SGP Memo 10

IMAGE DISPLAY SYSTEM EVALUATION CRITERIA

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Version 7
December 11, 1981

NOTE: This document describes our current thinking, but the details are still subject to revision. This document is provided for information purposes only. It is not intended to be a formal request for quotation.

1. INTRODUCTION

The purpose of this document is to help clarify our ideas about what is needed and wanted for the image display systems to be used for examining data in the "pipeline" system. A separate document (file IMDISC.SCR) contains a discussion of several currently available image display system features which may be non-obvious but relevant to our needs.

Section 2 will describe in general terms what we want our systems to do. It will also list the essential requirements for the display systems.

Section 3 will describe the scheme we will use for rating the importance of various features.

Section 4 will list most of the available features and our decisions about their importances.

Section 5 will list questions that remain to be answered in order to more completely define our evaluation criteria.

It should be noted that deciding which system to purchase is not just a simple matter of listing each available system and picking the cheapest one that matches our requirements. Most of the systems currently available are highly modular. By picking various options, a wide range of capabilities can be configured. And, various options may be mutually exclusive. For example, it may be possible to configure a system from a given vendor so that three stored images control the three color guns of the monitor. It may also be possible to configure the system so that we could blink compare two stored images. Both of these functions may be of interest to us. However, for some vendors it may not be possible to configure a system which can do both of these things under software control.

2. GENERAL DESCRIPTION OF OUR NEEDS AND PLANS

In general terms, our intention is to provide display capability that will aid users in making effective use of the map making capability that exists now (and will exist in the future) in the Control Building computer room. (This will only indirectly apply to capability to make maps in the DEC-10.)

We plan to initially (as soon as possible) purchase an image display which will give users the capability to get a "quick look" at their maps to see if they look OK. This display will be used in conjunction with the map making system that is primarily being used by the users. This will either be the current PDP-11/70 MAPPER system or some other PDP-11 system running Wim's new software.

As a "final" configuration, we plan to have two display systems. One is intended to allow users to display and interactively edit the visibility data in the "pipeline". The other is intended to allow users to display both continuum and spectral line maps produced by the "pipeline". The initial image display system will at some point be upgraded to become one of these two "final" display systems.

As specified in section 4, the two "final" systems have somewhat different requirements. However, as a practical matter, we would ultimately like the two systems to have essentially identical hardware configurations so that both displays can support both the visibility display function and the map display function. This will simplify the software and allow a user to use any available display for either function.

The initial display might at first be connected directly to the CPU where the maps are being made. However, the "final" image displays will be connected to a PDP-11/44 which has shared disk access with the GRIDDER CPU. (This 11/44 has already been ordered in the form of an "upgrade" to the 11/40.)

The details of how we will evolve from our current configuration to the "final" configuration are yet to be decided.

The following are the requirements for the initial map display system. Any system which does not meet ALL of these requirements will be considered to be unacceptable for our use:

1. DMA interface to the PDP-11/70 or PDP-11/44.
2. Storage for a single 512x512 (or 640x480 or 640x512) image.
3. Displayed image size of 512x512 (or 512x483 or 640x480 or 640x512).
4. Storage for at least 8 bits per pixel.
5. Image loaded as pixels (rather than as bit planes).
6. Image loaded both a line at a time and as partial lines starting within a line (this includes loading a single pixel).
7. At least one look up table with an input of at least 8 bits (i.e. 256 entries). Capability to display 256 gray scale levels. Also, pseudo color capability with 256 colors displayable on the screen with at least 4 bits for specifying each of RGB.
8. Computer read back of stored image data.
9. Cursor which can either be positioned by computer control or positioned by local interaction device with capability for computer to read cursor location.
10. Ability to use the same type of hard copy device as the IIS systems.
11. Ability to be upgraded to meet the requirements of the "final" configuration.

