

AWARD DOCUMENT

RITARS-12-H-UVM

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COOPERATIVE AGREEMENT No. RITARS-12-H-UVM

BETWEEN

University of Vermont
85 South Prospect Street, 340 Waterman Building
Burlington, VT 05405

AND

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND INNOVATIVE TECHNOLOGY ADMINISTRATION

FOR

Rapid Exploitation of Commercial Remotely Sensed Imagery for Disaster Response & Recovery

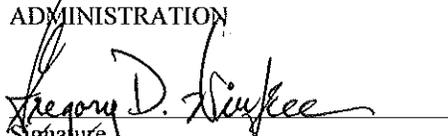
Total Amount of Agreement: \$754,380
Total Estimated Federal Government Funding of the Agreement: \$371,750
Total Estimated Recipient Cost-Share: \$382,630
Appropriation Data: 8083XXXDA0/2012/RDRNDRS0LU/53D0980000/41000 \$371,750

AUTHORITY: This agreement is entered into between the U.S. Department of Transportation (USDOT), represented by the Research and Innovative Technology Administration (RITA), and University of Vermont, DUNS: 066811191, Taxpayer ID#: 030179440, pursuant to and under the authority of Section 7301 of P.L. 109-59; the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

University of Vermont

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND INNOVATIVE TECHNOLOGY
ADMINISTRATION


Signature
Ruth Farrell, Associate Vice President
Research Administration


Signature
Gregory Winfree, Deputy Administrator

OCT - 5 2012

NOV 19 2012

Date

Date

DECEMBER 01, 2012
Effective Date

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AGREEMENT ARTICLES

1. INVOLVEMENT STATEMENT

Substantial involvement is anticipated between the Research and Innovative Technology Administration (RITA) (Government) and the University of Vermont (Recipient) through the terms of this Cooperative Agreement. In supporting the Cooperative Agreement, the USDOT /RITA is assisting the Recipient to put forth the recipient's best efforts to design and develop remote sensing-based tools for the identification of flood-induced road damage and calculation of fill volumes for road repair, which promises to extend the available Commercial Remote Sensing & Spatial Information tools to enhance the field of remote sensing of transportation infrastructure. The goal of this project is to develop decision support tools that harness cutting-edge CRS technology and supports incident and asset managers in state transportation departments by automating the process of identifying road damage and determining the amount of construction materials needed to make repairs after a major storm. The research team includes the following key persons:

Dr. Austin Troy, PhD, Director of the University of Vermont (UVM) Transportation Research Center

Jarlath O'Neil-Dunne, Faculty Research Associate and Director of the University of Vermont's Spatial Analysis Laboratory (SAL)

Amanda Hanaway-Corrente, Professional Engineer at University of Vermont (UVM)

James Sullivan, Research Analyst at UVM Transportation Research Center

Sean MacFaden, Research Specialist at UVM Spatial Analysis Laboratory

Ernest Buford, Research Specialist at UVM Spatial Analysis Lab

2. SCOPE/STATEMENT OF WORK

USDOT RITA is responsible for implementing the Commercial Remote Sensing and Spatial Information (CRS&SI) technology program. This includes the delivery of validated products for new applications to transportation infrastructure planning and construction, as required under Section 5506 of Public Law 109-59, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The purpose of this Cooperative Agreement is for University of Vermont to assist USDOT / RITA in this endeavor.

Under the terms of this agreement, University of Vermont will assist RITA with the following tasks:

Task 1: Creation of a Technical Advisory Committee

Task description:

A Technical Advisory Committee will be formed in the beginning of the project, composed of representatives from VTrans and other regional state DOTs, a member of the Metropolitan Planning Organization for Chittenden County or another metropolitan area in the study region, a US DOT representative, a disaster management specialist, an industry representative (e.g. from Geoeye or Trimble) and a remote sensing specialist, potentially among others. The US DOT project manager will be consulted before finalizing membership. This group will meet in person or by video conference twice per year or on an as needed basis.

Output/Deliverables:

The Advisory Board comprised of 6 to 8 members will provide guidance in specific technical and policy recommendations that the team would take into consideration for implementation. Notes will be taken at each meeting and provided to members as a brief summary report.

Task 2: Creation of a project website**Task description:**

The project web site will serve as the main portal from which collaborators, the funding agency, and the general public can find out more about the project, obtain up-to-date information, and download products.

Output/Deliverables:

A project web site will be created on the University of Vermont domain (www.uvm.edu) containing a password protected section for internal documents and data products that have access/use restrictions associated with them (e.g. commercial satellite imagery) as well as access to regularly updated public documents.

Task 3: Damage detection system methods development**Task description:**

Our proposed workflow, described in detail in the Technical Proposal document, consists of three phases: (1) data preparation, (2) damage detection/feature extraction, and (3) decision support tools.

The first phase of the workflow, data preparation, occurs once the CRS satellite imagery has been obtained, typically via an online portal such as the USGS Hazard Data Distribution System (HDDS). Due to the rapid tasking and posting of CRS imagery to HDDS, the data are typically not georeferenced with sufficient accuracy to support automated damage detection. To overcome this limitation the first phase will employ automated approaches to image registration using the AutoSync module within ERDAS IMAGINE. In this phase pre-event CRS imagery, primarily from the National Agricultural Imagery Program (NAIP), for which there is nationwide 1 meter coverage, will serve as the reference data set. Post-event CRS imagery will be registered to the pre-event imagery and placed on a server. Once on the server an automated import routine will then load the data into an object-based system for feature extraction and damage detection. The automated import routine will be built using the eXtensible Markup Language (XML). It will assemble the pre- and post-event imagery and the existing state transportation GIS vector road data into data stacks within the object-based system. The automated import routine will assign appropriate alias names to imagery bands and GIS vector data sets in addition to clipping the vector data to the extent of the imagery.

In the second phase the object-based image analysis system will automatically extract features and detect damage using a combination of pre- and post-event imagery in conjunction with transportation GIS data sets. A knowledge engineering approach will be used in which an expert system applies a series of segmentation, morphology, and classification algorithms to determine areas in which damage has likely occurred. These damaged areas are then presented to the user who has the option of either confirming or denying the presence of damage prior to sending the results on to the decision support tools (phase 3).

The first feature extraction process uses expert knowledge to extract road areas from the pre-event imagery and GIS transportation data sets. The expert system will be designed such that precise agreement between the vector GIS data and the pre-event imagery is not required. This will be accomplished by first using segmentation and classification routines to extract linear features resembling roads, then assigning those features to the appropriate road segment based on proximity and orientation measures. The feature extraction for the post-event imagery will be less specific. It will largely center on extracting object primitives. Using the roads identified from the pre-event imagery in combination with the object primitives from the post-event imagery damage areas will be identified. This will be accomplished using object-fate analysis. The underlying theory behind object-fate analysis is that features in imagery collected on two time periods will always differ in some way due to a range of factors from sensor collection parameters to actual modifications to the landscape. By comparing the roads with the object primitives, the expert system will be able to compute the magnitude of change between the two objects using spectral, textual, geometric, and contextual information. Fuzzy logic will then be employed to determine those areas for which damage has likely occurred based on both the magnitude and type of change.

