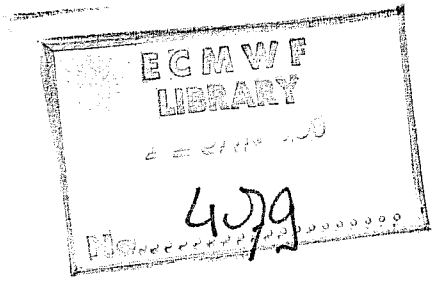
WORKSHOP

on

ECMWF FUTURE GRAPHICAL SYSTEM

10-13 July 1979



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Report on the Workshop on ECMWF Future Graphical System

by

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"C'est par la force des images que, par la suite des temps, pourraient bien s'accomplir les <<vraies>> révolutions."

André Breton

Workshop Report
Operations Department

October 1979

Introduction

In July 1979, an experts workshop on the future ECMWF graphical system was held at Shinfield Park, Reading.

This workshop was organised in order to provide the ECMWF telecommunication and graphic section with some advice about the future graphical system.

The number of attendees invited was restricted so as to keep the working party as efficient as possible (see Appendix A - List of Participants).

Each participant was asked to produce one or more papers on various related subjects. As many as 16 working papers have been written (see Appendix B - List of Working Papers). They were made available to all participants together with a collection of relevant published papers (see Appendix C - List of Reference Papers).

The program of the workshop (see section 1) was established in such a way that it covered most aspects of the design of a graphic system for meteorology, including hardware and software considerations, system organisation, standards for graphics, device-independence and, of course, the use of computer graphics for meteorological applications.

This report summarises the most important outcomes of the discussions which took place during the sessions of the workshop. Some sessions, namely sessions 1, 2 and 3, are not reported here since nothing significant has been added to the corresponding working papers, to which anyone interested should refer.*

The concluding section shows the main issues and recommendations to be considered while designing the future graphical system.

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* Due to the volume of working papers, they are not amended here but are available on demand. All requests should be addressed to the Librarian of ECMWF.

1. Program of the Workshop on ECMWF's Future Graphical System

Tuesday July 10

14.00 - 17.00
- Opening
- S1 Graphical activities in the different centres

Wednesday July 11

09.00 - 12.00
- S2 Evaluation of graphical software
- S3 Load of graphical applications on the computer system

14.00 - 17.00
- S4 Future trends in hardware
- S5 Distributed graphical systems

Thursday July 12

09.00 - 12.00
- S6 Standards for graphics (part I) and device independence

14.00 - 17.00
- S7 Use of graphics as a medium for meteorological applications

Friday July 13

09.00 - 12.00
- S8 Design of a graphical system for meteorological applications

12.00 - 18.00
- S8 continued
- S9 Standards for graphics (part II)

Session 1 - Graphical activities in the different centres

The intent of this introductory session is to provide each participant with some information concerning the main aspects of the other centres. This includes a brief description of the aims of the centre, the hardware and software configuration, as well as some indication of the future plans.
A presentation of the EMOS (ECMWF's Meteorological Operational System) will be made.

Session 2 - Evaluation of known graphical software

During this session some graphic packages (either general purpose or meteorological applications) will be described and critically evaluated.

Session 3 - Load of graphical applications on the computer system

This is an attempt to gain information on the impact of graphical applications on the performance of the computing system with respect to other non-graphical applications.

Session 4 - Future trends in hardware

This session will review the trend and applicability to meteorological applications and graphical techniques of new hardware, e.g. video displays, micro-processors, mini-processors and array processors.

Session 5 - Distributed graphical systems

Assuming that a graphical application takes advantage of a multiprocessor environment, the problem of distributing the graphical system will be dealt with during this session.

Session 6 - Standards for graphics - (part I) and device independence

This session will study and evaluate the applicability of the proposed SIGGRAPH GSPC "CORE" proposal for graphics standards in a meteorological environment. Device independence will be discussed as a major aspect of graphics standards.

Session 7 - Use of graphics as a medium for meteorological applications.

This is an important session where participants will attempt to evaluate how graphical devices and interactive techniques can (or could, in the foreseeable future) influence the evolution of meteorological applications.

