

Annotated Bibliography

- [ATKI89] Atkin, Phil, and Stephen Ghee (Division), "A low cost flight simulator", Computer Graphics '89, London, UK, pp. 439-450.

Provides an overview of a prototype BSP-based system.

- [BAKE94] Baker, Stephen J, Dennis A. Cowdrey, Graham J. Olive, Karl J. Wood (Rediffusion Simulation), "Image Generator for Generating Perspective Views from Data Defining a Model Having Opaque and Translucent Features", US Patent No. 5,363,475, Nov. 8, 1994.

Describes in great detail a complex IG architecture intended for high performance. Discusses anti-aliasing (via sub-pixel stack-based Z-buffer), NLIM, parallel issues, treatment of light points, and efficient scan conversion.

- [BOEI83] Boeing Aerospace Co., "A Multiprocessor Z-Buffer Architecture for High-Speed, High-Complexity Computer Image Generation", NTIS AD-A141-083, Dec. 1983. (290+ pages)

This is a comprehensive report not only about a particular IG system, but about all issues related to FS CIG, including some historical notes. Unfortunately, it's only from 1983.

- [BUNK89] Bunker, Marvin, and Richard Economy, "Evolution of GE CIG Systems", SCSO Document, General Electric Company, Daytona Beach, FL, 1989.

Describes the technical innovations present in GE CIG systems, from the NASA II through the COMPU-SCENE PT 2000.

- [CHAU94a] Chauvin, J.C. (Sogitec), "An Advanced Z-Buffer Real Time Image Computer", 5th ITEC, 1994, pp. 557-562.

Briefly, though with a surprisingly high information content, describes the APOGEE IG. Hierarchical area processing is used in the renderer, along with an advanced A/Z-buffer.

- [CHAU94b] Chauvin, J.C. (Sogitec), "An Advanced Z-Buffer Technology", IMAGE VII, 1994, pp. 76-85.

Describes a hybrid A/Z-buffer system that keeps track of a number of fragments per pixel, using merging techniques to keep the number limited.

- [CHRI89] Christianson, David C. (NASA), "History of Visual Systems in the Systems Engineering Simulator", NASA Johnson Space Center, Houston, Texas, N90-20681, Aug. 1989.

Mostly of historical interest. Talks about IG systems used starting from 1964 up to the E&S CT6.

- [CLAR87] Clark, L. Charles, and Thomas C. Brown (Evans and Sutherland), "Photographic Texture and CIG: Modeling Strategies for Production Databases", 9th I/ITSC, 1987, pp. 274-283.

Focuses on the creation of self-repeating texture patterns from photographs, but also discusses some of the E&S CT6's texture capabilities.

- [CLAR90] Clark, L. Charles, and Michael A. Cosman (Evans and Sutherland), "Terrain Independent Feature Modeling", 12th I/ITSC, 1990, pp. 7-17.

Describes how the architecture of the ESIG 4000 simplifies modeling techniques using R-buffer instead of priority-list rendering. Describes many advanced run-time database handling capabilities.

- [COSM81] Cosman, Michael, and Robert Schumacker (Evans and Sutherland), "System Strategies to Optimize CIG Image Content", Image II, 1981. [pp??]
- Overview of the E&S CT5 focusing on database management.
- [COSM89] Cosman, Michael A (Evans and Sutherland), "[title missing]", 11th I/ITSC, 1989, pp. 224-231.
- Introduces some analytical models which describe database behavior (paging rate, density). Describes a database strategy using regular gridded terrain and independent terrain features.
- [COSM90] Cosman, Michael, Allen Mathisen, and John Robinson (Evans and Sutherland), "A New Visual System to Support Advance Requirements", IMAGE V, 1990, pp. 370-381.
- Describes some of the capabilities of the ESIG 4000. Describes the regular grid terrain representation and the advanced run-time database handling capabilities. Also discusses texture (and global texture), R-buffer, and NLIM capabilities.
- [DOEN85] Doenges, Peter K. (Evans and Sutherland), "High Performance Image Generation Systems: Overview of Computer Image Generation in Visual Simulation", Course notes for course #14 (High Performance Image Generation Systems), ACM SIGGRAPH '85, July 22, 1985. (77+ pages)
- Provides a thorough treatment of the entire IG field. Packed with information, but varying in coverage. Focuses on the E&S CT5 architecture as an example.
- [DONO] Donovan, Ken (contact) (Martin Marietta) "Smart Technologies with Compu-Scene", Martin Marietta white paper, Daytona Beach, FL, (no date, acquired in 1994).
- Provides a very brief overview of certain features of the Compu-Scene SE IG system.
- [FERG84] Ferguson, Robert L. (General Electric), "AVTS: A High Fidelity Visual Simulator", IMAGE III, 1984, pp. 476-486.
- Describes AVTS, a tactical military FS system designed for a wide range of training tasks. The requirements were a 10-channel system with rich scene content and many moving features. Extensive database management, multi-level culling, and load-control are discussed. Also new is a type of "3D texture": a texture map indicates the presence of generic fill objects.
- [FOLE90] Foley, James D., Andries van Dam, Steven K. Feiner, and John F. Hughes, *Computer Graphics: Principles and Practice*, Addison-Wesley, Reading, MA, 1990.
- Everything you wanted to know about general purpose computer graphics and more, almost.
- [FOLL92] Follic, Andre (Sogitec), "Overload Management in a Real Time Visual System", 3rd ITEC, 1992, pp. 15-22.
- Briefly describes the approach taken by the GI 10,000 IG towards overload management.
- [GARD90] Gardiner, H. Dee, and Steven O. Hadfield (Evans and Sutherland), "Low Cost Visual System Challenges", IMAGE V, 1990, pp. 320-329.
- Describes an unnamed architecture that is designed for cost-effectiveness. Briefly discusses design decisions for the nature of the rasterizer. Also provides discussion on texture capabilities.

