INTERNATIONAL STANDARD

ISO 8805

First edition
1988-09-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Information processing systems — Computer graphics — Graphical Kernel System for Three Dimensions (GKS-3D) functional description

Systèmes de traitement de l'information — Infographie — Système graphique de base pour trois dimensions (GKS-3D) description fonctionnelle

Reference number
ISO 8805 : 1988 (E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 8805 was prepared by Technical Committee ISO/TC 97, *Information processing systems.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

© **International Organization for Standardization, 1988** •

Printed in Switzerland

Contents

0 Introduction 1
1 Scope and field of application 4
2 References 5
3 Definitions 6
4 The Graphical Kernel System for Three Dimensions 14
4.1 About this International Standard 14
4.1.1 Specification 14
4.1.2 Registration 14
4.2 Introduction to GKS-3D 15
4.3 Concepts 17
4.4 Graphical output 20
4.4.1 Output primitives 20
4.4.2 Output primitive attributes 21
4.4.3 Polyline attributes 26
4.4.4 Polymarker attributes 27
4.4.5 Text attributes 27
4.4.6 Text extent and concatenation 39
4.4.7 Fill area attributes 39
4.4.8 Fill area set attributes 41
4.4.9 Cell array attributes 42
4.4.10 Generalized Drawing Primitive attributes 42
4.4.11 Colour 42
4.4.12 View index 43
4.4.13 Hidden line/hidden surface removal (HLHSR) identifier 43
4.5 Workstations 44
4.5.1 Workstation characteristics 44
4.5.2 Selecting a workstation 45
4.5.3 Deferring picture changes 46
4.5.4 Clearing the display space 50
4.5.5 Elimination of primitives outside segments 50
4.5.6 Sending messages to a workstation 51
4.5.7 Hidden line/hidden surface removal 51
4.6 Coordinate systems and transformations 52
4.6.1 Normalization transformations 52
4.6.2 Clipping 53
4.6.3 Workstation transformations 53
4.6.4 Transformation of locator input 56
4.6.5 Transformation of stroke input 59
4.6.6 Viewing 59
4.6.7 Viewing utility functions 61
4.7 Segments 70
4.7.1 Introduction to segments 70
4.7.2 Segment attributes 71
4.7.3 Segment transformations 72
4.7.4 Clipping and WDSS 72

4.7.5 Workstation Independent Segment Storage 72
4.7.6 WISS functions and clipping 73
4.8 Graphical input 74
4.8.1 Introduction to logical input devices 74
4.8.2 Logical input device model 75
4.8.3 Operating modes of logical input devices 76
4.8.4 Measures of each input class 79
4.8.5 Input queue and current event report 80
4.8.6 Initialization of input devices 81
4.8.7 Locator and stroke input using 2D input devices 82
4.9 GKS-3D Metafile interface 83
4.10 GKS-3D levels 85
4.10.1 Introduction to levels 85
4.10.2 The level structure 85
4.10.3 Level functionality 86
4.11 States of GKS-3D and inquiry functions 91
4.11.1 Description of states 91
4.11.2 Inquiry functions 92
4.12 Error handling 94
4.13 Special interfaces between GKS-3D and the application program 96
4.14 2D functions 97
5 GKS-3D functions 101
5.1 Notational conventions 101
5.2 Control functions 102
5.3 Output functions 111
5.4 Output attributes 125
5.4.1 Workstation independent primitive attributes 125
5.4.2 Workstation attributes (representations) 140
5.5 Transformation functions 149
5.5.1 Normalization transformation 149
5.5.2 View transformation 152
5.5.3 Workstation transformation 154
5.6 Segment functions 158
5.6.1 Segment manipulation functions 158
5.6.2 Segment attributes 163
5.7 Input functions 167
5.7.1 Initialization of input devices 167
5.7.2 Setting the mode of input devices 182
5.7.3 Request input functions 185
5.7.4 Sample input functions 190
5.7.5 Event input functions 195
5.8 Metafile functions 200
5.9 Inquiry functions 202
5.9.1 Introduction to inquiry functions 202
5.9.2 Inquiry function for operating state value 202
5.9.3 Inquiry functions for GKS-3D description table 202
5.9.4 Inquiry functions for GKS-3D state list 204
5.9.5 Inquiry functions for workstation state list 214
5.9.6 Inquiry functions for workstation description table 245
5.9.7 Inquiry functions for segment state list 275
5.9.8 Pixel inquiries 276
5.9.9 Inquiry function for GKS-3D error state list 279
5.10 Utility functions 280
5.11 Error handling 284
6 GKS-3D data structures 286
6.1 Notation and data types 286
6.2 Operating state 289

