



SiliconGraphics
Computer Systems

Onyx™

Real-Time Image Generation

Generating imagery that represents the real world using digital computers is a demanding task. Photographic-quality images free from distracting visual anomalies must be created at the rate of at least 30 frames per second in order to maintain the appearance of smooth movement. Multiple high-resolution channels help to create immersive environments. Methods of handling dynamic objects in the scene, weather conditions,

different times of day, and other special visual phenomena require special handling. Methods for generating large visual databases quickly and efficiently using a variety of sources are essential to the image generation process. The Silicon Graphics® Onyx™ supercomputer with RealityEngine²™ graphics provides a scalable, open-architecture solution suitable for a wide range of computer image generation requirements.

Onyx Application Brief Number 5, Volume Three



ONYX

The generation of curved tracks requires high polygon capacities supported by Onyx RealityEngine²



Onyx is the first and only image generator able to support database interoperability without conversion.

Currently, over twenty database formats are supported.

Image generation is implemented using the general-purpose MIPS® R4400™ RISC CPUs, memory, and disk I/O subsystem of Onyx. Optimum performance is achieved using the CPU system to perform upfront graphics tasks such as field-of-view culling, selecting levels of detail, and performing other system load management functions. Data potentially in the field of view is transferred to the RealityEngine² graphics subsystem to be rendered. The RealityEngine² graphics subsystem performs the 3D-to-2D geometric transformations, hidden surface removal, texturing, anti-aliasing, and video output. Based on z-buffer technology for hidden surface removal, RealityEngine² graphics supports unlimited moving models, rapid database generation, and dynamic database changes. Tri-linear mip-mapped texture, sub-sample anti-aliasing, and non-interlaced video produce unprecedented image quality, free from distracting visual anomalies. Weather effects like fog, haze, rain, snow, and lightning are implemented using a combination of hardware and database modeling. Multiple channel displays can be provided by dividing individual RealityEngine² graphics pipelines using the Multi-Channel Option or using multiple graphics pipelines in a rack.

Providing the building blocks for all image generation applications is IRIS Performer™, an application programmers interface for real-time, 3D graphics developed by

Silicon Graphics. Performer provides a base level of image generation capability which can be enhanced by third-party software companies or system integrators.

Because Silicon Graphics image generation solutions are based on open architecture, they support databases developed in multiple formats, including those of other major image generator manufacturers. A variety of database development tools that can run on the same hardware used for image generation are also available. Onyx is the first and only image generator able to support database interoperability without conversion. Currently over twenty database formats are supported.

Adding CPUs to the existing Onyx chassis and using the REACT™ extensions for real-time computing provides for host-integrated computer image generation—HI-CIG—a feature exclusive to Silicon Graphics. The HI-CIG concept is more than packaging. Tight integration of host-compute CPUs with the image generator on the same 1.2GB data bus enables high-performance mission functions, reduced transport delay, dynamic terrain, and powerful special effects, all coupled with a common development environment.

Onyx RealityEngine², Multi-Channel Option, IRIS Performer, and REACT—commercial, off-the-shelf, open-architecture products for powerful, cost-effective computer image generation.



Photorealistic imagery like this is representative of all CORYS simulators.

CORYS-Twin-Cab Driving Simulator for the London Underground Ltd.

The London Underground carries millions of passengers to their destinations every day. Extensive training of the Underground's operators is vital to maintain safety. Traditional metro simulators have used video disk technology to create simulated out-the-window scenes. However, video disk technology can't reproduce emergency operating conditions, accurate visibility ranges, and interaction between trains. With the opening of the new Jubilee Line extension, London Underground Ltd. selected CORYS of Grenoble, France, to build a twin-cab driving simulator for training operators.

