How do we stand on the big board?

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INTRODUCTION

When is a display a large scale display? There are no hard and fast rules for answering this question. An arbitrary, but convenient starting point is to say that anything larger than 30 inches is considered large scale because 30 inches is the practical limit on cathode ray tube (CRT) size. Why should we want a large scale display? The most obvious reason is that many people have a need to view the same display surface and as the audience grows larger, so must the size of the display.

To illustrate this, Table I provides estimates of the audience area available for views of a given display size. The actual number of viewers will depend on the space allocated to each viewer.

TABLE I

SCREEN SIZE VS AUDIENCE AREA

WIDTH OF SCREEN	AUDIENCE AREA (sq ft)
40 in	120
60 in	340
7 ft	654
8 ft	848
9 ft	1078
10 ft	1338

This table is based on a rule of thumb that no viewer should be closer than two times the maximum screen dimension nor further than six times. The maximum viewing angle of any observer to the plane of the screen is considered as being limited to 60° in making these calculations.

As we have seen, the size of the display is determined by the number of viewers. You may then ask the question "why not provide each viewer with an individual display?". This is plausible under certain conditions, but large scale displays have unique characteristics that make them desirable for many applications. Some of these are:

1. In many cases, it is advantageous for an operator to have information concerning the overall environment within which he is functioning. He is better able to anticipate future problem areas and he is in a position to assume the functions of associated operators when he has knowledge of the overall system status.
2. In presenting available information to a group of individuals by means of a common display, there is some assurance that all persons are reacting to a common data base. This is a critical consideration in a rapidly changing environment where many people are pursuing interrelated tasks toward a common goal. When operators are "buried" within the confines of a console, the particular information being reacted to might be out of date or differ in some respects.
3. In an environment where a group of people require the same or very closely related information, a large display may be more economical of money and space. The addition of individual consoles may provide nothing but a duplication of data that are already available in a form suitable to the accomplishment of a particular mission.
4. The physical configuration of a particular work space may indicate one centrally accessible source of information rather than a number of independent ones. A particular environment may have size limitations that only a large display can adequately serve. An unused wall may be the only means available for the presentation of required information.
5. One display may present less of a maintenance problem than would a large number of consoles that require periodic servicing. This could result in a saving of manpower and of downtime with regard to overall display capability.

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6. When one individual can control the composition of a display, he can "force" the attention of all individuals concerned to one problem area. The capability to direct group activities in a required direction ensures that the lower echelons of a unit have the same reference point as the person making the ultimate decisions. All observers are using the same data base as indicated previously.

7. A large display can be viewed from a greater number of locations than can an individual console. The factor permits a degree of mobility and flexibility among interested personnel not afforded to individual console operators.

Use of large scale display

As can be expected, the uses of large scale displays are varied and manifold. It is beyond the realm of this paper to discuss this subject in any detail. The following is a partial list of present and future applications of large scale computer driven displays:

1. Briefing
2. Corporate Planning
3. Simulation
4. Business Gaming
5. Situation Monitoring
6. Traffic Handling
7. Training
8. Education
9. Marketing Analysis
10. Product Planning

Current state of the art

There are a limited number of available off-the-shelf approaches to the generation of automated large scale displays. The current technology includes rapid process film systems, scribe systems, light valves, and projection CRT's. A brief discussion of each technique follows:

1. Film systems

Present photo-recording equipments consist of a cathode ray tube (CRT) which provides a source image, a light sensitive medium on which the CRT image is recorded, and a processor which produces a positive transparency suitable for projection (Figure 1).

Special cathode ray tubes are used to convert electrical signals to alphanumeric and vector images suitable for photographic recording. These are generally five or seven inch flat face, high resolution CRT's with electromagnetic deflection and focus, and use P-11 phosphor as the light emitter. The cathode ray tube image is focused onto a film by means of a special camera. To form a multicolor image, three or four cameras are operated in parallel with each camera exposing a different portion of the film. During projection, each film area is projected with a different color filter and the images are superimposed at the screen

