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FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATION

INITIAL GRAPHICS EXCHANGE SPECIFICATION (IGES)

CATEGORY: SOFTWARE STANDARD
SUBCATEGORY: GRAPHICS AND INFORMATION INTERCHANGE

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Computer Systems Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

Issued November 30, 1992

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Foreword

The Federal Information Processing Standards Publication Series of the National Institute of Standards and Technology (NIST) is the official publication relating to standards and guidelines adopted and promulgated under the provisions of Section 111(d) of the Federal Property and Administrative Services Act of 1949 as amended by the Computer Security Act of 1987, Public Law 100-235. These mandates have given the Secretary of Commerce and NIST important responsibilities for improving the utilization and management of computer and related telecommunications systems in the Federal Government. The NIST through its Computer Systems Laboratory provides leadership, technical guidance, and coordination of Government efforts in the development of standards and guidelines in these areas.

Comments concerning Federal Information Processing Standards Publications are welcomed and should be addressed to the Director, Computer Systems Laboratory, National Institute of Standards and Technology, Gaithersburg, MD 20899.

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Abstract

This publication announces the adoption of American National Standard Digital Representation for Communication of Product Definition Data, ASME/ANSI Y14.26M-1989, as a Federal Information Processing Standard (FIPS). ASME/ANSI Y14.26M-1989, more commonly known as the Initial Graphics Exchange Specification (IGES), specifies file structure and syntactical definition, and defines the representation of geometric, topological, and nongeometric product definition data. ASME/ANSI Y14.26M-1989 establishes information structures for the digital representation and communication of product definition data. Use of this standard permits the compatible exchange of product definition data used by various computer-aided design and computer-aided manufacturing (CAD/CAM) systems.

Key words: CAD/CAM; digital data exchange; Federal Information Processing Standard (FIPS); graphics and information interchange; IGES; product definition data; software standard.

**Federal Information
Processing Standards Publication 177**

1992 November 30

Announcing the Standard for

INITIAL GRAPHICS EXCHANGE SPECIFICATION (IGES)

Federal Information Processing Standards Publications (FIPS PUBS) are issued by the National Institute of Standards and Technology (NIST) after approval by the Secretary of Commerce pursuant to section 111 (d) of the Federal Property and Administrative Services Act of 1949 as amended by the Computer Security Act of 1987, Public Law 100-235.

1. **Name of Standard.** Initial Graphics Exchange Specification (IGES) (FIPS PUB 177).

2. **Category of Standard.** Software Standard; Graphics and Information Interchange.

3. **Explanation.** This publication announces the adoption of American National Standard Digital Representation for Communication of Product Definition Data, ASME/ANSI Y14.26M-1989, as a Federal Information Processing Standard (FIPS). ASME/ANSI Y14.26M-1989, more commonly known as the Initial Graphics Exchange Specification (IGES), specifies file structure and syntactical definition, and defines the representation of geometric, topological, and nongeometric product definition data. ASME/ANSI Y14.26M-1989 establishes information structures for the digital representation and communication of product definition data. Use of this standard permits the compatible exchange of product definition data used by various computer-aided design and computer-aided manufacturing (CAD/CAM) systems.

4. **Approving Authority.** Secretary of Commerce.

5. **Maintenance Agency.** Department of Commerce, National Institute of Standards and Technology (Computer Systems Laboratory).

6. **Cross Index.**
   a. American National Standard Digital Representation for Communication of Product Definition Data, ASME/ANSI Y14.26-1989.

7. **Related Documents.**
   a. NBSIR 88-3813, Initial Graphics Exchange Specification (IGES) Version 4.0.
   b. NISTIR 4412, Initial Graphics Exchange Specification (IGES) Version 5.0.
   c. NISTIR 4600, IGES 5.0 Recommended Practices Guide.
   d. Federal Information Processing Standards Publication 29-2, Interpretation Procedures for Federal Information Processing Standards for Software.
   e. Federal Information Resources Management Regulations (FIRMR) subpart 201-20.303, Standards, and subpart 201-39.1002, Federal Standards.