Session 8 - Design of a graphical system for meteorological applications.

Having reviewed the major aspects and conceivable evolution of graphics for meteorology, we shall try to define the framework and draw the guidelines for a graphical system for meteorological applications at ECMWF.

Session 9 - Standards for graphics (part II)

A talk by Bert Herzog, Chairman of the GSPC, about the current situation and future evolution of the "CORE" proposal will give us a chance to discuss the matter in further detail.

2. Hardware : present situation and future trends

Working paper no. 11 was the basis of discussion for session 4. This paper reviews and comments on some of the predictions made by R.F. Riesenfeld in 1978 in his paper "Current Trends in Computer Graphics" (1).

Raster scan display

Raster scan displays are increasingly popular in the States and are nowadays more easily available in Europe. Because they are based on standard TV monitors they are rather cheap and will be cheaper in the future. They have the advantage of allowing colour and selective erasure.

Their major drawback is a poor resolution, i.e. often less than 512 x 512 addressable points. Higher resolution can be obtained either by interlacing which leads to flicker or by using non-standard higher broadcast rate and high speed memory access which leads to a far more expensive device. Software techniques like anti-aliasing can also be applied to enhance the aspect of low resolution pictures. However, it appears that the minimum acceptable resolution is 512 x 512.

Due to the large size of the raster buffer, typically 512 x 512 x 8 ≃ 2 megabits, to be transmitted to the display when the picture is updated, high speed connections to the computer are needed (16 bits parallel), thus involving the use of a mini-computer since this type of connection is in opposition to the time-sharing principles of large main-frames. Nevertheless, the increasing usage of micro-processors will allow higher level data to be transmitted, thus reducing the data-rate.

It should be noted that both AFOS and NEDS (2) are equipped with raster displays.

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32 bits mini-computers - satellite computers

Although already available from some computer manufacturers, they are still expensive. Meanwhile, memories for mini-computers are getting larger, more compact and cheaper. This fact is very important for meteorological applications where large amounts of data have to be processed (see §5).

Associative processors, multi-processors, array-processors

Associative processors and multi-processors are still in the domain of research and development. But array processors and fast floating point processors are already available although expensive.

These facts have to be considered and it is advisable to find those algorithms to which such techniques can be applied.

Micro-processors

Nowadays, the micro-processor appears in almost everybody's life and it is difficult to find any graphic device which does not contain at least one such processor.

Their addressability will be increased to 16 and even 32 bits in the near future.

Their range of applications will certainly increase considerably and it is really difficult to foresee completely what they are going to be used for.

Bubble memories

The development of bubble memories has been rather disappointing, but the situation may improve in the near future.

Panel displays

Here again, the development of such panels has been disappointing. It seems that cost limits the size of these panels.

Also, there is the fact that optical techniques associated with video displays make it possible to display bright computer generated pictures on large screens at a lower price.

Nevertheless, because of the advantage of their flatness, it is likely that they will replace the TV tube in commercial broadcasting, thus being available for computer graphics applications.

Video-disc

The video-disc was not mentioned by R.F. Riesenfeld. This device allows the storing and retrieval of large amounts of graphical data at low cost. It is used with common TV sets and allows the display on large screens.

It provides an easy and rapid access to pictures as well as animation.

Video discs will certainly have a big impact on day to day life and also, with the availability of read and write discs, on computer graphics.

3. Distributed graphical systems

Working paper no. 8 first shows the various components (data and processes) and the general structure of any graphic interactive application program and reviews the many ways in which such a program can be distributed among several processors.

Session 5 discussed the problem of distributed graphical systems at a rather general level and later, session 8 addressed the same problem in the meteorological and ECMWF context.

The first question which arises when considering distributed graphical systems is "Why distribute?", or put in another way "What's wrong with a single mainframe?".

Several answers were given to this last question:

i) The mainframe should only perform what it does well, i.e. number crunching and big data base management. Consequently, interactive work and complex device handling should be removed from it.

ii) When a single mainframe is assigned too many different tasks, the operating system becomes very complex and time consuming which leads to an inefficient and unreliable system.

iii) A big disadvantage of a single mainframe is the lack of flexibility. Expanding or modifying any part of the system cannot be performed without disturbing other users.

iv) Any mainframe becomes overloaded in due course of time; when this occurs either the mainframe has to be changed to a bigger one or part of its load has to be removed onto another computer. With the great development of mini-computers, this last approach, which is more flexible, is considered a better solution.