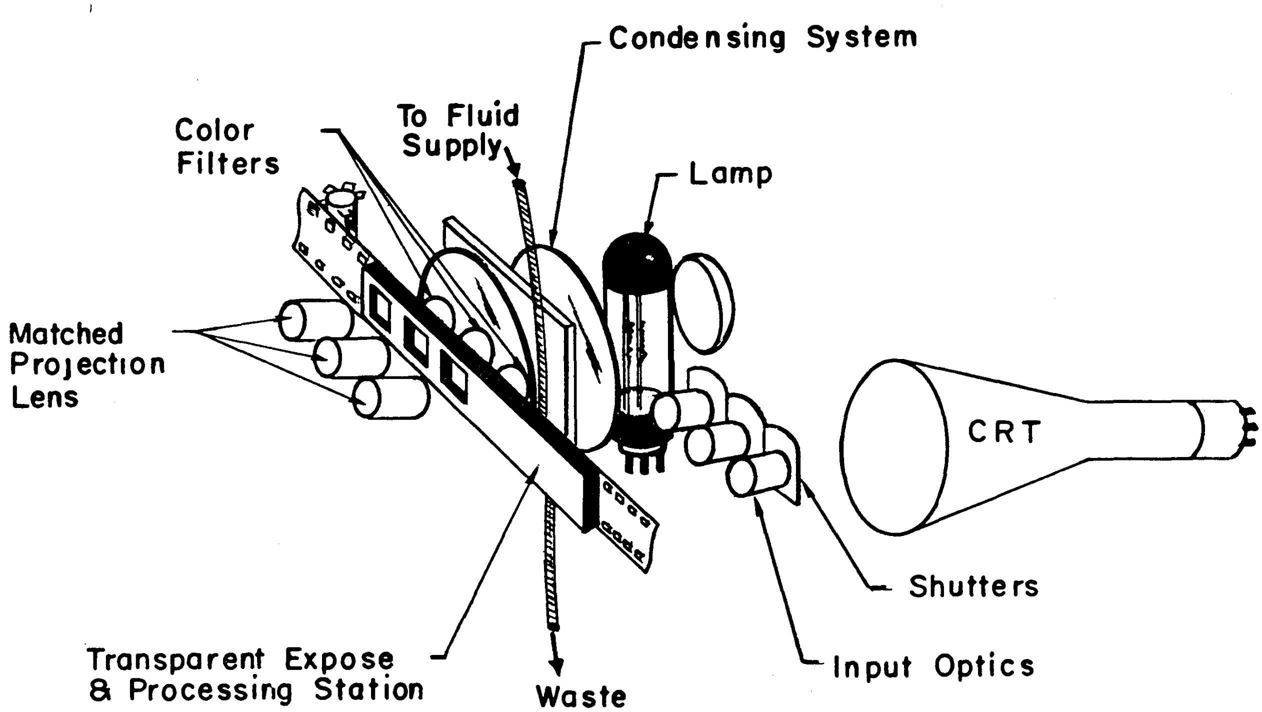

Figure 1—Multi-color film processor and projector

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to form a single multicolor image. To properly control the color of data, each camera has a shutter which is opened or closed, depending upon the color instruction from the computer. For example, to generate the green portion of a multicolor image, the proper shutter is opened, "green" data is written on the CRT, exposing the "green" frame on the film. Then after the other exposures have been made, the image is processed and projected.

The other colors are formed in the same way. For multi-component colors, more than one shutter is opened for a particular exposure.

Silver halide emulsion is the most widely used light sensitive medium for recording the CRT image. The absolute sensitivity of silver halide is such that character exposure times of 50 to 1000 microseconds can be used. It can be seen from Figure 2 that the spectral response of a blue-sensitive film such as Ansco Hyscan is relatively flat out to 500 millimicrons, and well matches the output of the P-11 phosphor which peaks at approximately 460 millimicrons.

