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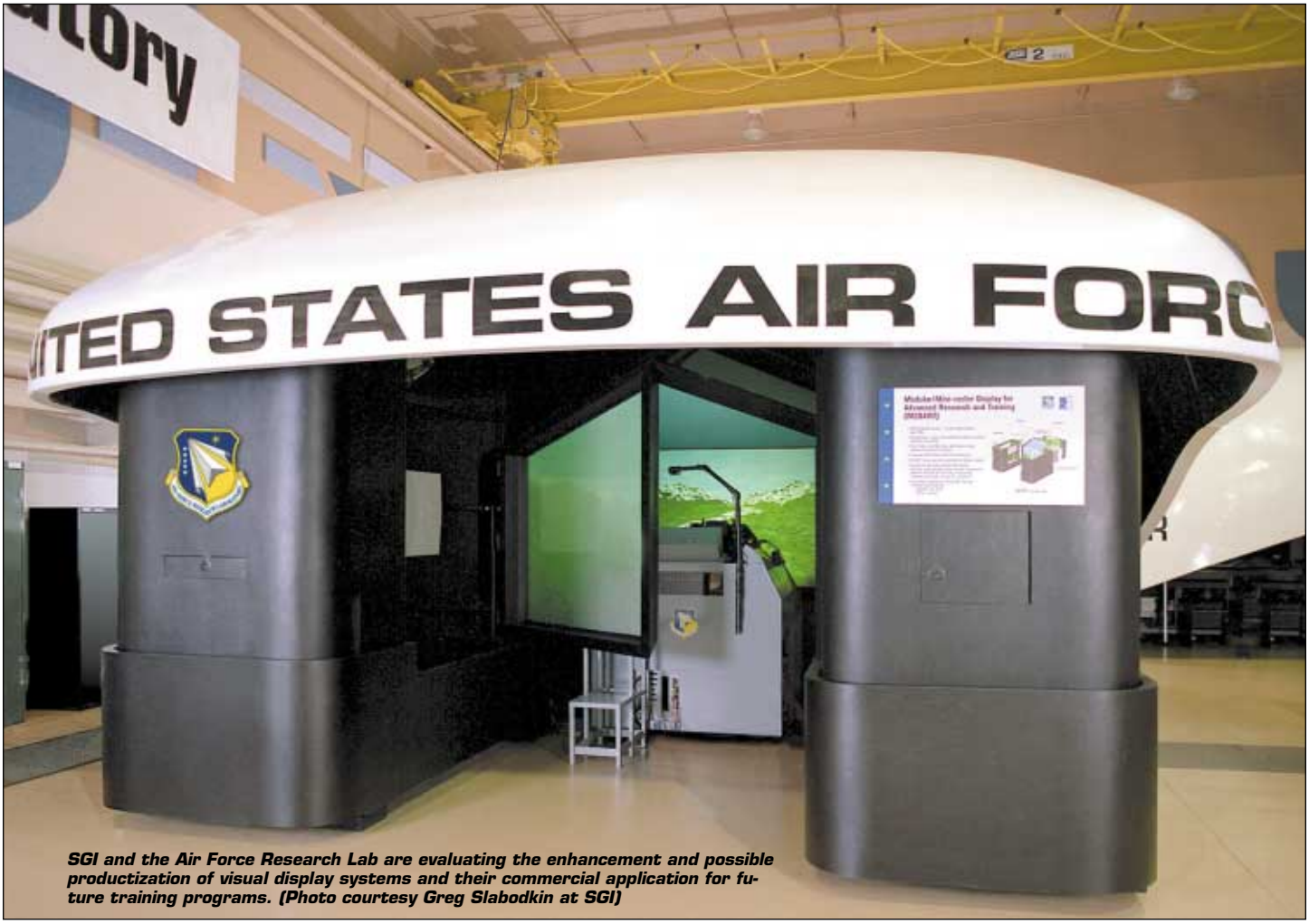

SGI and the Air Force Research Lab are evaluating the enhancement and possible productization of visual display systems and their commercial application for future training programs. (Photo courtesy Greg Slabodkin at SGI)

A Surprise in Networked Mission Training with Real and Timely Imagery

Not Just Better, but Cheaper

by Neal Schoenberg

The military simulation community has long known that moving to real images from graphic visualizations could increase accuracy. But a joint project between SGI and the Air Force is proving imaging to be less expensive.

