

# RESEARCH PERFORMANCE PROGRESS REPORT

## SUBMITTED TO:

U. S. Department of Energy  
National Energy Technology Laboratory

**WORK PERFORMED UNDER AGREEMENT:** DE-FE0029020

## PROJECT TITLE:

*Smart Methane Emission Detection System Development*

## SUBMITTED BY:

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**SUBMISSION DATE:** January 30, 2017

**DUNS NUMBER:** 007936842

## RECIPIENT ORGANIZATION:

Southwest Research Institute®  
6220 Culebra Road  
San Antonio, TX 78238

## PROJECT/GRANT PERIOD:

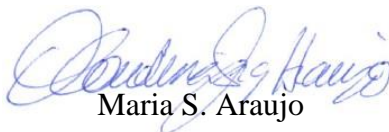
October 1, 2016 through September 30, 2017

## REPORTING PERIOD END DATE:

December 31, 2016

**REPORT TERM OR FREQUENCY:** Quarterly

## SIGNATURE OF SUBMITTING OFFICIAL:



Maria S. Araujo

## ACCOMPLISHMENTS

### What was done? What was learned?

As anticipated, and defined in the Project Management Plan (PMP), activities during the first two months of the quarter focused on management and document preparation, and included the ordering of equipment necessary to execute the project. This latter activity began in earnest during the second month of the quarter; equipment needed to start execution of technical tasks arrived on the first week of December 2016.

- **What are the major goals of the project?** The major objective of this Department of Energy (DOE) research project is to develop an autonomous, real-time methane leak detection technology, the Smart Methane Leak Detection System (SLED), which applies machine learning techniques to passive optical sensing modalities to mitigate emissions through early detection. The goal during Phase 1 is to develop the prototype methane detection system with integrated optical sensors and the embedded processing unit. The goal for Phase 2 will be to integrate and field-test the prototype system, and then demonstrate the capabilities to the DOE.

To accomplish these goals, Southwest Research Institute (SwRI®) has identified a comprehensive schedule with milestone dates for important activities that will evidence progress on the project. The milestone schedule, with actual completion dates or percentage, is shown below.

Phase	Milestone Description	Verification Method	Planned Completion	Completion Date or Percentage Completed
1	Prepare and Submit the PMP	Delivery to DOE	10/29/16	10/29/2016
1	Update PMP with DOE Comments	Delivery to DOE	12/2/16	11/16/2016
1	Update the Data Management Plan	Delivery to DOE	12/16/16	12/16/2016
1	Develop the Algorithm	Assessment Results	6/19/17	
1	Develop and Assemble Prototype	Testing Results	8/29/17	
2	Integrate and Test Prototype	Testing Results	4/23/18	
2	Demonstrate the System to DOE	Demonstration	8/21/18	

There have been no significant changes in approach or methods from the approved PMP.

- **What was accomplished under these goals?**
  - As part of the overall Task 1.0 Project Management, SwRI prepared a draft PMP and delivered it to the DOE for review. On 11/16/2016, the DOE notified the SwRI Project Manager (PM) that no changes were required on the PMP at that time, such that the draft PMP submitted on 10/29/16 was considered final for the purposes of the updated PMP that was to be submitted by 12/2/16.
  - SwRI updated the Data Management Plan (DMP) that was originally provided with the proposal, and that revised DMP was furnished to DOE on 12/16/16. Further, SwRI ordered equipment necessary to begin Task 2.0, Algorithm Development. The core equipment ordered included the following cameras:

- Niatros™ Optical Gas Imaging Camera (Mid-wave Infrared Camera)
- FLIR A6604 Optical Gas Imaging Camera (Mid-wave Infrared Camera)
- Once the equipment was received, SwRI began setting up, configuring, and calibrating the cameras, as shown in Figure 1. The Mid-Wave Infrared (MWIR) cameras are being utilized as the transducers to capture frames in search of methane gases. The cameras are configured and calibrated to effectively capture the environment under varying illumination, weather conditions, and distances.
- SwRI also evaluated an initial set of configurations under realistic conditions to establish a baseline database containing methane leaks of various concentrations, distances, and scenarios. These conditions include an initial set of varying ambient temperature conditions, cloud cover, presence and lack of obstacles (such as piping), and varying wind (including stagnant) conditions. Figure 2 shows one of the tests conducted during the month of December to acquire an initial set of data to train the classification algorithm.



