

Contract Number: OASRTRS-14-H-UARK  
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### 3. Glossary of Terms

ARSET	Applied Remote Sensing Training
BLM	Bureau of Land Management
CalTRANS	California Department of Transportation
CalOES	California Office of Emergency Services
CGS	California Geological Survey
CRS&SI	Commercial Remote Sensing and Spatial Information
Co-PI	Co-Principal Investigator
DOI	Department of Interior
DiGS	Directional Gamma-ray Spectrometer
FEMA	Federal Emergency Management Agency
GIS	Geographical Information System
GPRI-II	Gamma Portable Radar Interferometer Version II
GRA	Graduate Research Assistant
GRFP	Graduate Research Fellowship Program
I-Corps	Innovation Corps
IDL	Idaho Department of Lands
IDT	Idaho Department of Transportation
IFG	Idaho Forest Group
INL	Idaho National Laboratory
ISU	Idaho State University
MEPH	Microelectronics Photonics
NASA	National Aeronautics and Space Administration
NPS	National Park Service
NRCS	National Resource Conservation Service
NSF	National Science Foundation
PI	Principal Investigator
RECOVER	Rehabilitation Capability Convergence for Ecosystem Recovery
RCEW	Reynolds Creek Experimental Watershed
TAC	Technical Advisory Committee
TDiAL	Topographic Differential Absorption Light Detection and Ranging
TRB	Transportation Research Board
TRR	Transportation Research Record
UGRA	Under Graduate Research Assistant
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USFS	United States Forest Service
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, 2015 through December 30, 2015) is presented and discussed. To date (15 months into the project), seven deliverables were scheduled for completion. Four of the seven deliverable have been completed. Progress is being made on the remaining three deliverables. For completeness, the individual deliverables and the status of the respective deliverables are highlighted in Table 1.

**Table 1.** Status of deliverables.

<b>Deliverable</b>	<b>Status</b>
Development of TAC	<b>Due January 1, 2015</b> Completed on December 11, 2014
Development and Maintenance of Website	<b>Due January 1, 2015</b> Completed on December 11, 2014. Maintenance ongoing.
Quarterly Reports	<b>Due quarterly</b> Completed following end of each quarter.
Ground-based Remote Sensing Device Demonstration	<b>Due July 1, 2015</b> Completed on September 23, 2015 (Caesar Sing) Completed on October 7, 2015 (ARSET Workshop) Completed on December 3, 2015 (CSS&SI Workshop) Demonstration to TAC scheduled for April 12 in Denver, CO
Implementation Plan, Fee Structure, Utilization Rate Report	<b>Due October 1, 2015</b> Ongoing. Progress was made during this quarter by developing a scope of work for CALTRANS. Report expected to be finished by April 1, 2016.
Users Manual for Ground-based Remote Sensing Device Report	<b>Due October 1, 2015</b> Ongoing. Progress was made during this quarter; the users manual for the radar device was developed but delays in the fabrication of the TDiAL device have delayed the users manual for the TDiAL device. Report expected to be finished by April 12, 2016, for discussion during the TAC meeting.
Ground-based Remote Sensing System Report	<b>Due October 1, 2015</b> Ongoing. Progress was made during this quarter; the users manual for the radar device was developed but delays in the fabrication of the TDiAL device have delayed the users manual for the TDiAL device. Report expected to be finished by April 12, 2016, for discussion during TAC meeting.

A total of \$20,296.67 of USDOT funds were expended during the quarter. A total of \$3,208.92 dollars of cost-share (UofA) were expended during this quarter.

No pieces of equipment were purchased during this quarter. Therefore, no equipment related receipts are included herein. Two pieces of equipment (avalanche photodetectors) were returned to the supplier because of failure to meet specifications. The reimbursement and receipt for reimbursement will be included in the next quarterly report. The failure of these two components has led to the aforementioned delays in fabrication of the TDiAL device.

During this quarter, personnel from the University of Arkansas and Michigan Technological University traveled to Idaho to 1) attend the NASA sponsored ARSET workshop and 2) collect data using the ground-based device (GPRI-II, DiGS, and passive TDiAL) at the location of the Charlotte Fire (West of Pocatello) and at the location of the Soda Fire (South of Boise). Personnel from both institutions also attended the Commercialization Remote Sensing and Spatial Information Workshop 2. The ground-based equipment (GPRI-II, DiGS, and passive TDiAL) was demonstrated and discussed during the workshop. Through the demonstration at the NASA workshop, several other federal and state agencies (NASA, BLM, IDL, DOI, USFS, NPS, INL, IFG, Idaho State, Boise State) were made aware of the product that is being delivered through the RECOVER platform.

