ECMWF MODEL OUTPUT ON VIDEO

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1. INTRODUCTION

The ECMWF forecast model, which produces a 10 day forecast, generates over 5 gigabytes of data on a daily basis. Such a large volume of data can only be fully analysed using modern graphical and visualisation techniques.

Traditionally, meteorologists analyse forecast data using black and white hard copy maps. At ECMWF a major investment has been made in the Meteorological Applications Graphics Integrated Colour System (MAGICS) [1]. MAGICS has provided the Centre's meteorologists with a simple method of producing colour maps, which has lead directly to new presentation methods for meteorological data [2]. By adding colour to a black and white map, many more meteorological fields can be represented. For example, a simple black arrow drawn on a map can represent the wind speed and direction at a number of fixed points on the globe, or in the atmosphere. By colouring the arrows according to the temperature of the wind at these points, frontal systems stand out even to the untrained eye, and experienced meteorologists can spot interesting effects that they have not seen before in such detail.

The next step, after the introduction of colour, is to introduce a time factor by producing animated sequences of weather maps. Such sequences clearly depict the development and interaction of forecast weather systems.

2. The ECMWF VIDEO SYSTEM, HARDWARE CONFIGURATION AND OPERATION

The heart of the ECMWF video system is a single board display frame buffer, supplied by Dowty Computer Graphics, which sits in the UNIBUS of one of the Centre's VAX (see Fig. 1).

Animated sequences are produced on the Centre's X-MP/48 using the MAGICS package. Image files, in device dependent form, are then moved from Cray disk to VAX disk over the Centre's network. A simple program on the VAX then reads these image files and sends them along the UNIBUS to the frame buffer.

The frame buffer has a resolution of 768 by 574 pixels (i.e. normal PAL television resolution), 4 bit planes and a look up table of 4096 colours. Colours are selected by setting each of three guns (red, green and blue) to an intensity between 0 and 15 inclusive.

As output, the frame buffer produces a Red Green Blue (RGB) signal which is connected to an Abekas Cox PAL encoder. The encoder produces a standard PAL video signal, which can be recorded on any domestic PAL VHS video recorder, or more professional equipment. In order to produce good quality tapes, the video system uses a Sony U-MATIC 5850P recorder, which has the ability to record to single frame accuracy.

As the complexity of pictures does not permit their production in real time, it is necessary to record just a few frames of each picture at a time. When the picture has been recorded, the frame buffer can be erased and a new picture drawn, which can then, in turn, be recorded. It is therefore necessary to carefully synchronize the drawing of pictures on the frame buffer and their recording on the U-MATIC. This is achieved by connecting an animation control unit, from EOS Electronics A.V., to the U-MATIC. The VAX can communicate with the control unit along a standard RS232 interface. It can therefore instruct the U-MATIC to record a certain number of frames at the appropriate time, and can determine when the recording has been completed.

To summarize, image files that are dumped onto VAX disk from the CRAY are written to the frame buffer by a small program running on the VAX. When an image is completed, the program instructs the U-MATIC recorder, via the animation control unit, to record a certain number of frames. When the U-MATIC recorder has completed the recording it signals the VAX via the control unit. The program is then able to erase the frame buffer and draw the next image. This process continues until all the images have been recorded.