The "final" map display system will need to effectively handle a 1024x1024 image. It is not necessary to display the entire 1024x1024 image on the screen. It is sufficient to display a 512x512 window which can roam around on the stored image. The "final" visibility display system will need to effectively store two 512x512 images (amplitude and phase) and display them at the same time on the screen as intensity and hue. The "final" systems will thus have the following requirements in addition to the initial system requirements. Any system which cannot be expanded to meet ALL of these requirements will be considered to be unacceptable for our use:

1. Effective storage for a single 1024x1024 8 bit image with capability to roam around with the 512x512 (or 512x483 or 640x480 or 640x512) display window. The image must be displayable with gray scale or pseudo color encoding. There are at least two different ways that this could be done:
   a. Actually store a single 1024x1024 image.
   b. Store at least four 512x512 (or 640x480 or 640x512) separate images with the capability to use them together to effectively store a 1024x1024 image.
2. Capability to display two 512x512 (or 640x480 or 640x512) images as intensity and hue with ability to dynamically and independently change the intensity and hue assignments. There must be an effective stored dynamic range of at least 6 bits for each of the images. There are at least four different ways that this could be done:
   a. The refresn data path includes translation from intensity/hue values (stored as two separate images) to the RGB required by the monitor. There is a look up table between each of the two stored images and the translation hardware.
   b. The refresh data path does not specifically include intensity/hue to RGB translation, but it is flexible enough to effectively accomplish this.
   c. A single 12 bit stored image goes through a 12 bit input look up table (=> 4096 entries). Each table entry has at least 8 bits for specifying each of RGB.
   d. The system simultaneously reads out two stored images and sends each through a separate look up table. The hardware is built in such a manner that we can put our own intensity/hue to RGB translation hardware between the look up tables and the digital to analog converters.
3. Blink compare two or more 512x512 gray scale or pseudo color images with separate look up tables for each. Each image must be displayed with at least 64 different gray scale levels or colors.

4. Blink compare two or more sets of 512x512 images being displayed as intensity and hue with separate look up tables for each.
5. Zoom and roam with zoom factors of 2X or 4X. This must apply to handling a single 512x512 image with gray scale or pseudo coloring, handling a single 1024x1024 image with gray scale or pseudo coloring, and also handling two 512x512 images being displayed as intensity and hue.

In addition to the previously described required features, the following are some relatively important features that are highly desirable. Having a relatively large number of these features is considered important for a system to be acceptable for our use.

1. 9 or 10 bits per pixel for gray scale or pseudo color display of a single image.
2. Effective stored dynamic range of greater than 6 bits for the image that is determining intensity for the intensity/hue mode of display.
3. 1x1 aspect ratio for displayed pixels.
4. Load partial pixels (if using a single 12 bit image for intensity and hue).
5. Effectively store a short & fat and/or tall & thin image where the smaller dimension is 512.
6. Allow 8 or more bits for specifying each of RGB for pseudo color display.
7. Computer read back of look up tables and other internal registers and status information.
8. Software selectable screen appearance for cursor.
9. Zoom which doesn't change refresh memory contents.
10. Zoom and roam to give blink comparision or "movie" for a larger number of smaller images.
11. Negative zoom.
12. Independent X and Y zoom factors.
13. Inclusion of a (micro)processor which can be programmed by us to provide additional functions within the display system.
14. Character generator.

3. RANKING SYSTEM FOR IMPORTANCE OF HARDWARE FEATURES

The following section lists various features that an image display might have. We have attempted to assign three priorities or importances to each item. These correspond to the following three systems:

1. The "initial" map display system.
2. The "final" visibility dispay and editing sytem.
3. The "final" map display system.

The importance or priorities of the items are ranked on a scale of 1 to 5 as follows:

5 - required
4 - highly desirable
3 - would be nice to have
2 - not needed, but we would probably use it if present
1 - would not be used even if present

In some cases, an item will list a feature and then there will be other items indented below it. The intention of these indented items is usually to clarify the nature of the feature assuming is it present in some form. Thus, multiple image capability is not needed in the initial system. However, if we have two images, it is highly desirable to be able to blink compare them.

