AASHTO STANDING COMMITTEE ON RESEARCH

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

NCHRP Research Problem Statement

I. PROBLEM NUMBER

2011-SP-03

II. PROBLEM TITLE

Develop Technologies for Unmanned Aircraft for State Departments of Transportation

III. RESEARCH PROBLEM STATEMENT

Acquiring remote sensing data using small, low-cost, unmanned aerial vehicles (UAVs) could help State Departments of Transportation (DOTs) by reducing the cost, increasing the availability and by acquiring high resolution quality data in real-time. Most current sources of remote sensing (e.g. manned aircraft and satellite platforms) are expensive, have low spatial resolution and/or don't update frequently enough to be practical for many DOT applications. There is great interest in the transportation community for high resolution imagery that can be acquired more readily, at greater frequency and then incorporated in existing Geographic Information System (GIS) databases. For example, providing this technology to DOTs would allow them to monitor highway construction projects before, during and after construction for safety, design and decision-making purposes using aerial high resolution images. The imagery would also allow for immediate GIS updates. Also, it is expected that by using near infrared images that highway road conditions, wetlands and invasive plant species could be monitored at regular intervals. Because the images from the UAVs are geo-referenced, it is also possible to inventory highway structures and other features and their conditions. There is a need to develop the existing UAV technology so that it more effectively benefits the DOTs. There are many more applications for which the UAV technology can be applied to DOT needs.

IV. LITERATURE SEARCH SUMMARY

Various types of remote sensing platforms (e.g. satellite, manned aircraft and mobile ground vehicles) are currently used as tools to help reduce cost and increase the efficiency and accuracy for different types of field work dealing with transportation infrastructure. Specifically for roadways, some of this work includes the inventory of highway structure and mapping road, shoulder and easement conditions.

Herold et al. (2004) found that the aging and degradation of road surfaces are represented by distinct spectral characteristics which can be measured using hyper-spectral imagery. High correlation was found between the remote sensing data (in the visual near infrared range) and the Pavement Condition Index (PCI) which was acquired using conventional methods: field observations by experts and Pavement Management Systems (PMS). However, the resolution of the imagery had a significant effect on the correlation and only worked with high resolution (<0.5 m).

Schwarz et al. (1993) introduced a mobile survey system for road inventory called VIASAT. VIASAT can be used to help geo-locate objects and features on and around a road while driving 60 km/h. This is done by taking pictures of the area ahead of the vehicle and logging its position and orientation from a GPS receiver and an inertial navigation system (INS). The position and orientation of the vehicle is used afterwards, to geo-reference the images. Desired properties of the road and their geospatial data can then be extracted directly from the images.

Jensen et al. (2009) has shown the advantages of small, low-cost, high resolution, multispectral remote sensing aerial vehicles, which are completely autonomous, easy to use and have a fast turnover time for many applications including updating aerial imagery for roads and highways. Other UAV platforms have shown the same results for other applications. Berni et al. (2009) used a small UAV equipped with a visual, near infrared and a thermal infrared camera in order to measure the water stress of crops in real-time to irrigate more efficiently. Small, low-cost UAVs can also save lives by replacing human operators in hazardous situations. Casbeer et al. (2006) proposed using multiple UAVs to help firefighters by measuring the border of a forest fire in real-time. In military applications, Tisdale et al. (2008) used a low-cost UAV with a video camera to find and localize targets.

The function and performance of these UAV systems are rapidly improving. Specific research that integrates this leading edge technology to DOT applications is needed. DOTs of several states, including Utah, have shown specific interest in using UAV technology for tracking highway construction projects, updating GIS images following roadway construction, performing structure inventories, assessing wetlands within highway easements, monitoring noxious plants and weeds, and providing high resolution images for fish passage culverts, road surface conditions and many other traffic maintenance and safety issues.

V. RESEARCH OBJECTIVE

The objective for this project is to further develop existing UAV technologies as they apply to State DOTs. Specifically, the research objective would focus on critical State highway and road issues where high resolution imagery from UAV systems is most appropriate. Some of these capabilities include but are not limited to:

1. Monitoring wetland areas and regions of invasive plant species that are located along known DOT corridors.

2. Photographing highway construction projects before, during and after construction for safety, design and decision-making purposes.

3. Locating highway structures required for DOT inventories. Possible structures to identify include culverts, bridges, dividers, guard rails, road stripes, and signage, etc.

4. Photographing select highway sections to update GIS imagery for general road damage and maintenance issues, striping and safety issues, road hazards, etc.

To achieve these capabilities, the following tasks are expected:

Task 1, Review Existing Technologies: Determine the current state of the UAV technology in both private and University arenas. Specifically, it is important to research UAV platforms that are small, low-cost, high resolution, multispectral, remote sensing, autonomous, and simple to operate. It is also important that the UAV technologies can provide immediate aerial imagery that can be stitched and geo-referenced into GIS databases.

Task 2, UAV Development: Research methods to build upon existing UAV technology so that it most appropriately applies to DOT applications. This will require some interaction and coordination with State DOTs when it is necessary to use the aerial vehicles for flights and field tests.

Task 3, UAV Proof of Concept: Choose several State DOTs to perform multiple proof of concept flights from which geo-referenced images are utilized within the State's GIS database. Meet with each DOT to present the imagery, advise on the incorporation of the imagery into the DOT GIS database, and to determine specific future target zones for imagery that will benefit the DOT.

Task 4, Final Report: It is expected that the report will be written in three major sections, each including the approach and results from tasks 1 through 3.

VI. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

Recommended Funding:

$300,000

Research Period:

24 months

VII. URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

DOTs are facing unprecedented staff and budget reduction because of economic crises. This un-manned aircraft reconnaissance system can provide a less expensive, fast method for assessing conditions of various transportation field features, traffic, accidents, work zone and many others. This method uses very simple and easy to deploy model planes with digital cameras mounted on its wings. The plane is guided by satellite on a predetermined path. The mounted cameras collect ground photos at regular intervals or as needed. This technology could save many thousands of dollars while providing more reliable data.

VIII. PERSON(S) DEVELOPING THE PROBLEM STATEMENT

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XI. REFERENCES

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