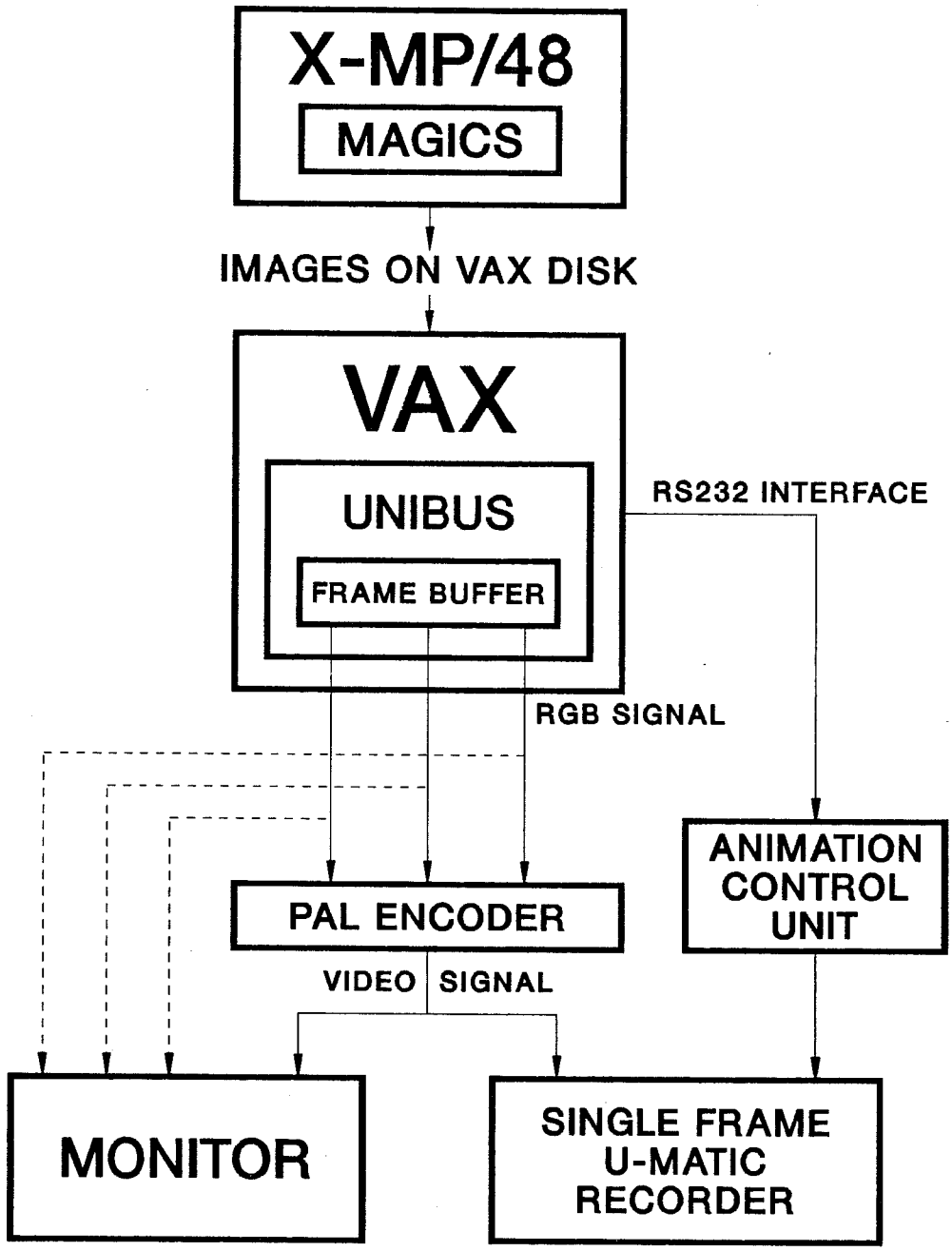

Fig. 1

3. PRESENTATION OF VIDEOS

The forecast, based on data for 16 March 1986, is presented at 15 minute intervals, interpolated from hourly model time steps. The horizontal resolution of the data points is 1.125 degrees latitude and longitude.

3.1 Contouring sequence

The sequence, which depicts a 2 day forecast, is a shading presentation of a humidity field and a contouring presentation of a mean sea level pressure field. The contouring depicts the pressure field, with an interval of 5 hPa, in the conventional way. The humidity field is depicted by three shading levels, coloured as below.