CORYS will use an Onyx™ RealityEngine2™ graphics super-computer from Silicon Graphics to reproduce the existing Underground line, the extension under construction, and the rolling stock operating on the line. An Onyx system with four 200MHz processors and RealityEngine2 graphics, configured with four raster managers and a Multi-Channel Option, will be used to create two high-resolution channels operating at 30Hz. An Indy™ workstation with Cosmo Compress™ will generate JPEG video for use in the instructor control station. The simulator will feature high-quality computer-generated images to provide trainees with a wide range of realistic normal and emergency operator situations. The Onyx solution offered by CORYS will provide training of two operators separately or networked training in which interaction can occur between trains—a first in the industry.

CORYS has become a world leader in the development of railroad training systems based on computer image-generated technology. In addition to the London Underground project, CORYS has been awarded contracts for six simulators for the French railroad and one for the Belgian railroad. Silicon Graphics computer image generators have been at the heart of each win, providing high-performance, cost-effective graphics solutions.

MarineSafety International Rotterdam b.v.—Marine Research and Training Center

Rotterdam, the Netherlands, is the world's busiest seaport, so it is appropriate that the city is also the home of MarineSafety Rotterdam b.v., the world's premier marine simulator research and training centre. As the city develops infrastructure in and around the port, such as bridges crossing major waterways or widening of channels, many questions have arisen as to how these changes will effect the operation. As a part of overall risk management, extensive research and analysis services for the planning and design of ports and channels was needed. MarineSafety International Rotterdam b.v. was created to provide both maritime engineering and training.

At the heart of the facility is a full-mission bridge simulator with a wheelhouse equipped with Det Norske Veritas-compliant instruments, exactly matching a real ship's bridge. This motion-based platform is surrounded by 360 x 35 degrees of computer-generated imagery produced by twelve Crimson™ RealityEngine™ graphics systems from Silicon Graphics. Two additional fixed-base simulators, with five-channel image-generation systems supported by Crimson RealityEngine systems, are used to simulate tugs which can be networked with the bridge simulator. These systems are used in conjunction with a geospecific database of the Rotterdam harbor to faithfully replicate the experience of operating ships at different times of day, weather conditions, and sea states.

Paradigm Simulations VisionWorks® is currently being used with databases Paradigm developed with MultiGen. The simulator required advanced image generation features to represent marine effects like three-dimensional waves, traffic motion, towlines, drawbridge openings, and navigational lights. MarineSafety Rotterdam helps ship owners and managers, municipalities and government agencies, oil companies, importers, exporters, and transportation companies protect their investments in safety, cargo, and the environment.

RealityEngine supports many dynamic effects necessary for marine simulation.



Hughes Training—Railroad Visual Upgrade for Burlington Northern Railroad

Locomotive engineers, like pilots, require extensive training to gain the necessary skills and experience, but have never had access to the railroad equivalent of flight simulation. Until now. Hughes Training of Arlington, Texas, recently installed the first computer image generation (CIG) system for railways in North America at the Burlington Northern training facility, in Overland Park, Kansas. The system, installed on four TS-2 simulators from IIT Research Institute of Chicago, helps locomotive engineers meet the Federal Railway Association's certification requirements.

Pre-CIG systems were limited by low-resolution, inflexible video disk technology. Hughes combined the high-performance, high-resolution graphics of the Onyx RealityEngine² system from Silicon Graphics with its own RightView™ visual software, based on Silicon Graphics IRIS Performer™, to create

a highly dynamic, flexible training environment. The two-processor desktide Onyx, RightView, and a database of 500 switchable objects simulate over 100 miles of track, including parallel segments, curves, and crossovers, complete with signs, signals, and moving trains and vehicles. Hughes developed the database of challenging training scenarios from six actual Burlington Northern routes using their simulator digital track file.

Instructors now can vary the weather and time of day, manipulate signals, and simulate emergencies in highly realistic situations that were previously impossible to recreate. The Hughes system also supports other Onyx RealityEngine² configurations for multi-channel displays, motion-based simulators, and higher update rates for rapid transit simulation. Hughes, IITRI, and Silicon Graphics have allowed Burlington Northern to take the lead in locomotive engineer training in North America.





