Unmanned vehicles

by Richard Bray

An ocean glider unmanned vehicle system is launched off the coast of Newfoundland. For more information, see the sidebar on page 9.

Going where man needs to go

ON THE NIGHT OF October 28, 2006, an unmanned Altair aircraft flew for 16 hours over the Esperanza wildfire in southern California, transmitting real-time thermal infrared data via satellite from an altitude of 43,000 feet to a fire management team on the ground. No other aircraft or resources were available to provide that capability. Planners used the infrared and visual pictures they received to brief fire fighters in the morning about the threats they faced in the day's work ahead.

Since 2004, in a slice of airspace above the border between the state of Arizona and Mexico, unmanned Predator B aircraft (a variant of the fire-fighting Altair) have been providing US Customs and Border Protection personnel with a comprehensive picture of the narcotics smuggling and illegal alien crossings below. Hundreds of operational flight hours have led to thousands of arrests, and more importantly, a safer working environment for border patrol personnel. These unmanned aircraft may soon be operating along the Canada-US border as well.

These are just two examples of the range of capabilities of unmanned aerial vehicles (UAVs). Proponents can point to these missions as key milestones in their efforts to have machines do the 3D work – 'dull, dirty and dangerous' – where they can outperform or replace their human counterparts.

UAVs can weigh anywhere from four ounces to 26,000 pounds and carry every kind of payload that scientific ingenuity can design and build into a package light enough for the aircraft to carry: still and video cameras; measurement and sensing devices; communications relay and broadcasting equipment; and, emergency medical supplies or food and water. Wherever governments need pictures or data of the physical world, especially in remote areas or hazardous situations, UAVs may play a role.

Greg Galloway, director of operations with Ottawa's ING Engineering, flew several different UAV types during his eight years with the US Army. He believes UAVs can do outstanding work in non-military government applications that include traffic control, weather observation, disaster relief and fisheries surveillance. "There are just so many good things you can do, especially given the persistence of UAVs. You can stay over an area for hours upon hours… up to 24 hours a day, seven days a week, making sure nothing illegal was going on."

Galloway says UAVs are built for work. "They're trucks that can carry multiple payloads and do the dull, dirty and dangerous missions. You still have an operator in the loop, so you still have to change out but it's not like you have to land your plane to change out pilots," he said. "It's an easily trained skill."

Technically, there is no doubt that UAVs can carry out their assigned tasks whether that means inspecting pipelines, monitoring traffic or even flying cargo into remote areas. Because they do not need a human presence onboard, they can fly higher and stay aloft longer – days or even weeks. Because they are often smaller and lighter than manned counterparts, they can operate from rough airstrips or no airstrip at all, and sustain harder landings. Instead of risking human life, ground controllers will be able to send machines into extremely dangerous situations, or when aircraft must operate at the limits of their range.


Predator B can conduct multiple missions simultaneously due to its large internal and external payload capacity.

http://www.airforce-technology.com

UAVs aerial vehicles in their own operations should look at each success story carefully; so far each mission has been far from routine. In Arizona, for example, airspace is closed to other traffic during UAV operations, and in California, the fire-fighting mission was the product of careful planning between the National Aeronautical and Space Administration, the US Forestry Service, and the UAV's manufacturer, General Atomics. In reality, it could be many years before UAVs routinely operate in close proximity to other aircraft in shared airspace.

Fences in the sky

Around the world, the sky is divided into blocks of space. In low traffic areas – deserts, oceans or wilderness – aircraft can operate with a minimum of regulation. As aerial traffic increases, so do the restrictions on their movements and control over their operations. The shared goal is to have UAVs operate alongside manned aircraft. As Bob Kirkby, chairman of the Canadian Owners and Pilots Association noted in a speech at the annual UVS Canada conference in Montebello, Quebec in October, "Segregated airspace is not the answer and only serves to undermine the long term integration of UAV operations by discouraging the development of coherent and compatible operational practices and regulations."