The expert system will purposely be designed in such a manner that it reduces errors of omission to as close to zero as possible, even if this means increasing errors of commission. The system will thus employ an optional tool that provides pre- and post-event image chips to the user that allows him/her to tagged false positives.

The object-based image analysis system will be built using Trimble's eCognition software platform. The expert system will be built using the Cognition Network Language (CNL) within eCognition Developer and deployed using eCognition Server. CNL provides the greatest number of and most robust set of segmentation, classification, and

morphology algorithms that we are aware of.

Testing and validation of this approach will occur for the areas of Vermont, New York, and New Hampshire using data collected in support of Tropical Storm Irene response. The expert system will be developed on a set of CRS scenes reserved specifically for development, and then validated on an entirely separate set of CRS images. We will employ standard remote sensing accuracy assessment protocols to assess producers, users, and overall accuracy of the damage detection. Once we have a validated system we will select at least one other geographical area outside of the Northeast to test its effectiveness. Preference will be given to a recent disaster and will be coordinated with the AmericaView network, a national remote sensing consortium with expertise in disaster response for which Co-PI O'Neil-Dunne serves on the board of directors. Thanks to the generosity of GeoEye we will have access to massive amounts of pre- and post-event imagery for which to test this within the United States.

In the third phase, the damage data from the object-based image analysis system is fed into the decision support tools. A geoprocessing routine will intersect the damage location with existing transportation GIS data sets to extract relevant attributes. This relatively simple procedure has the advantage in that it will work for standard (e.g. national road databases) and more complex (e.g. state transportation asset data) data sets. The end result of this operation will be a point location representing the center of the damage, an image chip of the damage from the post-event imagery, any information about the damage that can be extracted by the object-based image analysis system, and any information from the transportation GIS database (e.g. road name, mile marker, etc.). The point information will be uploaded to a web-based decision support portal using Google Fusion Tables, as described in task 5.

Output/Deliverables:

We will develop, validate, and accuracy assess a methodology for automating the identification of large road damage. This methodology will result in the development of a "knowledge base" of expert classification rules that remote sensing technicians can then reuse in other location. This knowledge base will be made available on our website along with documentation and tutorials on using it (see Task 6). We will also create and post an ESRI geoprocessing utility or standalone utility that extracts the geographic coordinates of the center of each damage polygon and then sends that coordinate to a web server (see Task 5).

Task 4: Fill calculation system methods development

Task description:

We intend to approach the second objective through the use of commercial, lightweight, deployable unmanned aerial vehicles (UAVs). We will make use of the Gatewing UAV, which flies low enough to be exempt from FAA regulations. Using preprogrammed flight paths that take it over the same feature from two slightly different angles, the Gatewing is capable of acquiring stereo imagery.

The first phase in developing the UAV approach will be calibrating our measurements over void areas for which precise volumes are already known. We plan to conduct these calibrations over empty swimming pools and/or quarries. 3D surface models will be extracted from the stereo imagery using cost-based image-matching techniques. These techniques are widely available in both open-source and commercial software packages. For this project, we will employ the Inpho software package. 3D surface models will be distributed in the GeoTIFF format, an open format that is supported by all open-source and commercial GIS, mapping, and computer-aided design (CAD) software packages.

In conceptual terms, the automated fill calculation algorithm will work by generating a digital surface model that includes the eroded or damaged void and its immediate surroundings. Interpolation will be used to create an artificial plane representing where the bottom of the pavement meets underlying fill. Using standard 3D GIS functionality, the volume of the area between that plane and the bottom of the void (as estimated by the digital surface model) will be calculated. This calculation will yield a total compacted fill quantity. However, a roadbed is made up of different layers, including the surface course, the base course, and the subbase course, each using different materials. Embankment materials may also be required on the side slopes of the roadway. Therefore, additional calculations will estimate the volume of each design layer in the void based on a specific thickness of each material, which will then help yield an estimated amount of material needed by type.

There are, however, many types of fill (4 types of stone fill are commonly used in Vermont, for instance) and embankment material, and the appropriate type and thickness varies by many factors relating to the site, like the

surrounding hydrology and the use of the road. Many states currently use a program called DARWin, which takes basic information input by the user, cross references the information with state standards and the 1993 AASHTO Guide for Design of Pavement Structures, and outputs the roadway design parameters needed to conduct repair. In this case, our model would allow users to take the outputs of DARWin and use them as inputs to our fill calculation module, thereby eliminating the need for a site visit. In the second phase of this task we work with our DOT counterparts to incorporate fill type into our algorithm and ensure that the appropriate information passes between our algorithm and DARWin. So cost savings will be realized from a more cost-effective design and from the elimination of the need for a site visit.

Whether the user is a field engineer trying to match pre-existing conditions or a design engineer using a program such as DARWin to calculate the roadway design, the interface will be the same. The third phase of this task will involve adapting the fill quantity and type algorithms for use in a reusable geoprocessing model interface. The model will consist of a series of geoprocessing tools within the commonly used ESRI ArcGIS platform and will utilize objects from ArcGIS 3D Analyst toolbox. When users click on the model, it will bring up an interface that will ask the user to draw a polygon around the segment of road for which they would like a fill estimate. Next, the user will be prompted to input the roadway design criteria by identifying the pavement surface, base, and subbase thicknesses and material types, as well as embankment armoring depth and material type. The module will take the typical cross section for the roadway, align it with the selected roadway segment centerline, apply it to the void identified in the 3D surface model, and provide an estimation of the type and quantity of fill required. If possible, it will also output a typical cross section for the roadway design. The geoprocessing tool will include functionality that allows users to automatically upload the outputs to the online database, which in turn will populate the damage-point web map (Task 5).

In any given year spring floods generally cause at least minor erosive damage to the transportation network. Working in collaboration with incident commanders at our partner state transportation departments we will receive notification when damage occurs and program our UAVs to fly these areas before they are repaired. Field crews will measure the volumes using ground-based measurement and photographic methods so that we can validate our estimates.

Output/Deliverables:

We will develop, validate, accurately assess and document a methodology for automating the calculation of the quantity of fill by type for road damage voids caused by flooding. We will produce a technical document and tutorial that outlines this methodology (see Task 6). We will also produce and make available an ESRI geoprocessing tool capable of performing the fill calculations.

Task 5: Development of web portal decision support tool

Task description:

We will work with our primary state DOT partner, VTrans, to develop a web portal that helps deliver incident information faster, more accurately, and with greater detail. Our proposed decision support system will feed information on damage locations and fill quantity/type into a common web portal from the desktop tools described in Tasks 3 and 4. The decision support system targets two main audiences. The first is the general public, which has a need to know about status of damage, road closures, surface conditions, and delays and the resulting impact on their transportation routes. The second audience is state DOT personnel, who have a similar need to know about the damage on roadways and the resulting impact on the transportation network, but also need to know technical information about road repair.