It wasn't all that long ago, in military simulation for training and mission planning, that synthetic graphic vendors would actually say such things to potential users as, "Why would you want to use photos or video? We can make it look so much better." Both sides of that conversation generally knew that this "looks nice" argument was feeble. But what difference did it make? The computer power to handle great masses of useful aerial and satellite imagery, let alone video, was a ways off in execution, and upgrading to "the real deal" from sophisticated cartoons, even those that might texture map imagery over their graphic skeletons, was just a dream for the future—and a financially challenging one, even for the world's military forces.

A combination of ingredients are making the crossover to imaging

AFRL's Mobile Modular Display for Advanced Research and Training (M2DART) will be used in the development of training simulation and hardware/software for military and commercial applications. (Photo courtesy Greg Slabodkin at SGI)

from graphics in simulation a reality right now—legal commercialization of once highly classified imagery that resolves objects of less than one meter resolution (and soon much less), new sophistication in databasing, data crunching chips, and compute architectures from a handful of firms such as SGI, which took an early lead in working out ways to maximize power—not just in triangle rendering, but in pixel flow.

Mission training simulators—taking practical steps toward the battlefield commander's Holy Grail of a really viable Mission Rehearsal Simulator with image data moving rapidly from Sensor to Shooter—are being put in place now, marrying photo-specific imagery with a shared, networked image and video data model for Distributed Mission Training.

A key example is found in the year-old Cooperative R&D Agreement (CRADA) between the U.S. Air Force Research Laboratory's Warfighter Training Research division (Mesa, AZ) and SGI Federal (Silver Spring, MD). The surprise that this system delivery effort is finding—for almost everyone who learns it, including providers of the most sophisticated imaging and image processing tools—is that the image database approach is turning out, in important aspects, to be cheaper and simpler than using graphic visualizations. That very significant set of benefits had never even been part of imaging's pitch—and the findings may be important in bringing these new, sophisticated capabilities to multiple imaging markets later.

ABOUT THE PROJECT

The goals of the SGI and AFRL CRADA have been ambitious all along: development, testing, and in-use evaluation of flight training image-generation technologies, of database development, and of image processing techniques to match them—specifically, first, for F-16 fighter training. The goals add up to delivery of the ability to download and ingest space and overhead imagery so that in-place details of a mission site can be updated rapidly and well enough to simulate the real ongoing situation.

"All pilots," says Colonel Jerald Straw, Chief of the AFRL Warfighting Training Research Division, "would prefer database displays that are indistinguishable from the real world. While such realistic environments, which look 'normal' to the pilots, aren't absolutely critical for air-to-air training, they do alleviate distractions caused by lower fidelity systems—and high-fidelity visual databases are even more important for air-to-ground missions requiring accurate identification of geo-references and targets at realistic tactical ranges."

As Graham Beasley, SGI's Defense Solutions marketing manager, based in Denver, CO, described to *Advanced Imaging*, F-16 training had basically involved sitting in a simulator cockpit, with representative scenes from the database projected on the helmet or dome. Space would be saved by making fields a mass of green polygons—and there probably wasn't more exact image detail available anyhow.

"The geo-specific data used to construct the visual database," Beasley notes, "had typically been classified or difficult to obtain," with the result that, for convenience alone, existing databases such as the fields of Eastern Germany—not considered an area likely to see much actual action, post–Cold War!—were used over and over for training purposes. The sheer time and expense of creating and rendering and then calling on these huge working databases built on mosaics of graphics cut down on the number of them that were made—let alone effectively modified for missions elsewhere.

An example of the technology used in the old context, Beasley noted in "Geo-Specific Databases for Flight Simulators," a white paper he'd written in support of the new approach, was the Special Operations Forces Aircrew Training Systems used to rehearse missions under specific local conditions shown in classified imagery. The hardware costs involved meant that less than a dozen were built—and with that limited end-use possibility, even

those were starved for useful source data.

"Today," Beasley points out, "it's possible to use software that had been built for the GIS community, from ERDAS or ESRI, for instance, and the mass of readily available existing and made-to-order imagery from the databases of Space Imaging, SPOT, even Microsoft," which radically simplifies and lowers the cost of modifying data.

The basic hardware used in the new effort, in use at the U.S. Air Force's F-16 Mission Training Centers under contracts with Lockheed Martin Integrated Systems and Boeing Aerospace Support, is the powerful SGI® Onyx® 3400 system, which can drive up to eight full pipelines—and users—at once, processing imagery, video, and, yes, 3D terrain and geospatial data at the same time. The Onyx 3400 systems are being used as image generators for both air-to-air and air-to-ground scenarios, in full-scene, 360-degree environments. They're proving vital in moving from the traditional post-image ingestion processing to a "clip-map"–based system—with the power to database key pieces of image-derived information.

