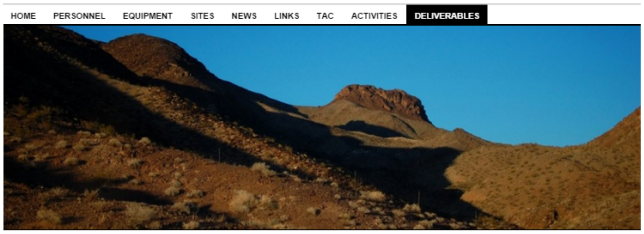
University of Arkansas: Developing a decision support system for mudslide risk

REMOTE SENSING FOR GEOTECHNICAL APPLICATIONS

University of Arkansas, 4190 Bell Engineering Center, Fayetteville, AR 72701. Contact details- Phone: 479-575-8767, Fax: 479-575-7168, Email: rick@uark.edu.

Remote Sensing for Evaluating Hazard Following Wildfires

HOME PERSONNEL EQUIPMENT SITES NEWS LINKS TAC ACTIVITIES **DELIVERABLES**



Deliverables

1. "Development of TAC." Report. Due within 3 months of project start date.
2. "Development and Maintenance of Website" Website posted online within the first 3 months of the project and then maintained indefinitely.
3. "Quarterly Reports." Reports. Due at 3 month intervals after the project start date.
4. "Ground-based Remote Sensing Device." Demonstration. Due within 9 months of project start date.
5. "Implementation Plan, Fee Structure, and Utilization Rate." Report. Due within 12 months of the project start date.
6. "Users Manual for Ground-based Remote Sensing Device." Report. Due within 12 months of project start date.
7. "The Development of a Ground-based Remote Sensing System for Collecting Data to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires." Report. Due within 12 months of the project start date.
8. "Database of Remotely Sensed Soil Properties." Demonstration and report. Due within 18 months and 21 months from the project start date, respectively.
9. "The Development of a Remote Sensing Based Decision Support System to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires" Demonstration and Report. Due within 18 months and 24 months, respectively, from the project start date.
10. "Remote Sensing Assessment System for Evaluating Risk to Transportation Infrastructure Following Wildfires." Due within 24 months from the project start date.

REMOTE SENSING FOR GEOTECHNICAL APPLICATIONS

University of Arkansas, 4190 Bell Engineering Center, Fayetteville, AR 72701. Contact details- Phone: 479-575-8767, Fax: 479-575-7168, Email: rick@uark.edu.

Disclaimer: The views, opinions, findings, and conclusions reflected on this page are the responsibility of the authors only and do not represent the official policy or position of the USDOT/OST-R, or any state or other entity.

Proudly powered by WordPress. Theme: Coraline by WordPress.com.

Activity 3

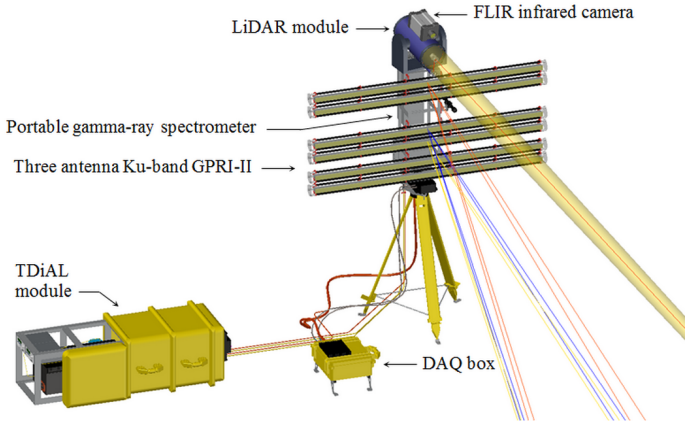
Richard A. Coffman

Disclaimer

The views, opinions, findings, and conclusions reflected in this presentation are the responsibility of the authors only and do not represent the official policy or position of the USDOT/OST-R, or any state or other entity.

Overview of Activity 3

Ku-Band RADAR
Differential Absorption LIDAR
Gamma-ray Detector
Theory
Preliminary Results



Parameters of Interest

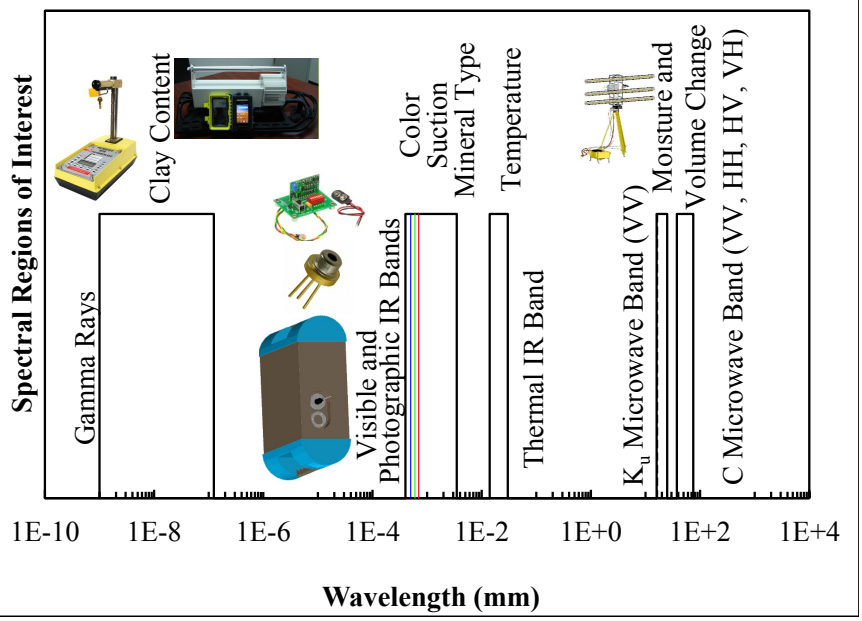
$P = e^x / (1 + e^x)$

$x = -5.22 + (0.003 \times ElevRange) + (0.008 \times HM50_{pct}) + (0.024 \times bslp_{pct}) + (-0.007 \times CC_{pct}) + (0.105 \times i30)$

Where

- ElevRange - is the range (maximum elevation–minimum elevation) of elevation values upstream of the point (in meters),
- $HM50_{pct}$ - is the percentage of the upstream watershed that was burned at high or moderate severity and has slope values in excess of 50 percent (in percent),
- $bslp_{pct}$ - is the average gradient of the burned pixels upslope of the point (in percent),
- CC_{pct} - is the average clay content of the soils in the basin (in percent) (Schwartz and Alexander, 1995), and
- i30 - is the spatially averaged upslope 30-min rainfall intensity for the design storm (in millimeters per hour [mm/h]).