This decision support tool will allow them to objectively detect most large damage sites is after a major event which in turn will allow for better strategizing about the response, particularly in terms of prioritizing sites for repair. The information on fill types and volumes available from this website will allow incident managers to more quickly and precisely determine the amount and type of materials that will be needed to make repairs, which will boost efficiency of repair crews. It will also save costs by resulting in more accurate orders of fill materials, eliminating the need to over-order more expensive fill types due to uncertainty. Furthermore, by visualizing where the fill needs are located, it will make it much easier for incident managers to design routes to deliver crews and materials to multiple sites in an efficient sequence. Having all this in an easy-to-use web portal will simplify and speed up the incident management process, eliminating many communication bottlenecks.

While public users will just have access to information on the location and severity of individual damage sites, DOT officials will have access through restricted login to greater amounts of information, including fill quantity and type

estimates and void dimensions, as well as contextual information (e.g. grade, hydrology, etc.), all by geographic coordinate. Point incident and attribute level controls will be implemented so that the same underlying data can feed into both the public and access-restricted versions of the web-based decision support system, with different data fields tagged by their access level.

This web portal will consist of a basic zoomable map interface (e.g. Google Maps, similar to what is currently used for Vermont's travel information web service) with damage points overlaid on it. A protocol will be developed to feed data from our damage identification analysis into a back-end database relying on Google Fusion Tables. Google Fusion Tables is a form of cloud computing that allows one to upload, display, and extract geospatial data, and have any number of authorized users modify that data. One key advantage is that this technology is that it is available to any organization or individual at no cost. Moreover, the multi-user editing functionality of Google Fusion Tables will allow incident commanders or other authorized personnel to update the information, for example, changing the status from "closed" to "delays" for a damaged section of road. The approach has an additional advantage in that the information can be made accessible for direct ingest into other web-based mapping portals without the need for download or perform any conversion.

The portal will pull data directly from Google Fusion Tables, resulting in a geocoded point on a map. Using automated GIS overlay analysis each point can be populated with a series of relevant attributes (e.g. proximity to stream, stream order, grade, soil type, road type, etc.) that will "pop up" as a callout when users click on a damage point. We envision that the product will look similar to the one developed by the Vermont Agency of Transportation following Hurricane Irene. Login-access users of the damage-point web map will be able to click on the damage points and then click on a number of links, including one to the fill volumes and type calculations, one to contextual information (e.g. slope or hydrology), and one to background information about how the fill calculation was done and what assumptions were used. If feasible, the map interface will also allow users to query for damage locations based on certain criteria, such as location within a town or county, network/Euclidean distance to a certain facility or location, or type of road. Realizing that there is a need to have the actual GIS data, the web portal will also include a link to download the point information in industry-standard KML and Shapefile formats.

For state DOTs without any type of existing decision support system they will be able to implement our system with very few modifications. The reliance on open source and freely available technology will permit a low barrier to entry. For state DOTs with existing decision support systems on the web, our use of Open Geospatial Consortium (OGC) compliant formats will likely allow them to seamlessly integrate the information into their existing system.

We will also experiment with using social media to report information on damage locations. Social media is increasingly being used as a mechanism for disseminating information during a disaster. As part of the damage detection geoprocessing operation we will incorporate a routine that tweets the location of the damage via the Twitter social media platform. This capability is available within the FME software package, a commercial software package used for data translation and conversion that runs on both the desktop and server.

Output/Deliverables:

Outputs will include development of a front-end website prototype on our own servers which will pull data from Google Fusion Tables, which is a cloud-based platform. We will then work with our VTrans partners to make these data sets and web resources available to them so that they can freely integrate them into their online information systems. We will document the process of developing the portal and will write up manuals for both users and for website administrators.

Task 6: Project outreach and communication

Task description:

We intend to make the methods and technologies developed in this project easily transferable to other state DOTs and to professionals in the fields of incident management or remote sensing. Towards this end we will make publically available all of the documentation, computer models, and support materials described in the tasks above. In partnership with our state DOT colleagues, will we explore whether the damage-point web map could potentially be expanded to include all states in the region. This expansion would require extensive coordination of information flows. Finally, this task will include presentations at conferences/professional meetings and publication of scholarly articles.

Output/Deliverables:

We will complete, make available and disseminate all outreach materials. For the damage-detection methodology, this will include our knowledge base of classification/detection rules, which can then be ported and reused in object-based image-classification software using different imagery, as well as a detailed methodological document and video tutorial that will assist technicians in replicating this system. For the fill calculation task, it will include the ArcGIS geoprocessing tool files and user manual, a methodological document, and a set of video tutorials. For the decision support portal development, we will include a methodological document about setting up the interface and serving the data from Google Fusion Tables, as well as guides for users and administrators. We will hold a focus group meeting with select partners to get feedback on our outputs and determine what additional information or clarification may be needed for subsequent adopters to make use of the project's methods. We will also follow up with VTrans and, if applicable, other New England DOTs, to determine if and how the methods we developed were actually employed and what improvements could potentially be made. Finally, we will write a final report (draft and revised versions), give presentations on the project at professional meetings and prepare manuscripts on the project for publication.

3. TERM OF THE COOPERATIVE AGREEMENT

This Cooperative Agreement is valid for a period of two (2) years from the effective date, except as otherwise provided under 49 CFR, Part 19, Subpart C Post Award Requirements, Section 19.62, Enforcement, and Section 19.61, Termination. As noted above Section 19.25, Revision of Budget & Program Plans, the Agreement may be extended for additional periods pending successful completion of previous project tasks, perceived program needs and availability of funds.

The total value of this agreement is \$754,380. RITA will provide \$371,750 to support the project as described in this agreement. Recipient's proposed cost share amount for the project is \$382,630.

Any modifications including no cost extensions as well as technical or financial changes to this Cooperative Agreement must be in writing and signed by both the Recipient and the Program Manager.

Material compliance of this Cooperative Agreement consists of the following items:

- Successful & timely completion of all tasks, deliverables, activities and milestones proposed as per the full proposal submitted on June 22, 2012, and described in Attachment 1, "Team Project Activities," Attachment 2, "Project Deliverables," and Attachment 3, "Technical and Deliverable Milestone Schedule".
- Strict & satisfactory adherence to Effort for all staff categories as per the full proposal submitted on June 22, 2012, and the Principal Investigator shall be responsible for ensuring the compliance.

4. DELINEATION OF TASKS

The Recipient is responsible for performing the tasks and deliverables associated with those tasks as identified in Section 2, above, and in Attachments 1, 2, and 3 of this agreement. The Recipient's approach for carrying out these tasks is described in its Technical and Staffing Proposal dated June 22, 2012, and in the Recipient's revised Cost Proposal, dated September 5, 2012, which is incorporated into this agreement by reference. Attachment 1, "Team Project Activities," Attachment 2, "Project Deliverables," and Attachment 3, "Technical and Deliverable Milestone Schedule," are also incorporated into this Agreement.