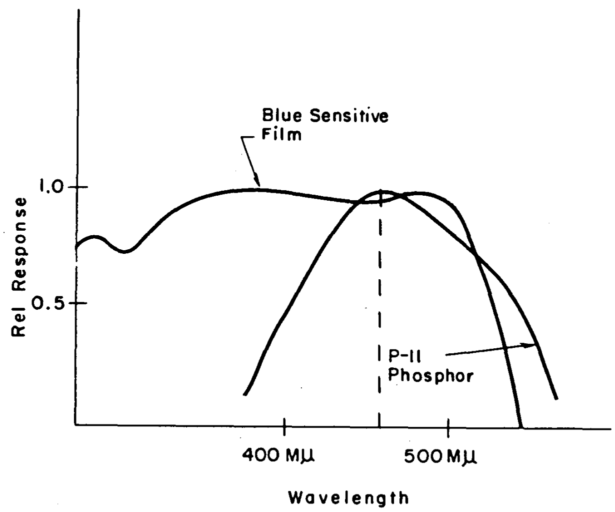

Figure 2—Film phosphor spectral characteristics

The demand for rapid response in computer-type displays has been met by the development of rapid processing techniques. The process consists of the use of special films containing hardened, large grain emulsions which make them suitable for processing at elevated temperature without appreciable loss in image quality. Total processing times of five to ten seconds can be achieved with developer temperatures of 130° to 140° F. The negative image produced in conventional film processing is not suitable for projection in a color additive process and therefore reversal processing is used to obtain a positive image. The steps involved in reversal processing are: (Figure 3)

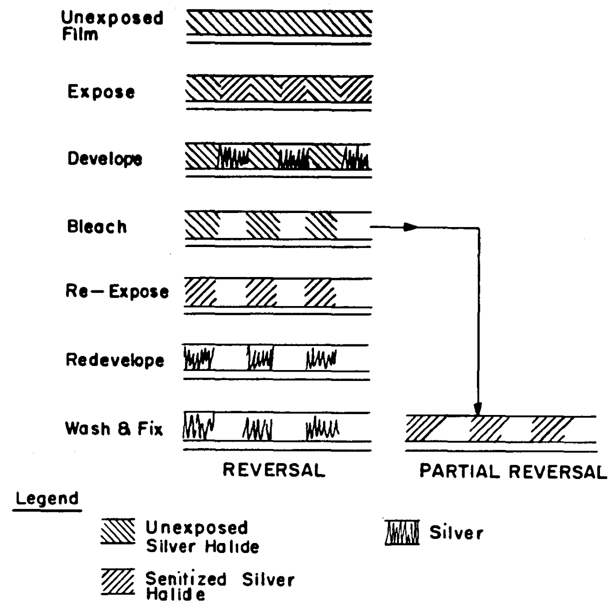

Figure 3—Reversal processing

Develop—Reduces the exposed halide crystals to metallic silver and leaves unexposed areas unreduced. The light energy absorbed by the exposed crystals increases their sensitivity to the developer and consequently they are reduced before the unexposed crystals.

Bleach—Converts the metallic silver into a water soluble compound so that it can be washed from the base material.

Wash—Removes the soluble products of the bleach process and leaves the exposed areas of the film clear, and the unexposed areas, which contain silver halide, opaque.

The previous three steps constitute a partial reversal process. The final image is the clear information areas against the unexposed silver halide background. To obtain a full reversal process, the following steps are added:

Re-expose—Sensitizes the remaining silver halide by exposure to light.

Redevelop—Converts to metallic silver the exposed silver halide crystals.

Wash—Removes remaining chemicals.

Under zero ambient illumination conditions, the partial reversal processes are capable of producing an image contrast of better than 50 to 1, and full reversal processes a contrast of better than 100 to 1. In applications where the surface area to be illuminated is greater than 150 square feet, the increased contrast afforded by the full reversal process can compensate for the lower display brightness resulting from the large screen area and enhance display legibility.

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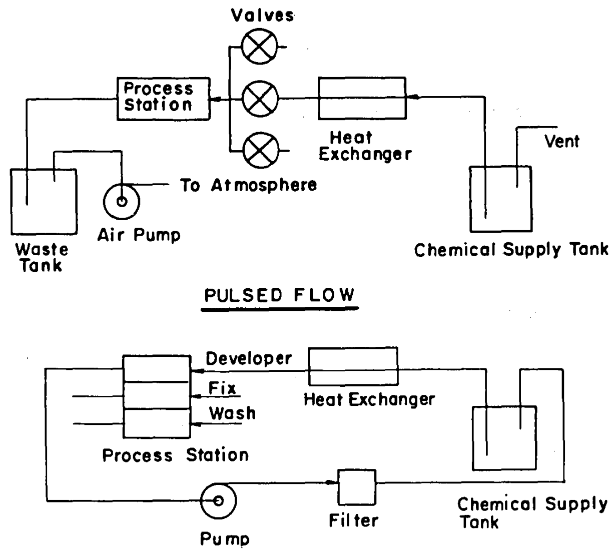

Figure 4—Basic fluid handling systems

There are two systems of chemical fluid handling currently in use; continuous flow and pulsed flow. Both of these techniques maintain the processing chambers below atmospheric pressure to lower the probability of leaks.

