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DOCUMENTATION

LAWRENCE LIVERMORE LABORATORY
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LLL COMPUTER GRAPHICS OUTPUT DEVICES

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DISCLAIMER

A chart for summarizing and comparing computer graphics facilities as LLL was the idea of Robert M. Lee; Michael Archuleta was the first to act on this idea and came out with a preliminary chart early in the summer of 1973. The chart herein contained is an expansion and refinement of Mike's chart.

The purpose of this chart is to let a user quickly see what is available in computer graphics output devices and thereby to aid him in choosing the most appropriate method for putting out computer-contained information in graphic form. Listed on the chart are the most commonly used graphic output devices with those used more frequently appearing higher on the list. At the bottom are devices which are anticipated in the near future. In addition to providing technical information, the chart also includes information about available literature, use of the devices, and most importantly about who to contact for help (or sympathy). These "contacts" have volunteered or been volunteered to answer questions or direct you to someone who can. It is from these "contacts" that most of the information in the chart and in the subsequent explanatory pages was obtained; their help is greatly appreciated.

Please address information concerning errors, omissions and updates to me. I will attempt to keep an up-to-date copy of this report on photostore.

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LLL COMPUTER GRAPHICS

DEVICE	MACHINE	GRAPHIC INPUT	GRAPHIC OUTPUT	HARDWARE GENERATION OF SC VEC CH*	RESOLUTION ADDRESSABLE ON VIEWING AREA	RESOLUTION BITS IN ADDRESS WORDS	RESOLUTION APPROXIMATE ADDRESSABLE POINTS/IN	TURNAROUND	GREY LEVELS
TMDS	RSTUL	keyboard cursor vidicon graf/pen	10x10" TV grey-level TV color monitor hardcopy	N N Y	512x512	9	50	.5-10 sec	64
FR80	off line		16mm unsprock 16mm sprocket 35mm sprocket 4x6" fiche 11x11" Xerox (b & w only)	- Y Y	16Kx16K	14	4920 on 3.25x 3.25" CRT	2-3 hr without backlog for fiche. Overnight otherwise.	9 (3 when simulating DD80 output)
DD80c	L		35mm b & w 11x11" Xerox	- Y Y	1024x1024	10	450 on 2.25x 2.25" CRT	2-3 hr optimum	2
SIGMA-7	off line	keyboard light pen function bx	11x11" CRT	- Y Y	1024x1024	11	90	interactive	5
PDP-1	off line	keyboard light pen "eyeball" Rand tablet	10x10" CRT 3x3" prec CRT 4x6" film 35mm film	N N N N N N	1024x1024 4096x4096 4096x4096	10 12 12	100 1360 1360	"hands on"	3
GERBER	off line	Digi-Data digitizer	ink on paper light on film	- Y N - Y N	+,- 3 mils +,- 1 mil	-- --	330 1000	1-60 min	
CALCOMP	PDP-1 or off line		10" drum 29" drum	- Y N - Y N	.01" step .01" step	-- --	100 100	"hands on" or overnight by operator	
VERSATEC	G RSTUL		8.5x11" paper 8.5x11" paper	N N Y N N Y	1024x850 512x512	10 9	100 100	7 sec/page 10-30 sec	2
STORAGE SCOPES	G		6.5x8.5" CRT	N N N	512x512	9	80	1-10 sec	2
LDS-1	Q	keyboard function bx graf/pen	10x10" CRT	- Y Y	4096x4096	18	410	interactive	variable up to 2048
DD80a **	RS		35mm b & w 35mm color 16mm color	- Y Y	1024x1024	10	450 on 2.25x 2.25" CRT	< 1/2 day	32
TMDS II**	RSTUL	keyboard	10x10" TV	N N Y	512x512	9	50	.5-10 sec	2
CHORS **	RSTUL		11x11" paper	Y N Y	2048x2048	11	200	1-2 hr	2