5. PROJECT OFFICIALS

Program Manager (PM) - The Program Manager (PM), Mr. Caesar Singh, will monitor the work under this Cooperative Agreement and will oversee the technical administration of this Cooperative Agreement and act as technical liaison with the performing organization. In addition, the PM has full authority to negotiate, administer and execute all business matters of this Cooperative Agreement. Further, should any changes to the scope, budget, schedule or any other terms of the agreement become necessary, only the PM has the authority to amend the Cooperative Agreement.

Principal Investigator (PI) - The Principal Investigator (PI) is the individual designated by the Recipient and approved by USDOT/ RITA, who is responsible for the technical direction of the project. The PI cannot be changed or become substantially less involved than was indicated in the Recipient's proposal, without the PM's prior written approval. The PI assigned to this Agreement is **Austin Troy**.

6. CONSIDERATION AND PAYMENT

A. Delphi eInvoicing System for Department of Transportation (DOT) Financial Assistance Awardees

Reimbursable Payments will be made, on a quarterly basis, after receipt of a Request for Advance or Reimbursement, SF-270, acceptable to USDOT. Each voucher must show the Cooperative Agreement number, cost for billing period, and costs to date.

NOTE: Payments to the Recipient will be made to reimburse incurred expenses which were reasonable, allocable and allowable in the performance of this Cooperative Agreement. USDOT does not plan to make any advance payments to the Recipient. The timing of payments will be as close as is administratively feasible to actual disbursements.

Subject to the requirements in 49 CFR 18.21, payments will be made after receipt of required modal reporting forms. Each payment request must be made electronically via the Delphi eInvoicing System.

The following are the procedures for accessing and utilizing the Delphi eInvoicing System.

a) Grant Recipient Requirements

- Grantees must have internet access to register and submit payment requests through the Delphi eInvoicing system.
- Grantees must submit payment requests electronically and DOT Operating Administrations must process payment requests electronically.

b) System User Requirements

- Grantees should contact the DOT Operating Administration's grants office directly to sign up for the system. The Operating Administration awarding the grant will provide the grantee's name and email address to the DOT Financial Management Office. The DOT will then invite the grantee to sign up for the system.
- The DOT will send the grantee a form to verify the grantee's identity. The grantee must complete the form, and present it to a Notary Public for verification. The grantee will return the notarized form to:

DOT Enterprise Services Center
FAA Accounts Payable, AMZ-100
PO Box 25710
Oklahoma City, OK 73125

- The DOT will validate the form and email a user ID and password to the grantee. Grantees should contact the Operating Administration's grants office with any changes to their system information.

Note: Additional information, including access forms and training materials, can be found on the DOT eInvoicing website (<http://www.dot.gov/cfo/delphi-einvoicing-system.html>)

c) Waivers

DOT Financial Management officials may, on a case by case basis, waive the requirement to register and use

the electronic grant payment system. Waiver request forms can be obtained on the DOT eInvoicing website (<http://www.dot.gov/cfo/delphi-einvoicing-system.html>) or by contacting the Operating Administration's grants office. Recipients must explain why they are unable to use or access the internet to register and enter payment requests.

All waiver requests should be sent to the Director of the Office of Financial Management, US Department of Transportation, Office of Financial Management, B-30, room W93-431, 1200 New Jersey Avenue SE, Washington DC 20590-0001, DOTElectronicInvoicing@dot.gov. The Director of the DOT Office of Financial Management will confirm or deny the request within approximately 30 days.

If a grantee is granted a waiver, the grantee should submit all hard-copy invoices directly to:

RITA
P. O. Box 268861
Oklahoma City, OK 73126-8861

The Recipient must submit a copy of all requests for reimbursable payments to the Government office below:

U.S. Department of Transportation
Research and Innovative Technology Administration (RITA)
1200 New Jersey Avenue, S.E., Room # E33-467
Washington, DC 20590
ATTN: Mr. Vasanth Ganesan
PH: (202) 366-0623 e-mail: vasanth.ganesan.ctr@dot.gov
FAX: (202) 366-3671

The requirements set forth in these terms and conditions supersede previous financial invoicing requirements for Financial Assistance awardees.

B. Approved Project Proposal/Budget

The Recipient's approved proposal/application entitled, **Rapid Exploitation of Commercial Remotely Sensed Imagery for Disaster Response & Recovery** and accompanying Project Budget, SF 424 and SF424A, as finally revised on **September 9, 2012**, is incorporated into and made a part of this Cooperative Agreement. (SF 424 Series of forms are incorporated by reference). Any reallocation of funds is governed by and subject to 49 CFR, Part 19, Subpart C Post-Award Requirements, Section 19.25, Revision of Budget and Program Plans."

C. Payment of Reimbursement

NOTE: The Recipient must be registered in the Central Contractor Registration (CCR) to receive payment on its invoices. For information on how to register, log on to www.ccr.gov.

(a) Method of Payment.

- (1) All payments by the Government under this agreement will be made by electronic funds transfer (EFT), except as provided in paragraph (a)(2) of this clause. As used in this clause, the term "EFT" refers to the funds transfer and may also include the payment information transfer.
- (2) If the Government is unable to release one or more payments by EFT, the Recipient agrees to either—
 - (i) Accept payment by check or some other mutually agreeable method of payment; or
 - (ii) Request the Government to extend the payment due date until such time as the Government can make payment by EFT (but see paragraph (d) of this clause).

(b) Recipient's EFT Information. The Government will make payment to the Recipient using the EFT information contained in the CCR database. If the EFT information changes, the Recipient is responsible for providing the updated information to the CCR database.

(c) Mechanisms for EFT Payment. The Government may make payment by EFT through either the Automated Clearing House (ACH) network, subject to the rules of the National Automated

Clearing House Association or the Fedwire Transfer System. The rules governing Federal payments through the ACH are contained in 31 CFR Part 210.

(d) **Suspension of Payment.** If the Recipient's EFT information in the CCR database is incorrect, the Government need not make payment to the Recipient under this agreement until correct EFT information is entered into the CCR database. Any invoice or agreement-financing request sent during this period will not be considered a proper invoice for the purpose of prompt payment under this agreement. The prompt payment terms of the agreement regarding notice of an improper invoice and delays in accrual of interest penalties apply.

(e) **Recipient EFT Arrangements.** If the Recipient has identified multiple payment receiving points (i.e., more than one remittance address and/or EFT information set) in the CCR database, and the Recipient has not notified the Government of the payment receiving point applicable to this agreement, the Government will make payment to the first payment receiving point (EFT information set or remittance address as applicable) listed in the CCR database.

(f) **Liability for Uncompleted or Erroneous Transfers.**

(1) If an uncompleted or erroneous transfer occurs because the Government used the Recipient's EFT information incorrectly, the Government remains responsible for:

- (i) Making a correct payment;
- (ii) Paying any prompt payment penalty due; and
- (iii) Recovering any erroneously directed funds.