In the continuous flow fluid system, the processing fluids flow continuously through separate channels and the film is moved across each head sequentially in such a way as to come in contact with the required chemical at the proper time. The supply tanks are then maintained at some temperature less than that required for processing to extend the life of the chemicals and a heat exchanger provides the capability of heating the chemicals to the proper temperatures as needed. With the pulse flow system, the chemicals required for processing of the film pass sequentially through a single processing head. Normally-closed solenoid actuated pinch valves are used to sequentially open the appropriate fluid lines and allow chemical flow, and then to close the line after the required quantity of chemicals have flowed into the head. This technique is more reliable since an air pump is used, and because only one head seal is required.

Table II is a tabulated summary of the pertinent performance parameters of three systems which utilize this technique for their display capability. The values of the individual parameters do not necessarily represent a maximum, but rather represent a set of performance characteristics which have been achieved.

This summary includes the practical results of the technique in two large screen applications and in a small screen application.

TABLE II

PERFORMANCE CHARACTERISTICS

	Full Reversal	Negative Positive	Partial Reversal
Projection Scheme	Rear	Front	Rear
Screen Size (Ft)	12×16	8 × 8	1×1
Projection Distance (Ft)	22±¼	28±¼	3
Incident Illumination (Ft Candles)	26	30	100
Fall-Off (%) of Center to Edge Brightness	22	23	25
Symbol Brightness (Ft. Lamberts)	13	15	50
Contrast Ratio (Zero Amb.)	150:1	100:1	30:1
Symbol Height (Inches)	1.63	1.40	0.210
Colors	Seven	Seven	Four
Color Fringing (Inches)	0.13	0.12	N/A
Resolution (Line Pairs Per Screen Ht)	940	910	1000
Linearity (%) of Screen Width	0.5	0.5	0.5
Registration (%) of Screen Width	N/A	1.0	0.7
Response Time (Sec)	10	15	15

In summary, film systems can provide high quality, colored, large scale displays of almost any size. They are simple to integrate into data processing systems and present no unusual demands on the data processor. They are mechanical devices and utilize corrosive chemicals heated to high temperatures. Film systems by their very nature are static displays and best applied to tasks such as status monitoring and other functions where the 10 to 15 second update delay is not objectionable. They are available off the shelf from many manufacturers.

2. Scribe systems

Scribe projectors can provide the dynamics lacking in the film approach to large scale displays. These devices resemble a miniaturized x, y plotter. They utilize a servocontrolled stylus to scribe lines through opoque metallic coating on a transparent base material (Figure 5). The resultant image is then projected by a conventional optical system which resembles a 35mm slide projector. Some form of slide storage and access is usually provided. The scribe projector is usually of modular design; projection optics, light source, filters,

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and scribing mechanism can be interchanged and configured to meet many requirements. Prepared slides can be substituted for the scribed slide and projected for use as background material. A cursor can be substituted for the scribing stylus and various combinations of light source and projection optics are available

An analog character generator and a manual input device may be included in the system. The manual input device will include a plotting surface and an auxiliary alphanumeric key board.