During this quarter, and because of a debris flow event that occurred in California, the decision support system was demonstrated to CalTRANS while it was utilized to evaluate the potential for debris flow associated with the Powerhouse, Rancho, and Water Fires, along Interstate 5. In working with Herby Lissade, the Chief of the Office of Emergency Management of CalTRANS and TAC member for this project, the debris flow hazard was modeled. E-mail correspondence with Mr. Lissade is included within this quarterly report for completeness. Through the demonstration of the RECOVER DSS to CalTRANS, several other federal and state agencies (FEMA, CGS, CalOES) were made aware of the product that is being delivered through the RECOVER platform.

## 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) and the first TAC committee meeting was held on December 12, 2014 in Denver, CO. As documented in the last quarterly report (Quarterly Report 4), a virtual meeting of the TAC was held on August 3, 2015. However, the in-person meeting of the TAC that was supposed to be held in September of 2015 did not occur. The September meeting was supposed to coincide with a trip of UofA personnel to Boise, ID, to monitor a prescribed burn that had been arranged by Dr. Kathleen Lohse from the University of Idaho. Due to the Soda Fire, which started burning on August 12, 2015, and was located immediately next to the location of the prescribed burn, the prescribed burn was canceled. Also, in the interest of time, the UofA personnel decided to ship the equipment and fly on an airplane instead of transporting the equipment via a trailer through Denver, CO to Pocatello, ID.

As mentioned in the previous section, the next in-person meeting of the TAC will be held on April 12, 2016. During this meeting, the ground-based device and the decision support system will be demonstrated to the TAC. Moreover, the implementation plan, fee structure, utilization rate, users manual, and report about the device will be presented to the TAC and discussed.

#### *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. Additional content, including a video of the GPRI-II, and any updates/data from the project have been added as the content became available.

The development of the implementation plan and service provider are underway. Although the “Implementation Plan, Fee Structure, and Utilization Rate” report was due within the first 9 months of the project start date, the delay in obtaining the equipment has prevented the completion of the report. All of the required equipment must be obtained prior to the “Implementation Plan, Fee Structure, and Utilization Rate” report because the depreciation schedule and utilization rate will be based on the actual cost of the equipment. It is estimated that the report will be completed within the next three months.

The fee structure and utilization rate of the decision support system was investigated during this quarter. Specifically, in response to a debris flow that blocked Interstate 5 on October 16, 2015, Herby Lissade, the Chief of the Office of Emergency Management for CalTRANS, requested a proposal to evaluate the probability of debris flows for the locations of all wildfires that occurred within the 2013, 2014, and 2015 years. The proposal and accompanying correspondence are included in the Appendix for completeness. Unfortunately, Mr. Lissade was made aware that the USGS provides a similar service (albeit an inferior service), and due to

a previous working relationship between the USGS and CalTRANS, the CalTRANS management decided to utilize the services of the USGS. Although the RECOVER DSS platform was unable to be utilized for CalTRANS purposes, the discussions and dialogue that was developed regarding the need for monitoring debris flow risk following wildfires led CalTRANS to find a vendor to provide these services. Moreover, because of the workload that was generated from this request, the USGS was awarded with an additional \$500,000 (see enclosed highlighted press release).

### **Natural Hazards**

The FY 2017 USGS budget request for Natural Hazards includes a \$10.7 million increase above the FY 2016 enacted level for a total of \$149.7 million. It funds science to help protect the Nation's safety, security, and economic well-being, to make the United States more resilient to natural hazards, and to develop user driven tools to make communities safer.

The Earthquake Hazards Program increase of \$1.7 million would fund induced seismicity research related to unconventional oil and gas production and improve earthquake monitoring by assuming long-term operations of about 160 seismographs in the Central and Eastern U.S. An additional \$860,000 would fund sensors at select Global Seismographic Network sites. The budget continues funding of \$8.2 million to implement a limited earthquake early warning system on the West Coast by expanding seismometer coverage outward around major urban areas, integrating fault slip data into the system, developing and testing the system to improve reliability, and end-user education efforts on how to understand and use alerts.

The Natural Hazards budget increase includes a Coastal and Marine Geology Program increase of \$5.8 million, which would benefit coastal communities, including those in the Arctic, dealing with sea-level rise, severe storms, and melting permafrost. The increase would also fund research and modeling to apply findings from Hurricane Sandy to other parts of the U.S. coastline.

