



Fused Reality for Enhanced Flight Test Capabilities

Complex maneuvers can be accomplished without additional aircraft resources or risk.

Dryden Flight Research Center, Edwards, California

The feasibility of using Fused Reality-based simulation technology to enhance flight test capabilities has been investigated. In terms of relevancy to piloted evaluation, there remains no substitute for actual flight tests, even when considering the fidelity and effectiveness of modern ground-based simulators. In addition to real-world cueing (vestibular, visual, aural, environmental, etc.), flight tests provide subtle but key intangibles that cannot be duplicated in a ground-based simulator. There is, however, a cost to be paid for the benefits of flight in terms of budget, mission complexity, and safety, including the need for ground and control-room personnel, additional aircraft, etc.

A Fused Reality™ (FR) Flight system was developed that allows a virtual environment to be integrated with the test aircraft so that tasks such as aerial refueling, formation flying, or approach and landing can be accomplished without additional aircraft resources or the risk of operating in close proximity to the ground or other aircraft. Furthermore, the dynamic motions of the simulated objects

can be directly correlated with the responses of the test aircraft. The FR Flight system will allow real-time observation of, and manual interaction with, the cockpit environment that serves as a frame for the virtual out-the-window scene.

FR is a mixed-reality approach that employs four technologies: live video capture, real-time video editing, machine vision, and virtual environment simulation. Video from the trainee's perspective is sent to a processor that preserves pixels in the near-space environment (i.e., cockpit), and makes transparent the far-space environment (outside the cockpit windows) pixels using blue-screen imaging techniques. This bitmap is overlaid on a virtual environment and sent to the trainee's helmet-mounted display (HMD). The user can directly view and interact with the physical environment, while the simulated outside world serves as an interactive backdrop.

The system employs a head-mounted camera and display assembly, where the camera captures live video from the user's perspective and sends it to a computer for processing. The window frames

of the cockpit are bordered with colored tape, and when these color-coded borders are sensed, the computer keys out pixels lying within each window so that an underlying virtual scene is seen in place of the window pixels. The virtual simulation reacts to the user's head motion and control inputs, and the two layers — processed video and virtual scene — are combined and viewed by the user through a head-mounted display.

Critical hardware challenges included selection of color and material of the window bordering material, and identifying a lens filter to allow machine color recognition in the presence of bright sunlight. Software challenges included accommodating for every possible view (of one or more window borders), balancing sensor noise-smoothing against precision loss, and creating a means for rapidly calibrating color sensing thresholds for a given lighting environment.

This work was done by Ed Bachelder and David Klyde of Systems Technology, Inc. for Dryden Flight Research Center. Further information is contained in a TSP (see page 1). DRC-010-033

Thermography to Inspect Insulation of Large Cryogenic Tanks

Significant cost and schedule savings may be realized.

John F. Kennedy Space Center, Florida

Thermography has been used in the past to monitor active, large, cryogenic storage tanks. This approach proposes to use thermography to monitor new or refurbished tanks, prior to filling with cryogenic liquid, to look for insulation voids. Thermography may provide significant cost and schedule savings if voids can be detected early before a tank is returned to service.

The Launch Complex 39 Pad B liquid hydrogen storage tank at Kennedy Space Center has had performance issues since it was put into service in 1965. The loss rate from the Pad B tank was two to three times more than the

Pad A tank, which has resulted in a significant cumulative loss of hydrogen over more than 40 years of service. It has been theorized for years that the performance degradation was due to an insulation void; however, because of the cost and schedule disruption that would be required to fix the problem, it remained in service until Pad B was turned over after its support for the Shuttle program was finished. With the tank taken out of active service, it was confirmed that a major insulation void was present.

Because of the large thermal mass of the inner and outer spheres, heat trans-

fer between surfaces to equalize temperatures can be relatively slow, even when the temperature differences between the spheres themselves is small. Therefore, thermography has been suggested as an aid in acceptance testing of the tanks before cryogen is introduced to any tank, new or refurbished.

Models suggest that areas without insulation will heat less rapidly under solar illumination than areas with insulation, due to better thermal contact with the inner storage sphere. The resulting temperature difference across the outer shell of the tank should be a few degrees Celsius, which can be easily

visualized by off-the-shelf long-wave and mid-wave cameras.

The opportunity to test this theory presented itself over the last year as the Launch Complex 39 hydrogen tank was taken out of service in order to complete weld repairs.

The ability to detect insulation voids prior to filling with cryogen will save money and time, eliminating the expense of losing cryogen and the months required for chilling down and warming up the tank if a void is discovered after the cryogen is introduced

into the system. Potential savings could be in the millions if large voids are detected early.

This work was done by Ellen Arens and Robert Youngquist of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13575

Crush Test Abuse Stand

This technology can be used in most applications for the performance of battery testing.

Lyndon B. Johnson Space Center, Houston, Texas

The purpose of this system is to simulate an internal short on battery cells by causing deformation (a crushing force) in a cell without penetration. This is performed by activating a hydraulic cylinder on one side of a blast wall with a hydraulic pump located on the other. The operator can control the rate of the crush by monitoring a local pressure gauge connected to the hydraulic cylinder or a load cell digital display located at the hydraulic pump control area. The internal short simulated would be considered a worst-case scenario of a manufacturer's defect. This is a catastrophic failure of a cell and could be a very destructive event.

Fully charged cells are to have an internal short simulated at the center of the length of the cell (away from terminals). The crush can be performed with a ¼- to 1-in. (≈0.6- to 2.5-cm) rod placed crossways to the cell axis, causing deformation of the cell without penetration. The OCV (open-circuit voltage) and temperature of the cells, as well as the pressure and crushing force, are recorded during the operation. Occurrence of an internal short accompanied by any visible physical changes such as venting, fires, or explosions is reported. Typical analytical data examined after the test would be plots of voltage, temperature, and pressure or force versus time.

The rate of crushing force can be increased or decreased based on how fast the operator pumps the hydraulic pump. The size of cylinder used to compress the battery cell can be easily changed by adding larger or smaller fittings onto the end of the hydraulic cylinder based on the battery/cell size being tested. The cell is crushed remotely and videotaped, allowing the operator to closely monitor the situation from a safe distance.

This work was done by Jacob Collins, Judith Jeevarajan, and Mike Salinas of Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-23700-1

Test Generator for MATLAB Simulations

Goddard Space Flight Center, Greenbelt, Maryland

MATLAB Automated Test Tool, version 3.0 (MATT 3.0) is a software package that provides automated tools that reduce the time needed for extensive testing of simulation models that have been constructed in the MATLAB programming language by use of the Simulink and Real-Time Workshop programs. MATT 3.0 runs on top of the

MATLAB engine application-program interface to communicate with the Simulink engine. MATT 3.0 automatically generates source code from the models, generates custom input data for testing both the models and the source code, and generates graphs and other presentations that facilitate comparison of the outputs of the models and the

source code for the same input data. Context-sensitive and fully searchable help is provided in HyperText Markup Language (HTML) format.

This program was written by Joel Henry of the University of Montana for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-14861-1

Dynamic Monitoring of Cleanroom Fallout Using an Air Particle Counter

Goddard Space Flight Center, Greenbelt, Maryland

The particle fallout limitations and periodic allocations for the James Webb Space Telescope are very stringent. Standard prediction methods are complicated by non-linearity and monitor-

ing methods that are insufficiently responsive. A method for dynamically predicting the particle fallout in a cleanroom using air particle counter data was determined by numerical correlation.

This method provides a simple linear correlation to both time and air quality, which can be monitored in real time. The summation of effects provides the program better understanding of the