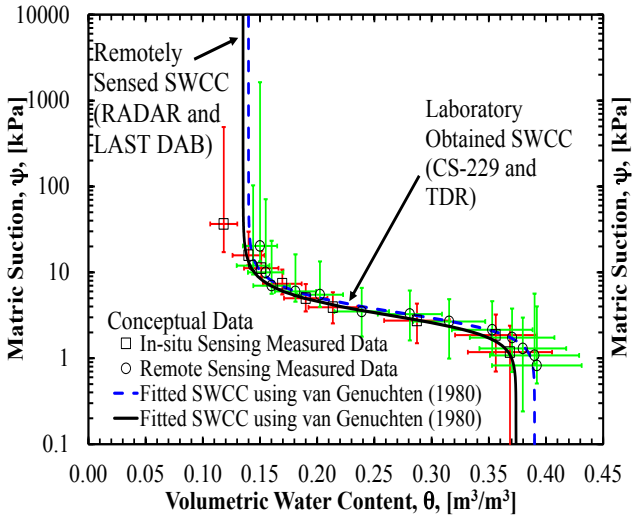
Remote Sensing Methods for Unsaturated Soils

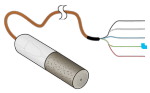


Soil Water Characteristic Curve (SWCC)

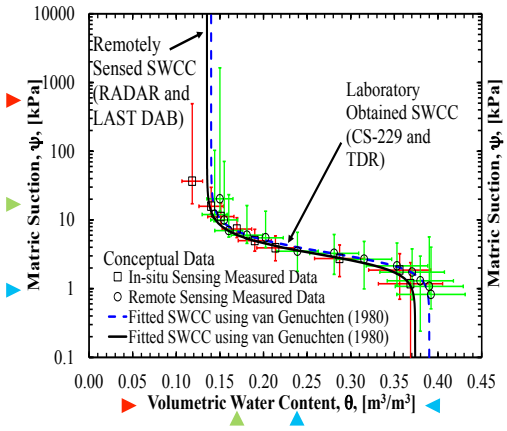
Relationship Between:

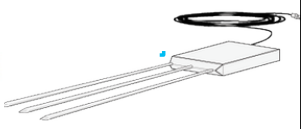
Volumetric Water Content (θ)
Soil Suction (ψ)





SWCC and Remote Sensing





Images from Campbell Scientific (2014), Soil Moisture (2013), APSWT (2014), Thorlabs (2014), AEC (2014)

SWCC

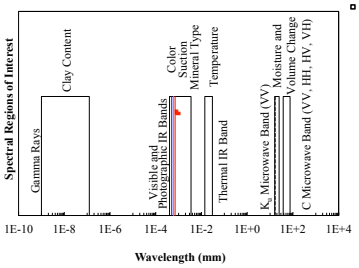
Soil Suction

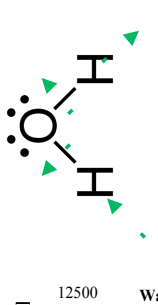
$$\Psi_T = \Psi_p + \Psi_z + \Psi_o + \Psi_m \quad \text{Eqn. 1}$$

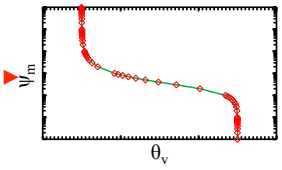
$$\Psi_T = \frac{RT}{V_w} \ln\left(\frac{\rho_{H_2O}}{\rho_{sat}}\right) \quad \text{Eqn. 2}$$

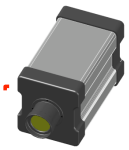
In Equations 1 and 2, Ψ_T is the total soil water potential, Ψ_p is the pressure head, Ψ_z is the elevation head, Ψ_o is the osmotic head, Ψ_m is the matric potential, R is the ideal gas constant, T is the temperature (˚K), V_w is the partial molar volume of liquid water, ρ_{H20} is the partial pressure of water vapor, and ρ_{sat} is the saturation partial pressure for water vapor under ambient temperature and pressure.

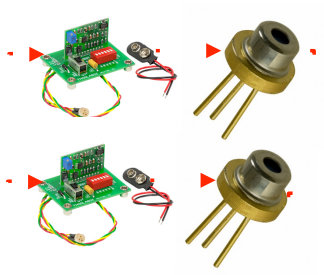
Development of LAST Device

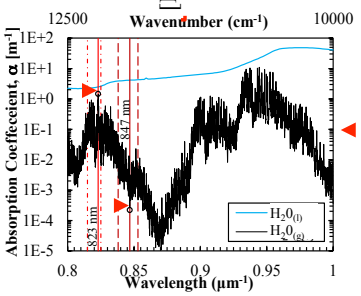


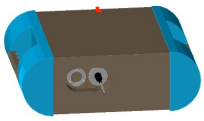








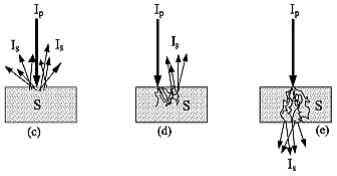




DRIFTS

Diffuse Reflectance Infrared Fourier-Transform Spectroscopy

1) Optical Penetration Depth
2) Use of Kubelka-Munk Color Theory to Model Behavior
3) Test Optically Opaque Materials (Soils)
4) Qualitative Analysis



$$1 = R + A + T \quad \text{Eqn. 3}$$

In Equation 3, R is relative reflection, A is the relative absorption, and T is the relative transmission.