There are substantial technical barriers to surmount before unmanned vehicles can share the sky with other aircraft. They must be able to 'sense and avoid' other aircraft. Most large, commercial aircraft have TCAS or traffic alert and collision avoidance systems that alert them to each other's presence and warn when collisions are imminent. In smaller aircraft, however, human pilots must see and avoid other traffic. That means unmanned vehicles must be able to 'see' and avoid all other air traffic, including parachutists, hot air balloons and gliders. If other airspace users believe UAVs are a threat, they will be active and vocal opponents. Just one UAV accident could set the entire sector back for years.

Unmanned, underwater

While proponents of civilian UAVs generally take advantage of exceptional circumstances – illegal immigration or fire emergencies – to demonstrate their technology, another class of uninhabited vehicle is quietly learning a useful trade off Canada's east coast. The Newfoundland Centre for Ocean Gliders has been testing autonomous submersible vehicles that can independently travel thousands of miles for weeks at a time, collecting oceanographic information.

Ralf Bachmayer, a research engineer with the National Research Council's Institute for Ocean Technology said the project complements work typically done from surface vessels. "We are collecting data that's collected by other agencies on a regular basis, with different means, typically ship-based," Bachmeyer said. The gliders would probably not replace completely surface sampling, he said, but it could augment their capabilities and fill in time gaps that the ships might not be able to cover. The net benefit, he said, is based on the comparatively high cost of manned ships, "So we might get a reduced dataset from these gliders but at a much lower cost. That might fill in the gap that some of the researchers are looking for, for climate modelling for example," Bachmeyer explained.

Bachmeyer cheerfully concedes that underwater gliders can operate with fewer constraints than their aerial counterparts. "This is great for us," he said but underwater gliders do have their challenges. "The problem is basically on the insurance level. It is very hard, indeed impossible, to insure platforms that you launch in the water that are not connected by any means to a vessel…" The gliders are small, at about two metres in length, and move quite slowly compared to surface vessels they might encounter, so the gliders would suffer in a collision. Through Notices to Mariners, the project advises other ships that they are operating in the area and to date there have been no problems. Each glider system costs about US$100,000, including system integration and software.

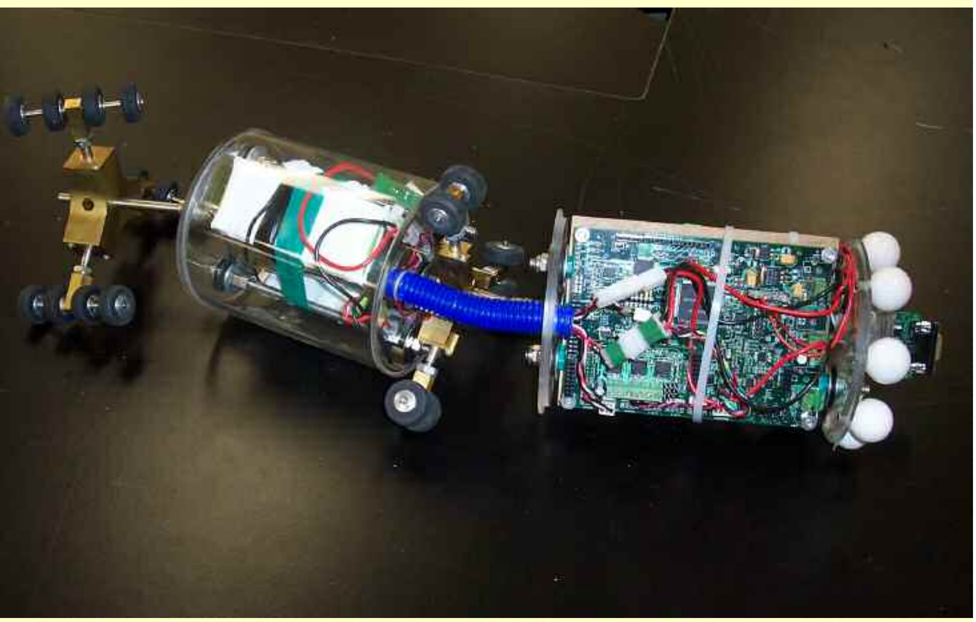
Bachmeyer said the gliders still have major challenges. They can only transmit the information they have gathered when they are on the surface, and satellite communication is expensive. The gliders cannot navigate precisely underwater, limiting their use

The Department of Fisheries and Oceans is already observing the glider experiments and reviewing the collected data said Bachmeyer. "They are looking into complementing their existing programs and I would think in the next 2-5 years, you will probably see an appearance of these assets in the fleet of some government agencies."