As you will see, not many items can be listed as absolute requirements. Also, not many items can be listed as things that we would not use even if present. Most items are in the intermediate grey area. We could find a use for almost any feature. (This assumes that a real effort will be made to make effective use of the hardware capabilities. This is something that has not yet been the case with either the IMPS/COMTAL system or the AIPS/IIS system.) Almost any feature would be nice to have if it were free. Since most features aren't free, we will have to evaluate the relative costs and desirabilities of the various features.

4. LIST OF POSSIBLE IMAGE DISPLAY SYSTEM HARDWARE FEATURES

REFRESH MEMORY SIZE FOR EACH IMAGE:	512x512 (or 640x480 or 640x512)?	(5, 5, 5)
	1024x1024?	(2, 2, 2)
	Larger than 1024x1024?	(1, 1, 2)
DISPLAYED IMAGE SIZE: (Without Zoom)	512x512 (or 512x483 or 640x480 or 640x512)?	(5, 5, 5)
	1024x1024?	(2, 2, 2)
	SOFTWARE SELECTABLE DISPLAY SIZE?	(3, 3, 3)
REFRESH RATE & TYPE:	30 HZ, INTERLACED?	(5, 4, 5)
	60 HZ, NON-INTERLACED?	(3, 4, 3)
	SOFTWARE SELECTABLE REFRESH RATE?	(2, 2, 2)
COMPATIBILITY WITH STANDARD VIDEO EQUIPMENT (e.g., CAMERA, TAPE, or DISK - This implies a 30-Hz interlaced display with 480 or 483 displayed lines)?		(2, 2, 3)
BITS PER PIXEL (EACH IMAGE):	at least 8?	(5, 5, 5)
	10?	(2, -, 4)
	12 (if used as two 6-bit images for hue & intensity)	(2, 5, 4)
	12 (if NOT used as two 6-bit images for hue & intensity)	(2, 2, 2)
1x1 ASPECT RATIO FOR DISPLAYED PIXELS?		(3, 2, 3)
1x1 ASPECT RATIO FOR PIXELS ON HARD COPY?		(4, 4, 4)
INTERFACE TO PDP-11:	DMA?	(5, 5, 5)
	SOFTWARE DMA DRIVER?	(4, 4, 4)
	RS-232C?	(2, 2, 2)
IMAGE LOADED DIRECTLY FROM THE COMPUTER'S DISK?		(3, 3, 3)
IMAGE LOADED DIRECTLY FROM THE DISPLAY SYSTEM'S DISK?		(2, 2, 2)