8. **Objectives.** Federal standards for electronic interchange permit Federal departments and agencies to exercise more effective control over the production, management, and use of the government's information resources. The primary objectives specific to IGES are to:

   - Allow digital exchange of product definition data independent of any particular CAD/CAM system.
   - Enable users of CAD/CAM equipment to effectively exchange product definition data throughout the life cycle of a given product.
   - Exchange digital representations of product definition data in various forms: illustrations, 2-dimensional drawings, 3-dimensional edge-vertex models, surface models, solids models, and complete product models.

- Aid CAD/CAM equipment manufacturers as a guideline for identifying useful combinations of product definition data capabilities in any CAD/CAM system.
- Reduce the cost of design by achieving increased designer productivity and design accuracy through the use of a standard for product definition data.
- Reduce the overall life-cycle cost for digital systems by establishing a common exchange format for the transfer of product definition data digitally across organizational boundaries.

9. Applicability.

a. This graphics information interchange or software standard is intended for the exchange of CAD/CAM product definition data among applications and programs that are either developed or acquired for government use. FIPS for IGES provides a mechanism for the digital exchange of database information among computer-aided systems. It is designed to support applications which enhance 2-dimensional or 3-dimensional geometry representations with rich attribute information. It provides a data format for describing product design and manufacturing information that has been created and stored in a computer-readable form. IGES information is intended for machine interpretation at the receiving site, but sometimes requires human intervention.

b. The use of FIPS for IGES is strongly recommended for exchange between product definition applications when one or more of the following situations exist:

- The product definition application or program is under constant review, and changes may result frequently.
- It is anticipated that the life of the data files will be longer than the life of the presently utilized CAD/CAM equipment.
- The application is being designed centrally for a decentralized system that may employ computers of different makes and models and different CAD/CAM devices.
- The product definition application may run on equipment other than that on which it was developed.
- The product definition data is to be used and maintained by other than the original designer.
- The product definition data is or is likely to be used by organizations outside the Federal Government.
- It is desired to have the design understood by multiple people, groups, or organizations.

c. Functionality not specifically cited in IGES should be used only when such functionality cannot be implemented with standard features alone. Although nonstandard features can be very useful, it should be recognized that the use of these or any other nonstandard features may make the interchange of IGES files, future conversion to a revised standard or replacement CAD/CAM systems more difficult and costly.

d. It is recognized that programmatic requirements may be more economically and efficiently satisfied through the use of a CAD/CAM system employing a different data transfer mechanism other than that provided by FIPS for IGES. The use of any facility should be considered in the context of system life, system cost, data integrity, and the potential for data sharing.

10. Specifications. The ASME/ANSI Y14.26M-1989 standard for IGES, describes the form of the physical file but not how IGES preprocessor or postprocessor software should behave. There is a lack of fundamental rules to describe minimum levels of processor functionality. The requirements specified herein will be part of this standard and apply to Federal Government implementations and procurements of this standard:

Conformance Requirements. The conformance rules given here are based on three principles. First, conformance is defined in terms of a conforming data file. Second, conformance is defined for a single processor in isolation (i.e., not in terms of interoperability). Third, conformance is defined separately for preprocessor and postprocessor.

These requirements detail minimum conformance criteria for processors. All processors claiming conformance to this version of the standard must adhere to the general rules below. In addition, conforming processors must adhere to all the rules appropriate to specific features such as entities defined within ASME/ANSI Y14.26M-1989.

Conformance Rules for Data Files. A conforming data file shall be syntactically, semantically and structurally correct as defined by this standard. This applies to all sections of the data file.

Conformance Rules for Preprocessors. A preprocessor which claims conformance to this standard must satisfy the following rule:

- A conforming preprocessor shall create only conforming data files which correctly represent the native database which was input to the preprocessor.

Conformance Rules for Postprocessors. A postprocessor, which claims conformance to this standard, must satisfy the following rule:

- A conforming postprocessor shall be capable of reading and correctly processing any conforming data file without halting or aborting, such that it produces the correct results.

Additional conformance rules may be specified for particular applications or by specific purchasers of IGES processors. As long as these rules do not contradict the conformance rules defined within FIPS IGES, such processors would still conform.