* SC = Scan Conversion
VEC = Vector Generation
CH = Character Generation

** Not yet available.

SUMMARY CHART

	PERTINENT LITERATURE	CONTACT	PHONE	WHEN TO USE
	UCID-30020,30048 UCID-30057,30058 OC-474,585,667 UR-209 (JED) UR-320 (RELEASE) UR-412 (DDTV) UR-906 (SHORT) CDTN-73-3 (GAP) Memorandum 7/31/73 TV80 (in progress)	Pete Keller Erv Ferris (graf/pen)	3363 3295	Use for previewing DD80 and FR80 pictures and for quickly observing and editing text files. Color and grey-level output is expensive in terms of computer time and facilities.
	UCID-30020,30048 UCID-30063 OC-606,637,655,685 UR-405 (ALLOUT) UR-415 (DISPLAY) UR-417 (FICHOUT) TV80 (in progress)	Carolyn Hunt	3069	Use when fiche or movie output is needed. This is slower than DD80c for Xerox output. Useful for report writing and text output. Better quality and registration than DD80c for movies.
	LTSS-7, sec. 3 LTSS-302, sec. 3 LTSS-303, sec. 3 LTSS-304, sec. 3 UCID-30048 (SHOC) UR-415 (DISPLAY) TV80 (in progress)	Carolyn Hunt	3069	Use for inexpensive, medium quality black on white paper plots. Easiest output to obtain from standpoint of user effort.
	Gordo Manual ENR 72-16 (AGED)	Kelly Booth (graphics) John Beatty (system)	3359 3114	Useful for interaction with problems which do not require the computational power of the octopus system.
	OC-652 PDP-1 I/O Manual	Roger Anderson (use) Jack Oliver (programs) John Beard (hardware)	3278 3272 3272	Use for copying data stored on unusual mediums to more standard mediums. Use for digitally scanning photograph negatives and for applications requiring interfacing with special hardware.
	For manuals, see the appropriate "contact."	John Martin Woody Manchester	8225 8425	Use when high quality ink on vellum output is necessary. Allows for different colors of ink and different line weights. Light Gerber is for doing negatives -- slower but more accurate than ink. Good for extremely large plots.
	UCRL-14834 LTSS-302, sec. 4 LTSS-303, sec. 4	Carolyn Hunt	3069	Use for medium quality plotting where ink or good quality paper is desired. Useful or physically long plots, for colored ink plots, and for plots on specially gridded paper.
	OC-605	Nancy Storch (G machine) Hans Bruijnes (RJET)	3362 3094	Use for fast, good quality paper hardcopy where pictures and text must be intersperced. Use for hardcopy graphics on the RJET and the G machine.
	UR-407 (HSPEDIT) UR-505 (CURVE)	Barry Howard (software) Erv Ferris (hardware)	3242 3295	Use when unclassified softcopy needs to be viewed and when speed in going from one frame to another is not essential. Inexpensive softcopy graphics.
	Display-A-Mesh GATOR Manual LDS-1 Sys Ref Man	Joe Rinde (software) Ted Rombough (hardware)	7231 3050	Useful for high quality softcopy. Has special hardware to allow sophisticated, quick response interaction.
	Memorandum from Nancy Storch 26 June 1973 LEA-73-3005-99	Steve Levine	3360	Use when good quality, color, continuous-tone film is desired. Will be useful for computer-generated movies and will even allow computer-generated sound.
		Stu Stone (procurement) Pete Keller (use)	3283 3363	See comments for TMDS. Initially this will have neither grey-level nor color capabilities.
	UCID 30072	Clarence Badger	3104	Will be useful for fast, fairly high-quality white paper hardcopy where text and graphics need to be mixed.

TMDS

Television Monitor Display System is a disc-refreshed TV facility capable of providing 16 channels of graphic information. One channel is devoted to displaying the OCTOPUS status picture but the other 15 channels are available to users on over 100 monitors distributed throughout the Lab. Present switching mechanisms will allow for a maximum of 128 monitors. The 30 frames per second refresh rate is a function of the TV hardware and is independent of the number of vectors being displayed.

Several TMDS I/O devices are unfamiliar to many users. Such input devices are the joystick, the graf/pen, and the vidicon. The joystick and graf/pen may be attached to any TMDS monitor to allow "cursor" or pointing capability as described by Dieter Fuss in OC-474. Unlike the joystick, the graf/pen may also be used as an input device completely independently from TMDS. Graf/pens are at various locations throughout the Lab including one in Building 113 and two in Building 131. There is also one on the G machine in room 1856 of Building 117. The graf/pen can be used as a digitizer and is capable of digitizing to within one part in 1024 (about 75 parts per inch) on a 14 inch square. The vidicon may be attached for short periods to any TMDS monitor in such a manner that the resulting TMDS picture is a composite of information from the disc and from the view "seen" by the vidicon.