IMAGE LOADING:	LOADED AS PIXELS?	(5, 5, 5)
	OPTIONALLY LOADED AS BIT PLANES UNDER SOFTWARE CONTROL?	(3, 3, 3)
	LOAD PARTIAL PIXELS (IF USING A 12-BIT IMAGE FOR HUE & INTENSITY)?	(4, 4, 4)
	LINE AT A TIME?	(5, 5, 5)
	PARTIAL LINE STARTING AT LEFT?	(3, 5, 3)
	PARTIAL LINE STARTING WITHIN THE LINE?	(3, 5, 3)
	MORE THAN ONE LINE AT A TIME - LINES GOING DOWN?	(2, 2, 2)
	MORE THAN ONE LINE AT A TIME - LINES GOING UP?	(3, 3, 3)
	MORE THAN ONE LINE WITHIN RECTANGULAR SUBSECTION - LINES GOING DOWN?	(2, 2, 2)
	MORE THAN ONE LINE WITHIN RECTANGULAR SUBSECTION - LINES GOING UP?	(3, 3, 3)
	COLUMN LOADING?	(2, 2, 2)
	SCROLL LOADING?	(3, 3, 3)
MULTIPLE 512x512 IMAGE CAPABILITY?		(2, 4, 5)
HOW MANY ARE NEEDED:	2 or 3?	(2, 4, 5)
	4?	(2, 3, 5)
	>4?	(2, 2, 2)
BLINK COMPARE TWO OR MORE IMAGES?		(4, 3, 4)
SPLIT SCREEN COMPARISION?		(2, 2, 2)
THREE IMAGES DISPLAYED AS RED, GREEN, BLUE?		(2, 2, 2)
THREE IMAGES DISPLAYED AS INTENSITY, HUE, SATURATION (OR TWO AS INTENSITY, HUE)?		(2, 5, 4)
EITHER RGB OR IHS SELECTABLE BY SOFTWARE?		(2, 2, 2)
SOFTWARE CONTROL OF WHICH STORED IMAGE CONTROLS WHICH COLOR?		(2, 2, 2)
USE 4 512X512 IMAGES (IF 4 AVAILABLE) AS A SINGLE 1024x1024?		(3, 3, 5)
USE MULTIPLE IMAGES AS SINGLE TALL/THIN OR SHORT/FAT IMAGE?		(1, 4, 1)
USE TWO 8-BIT IMAGES TOGETHER FOR DYNAMIC RANGE GREATER THAN 8-BITS?		(3, 3, 3)
MULTIPLE 1024x1024 IMAGE CAPABILITY?		(2, 2, 2)

RAPHIC OVERLAY PLANE:		
MAXIMUM NUMBER NEEDED:	AT LEAST 1?	(2, 3, 3)
	2?	(2, 2, 2)
SOFTWARE SELECTION OF USING AN IMAGE BIT AS A GRAPHIC OVERLAY?		(2, 2, 2)
CAPABILITY TO USE REFRESH MEMORY AS IF IT WERE LARGER IN SIZE WITH FEWER BITS PER PIXEL, E.G. USE A 512X512X8 MEMORY AS IF IT WERE 1024X512X4 OR 1024X1024X2?		(2, 2, 2)
LOOK-UP TABLE:		
AT LEAST ONE LUT IN THE REFRESH DATA PATH?		(5, 5, 5)
2 LUT'S IN SERIES - ONE FOR TRANSFER FUNCTION, ONE FOR COLOR?		(3, 3, 3)
INPUT ADDRESS BITS (=> NO. OF TABLE ENTRIES):		
AT LEAST 8?		(5, 5, 5)
12 (FOR 12-BIT HUE/INTENSITY IMAGE)?		(2, 5, 4)
BITS PER ENTRY FOR EACH OF RGB:	4?	(5, -, 5)
	8?	(2, 5, 4)
SEPARATE PARALLEL LUT FOR GRAY-SCALE?		(2, 2, 2)
SEPARATE LUT FOR EACH IMAGE FOR BLINK COMPARE?		(2, 2, 4)
CAPABILITY TO INTERCEPT REFRESH DATA STREAM BETWEEN LOOK-UP TABLE AND DIGITAL TO ANALOG CONVERTER (ASSUMING WE DON'T USE 12-BIT IMAGE FOR HUE/INTENSITY)?		(2, 5, 4)
COMPUTER READ-BACK:	IMAGE DATA?	(5, 5, 5)
	LOOK-UP TABLE DATA?	(4, 4, 4)
	OTHER INTERNAL REGISTERS?	(4, 4, 4)
INTERACTION DEVICES:	DATA TABLET?	(, ,)
	TRACKBALL?	(, ,)
	JOYSTICK?	(, ,)
	CONTROL PANEL?	(, ,)
	KEYBOARD?	(2, 2, 2)
USER INTERRUPT OF THE SYSTEM?		(5, 5, 5)
AT LEAST SOME KIND OF CURSOR?		(5, 5, 5)
TWO CURSORS?		(2, 2, 2)
SOFTWARE SELECTABLE SCREEN APPEARANCE?		(4, 4, 4)
LOCATION SET BY COMPUTER (If cursor controlled by local interaction device)?		(2, 2, 2)
LOCATION SET BY LOCAL INTERACTION DEVICE?		(4, 4, 4)
COMPUTER READ OF CURSOR LOCATION?		(5, 5, 5)

