2021 Award Nomination

Title of Innovation:

A Tethered Aerial Robotic Drone for Visible Surface Cleaning and Removal of Nonvisible Contamination on Elevated Structures

Nominee(s)

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Category:

(select one below)

Coatings and Linings	Instrumentation
Cathodic Protection	Testing
Materials Design	Modeling/Risk Assessment
Chemical Treatment	Other—**Surface prep and cleaning, extending coatings life**

Dates of Innovation Development:

from January 2020 to September 2020 and ongoing

Web site: https://www.Apellix.com video at https://youtu.be/77sJ2IS6Sq4

Summary Description:

Apellix has created a tethered aerial robotic system for performing chemical wash using a pressurized high-volume flow of water or chemicals (e.g., NaClO, H3NSO3, Chlor-RidTM, etc.) to clean exterior structures. The system operates at up to 150' (~45 meters) at up to 1,450 psi (~100 bar) with 8 gpm (~30 liters per minute) of water, chemical agent, or a mix. The system utilizes Apellix's existing aerial robotic precision flight control autonomous features but remains under the direct supervision and control of a pilot and optional engineer or spotter positioned safely out of harm's way, on the ground.

Full Description:

(Please provide complete answers to the questions below. Graphs, charts, and photos can be inserted to support the answers.)

1. What is the innovation?

Many elevated structures are difficult to access and exist in environments that expose the fabric to salt, moisture and environmental factors that can reduce the effectiveness and longevity of protective coatings. The accumulation of mold, salt and other contaminants can reduce the lifespan of the coating as well as create aesthetic issues.

Apellix has created a tethered aerial robotic system for performing chemical wash capable of using a pressurized high-volume flow of water or chemicals (e.g., NaClO, H3NSO3, Chlor-RidTM, etc.) to clean exterior structures. Currently the system can operate at up to 150' (~45 meters)[i] at up to 1,450 psi (~100 bar) with 8 gpm (~30 liters per minute) of water, chemical agent, or a mix. The system operates with Apellix's existing aerial robotic precision flight control autonomous features but remain under the direct supervision and control of a pilot and optional engineer or spotter positioned safely out of harm's way, on the ground.

2. How does the innovation work?

Apellix has designed and built the Opus X8, a heavy lift aircraft capable of operating at heights of up to 150' while handling the weight of hoses, cleaning and wash components and sprayers. The system keeps all reservoirs and pumps on the ground, connected to the aircraft via a tether/umbilical cord. The airframe operates with ground power (single phase 240vac at 50A) via tether with a battery backup, eliminating the need to stop for battery changes.

The Opus X8 softwash (SW) operates semi-autonomously, where the aircraft remains a fixed distance from the structure determined by the pilot and cleaning conditions, and "locked" into by the software and flight control. The pilot determines the speed and horizontal or vertical direction, with the software controlling the remainder of the flight operations. We are currently in field trials using sodium hypochlorite cleaning of mold off above-ground water storage tanks. The technology readiness level of the Opus X4 SW (softwash) system is "lab-scale tested", TRL 7. While our current abilities are for water cleaning (WC) for visible surface cleaning (VC) and removal of nonvisual contamination (NV) our short term product development timeline includes improvements to the system to obtain results roughly measurable as NACE No. 4/SSPC-SP 7, we believe our ability to do dry blasting to SSPC-SP-10, slurry blasting to SSPC-SP-10, and water jetting to SSPC-SP-12 WJ2 levels are achievable with additional long term development.

The current Apellix aerial robotic systems are optimized, in most cases, for simple mostly flat vertical surfaces. The ability to surface prep horizontal, upside down/underside, or other areas that may be inaccessible or difficult to reach with an aircraft will be assessed as we continue to develop the iterate the technology. Our mantra at Apellix is to crawl, walk and then run meaning we work to perfect our technology on simple high value use cases fist and then develop the capability to accomplish the more complex use cases.

3. Describe the corrosion problem or technological gap that sparked the development of the innovation. How does the innovation improve upon existing methods/technologies to address this corrosion problem or provide a new solution to bridge the technology gap?

Currently one needs to utilize a lift, scaffolding, ladders or other systems to reach areas of height to performing chemical wash capable of using a pressurized high-volume flow of water or chemicals fir fabric maintenance and cleaning elevated exterior structures. This is both dangerous, due to the possibility of falls, and time consuming. The Opus X8 softwash system allows the operator to remain safely on the ground while the robotic system is utilized. Further, since there is no need to bring in a lift, JLG, cherry picker of assemble scaffolding or ladders the cleaning process is faster in addition to being safer.