**Figure 1: Niatros™ and FLIR MWIR Cameras**



**Figure 2: Niatros™ and FLIR MWIR Cameras Acquiring Data During a Supervised Methane Release**

- **What opportunities for training and professional development has the project provided?**  
Nothing to report during this reporting period.
- **How have the results been disseminated to communities of interest?** Nothing to report during this period. With the DOE's concurrence, SwRI would like to publish papers at key conferences to disseminate information about this project.
- **What does SwRI plan to do during the next reporting period to accomplish the goals?**  
During the next reporting period, SwRI will:
  - Continue to perform the data collection and cataloguing, and work on the feature extraction and analysis. The former activity will involve several rounds of data collection, varying from simplified to more complex, realistic methane emissions scenarios.
    - The sensor setup will be used to capture data from several controlled methane releases under varying flows and environmental conditions.
    - Data will consist of images and continuous frames from the two MWIR cameras that will be used during this project. This data will be parsed, catalogued, and stored for the algorithm development.
  - Initiate algorithm development. For this task, a set of comprehensive image processing and convolutional neural networks (deep learning) techniques will be applied to evaluate the captured baseline database containing various methane leaks to extract significant spectral, spatial, and temporal information unique to methane gas.
    - The algorithm development will utilize ground truth labels to define key methane characteristics, such as, but not limited to, flow rate and concentration. These characteristics will not be determined by the feature analysis but instead used to evaluate the quality of the features.
  - Initiate embedded processor code development.
    - This task will involve acquiring the embedded processor boards and developing the initial embedded environment.

## PRODUCTS

### What has the project produced?

As explained earlier, the first quarter of the project focused primarily on management and document preparation, and procurement activities for the required equipment. Initial methane release tests were conducted as well for initial calibration, setup, and algorithm development. To date, the project has not produced anything of merit.

- **Publications, conference papers, and presentations**
  - **Journal publications** - Nothing to Report
  - **Books or other non-periodical, one-time publications** - Nothing to Report
  - **Other publications, conference papers and presentations** - Nothing to Report
- **Website(s) or other Internet site(s)** - Nothing to Report
- **Technologies or techniques** - Nothing to Report
- **Inventions, patent applications, and/or licenses** - Nothing to Report
- **Other products** - Nothing to Report

## PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (optional)

### Who has been involved?

Per the reporting guidance, no staff member has yet worked 160 hours on this project. The primary participant to date has been the Principal Investigator (PI).

- **What individuals have worked on the project?**

The following individuals were the main contributors to this project during this reporting period:

1. **Name:** Maria Araujo
  - a. **Project Role:** PI
  - b. **Nearest person month worked:** 1
  - c. **Contribution to Project:** Ms. Araujo performed the project planning, participated in the kick-off meeting with the DOE, prepared the PMP and DMP documents and updates, and oversaw tests performed during this reporting period.
  - d. **Funding Support:** N/A
  - e. **Collaborated with individual in foreign country:** No
  - f. **Country(ies) of foreign collaborator:** N/A
  - g. **Travelled to foreign country:** Yes, Canada (travel unrelated to this project)
  - h. **If traveled to foreign country(ies), duration of stay:** 1 week
2. **Name:** Edmond DuPont
  - a. **Project Role:** Co-PI
  - b. **Nearest person month worked:** 1
  - c. **Contribution to Project:** Dr. DuPont assisted with tests performed during this reporting period.
  - d. **Funding Support:** N/A
  - e. **Collaborated with individual in foreign country:** No

- f. **Country(ies) of foreign collaborator:** N/A
  - g. **Travelled to foreign country:** No
  - h. **If traveled to foreign country(ies), duration of stay:** N/A
3. **Name:** Daniel Davila
- a. **Project Role:** Developer
  - b. **Nearest person month worked:** 1
  - c. **Contribution to Project:** Mr. Davila assisted with tests performed during this reporting period.
  - d. **Funding Support:** N/A
  - e. **Collaborated with individual in foreign country:** No
  - f. **Country(ies) of foreign collaborator:** N/A
  - g. **Travelled to foreign country:** Yes, Canada (travel unrelated to this project)
  - h. **If traveled to foreign country(ies), duration of stay:** 1 week

- **What other organizations have been involved as partners?** There are no other planned partner organizations besides the cost share partners.
- **Have other collaborators or contacts been involved?** Although this is planned, no other collaborators or contacts have yet been involved.

