Advanced Cockpit Evaluation System—Display and Control Testing Using Small Radio-Controlled Based Analogs

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How can one test real-time commanded augmented reality display and control (D&C) concepts on the ground and in three-dimensional space quickly, routinely, and at low cost and risk? Use low-cost analogs such as small radio-controlled (RC) vehicles to move video and position sensors around, and to downlink the data to a wide-field-of-view mobile cockpit generating an "out-the-window" view. Also, control these vehicles in the RC realm, as any object controlled remotely from a closed cockpit could be 1.5 m (5 ft) away, and mimic one many thousands of miles away.

These concepts can obviously be tested on full-scale aircraft, but the cost and scheduling for such platforms do not allow for a rapid testing and turnaround of various D&C concepts. Using small, low-cost platforms operating in the RC realm make this rapid prototyping model much simpler.

Creative Resourcing

Other nontechnical—though no less important—aspect of the project's success was the partnering and reuse of assets. The team was able to compete for small innovation funding to construct an RC helicopter and associated sensor pallet; build a rover with education funds in exchange for doing student outreach; borrow and use the central processing units that drive Orion displays in a lab to drive the software in the Advanced Cockpit Evaluation System (ACES) remote cockpit; and to reuse the X-38 Remote Cockpit van and convert it to the ACES configuration. All of these methods represent creative ways to team across different organizations to achieve mutual goals through the sharing of assets.

Test Platform Overview

Basic elements of the ACES system were built/integrated over a 6-week period in the summer of 2011. The hardware includes a remote cockpit built into the back of a 15-passenger van, an RC helicopter, and a rover (RC rock crawler). The helicopter is flown in typical RC fashion using a standard transmitter. The outside line-of-sight safety/backup pilot performs the takeoffs and landings, and hands over control to the inside van operator who flies it to preselected points in the same way a shared "buddy" box transmitter is used to train a new RC pilot where the safety pilot can always assume control with the release of a single spring-loaded switch. The rover is controlled from inside the van using a standard RC controller. Both air and ground configurations are able to view video and navigation downlink from the sensor pallet. Video camera and attitude/position data are also downlinked to the van where it creates a natural out-the-window view in a multi-paneled wide-field-of-view cockpit. Although quite challenging, special attention was paid to deconflict and keep all frequencies in the unlicensed "free" band.

Additional details:

Van: GSA Ford E-350 15 Passenger Van (figure 1) with tow-behind trailer housing a 4-kilowatt generator, pilot seat, five wraparound liquid crystal display (LCD) displays, one downward-looking LCD display, joystick/

Fig. 1. *Advanced Cockpit Evaluation System Van (top), 5 panel wraparound displays (bottom).*

pedals, intercom, blacked-out windows, video receivers for four onboard video signals, telemetry receiver, and network of seven computers.

Sensor Pallet: A small carbon fiber pallet was built to house three forward-looking and one downward-looking low-cost color cameras that are linked to four video transmitters and downlinked to the van. A second set of low lux black-and-white cameras can be used for night flying. An attitude/position sensor is downlinked to the van, as well. The flexible mounting system allows for transfer of the pallet from the helicopter (air/three-dimensional based) to rover (ground/two-dimensional based) in just a couple minutes.

Helicopter: An electric T-REX 600 class helicopter (figure 2) was selected to keep vibration and noise to a minimum while keeping the operation simple by merely charging batteries. Typical flight times with up to a 3.6-kg (8-lb) payload are 6 to 7 minutes with a single battery and marginally longer with dual batteries. The helicopter is also equipped with a spare receiver to perform several other operations such as gimballing of the camera mount and activation of the subscale article release mechanism. A custom landing gear was built to accommodate the sensor platform.

Rover: A 1:5 scale rock crawler (rover) platform was selected to allow for sensor information to be downlinked to the van in times where testing is required, but the helicopter cannot be flown due to weather, pilot availability, etc. High-torque motors were selected to accommodate the sensor pallet and additional payloads in the 9- to 11-kg (20- to 25-lb) range, such as a robotic arm or additional sensors.