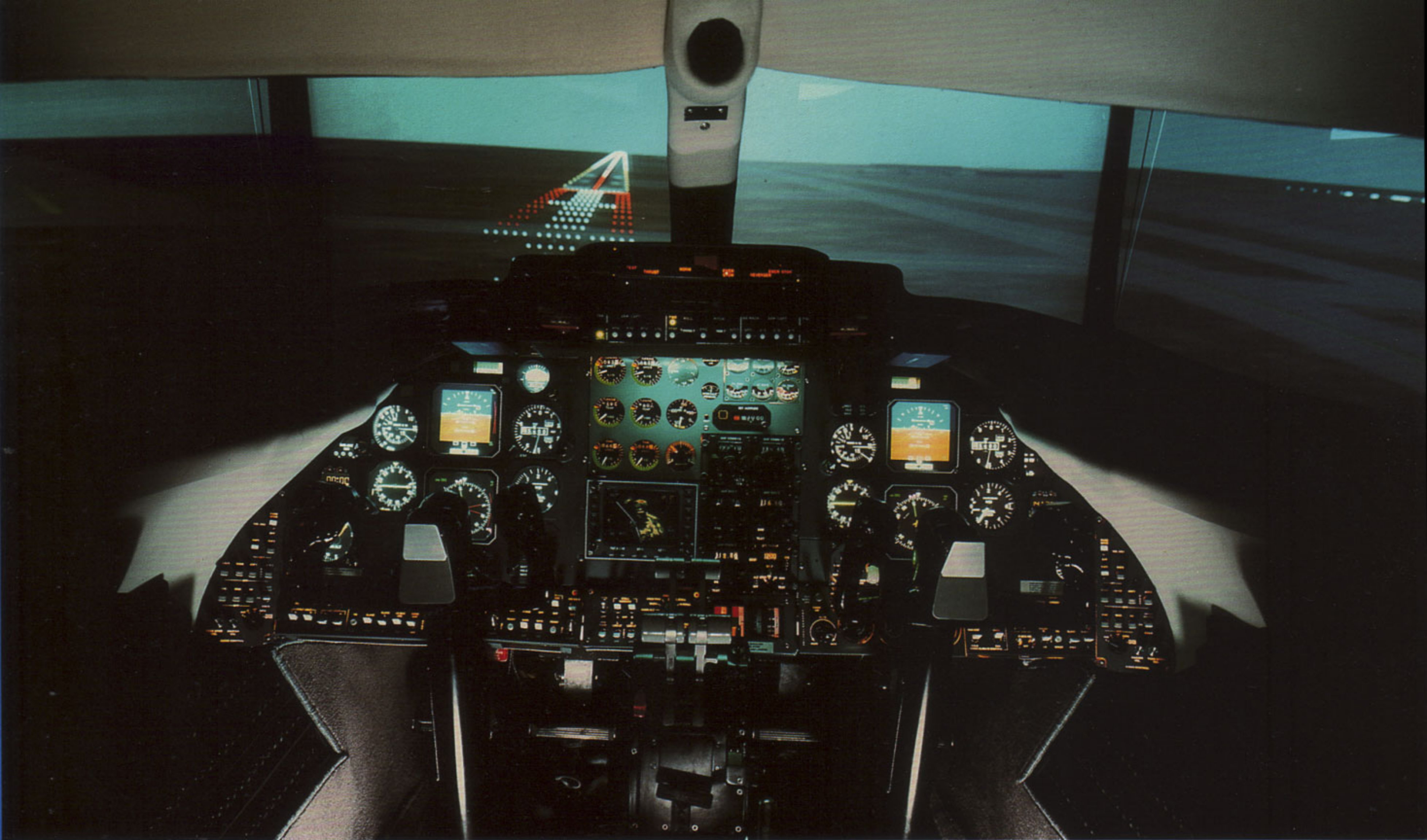
The degree of realism provided by the intelligent traffic is unparalleled in the industry.