LEAST SOME KIND OF ZOOM AND ROAM?	(2, 5, 5)
ZOOM FACTORS NEEDED: AT LEAST 2X, 4X?	(4, 5, 5)
>4X (POWER OF 2)	(2, 2, 2)
INTEGER FACTORS?	(2, 2, 2)
INDEPENDENT X & Y FACTORS?	(1, 3, 2)
ZOOM WHICH DOESN'T CHANGE REFRESH MEMORY?	(4, 4, 4)
ROAM CONTROLLED BY: COMPUTER?	(4, 4, 4)
LOCAL INTERACTION DEVICE?	(4, 4, 4)
ROAM BY ONE DISPLAYED RATHER THAN ONE STORED PIXEL?	(2, 2, 2)
ZOOM & ROAM TO GIVE BLINK COMPARISION?	(2, 2, 4)
NEGATIVE ZOOM, E.G., DISPLAY EVERY OTHER PIXEL TO DISPLAY A 1024X1024 STORED IMAGE AS A 512X512 IMAGE?	(-, 3, 4)
INDEPENDENT X & Y FACTORS?	(-, 4, 2)
CONTROL FUNCTIONS PERFORMED LOCALLY WITHIN THE DISPLAY:	
MOVE CURSOR IN RESPONSE TO INTERACTION DEVICE?	(4, 4, 4) ?
SET ZOOM FACTOR?	(3, 3, 3)
ROAM IN RESPONSE TO INTERACTION DEVICE?	(4, 4, 4)
MODIFY LOOK-UP TABLE IN RESPONSE TO INTERACTION DEVICE?	(4, 4, 4)
IMAGE PROCESSING OPERATIONS PERFORMED LOCALLY WITHIN THE DISPLAY:	
ARITHMETIC COMBINATIONS OF IMAGES?	(2, 3, 3)
WHICH ONES? DIFFERENCE	
LOGICAL OPERATIONS?	(2, 2, 3)
SHIFT OPERATIONS?	(2, 2, 2)
PIXEL STATISTICS?	(2, 2, 3)
OTHERS?	
CAPABILITY FOR THE ABOVE LOCAL FUNCTIONS TO BE INITIATED AND CONTROLLED LOCALLY RATHER THAN BY THE HOST?	(2, 2, 2)
INCLUSION OF A (MICRO)PROCESSOR WITHIN THE DISPLAY WHICH CAN BE PROGRAMMED TO PERFORM ADDITIONAL LOCAL FUNCTIONS?	(2, 4, 4)
CAPABILITY TO OPERATE AS A COMPLETELY STAND-ALONE SYSTEM?	(3, 3, 3)
CAPABILITY TO SUPPORT MORE THAN ONE INDEPENDENT USER?	(1, 1, 1)