Processor Reporting. It is desirable and recommended that processors report on the following. (This is not a conformance requirement at this time.) Preprocessors should report on any CAD/CAM system feature or entity which has not been written to the IGES file. Postprocessors should 1) report on any IGES entities or features which have been discarded, and 2) handle any errors encountered within the IGES file in a preferred manner. The following techniques are suggested.

Selected Methodology. The functions of an IGES postprocessor are similar to those of a compiler. The postprocessor shall recognize errors encountered when an IGES file is processed, shall provide the user with an indication of the error, and shall continue processing the file if possible.

The key elements of a diagnostic capability are:

- Determine Seriousness of Error. The postprocessor determines the impact the error will have on the processing of the file and categorizes the error. Possible categories include **FATAL ERROR, ERROR, WARNING.**
- Continue Processing when Possible. After an error is identified, the postprocessor attempts to continue processing the file. Many errors will not prevent processing, and multiple errors that may exist will need to be identified. Options can be included to stop processing if a fatal error occurs, or a specific number of errors occur, to avoid wasting computer processing time when a file is not processable.
- Provide Meaningful Error Messages. The postprocessor provides complete error messages that include a description of the error and the location of the error in the file. For display on a terminal, the postprocessor should also provide a summary description of the error and the actions taken.

Common Errors. The following table lists some common errors. This list is not complete but contains a variety of errors. After each error message, the list contains a suggested action. The processor may need to take some corrective action before continuing after nonfatal errors. The processor should always output some type of message to the user.

11. Implementation. The implementation of this standard involves three areas of consideration: acquisition of IGES implementations, interpretation of FIPS for IGES, and validation of IGES implementations.

11.1 Acquisition of IGES Implementations. This publication is effective April 30, 1993. Product definition systems acquired for Federal use after this date shall support IGES preprocessors and postprocessors. Conformance to this standard should be considered whether the CAD/CAM systems are developed internally, acquired as part of a system procurement, acquired by separate procurement, used under a leasing arrangement, or specified for use in contracts for programming services.

Common Processing Errors	
Possible Error	*Suggested Action*
Global delimiters in error	Terminate
Tape format — not ASCII	Terminate
Binary section missing — binary format	Terminate
Entity not supported	Bypass & continue
Global version not supported	Bypass & continue
No end of record delimiter	Bypass & continue
Terminate section missing	Continue
DE section missing	Terminate
Sequence field	
Out of order	Continue
Missing	Continue
Wrong format	Continue
Parameters	
Wrong type	Use default & continue
Invalid value 106 — (IP parameter	
not equal to 1,2,3)	Adjust & continue
Endpoints not on circle/conic	Adjust & continue
Pointers not in DE range	Continue
Out of range	Continue

A transition period provides time for industry to produce product definition systems conforming to this standard. The transition period begins on the effective date and continues for one (1) year thereafter. The provisions of this publication apply to orders placed after the effective date; however, an IGES implementation conforming to FIPS for IGES, if available, may be acquired for use prior to the effective date.

ASME/ANSI Y14.26M-1989 does not specify conformance requirements; in lieu of this, the conformance requirements enumerated herein, section 10, apply.

11.2 Interpretation of this FIPS. NIST provides for the resolution of questions regarding FIPS for IGES and its requirements.

All questions concerning the interpretation of FIPS for IGES should be addressed to:

Director, Computer Systems Laboratory
ATTN: FIPS IGES Interpretation
National Institute of Standards and Technology
Gaithersburg, MD 20899

11.3 Validation of IGES Implementations. Validation of IGES implementations is not mandatory at this time. Future versions of this FIPS may mandate the validation of IGES implementations for government use. Testing of an implementation's conformance to this FIPS IGES will be optional by the agency. Until a formal conformance testing service is available, government agencies acquiring implementations in accordance with this standard may wish to require testing for conformance, interoperability, and performance. The tests to be administered and the testing organization are at the discretion of the agency Acquisition Authority.

12. Waivers. Under certain exceptional circumstances, the heads of Federal departments and agencies may approve waivers to Federal Information Processing Standards (FIPS). The head of such agencies may redelegate such authority only to a senior official designated pursuant to section 3506(b) of Title 44, U.S. Code. Waivers shall be granted only when:

a. Compliance with a standard would adversely affect the accomplishment of the mission of an operator of a Federal computer system, or

b. Cause a major adverse financial impact on the operator which is not offset by Governmentwide savings.