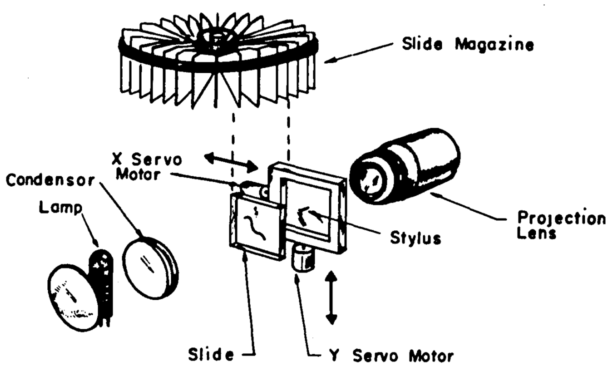

Figure 5—Plotting projector

In an operating system, a group of plotting projectors generally share a common set of control electronics. Combinations of plotting, spotting (cursor), and background projectors can be used. Two projectors are generally provided for each color required. This is to allow one active projector for current data and one idle projector to be used as follows. When the display on the active projector becomes too cluttered and must be changed, a limited history of past events is transferred to the idle projector. This projector is now activated and continues to plot, and the previously active machine is shut off. The slide can be then changed with no blank display time and the cycle repeated.

Table III is a brief resume of the typical performance that can be expected of currently available scribe system.

Scribe systems can provide dynamic displays of high quality. They are slow devices and can be interfaced with most remote communications channels. Because of their versatility, they can be configured to meet many applications. They are highly mechanical devices and contain many moving parts which limits the reliability that can be expected of the device. Scribe systems are best applied where the total amount of data is limited and where their dynamic characteristics are desired.

TABLE III

TYPICAL SCRIBE SYSTEM PERFORMANCE

Stylus Slew Time	60 miliseconds (Full Scale)
Symbol Scribing Time	
Random Position	10 Symbols per second
Adjacent Position	20 Symbols per second
Stylus Positioning	
Accuracy	.1% Screen Height
Repeatability	.03% Screen Height
Slide Storage Capacity	40 Slides
Scribing Area on Slide	1 in x 1 in
Resolution at Screen	1000 line pairs (1.5 mil stylus)
Slide Changer	
Time to Adjacent Slides	500 milliseconds

3. Projection CRT's

Projection CRT's have been utilized mainly in the TV mode of operation. They have been widely used in simulators and trainers to portray to the operator the world as it would appear to him in an actual situation. In this application a computer would control the presentation by controlling a camera which viewed a model of the terrain to be pictured. Projection TV systems have also been utilized to display computer generated data. Here scan conversion or direct digital conversion of data is required to provide a TV format.

Two types of optical systems can be used with projection CRT's. Schmidt optics (Figure 6) provide the best collection efficiency, but have poor resolution and high distortion. Refractive optics are of better quality and can be highly corrected for a given system. Their optical efficiency is lower and their cost higher than Schmidt systems. The CRT's used for projection are 5 or 7 inch tubes and are operated at voltages in excess of 30 KV. Voltages as high as 80 KV have been used for some applications. In this range, X-rays can be a serious factor. Life of the projection CRT is severely limited by degradation of the phosphor and darkening of the face plate due to electron bombardment.

Typical performance of a Schmidt TV projection system is:

Resolution	600 TV Lines
Light Output	200 Lumens
Screen Size	5 ft to 15 ft
Throw Distance	10 to 25 ft.
CRT Voltage	40 KV
Tube Life	500 hrs.

Projection CRT's have been used for direct dis-

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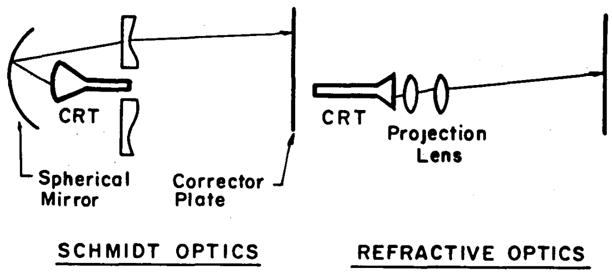

Figure 6—Projection CRT systems

play of computer generated data, but the results to date have been poor. The resolution of available CRT's is not high enough for this mode of operation. Also protection of the phosphor and face plate from damage by a static or slowly moving high energy electron beam has been difficult.

The low level of general performance has limited the use of projection CRT's for large scale displays. Their use has been confined mostly to the display of pictorial information.

4. Light valve systems

Another approach to the large screen projection of TV images is the "Light Valve" technique in which a control medium is used to control the transmission of light from a light source to the screen. The "Eidophor" is an example of such a device and uses a thin film of oil as the modulation medium. Figure 7 depicts the basic "Eidophor" operation. In the "Eidophor" a thin film of oil is continuously applied to a rotating spherical mirror and mechanically smoothed to a thickness of .1 millimeter.