Uncommon TMDS output devices include grey-level and color monitors and a Tektronix hardcopy unit. Pictures with up to 64 levels of grey, including the black background, are available on the grey-level monitor. A new CRT and a lock have recently been added to the grey-level monitor in order to eliminate the status picture image which had been burned into the old CRT and to prevent it from being burned into the new one. "A" Division has one monitor capable of displaying three bits of color information. There are three other TMDS color monitors on site which are yet to be installed. Color monitors require three channels; six channels are required for pictures with 64 levels of grey. The Tektronix hardcopy device, also in "A" Division, will allow immediate black on white copies of pictures seen on the TMDS screen.

FR80

The FR80 is a versatile, high resolution computer output microfilm (COM) device which is available for graphics output, though it is primarily used as a printer substitute. For graphics, it is several times slower than the DD80c but produces far better quality images on film and has a larger number of output forms including 16mm and 35mm sprocketed film, 16mm unsprocketed microfilm, and four by six inch 42x microfiche. White paper Xerox output can be made from the 35mm film as with the DD80c. Hardware allows text to be generated in 64 different sizes from memory-stored fonts and displayed at the rate of about 30,000 characters per second. Current hardware allows for eight levels of intensity (nine "grey levels") though film and processing now limit the levels of intensity to about three. A hardware modification easily can be made to get 256 levels of grey on FR80 output. This would produce output with grey-level information far beyond the 64 levels which are commonly considered sufficient to satisfy most people. In addition, there are eight programmable spot sizes or line widths.

Recent turnaround on the FR80 has been poor because of its heavy workload. In July 1972 output from the FR80 was 1,400,000 pages whereas 3,000,000 pages were printed on the Radiation Printer. In May 1973 FR80 output was 4,000,000 pages compared to 2,000,000 pages from the Radiation Printer. With no backlog FR80 turnaround should be two to three hours for microfiche and overnight for other output forms. Unfortunately, the FR80 is almost always backlogged.

Proposed changes to the FR80 should ease the backlog. One change is to get a second FR80 sometime in winter 1973-4. Also, it is anticipated that the microfiche reduction size will be changed to 48x; 24x should be added sometime later. Another proposed change is to put the second FR80 on-line under a subnetwork called CHORS. Easing the backlog will make the FR80 more available for experimentation with 256 grey levels and for development in the area of graphics.

DD80c

LLL has two medium precision CRT devices known as DD80. Both devices output a 2.25 by 2.25 inch picture to a 5 inch diameter CTR. In its present configuration, the DD80c is used predominantly as a black on white paper hardcopy device; actually, output from the DD80c is in the form of 35mm film. With very few exceptions, however, the film is never seen by a user. Instead it is fed into a Xerox Copy-flo printer which copies the film to an 8 by 8 inch image on 11 by 11 inch paper. The resulting image quality is degraded from that on film but is adequate for most uses.

The DD80c is on line to the L machine but is normally used as an off-line device. In off-line mode, data to be plotted are put on designated magnetic tapes by giving the data to user 999999. These tapes are carried to the L machine and the data are transferred to 35mm film which is cut every 90 minutes during the day starting at 8:00 a.m. Data to be plotted must be on magnetic tape at least 20 minutes before the film is cut. After cutting, the film is developed and sent to the Xerox Copy-flo for printing; the developing and printing processes take a total of about one hour.

As was implied, the transferring of data from magnetic tape to film is done by photographing a CRT with a 35mm camera. The data may also be displayed on a nearby monitor CRT which can be refreshed from an L machine PPU. This monitor CRT is in turn "watched" by a vidicon which presents the refreshed picture to several TV monitors located within "A" Division.

There are several points of interest concerning the DD80c. First, it is inherently two to three times faster per frame than the FR80. Second, those using DDTV to preview DD80 files on TMDS should realize that when text is superimposed on graphical data, the relative position of the text will be slightly different on the TMDS picture than on the Xerox hardcopy. Also, lower case DD80 text will appear as upper case on TMDS. Third, DD80 files can alternatively be displayed on TMDS, FR80, VERSATEC, and eventually on TMDS II and CHORS.

SIGMA-7

The SIGMA-7 is a 32-bit Xerox Data System medium scale computer. It is housed in Building 115 and is equipped with two 7-track tape drives, a card reader, a card punch, and a line printer. It is operated in time-sharing mode with the aid of a random access disc and 128K of core.

