NYSEARCH/Northeast Gas Association

Drone/sUAS Applications for Gas Industry Inspections and Leak Surveys

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Background

Gas industry Local Gas Distribution Companies (LDC) continuously pursue efforts to improve efficiencies and thoroughness of inspections and leak surveys. Recognizing the emerging capabilities of small unmanned aerial systems (sUAS) or drones, LDCs became interested in developing possible applications for sUAS stable aerial platforms with sensors for inspections and surveys. Concurrently, emergence of smaller, lighter weight and higher sensitivity sensors had become available for practical pairing with these agile sUAS for consideration of routine and emergency inspections and surveys. Initial field testing began with general photography and video capture of LDC-owned above ground assets and infrastructure. Images of once inaccessible pipeline and infrastructure were readily revealed providing insightful results and leading to expanded field trials and broadening sensor trials. Recognizing the value of this new sUAS inspection and survey accessibility, it became evident that going beyond photographs would further enhance the sUAS capabilities by applying advanced sensors for applications of this technology.

Through a series of coordinated controlled and field tests incorporating various sensors and instruments, it was determined that improvements to routine and emergency inspections and leak surveys were evolving with sUAS-based adaptations, as shown in Figure 1.

Figure 1. sUAS platform with specific mounted sensors

Of equal importance in integrating sUAS usage into LDC operations is staying within the governing regulations. As part of the NYSEARCH sUAS evaluation of technology applications, it was recognized that regulatory constraints meant understanding and planning sUAS flights within the Federal Aviation Administration's (FAA) commercial sUAS regulations, today known as FAA Part 107. The Part 107 regulation applies to commercial piloting of sUAS aircraft, primarily limiting operation of an sUAS to weight limits of less than 55 pounds, daylight flights only and flying within visual line of sight. There are many other restrictions within Part 107 but these are the most immediate impact to LDC implementation. See Figure 2.

Figure 2. sUAS pipe bridge crossing inspection and leak survey flying within FAA Part 107 regulation restriction

LDC Interest in sUAS Inspection and Leak Survey Development

The initial step of targeting specific areas of interest was decided by a NYSEARCH LDC working group. There was interest in improving overall emergency and routine inspection and leak survey processes where sUAS advantages could be implemented; not to replace the existing process but rather in using a sUAS as a tool to provide enhanced insights and features to these processes.

Emergency Situational Response and Planning

The gas company members expressed interest included development of capabilities that included immediate first responder investigations such as remote and agile immediate visualization of an evolving emergency situation from a safe distance to access hazards such as methane and other chemical hazard releases, fire, flooding, and other identifiable information. See Figure 3.

Figure 3. sUAS inspection during emergency response evaluations where access is difficult or prohibitive

<u>Gas Leak Detection and Ground Emission Localization</u>

Another focus of sUAS development involved leak detection surveys and mapping, then specific identification of ground emission localization. It was determined that aerial sUAS methane detection is relatively straightforward as there are detectable methane emissions from many sources both naturally and man-made within the environment. Any methane measured that was not related to gas pipeline leaks was considered a false-positive during a survey. The more difficult task was determining where the ground location emission point(s) were for a true-positive leak detection from a gas pipeline. Several methane detection sensors and instruments were evaluated to establish optimum sUAS flight patterning to determine the ground emission point while greatly reducing false-positive detections. Controlled test conditions confirmed the ability to detect a leak down to 0.1scfh, however in field test conditions detection of 0.1scfh was consistently difficult and not always repeatable. A larger leak above 5scfh was more likely to be detected consistently and repeatably, similarly to traditional leak survey methods. Figure 4 illustrates an sUAS configured for leak detection.

Figure 4 – sUAS platform with gas leak detection sensor

Results of sUAS leak surveys produce several visual interpretations depicting captured data. The individual methane concentration measurements can be reviewed per specific GPS point identifications, as indicated in the left portion of Figure 5. Additionally, another method of result analysis is a “heat map” generated by the individual methane concentration measurements integrated with environmental influences, including wind direction and velocity. The “heat map” proved especially effective in recognizing very small leaks as it provided an expanded modeling prediction of the leak plume path migration pattern, as shown in the right portion of Figure 5.