Kubelka-Munk Color Theory

Assumptions

1) Isotropic Light Source
2) Substrate Perfectly Reflective or Perfectly Absorptive
3) Two Way Optical Flux
4) Perfectly Diffuse Reflection

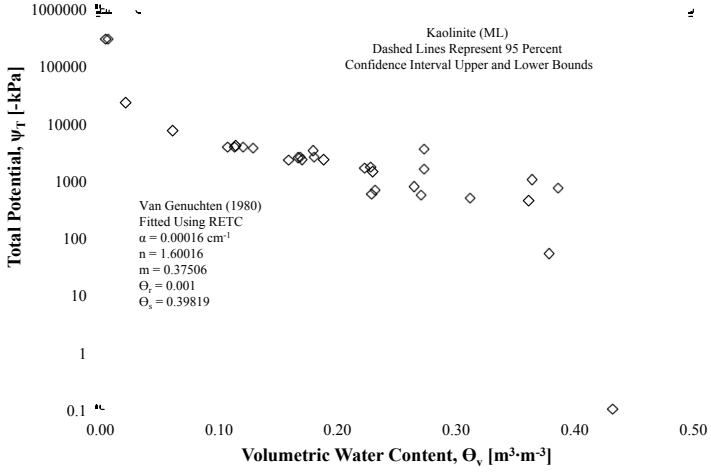
$$A_\infty = Log_{10}\left(\frac{1}{R_\infty}\right) \quad \text{Eqn. 4}$$

$$f(R_\infty) = \frac{k}{s} = \frac{(1-R_\infty)^2}{2R_\infty} \quad \text{Eqn. 5}$$

$$\frac{k}{s} = \sum_{i=1}^{n} \frac{k_i m_i}{s_i m_i} = \frac{k_s m_s + k_w m_w + k_g m_g}{s_s m_s + s_w m_w + s_g m_g} \quad \text{Eqn. 6}$$

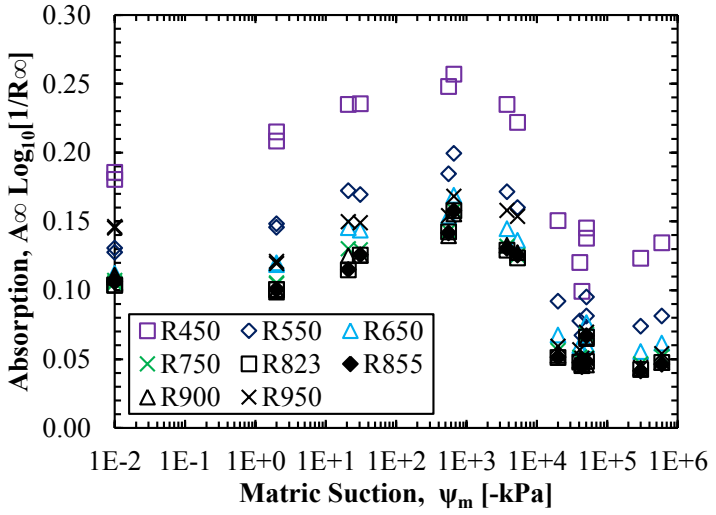
In Equations 4 to 6, $f(R_\infty)$ is the Kubekla-Munk function, k is the absorption coefficient, s is the scattering coefficient, R_∞ is the infinite depth reflectance, m is the mass fraction, and the i subscript indicates a component value.

Preliminary Results: LAST



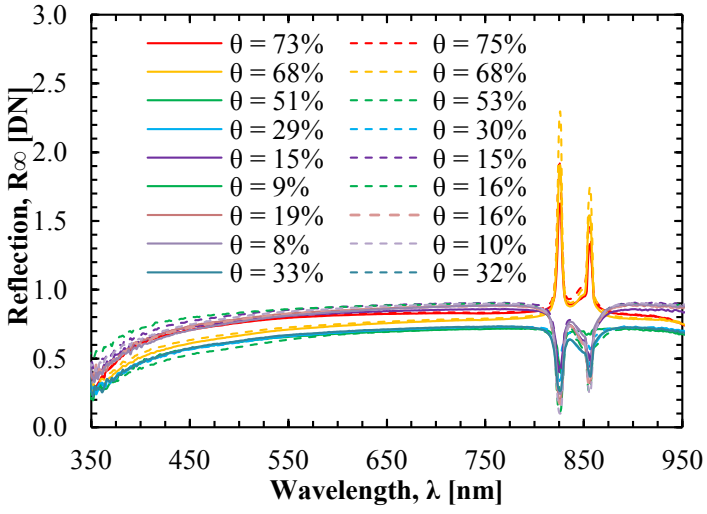
Preliminary Results: LAST

Soil Suction



Preliminary Results: LAST

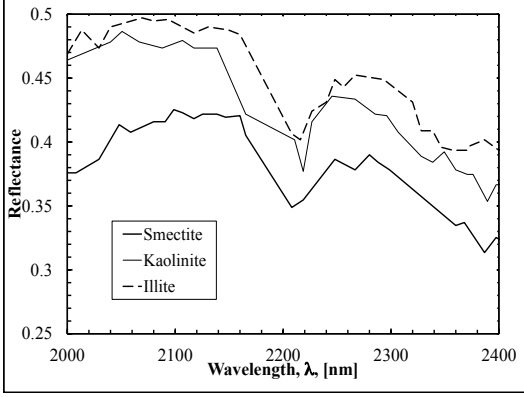
Atterberg Limits

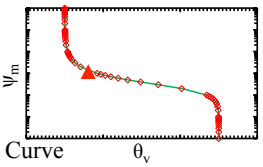


Clay Content from Nuclear Decay/Gamma Ray Spectrometry, Clay Mineralogy from NIR

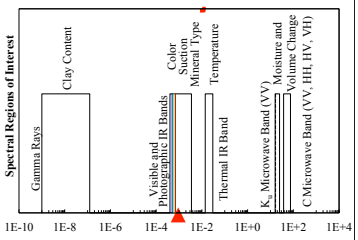
Key Work in Clay Content

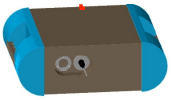
Gabriella, P. Adams, M. Smettem, K., Harper, R. (2006). "Determination of spatial distribution of clay and plant available potassium contents in surface soils at the farm scale using high resolution gamma ray spectrometry. Plant and Soil, 282, p. 67-82.