An increase of \$1.7 million for the Geomagnetism Program would enhance USGS monitoring of electrical currents in the Earth's crust, and improve global magnetic field data. This monitoring by USGS is an integral component of the National Space Weather Strategy to protect against the harmful effects of magnetic storms. The Sun is always emitting a wind of electrically charged particles, but when a large sunspot emerges on the face of the Sun, there is an increased chance for abrupt emission of strong solar wind and a magnetic storm. An intense magnetic storm can affect many technological systems. In particular, storms can overload and interfere with the operation of electric-power grids on the Earth, sometimes causing blackouts.

In addition, an increase of \$0.5 million in the Landslide Hazards Program would expand post-wildfire debris-flow hazard assessments and bolster the USGS capacity to respond to landslide crises.

To successfully commercialize the technology that is being developed in association with this project, the PI, Co-PI, and UofA GRA attended the Commercial Remote Sensing Workshop 2 in Oklahoma City, OK, on December 3, 2015. This workshop contained similar material, and may have been based on, the 4<sup>th</sup> Annual Arkansas Commercialization Retreat that the PI attended during the summer of 2015.

A GRA that is affiliated with this project is also planning to take the Emerging Technologies in Industry (MEPH 5253) course that is being offered at the UofA. A syllabus of the course is included within the appendix. Moreover, the PI has been asked to participate within the NSF I-Corps Southwest Node two-week regional training workshop that will be held in Arkansas in May (see flyer in the Appendix).

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

Although the instrument has been demonstrated at various venues (presentation to Caesar Singh during yearly report visit, demonstration at NASA ARSET Workshop, demonstration at USDOT CRS&SI Workshop), the TDiAL device has only been demonstrated and tested in the passive mode instead of in the active and passive mode due to the failure of the two optical components (avalanche photodiodes) and due to the delay in the delivery of the data acquisition system (refer to e-mail from National Instruments in the Appendix). Additional adapters and mounts have also been, and are currently being, purchased to facilitate operation of the active portion of the TDiAL device.

In addition to the demonstrations, several of the independent pieces of required equipment have already been utilized to collect data on soil samples in the laboratory. Specifically, the active portion of the TDiAL device is being utilized in the laboratory. As discussed in Activity 6, several papers have resulted from the data that were collected in the laboratory. The “Users Manual for Ground-based Remote Sensing Devices” report is still being developed although it was 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 still being developed although it was due within the first 12 months of the project start date.

### *Activity 4: Collection of Data/Creation of Databases*

Data was collected during October 2015 at two locations in Idaho (Soda Fire and Charlotte Fire). Moreover, a decision support system was created for three historic wildfires in California (Powerhouse Fire, Water Fire, Rancho Fire). These data have been archived in a GIS database (<http://naip.giscenter.isu.edu/recover2/powerhousefire/>). Additional processing is being completed on all of the data that were collected from the Soda Fire site. These data will serve as the basis for the next journal article that will be written. As discussed in Activity 6, several papers have been developed based on the data that were collected and analyzed. The actual “Database of Remotely Sensed Properties” will be demonstrated and reported within 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 debris flow probabilistic model for the RECOVER decision support system is much needed. The model that has been developed is similar to 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 in person meeting with the members of the TAC is planned to occur on April 12, 2016. The creation of a new model, based on statistical analysis of the USGS data, will be presented and discussed during the virtual meeting. Moreover, the ingestion of the statistical model (R-based computer code) into the GIS-based RECOVER system will also be discussed during the meeting. “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 18 to 24 months from the project start date, respectively.

#### *Activity 6: Reporting and Publication*

This quarterly report is the fifth in a series of quarterly reports. A synopsis of the results that were developed from the obtained data is reported herein. Based on the obtained data, several papers and presentations have been prepared and presented, respectively. Specifically, the authors and titles of the papers and presentations are included below.

Kern, A.N., Addison, P., Oommen, T., Salazar, S.E., Coffman, R.A. (2016) “Machine Learning Based Predictive Modeling of Debris Flow Probability in the Intermountain Western United States.” *Mathematical Geosciences*. Conditional Acceptance, Resubmitted for Review on January 5, 2015. Manuscript Number: MATG-D-15-00135-R1.