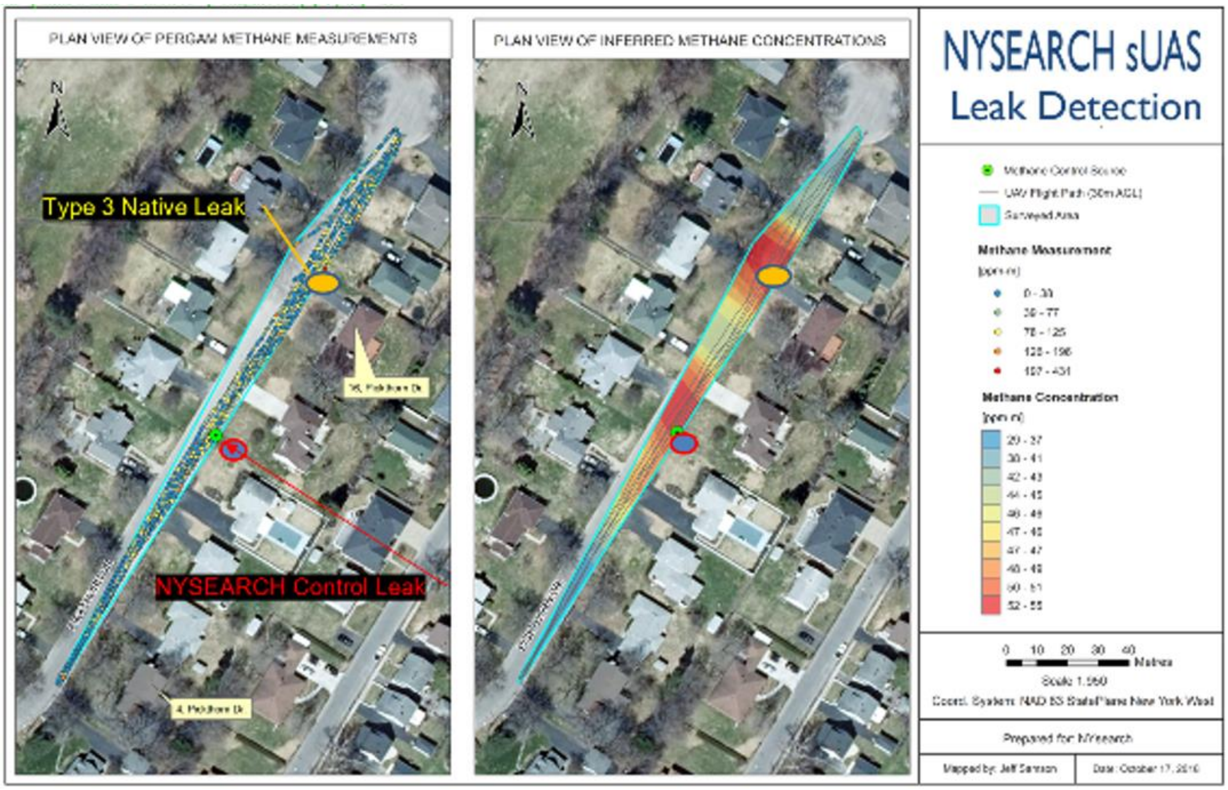

Figure 5 – Gas leak survey results - left image, specific Methane detection locations and right image, “heat map” illustrating gas leak plume

<u>**Right-of-Way (ROW) Management**</u>

Another area of sUAS interest that required further development pertained to performing ROW inspection for actual and even future potential damage to facilities, encroachment, vegetation management, geological /geohazard disturbances, and other damage prevention measures. Also evaluated were sUAS capabilities for leak survey and monitoring within a specific fixed area of a ROW or fenced asset infrastructure that warns of possible impact to normal operation of a LDC gas pipeline. One example of sUAS evaluation involved difficult inspection of a ROW that varied abruptly in height, changing vertical elevation of 80 feet over a short distance as the LDC pipe followed the land contours. sUAS imagery was collected and analyzed. It resulted in mapping the elevation profile while providing insights to inspection interests mentioned above. See Figure 6. sUAS possess high accuracy global positioning system (GPS) devices to accurately navigate but can also be used for specific sUAS sensor correspondence, specifically to identify the gas pipeline location for confirmation of an LDC geographic information system (GIS). See Figure 7.