SIGMA-7 was purchased to provide an interactive timesharing graphics facility. Only recently has it been able to approach the desired level of interactivity. It drives six CRT terminals, two of which are in Building 131 and are connected to the SIGMA-7 by a SIGMA-3 via a high-speed data link. Though the graphic terminals will display 10-bit resolution data, they will accept 11-bit information which is electronically mapped onto the 10-bit screen. The 128K of core previously mentioned represents a recent increase of 96K. This additional core will increase the rate of computation and interactivity but will have no effect on display flicker rate. The SIGMA-7 computer is intended to provide interactivity and not powerful computational ability.

In order to provide some hardcopy graphics capabiltiy, routines have been written which create magnetic tape copies of information displayed at the terminals. These tapes can then be carried to the Gerber for plotting or to the 7600s for software conversion to DD80c formatted files. It is anticipated that it will soon be possible to generate FR80 compatible tapes and that operators will automatically carry these tapes for overnight plotting. It is also hoped that sometime next year a direct wire link will be made between the SIGMA-7 and the OCTOPUS network. Users should be aware that SIGMA-7 FORTRAN conforms to ANSI standard and is not fully compatible with either CHIP or CHAT FORTRAN.

PDP-1

The DEC PDP-1 is an 18-bit, medium speed, 24K core, stand-alone computer with a wealth of peripheral equipment attached to it. Its input devices include a paper tape reader, a card reader, several 7-track magnetic tape drives, an A/D converter, an IBM electric typewriter, a light pen, a microphone, a Rand tablet, three Calcomp plotters, and an "eyeball" for scanning film with up to 10 levels of grey. It outputs to paper tape, cards, magnetic tape, a typewriter, a line printer, a speaker, and to three cathode-ray tubes from which it is possible to get 4X5 inch and 35mm film. The console CRT has 1024 by 1024 addressability and the two precision CRTs each have 4096 by 4096 addressability on their five inch diameter tubes. The "eyeball" also has 4096 by 4096 addressable resolution. Proposed expansion calls for a high precision electrostatic CRT with filters for digitizing color information from color film.

Capabilities of the PDP-1 are many but it is most widely used for conversion of data from one medium or format to another and for film digitization necessary for digital picture processing. Though it has no high-level language in use at the present time, the PDP-1 is often used to cross-assemble programs for PDP-8 computers. The light pen, tablet, and arrays of buttons and switches make the PDP-1 useful for interactive computer graphics. Mike Wirth and Mike Ekstrom are building an interface for a Comtel color TV which will tie into the PDP-1 through a PDP-11.

GERBER

LLL has two Gerber plotters, both housed in Building 131. One plotter is used strictly for high quality ink on paper plots and the other is used predominantly for drawing with a light beam on film. Both plotters are slow but very accurate and both are equipped with a 5x8 foot drawing surface. Two separate Honeywell DDP-116 computers, each with 8K of 16-bit memory, tape drives, and control consoles, drive the plotters. Both computers are configured to accept paper tape, magnetic tape, and TTY input. Neither computer is tied directly to the OCTOPUS network; they are, however, mutually tape to tape compatible.

The ink plotter was purchased by Weapons Division of Mechanical Engineering Department but its availability is lab-wide when it is not being used by Weapons. One may use it in the "do-it-yourself" mode after a few minutes of instruction from John Martin. Plotting can be done at a rate of 300 inches per minute with an accuracy of plus or minus three mils. A six-hole turret attached to the drawing head allows one to use six different colors and/or line widths without having to physically change pen tips. The practicality of the six-hole turret is reduced, however, by the fact that the exposed ink in the unused tips drys in a short time.

The light plotter belongs to ME Nuclear Explosive and Experimentation Division, formerly Device Division, and is also available for lab-wide needs though Woody Manchester is the only authorized operator. This plotter operates at a maximum rate of 70 inches per minute with an accuracy of plus or minus one mil and is therefore slower but more accurate than the ink plotter. Since a light is used to expose film, the plotter is operated in a darkroom. A turret with 24 aperatures rotates beneath the mercury-xenon light to produce 13 line thicknesses ranging from two mils to 150 mils. Eleven of the aperatures are used for specialized circuit board symbols or "pads." The final output is typically a "positive," black on clear film.