(In the ECMWF context, the "mainframe" referred to above is the Cyber 175 and not the Cray-1. The Cray-1 is more like a number crunching peripheral and is rather specialised in its usage).

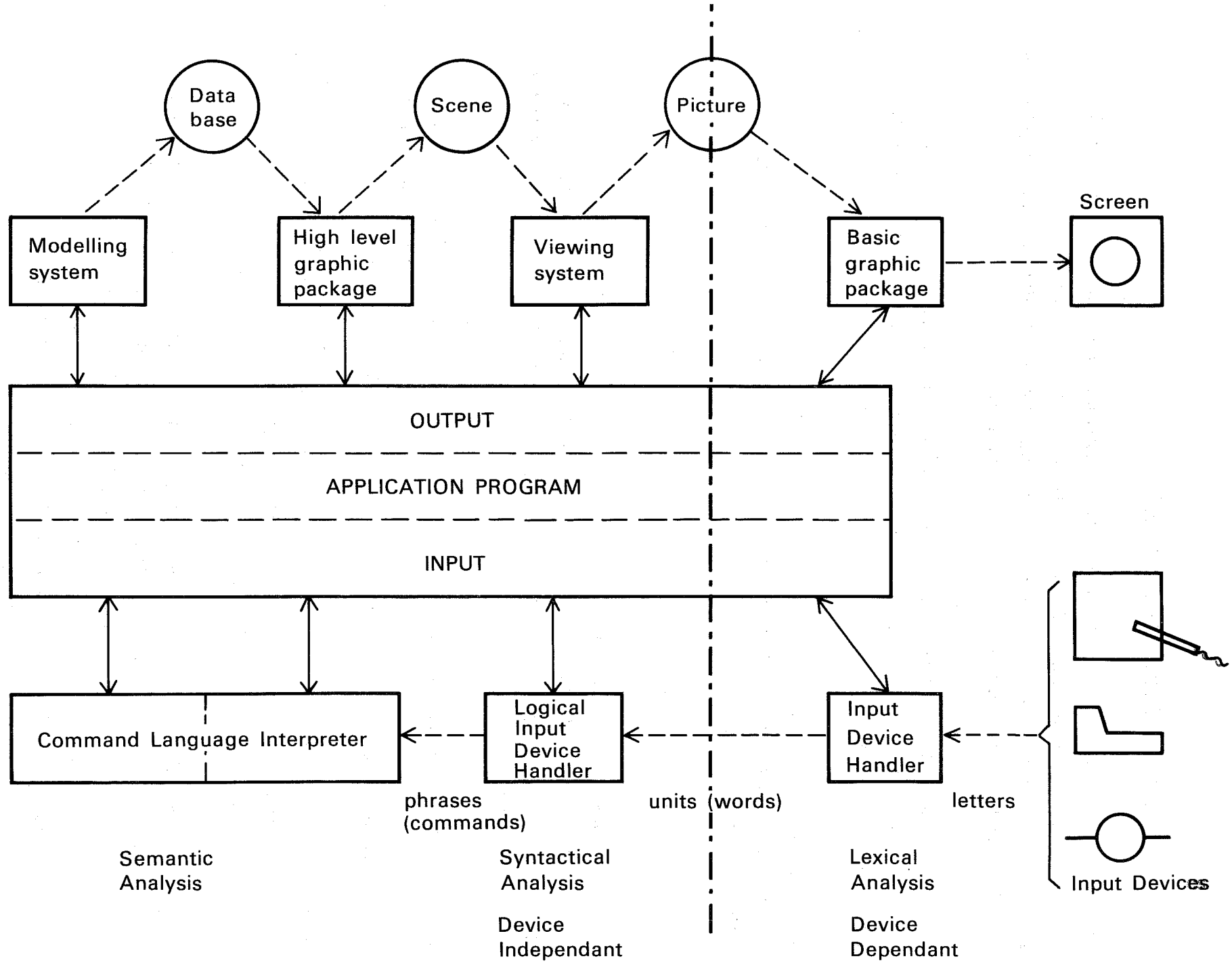

Fig. 1 General structure of a graphical application program

The second question to be considered is : "Are graphical applications good candidates for being distributed?" A candidate for distribution is good when it does not lead to a complex and inefficient system. It is the case when the application is highly modular and when communications between modules occur by burst and not continuously.