- [HEAN89] Heaney, Brian S. (Star Technologies), "Real-Time PHIGS: Applying Graphics Standards to Simulation", 11th I/ITSC, 1989, pp. 349-356.
- Describes the benefits of using a database system built on the PHIGS standard. Discusses extensions to tailor the system towards the real-time IG needs.
- [HOWI84] Howie, J. Bruce (Rediffusion Simulation), and Michael A. Cosman (Evans and Sutherland), "CIG Goes to War: The Tactical Illusion", IMAGE III, 1984, pp. 439-454.
- Provides a high-level overview of the E&S CT5A IG architecture and capabilities.
- [JARV87] Jarvis, Kevin M. (Singer Link-Miles), "Visual Performance Requirement Below the Skyline, A Cost Effective Solution to Low Level Flight", IMAGE IV, 1987, pp. 230-235.
- Briefly describes the IMAGE IV IG architecture. It uses a priority method for occlusion. Discusses the need for a centralized "topographical processor" for LOD fading and load control.
- [JARV94a] Jarvis, Kevin M. (Thomson-CSF), "SPACE Visual System Technical Achievements", 5th ITEC, 1994, pp. 551-556.
- Briefly highlights the SPACE IG. See related Jarvis reference for more information.
- [JARV94b] Jarvis, Kevin (Thomson-CSF), "Shifting the Visual Paradigm", Image VII, 1994, pp. 67-75.
- Briefly describes the features of Thomson's SPACE IG. Advertises the benefits of non-interlaced displays and Z-buffers. A full sub-pixel depth buffer is used for antialiasing. COTS VME CPUs are used for the polygon processors.
- [JOHN87] Johnston, Richard S. (BBN), "The SIMNET Visual System", 9th I/ITSC, 1987, pp. 264-273.
- Describes the architecture of the SIMNET IG, designed for networked tank combat. The requirements were: 8 visual channels (though low resolution and low update rate), low cost, and network capability. Gives a fairly detailed architecture description.
- [LACR94] Lacroix, Michel (Thomson-CSF), and James Melzer (Kaiser Electro-Optics), "Helmet-Mounted Displays for Flight Simulators", IMAGE VII, 1994, pp. 35-41.
- Discusses HMD requirements and describes some current technologies for achieving high-resolution HMDs.
- [LATH83] Latham, Roy (Singer Co., Link FS Div.), "Image Generator Architectures and Features", 5th I/ITEC, 1983, pp. 19-26.
- A good paper that focuses on surface prioritization method and how the choices affect the overall IG architectures and features.
- [LATH85] Latham, Roy (Singer Co., Link FS Div.), "A VLSI-based Digital Image Generator", 7th I/ITEC, 1985, pp. 107-112.
- Describes the Singer-Link MOD DIG (Modular Digital Image Generator) architecture, with emphasis on the importance of modularity and on the importance of good load-control.
- [LATH94] Latham, Roy (CGSD), "Advanced Image Generator Architectures/Course Reference Material", IMAGE VII, 1994.

