Research Note

From the WSDOT Research Office
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Washington State Department of Transportation

The R-MAX in flight

The R-MAX Control Station

Exploring Transportation Applications of Small Unmanned Aircraft

The Issue
Avalanche control is dangerous work. Technology that can minimize risk to employees is advantageous. As well, adoption of tools that improve our ability to easily and inexpensively survey conditions - whether for traffic management, data collection, security inspections or other operations – are encouraged. This project tested the feasibility of unmanned aerial vehicles (UAVs) in both avalanche control and highway operations..

Background
Unmanned aerial vehicles have become smaller, more capable, and less expensive because of military investment in the UAV industry and improved technology. Current generation UAVs can be transported in small vehicles and launched from a road or a small truck but are still large enough to be equipped with cameras that can provide high quality aerial information. These aircraft are capable of flying autonomously and completing preset flight plans. This technology holds considerable promise for traffic and transportation organizations because a UAV could be a useful tool for a range of maintenance, planning, and operations functions. Potential uses of UAVs include avalanche control, crash scene photography, surveying, security inspections, construction data collection, and monitoring the condition and congestion of roadways.

Despite the promise of this technology, actual applications in the transportation world are limited. A major reason for this involves institutional issues, particularly approval to fly by the Federal Aviation Administration (FAA). The FAA is responsible for the National Air Space over the United States and is concerned about a UAV's ability to "see and avoid" manned aircraft. The FAA requires each UAV user to apply for a project-specific Certificate of Authorization. The FAA realizes that there is a considerable desire to use UAVs commercially, but it is still formulating policies.

What We Did
The University of Washington and the Washington State Department of Transportation (WSDOT) conducted a test of two types of UAVs to evaluate their technical capabilities while also exploring the institutional concerns associated with UAV use. The test was devised as an effort to "get a foot in the door" so that WSDOT could become familiar with UAV technology and FAA requirements and also to help guide the development of longer-term policies on the use of UAVs.

The effort was completed in conjunction with WSDOT's avalanche control operations because there was an obvious and immediate need for UAV capabilities. Current avalanche control efforts involve the use of military equipment to shoot explosives and the dispatching of snowmobilers

The BAT

or skiers with handheld charges, plus the occasional use of helicopters to drop explosives into inaccessible areas. This project's test flights explored whether UAVs could fit within WSDOT's maintenance and operations program and provide more options for avalanche control and potentially other tasks.

A review of other UAV studies, as well as discussion with WSDOT staff, suggested the following test parameters:

- The tests should use smaller UAVs that could be operated on or next to a state highway.
- The test would use a UAV system that would potentially be affordable to WSDOT, and it was decided that the system should cost no more than $500,000. In addition, the UAV should be operable and maintainable by WSDOT personnel with appropriate training.
- Both fixed and rotary wing (helicopter) systems would be considered.

The researchers tested two aircraft. Because the UAVs would be used in conjunction with avalanche control operations, a test area was selected above State Route 20 (the North Cascades Highway) in rugged terrain in north central Washington State.

Fixed Wing Flight Test

The aircraft selected for the first test was the MLB Company's BAT. This 24 pound UAV had an 80-inch wingspan and carried both a pan-tilt video camera and a digital camera. The BAT could be disassembled and placed in a car trunk and could be launched from a vehicle and landed on the roadway. The ground control station consisted of a portable computer and a video screen, which were placed in the back compartment of a van.

The test of the UAV occurred in April 2006 along an avalanche-prone section of roadway that had been closed for the winter because of snow. WSDOT was in the midst of an effort to reopen the road and was conducting avalanche control operations with a surplus military howitzer. The test flight evaluated the ability of the UAV to use a video camera to view the roadway and survey the surrounding terrain, as well as to operate off a highway. The plane traveled to selected avalanche-prone snow chutes, where it successfully captured video images. The plane also flew at 800 feet above the highway; the resulting videos provided a clear view of the roadway, and individual vehicles could easily be identified.

The R-MAX

Rotary Wing Flight Test
A vertical takeoff and landing UAV was selected for the second test. This aircraft, known as the R-Max, made by Yamaha, weighed 200 pounds, and had a rotor span of 12 feet. The second test occurred in September 2007. The ground station for this aircraft was set up in the back of a specially equipped truck that doubled as a transporter for the aircraft. Initially, the aircraft demonstrated the ability to autonomously follow a road by using predetermined waypoints. This exercise was designed to simulate a survey before the start of snow clearing operations on the road, but it was also a successful test of the UAV's ability to fly along a roadway to record traffic or roadway conditions. The ability of the aircraft to hover provided a stable platform on which camera use was effective.

This test also demonstrated the R-Max's ability to survey terrain alongside a roadway. This capability could easily be used for construction site surveys, security checks, and other tasks that require an aerial view.

What the Researchers Found
The researchers found that both aircraft types showed considerable potential for aerial roadway surveillance and traffic monitoring as well as avalanche control. They were able to obtain clear videos of the roadway at a height that allowed efficient viewing of roadway conditions and traffic. However, the rugged mountainous terrain and weather provided operational challenges, and in order for WSDOT to routinely use UAVs, the cost-benefit would need to be determined.

There is limited information about the initial cost of UAVs, but the cost for the fixed wing BAT system used in these tests is around $50,000 and the cost for the rotary wing R-Max is around $270,000. As a point of comparison, renting a manned helicopter costs the WSDOT $800 per hour. In addition, as UAVs become more effective and less costly, they become candidates for applications that cannot be addressed by manned flight.

A limitation on the adoption of UAVs is the uncertainty about the reliability of UAVs related to the costs for equipment replacement and the consequences of a crash. Although UAV technology is maturing, they are not as reliable as manned aircraft. Liability and privacy are also concerns, but WSDOT already has mechanisms to deal with these issues. In addition, as UAVs have become more effective and less costly they have become candidates for applications that cannot be practically addressed by manned flight.

The major barrier for transportation agencies flying UAVs is related to the ability of a UAV to "see and avoid" other aircraft. This is the

The BAT Catapult Launch

The BAT Control System

main reason that the FAA requires UAV flights to obtain a Certificate of Authorization. The FAA recognizes the increasing interest in non-military UAV use and is developing a roadmap for integrating UAVs into the national air space. Concurrently, improved technology—such as detect, see, and avoid systems—may enhance a UAV's ability to fly safely.

Next Steps

Unmanned aircraft systems have become more affordable and capable, so WSDOT could operate them without major organizational additions. These aircraft systems are technically able to complete a range of surveillance and monitoring tasks that are potentially useful to WSDOT. However, FAA policies on use need to be developed and evaluated before an investment in UAVs is clearly advantageous.

This project did find that UAVs hold considerable promise for WSDOT's avalanche control operations. Not only is the ability to obtain FAA approval to fly for avalanche controls less complicated because of the unpopulated flight area, but also the ability of the UAV to effectively supplement routine avalanche control operation was shown to be effective. WSDOT's avalanche control staff hopes to expand the use and testing of UAVs. Efforts are currently underway to identify partners to assist in the funding of these additional tests.

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