ON-IMAGING FEATURES:	
CHARACTER GENERATOR?	(3, 3, 4)
MULTIPLE CHARACTER SIZES?	(2, 2, 2)
MULTIPLE FONTS?	(2, 2, 2)
USER DEFINABLE FONTS?	(2, 2, 2)
ROTATED CHARACTERS?	(2, 2, 2)
LINE GENERATOR?	(2, 2, 2)
MULTIPLE LINES?	(2, 2, 2)
MULTIPLE LINE TEXTURES?	(2, 2, 2)
MULTIPLE LINE WIDTHS?	(2, 2, 2)
POLYGON FILL?	(2, 2, 2)
PATTERN FILL?	(2, 2, 2)
TEKTRONIX 4010/4012 TERMINAL EMULATION?	(1, 1, 1)
TEKTRONIX 4014 TERMINAL EMULATION?	(1, 1, 1)
HOST CALLABLE SOFTWARE WHICH FOLLOWS THE SIGGRAPH CORE STANDARD?	(3, 3, 3)
BILITY TO FUNCTION AS AN ALPHANUMERIC TERMINAL IN ADDITION TO BEING AN OUTPUT DISPLAY DEVICE?	(2, 3, 3)
FRAME GRAB, E.G., DIGITIZE A VIDEO SIGNAL AND PUT IT INTO THE REFRESH MEMORY?	(2, 2, 2)
CAPABILITY TO MIX OR BLINK ANOTHER VIDEO SIGNAL, E.G. FROM A VIDEO CAMERA?	(1, 1, 2)
DIAGNOSTIC SOFTWARE:	(3, 3, 3)

)ILITY TO SHARE A HARD COPY DEVICE WITH THE EXISTING COMTAL SYSTEM? (4, 4, 4)

ABILITY TO SHARE A HARD COPY DEVICE BETWEEN THE TWO "FINAL" SYSTEMS? (-, 5, 5)

ABILITY TO USE THE SAME TYPE OF HARD COPY DEVICE AS THE EXISTING COMTAL SYSTEM(S) (SHARED USE OF SAME PHYSICAL DEVICE NOT NEEDED)? (4, 4, 4)

ABILITY TO USE THE SAME TYPE OF HARD COPY DEVICE AS THE EXISTING IIS SYSTEM(S) (SHARED USE OF SAME PHYSICAL DEVICE NOT NEEDED)? (5, 5, 5)

5. QUESTIONS STILL UNANSWERED

5.1. Do we really require 30 Hz interlaced refresh for the map display system?

5.2. We clearly require an 8 bit input LUT (=> 256 entries) for grey scale display. However, for pseudo-color display, is a system like our existing COMTAL acceptable, i.e., a 64 entry color table which has 4 bits for each of RGB? Should we make 8 bits for each of RGB a requirement?

5.3. Since we are planning to have the image display controlled by a separate PDP-11/44, is it important for the display to be able to move the cursor in response to an interaction device directly connected to the display? How about changing the roam location and look up table contents?

5.4. What interaction device should be used? What about the idea of building our own control panel?

5.5. Assuming that use of the new system will completely replace the use of IMPS at some point in the future, what will we then do with the PDP-11/40? What will we do with the COMTAL display? Would it be desirable to use the data tablet and/or VT-11 with the new image display system?

5.6. Will the user control the system through textual interaction, through graphical interaction, or through a combination of these? If textual interaction is used, will it look like the DEC-10 standard commands system or AIPS or GIPSY?

5.7. How will the development evolve from our present configuration of computers and display equipment to the "final" configuration?

5.8. Will both "final" image display systems be connected to the same CPU? Would it make sense for one of them to be connected to the PDP-11/44 with shared access to the GRIDDER disk and for the second to be connected to another CPU (the PDP-11/40?) with a link to the PDP-11/44?

5.9. What will become of the Dicomed when we quit using IMPS and the PDP-11/40?

5.10. What will become of the Versatec when we quit using IMPS and the PDP-11/40?

5.11. Do we really want to make blink comparision a requirement? If so, is separate look up tables a requirement? Is 6 bits of dynamic range for each blinked image sufficient or should we require 8 bits? (The answers to these questions relate to the question of whether or not it is acceptable to have a system which stores a single 1024x1024 image with 12

its per pixel and a 4096 element look up table. Such a system could blink compare two 512x512 images with 8 bits (or even 12 bits) of dynamic range for each image with both images going through the same look up table. Or, it could effectively blink two 6 bit images with separate look up tables. It could not give the effect of blinking two 8 bit images with separate look up tables. Also, it could not blink compare two sets of intensity/hue images with separate look up tables.)