(2) If an uncompleted or erroneous transfer occurs because the Recipient's EFT information was incorrect, or was revised within 30 days of Government release of the EFT payment transaction instruction to the Federal Reserve System, and—

- (i) If the funds are no longer under the control of the payment office, the Government is deemed to have made payment and the Recipient is responsible for recovery of any erroneously directed funds; or
- (ii) If the funds remain under the control of the payment office, the Government will not make payment, and the provisions of paragraph (d) of this clause apply.

(g) **EFT and Prompt Payment.** A payment is deemed to have been made in a timely manner in accordance with the prompt payment terms of this agreement if, in the EFT payment transaction instruction released to the Federal Reserve System, the date specified for settlement of the payment is on or before the prompt payment due date and the specified payment date is a valid date under the rules of the Federal Reserve System.

(h) **EFT and Assignment of Claims.** If the Recipient assigns the proceeds of this agreement as provided for in the assignment of claims terms of the agreement, the Recipient must require as a condition of any such assignment that the assignee register in the CCR database and be paid by EFT in accordance with the terms of this clause. In all respects, the requirements of this clause apply to the assignee as if it were the Recipient. EFT information that shows the ultimate recipient of the transfer to be other than the Recipient, in the absence of a proper assignment of claims acceptable to the Government, is incorrect EFT information within the meaning of paragraph (d) of this clause.

(i) **Liability for change of EFT Information by Financial Agent.** The Government is not liable for errors resulting from changes to EFT information made by the Recipient's financial agent.

(j) **Payment Information.** The payment or disbursing office will forward to the Recipient available payment information that is suitable for the transmission as of the date of release of the EFT instruction to the Federal Reserve System. The Government may request the Recipient to designate a desired format and method(s) for delivery of payment information from a list of formats and methods the payment office is capable of executing. However, the Government does not guarantee that any particular format or method of delivery is available at any particular payment office and retains the latitude to use the format and delivery method most convenient to the Government. If the Government makes payment by check in accordance with paragraph (a) of this clause, the Government will mail the payment information to the remittance address contained in the CCR database.

D. Funding and Funding Schedule

(1) Resources provided by USDOT RITA to the Recipient under this agreement are required to be matched by the Recipient, in cash and/or in-kind, and from non-Federal sources, on at least a 100% basis. That is, the Recipient

(and / or the Recipient's sub-Recipients) must contribute to this project, from non-Federal sources, one dollar for every dollar that the USDOT pays to the Recipient. USDOT RITA will provide funds in the amount of \$371,750 to support the Recipient for a two-year period beginning on the effective date of this Agreement. The Recipient's share of the fund matching and in-kind contributions for the two-year period shall be at least \$382,630. The Total Project Value (total Federal Price, plus total cost-share) is \$754,380. The Recipient bears any cost overruns exceeding RITA's share.

Funding in addition to the amount initially obligated (but never exceeding the agreed-upon total Federal price of this project) may be provided subject to availability of future appropriated funds and the successful completion of planned efforts.

(2) The Recipient is responsible for documenting and maintaining all cost sharing records for a period of three years after the expiration date of this agreement. The Recipient (and / or the sub-Recipients) will provide cost-sharing in an amount to at least match this project's Federal funding requirement over the period of the award, in a flexible schedule of delivery that will accomplish the level of match proposed during the period of performance. The Recipient will track the matching with a dedicated accounting system. The Program Manager may request these detailed cost share records if further clarification for appropriateness is required.

(3) During the period of this agreement, the Recipient will match in cash and/or in-kind, on at least a 100% (dollar-for-dollar) basis, any additional Federal funding USDOT provides.

Also, the recipient must satisfactorily meet the cost share requirements annually during this period.

7. REPORTS, REVIEWS, AND DELIVERABLES

The following items will be applicable for the period of performance of the original awards & all subsequent extensions, if any:

A. Financial Reporting Requirements

(1) The Recipient must submit an original and one copy of the Federal Financial Report (Standard Form 425) to report the status of funds for all non construction cooperative agreements. Each report is due 30 days after completion of each quarter of the project, except for the final Financial Status Report, which is due 90 days after projection completion. The report must be prepared in accordance with the instructions on the reverse side of the form. The Recipient must submit a check made payable to "U.S. Department of Transportation" for the unobligated balance of Federal funds remaining at the end of the project period (this report is subject to audit). All reports should be prepared on an accrual basis. If the Recipient's accounting records are not normally kept on the accrual basis, the Recipient is not required to convert its accounting system but must develop such information through best estimates based on an analysis of the documentation on hand.

(2) If this agreement provides for advances to Recipient, the Recipient must submit a Federal Cash Transaction Report (Standard Form 272) 15 working days following the end of each quarter.

(3) The Recipient must submit an original and one electronic copy of the reports to the PM - Refer to Section 7.C. of this Agreement.

B. Reports and Performance Review Requirements

(1) **Quarterly Progress Reports.** The Recipient must submit a quarterly report, by the 15th calendar day after the end of each 3-month period, in electronic format, to the PM. Further details on requirements for this submission are shown in Attachment 2, Project Deliverables, and Attachment 3, Technical and Deliverable Milestone Schedule, to this Agreement. The report must address the following:

- **Accomplishments.** Provide a clear and complete account of work performed on each task and its relationship to task objectives and milestones;
- **Future Plans.** Discuss work planned for the next period and its relationship to the present period. Provide an outline of the work to be accomplished during the next report;

- **Problems Encountered.** Describe any problems encountered or anticipated that will affect the completion of the agreement within the time and fiscal constraints as set forth in the agreement, together with recommended solutions to such problems, or a statement that no problems were encountered;
- **Funds Expended and Program Schedule.** Highlight any changes to the schedule as previously reported and provide a tabulation of the planned, actual and cumulative labor-hours expended for the program along with a chart showing current and cumulative expenditures versus planned expenditures; and
- **Effort.** Effort expended by task for all staff categories must be reported.

(2) **Bi-Annual Performance Reviews.** A Bi-Annual Review must be conducted six months of Agreement performance. The Recipient’s Principal Investigator must make a presentation using visual aids, such as slides, view graphs, handouts, and any other graphic display that will aid the reviewer in understanding the status of the agreement performance. The presentation must cover the status of agreement tasks and deliverables and include a summary of the activity and the progress made during the past six months and the projected activity for the next six months. Any problems encountered will be addressed in the review.

The Bi-Annual review will also consist of a project status session that shall include, as participants, the Recipient, and the PM. This session will be used as a forum to discuss key scheduling and resource issues including costs incurred, cost budgeted, and costs to complete each agreement task.

The Recipient must provide an agenda of each review, along with copies of materials to be presented, to the PM at least five (5) days prior to each review. Scheduling of the Bi-Annual Reviews will be mutually agreed upon between the Government’s PM and the Recipient’s PI.

(3) **Final Progress Report.** The Recipient must provide a final progress report within 30 days following the Agreement expiration date. Copies are to be provided, in electronic format, to the PM. The final report must include the details of accomplishing the tasks and described as prescribed in the Agreement statement of work.