Agency heads may act upon a written waiver request containing the information detailed above. Agency heads may also act without a written waiver request when they determine that conditions for meeting the standard cannot be met. Agency heads may approve waivers only by a written decision which explains the basis on which the agency head made the required finding(s). A copy of each such decision, with procurement sensitive or classified portions clearly identified, shall be sent to: National Institute of Standards and Technology; ATTN: FIPS Waiver Decisions, Technology Building, Room B-154; Gaithersburg, MD 20899.

In addition, notice of each waiver granted and each delegation of authority to approve waivers shall be sent promptly to the Committee on Government Operations of the House of Representatives and the Committee on Government Affairs of the Senate and shall be published promptly in the *Federal Register*.

When the determination on a waiver applies to the procurement of equipment and/or services, a notice of the waiver determination must be published in the *Commerce Business Daily* as a part of the notice of solicitation for offers of an acquisition or, if the waiver determination is made after that notice is published, by amendment to such notice.

A copy of the waiver, any supporting documents, the document approving the waiver and any supporting and accompanying documents, with such deletions as the agency is authorized and decides to make under 5 U.S.C. Sec. 552 (b), shall be part of the procurement documentation and retained by the agency.

13. Where to Obtain Copies. Copies of this FIPS IGES are for sale by the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. (Sale of the included specification document is by arrangement with the American Society of Mechanical Engineers and the American National Standards Institute.) When ordering, refer to Federal Information Processing Standards Publication 177 (FIPSPUB177) and title. Payment may be made by check, money order, or deposit account.

APPENDIX A

The Family of Graphics Standards

The following computer graphics standards are now available to address the needs of government applications in creating, modifying, manipulating, and exchanging computer-generated pictures:

- FIPS PUB 120-1, the Graphical Kernel System (GKS), which adopts ANSI X3.124-1985;
- FIPS PUB 153, the Programmer's Hierarchical Interactive Graphics System (PHIGS), which adopts ANSI/ISO 9592-1989;
- FIPS PUB 128, the Computer Graphics Metafile (CGM), which adopts ANSI/ISO 8632-1992 and
- FIPS PUB 177, the Initial Graphics Exchange Specification (IGES), which adopts ASME/ANSI Y14.26M-1989.

In addition, the Computer Graphics Interface (CGI) has recently become an International standard, and is expected to be issued as a FIPS.

These standards fall into two categories: Application Programmer's Interface (API) standards, and Interoperability standards. The goal of API standards is to enhance the portability of graphics programs (and programmers) between installations and environments. The goal of Interoperability standards is to enable graphics data to be exchanged successfully between graphics systems and devices.

Figure 1 is a very simple reference model of a computer graphics operating environment. The model emphasizes that a graphics application program interacts with physical devices and human operators via a computer graphics environment. Figure 1 also shows that the application may receive information from an external database.

The output of the graphics program, as shown in Figure 1, is directed to a virtual graphics device (i.e., Virtual Device Interface or VDI) rather than directly to a physical device. A Device Driver provides an interface, implemented in either hardware or software, for translating virtual device commands to commands understood by a particular physical device. By substituting one device driver for another, an application can run on a different physical device. This device independence is a central concept of this graphics reference model.

In Figure 1, the API standards reside in the box labelled the Device Independent Graphics Package. Interoperability standards are related to the boxes in Figure 1 labelled Metafile, Database and Virtual Device Interface. Figure 2 depicts the various graphics standards associated with the general model shown in Figure 1. These are discussed below.

Application Programmer's Interface (API) Standards

Standards at the API promote program and programmer portability. A standard at this level specifies a set of operations on a variety of graphics objects. An API standard provides for the portability of applications across a wide range of computer hardware, operating systems, programming languages, and graphics devices. A program written to an API standard at one facility in one environment should be easily transferable to another facility in a different environment. Facility dependencies should be the major area requiring modification.

The specific functions supported by a particular API standard provide certain capabilities. The application programmer, by identifying the capabilities needed, determines the API better suited for the application. As shown in Figure 2, there are currently two graphics API standards, GKS and PHIGS.