IMAGE AUTOMATION POWER

Developers working on this project agree that the key immediate issue is further enhancement of databasing capabilities—and that important progress has been made here, thanks to imaging.

"The capability to update databases in real time," says Col. Straw, is essential for optimum mission preview/rehearsal. While aircrews can preview a mission into or over any target area available in the database, optimum rehearsal requires real-time update, revealing recent battle damage, enemy force movements, threat system locations, and so forth—preferably from the last few hours or minutes!

"Odds of first-pass success and survival increase tremendously if aircrews have 'been there before' and have seen exactly where the target is, how recent battle damage has changed its appearance, and where the threats are."

The effective and timely updating of image-specific databases would not be possible without a series of automated imaging capabilities already familiar to Advanced Imaging readers. In order to be mosaicked or data-based, satellite imagery—on file or freshly captured—needs to be orthorectified to account for both geometric distortions and radiometric differences between image clips caused by the earth's round shape, and even distortions in the specific ground target. Correlation of stereo image pairs is often used in this regard—and if you add the new requirement for more frequent updating, that simply adds up to a tremendous amount of batch image processing. These processes, of course, can now be automated, in many cases using image recognition tools developed for industrial vision to do the job.

One of these image content recognition-based abilities, which SGI's Beasley says the team calls "Focused Fidelity," is the automatic determination of what parts of an image or image stream are most significant—and follow-up automatic adjusting of the detail level displayed, on-the-fly. This delivers the most detail for pilot training where hazards demand it, or—more often, perhaps—where key changes on the ground have been noted in the updated database and need to be noted and accounted for.

ON TO VIDEO?

The approach has been seen before, in the mirror-opposite situation in which so much live digital video of a situation was incoming—and here too, it was usually a military or intelligence situation originally—that vision was applied to identify the key elements of a frame or sequence that needed to be seen. Less lossy compression was then applied to those areas of interest than to the rest of the frame—as it was delivered.

The two scenarios are likely to meet, given part of the SGI Federal and AFRL teams' goals—moving from orthrectified, updated image database sources to live incoming video—including video that would be downloaded in real time from the likes of the Predator Unmanned Aerial Vehicle (the basis of genuine mission rehearsal) and, without too much stretch of the imagination, eventually a degree of remote, telepresence-based warfighting built on image data incoming to mission control far from the scene.

Live video handling is not the first issue on the team's plate, however. Colonel Straw notes, "Today, we already can and do create simulation databases using a variety of photo-based, geospecific imagery sources—including everything from satellites and air-breathing manned and unmanned platforms to photos taken with handheld cameras. Obtaining high-resolution hyper-spectral imagery of all areas of the globe that may be of interest remains a challenge. So the larger technical challenge is converting available imagery into simulation databases in real time—which is required for mission rehearsal."

DISTRIBUTED MISSION TRAINING

Generally available still imagery will itself soon be presenting both better data and tougher challenges for processing and handling, as legal limitations are lifted from resolutions well under a meter, in the months just ahead. Add to that, immediately, the increasing imperative to share all of this new data.

It's not an accident that the SGI and AFRL CRADA has been part of the U.S. Air Force Distributed Mission Training (DMT) initiative. It is a given of the effort that the image data, from existing databases or grabbed and delivered in real time, will be generated worldwide—and needed everywhere, made vital, in fact, for being updated more often.

The need for distributed training, SGI's Beasley points out—with mission simulators able to call on the same data across networks, with different needs in mind—is only accentuated when the incoming data, across the network becomes more enriched and up-to-date this way.

"You don't want the updated image information lying around for training in one place and not another—which was never the practical issue" in the era of use and reuse of the same old graphic simulations.

MIGRATION

SGI has already seen sales of similar systems for Air Force training across Europe and in Israel. Where might the combination of photo-specific imaging and distributed training be delivered and commercialized next? Where scale matters—and where batch processing of massive image databases is part of the question. With these sales and dozens of related patents under its belt, SGI has naturally been giving these questions considerable thought.

There are already military command and control simulation extrapolations, Beasley reports, "and, believe it or not, uses in art—big frescoes in the Vatican that are so detailed and remote from viewers that you need to 'fly' over them to study them … and that star database at the new Hayden Planetarium in New York, which uses a similar system, with its very large and image-based but changeable star database." Medical simulation is another obvious area for development.

"The potential applications of these capabilities are limited only by our imagination," Colonel Straw adds. "Certainly, in the training and rehearsal arena, there are obvious applications for medicine, maintenance, force protection, and much more. And 3D volumetric weather effects are needed across various domains, including future single display systems of commanders. High-fidelity, photo-realistic, geospecific synthetic databases provide the underlying technology for such a display system." ◆

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