Figure 1 shows that a graphical application is indeed modular and that, provided a judicious distribution of task is done, it is efficient.

Furthermore, graphics very often means interactive work and complex device handling which are very difficult and even impossible tasks to perform on a single mainframe. In other words, in order to ensure a reasonable response time to the graphics user, one has to introduce, for the connection of the graphic device hardware and software, solutions which are highly incompatible with the time-sharing systems and, will, in any case, represent a very important load on the mainframe for both CPU time consumption and memory occupation.

Graphic applications being good candidates for distribution then comes the question "How to distribute the graphical application in the case of meteorology, and more precisely of ECMWF, i.e. what type of connection should be used between the two computers (assuming the simple case of a host and a satellite configuration) and which task to attribute to each of them?"

Concerning the type of connection it was the general feeling that "remote batch" should be very adequate.
There are three reasons for this:

i) It is a very common and very simple type of connection.

ii) The nature of meteorological applications is such that one can distinguish several phases, e.g. observations checking, analysis, forecast, forecast checking which are clearly separated in time.

iii) Existing systems like AFOS and NEDS (2) are based on this type of connection and appear satisfactory in this respect.

The question of the distribution of tasks is much more debatable. It was recognised that the housekeeping of the data base should stay in the mainframe while device dependant code generation and interaction at the picture level should occur on the satellite computer. But the task of map generation, such as contouring, can be performed on either machine. Keeping the main routines on the mainframe has been argued as follows:

Pros:

i) A mainframe is well suited for performing contouring.

ii) Most minicomputers are not powerful enough to perform the contouring of large arrays as it is especially the case at ECMWF.

iii) The data base is stored in the mainframe.

iv) Interaction with data is not a requirement (see §5), i.e. modifying the data (grid point value) and re-contouring interactively is not needed.

Cons:

i) The load of graphical activities on the mainframe remains unchanged although more graphics activity can be achieved, e.g. local interaction.

ii) The power and capacity of minicomputers are continously increasing and specialised processors could be used for contouring. Indeed future plans at NWS Washington include performing contouring at the local site using an array processor.

iii) In order to display quickly any field which may be requested interactively by the user, almost all possible fields will have to be processed and the resulting pictures sent to the

local site. If contouring is performed locally, only requested fields will be processed and the mainframe has only to send the data to the satellite.

The only conclusion which could be drawn was that only experiments will show the proper distribution of tasks.

4. Standards for graphics - device independence

The availability of a widely adopted device independent standard for graphics is of great importance for allowing easier portability of graphical programs and easier adaptation to new graphical devices. More than 20 years of experience and the wide usage of graphical equipments and software make it possible to attain such a standard in a few years.

Already the ACM SIGGRAPH GSPC has produced three versions of a report on this matter, known as "The CORE proposal" (3). This report contains a methodology for graphical programming, the definition of a terminology and a proposal for concepts and functional capabilities of a "standard" graphic package. It will now serve as a basis for the ANSI working group on graphic standards.

Other countries like Germany, UK and Norway are also very active and the German DIN working group has produced a proposal named GKS (4).

At the moment ISO organises international meetings in order to compare those proposals and try to remove unnecessary issues.

This information on the international activity about standards was given by Dr. B. Herzog, Chairman of GSPC, during the presentation he made at session 9.

He also described the various modifications and extensions of the CORE proposal contained in the last report to be presented at the SIGGRAPH conference in Chicago. He also explained the major issues about the CORE proposal.

However, these proposals have not yet reached a general agreement and they do not deal with such important matters as raster devices, standard format for storage and transmission of pictures, subroutine or procedure implementation, distributed graphics. Bert Herzog mentioned that almost all of these matters have already been discussed but not yet included in the CORE proposal.