GKS provides a functional description of a two-dimensional (2D) graphics interface. It provides the basic graphics support required by a wide variety of applications requiring the production of computer-generated pictures. A procedural language binding of a functional standard specifies the exact name for each operation, its parameter sequence, and the data types for the parameters. FORTRAN, Pascal, and Ada language bindings are parts of GKS.

GKS is suitable for use in graphics programming applications that employ a broad spectrum of graphics, from simple passive graphics output (where pictures are produced solely by output functions without interaction with an operator) to interactive applications; and which control a whole range of graphics devices, including but not limited to vector and raster devices, microfilm recorders, storage tube displays, refresh displays, and color displays.
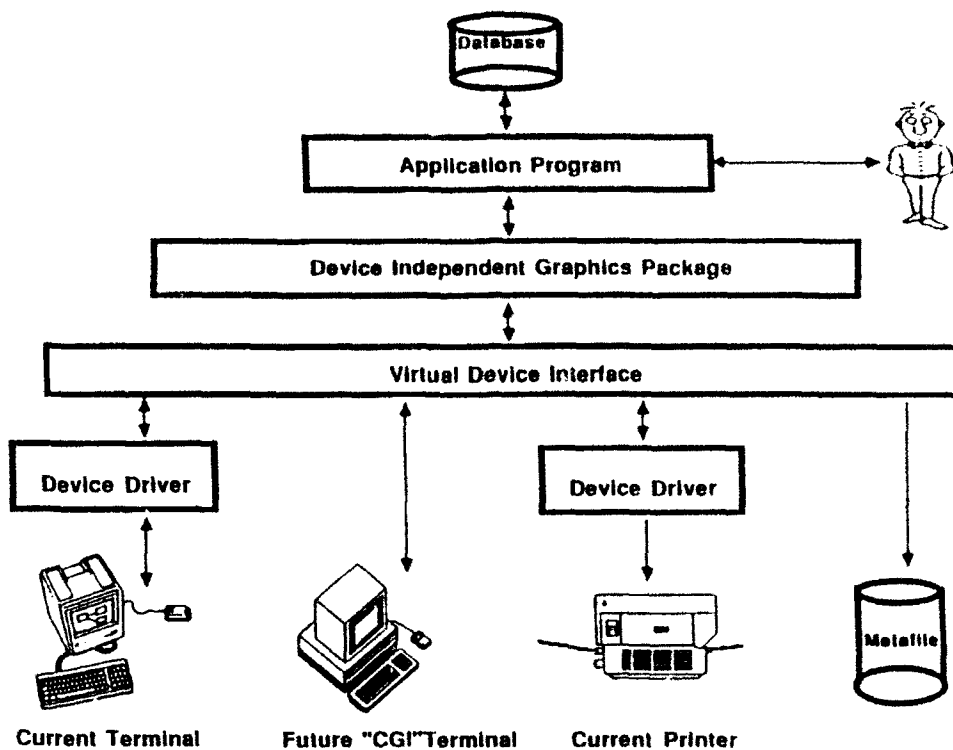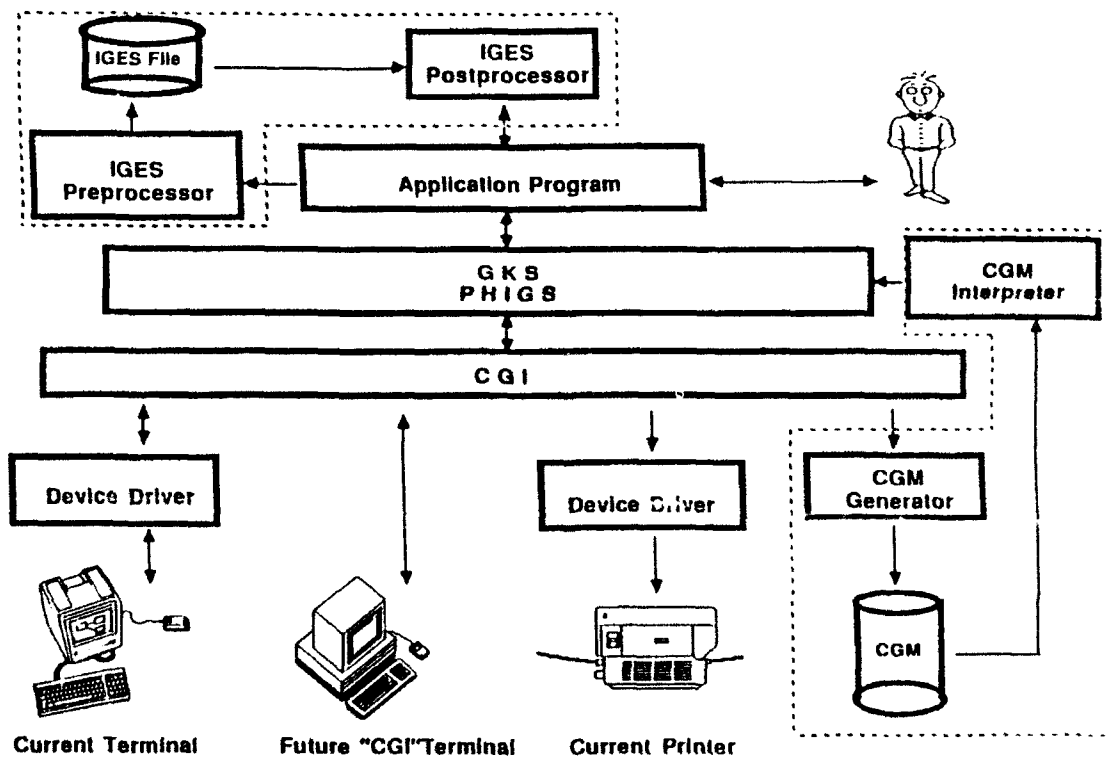
Figure 1. *Computer Graphics Reference Model*