6.3 GKS-3D description table 290
6.4 GKS-3D state list 291
6.5 Workstation state list 294
6.6 Workstation description table 298
6.7 Segment state list 303
6.8 GKS-3D error state list 304
A Function lists 305
A.1 Alphabetic 305
A.2 Order of appearance 310
A.2.1 Control functions 5.2 310
A.2.2 Output functions 5.3 310
A.2.3 Output attributes 5.4 310
A.2.3.1 Workstation independent primitive attributes 5.4.1 311
A.2.3.2 Workstation attributes (representations) 5.4.2 311
A.2.4 Transformation functions 5.5 311
A.2.4.1 Normalization transformation 5.5.1 311
A.2.4.2 View transformation 5.5.2 312
A.2.4.3 Workstation transformation 5.5.3 312
A.2.5 Segment functions 5.6 312
A.2.5.1 Segment manipulation functions 5.6.1 312
A.2.5.2 Segment attributes 5.6.2 312
A.2.6 Input functions 5.7 312
A.2.6.1 Initialization of input devices 5.7.1 312
A.2.6.2 Setting the mode of input devices 5.7.2 313
A.2.6.3 Request input functions 5.7.3 313
A.2.6.4 Sample input functions 5.7.4 313
A.2.6.5 Event input functions 5.7.5 313
A.2.7 Metafile functions 5.8 313
A.2.8 Inquiry functions 5.9 314
A.2.8.1 Inquiry function for operating state value 5.9.2 314
A.2.8.2 Inquiry functions for GKS-3D description table 5.9.3 314
A.2.8.3 Inquiry functions for GKS-3D state list 5.9.4 314
A.2.8.4 Inquiry functions for workstation state list 5.9.5 314
A.2.8.5 Inquiry functions for workstation description table 5.9.6 315
A.2.8.6 Inquiry functions for segment state list 5.9.7 316
A.2.8.7 Pixel inquiries 5.9.8 316
A.2.8.8 Inquiry function for GKS-3D error state list 5.9.9 316
A.2.9 Utility functions 5.10 316
A.2.10 Error handling 5.11 316
A.3 Ordered by level 316
A.3.1 Level 0a 316
A.3.2 Level 0b 319
A.3.3 Level 0c 320
A.3.4 Level 1a 320
A.3.5 Level 1b 321
A.3.6 Level 1c 322
A.3.7 Level 2a 322
A.4 Applicability to workstation groups 323
B Error list 329
B.1 Implementation dependent 329
B.2 States 329
B.3 Workstations 329
B.4 Transformations 329
B.5 Output attributes 330
B.6 Output primitives 330
B.7 Segments 331
B.8 Input 331