The paper that was prepared for the 95<sup>th</sup> Annual Meeting of the TRB was accepted for presentation but not accepted for publication in the TRR. Sean Salazar will give the presentation at TRB in the “Determination of Soil Properties, Consolidation Properties, and Shear Stress Factors Including Resilient Modulus of Subgrade” session. Because the paper was not accepted for publication in the TRR, the paper has been revamped and will be submitted to *Geodurma* (as listed below).

Garner, C.D., Salazar, S.E., Coffman, R.A., (2016). “Evaluation of a Field and Laboratory Remote Sensing Method for Determining Soil Atterberg Limits and Clay Content.” Presentation at the 95<sup>th</sup> Annual Meeting of the Transportation Research Board.

Garner, C.D., Salazar, S.E., Coffman, R.A., (2016). “Evaluation of Visible-Near Infrared Reflectance Spectroscopy as a Rapid Non-Destructive Measurement of Soil Hydraulic Properties and Soil Index Properties.” *Geodurma* (In preparation).

As previously mentioned, several presentations related to the project were made at various events. These events are itemized below.

- Coffman, Richard A., (2015). “Demonstration of Ground-based Equipment for Identification of Debris Flow Materials to Mr. Caesar Singh.” Fayetteville, AR, September 23.
- Coffman, Richard A., (2015). “Demonstration of Ground-based Equipment for Identification of Debris Flow Materials at the Location of the Charlotte Wildfire.” NASA ARSET Workshop, Pocatello, ID, October 9.
- Coffman, Richard A., (2015). “Discussion of Results Obtained via Ground-based Equipment for Identification of Debris Flow Materials at the Location of the Charlotte Wildfire.” NASA ARSET Workshop, Pocatello, ID, October 10.
- Coffman, Richard A., (2015). “Demonstration of Ground-based Equipment for Identification of Debris Flow Materials at the Location of the Soda Wildfire to Mr. Mark Seyfried of USDA NRCS.” Reynolds Creek, ID, October 11.
- Coffman, Richard A. (2015). “University of Arkansas Hazard Modeling.” Personal Correspondence with Bill Short, Department of Conservation, California Geological Survey (e-mail correspondence). November 12.
- Coffman, Richard A. (2015). “Proposal for Debris Flow Mapping from the 2012-2014 California Wildfires”. Submitted to Herby Lissade. November 16.
- Coffman, Richard A. (2015). “Discussion of Differences between RECOVER Debris Flow Mapping Models and USGS Debris Flow Mapping Models.” Personal Correspondence with Herby Lissade (e-mail correspondence). November 18.
- Coffman, Richard A., (2015). “DEMO 8: Remote Sensing Based Assessment for Evaluating Risk to Transportation Infrastructure Following Wildfires.” USDOT Remote Sensing Workshop 2, Oklahoma City, OK, December 3.

In addition to the aforementioned papers, conference presentations, and workshops, 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.

### **Problems Encountered**

The avalanche photodiodes that were required and purchased for the TDiAL device did not meet the manufacturer’s specifications. The items were sent back to the manufacturer but the manufacturer stated that the required specifications cannot be met. Therefore, this portion of the TDiAL device is being redesigned. It is anticipated that this portion of the device will be ready to be demonstrated to the TAC on April 12, 2016. The data acquisition system was delayed in shipping (see attached

e-mail correspondence). The data acquisition system has now arrived and is being utilized on the project.

Several discussions were had with various stakeholders in California. These stakeholders included: CalTRANS, California Geological Survey, FEMA, California Office of Emergency Services. After these discussions, officials from USGS stated that USGS would be able to provide the requisite services to CalTRANS, California Geological Survey, FEMA, California Office of Emergency Services, free of charge. Additional support from USDOT and communication between USDOT and USGS may have aided in the USGS personnel realizing the debris flow model provided by RECOVER (supported by UofA, MTU, and ISU) is more reliable than that offered by USGS.

### **Future Plans**

Several milestones are required to be accomplished during the next quarter. These milestones include milestones that were not completed during the quarter that is being reported in this quarterly report (Quarter 5) and previously planned Quarter 6 milestones that will be completed, on schedule, during the next quarter. The specific milestones that will be completed are listed below; interesting findings associated with these milestones will also be reported.

- "Implementation Plan, Fee Structure, and Utilization Rate" report.

- "Development and Maintenance of Website" report.

- "Users Manual for Ground-based Remote Sensing Device" report.

- "The Development of a Remote Sensing Based Decision Support System to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires" demonstration.