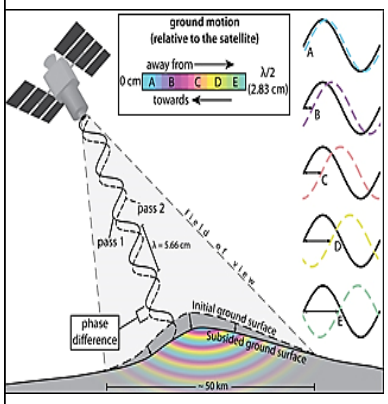
SWCC Curve Parameters (α, m, n)

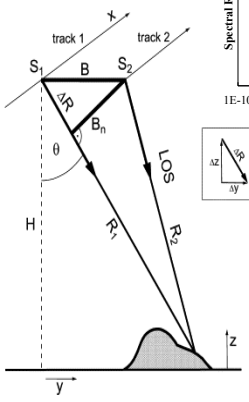


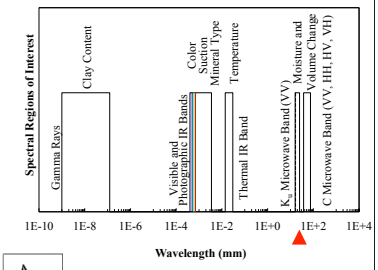


Chabrillat et al. (2002)

Remote Sensing Methods (Topography and Deformation)







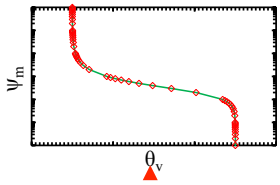
$$I = I_1 I_2^* = A_1 e^{i\phi_1} \cdot A_2 e^{-i\phi_2} = A_1 A_2 \cdot e^{i(\phi_1 - \phi_2)} = A \cdot e^{i\phi} \quad \text{Eqn. 7}$$

Images from Rott and Nagler (2006), GVP (2012)

Remote Sensing Methods (Volumetric Water Content)

$$\sigma^0(dB) = 10 * \log(\sigma^0)(m^2 m^{-2})$$ Eqn. 8

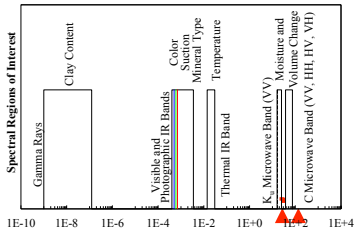
$$m_s(t) = \frac{\sigma^0(40,t) - \sigma^0_{dry}(40,t)}{\sigma^0_{wet}(40,t) - \sigma^0_{dry}(40,t)}$$ Eqn. 9

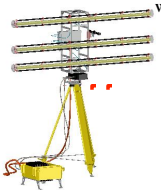


$$m_v = m_{v.o} + 0.042(\Delta\sigma^0|dB| - \Delta\sigma^0_0|dB|)$$ Eqn. 10

$$m_v = \frac{\sigma^0 - i}{8.56 - 1.56i}$$ Eqn. 11

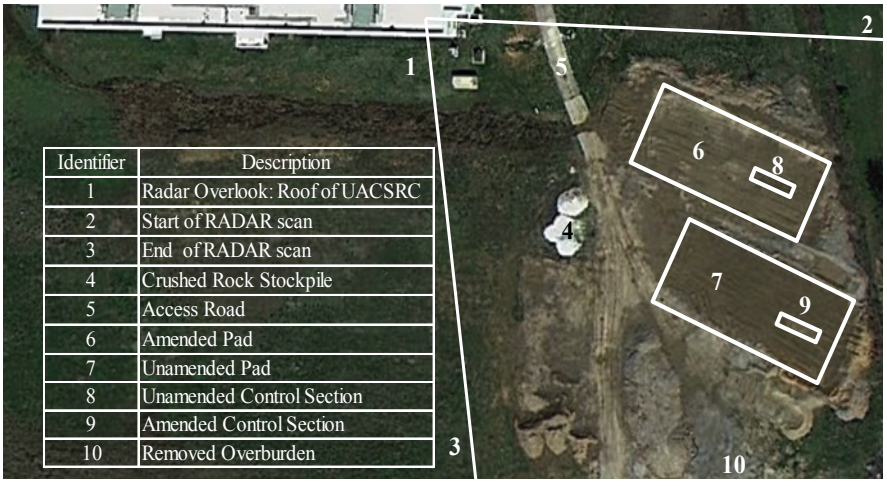
$$i = \frac{\sigma^0_0 - 8.56 m_{v.0}}{8.56 - 1.56i}$$ Eqn. 12





Preliminary Results: GPRI-2

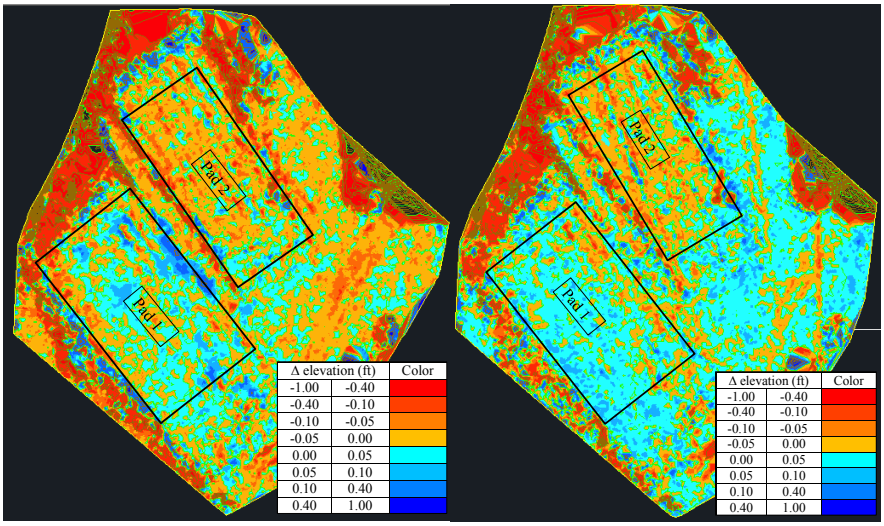
Deformation



Identifier	Description
1	Radar Overlook: Roof of UACSRC
2	Start of RADAR scan
3	End of RADAR scan
4	Crushed Rock Stockpile
5	Access Road
6	Amended Pad
7	Unamended Pad
8	Unamended Control Section
9	Amended Control Section
10	Removed Overburden