AITEC GmbH & Co.—The New Dimension in Driving Instruction

Flight simulators have vastly improved the economy, ecology, and safety of the airline industry. AITEC Gesellschaft für Simulatorgestützte Fahrerschulung mbH of Cologne, Germany, is in the process of opening a series of world-class simulator-based training centers in Europe to bring similar advantages to car and truck drivers. Building a simulator capable of providing adequate training requires sophisticated vehicle modeling and high-fidelity computer image generation. It is essential to generate proper physiological cues, speed and distance perception, realistic color, and photorealistic imagery at a fixed frame rate of at least 30Hz. Multiple channels are needed for the forward displays and for the rear view mirrors. And since many regional centers are needed to train large numbers of drivers, low cost is essential.

To meet these complex requirements, AITEC Dortmund, the development company, is using a Silicon Graphics Onyx rack system with eight 200MHz processors and two RealityEngine² pipelines to provide Host Integrated Computer

Image Generation. Multi-Channel Options split the capacity of the RealityEngine² pipelines to drive a three-channel SEOS Prodas[®] display system and two rearview mirrors. High-quality anti-aliasing and tri-linear mip-mapped texture combine to create imagery so real that trainees often insist on driving back to the starting point of the exercise before getting out of the simulator. AITEC uses the MultiGen[®] modeling system with their own enhancements to build databases according to official road design regulations. The real-time software is also developed by AITEC based on IRIS Performer. AITEC innovations and Onyx RealityEngine from Silicon Graphics enable the AITEC truck driving simulator to achieve an unrivaled degree of reality—just like actual traffic. The simulated road users behave autonomously and intelligently, and interact both with each other and the trainee. The five channels of imagery provide an immersive environment capable of providing training in traffic and driving situations too dangerous or difficult to reproduce in real-life road traffic. With training from AITEC and Silicon Graphics, Germany's autobahns will be safe as well as fast.



RealityEngine² graphics provides a totally immersive synthetic environment for civil airline training.