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It was the purpose of working paper no. 4 and session 6 to present and discuss the CORE proposal, as presented in (3) and to examine the problem of device independence.

As the CORE proposal was only known by a few participants, the discussion has not been very lively, since, for them, the session was primarily informative.

The major criticisms that were put forward against the CORE with respect to meteorological applications, can be summarised as follows:

i) Lack of flexibility. For instance, although a viewing system and a basic graphic system are clearly distinguishable(refer to fig. in the presentation of the CORE, there is no direct access provided to the basic graphic system. This is of great importance for meteorology where the CORE proposed viewing transformations are not suitable. Making these transformations transparent would result in a very inefficient system.

ii) High level specificity. The CORE system appears like a very nice and well defined package for three dimensional wire-frame picture generation and interaction. Such a package suits well many Computer Aided Design applications but is really unsuitable for other classes of applications in particular meteorology. As a result, a rather important feature like shielding, i.e. erasure of areas in the picture, cannot be implemented on top of the Core, as demonstrated by A. Vinberg in (5).

This shows that the CORE, as a whole, is not usable for meteorological applications. However, the methodology, the terminology and many aspects of this proposal are valid and should be used in any graphic package.

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Another area where standards could apply is the storage and transmission of pictures. Storage of pictures has not been discussed since it is more or less a matter of local implementation where effeciency is more important than standardisation, i.e. computer dependent internal representation of numbers and character strings may be used to avoid needless encoding and decoding.

Transmission of pictures was discussed during the course of several sessions. It was pointed out that a unique standard will hardly be suitable for all types of pictures. First there is the problem of choosing between (or eventually mixing) raster type and vector type pictures. Secondly, as efficiency is of prior importance in this matter, it is difficult to find a unique compaction technique suitable for all pictures. Thirdly, comes the problem of the accuracy of the co-ordinates. How many bits to use when one wants at the same time to satisfy highest resolution devices together with the reduction of transmitted data for lowest resolution devices. This problem can be solved dynamically in the case of an on-line connection between the transmitter and the receptor, but not for off-line connections. Finally, for the implementation of local interactive picture editing facilities, it is often necessary to add non-graphical application dependent data to the graphical data, e.g. geographical area, contour levels in meteorology, and to provide some sort of (application dependent?) structuring of the graphical data transmitted.

Related to picture transmission and device independence is the problem that some high level algorithms and program structure do rely on properties and characteristics of the device in use. In the particular case of contouring for example, the actual size of the frame is used to determine the number of contours to be drawn, the placement of labels, etc. Once again, on-line systems allow one to solve the problem by dynamically enquiring about the device, but off-line systems do not. Allowing the programmer to define the units in which he wants to express the co-ordinates solves the programmer's problem but still, applying a different scale at display time could lead to unsatisfactory pictures.

5. Use of graphics for meteorology

It is obvious that graphics is an essential tool for meteorology, and, indeed, meteorology was among the first in using computer graphics.

It was not, in fact, the purpose of session 7 to establish this truth. Neither was it the intention to list the various types of graphical output that meteorological applications usually produces. The objective was rather to investigate what the problems are, if any, in producing and using graphical output and how new devices and techniques, e.g. raster displays, distributed systems, interactive techniques, could help to solve them. In this respect, working paper no. 10 was a good basis for discussion.

The first comment to be made at the opening of the workshop and which has been repeated later was to point out the tremendous and continuously increasing amount of graphical data to be produced and examined. This happens to be particularly true at ECMWF since medium range forecast means an order of magnitude increase in the amount of graphical products over short term forecasting. This fact leads to two consequences:

i) The load of graphical activity on the computer system is very heavy.

ii) The usage of paper as a medium for graphical output tends to be less suitable because of the space needed to display and to store the products, and because of the difficulty of retrieving pictures. This is particularly important for operational forecast when time is restricted.

Following the discussions on hardware and distributed graphical systems, it was a common agreement that the use of COM equipment and of a satellite system with various graphic and alphanumeric displays and hardcopy unit(s) is the right way towards a solution of these problems.