Figure 2. *Standards in the Computer Graphics Reference Model*

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PHIGS provides for the definition, display, modification, and manipulation of 2D and 3D graphical data. It provides functionality to support storage of graphics and application data in a hierarchical form. Information may be inserted, changed, and deleted from the hierarchical data storage with the functions provided by PHIGS. Language binding specifications for PHIGS include FORTRAN and Ada.

PHIGS is specifically designed to meet the performance requirements of such demanding applications as Computer Aided Design/Computer Aided Engineering/Computer Aided Manufacturing, command and control, molecular modeling, simulation and process control.

Capabilities in PHIGS but not in GKS include: the centralized hierarchical data storage; the dynamic and responsive nature of interactions; the addition of a modeling capability; and support for color models other than Red-Green-Blue (RGB).

Interoperability Standards

Graphics Interoperability standards allow graphical data to be interchanged between graphics devices. As shown in Figure 2, there are three graphics interoperability standards, CGM, (future) CGI, and IGES.

CGM is used for the storage and transfer of picture description information. It enables pictures to be recorded for long term storage, and to be exchanged between graphics devices, systems, and installations. As indicated in Figure 2, the storage mechanism for CGM is in the form of a neutral file format called a metafile. The software which creates the metafile is known as a CGM Generator. The software which reads and displays a CGM metafile is known as an Interpreter.

CGM specifies a semantic interface that describes 2D graphical entities using primitives (like polyline, text, and ellipse) and attributes (like color, line width, interior style, and fonts). CGM is compatible with the specification of 2D elements in GKS. A data encoding specifies the exact sequence of bits used to represent each operation and its parameters. CGM contains three types of data stream encodings (binary, character, and clear text) to provide the implementor choices depending on the particular application.

IGES provides a method for representing and storing geometric, topological, and nongeometric product definition data that is independent of any one system. Where CGM transfers graphical pictures, IGES transfers a graphical database which can be processed to represent a picture. Thus IGES represents more than just purely graphical data. As Figure 2 indicates, the storage mechanism for IGES is in the form of a neutral file format that must be translated by a Preprocessor and Postprocessor for conversion between systems. IGES permits the compatible exchange of product definition data used by various computer aided design/computer aided manufacturing (CAD/CAM) systems.

The future CGI standard is designed to specify the exchange of information at the Virtual Device Interface. It will provide an interface between the device independent and device dependent parts of a graphics system. Since CGI contains information at a virtual level, it can be used to create a CGM. A CGM can also be output on a CGI device in a straightforward manner.