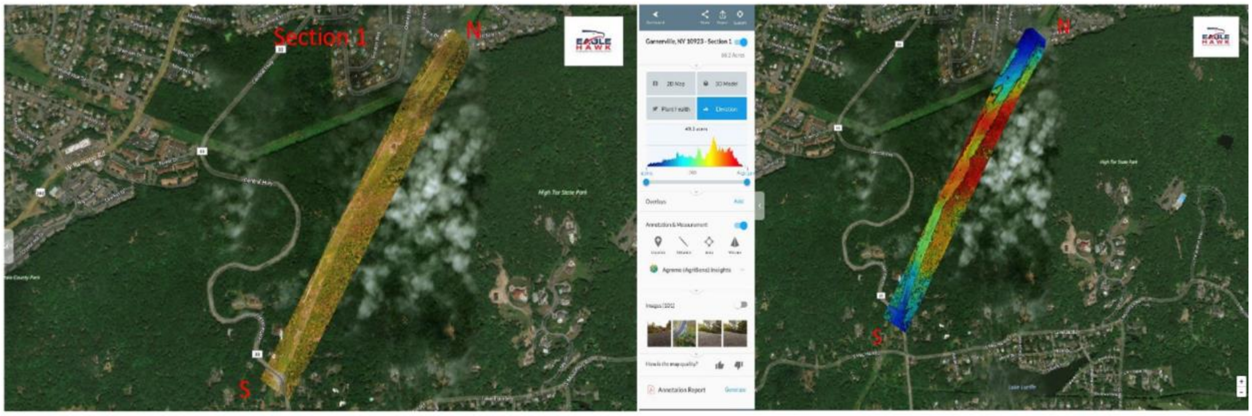

Figure 6 – Inspection and leak survey of ROW results and terrain change elevation profile

Figure 7 – sUAS identifying specific pipeline GPS location for GIS confirmation, here a valve box marker

An additional benefit was uninterrupted sUAS flights in ROWs while performing inspections over terrain such as tall vegetation, swamps and environmentally sensitive areas. It also availed information on worker safety hazard concerns such as trips and falls, geohazard changes in ground contours, avoiding ticks, spiders, snakes and other potential dangers. Visual imagery and sensor interpretation provide records of location where repair or maintenance work must be performed to bring the ROW back to mandated operational conditions. In contrast, these same results may confirm that no repair or maintenance work needs to be dispatched. For example, sUAS information make show that there is no longer a need for vegetation management in areas of low or no growth.

Infrastructure Inspection and Leak Survey

Inspection and leak survey of difficult-to-reach and inaccessible gas facilities were additional areas of development interest. Bridge pipe crossings and other suspended expanses of pipe are commonly difficult structures for inspections and gas leak surveys for several reasons including loss of close proximity to the pipe, traffic and lane closure requirements and overall safety concerns for aerial harnessing of inspection personnel. An extreme example of inspection is that of a pipeline under a bridge with no direct access for examination. A plan was developed to inspect the piping and supporting infrastructure from a sUAS platform. See Figure 8. The closest the sUAS pilot could stand was a position of 1,000 feet away from the actual pipe while maintaining FAA’s visual direct line of sight requirement to safely perform the inspection.

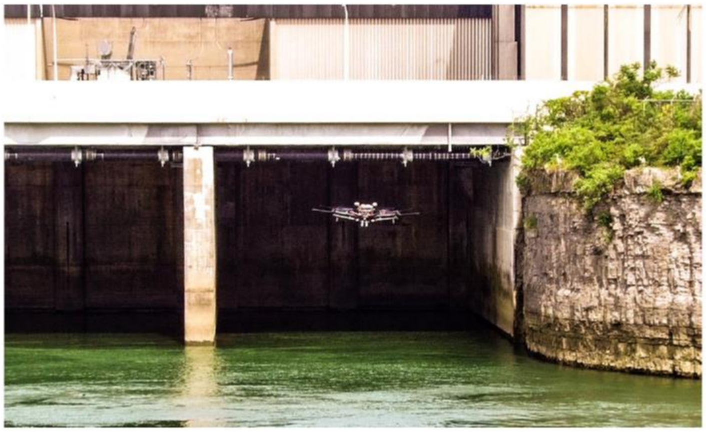

Figure 8 – sUAS pipe inspection in a difficult access location, here the distance from pilot to pipe is 1,000 feet

Even with this great distance from the pipe, the high resolution captured with photographic and video imagery provided more than enough detail of the pipe and supporting infrastructure for an acceptable inspection and proper interrogation of the pipe integrity, as shown in Figures 9 and 10.

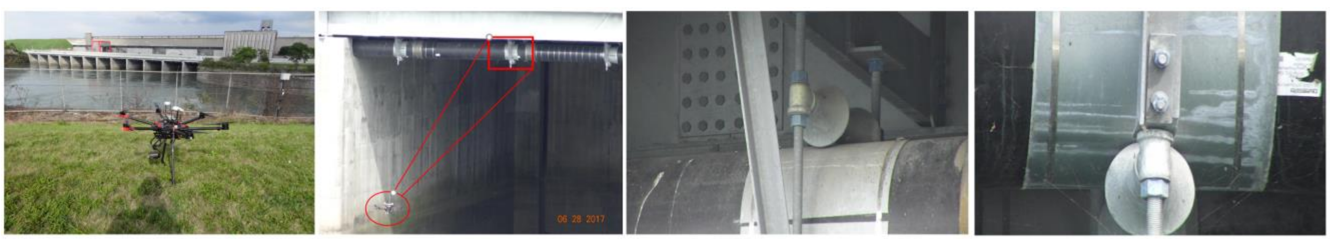

Figure 9 – Pipe inspection effectively performed with sUAS mounted high definition camera, illustration showing inspection of pipe and supports