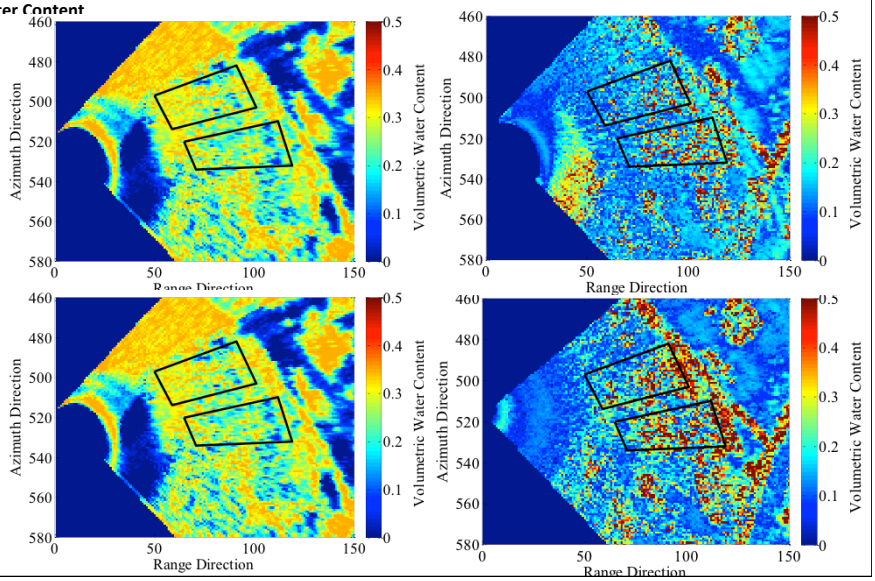
Preliminary Results: GPRI-2

Deformation



Preliminary Results: GPRI-2

Water Content



Remote Sensing Based Assessment System for Evaluating Risk to Transportation Infrastructure Following Wildfire

Thomas Oommen[1]

[1] Department of Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI.

USDOT-Office of the Assistant Secretary for Research and Technology,
Commercial Remote Sensing & Spatial Information Technologies – Phase VI
Program Manager: Caesar Singh
Cooperative Agreement #RITARS-14-H-MTU

Disclaimer |

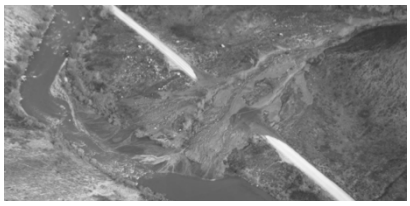
The views, opinions, findings, and conclusions reflected in this presentation are the responsibility of the authors only and do not represent the official policy or position of the USDOT/OST-R, or any state or other entity. bands 3-2-1, March 2, 2014

2

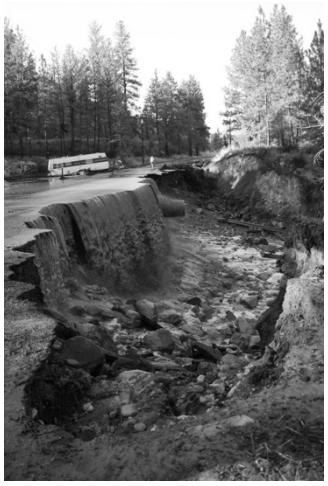
Motivation |

Post-wildfire responses that could impact transportation infrastructure

Rockfall, Estacada fire: Oregon Department of Transportation



Debris flow, Elk fire: Idaho Department of Transportation



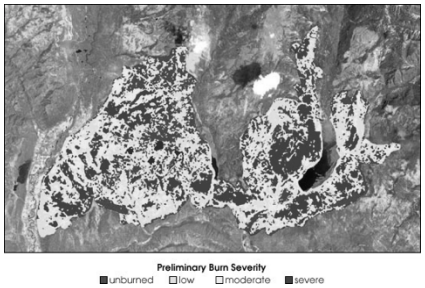
Flash flood & washout, Carlton complex fire: Washington Department of Transportation

3

Motivation |

Significant progress in quantifying post-wildfire responses

- Scientific understanding of the process
- Advancement in burn severity mapping using remote sensing
- Development of empirical models
  - Probability of debris flow
  - Flow volume
  - Inundation areas
  - Rockfall hazard rating system



Source: NASA

4

Goal |

Goal-1: Build on the scientific advancement and develop a probability based decision support system for highway managers that quantifies the risk from post-wildfire responses to transportation infrastructure

Goal-2: Evaluate the applicability of UAV based platform to obtain high spatial and temporal inputs for hazard evaluation

5

Methodology |

USGS models

6

Input Parameters |

Inputs

7

Input Parameters |

Improving inputs using UAV

8

Database |

Model development

9

Model Validation |

Model

10

Risk to Transportation Infrastructure |

Risk evaluation

Risk Model Visualization |

Integration of risk model with RECOVER

Outreach |

Develop outreach video

Remote Sensing for Evaluating Hazard Following Wildfires

Home

Welcome to ***Remote Sensing for Evaluating Hazard Following Wildfires***. Please find information regarding this project under each of the tabs above.

This project is made possible by the United States Department of Transportation and the following entities: University of Arkansas, Michigan Technological University, and Idaho State University. The cost sharing structure is as follows: United States Department of Transportation: $571,901, University of Arkansas: $434,990, Michigan Technological University: $116,864, Idaho State University: $20,052.

UNIVERSITY OF ARKANSAS

Michigan Tech

Idaho State UNIVERSITY

www.wildfire-landslide-risk-dss.uark.edu/

Michigan Tech

USDOT-Office of the Assistant Secretary for Research and Technology,
Commercial Remote Sensing & Spatial Information Technologies – Phase VI
Program Manager: Caesar Singh
Cooperative Agreement #RITARS-14-H-MTU

8. CONFERENCE PRESENTATIONS/PUBLICATIONS DETAILS BY PROJECT TEAM MEMBER IN UPCOMING QUARTER

No conference presentations or publications are anticipated in the upcoming quarter. However, Sean Salazar (the PhD student from the UofA) that is working on the project is scheduled to present to the UofA Graduate Seminar Series on March 5, 2015.

Although outside of the upcoming quarter, the personnel associated with the project plan on preparing papers and conference presentations for the 95th Annual Meeting of the TRB that will be held in Washington, DC from January 10-14, 2016. The full papers for the conference are due on August 1, 2015.

Furthermore, personnel from the University of Arkansas have contacted the research office at the AHTD and anticipate presenting the results of this project at the Spring 2016 AHTD TRC conference.

9. APPENDIX FOR QUARTER

A copy of the executed subcontract between the UofA and the MTU is included herein. Although ISU will not be involved in the project until Year 2, the subcontract documentation is being prepared at this time to ensure a smooth transition between Year 1 and Year 2. Although the subcontract with Idaho State University has not yet been executed, a copy of the working document is included herein for completeness.