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The agreement was not so unanimous concerning the tasks to be performed at the local site. However, three functions were strongly requested:

i) Temporary storage and retrieval of pictures.

ii) Composition and super-imposition of pictures.

iii) Limited animation, i.e. short sequences of pictures to be viewed back and forth, automatically or under user control.

Rotation of pictures was not felt of much interest.

Scaling of pictures was very much debated, and no agreement was reached. However, if applied, it should be "true" magnification, i.e. with added information. Such a function is essentially related to plotting of observations although contour lines, e.g. analysis fields, could be superimposed.

Updating pictures using a light pen or a tablet was not felt very useful, although it was stressed that drawing on a map was essential for the meteorologist to keep close to the data he is studying.

The question whether to perform high level functions like contouring at the local site was also much debated but no unanimous conclusion could be agreed upon.

Apart from the attribution of tasks to a local satellite system, some other matters were discussed with respect to their usefulness to the meteorologist.

The availability of colour was put forward as a major request for several reasons:

i) Colour makes if far easier to compare maps.

ii) Colour adds a third dimension to flat pictures.

iii) Colour allows clear highlighting of interesting features.

iv) Colour allows more information to be displayed on one picture while the eye is still able to distinguish between separate types of information.

Satellite pictures were mentioned as a useful tool to be considered although not of first importance.

Resolution and size of the screen have also been discussed. Obviously, the bigger they are, the better. Yet it was observed that a resolution better than that of the data does not add any information and that interpolations between data points could be misleading.

The usage of a large and bright screen or the duplication of pictures onto several screens was felt very useful, especially for the operational briefings at ECMWF. Tele-conferencing with graphics was also mentioned but did not receive much attention.

The short term storage and retrieval of pictures was considered very useful especially and essentially if the pictures can be retrieved and displayed quickly and easily at any time.

Finally, it was an overwhelming opinion that deciding upon the utility of new features and techniques was very difficult without actual experiments. There, the availability of a "laboratory" to conduct such experiments was felt very worthwhile.

Conclusion

In the opinion of every participant, this workshop has been very valuable. First, at the preparation stage it was fruitful for everyone to lay down ideas and to think again on various topics. Periodically, reconsideration of the way things are done has always been a healthy activity. Secondly, the discussions that took place during the workshop were very useful for clarifying confirming or invalidating ideas. Unfortunately, some of the sessions were not as lively as hoped because few attendees had the opportunity to study all the subjects in the program, which, to be honest, was really asking a lot.

From the point of view of ECMWF Telecommunications and Graphics group, this workshop has been very helpful since it confirmed, reinforced, clarified and specified some of the ideas we had about the future system. More precisely, the main conclusions that we can draw are:

i) Introduce a satellite mini-computer to drive a variety of graphic devices and relieve the mainframe of some of its load. The type of connection should be 'remote job entry'.
ii) Reduce the use of paper as a medium for graphical output. Investigate the usage of graphical displays, COM equipment and later, the video-disk.
iii) New techniques (interaction?) have to be developed to allow the study of the vast amount of graphical products. In this respect, colour is a very important factor.
iv) Limited animation should be available on a non-operational basis.
v) Investigation and experimentation about new techniques and new technologies should be carried out on a dedicated experimental system.
vi) Raster displays which offer colour, interaction possibility and large screen display at decreasing prices, should be considered for the future graphical equipment.
vii) The introduction of some standard basic graphic package is considered very important to ensure device independence and program portability. The SIGGRAPH GSPC CORE proposal should be considered but does not fit all the requirements of meteorological applications. Such standards should be

agreed upon at least by the Member States and a further workshop on this matter would help considerably in reaching an agreement.

viii) The main design criterium for the future graphical system should be flexibility. This applies to software as well as to hardware organisation.

Acknowledgements

The Telecommunications and Graphics Section at ECMWF wishes to thank all participants and attendees for their valuable contributions.

Janice Brown is to be thanked for all the typing she did on this occasion.

References

(1) Riesenfeld, R.F., "Current Trends in Computer Graphics", Computer and Graphics, Vol. 3, 1978.