4. Has the innovation been tested in the laboratory or in the field? If so, please describe any tests or field demonstrations and the results that support the capability and feasibility of the innovation.

Lab testing has occurred, and a field testing and demonstration is scheduled for early October 2020. The system operates such that a drone pilot/system operator flies the tethered drone up to the start area on a structure, an assistant on the ground starts the gas-powered pump that is connected to a rinse and wash reservoir, and the drone pilot then engages the onboard software that automatically controls and holds the aircraft a consistent distance from the structure, then with computer assist the operator would start the stream and move the aircraft left and right or up and down. Video of the current proof of concept is available at https://youtu.be/77sJ2IS6Sq4

Further we are working with AkzoNobel's innovation group to determine if we can expand the ability to "wash" and clean surfaces to help protect coatings and reduce corrosion by increasing the blast pressures for more surface preparation, hydro blasting, and water jetting work. We envision the Apellix Opus X8 aircraft and Apellix precision flight control can be scaled to solve more sophisticated and potentially more complicated tasks.

5. How can the innovation be incorporated into existing corrosion prevention and control activities and how does it benefit the industry/industries it serves (i.e., does it provide a cost and/or time savings; improve an inspection, testing, or data collection process; help to extend the service life of assets or corrosion-control systems, etc.)?

The DFT Smart Bee from Apellix offers not only cost and time savings but also provides safety benefits. In the United States alone, 95 climbers working on industrial towers died between 2004 and 2012. While those deaths are most likely not related to DFT measurement activities, the ability to move workers from harm's way and prevent potential injury (or death) is a benefit to the corrosion industry. Further, the DFT Smart Bee system has the potential to improve the inspection, testing and data collection aspects of coated/painted assets. Also, by making the DFT measurement "process" easier and safer Apellix (and I) believe more measurements will be taken thus expanding the scope, scale, and frequency of DFT measurements. With an easier, faster, and hopefully less expensive method to collect DFT measurements from locations of "height" I believe we can expand the science of coating thickness measurements by collecting data from locations where data was either inaccessible or difficult to obtain (access issues, safety considerations, etc.).

6. Is the innovation commercially available? If yes, how long has it been utilized? If not, what is the next step in making the innovation commercially available? What are the challenges, if any, that may affect further development or use of this innovation and how could they be overcome?

No, however we believe it will be by year end. It has been in laboratory testing since early 2020 and builds upon proprietary technology developed (and invented) by Apellix since June 2014. There are challenges to ensure future development continues including market receptivity and acceptance. Apellix is working with a company that provides soft wash services washing over 150 elevated water towers per year. This company will be using the Apellix Opus X8 softwash systems in their day to day operations which will allow us to iterate, improve and further develop this innovation. Once the majority of the issues found are corrected we will be offering the Opus X8 softwash system to the general corrosion prevention, surface maintenance and coatings surface preparation market.

7. Are there any patents related to this work? If yes, please provide the patent title, number, and inventor.

Yes, most of the technologies are covered in the following USTPO patents.

Indoor and Outdoor Aerial Vehicles for Painting and Related Applications
US 10,399,676 B2 Inventor: Robert L. Dahlstrom
http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=10399676.PN.&OS=PN/10399676&RS=PN/10399676

Mobile computing device-based guidance navigation and control for unmanned aerial vehicles and robotic systems
US 9,611,038 B2 Inventor: Robert L. Dahlstrom
http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=9611038.PN.&OS=PN/9611038&RS=PN/9611038

System, mobile base station and umbilical cabling and tethering (UCAT) apparatus
US 10,195,629 B1 Inventor: Robert L. Dahlstrom
http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=10195629.PN.&OS=PN/10195629&RS=PN/10195629

System, mobile base station and umbilical cabling and tethering (UCAT) assist system
US 10,011,352 B1 Inventor: Robert L. Dahlstrom
http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=10011352.PN.&OS=PN/10011352&RS=PN/10011352

[i] The Apellix system can operate above 150'subject to limitations of commercial pump and spray systems, including a reduction in nozzle pressure. In the instance of cleaning, production above 100' would be limited to ¼"ID hose which may limit the liquids flow/gpm.