A copy of the receipts for equipment that was ordered/purchased during the quarter are also included herein. These receipts are included for equipment from the following manufacturers: ASD Inc., Data Physics, Gamma Remote Sensing, and Pico Envirotec.

- The ASD Inc., device was delivered on December 1, 2014.
- The Data Physics devices were delivered on December 5, 2014.
- The University of Arkansas Gamma Remote Sensing Portable Radar Interferometer Version II device was sent back to Switzerland on November 13, 2014, for upgrades. Based on correspondence with Gamma Remote Sensing, the modified device should be sent back to the University of Arkansas in early February.
- The Purchase Order for the PicoEnvirotec device was submitted to the company on October 24, 2014. Based on correspondence with PicoEnvirotec, the device is expected to be delivered in early February.

Data Physics Corporation

Invoice

Date	Invoice #
11/21/2014	14US4966

1741 Technology Drive
Suite 260
San Jose CA 95110
United States
(408) 437 0100

2592494

Bill To

Accounts Payable Division
University of Arkansas
321 Administration Bldg
Fayetteville AR 72701
United States

Ship To

Rick Coffman
University of Arkansas
4190 Bell Engineering Center
800 W Dickson Street
Fayetteville AR 72701
United States

Terms	PO #	Ship Via	Ship Date
Net 30	816769	UPS Ground ...	11/20/2014

Item	Back Ord.	QTY	Description	Unit Price	Amount	System #
			4 Channel Quattro / SignalCalc ACE Dynamic Signal Analyzer			
DP240-4C2S	0	2	Quattro DSPcentric Signal Processing Hardware, four 24 bit Inputs, two 24 bit Outputs, 40 kHz analysis bandwidth	8,550.00	17,100.00	21975-6
			Software to be provided through the Data Physics University Program			
			Data Physics University Program:			
			The Data Physics University Software Grant program is designed to provide access to SignalStar and SignalCalc software at no cost to Universities. The University is only required to purchase Data Physics Quattro or Abacus hardware.			
			The software will be provided as an annual grant, licensed one year at a time. In exchange for the software grant, the University will agree to joint publications with Data Physics of Application Notes and/or Technical Papers based on the work at the University with relevance to the application of Data Physics products.			
			As long as the hardware is still in use at the University the license will be renewed free of charge.			

RVCD 1DEC14 12:33

BUSINESS AFFAIRS

Data Physics Corporation

Invoice

Date	Invoice #
11/21/2014	14US4966

1741 Technology Drive
Suite 260
San Jose CA 95110
United States
(408) 437 0100

Item	Back Ord.	QTY	Description	Unit Price	Amount	System #
			Based on the hardware system purchased, the software offered under this program will consist of three separate bundles: a) The "SignalCalc ACE University Bundle" consisting of all DP240 software only options. b) The "SignalCalc Mobilyzer University Bundle" consisting of all DP730 software only options. c) The "SignalStar Vector University Bundle" consisting of all DP760 software only options. To qualify for this program, the University must complete the one page "DP University Program Annual Software License Registration Form".			
DP240-00	0	2	Quattro Demo Software	0.00	0.00	

These commodities, technology or software are subject to the US Export Administration Regulations. Export, re-export or diversion contrary to U.S. law prohibited.

Subtotal	17,100.00
Shipping Cost (UPS Ground Collect)	0.00
Total	$17,100.00

ASD Inc.
IS NOW PANalytical
www.asdi.com

REMIT TO: PANalytical Boulder
2555 55th Street, Suite 100
Boulder, CO 80301 USA
Phone: (303) 444-6522
Fax: (303) 444-6825
TIN: 84-1135368
DUNS: 610607723

2591871

Invoice: 13092

INVOICE

Page: 1 of 5
Date: 11/19/2014

Sold To:
University of Arkansas
Accounts Payable
321 Administration Bldg.
Fayetteville AR 72701
United States

Ship To:
Richard A. Coffman
University of Arkansas
Bell Engineering Center
800 W. Dickson Street, Room 4190
Fayetteville AR 72701
United States

Fax: 479-575-2846 EMail:

PO Number: 815994 Terms: NET 30 Incoterm: CIP
Sales Rep: Jason Peoples Ordered: 11/12/2014 Ship Via: UPS
Packing Slip: 13200 Sales Tax ID: Ship Date: 11/19/2014

US Dollar

Legal Number: 13092

Line	Part Number/Description	Revision	Quantity	Unit Price	Ext Price
1	FS4H-J-2-D-1-L-0	A	1.00 EA	68,061.0000 /1	68,061.00
	FieldSpec 4 Hi-Res Spectroradiometer, 350-2500nm, Ruggediz		*PO Number:* 815994		
			Sales Order: 5002902		
				Disc %	2,111.00
				Warehouse Code: MAIN	
	Our Part: FS4H-J-2-D-1-L-0				
	Warranty: Standard 1 Year				
	Material Duration 1 YEARS / Duration 1YEARS / Misc Duration 1YEARS				
	SerialNumber 18304				
2	S701500		1.00 EA	475.0000 /1	475.00
	RadCal 25 Degree Full-range Bare Fiber Optic		*PO Number:* 815994		
			Sales Order: 5002902		
				Disc %	15.00
				Warehouse Code: MAIN	
	Our Part: S701500				
3	A119250	B	1.00 EA	944.0000 /1	944.00
	Fore Optic Lens, 1 Degree Field-of-view, NIR or Full-range		*PO Number:* 815994		
			Sales Order: 5002902		
				Disc %	30.00
				Warehouse Code: MAIN	
	Our Part: A119250				

RUCD 24NOV'14PM3:34
BUSINESS AFFAIRS

65,950.00
460.00
914.00

ASD Inc.
IS NOW PANalytical
www.asdi.com

REMIT TO: PANalytical Boulder
2555 55th Street, Suite 100
Boulder, CO 80301 USA
Phone: (303) 444-6522
Fax: (303) 444-6825
TIN: 84-1135368
DUNS: 610607723