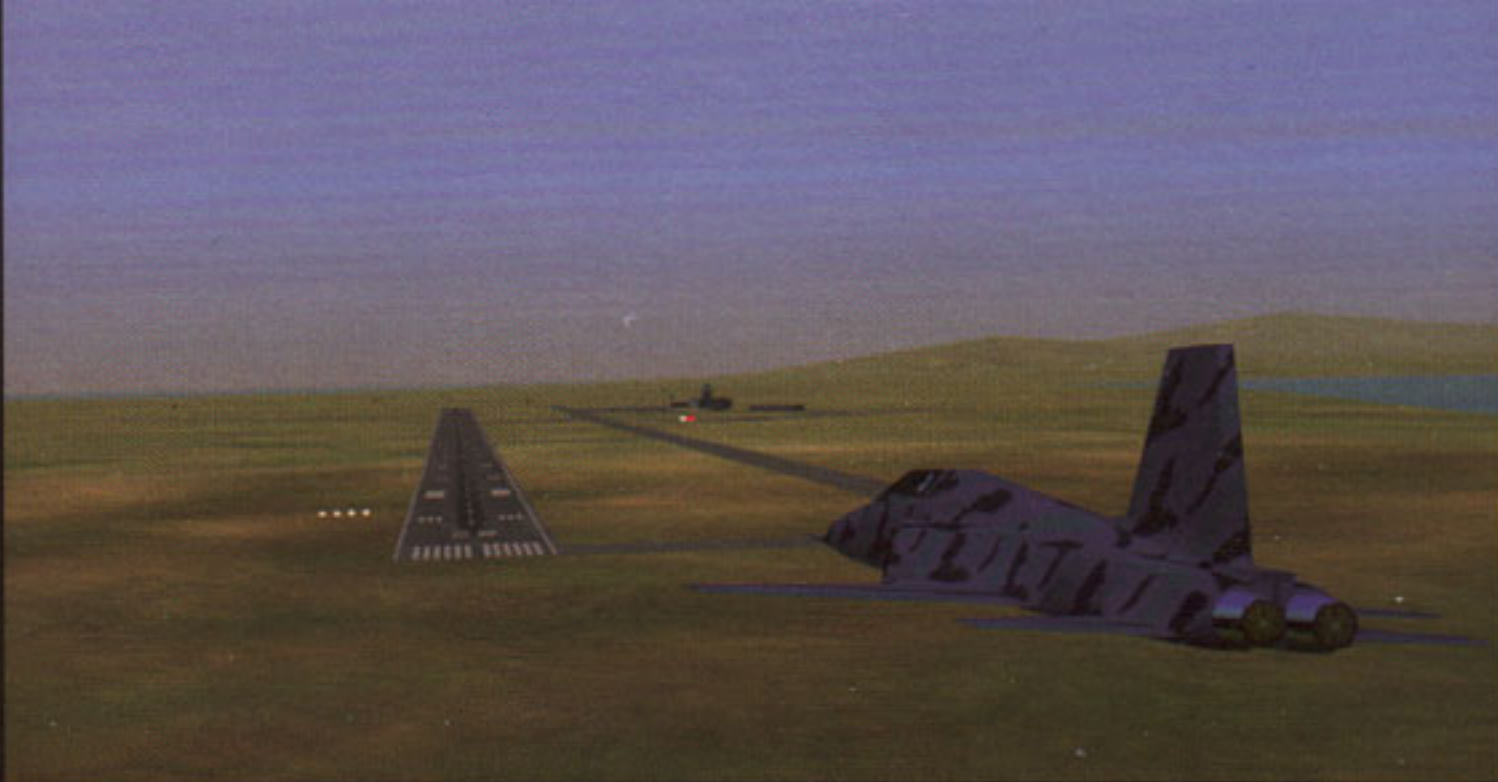
CTA, Incorporated—Flight Simulation for Pilot Training

Pilots in training need all the time they can get in the cockpit in order for flying to become second nature. CTA, Incorporated, of Denver, Colorado, has developed a Flight Training Device (FTD) and associated Computer-Based Training (CBT) courseware to assist Saudi Arabian Airlines (Saudia) pilots in transitioning from general aviation aircraft to advanced commercial transport planes. The course consists of 10 hours of flight time, 32 hours of FTD time, and 80 hours of CBT.

CTA turned to Silicon Graphics, the world's leading manufacturer of high-performance visual computing systems, to recreate the pilot's flight experience in a Lear35 as accurately as possible. The FTD uses a two-processor Onyx RealityEngine² system with a Multi-Channel Option to render three out-the-window (OTW) channels in a four-display collimated optic image. Onyx also performs all of the aerodynamics, avionics, navigation, engine, electrical, and hydraulic models as well as I/O tasks. CTA's visual software, based on IRIS Performer, drives all of the image generation

functions. The OTW provides realistic representations of the San Francisco Bay area and the Denver region, complete with terrain, airports, landmarks, and simulations of day, night, and dusk. The Instructor Operator Station, based on the Indigo²™ XL workstation, replicates atmospheric conditions and provides maps and simulator control for the flight instructor, and can even be accessed from within the cockpit for operation without an instructor. Another Indigo² system simulates the Lear35 flight instruments down to the last switch. The multimedia capabilities of the Indy workstation allowed CTA to offer Saudia pilots realistic, easy-to-use tutorials.

The FTD, designed to be certified to FAA FTD Level 5 specifications, includes the ability to navigate and fly anywhere in the continental United States. It offers low-cost training to pilots who otherwise would not have access to flight simulation. By the time Saudia pilots enter the cockpit of a real Lear35, the complete training experience provided by CTA with Silicon Graphics has prepared them for anything.