A copy of the slides used for the Image Society's 1994 tutorial on advanced IG architecture. A good overview of the important issues. Also includes some article reprints from Real Time Graphics.

- [LEWI81] Lewis, Jerry T. (ATS), "Computrol - A New Technique in Computer Image Generation", IMAGE II, 1981, pp. 420-429.
- Describes in a fair amount of detail how 30K+ edge/scene performance was packed into 225 cubic feet of cabinet space. It's a scan-line-based system using several highly-pipelined "array" processors.
- [LORA] Loral ADS, "GT200T Level II Image Generator Product Overview", Bellevue, WA, (no date, acquired in 1994).
- A set of slides outlining the features of the GT200T.
- [MOON85] Moon, Richard N. (Evans and Sutherland), "Providing High Performance Visual Simulation at Low Cost", 7th I/ITEC, 1985, pp. 100-106.
- Describes the E&S SPX (ESIG 500) IG architecture. Discusses the importance of database management for proper load-control. It also discusses the advantages of parallel rather than pipelined processors.
- [NIGU94] Nigus, Steven G. (FlightSafety), "New System Advances Visual Simulation Core Technologies", IMAGE VII, 1994, pp. 87-95.
- Briefly describes what's different about FlightSafety's VITAL VIII IG. The three areas describe are IG advances, database advances, and display system advances. Include a couple of pages on special weather effects.
- [PADM92] Padmos, Pieter, and Maarten Milders (TNO Inst. for Perception), "Checklist for outside-world images of simulators", 3rd ITEC, 1992, pp. 2-14.
- An interesting study on perception-related issues of display systems and IGs. Has a lengthy bibliography.
- [RICH89] Rich, Henry (Star Technologies), "Tradeoffs in Creating a Low-Cost Visual Simulator", 11th I/ITSC, 1989, pp. 214-223.
- Describes the architectural tradeoffs made in the design of the Graphicon 2000 IG. Topics include texture, occlusion method, and processor selection and arrangement.
- [RICH92] Rich, Henry H. (Star Technologies), "The Active Database/Using Software to Save CIG Hardware", 14th I/ITSEC, 1992, pp. 858-866.
- Describes some run-time database handling techniques which can be used to increase apparent performance. Techniques include separately evolving terrain and decals, algorithmic generic fill, and hidden-valley removal.
- [ROBI85] Robinson, John, and Stephen Zimmerman (Evans and Sutherland), "Exploiting Texture in an Integrated Training Environment", 7th I/ITEC, 1985, pp. 113-121.
- An in-depth look at texturing on the E&S CT6. Also discusses creation and use of texture patterns.
- [ROLF86] Rolfe, J.M., and K.J. Staples (eds.), *Flight Simulation*, Cambridge University Press, 1986, Cambridge, UK.

Mostly about the non-IG parts of flight simulation, but does provide some historical overview and a bibliography for visual simulation.

- [SCHA83] Schachter, Bruce J. (ed.), *Computer Image Generation*, John Wiley & Sons, New York, 1983. (236+ pages)

One of the few (only?) books that exist about CIG. Fourteen chapters, the last seven of which are basically short articles. The main chapter provides architectural overviews of numerous historical IGs.

- [SCHU80] Schumacker, Robert A. (Evans and Sutherland), "A New Visual System Architecture", 2nd I/ITEC, 1980. [pp??]

Informative overview of the E&S CT5.

- [SODE93] Soderberg, Brian, and Dale Miller (BBN), "Image Generation Design for Ground-Based Network Training Environments", 4th ITEC, 1993, pp. 320-329.

Describes architectural considerations for ground-based training applications (such as SIMNET). Discusses the issues of high depth complexity, uneven scene complexity, load-balancing, use of standards, and volumetric smoke. All this reappears in Loral's GT200 (see elsewhere).

- [STAR] Star Technologies, "Graphicon 2000 Technical Overview", Sterling, VA, 1990.

Fairly comprehensive overview of this system.

- [TUCK84] Tucker, Jonathan B., "Visual Simulation Takes Flight", *High Technology*, Dec. 1984, pp. 34-47.

A general coverage article on the IG industry. Discusses the field, databases, scene management, texturing, videodisc systems, and displays.

- [WALE83] Wales, Cary E., and Michael A. Cosman (Evans and Sutherland), "DMA and CIG: A Shotgun Wedding", 5th I/ITEC, 1983, pp. 97-104.

Discusses the construction of terrain databases from the Defense Mapping Agency's Digital Terrain Data Base. Talks about database related IG issues and the CT5.