Invoice: 13092

INVOICE

Date: 11/19/2014

Legal Number: 13092

Line	Part Number/Description	Revision	Quantity	Unit Price	Ext Price
4	S701510 RadCal 1 Degree Full-range Field-of-view Lens		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	475.0000 /1	475.00
	Our Part: S701510		*Disc %* *Warehouse Code:* MAIN	15.00	460,00
5	A120500 Fore Optic Lens, 8 Degree Field-of-view, NIR Full-range	C	1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	944.0000 /1	944.00
	Our Part: A120500		*Disc %* *Warehouse Code:* MAIN	30.00	914,00
6	S701570 RadCal 8 Degree Full-range Field-of-view Lens		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	475.0000 /1	475.00
	Our Part: S701570		*Disc %* *Warehouse Code:* MAIN	15.00	460,00
7	128170 Spectralon, 10X10-inch, Calibrated, 99% Reflective		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	1,572.0000 /1	1,572.00
	Our Part: 128170		*Disc %* *Warehouse Code:* MAIN	49.00	1,523,00
8	128311 Wooden Case for 10X10-inch Spectralon		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	548.0000 /1	548.00
	Our Part: 128311		*Disc %* *Warehouse Code:* MAIN	17.00	531,00
9	A124505 Remote Cosine Receptor, Full-sky	A	1.00 EA *PO Number:* 815994 *Sales Order:* 5002902	900.0000 /1	900.00
	Our Part: A124505		*Disc %* *Warehouse Code:* MAIN	28.00	872,00

ASD Inc.
IS NOW PANalytical
www.asdi.com

REMIT TO: PANalytical Boulder
2555 55th Street, Suite 100
Boulder, CO 80301 USA
Phone: (303) 444-6522
Fax: (303) 444-6825
TIN: 84-1135368
DUNS: 610607723

Invoice: 13092

INVOICE

Date: 11/19/2014

Legal Number: 13092

Line	Part Number/Description	Revision	Quantity	Unit Price	Ext Price
10	S701550 RadCal Remote Cosine Receptor		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	475.0000 /1 Disc % 15.00	475.00 400.00
	Our Part: S701550				
11	A128950 Illuminator- 70W 3100K LIGHT SOURCE	C	1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	874.0000 /1 Disc % 28.00	874.00 846.01
	Our Part: A128950				
12	126550 Replacement Bulb, Illuminator; Halogen 12V		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	26.0000 /1 Disc % 1.00	26.00 25.00
	Our Part: 126550				
13	128780 Tripod, Medium-Duty, All-Purpose		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	50.0000 /1 Disc % 2.00	50.00 48.00
	Our Part: 128780				
14	128565 Tripod, Heavy-Duty		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	341.0000 /1 Disc % 11.00	341.00 330.01
	Our Part: 128565				
15	128771 Tripod, Mini		1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 *Warehouse Code:* MAIN	35.0000 /1 Disc % 2.00	35.00 33.00
	Our Part: 128771				

ASD Inc.
IS NOW PANalytical
www.asdi.com

REMIT TO: PANalytical Boulder
2555 55th Street, Suite 100
Boulder, CO 80301 USA
Phone: (303) 444-6522
Fax: (303) 444-6825
TIN: 84-1135368
DUNS: 610607723

Invoice: 13092

INVOICE

Date: 11/19/2014

Legal Number: 13092

Line	Part Number/Description		Quantity	Unit Price	Ext Price
16	A122300 Contact Probe	B	1.00 EA	1,724.0000 /1	1,724.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	54.00
				Warehouse Code: MAIN	
	Our Part: A122300				1670,01
17	A354217 Accessory Power Cable 1.5 meter	A	1.00 EA	67.0000 /1	67.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	3.00
				Warehouse Code: MAIN	
	Our Part: A354217				64,00
18	A146541 Power Supply, 12 VDC 30 Watt	A	1.00 EA	60.0000 /1	60.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	2.00
				Warehouse Code: MAIN	
	Our Part: A146541				58,00
19	128001 Spectralon, 3.62-inch Diameter, Uncalibrated		1.00 EA	155.0000 /1	155.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	5.00
				Warehouse Code: MAIN	
	Our Part: 128001				150,00
20	A122100 Muglight	B	1.00 EA	1,789.0000 /1	1,789.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	56.00
				Warehouse Code: MAIN	
	Our Part: A122100				1733,0
21	A354217 Accessory Power Cable 1.5 meter	A	1.00 EA	67.0000 /1	67.00
			PO Number: 815994		
			Sales Order: 5002902		
				Disc %	3.00
				Warehouse Code: MAIN	
	Our Part: A354217				64,00

ASD Inc.
IS NOW PANalytical
www.asdi.com

REMIT TO: PANalytical Boulder
2555 55th Street, Suite 100
Boulder, CO 80301 USA
Phone: (303) 444-6522
Fax: (303) 444-6825
TIN: 84-1135368
DUNS: 610607723

Invoice: 13092

INVOICE

Date: 11/19/2014

Legal Number: 13092

Line	Part Number/Description	Revision	Quantity	Unit Price	Ext Price
22	A129221 Small Sample Holder	C	3.00 EA *PO Number:* 815994 *Sales Order:* 5002902 Disc % *Warehouse Code:* MAIN	158.0000 /1	474.00 15.00 459,00
	Our Part: A129221				
23	131222 Cover Insert for Small Sample Holder	A	3.00 EA *PO Number:* 815994 *Sales Order:* 5002902 Disc % *Warehouse Code:* MAIN	53.0000 /1	159.00 6.00 153,00
	Our Part: 131222				
24	A128003 Spectralon, Small White for Muglight	A	1.00 EA *PO Number:* 815994 *Sales Order:* 5002902 Disc % *Warehouse Code:* MAIN	158.0000 /1	158.00 5.00 153,00
	Our Part: A128003				
25	128008 PETRI DISH 100 X 15MM	A	3.00 EA *PO Number:* 815994 *Sales Order:* 5002902 Disc % *Warehouse Code:* MAIN	14.0000 /1	42.00 3.00 39,00
	Our Part: 128008				

Payment Schedule		
	Due Date	*Amount*
1	12/19/2014	78,369.00
	Total	78,369.00

Total: $ 78,369.00

BOK FINANCIAL SERVICES
INTERNATIONAL BANKING CENTER
ONE WILLIAMS CENTER, 15TH FLOOR
TULSA, OK 74172

2580784

INTERNATIONAL WIRE TRANSFER DEBIT

Sender
Name: UNIVERSITY OF ARKANSAS
DEL TO LOCKBOX FOR
CUSTOMER PICKUP

Reference: 141031140417H400

Beneficiary: Pleo Envirotec Inc.
222 Snidercroft Rd
Concord, Ontario, L4S 2K1
Canada

Beneficiary Bank: TORONTO-DOMINION BANK, THE
Beneficiary Account : XXXXXXX6997
Originator to Beneficiary:

University of Arkansas Fayetteville Bell Eng Ctr, Attn: Richard Coffman
Portable Gamma Ray Spectrum System, Invoice # 600630

THE FOLLOWING REPRESENTS YOUR DEBIT UNDER
OUR REFERENCE NO: 141031140417H400 ON 2014-10-31.