(4) **Research Project Descriptions.** Within one month after project selection, the PI shall submit to the Transportation Research Board's Research in Progress (RiP) database a project description. The project information can be entered into the RiP database directly; Recipients are required to provide complete submissions to RiP including the fields for start and completion dates, total planned costs and sponsoring agency. To obtain login credentials, please contact Lisa Loyo, (lloyo@nas.edu), TRB's Manager of Information Services. Once logged in, please view the webinar on how to enter the records. The PI is responsible for updating and maintaining project information in RiP.

C. Deliverables Matrix

All quarterly deliverables will be based on a calendar year format covering the periods: January 01 to March 31, April 01 to June 30, July 01 to September 30, October 01 to December 31. Deliverables covering partial periods of performance up to one month will be rolled over into the subsequent period of performance reports.

The Recipient must provide copies of all deliverables to the PM as shown in the Matrix shown below.

<u>Report</u>	<u>No. Copies</u>	<u>Submit To:</u>	<u>Due Date</u>
Deliverables as identified in Attachment 2	1 Electronic	PM	Delivery Times as stated in Agreement Attachment 3, Technical and Deliverable Milestone Schedule
Quarterly Status Report	1 Electronic	PM	15 calendar days after the end of each quarter and as stated in Agreement Attachments 2 and 3

Final Report	2 Original {Color} + 1 Electronic	PM	30 calendar days following Agreement expiration and as stated in Agreement Attachments 2 and 3
SF-425	Original + 1 Electronic	PM	30 calendar days after the end of each quarter and 90 days after Project Completion

Please copy Vasanth Ganesan (vasanth.ganesan.ctr@dot.gov) on all electronic submissions to the PM.

8. NOTICE OF NEWS RELEASES, PUBLIC ANNOUNCEMENTS, AND PRESENTATIONS

The Recipient must provide to the PM for agency review, prior to release, one (1) copy of all press releases, formal announcements, or other planned public announcements in newspapers, magazines, journals, conferences etc. containing news or information concerning this Cooperative Agreement. The Recipient must submit for PM's advance review: (a) any such planned public presentations/briefings related to this Cooperative Agreement; and (b) the actual presentation (e.g. slides/vu-graphs) to be used. Also, a disclaimer shall be included in all the materials. The following is an example disclaimer statement for your use:

"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/RITA, or any State or other entity."

The PM will coordinate with the RITA Office of Governmental, International and Public Affairs, which has final approval authority over all press releases, public announcements and other informational and marketing materials.

9. CONTRACTING WITH SMALL AND MINORITY FIRMS, WOMEN BUSINESS ENTERPRISES, VETERAN-OWNED, AND HUB-ZONE AREA FIRMS

A. It is Department of Transportation (DOT) policy to award a fair share of contracts to small, minority business, women-owned, veteran-owned and HUBZone firms. USDOT is strongly committed to the objectives of this policy and encourages all recipients of its grants and cooperative agreements to take affirmative steps to ensure such fairness on the awarding of any subcontracts under this agreement.

B. The Recipient and any sub-recipient must take all necessary affirmative steps to assure that small, women-owned, minority disadvantaged businesses, veteran, and HUBZone business firms are used when possible.

C. Affirmative steps include:

(1) Placing qualified small and minority disadvantaged businesses, women-owned business enterprises, veteran-owned and HUBZone business firms on solicitation lists;

(2) Assuring that small and minority businesses, women business enterprises, veteran-owned and HUBZone business firms are solicited whenever they are potential sources;

(3) Dividing total requirements, when economically feasible, into small tasks or quantities to permit maximum participation by small and minority business, women business enterprises, veteran-owned, and HUBZone business firms;

(4) Establishing delivery schedules, where the requirement permits, which encourage participation by small and minority business, women business enterprises, veteran-owned, and HUBZone business firms; and

(5) Using the services and assistance of the Small Business Administration and the Office of Small and Disadvantaged Business Utilization of the Department of Transportation as appropriate.

10. SEAT BELT USE POLICIES AND PROGRAMS

In accordance with Executive Order 13043, the Recipient of this award is encouraged to adopt on-the-job seat belt use policies and programs for its employees when operating company-owned, rented, or personally-owned vehicles. The National Highway Traffic Safety Administration (NHTSA) is responsible for providing leadership and guidance in support of this Presidential initiative.

For information on how to implement such a program or for statistics on the potential benefits and cost-savings to your company or organization, please visit the *Buckle Up America* section on NHTSA's website at www.nhtsa.dot.gov. Additional resources are available from the Network of Employers for Traffic Safety (NETS), a public-private partnership headquartered in Washington, D.C. dedicated to improving the traffic safety practices of employers and employees. NETS is prepared to help with technical assistance, a simple, user-friendly program kit, and an award for achieving the President's goal of 85 percent seat belt use. NETS can be contacted at 1 (888) 221-0045 or visit its website at www.trafficsafety.org.

11. PATENTS AND COPYRIGHTS

a) **Patent Rights.** The Recipient shall notify USDOT promptly if any patentable invention(s), improvement(s), or discovery/discoveries are produced under this Agreement. The rights and responsibilities of the Recipient and the Federal government with respect to such patentable items will be determined in accordance with applicable Federal laws, regulations, policies, and any waiver thereof.

b) **Copyrights.**

i) The author or the Recipient organization may copyright any books, publications, or other copyrightable materials developed in the course of or under this Agreement, but USDOT hereby reserves a royalty-free, nonexclusive and irrevocable license to reproduce, publish, or otherwise use and to authorize others to use the work for government purposes.

ii) The Recipient shall not incorporate material copyrighted by others into any work product delivered under this Agreement unless it has acquired for USDOT a royalty-free, nonexclusive and irrevocable license to reproduce, publish, or otherwise use and to authorize others to use the work for government purposes.

iii) The Recipient may arrange for publication of initial reports of original research, supported in whole or in part by USDOT funds, in primary scientific journals and copyright by the journal unless the journal's copyright policy would preclude an individual from making or having made by any means available, without regard to the copyright of the journal and without royalty, a single copy of any such article for the individual's own use.

iv) The Recipient shall be responsible for any losses that result from or arise out of the negligent use of or breach of provisions by its employees or agents under this Agreement regarding the publication, translation, reproduction, delivery, use, or disposition of any data or protected privacy information furnished under this Agreement provided that this provision shall not be deemed a waiver by Recipient of any immunities to which it may be entitled under applicable Federal, State, or Tribal law.

12. ADHERENCE TO ORIGINAL PROJECT OBJECTIVES AND BUDGET ESTIMATES

A. The Recipient is responsible for any commitments or expenditures it incurs in excess of the funds provided by an award. Expenditures incurred prior to the effective date of an award cannot be charged against award funds unless provided for in the award.

B. The Recipient must submit any proposed change that requires USDOT's written approval 30 days prior to the

requested effective date of the proposed change. No change to the award will be approved during the last 30 days of the award period.

C. (1) The following expenditures require the PM's advance written approval:

(a) Changes in the scope, objective, or key personnel referenced in the Recipient's proposal.

(b) Transfer of funds between direct cost categories when the cumulative amount of transfers during the project period exceeds \$5,000.