Accurate lighting models generated on RealityEngine² create realistic F-5 flight training scenarios.

Camber Corporation, SBS Simulation Systems Division—Weapon Systems Training for the Mexican Air Force

Fighter pilots have no margin for error. To ready them for combat, it is crucial that flight training be as realistic as possible. Camber Corporation, SBS Simulation Systems Division, of Dallas, Texas, recently delivered two weapon system trainers to the Mexican Air Force—one for the Bell 212 helicopter and one for the F-5 fighter aircraft. SBS accomplished the formidable task of developing a common visual environment for both fixed-wing and helicopter trainers—a visual database simulating 130,000 square nautical miles of geospecific terrain with airfields and bombing ranges. It also includes weapons models, rocket effects, airport lighting controls, collision detection, and other standard simulation features. Because the database was too large to fit entirely in RAM, SBS developed software to read data from disk as needed and incorporate it into the database structure in real time.

SBS selected two Onyx RealityEngine² systems from Silicon Graphics as the image generators, each with four 150 MHz R4400 processors running a multistage Performer GL software pipeline to achieve real-time image generation. The F-5 trainer's single-channel video is generated by a deskside Onyx system which also supports an air-to-air radar simulator. The B-212 simulator, mounted on a motion base, has three-channel video generated by a rack-mounted Onyx system, with Multi-Channel Option hardware for left, forward, and right out-the-window views. Both trainers use a Crimson system as the host computer, and Indigo[®] workstations to run Instructor Operator Stations.

SBS chose Silicon Graphics systems over traditional turnkey image generation solutions to take advantage of the flexibility and control of solving trainer problems internally. With the IRIS Performer library as a foundation, SBS was able to create its own real-time application software. With its customized, advanced visual simulation system up and running, the Mexican Air Force can now be confident that its pilots are well prepared.

Onyx RealityEngine² graphics supports high-resolution imagery for wide field-of-view multichannel displays.

Wormald Technology—F-111C Mission Simulator Upgrade Program

The Advanced Systems Engineering team at Wormald Technology in Dee Why, Sydney, Australia, was faced with quite a task recently when the Royal Australian Air Force (RAAF) awarded it the contract for the F-111C Mission Simulator Upgrade project. The team opened four forty foot containers of equipment furnished by the government for the program to find a mixture of real aircraft hardware and digital and analog computers. They brushed the cobwebs from the equipment and have been working to integrate it into a high-performance mission trainer for F-111C RAAF aircrew. Phase one of the project involves converting and extending an ex-U.S. Air Force F-111F simulator to an Australian F-111C. Phase two will update the training device to simulate the performance and function of the RAAF's post-Avionics Upgrade Program aircraft.

Wormald selected the Onyx supercomputer with RealityEngine² graphics from Silicon Graphics for the out-the-window visual, weapons, and infrared systems with integrated host functions. The new visual system is composed of a partial-dome projection display driven by Onyx RealityEngine², and visual software developed in-house. Additional Silicon Graphics CHALLENGE[®] servers provide host computing and digital radar landmass simulation capability. Two Indy[™] XZ workstations host the updated Instructor Operator Station.

The F-111C is Wormald Technology's first mission simulator project. Wormald is using Silicon Graphics' broad family of binary-compatible products to consolidate its avionics, Instructor/Operator Station, simulation, image, and database generation software skills. Wormald's years of proven experience integrating real-time systems and Silicon Graphics' open-architecture computer systems provide the right combination to integrate new development with legacy hardware and software into a trainer for today's F-111C pilots and navigators.