Several demonstrations of the complete device will take place during the upcoming quarters (Quarters 6 and 7). These demonstrations include 1) a demonstration to the TAC at the Waldo Canyon Wildfire site near Manitou Springs, CO, on April 12, 2016, and 2) a post-fire demonstration to additional stakeholders (IDT, USGS, USDA, BLM, NSF, NASA) at Johnston Draw within the RCEW, Owyhee County, south of Boise, ID, in July, 2016

## 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. Time has been expended and charged for the academic year and summer costs associated with the PI and Co-PI. The number of expended hours that are reported in Table 1 were associated with time spent in: weekly meetings (PI, GRA, UGRA); in bi-weekly meetings (PI, the GRA, the Co-PI, Co-PI's GRA, Co-PI's UGRA); developing and maintaining the website; preparing and providing presentations and demonstrations; collecting data with the new equipment; collecting data related to the probabilistic model; and preparing the quarterly report.

The GRAs expended the allocated amount of hours on the project. Although Sean Salazar is a NSF GRFP recipient, Sean will continue to assist with the USDOT project but his time will be allocated to the NSF GRFP project. Cyrus Garner will be graduating in January 2015. Cyrus will not be replaced on the project with another student until the summer of 2016. The funds that would have been utilized for Cyrus will be saved in hopes of using these funds to fund a student in the event of a project extension. Two UGRAs (Leah Miramontes and Brendan Yarborough) spent time working on the project during this quarter.

Table 1. Hours allocated and expended.

Quarter 1, Year 2	USDOT Allocated (Hours)	UofA Allocated (Hours)	USDOT Expended (Hours)	UofA Expended (Hours)
PI – Quarterly Report	16	16	16	16
PI -Website		10		10
PI – Ground Based Device	24	46	24	46
PI – Data Collection / Data Processing	55	70	55	70
GRA – Quarterly Report	20		20	
GRA - Website	10		10	
GRA – Ground Based Device	0		0	
GRA – Data Collection / Data Processing	200		200	
GRA - Publications	80		80	
UGRA - Website	20		0	
UGRA – Ground Based Device	0		0	
UGRA – Data Collection	80		67.75	
Admin - Website	21.7		21.7	

Based on the number of hours expended, the level of effort that was expended by personnel from the UofA was 100.0 percent for the PI, 100.0 percent for the GRA, 67.75 percent for the UGRA, and 100 percent for the Admin. The UGRA students

were on break associated with the holidays during the last month of the quarter which led to a reduction in the number of hours worked.

As shown in Table 2, the amount of Year 2 funds that were allocated for the project and the amount of funds that were expended on the project are documented. No pieces of equipment were purchased during Quarter 5; no receipts are enclosed within this quarterly report. A total of \$4,899.27 of sponsor funds were spent on travel this quarter. This amount of funds is greater than that budgeted for Year 2. An accounting mistake led to these funds being spent on the sponsor side of the project instead of on the cost-share side of the project. These funds will be correctly appropriated and reported as such in the next quarterly report.

Table 2. Funds allocated and expended for Year 2.

Year 2	USDOT Allocated (\$)	UofA Allocated (\$)	USDOT Expended (\$)	UofA Expended (\$)
Salaries	34,203.00	15,580.00	5,081.67	2,551.02
Fringes	2,544.00	3,988.00	247.28	657.90
Supplies	6,750.00	0.00	3,556.07	0.00
Travel	3,250.00	15,000.00	4,899.27	0.00
Other	0.00	75,000.00	0.00	0.00
Indirect	21,737.00	0.00	6,112.93	0.00
Tuition	0.00	8,963.00	0.00	0.00
Subcontract	82,128.00	84,994.00	0.00	0.00
Subcontract Indirect	20,052.00	0.00	399.45	0.00
Equipment	0.00	0.00	0.00	0.00

## **7. ADVISORY/STEERING COMMITTEE MEETING**

No TAC meetings were held during this quarter.

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

The paper written by UofA members will be presented at the 95<sup>th</sup> Annual Meeting of the TRB. As mentioned previously in this quarterly report and in other quarterly reports, because the paper was not selected to be published in the TRR, the paper will be published in another journal. Even though the paper will not be published in TRR, a presentation on the research will be presented at the 95<sup>th</sup> Annual Meeting of the TRB.

## **9. APPENDIX FOR QUARTER**

No pieces of equipment were purchased during this quarter. Therefore, no receipts are included in this quarterly report. The correspondence with the California agencies regarding debris flow probability is attached. Also, the NSF I-Corps solicitation that the PI will be attending is also attached.