(c) Acquisition of nonexpendable property having a useful life of more than 2 years and having an acquisition cost of \$5,000 or more.

(d) Change in the project period. This request must be received no later than 30 calendar days prior to the end of the project period. The Recipient must submit a revised budget indicating the planned use of all unexpended funds during the extension period.

(2) The Recipient must submit a revised financial estimate and plan for (a) through (c) above.

(3) The PM will notify the Recipient in writing within 30 calendar days after receipt of the request for revision or adjustment whether the request has been approved.

D. Foreign Travel. Travel outside the 50 states and District of Columbia is considered foreign travel and a written request must be approved by the USDOT prior to such travel. In order to be approved, the need for the proposed foreign travel and the value to be gained by the participant(s) must be clearly demonstrated. Requests for approval shall include a written justification that states the name and relationship of the traveler to the agreement, describes how the travel will further the goals of the agreement, provides a detailed itinerary and breakdown of planned expenses, and carries the endorsement of the Principal Investigator. No requests submitted after the travel has begun will be approved. Inclusion of an amount for foreign-travel costs in an approved annual budget does not satisfy the requirement for prior approval.

13. VIOLATION OF AWARD TERMS

If the Recipient has materially failed to comply with the terms of the award, then the Program Manager may suspend or terminate the Agreement, or take other remedies as may be legally available and appropriate in the circumstances. In addition, this cooperative agreement may be terminated by the Recipient as well. Under the terms of this agreement, a written Notice will be provided to the other Party, at least thirty (30) days prior to the effective date of termination. The Recipient shall be reimbursed for all costs and any non-cancelable obligations which were properly incurred up to the date of Notice of Termination.

14. APPLICABLE CIRCULARS/REGULATIONS

The Recipient is subject to the following OMB circulars/regulations as amended, which are incorporated into this Agreement by reference. Copies of these Circulars can be obtained directly from the Internet at: http://www.whitehouse.gov/omb/circulars_default.

A. Nonprofit Organizations

1) OMB Circular A-110, Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Nonprofit Organizations;

2) Federal Acquisition Regulation (FAR) Part 31, Contract Cost Principles and Procedures shall apply in lieu of OMB Circular A-122, Cost Principles for Nonprofit Organizations; and,

3) OMB Circular A-133, Audits of States, Local Governments and Non Profit Organizations. University of

Vermont currently is audited by KPMG. Annual copies for recipients A-133 compliance audit will be Mailed upon request and recipient shall address any non-compliance issues.

B. Department of Transportation - Copies of these regulations can be accessed via USDOT's website at www.dot.gov/ost/m60/grant/regs.htm.

- 1) 49 CFR Part 17 "Intergovernmental Review of Department of Transportation Programs and Activities"
- 2) 49 CFR Part 19 "Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Non-Profit Organizations"
- 3) 49 CFR Part 20 "New Restrictions on Lobbying"
- 4) 49 CFR Part 21 "Nondiscrimination in Federally-Assisted Programs of the Department of Transportation Effectuation of Title VI of the Civil Rights Act of 1964"
- 5) 49 CFR Part 29 "Governmentwide Debarment and Suspension (Non-Procurement)"
- 6) 49 Part 32 "Governmentwide Requirements for Drug Free Workplace (Financial Assistance)"
- 7) DOT Order 4600.17A "Financial Assistance Management Requirements (March 30, 2000)"
- 8) As a recipient of USDOT assistance, you must review the list of parties excluded from Federal procurement or non-procurement programs located on the Excluded Parties List System (EPLS) website: <http://www.epls.gov/> before entering into a sub-agreement or contract.

As a recipient of USDOT assistance, you must inform RITA when you take action to suspend or debar a contractor, person or entity.

C. Others

- 1) Treasury Circular No. 1075 "Regulations Governing Withdrawal of Cash from the Treasury for Advances under Federal Grant and Other Programs"
- 2) 31 CFR 205 "Rules and Procedural Guidelines for Efficient Federal-State Funds Transfers"
- 3) Assurances and Ratifications "Grant/Cooperative Agreement Application and Assurances Contained Therein"

Attachments 1, 2, and 3 follow

ATTACHMENT 1: TEAM PROJECT ACTIVITIES

- Task 1: Creation of a Technical Advisory Committee
- Task 2: Creation of a project website
- Task 3: Damage detection system methods development
 - Data preparation
 - Rule set development
 - Feature extraction
 - Object fate analysis
 - Testing and validation of detection algorithms
 - Overlay analysis, extraction of coordinates, feeding to web portal
- Task 4: Fill calculation system methods development
 - Calibration of fill quantity algorithm.
 - Fill type algorithm development.
 - Geoprocessing model and interface development
- Task 5: Development of web portal decision support tool
 - Google Fusion Tables back-end architecture development
 - Interface development
 - Social media integration
- Task 6: Project outreach and communication
 - Damage detection methodology documentation, video tutorial and expert rule set publication
 - Fill calculation methodological documentation, geoprocessing tool files/user manual, and video tutorial
 - Decision support web portal methodology document with guides for users and IT administrators
 - Focus group meeting with partners to get feedback on outputs
 - Exploration of transfer of tools to other DOTs
 - Publications and presentations
 - Final draft and revised reports

ATTACHMENT 2: PROJECT DELIVERABLES

- Convening of first advisory board meeting and summary report of meeting notes. 2 months, followed by 2-3 more meetings during the project.
- A web page for the project that provides a centralized location for information on the project, project updates, and links to products. 2 months for setup, then regular updates.
- A white paper technical document outlining the role in which CRS satellite imagery plays in disaster response and recovery targeted at state transportation departments. 3 months.
- A minimum of four blog posts about various aspects of the project posted to the Spatial Analysis Lab's blog "Letter from the SAL" (<http://letters-sal.blogspot.com/>). Letters from the SAL is replicated through the popular Planet Geospatial blog aggregator. Completed at 6, 12, 18, and 24 months.
- A video showing users how to download CRS satellite imagery from the USGS Hazard Data Distribution System. 2 months.
- A knowledge base of feature extraction and classification rules for identifying road damage from high-resolution imagery, for re-use in commercially available object-based image analysis software. 12 months.
- An object-based image analysis system that allows an end-user with basic GIS skills to load imagery, detect damage, and review candidate damage locations. 18 months.
- A video demonstrating the damage detection workflow within the object-based image analysis system. 18 months.
- A customized geoprocessing model that automates the calculation of fill amounts by type for road damage. 20 months.
- An operational web-mapping portal that identifies road damage on a web map and, when points are clicked, gives information on fill. This web map will be deployed for Vermont, including data from the 2011 Tropical Storm Irene and any subsequent major spring floods that occur during the project period. We will also deploy a similar web-mapping portal for one other flood disaster in another state. 22 months
- A technical report that describes in accessible terms the damage detection and fill calculation methodologies plus the development of the web portal and Google Fusion Tables. 22 months
- Brief web portal manuals for users and IT administrators. 23 months
- A minimum of one scholarly publication on the methodological approach. 24 months.
- A "best practices" technical document on the use of low-cost commercial UAVs for transportation-related mapping. 18 months.
- A draft and revised final report summarizing all the project activities. 24 months.
- A minimum of two presentations on the project or aspects of the project at regional or national transportation/geospatial conferences. 12 months and 24 months.
- Scholarly publications on the methodology. 24 months.