In a room adjoining the two adjacent Gerber plotter rooms is a large digitizer for use in conjuction with the plotters. The Digi-Data Corporation digitizer has an accuracy of plus or minus five mils on a 42 by 60 inch table. A Digi-Data controller will output the digitized information directly to magnetic tape, punched cards, or to an attached TTY.

CALCOMP

There are three Calcomp plotters available at the Computer Center, two with 10-inch drums and one with a 29-inch drum. One 10-inch plotter can be run directly from data generated within the PDP-1. The other two can be used under control of an independent Calcomp 570 tape drive and controller. Any of the three plotters can be run from the PDP-1 with program CAL, which simulates the 570. The plotters, which are located in the PDP-1 room of Building 117, are standing idle a good deal of the time and may be used on a first-come-first-served basis. Magnetic tapes containing data to be plotted are usually prepared on the worker computers. When plotting from such tapes, one can either mount his own tapes and plot them or leave them in the rack by the 570 for overnight plotting by an operator. All jobs should be logged whether done by the user or by an operator.

Pen motion of the plotters is limited to just a few basic directions. The pen may be moved in .01 inch increments back and forth along either the transverse or longitudinal axis of the paper or it may be moved along both axes simultaneously giving 45 degree lines. Because of the restrictions in the direction of pen motion, lines may appear rough or jagged. Plotting speed is about 180 inches per minute.

Calcomp plotters are useful where it is necessary to have several colors of ink on good quality paper. They are useful for plots of unusual dimensions, up to 29 inches by 120 feet. There is a large array of plotting paper to choose from; the supply includes preruled linear, log, and semilog paper and some is even imprinted with a continental outline of the world.

VERSATEC

The Versatec printer/plotter uses an electrostatic fluid-toned process to produce an 8.5 by 11 inch black on white sheet of paper. The sheets are fanfolded with perferations along the longer edges. In printer mode each alphanumeric character is printed in a 7 by 9 dot matrix and there are 60 lines of 128 or 132 characters per page. Most RJET terminals are equipped with Versatec printers and it is now possible to use some RJET Versatecs to output DD80 graphics files. Plans are underway to allow outputting DD80 files on all RJET Versatecs and also to allow alternating between text and graphics modes on these units. There is currently a software-imposed 512 by 512 raster limit on RJET Versatecs in graphics mode. More information on RJET Versatec DD80 graphics can be obtained from .253700:RJPLDOC or from contacting Don Emery or Hans Bruijnes.

In addition to the RJET Versatecs, one Versatec is attached to the G machine. The G machine Versatec has no physical connection to the OCTOPUS network. Routines have been written to convert both printer and DD80 files to the G machine Versatec format. For information on how to use these routines and for samples of graphic output see OC-605. The G machine Versatec plots 300 raster lines in 2.4 seconds or a page in just under seven seconds and is therefore faster than RJET Versatecs. It also can take advantage of full 1024 by 1024 addressable points though anything over 850 points in the "Y" direction spills over onto a separate sheet.

STORAGE SCOPES

There are several storage scopes at LLL. The two most available to general users are Tektronix 611 scopes and are located in room 1856 of Building 117. These scopes were purchased to provide softcopy graphics on the G machine, a computer which cannot be tied into TMDS. The scopes themselves allow 1024 by 1024 addressability but software limits this to 512 by 512 which is closer to the actual number of resolvable positions on the screen. A picture, after being sent to the scope, will remain brightly visible for ten to 15 seconds and will then be dimmed to protect the scope. Further viewing of the same picture is possible by pressing a VIEW button on the scope face.

This fall the two Tektronix scopes will be connected on an experimental basis to a station of CAIAC, Cable Assisted Information Asynchronous Communication. CAIAC is a system designed to drive multiple devices from a single large coaxial wire using a "daisy chain" process. Coded information will be sent down the wire and will be intercepted only by that device for which it is intended. Each CAIAC station will be capable of driving eight scopes and a second hardware output type -- possibly a Versatec printer. Data rates on CAIAC will allow a raster data picture to be displayed on a scope in less than one second.

LDS-1

The Evans and Sutherland LDS-1 is a sophisticated, highly interactive graphics system. The version in operation at the Lab has two graphics terminals and is capable of displaying a total of 6,000 vectors without flicker. The two terminals have 4096 rasters and hardware vector generators which produce good quality vectors without noticeable "swimming." Other useful features of the LDS-1 are software controlled intensity on a 0-2047 scale, and hardware clipping. It shares core with the Q machine, a PDP-10, and has full access to the OCTOPUS file transport subnetwork. Conflicting use of the Q machine limits use of the LDS-1 hardware predominantly to the afternoon.