Colour scale for humidity:

0% to 65% :	no colour
65% to 95% :	light green
95% to 100% :	dark green

3.2 Single relief sequence

The sequence, which depicts a 4 day forecast, is a relief presentation of a model predicted mean sea level pressure field over the North Atlantic. Relief plotting is a simple, but efficient way of representing a contoured field. The resolution of the squares corresponds to the resolution of the forecast model, and their colour represents the numerical value of the pressure field at each grid point, as below.

Colour Scale:

below 970 hPa :	blue
970 hPa to 980 hPa :	greenish-blue
980 hPa to 990 hPa :	cyan
990 hPa to 1000 hPa :	green
1000 hPa to 1010 hPa :	yellow
1010 hPa to 1020 hPa :	orange
above 1020 hPa :	red

3.3 Quadruple relief sequence

The sequence, which depicts an 18 hour forecast, is a relief presentation of four model predicted fields over the north atlantic.

The fields, which are drawn in four windows show the forecast mean sea level pressure, 850 hPa Temperature, 30 Metre vorticity and total cloud cover.

Such a presentation allows the comparison of related fields.

The resolution of the squares corresponds to the resolution of the forecast model, and their colour represents the numerical value of the field at each grid point, as below.

Colour scale for mean sea level pressure:	Colour scale for 30 m vorticity:
below 970 hPa : blue	below -1.5E-4/S : blue
970 hPa to 980 hPa : greenish-blue	-1.5E-4/S to -1.0E-4/S : greenish-blue
980 hPa to 990 hPa : cyan	-1.0E-4/S to -0.5E-4/S : cyan
990 hPa to 1000 hPa : green	-0.5E-4/S to 0.0E-4/S : green
1000 hPa to 1010 hPa : yellow	0.0E-4/S to 0.5E-4/S : yellow
1010 hPa to 1020 hPa : orange	0.5E-4/S to 1.0E-4/S : orange
above 1020 hPa : red	above 1.0E-4/S : red

Colour scale for 850 hPa temperature:	Colour scale for total cloud cover:
below -8C : blue	0% to 70% : blue
-8C to -4C : greenish-blue	70% to 75% : greenish-blue
-4C to 0C : cyan	75% to 80% : cyan
0C to 4C : green	80% to 85% : green
4C to 8C : yellow	85% to 90% : yellow
8C to 12C : orange	90% to 95% : orange
above 12C : red	95% to 100% : red

3.4 Wind Sequence

The sequence of forecasts, which covers the full 10 days of the forecast model, shows the development and movement of an atlantic cyclone. It is depicted by the model predicted wind at 30 metres above the model surface. The length and thickness of the arrows is proportional to the wind speed. Colour is used as an additional dimension to present 850hPa temperature combined with the wind field. Cyan indicates the lowest temperature class and the colour range extends across blue, purple, yellow, orange and pink to red, which identifies the warmest air.

Colour Scale:

below -12C :	cyan
-12C to -8C :	blue
-8C to -4C :	purple
-4C to 0C :	yellow
0C to 4C :	orange
4C to 8C :	pink
above 8C :	red

4. EXPERIENCES AND CONCLUSIONS

As the video system was only installed in mid-November our experiences are, as yet rather limited. For a device at the lower end of the visualization market, it is simple to use and produces good results. The colour palette is rather limited, but the mark II version of the board has a look up table of 262,144 colours, but still only 4 bit planes.

The quality of the pictures could be improved by anti-aliasing and genlocking. Anti-alising, which is a software technique, reduces the staircase effect of lines by varying the intensities of adjacent pixels. Genlocking is a video technique which permits the synchronization of video signals. Another (more expensive) board supplied by Dowty will give us genlocking capability.

Overall, we have been impressed by the speed with which we have been able to install the video system and obtain interesting animated sequences. However, we have only just started to learn how to exploit the video media to its full potential in the field of meteorology.

5. REFERENCES

[1] ECMWF Annual Report 1985

[2] WMO Bulletin, Volume 36, Number 1, January 1987