WE HAVE DEBITED YOUR ACCOUNT NO: XXXXXX3246
ACCOUNT TYPE: DDA

WIRE TRANSFER AMOUNT$ 6,780.00

(encrypt)

****

The company reserves the right to amend statements made herein in the event of a mistake. Unless expressly stated herein to the contrary, only agreements in writing signed by an authorized officer of the Company may be enforced against it.

****

UNIVERSITY OF ARKANSAS

The University of Arkansas is not exempt from sales /use tax except for those items specifically exempted by State law.

The laws of the State of Arkansas shall govern this Purchase Order.

Purchase Order		
Purchase Order Date	PO/Reference No.	Revision No.
Oct 24, 2014	**816064**	**0**

Contact Information

Contact	Sandra Hancock
Email	shancock@uark.edu
Phone	+1 (479) 575-6021

CVEG 2580784

Order acceptance instructions:

Complete list of terms can be seen at: http://procurement.uark.edu/terms.pdf Mark all packages and freight documents with purchase order number. Invoice must show purchase order number. The University of Arkansas is not exempt from sales/use tax except for those items specifically exempted by State law. Any change(s) to purchase order must be approved by Purchasing prior to shipment.

Supplier Information	
Supplier Name	Pico Envirotec Inc.
Address	222 Snidercroft Rd Concord, Ontario, L4K 2K1 CA
F.O.B./Freight	Destination
Supplier Payment Terms	0, Net 30

Delivery Information

Delivery Address
University of Arkansas

Attn:	Richard Coffman
Room:	4190

Bell Engineerng Center
800 W DICKSON STREET
Fayetteville, AR 72701
United States

Shipping Information

Delivery Date	Oct 19, 2014
Expedite	No
Ship Via	Best Carrier-Best Way

Notes to Supplier

Attachments for supplier

Final-Pico Sale S... (160k)

Line No.	Product Description	Catalog No.	Size / Packaging	Unit Price	Quantity	Ext. Price
1 of 1	Portable Gamma Ray Spectrometer System *controlled by Android based device, integrated GPS navigation and positioning system*	PGIS-2-128	1/EA	33,900.00 *USD*	1 EA	33,900.00 *USD*

ADDITIONAL INFO

Catalog No.	PGIS-2-128
Unit Price	33,900.00
Taxable	Yes
Capital Expense	No
Commodity Code	41100000

	Laboratory and scientific equipment	1	

Invoices must be submitted to the Billing Address indicated below to assure timely payment.

Subtotal	33,900.00
Tax1	3,305.25
Shipping	0.00
Handling	0.00
Total	37,205.25 USD

Billing Information	Billing Address
To avoid payment delays, invoice must include the PO referenced above Contract *no value* Quote number	University of Arkansas University of Arkansas Accounts Payable 321 Administration Bldg Fayetteville, AR 72701 United States

Wire $6,780.00 U.S. Dollars V. Necessary
10/31/14

No JE Required

0132-12501-23-0000

80574300 Equipment

Wire Transfer Details Form

In order to process a wire transfer:

For procurement: A check with order requisition must be entered into the BASIS Accounting system.

For travel: Departments must create a TRPO against a valid TA in the BASIS Accounting System.

Please note: A $15 fee applies for domestic wire transfer and a $35 wire transfer fee will apply for international wire transfers. In the event that foreign currency is requested, the transfer is subject to the current exchange rate at our bank.

Important: The vendor name on the PO/TRPO must match the account holder's name and address.

The following information is also required to complete the transfer.

Requisition/PO Number or TA Number _____*PO: 816064*_____

Name of Bank Receiving Transfer:

_____The TD Canada Trust _____

Bank's Address:

___York Region Commercial Banking Centre, _____

___220 Commerce Valley Drive East, Markham, Ontario, Canada, L3T 0A8_____

Name of Account Holder for deposit of funds:

_Pico Envirotech Inc._____

Account Holder's Address: __222 Snidercroft Road, Concord, ON L4K 2K1_____

_____

Routing Information: (ABA/Routing number, Swift Code, IBAN number etc.):

__Swift Code: TDOMCATTTOR _____

_____

Account Number for deposit of funds:

_____ Account #: 1085-7306997_____

Amount and Type of Currency (ex. US Dollars, Euro, etc.):___USD_____

Information to be listed in memo field (reference#, invoice# etc.):

_____

Revised 11/11/13 KJ

816064

Pico Envirotec Inc.

222 Snidercroft Road
Concord, ON
L4K 2K1

Invoice

Date	Invoice #
10/23/2014	600630

Invoice To
University of Arkansas Department of Civil Engineering 4190 Bell Engineering Centre Fayetteville, AR 72701, USA Attn. Prof Richard A. Coffman, PhD, PE

Ship To
University of Arkansas Department of Civil Engineering 4190 Bell Engineering Centre Fayetteville, AR 72701 USA

P.O. No.	Terms	Project
Quote LK141008-1...		

Description	Qty	Rate	Amount
PGIS - 2 - 128: Portable Gamma Ray Spectrometer System 20% of USD 33,900.00 that is USD 6,780.00 is required as down payment. THE TD CANADA TRUST YORK REGION COMMERCIAL BANKING CENTRE 220 COMMERCE VALLEY DRIVE EAST MARKHAM, ONTARIO, CANADA, L3T 0A8 SWIFT CODE: TDOMCATTTOR ACCOUNT NAME: PICO ENVIROTEC INC. BRANCH: 10852 INSTITUTION: 004 ACCOUNT# 1085-7306997		33,900.00	33,900.00

Total	USD 33,900.00
Payments/Credits	USD 0.00
Balance Due	USD 33,900.00

GST/HST No. 880172184