B.9 Metafiles 331
B.10 Escape 331
B.11 Miscellaneous 331
B.12 System 331
B.13 3D transformations 332
B.14 3D output attributes 332
B.15 3D output primitives 332
B.16 Reserved errors 332
C Interfaces 333
C.1 General 333
C.2 Language binding 333
C.3 Implementation 334
D Allowable differences in GKS-3D implementations 336
D.1 General 336
D.2 Global differences 336
D.3 Workstation dependent differences 337
E Metafile structure 340
E.1 Metafiles 340
E.1.1 General 340
E.1.2 ISO 8632 Metafile 340
E.1.3 Metafile designed for GKS-3D 341
E.2 File format and data format 341
E.3 Generation of metafiles 342
E.4 Interpretation of metafiles 346
E.4.1 General 346
E.4.2 Control items 346
E.4.3 Output primitives 346
E.4.4 Output primitive attributes 346
E.4.5 Workstation attributes 346
E.4.6 Transformations 346
E.4.7 Segment manipulation 347
E.4.8 Segment attributes 347
E.4.9 Items from a GKSM written by a GKS system 347
E.5 Control items 347
E.6 Items for output primitives 350
E.7 Items for output primitive attributes 351
E.8 Items for workstation attributes 355
E.9 Items for transformations 357
E.9.1 Items for clipping 357
E.9.2 Items for viewing 357
E.9.3 Items for HLHSR 357
E.9.4 Items for workstation transformation 358
E.10 Items for segment manipulation 358
E.11 Items for segment attributes 358
E.12 User items 359
F Sample programs 360
G GKS-3D functions summary 369
G.1 Control functions 369
G.2 Output functions 369
G.3 Output attributes 370
G.3.1 Workstation independent primitive attributes 370
G.3.2 Workstation attributes (representations) 372
G.4 Transformation functions 372
G.4.1 Normalization transformation 372
G.4.2 Viewing transformation 372
G.4.3 Workstation transformation 373

G.5 Segment functions 373
G.5.1 Segment manipulation functions 373
G.5.2 Segment attributes 374
G.6 Input functions 374
G.6.1 Initialization of input devices 374
G.6.2 Setting mode of input devices 375
G.6.3 Request input functions 375
G.6.4 Sample input functions 375
G.6.5 Event input functions 376
G.7 Metafile functions 377
G.8 Inquiry functions 377
G.9 Utility functions 377
G.10 Error handling 377
H Colour models 379

This page intentionally left blank

Information processing systems - Computer graphics - Graphical Kernel System for Three Dimensions (GKS-3D) functional description

0 Introduction

The Graphical Kernel System for Three Dimensions (GKS-3D) provides a set of functions for:

a) definition and display of 2D and 3D graphical data;

b) storage and manipulation of graphical data;

c) input of graphically related data.

The main reasons for introducing this International Standard for computer graphics is:

d) to allow application programs involving graphics to be easily portable between different installations;

e) to aid the understanding and use of graphics methods by application programmers;

f) to serve manufacturers of graphics equipment as a guideline in providing useful combinations of graphics capabilities in a device.

In order to reach these main objectives, the GKS-3D design was based on the following requirements:

g) GKS-3D should include all the capabilities that are essential for the whole spectrum of graphics, from simple passive output to highly interactive applications.

h) The whole range of graphics devices, including vector and raster devices, microfilm recorders, storage tube displays, refresh displays and colour displays should be controllable by GKS-3D in a uniform way.

i) GKS-3D should provide all the capabilities required by a majority of applications.

These requirements were used to formulate a number of principles that were used to judge specific design alternatives. Thus it was possible to contribute to the overall design goals while focussing on certain aspects. Five design aspects were identified, each having a group of principles

j) Design goals: The following principles should not be violated by any technical design:

1) consistency: the mandatory requirements of GKS-3D should not be mutually contradictory;

2) compatibility: other standards or commonly accepted rules of practice should not be violated;

3) orthogonality: the functions or modules of GKS-3D should be independent of each other, or the dependency should be structured and well defined.

k) Functional capabilities: The following principles were used to define the extent of GKS-3D:

1) completeness: all functions that a majority of applications want to use on a given level of functionality should be included;

2) minimality: functions that are unnecessary for applications of a given level of functionality should not be provided;

3) compactness: an application should be able to achieve a desired result by a set of functions and parameters that is as small as possible;

4) richness: a rich set of functions offers an extensive range of facilities that stretches beyond the basic functions and includes higher order capabilities.