Onyx™ Technical Specifications

Product Scope

- A flexible, open architecture image generation system for flight, ground, space, maritime and virtual reality applications

Visual Output

- 1 to 6 high-resolution, non-interlaced (1,280 x 1,024) outputs/system
- Up to 18 independent channels per system with individual eyepoints
- Up to 3 graphics pipelines per system
- Up to 220 million anti-aliased, trilinear mip-map textured, pixels per second fill rate per 4RM graphics pipeline
- Redefinable display line rates
- Separate NTSC or PAL composite video output standard
- Multichannel capability in deskside and rack chassis

Visual Priority

- Up to 32-bit Z-buffer—fully integrated with anti-aliasing
- Coplanar surface support
- Texture decal support

Surface Capacity

- Over 9,000 polygons/pipeline @ 30Hz
- Polygons textured, anti-aliased and Z-buffered
- Up to 27,000 polygons/system @ 30Hz

Texture Capability

- Photomap texture
- 4MB or 16MB texture capacity
- Programmable texture map sizes from 2 x 2 to 1,024 x 1,024 texels
- Trilinear mip-map capability standard
- 3D texture
- Detail Texture
- Sharp Texture
- Up to 380 128 x 128 mip-mapped textures
- From 4 to 48 bits per texel
- Lighting and smooth shading blended with texture
- Dynamic texture projection
- Environment mapped texture

Image Quality

- Up to 16 sub-sample anti-aliasing
- 8 or 12-bits per color component
- Lighting, shading, reflection, Z-buffering, anti-aliasing, and translucency, all combinable on same surface

Scene Management

- Database traversal, culling, and rendering
- Fade level of detail
- Overload management
- Fixed frame rate control

Mission Functions

- Height above terrain
- Collision detection
- Range finding
- Line of sight

Special Effects

- Environment mapping
- Steerable light lobes
- Texture animation
- Articulation and geometry animation
- Custom programmable special effects
- Directional shading and lighting
- 8 configurable light sources with material properties control
- Lighting functions definable: ambience, diffusion, specular, shininess, emissivity, position, and color

Moving Models

- > 100 simultaneous moving models (6 DOF)
- All models Z-buffered and anti-aliased at sub-pixel level

Weather/Environmental Effects

- Fog, haze, clouds
- Tunable fog functions, spline fog
- Time of day
- Horizon glow

Transport Delay

In synchronous mode:

- Min 33ms @ 60Hz frame rate and 60Hz refresh
- Min 50ms @ 30Hz frame rate and 60Hz refresh

Video Capabilities

- Standard 21" multisync monitor
- Real-time analog and digital video I/O capability
- Selectable display resolutions from VGA to HDTV, including field sequential output
- Genlock synchronization standard
- Separate composite video output standard
- Video image transfer from disk to texture or frame buffer at real-time video frame rates

Translucency

- Up to 4,096 levels of translucency
- Alpha to coverage function allows translucency, Z-buffering, and anti-aliasing simultaneously

Software Tools

- IRIS Performer™: Simulation development library enables flexible and rapid application development
- Debug and performance tuning tools
- Developer Magic™ software development environment

Light Points

- Raster-based round light point support
- Brightness and size vary with distance
- Independent light point fog control
- 3:1 tradeoff with polygons
- Directional lights
- Strobes, beacons, flashing, and rotating lights

Host Functionality

- Up to 24 multiprocessing RISC CPUs
- 180 - 4,325[†] SPECint and 177 - 4,248[†] SPECfp[†]
- REACT™ real-time system kernel
- 1.2GB/sec internal system bus
- Shared-memory multiprocessor architecture
- 3 to 23 VME slots
- High-speed disk and peripheral I/O support
- Up to 50MB/sec VME rate per VME bus
- Up to 5 VME buses supported
- Fast and wide SCSI-2 support at 20MB/sec per SCSI bus
- Up to 32 SCSI buses per system
- Up to 16GB of main system memory
- Ada95 language support

Sensor Simulation

- Support for correlated infrared, night-vision goggles, and radar

Sound

- Optional digital audio board
- Programmable audio library

[†] Estimated on 250MHz R4400™ processor

For more information please call:

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