Like the SIGMA-7 and the PDP-1 console, the LDS-1 has the facility to display successive views of computer-simulated or "synthetic" objects so rapidly that the objects appear to move as though viewed in a motion picture. Though the PDP-1 is dedicated to a single console when being used in an interactive mode, it is limited by not having hardware vector generation. The SIGMA-7 cannot present to each user the interaction and refresh power of the LDS-1 because it is generally being shared by several users -- up to six. The LDS-1, then, represents the greatest power at LLL from the standpoint of real-time refresh and interaction. However, because the LDS-1 system has been here for a shorter time, it does not have the backing of many often-used and time-proved utility routines as does the SIGMA-7.

Future hopes for the LDS-1 include replacing the current CRT displays with color displays, purchasing a hardware matrix multiplier to more conveniently handle real-time motion, and adding 16 buttons, eight knobs and a "mouse" or joystick to the array of input devices.

DD80a

The DD80a is being modified by Steve Levine to produce color, grey-level movies. It will be on line to the R and S machines in late fall of 1973. Initially the output will be 35mm black and white or color film; 16mm color output will be added later. The DD80a will accept files created by the CLIB and ORDERLIB DD80 subroutine calls; additional calls for producing color shaded-tone pictures will be added.

The Lab is purchasing a color movie processor just for the DD80a so a user can expect one-half day or better turnaround on color movies or slides. With the driving power of the R or S machine, exposure time per frame for color will make the DD80a the fastest color shaded-tone computer picture generator available.

TMDS II

TMDS II, alias "BRATS," for Buffer Resource Allocatable Terminal System, is a system which will replace the now defunct Keyboard Interactive Display System (KIDS). The name by which TMDS II is known to the companies bidding on it is Remote Terminal Display System. The long overdue KIDS formally met its demise in spring 1973 when the contract was terminated after waiting several years.

KIDS was a "smart terminal" with such features as hardware scan conversion, selective erasing, hardware zooming, and cursor capability. TMDS II, on the other hand, will probably be very much like the present TMDS. Since the contract has not yet been awarded, it is difficult to say exactly what TMDS II will be like. However, the specifications do mention that it will use 512 by 512 raster displays, centralized digital storage (disc, core, or MOS, etc.), a 256 character set, a minimum of 64 channels (preferrably 96), and that it will have no vector generator nor cursor facility. Early delivery, in the order of 120 days, is an important factor in choosing a vendor for TMDS II.

TMDS II will be a separate subnetwork and will operate independently of the current TMDS. Whereas TMDS has 15 available channels switchable to 128 monitors, TMDS II will be switchable to 256 or more monitors through an LLL provided electronic crossing switch -- the largest of its kind.

CHORS

Computer Hardcopy Output Recording System (CHORS) is a proposed OCTOPUS subnetwork for driving an FR80 and two 15,000 line per minute printers. The two line printers will replace the Radiation printer and will print on white 11 X 11 inch paper with an electrostatic non-impact process similar to that used in Versatec printers. The paper will be cut, not fanfolded, sheets and the printing will be done using a dot matrix with 2048 dots or 132 characters per line.

Initially the two printers will operate off line and will be driven by two Honeywell 716 computers which are scheduled to arrive with the printers in December 1973. The finished subnetwork will employ two MOD-COMP II computers, one as a backup, and five CDC 644 disc packs. It is anticipated that hardware debugging will be completed in March 1974 and software debugging sometime near May 1974. The hardware will eventually be on line to all worker computers and will provide a one to two hour turnaround.

Several steps are being taken to allow graphics output in addition to text on the two printers. John Randolph is building a hardware scan converter which will be hung on a direct port to the printers, bypassing the Honeywell computers. This hardware will quickly perform the scan conversion necessary to display vector graphics on raster output devices. Currently scan conversion for the Versatec and TMDS is done relatively slowly by software.

DISTRIBUTION

LLL Internal Distribution

CHESHIRE LIST 44		(800)
Don Vickers	L-307	(25)
Bob Westbrook	L-123	(20)
TID File	L-3	(200)

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