It is obvious that there is a trade off between the principles in this group. Therefore, the functions of GKS-3D are organized in nine levels. An implementation of GKS-3D provides precisely the functions of one of these levels. While the lowest level contains only a minimal set of functions, higher levels are allowed to extend beyond the basic needs towards greater richness.

l) User interface design: The following principles were used to define the user interface design:

1) user friendliness: GKS-3D should allow the design of a desirable user interface;

2) clarity: the concepts and functional capabilities of GKS-3D should be easily understandable, especially by the application programmer;

3) error handling: failure of system functions or modules, caused by errors of the system itself or by the application program, should be treated in such a way that the error reaction is clearly understandable and informative to the application programmer and that the impact on the system and the application program is as small as possible.

Clarity and sound error handling are essential parts of user friendliness. Error handling is an integral part of GKS-3D. To aid clarity, the system and its state can be presented to the user in an easily comprehensible manner.

Clarity applies not only to the system design but also to the system description. To this end, the GKS-3D specification is divided into a general description, a description of the underlying logical data structures representing the state of the system, and a description of the functions and their effects on these data structures.

m) Graphics devices: The following principles are associated with the range of graphics devices that can be addressed by GKS-3D:

1) device independence: GKS-3D functions should be designed to allow an application program, using these functions, to address facilities of quite different graphics output and input devices without modification of the program structure;

2) device richness: the full capabilities of a wide range of different graphics output and input devices should be accessible from the functions of GKS-3D.

These principles led to a fundamental concept underlying the GKS-3D architecture: the concept of multiple independent graphical workstations connected to and driven by GKS-3D. The application program can inquire the capabilities of every workstation. The GKS-3D design includes escape functions that are easily identifiable within an application program and can be used to access special facilities of a particular device.

n) Implementation: The last group of principles is related to the implementation of GKS-3D:

1) implementability: it should be possible to support the GKS-3D functions in most host languages, on most operating systems and with most graphics devices;

2) language independence: it should be possible to access the facilities of GKS-3D from all International Standard programming languages;

3) efficiency: GKS-3D should be capable of being implemented without time consuming algorithms;

4) robustness: the operator and application programmer should be protected in the best possible way from hardware or software failure of the system.

The five groups of principles are interconnected. For example, design goals and functional capabilities both contribute to user friendliness. Efficiency is also important when considering response time in an interactive environment. Some principles may be conflicting, such as richness versus minimality, comprehensive error handling versus efficiency, and compactness versus device richness. Compromises needed to be made to achieve the overall design objective: GKS-3D should have an easily comprehensible structure and a set of functions that enables a vast majority of computer graphics users to design portable, device independent application programs addressing the whole range of computer graphics equipment.

o) Relationship to ISO 7942: This International Standard adheres to the following design goals with respect to ISO 7942:

1) the relationship between the functions in ISO 7942 and the functions described in this International Standard should be precisely defined and not be implementation dependent;

2) the format of functions and their parameters in ISO 7942 will remain unchanged in this International Standard;

3) additional functions will be added solely to support the new 3D functionality.

p) Compatibility of Application Programs: a major goal of this International Standard is that application programs written using the functions specified in ISO 7942 will run without modification on implementations conforming to this International Standard and produce the same results on workstations of the same type, subject to the allowable differences as detailed in Annex D. However, it is recognized that in certain situations, especially involving the use of metafiles, this goal cannot always be achieved (see Annex D for further details).

q) Relationship to ISO 9592: This International Standard has the following relationship to ISO 9592 (PHIGS):

The primary emphasis of PHIGS is different from that of GKS/GKS-3D. Unlike GKS/GKS-3D, PHIGS is not restricted to graphics and provides data structure definition and editing facilities which are not necessarily related to graphical output. PHIGS provides data structure facilities which can be rendered as graphical output, rather than being purely directed towards providing graphical output and interaction.

GKS/GKS-3D is oriented towards the direct output of graphical primitives grouped into segments, PHIGS provides data structures which are traversed to produce graphical output. However, the output primitives and their attributes generated at structure traversal time are almost identical to those of GKS-3D.