Planned and Potential Uses

Initial use of the ACES system included the test of augmented reality software through the blending of live images with synthetic obstructions and navigation information to help identify hazards in a pilot's flight path (figure 3). The other planned use was to fly the helicopter in such a way as to emulate a planetary lander. Integration of a processor and sensor hardware aboard the helicopter is in work to test automated rendezvous and docking

Fig. 2. *Helicopter (top), landing gear with dual-use sensor pallet (center), rover (bottom).*

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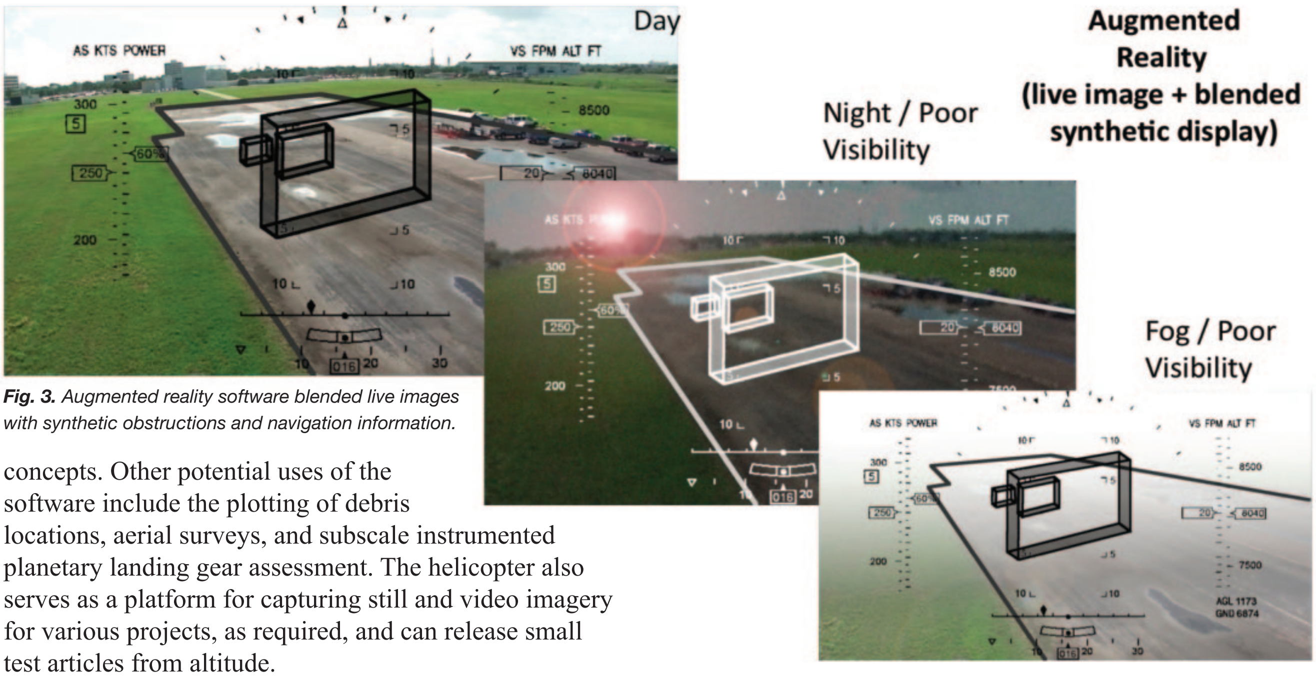

Fig. 3. *Augmented reality software blended live images with synthetic obstructions and navigation information.*

concepts. Other potential uses of the software include the plotting of debris locations, aerial surveys, and subscale instrumented planetary landing gear assessment. The helicopter also serves as a platform for capturing still and video imagery for various projects, as required, and can release small test articles from altitude.

Summary

This system represents a robust, flexible, hands-on D&C test platform. Engineers are encouraged to use its capabilities to supplement office design with "in-the-field" testing. Low-cost, rapid prototyping test platforms such as this provide another opportunity for risk mitigation and requirements refinement by identifying issues in the field with real hardware and software in the loop, which raises the "reality and criticality" factor, thus creating increased awareness of a system's operation.

The team purchased the helicopter and sensor system, and the team built, tested, and flew the system in just 6 weeks. Rapid flight tests at the rate of up to twice weekly followed. The low dollar and risk factor made this aggressive test program possible. All this was accomplished for approximately $5,500, roughly the cost of "1" hour of typical jet aircraft flight time.

The ACES assets are expanding to include an additional RC helicopter and RC fixed-wing aircraft, which will create new innovative test platforms and partnering opportunities. Work continues to complete integration of the augmented reality software.