Completion times given in months from start of project

Attachment 3: MILESTONES FOR TASKS AND DELIVERABLES							
Task No.	Activity/Deliverable	Quarter No.	Expected Completion Date/Mos	Milestone	Projected		
					Federal Payment	Projected Partner Cost-Sharing Total	
2	Internal kick-off activities, additional background research, hardware/software purchase and installation, web site	1	month 3	Project startup activities, including advisory board meeting, project website setup, and software acquisition	\$35,800	\$275,000	\$310,800
1	Stakeholder/partner kick-off meetings	1	month 3	White paper on CRS in disaster response and recovery.	\$1,750	\$5,490	\$7,240
3	Imagery archive queries and download	1	month 1	CRS satellite imagery acquisition	\$3,800	\$55,000	\$58,800
6	1st Quarterly Status Report	1	month 3	Submit 1st quarterly report	\$2,500		\$2,500
First Payable Milestone					\$43,850	\$335,490	\$379,340
3	Damage detection decision support design	2	month 5	Damage detection decision support design detailed specification	\$5,000		\$5,000
4	Fill estimation decision support design	2	month 5	Fill estimation decision support design detailed specifications	\$4,100		\$4,100
4	UAV flight training and testing	2	month 21	UAV flight operations	\$1,267		\$1,267
6	2nd Quarterly Status Report	2	month 6	Submit 2nd quarterly report	\$2,500		\$2,500
Second Payable Milestone					\$12,867	\$0	\$12,867
1	System design review	3	month 7	Stakeholder/partner meetings	\$2,450	\$5,490	\$7,940
3	Image registration routines	3	month 8	Damage detection decision support development	\$9,600		\$9,600
3	Import routines	3	month 8	Damage detection decision support development	\$5,400		\$5,400
3	Ruleset set development	3	month 20	Damage detection decision support development	\$8,440	\$10,000	\$18,440
4	Fill calculations prototyping	3	month 16	Fill estimation decision support development	\$2,050		\$2,050
4	UAV flight training and testing	2	month 21	UAV flight operations	\$1,267		\$1,267
6	3rd Quarterly Status Report	3	month 9	Submit 3rd quarterly report	\$2,500		\$2,500
Third Payable Milestone					\$31,707	\$15,490	\$47,197
5	Web-site front end/back end work	4	month 24	Web-based tool development	\$13,200		\$13,200
5	Post damage geoprocessing tools	4	month 13	Damage detection decision support development	\$15,000		\$15,000
3	Damage detection routine testing	4	month 11	Damage detection decision support deployment	\$8,400	\$9,844	\$18,244
4	Cost-based image matching	4	month 13	Fill estimation development	\$14,000	\$15,000	\$29,000
4	Fill calculations geoprocessing tool development	4	month 13	Fill estimation development	\$13,000		\$13,000
6	HDDS tutorial video	4	month 10	Outreach materials	\$1,410		\$1,410
3	Ruleset set development	3	month 20	Damage detection decision support development	\$8,440		\$8,440
4	Fill calculations prototyping	3	month 16	Fill estimation decision support development	\$2,050		\$2,050
4	UAV flight training and testing	2	month 21	UAV flight operations	\$1,267		\$1,267
6	4th Quarterly Status Report	4	month 12	Submit 4th quarterly report	\$2,500		\$2,500
Fourth Payable Milestone					\$79,267	\$24,844	\$104,111
3	Validate damage detection routines	5	month 13	Damage detection decision support development	\$8,149		\$8,149
4	Field crews deploy for fill estimation	5	month 22	Fill estimation decision support deployment	\$1,775		\$1,775
4	Validate fill estimation	5	month 14	Fill estimation decision support validation	\$1,600		\$1,600
3	Ruleset set development	3	month 20	Damage detection decision support development	\$8,440		\$8,440

4	Fill calculations prototyping	3	month 16	Fill estimation decision support development	\$2,050	
4	UAV flight training and testing	2	month 21	UAV flight operations	\$1,267	
6	5th Quarterly Status Report	5	month 15	Submit 5th quarterly report	\$2,500	\$2,500
Fifth Payable Milestone						
4	Identify additional site for damage detection decision support	5	month 15	SUBTOTAL	\$25,781	\$0
4	3D model generation refinement	6	month 16	Damage detection decision support deployment	\$1,850	\$1,850
3	Ruleset set development	6	month 18	Fill estimation decision support development	\$6,300	\$6,300
4	Fill calculations prototyping	3	month 20	Damage detection decision support development	\$8,440	\$8,440
4	UAV flight training and testing	3	month 16	Fill estimation decision support development	\$2,050	\$2,050
4	Field crews deploy for fill estimation	2	month 21	UAV flight operations	\$1,267	\$1,267
6	6th Quarterly Status Report	5	month 22	Fill estimation decision support deployment	\$1,775	\$1,775
		6	month 18	Submit 6th quarterly report	\$2,500	\$2,500
Sixth Payable Milestone						
6	Stakeholder/partner meetings to review decision support systems	6	month 18	SUBTOTAL	\$24,182	\$0
5	Damage detection decision support final deployment	7	month 19	Meetings with stakeholders and partners	\$3,300	\$1,179
5	Fill estimation decision support final deployment	7	month 21	Damage detection decision support deployment	\$74,651	\$74,651
3	Ruleset set development	7	month 21	Fill estimation decision support deployment	\$37,190	\$2,129
4	UAV flight training and testing	3	month 20	Damage detection decision support development	\$8,440	\$8,440
4	Field crews deploy for fill estimation	2	month 21	UAV flight operations	\$1,267	\$1,267
6	7th Quarterly Status Report	5	month 22	Fill estimation decision support deployment	\$1,775	\$1,775
		7	month 21	Submit 7th quarterly report	\$2,500	\$2,500
Seventh Payable Milestone						
6	Write technical documentation and manuals	7	month 21	SUBTOTAL	\$129,123	\$3,308
4	Field crews deploy for fill estimation	8	month 23	Technical documentation and manuals	\$2,800	\$2,800
6	Write publications	5	month 22	Fill estimation decision support deployment	\$1,775	\$3,498
6	Write presentations	8	month 23	Peer-reviewed publications	\$9,000	\$12,498
6	Draft final report	8	month 24	Presentations	\$7,000	\$7,000
6	Revised final draft report	8	month 24	Submit Draft Final Report	\$4,400	\$4,400
		8	month 24	Submit Revised Final Draft Report	\$0	\$0
Eighth Payable Milestone						
		8	month 24	SUBTOTAL	\$24,975	\$3,498
GRAND TOTALS						
					\$371,750	\$382,630
						\$754,380

#####End of Cooperative Agreement # RITARS-12-H-UVM#####