(2) Lemaire, A., "Report on Visits to Places of Interest in the United States", ECMWF Workshop on Future Graphical System, Working Paper no. 1.

(3) Graphics Standards Planning Committee, "Status Report of the GSPC of ACM/SIGGRAPH", Computer Graphics, Vol. 11, No. 3, 1977, and Computer Graphics, Vol. 13, No. 3, 1979.

(4) Brester, F., Eckert, R., Enderle, G., Kansy, K., "GKS'79. DIN Standard Proposal for a Graphical Kernal System", proceedings EUROGRAPHICS 79, Bologna, Italy.

(5) Vinberg, A., "Position Paper on Graphics Standards", Computer Graphics, Vol. 12, No. 4, 1978.

APPENDIX A

ECMWF Workshop on Future Graphical System

July 10 - July 13 1979

List of Participants

Lofton Henderson	NCAR
Bertram Herzog	Univ. of Colorado Computing Center
Russell Hovey	National Weather Service - Washington
Louis Jouaillec	Meteorologie Nationale - France
Fritz Königshofer	ECMWF
Jean Labrousse	ECMWF
Alain Lemaire	ECMWF
Roger Newson	ECMWF
Paddy O'Sullivan	ECMWF
Robert Pône	Meteorologie Nationale - France
Herbert Pumpel	ECMWF
Howard Watkins	ECMWF
Lars Winberg	Finnish Meteorological Institute

Other members of ECMWF also attended some of the sessions.

APPENDIX B

ECMWF Workshop on Future Graphical System

July 10 - July 13 1979

Working Papers

Number	Title	Author
1	Report on Visit to Places of Interest in the United States	A. Lemaire
2	A Study of some Graphical Software Packages	K. Petersen
3	The Design of the ECMWF Contouring Package	K. Petersen
4	Some Comments on Graphic Standards and Device Independence	A. Lemaire
5	ECMWF Contouring Package, an Overview	H. Watkins
6	Computer Graphics Activities at the National Center for Atmospheric Research	L.R. Henderson
7	Quantative Studies of Graphics Load on the Computing System at NCAR	L.R. Henderson
8	Distributed Graphical Systems	A. Lemaire
9	Design of a Graphical System for Meteorological Applications	A. Lemaire H. Watkins
10	Use of Graphics in Meteorology	H. Pumpel
11	Future Trends in Hardware - Applicability to Meteorological Applications	A. Lemaire
12	The Design of a Graphics Package	H. Watkins
13	Comments on the Graphics Situation at the Computing Centre in Paris	R. Pône
14	Report on Considerations for On-line Raster Plotter for ECMWF	K. Petersen
15	Graphical Activities at the French Meteorological Office	L. Jouaillec
16	The Graphical System at the Finnish Meteorological Institute	L. Winberg

APPENDIX C

ECMWF Workshop on Future Graphical System

July 10 - July 13 1979

List of Reference Papers

J.R. Warner "Activities within the Graphics Standards Planning Committee." Proceedings of VIM Conference, 1979.

W. Newman, A. Van Dam "Recent Efforts towards Graphics Standardisation", Computing Survey, Vol. 10, No. 4, 1978.

J.C. Michener, A. Van Dam "A Functional Overview of the Core System with Glossary", Computing Survey, Vol. 10, No. 4, 1978.

J.C. Michener, J.D. Foley "Some Major Issues in the Design of the Core Graphics System", Computing Survey, Vol. 10, No. 4, 1978.

A. Vinberg, "Position Paper on Graphics Standards", Computer Graphics, Vol. 12, No. 4, 1978.

P. Wisskirchen, K.H. Klein, P. Seuffert, G. Woetzel, "Implementation of the Core Graphics System GKS in a Distributed Graphics Environment", proceedings of the Conference on Interactive Techniques in Computer Aided Design, Bologna, Italy, 1978.

J.R. Warner, "GSPC Proposed Metafile", draft of a paper for Computer Graphics, Vol. 13, No. 1, 1979.

R.F. Riesenfeld, "Current Trends in Computer Graphics", Computer and Graphics, Vol. 3, 1978.

K.W. Bowyer, "ADD-ON Array Processors : The Poor User's Super-Computer?"