The collimated light from a high pressure short are Xenon lamp source is reflected off the bar system and onto the oil surface which is contained with a vacuum tight chamber.

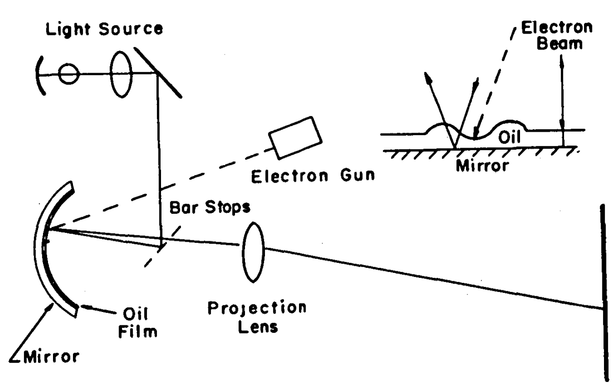

Figure 7—"Eidophor" light valve projector

An electron beam impinging upon the oil surface causes deformation to form in the control layer. Light passing through the deformed layer is refracted, reflected off the spherical mirror and refracted again; thus by-passing the stop and reaching the projection lens to be imaged on the screen. Light striking the non-deformed region of the oil film is imaged back upon the stops and does not reach the projection lens. By changing the size of the electron beam, the shape of the deformation can be changed and the amount of light passing through the system controlled.

Typical operating parameters are as follows:

Resolution	1000 TV Lines
Light Output—525 line B&W	4000 Lumens
Lamp Size	2500 Watt Zenon
Bandwidth	Up to 30 MC
Screen Size (ft)	9 × 12 at 50 ft projection distance
Throw Distance	50 ft.
Linearity	1% screen width
Cathode Life	100 hrs

To utilize the Eidophor—to display computer generated information, the data must be converted into a form compatible with the TV mode of operation. This can be accomplished in many ways. Some examples are:

a. View with a camera, the display being created on a small CRT operating on the conventional random writing mode.

b. Utilize a double ended electrical-in electrical-out storage tube. In this device, the display would be written onto one side of a storage target in the random mode and scanned off the other side of the target in the TV mode.

c. Utilize a digital data converter which, in real time, converts digital descriptions of the display into video signals compatible with TV operations.

While the Eidophor overcomes the limitation of brightness and resolution, it still requires data conversion to effectively display computer generated data. The present systems contain not only mechanical systems to distribute the oil but also have a complete, continuously operating vacuum system which includes a mechanical pump and an oil diffusion pump. These mechanical components coupled with the short life of the electron gun cathodes limit the applications to situations where large amounts of periodic maintenance can be performed and where continuous operation for long periods of time is not desired.

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CONCLUSION

While large scale display techniques have advanced considerably in the past few years, these is still much room for improvement. Their capability to handle dynamic data needs considerable expansion. Cost which is now high must be lowered and reliability needs improvements.

Toward this end, considerable research is now underway to improve existing techniques. New films which do not need wet chemicals are being explored along with novel methods of processing conventional films. Considerable effort is under way to improve the performance of the light valve technology. Also, new and better techniques are being developed to convert digital data to the analog form necessary for the exploitation of TV type devices.

Some of the specific techniques under study now are:

a. The use of the "Bimat" process where the processing chemicals are contained in an absorbtive web material, processing is accomplished by placing the film to be developed in contact with the chemical saturated web and maintaining this contact for a period of time. A conventional negative and a positive result from this system.

b. Photochromic flim, a reusable UV sensitive recording media has progressed to the point where prototype equipment is being designed.

c. Laser displays have been under study for some time. Results at this time are not conclusive and it is doubtful if any application of the laser to large scale display is in the near future.

d. Electroluminescence has been under study for many years. While much progress has been made, we are still far from applying this technology in practical systems, but electroluminescence has reached the point where it can be considered for use as discrete indicators.

With the concerted research directed at improving the display art and the increased demand for large scale displays generated by the growth of data processing into the higher echelons of management, we will see a dramatic expansion of the use of large scale displays.

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