PHIGS provides the same underlying model of input as GKS-3D. The measure of the pick logical input device is extended to identify the structure element in the PHIGS Central Structure Store which generates the primitive picked by the operator.

Annexes C to H are given for information; they do not form part of the specification.

1 Scope and field of application

This International Standard specifies a set of functions for computer graphics programming, the Graphical Kernel System for Three Dimensions (GKS-3D). GKS-3D is a basic graphics system for applications that produce computer generated three dimensional pictures on graphics output devices. It supports operator input and interaction by supplying basic functions for graphical input and picture segmentation. It allows storage and dynamic modification of pictures. A fundamental concept in GKS-3D is the workstation, consisting of a number of input devices and a single output device. Several workstations can be used simultaneously. The application program is allowed to adapt its behaviour at a workstation to make best use of workstation capabilities. This International Standard includes functions for storage on and retrieval from an external graphics file. Also, the functions are organized in upward compatible levels with increasing capabilities.

This International Standard provides application programs with the capability to define and display 3D graphical primitives, specified using 3D coordinates. In addition, the GKS-3D input model provides 3D locator and stroke input.

The output primitives of this International Standard differ from the output primitives of ISO 7942 in the following ways:

a) the polyline and polymarker primitives are defined by an arbitrary sequence of 3D coordinates;

b) the text, fill area and cell array primitives remain planar, but may lie in a plane positioned arbitrarily in 3D space;

c) the fill area set primitive is introduced.

Functions are provided in this International Standard to generate these primitives.

The functions of ISO 7942 can be used in this International Standard. However, the output functions generate instances of 3D primitives — instances that are constrained to lie in a plane. Furthermore, additional capabilities are provided in this International Standard to:

d) specify views of 3D objects;

e) obtain information from 3D input devices;

f) permit workstations to perform hidden line/hidden surface removal (HLHSR).

This International Standard provides no specific functions for controlling such rendering techniques as light source, shading, texturing, and shadow computations. However, workstations may apply these techniques, locally as the primitives and attributes are realized, provided that the general guidelines of Annex D concerning allowable workstation differences are followed.

NOTE - For certain parameters of the functions, GKS-3D defines value ranges as being reserved for registration (see 4.1.2). The meanings of these values will be defined using the established procedures.

GKS-3D defines a language independent nucleus of a graphics system. For integration into a programming language, GKS-3D is embedded in a language dependent layer obeying the particular conventions of that language.

2 References

ISO 646, *Information processing - ISO 7-bit coded character set for information interchange.*

ISO 2022, *Information processing - ISO 7-bit and 8-bit coded character sets - Code extension techniques.*

ISO 2382/13, *Data processing - Vocabulary - Part 13: Computer graphics.*

ISO 6093, *Information processing - Representation of numerical values in character strings for information interchange.*

ISO 7942, *Information processing systems - Computer graphics - Graphical Kernel System (GKS) functional description*

ISO 8632, *Information processing systems - Computer graphics - Metafile for the storage and transfer of picture description information* [1)]

- *Part 1 : Functional description.*
- *Part 2 : Character encoding.*
- *Part 3 : Binary encoding.*
- *Part 4 : Clear text encoding.*

ISO/IEC 8806 *Information processing systems - Computer graphics - Graphical Kernel System for Three Dimensions (GKS-3D) Language Bindings* [2)]

- *Part 1 : FORTRAN*
- *Part 2 : PASCAL*
- *Part 3 : ADA*
- *Part 4 : C*

ISO/IEC 9592, *Information processing systems - Computer graphics - The Programmer's Hierarchical Interactive Graphics System (PHIGS)*

- *Part 1 : Functional description.*
- *Part 2 : Archive file format*
- *Part 3 : Clear text encoding.of archive file*

CIE Recommendations on colour space - supplement to CIE publication 15

CIE 1976 Supplementary standard colour metric of server and coordinate systems

1) Two addenda are being produced which support segmentation and three dimensions.
2) At present at the stage of draft; publication anticipated in due course.