Smart Heterogeneous Robot for Inspecting Main (water) Pipes – SHRIMP

A pipe crawler for doing inspection on in-service water pipes has been designed and built at the University of Regina. This prototype can move inside pipes of 6-in diameter in light of its spring-loaded passive wheels. This robotic platform is equipped with pipe inspection instruments including non-destructive testing (NDT) sensors to inspect in-service water mains of different materials. The system includes an onboard data acquisition unit that can store and/or transmit sensory data to the surface facilities in real time. The robot can also provide information about the 3D profile of the interior surface of the pipe using vision, laser fans, and other non-contact imaging techniques. This sensory information is then synergistically used to make a reliable decision about the condition of the pipe. The following factors have been taken into consideration in the final design:

- minimal blockage of the live pipes;
- submergibility;
- nominal pressure fluctuation tolerance;
- easy retrieval;
- sensor payload capacity;
- manoeuvrability in curved and/or vertical pipes;
- low power consumption.



Development team members are: S. Poozesh, Industrial Systems Engineering, University of Regina; M. Mehrandezh, Industrial Systems Engineering, University of Regina; R. Paranjape, Industrial Systems Engineering, University of Regina; H. Najjaran, Faculty of Engineering, University of British Columbia.

The robot is designed in a way that its spinning head can generate a helical forward motion inside the pipe, utilizing a track of motorized wheels positioned with an angle with respect to the longitudinal axis of the robot. The wheels can exert a normal force onto the inner wall of the pipe supporting robot's own weight when moving vertical. The translational motion (i.e., position and velocity) of the main body of the robot carrying onboard non-destructive testing units and/or navigation sensors must be accurately controlled for precise inspection of pipes at any bandwidth and/or accurate autonomous navigation. For this purpose, a *hardware-in-the-loop* simulator is developed for rapid prototyping of different control strategies in a dry laboratory for regulating robot's movement, taking the hydrodynamic forces exerted on the system and its dynamics into account.

Because most UAV operations call for a ground-based pilot, the communications links between the aircraft and the human operator must be uninterrupted. Today, there are no radio frequencies dedicated to UAV control. The group that negotiates with users to assign frequencies, the International Telecommunication Union, only meets every four years to allocate channels, and in the opinion of many observers, 2011 is the soonest that could happen. Until then, UAV operators contend with the possibility that competing radio traffic will disrupt communications with their aircraft.

In the case of any air-to-ground communications breakdown, the UAV must be able to return safely to earth on its own. Work is underway to design communications systems that would allow air traffic controllers to 'talk' directly with UAVs but that capability is still far in the future. As Greg Galloway said, it may be relatively easy to train UAV pilots, but civil aviation authorities will insist on licensing them and ensuring their medical fitness.

UAVs combine three systems – the machine, the ground-based pilot and the communications system that links them together. All three will be regulated. At the US Federal Aviation Administration, Doug Davis is in charge of the Unmanned Aircraft Program Office, developing the policies and regulations that will govern their use in civilian airspace. "The reason the US calls these unmanned aircraft systems is because they are aircraft," he said. "Some of the equipment is on the ground somewhere else, [but] it is part of the aircraft and will be considered in the certification path as we go forward."

Today, UAVs are supporting combat operations in Iraq and Afghanistan, acting as eyes, ears and sensors for military personnel. Governments are beginning to use them in other extreme environments where there is danger to human life or where the benefits greatly outweigh the risk – over the Arctic, in disaster areas or high above most other air traffic. As manufacturers, operators and government regulators solve the shared airspace challenges, UAVs will come into more general use but progress will probably be measured by the speed of the slowest committee.

Richard Bray is an Ottawa-based freelance writer and editor specializing in the IT sector. He has been published in magazines and newspapers in Australia, the US and Canada. Before freelancing, he worked as a producer, reporter and senior writer for CBC in Toronto.