### **IMPACT (optional)**

#### **What is the impact of the project? How has it contributed?**

Although SwRI fully expects this project to provide significant impacts that benefit the nation, development is not yet to a point where any impacts can be noted.

- **What is the impact on the development of the principal discipline(s) of the project?** Nothing to Report
- **What is the impact on other disciplines?** Nothing to Report
- **What is the impact on the development of human resources?** Nothing to Report
- **What is the impact on physical, institutional, and information resources that form infrastructure?** Nothing to Report
- **What is the impact on technology transfer?** Nothing to Report
- **What is the impact on society beyond science and technology?** Nothing to Report
- **What dollar amount of the award's budget is being spent in foreign country(ies)?** Nothing to Report

### **CHANGES/PROBLEMS**

SwRI does not anticipate any significant changes in the project or its direction. If this should occur, SwRI is fully aware of its responsibility to provide all relevant details, and to obtain prior written approval from the Contracting Officer.

- **Changes in approach and reasons for change** - Nothing to report during this reporting period.
- **Actual or anticipated problems or delays and actions or plans to resolve them** - Nothing to report during this reporting period.
- **Changes that have a significant impact on expenditures** - Nothing to report during this reporting period.
- **Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards** - Nothing to report during this reporting period.
- **Change of primary performance site location from that originally proposed** - Nothing to report during this reporting period.

### **SPECIAL REPORTING REQUIREMENTS**

SwRI is not aware of any special reporting requirements in the award terms and conditions.

### **BUDGETARY INFORMATION**

The cost status is provided on the next page. It identifies the baseline cost plan, actual incurred costs, and variance.

Budget Reporting Quarter	Budget Period 1								Budget Period 2							
	Q1		Q2		Q3		Q4		Q1		Q2		Q3		Q4	
	10/1-16 - 12/31/16		1/1/17 - 3/31/17		4/1/17 - 6/30/17		7/1/17 - 9/30/17		10/1-17 - 12/31/17		1/1/18 - 3/31/18		4/1/18 - 6/30/18		7/1/18 - 9/30/18	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
<b>Budget Cost Plan</b>																
Federal Share	\$49,000	\$49,000	\$160,000	\$209,000	\$165,000	\$374,000	\$143,407	\$517,407	\$27,748	\$545,155	\$27,747	\$572,902	\$27,747	\$600,649	\$27,747	\$628,396
Non-Federal Share	\$39,345	\$39,345	\$39,345	\$78,690	\$39,345	\$118,035	\$39,345	\$157,380	\$0	\$157,380	\$0	\$157,380	\$0	\$157,380	\$0	\$157,380
Total Planned	\$88,345	\$88,345	\$199,345	\$287,690	\$204,345	\$492,035	\$182,752	\$674,787	\$27,748	\$702,535	\$27,747	\$730,282	\$27,747	\$758,029	\$27,747	\$785,776
<b>Actual Incurred Cost</b>																
Federal Share	\$12,307	\$12,307														\$12,307
Non-Federal Share	\$0	\$0														\$0
Total Incurred Costs	\$12,307	\$12,307														\$12,307
<b>Variance</b>																
Federal Share	\$36,693	\$36,693														\$616,089
Non-Federal Share	\$39,345	\$39,345														\$157,380
Total Variance	\$76,038	\$76,038														\$773,469

The variance for Q1 as shown above. Not only have project expenditures been below the original plan, but the anticipated cost share has not yet been recorded so it also shows as a variance. SwRI expects to make up much of this variance during Q2.