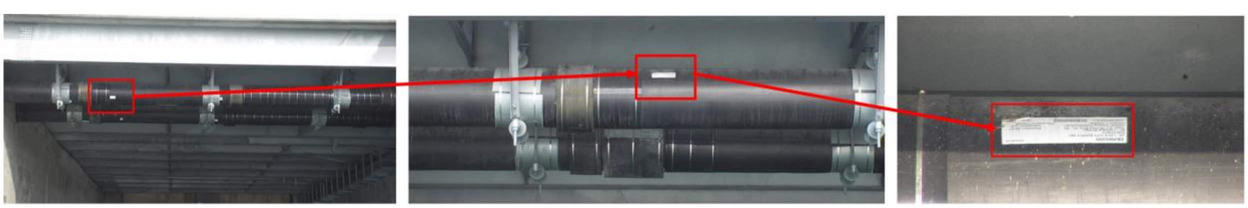

Figure 10 – Testing the agile sUAS inspection capability and image resolution, illustration showing ability to identify and read a name plate clearly from 1,000 feet way.

Distribution/Transmission Integrity Management Programs (DIMP/TIMP)

Expanding further on infrastructure inspections and leak survey, most of the sUAS inspections and leak survey techniques described and illustrated can be applied to enhance a DIMP and TIMP program. Incorporating sUAS techniques to assist in DIMP and TIMP program management provides greater insight to data that would not otherwise be unavailable using traditional methodology.

The sUAS inspection of above ground pipeline features have proven to be most effective. An inspection of pipe crossing on a bridge can be enhanced readily with improved results in imagery and thoroughness without the typical lane closures or crew safety concerns. A busy bridge high above an active navigable river provides a challenge for any LDC to perform adequate integrity inspection of a bridge crossing gas pipe. Multiple sUAS inspection technique applications provide avoidance of roadway lane closures, traffic interruption and inspection crew safety concerns.

The advantage of agile maneuverability of an sUAS platform provides inspection coverage around the pipe from above, level to and below the pipe. Additional benefits recognized on sUAS bridge applications were no lane closures or traffic interruptions as well as greatly reduced time required to perform the inspections and leak surveys. Combining individual images with post-processing mosaic and video capture provides recorded confirmation of damage concerns, all tagged with GPS identification. See Figures 11 and 12.

Figure 11 – sUAS inspection reveals pipe coating loss and corrosion initiation difficult to detect by traditional inspection techniques, here corrosion hidden from typical visual inspection perspective

Figure 12 – sUAS provided difficult-to-access suspended pipe inspection, providing record of current condition of the pipe coating, support engagement and corrosion

Simultaneous pipeline inspection for integrity (i.e.- damage, coating assessment, corrosion identification) and leak surveys are performed with one planned and executed flight with an sUAS equipped with proper sensors.

Permanent digital records of infrastructure conditions are created using a sUAS platform and appropriate sensors to provide enhanced annual review and documentation of change. Analyses based on this trending may be incorporated into established DIMP and TIMP programs to better understand and predict future maintenance and pipe replacement efforts.

LDC Internalization and Commercial sUAS Integration Readiness

NYSEARCH assessed and developed these sUAS inspection and leak survey techniques with iterative laboratory and field testing. Also, several LDCs including members who participated in this project have developed internal groups of pilots while other LDCs have contracted sUAS commercial services for enhanced inspections and leak surveys.

NYSEARCH Advancement in Research and Development – Additional potential applications

Evaluation of advanced sensors adaptable to sUAS have been continuing as these initial tests confirmed successful sUAS application for inspection and leak survey capability. With methods now developed for sUAS leak detection, advancement of emission quantification is the next logical step.

Additional sensors are becoming available for direct sUAS adaptation. With communication advancement in data and control telemetry over extended distances, live sUAS-to-ground station data transfer brings imagery and sensor data from the in-flight sUAS immediately to a ground station while performing an inspection or leak survey. This sUAS telemetry capability captures immediate imagery and sensor data for ground crews to identify problems and level of urgency to schedule repairs. Also, sUAS applications can provide annual inspections and update leak survey records thus enabling trending of changes occurring within a targeted infrastructure.

Advancement in sensor technology continues in many areas that will assist in LDC inspections and leak surveys, such to enable sensor mounting and sUAS maneuverability by reducing the sensor size and weight; thus consuming less power while in flight. NYSEARCH plans to continue to test and evaluate these sensor improvements.

Acknowledgements

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