- [WARW91] Warwick, Graham, "Military Simulator Directory", *Flight International*, 16-22 October, 1991, pp. 31-39.

A directory of companies that provide systems for military simulation and training.

- [YAN85] Yan, Johnson K. (Singer Co., Link FS Div.), "Advances in Computer-Generated Imagery for Flight Simulation", *IEEE CG&A*, August 1985, pp. 37-51.

Provides a good general IG architecture overview. Also discusses displays, use of curved surfaces, anti-aliasing (in detail), and texture. Has a fair bibliography.

- [YAN86] Yan, Johnson K., and Judit K. Florence (Singer Co.), "Modular digital image generator", US Patent No. 4,570,233, Feb. 11, 1986.

Describes in detail the pixel processor used by MOD DIG. This includes information about the antialiasing method and hierarchical area skip-over system.

Appendix

Listed below are some of the various resources that one can use to find out more about CIG.

AIAA Conferences:

The American Institute of Aeronautics and Astronautics sponsors a wide variety of conferences on topics related to aeronautics and astronautics, including CIG.

Annual Image Generator Survey:

A valuable resource published by the Image Society (see below). Contains company-filled-out standardized forms indicating performance and capability facts (and propaganda) about a wide array of IGs. Very informative in some cases, less so in others.

I/ITEC, I/ITSC, I/ITSEC:

The Interservice/Industry Training Systems and Education Conference series contains many papers related to various areas of training simulation systems, including computer image generation.

1985 and up are available through:

American Defense Preparedness Association (ADPA)
2101 Wilson Boulevard
Suite 400
Arlington, VA 22201-3061

For proceedings information, contact:
Kim Britton (703)522-1820, FAX (703)522-1885, ext. 231.

Earlier volumes are available through NTIS (see below):

Seventh N/IC, November 1974:	AD-A000-970 NTEC
Eighth N/IC, November 1975:	AD-A028-885 NTEC
Ninth N/IC, November 1976:	AD-A031-447 NTEC
Tenth N/IC, November 1977:	AD-A047-905 NTEC
Eleventh N/IC, November 1978:	AD-A061-381 NTEC
First I/ITEC, November 1979:	AD-A077-656 NTEC
Third I/ITEC, November 1981:	AD-A109-443 NTEC
Third I/ITEC, November 1981, Vol. 2:	ADA1525443XSP
Fourth I/ITEC, November 1982, Vol. 1:	ADA1221555XSP
Fourth I/ITEC, November 1982, Vol. 2:	ADA1331925XSP
Fifth I/ITEC, November 1983, Vol. 1:	ADA1427749XSP
Fifth I/ITEC, November 1983, Vol. 2:	ADA1427756XSP
Sixth I/ITEC, October 1984, Vol. 1:	ADA1491984XSP

The IMAGE Society, Inc.

The IMAGE Society hosts periodic conferences on the topic of computer image generation for simulation systems. They also publish the *Annual Image Generator Survey* mentioned above.

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Eric G. Monroe, Publisher

ITEC:

The International Training Equipment Conference is similar to I/ITSEC and provides another resource for papers on CIG.

These are also available through ADPA, above.

NTIS:

The National Technical Information Service provides a wealth of reports, indexes, and bibliographic searches on a large variety of information. If it was produced for the U.S. government, it is probably available through NTIS. CD-ROM databases are available at many libraries to search through this resource.

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
General information: (703) 487-4660
Sales desk: (703) 487-4650 or (800) 336-4700

Real Time Graphics:

A valuable periodical (ten issues yearly) containing information and technical articles related to the IG industry.

Roy Latham, editor
Computer Graphics Systems Development Corporation
Mountain View, California.

Technical Overviews:

Evans and Sutherland, "ESIG 4000 Technical Overview".
Evans and Sutherland, "ESIG 3000 Technical Overview".
Evans and Sutherland, "ESIG 1000 Technical Overview".
Star Technologies, "Graphicon 2000 Technical Overview".
Loral ADS, "GT200T Level II Image Generator Product Overview".
Martin Marietta, "Smart Technologies with Compu-Scene".
etc.

Provide varying amounts of information on the respective systems. Star provides the most detailed information; the others are more feature oriented.

US Patent and Trademark Office:

The US PTO can often be a good source of technical information on certain products. CD-ROM and online databases are available in many libraries for searching.

Through the World Wide Web, use: <http://town.hall.org/patent/patent.html>
The patents from 1994 and 1995 are available for searching from this site.