AERIAL EMISSION DETECTION AND MAPPING

Executive Summary Report

The ability to rapidly deploy unoccupied aerial vehicle (UAV) technology for real-time assessments of site emissions could enable oil and gas companies to quickly analyze air quality, identify sources of emissions, and apply mitigation measures if/when appropriate, thereby improving both public and employee safety. The Remote Methane Leak Detector (RMLD) UAV developed by Physical Sciences Inc. (PSI) and manufactured by Heath Consultants Incorporated (Heath) serves as a platform to map path-integrated concentrations of methane in a local area, localize fugitive emissions, and estimate emission rates. The objective of this project was to test and validate the practical application of the RMLD-UAV.

The primary systems that make up the package are the RMLD payload, the UAV, the ground station personal computer (PC), the anemometer, and the handheld ground controller. The specific quality goals and criteria were to locate the leak source to one metre precision and detect and quantify the methane emission with 20% accuracy relative to metered leak rate for each test.

Real time data can be viewed on the ground level PC during the flight of the RMLD-UAV. The location of the UAV and methane concentration in ppm-m is displayed on the screen. After the flight, a heat map is immediately created in which the general location of the elevated methane readings can be seen. This may be useful for operators in the field trying to quickly identify if there is a leak on site and the general area it is located. As this technology is still in development, post-processing time is required to validate the data that may take up to one week. Further processing time may be required to overlap the data onto a high resolution aerial image.

The first field test campaign occurred November 13-17, 2017. A variety of conditions were experienced throughout the week of testing that limited the testing hours and caused the test plan to change. Instead of four full days of testing, due to weather and power issues, two full days of testing were performed. The mass flow controller was only able to run one leak rate at a time, therefore no tests with multiple leak locations were performed.

Two RMLD payloads were used at the beginning of the testing. After the fist two tests with the first generation RMLD, it was discovered that the optics were out of alignment resulting in poor data quality. As a result, Test 1 data was poor quality and not usable. The second generation RMLD was used for the remainder of the testing. The results of all tests are displayed in the table below.

	Actual Leak Rate (L/min)	PSI Estimated Leak Rate (L/min)	Approx. off-set Distance from Actual Leak Location (m)
Test 1	1	No result	No result
Test 2	10	27	5
Test 3	5	-1.4	9
Test 4	3	No leak	No result

Technical difficulties required piecing together multiple data sources, resulting in a loss of data quality and more time to complete the data analysis. Positional accuracy to one metre was not obtained during the tests. The GPS telemetry from the aircraft was not differentially corrected which resulted in positional error of up to 9 metres. The UAV's angle of flight (orientation with respect to the ground) also exaggerates the error. This was a new environment for the RMLD-UAV. The data collected during these tests further enabled algorithm refinement, and modifications to the system hardware were made to address the technical issues encountered.

Due to the less than ideal weather conditions and technical difficulties encountered during the first field test campaign in November 2017, the second field test campaign was designed to repeat the testing done in order to collect better data. Two test areas were used on the same site as the first field campaign, including an open field test area beside the site with no structures. Testing took place July 23rd to 27th, 2018. Weather conditions were favorable for flying and there were no major technical difficulties.

The test results of the second field campaign are summarized in the table below. For the tests where two leak locations were used, the location and leak rate of the larger leak is reported using current algorithms which currently cannot separate and calculate two separate leak rates. In the table of results below, the PSI Estimated Leak Rate is an estimate of the higher of the two Actual Leak Rates in a dual-leak scenario. PSI is continuing to develop and refine alternate algorithms to accurately compute the leak rates for multiple leak locations.

	Actual Leak Rate (L/min)	**PSI Estimated Leak Rate (L/min)**	**Relative Accuracy**
Test 1A	10	7.7	77%
Test 2A	1	1.9	190%
Test 3A	5,10	7.3	73%
Test 4A	5,2	3.0	60%
Test 1B	3,10	12.6	120%
Test 2B	5	14.1	282%
Test 3B	1	14.8	148%
Test 4B	10	9.4	94%
Test 5B	5	5.5	110%
Test 6B	2	6.1	305%
Test 7B	5,10	9.8	98%
Test 8B	1,5	6.4	128%

The accuracy of the leak rate estimation is significantly dependant on an accurate leak location estimation. There was a pool of water on site, which was highly reflective, and it skewed the readings high of tests 2B and 3B, where the leak location was beside the water. Other shiny surfaces may have the same effect as water on the readings. This also may be due to the accumulation of the methane over the water, contained between the berm and infrastructure.

There is some concern with establishing accurate GPS or Global Navigation Satellite System (GNSS) positions with respect to methane leak detection tools. Being able to identify leaks to one metre accuracy seems to be a reasonable objective; however, obtaining this level of precision may not be practical in the real world, as seen in the results presented in the table below. This is especially true when facility structures are involved. The precision is affected by error due to the position of the UAV as well as the tilt experienced by the UAV and methane sensor during flight. A summary of the differential in GPS position with respect to the actual leak locations for Area B is shown in the table below.

Leak Location	**Approx. off-set Distance from Actual Leak Location (m)**
1B Red	3.2
1B Black	4.1
4B Red	3.3 (estimate)
4B Black	1.3
8B Red	2.2
8B Black	2.6

UAV's may be a useful tool in identifying methane emissions for the oil and gas industry when used in conjunction with other leak detection tools. It is a relatively quick way to scan a facility in order to identify approximate locations of emission leaks. Another tool, such as infrared thermal imaging, could then be used to identify source of the emission. More testing and refinement is needed in order to obtain the precise leak location using GPS and UAVs.