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DESIGN OF A LOW-COST AUTOMATED LANDSAT DATA ANALYSIS SYSTEM

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA

FINAL REPORT ON
NASA CONTRACT NO. NAS8-33136

JULY, 1979

PREPARED BY

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DESIGN OF A LOW-COST AUTOMATED LANDSAT DATA ANALYSIS SYSTEM

Prepared for

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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

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ABSTRACT

Several commercial Landsat data processing systems are currently available. However, most state agencies cannot afford the price of these systems nor the price of "low-cost" digital systems assembled by some universities. The state agencies are therefore effectively precluded from obtaining the in-house capability to process Landsat data. A system is needed that can be purchased by state agencies for approximately $20,000 and which can provide a measure of automation to the processing of Landsat data.

Alabama and Tennessee both have natural resource information retrieval systems to which Landsat digital data input capability could be added. An automated low-cost Landsat processing system was designed for the two states to permit this capability. As a first step, a list was compiled of available commercial equipment components that could be included in the final system design. Alternative equipment as well as alternative technologies were investigated to determine cost-reduction options that would lower the cost of an automated system. For example, inexpensive disk drives can be substituted for tape drives in the designed system.

Although the prototype system exceeds the original cost goal of $20,000, the system was designed such that a state with some existing equipment or a state which can use less than optimum products can have some Landsat processing capability for $20,000. Elimination of the color display selected for the base system would achieve the original cost objective but would significantly degrade performance. The system may also be upgraded to the point that faster and, therefore, larger-scale processing of Landsat data could be achieved.

Alternative systems are defined based on a single minicomputer; the peripherals can vary depending on the capability emphasized in a particular system. In this manner, it is possible to take into account the existing computer equipment/facilities that each state has or has access to. In addition, the annual operating costs for the specified system(s) are estimated, taking into account the differences in facilities and personnel which may be available to each state.

While numerous software packages have been developed to process Landsat data, not all of these perform satisfactorily on a minicomputer installation. Therefore, it was necessary to select a software package which is not only capable of performing standard Landsat data processing functions but which is also compatible with the hardware system(s) specified. The software routines selected also meet the objectives expressed by Alabama and Tennessee officials for effectively interfacing with their natural resource information systems.

In summary, this paper details a minicomputer-based system capable of automated processing of Landsat data. The system is well within the budget of many state, regional and local agencies that previously could not afford digital processing capability. Furthermore, as needs for Landsat-derived information grow, the system can be expanded to meet these increased demands.

Conclusions and Recommendations

Results of this project indicate that it is possible to construct a low-cost digital Landsat processing system which utilizes existing, available software. Furthermore, the system can be adapted to meet the needs for more extensive processing tasks with additional hardware.

This project has taken the design of a low-cost system as far as it can go on paper. All of the tradeoffs necessary to select the specific items of equipment have been performed. What remains is the actual demonstration of such a system.

Therefore, it is recommended that the low-cost Landsat processing system described here be assembled and demonstrated to NASA and to the cooperating states. The demonstration effort would have at least two very significant benefits. First, the system as described would be proven workable. In addition to the practical utility of having a proven, working system to recommend, however, the demonstration system itself could be put to good use. It could, for example, be used for training purposes in a remote sensing laboratory or it could be mounted in a mobile van to serve as an on-site demonstration and analysis tool for Landsat technology transfer.

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INTRODUCTION

Several commercial Landsat data processing systems are currently available. The price of these systems typically is in the $400,000 - $1,000,000 range. Even the "low-cost" systems assembled by some universities cost $75,000-$100,000 or more. Most state agencies cannot afford these prices for automated Landsat data analysis systems. Therefore, they are effectively precluded from obtaining the in-house capability to process Landsat data.

A previous study for NASA/MSFC*, however, raised the possibility that an automated Landsat data analysis system could be assembled for a cost of $22,000 - $45,000. Even these figures often prove to be too high for many state agencies. What is needed is a very low-cost system (i.e., approximately $20,000) that can be purchased by state agencies and which will provide a measure of automation to the processing of Landsat data. It is the intent of this project to define such a system.

Purpose, Scope, Objectives

The purpose of this project is to design a system based upon the requirements of the states of Alabama and Tennessee. The scope of the project includes the design of an automated low-cost Landsat processing system which could be purchased by these states. Other agencies might need design changes to fit their individual needs. Specific objectives of the project include:

- investigation of commercial equipment available to complete a stand-alone digital Landsat data analysis system;
- investigation of cost-reduction options which would lower the total cost of a Landsat data analysis system;

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*Low-Cost Earth Resources Data Analysis System, by N. L. Faust and G. W. Spann, Prepared under NASA/MSFC Contract #NAS8-32397, August, 1978, CR #150838.

- investigation of the technical requirements necessary to have the Landsat processing system outputs feed directly into the information systems of the two states;
- production of a block diagram defining a low-cost Landsat digital analysis system and discussion of the various alternatives available;
- production of a set of specifications for each component of the system;
- specification of software alternatives; and
- estimation of annual operating costs.

Coordination with State Agencies

In order to accommodate the needs of the states of Alabama and Tennessee for Landsat digital processing capabilities, liaison was established with the appropriate agencies in each state: the Alabama Development Office (ADO), Montgomery, Alabama, and the Tennessee State Planning Office (TSPO), Nashville, Tennessee. In addition, liaison was established with the universities assisting these state agencies: in Alabama, Auburn University, and in Tennessee, the University of Tennessee Space Institute.

Report Organization

Section 2 of this report presents the design of a low-cost Landsat analysis system and discusses possible alternatives and options for Alabama and Tennessee. Section 3 describes the available software which is capable of performing Landsat data processing functions and which is compatible with the hardware system specified. A brief summary of the project is presented in Section 4. Appendix A provides specifications on the components of the designed system. Appendix B describes the natural resource systems and existing equipment in Alabama and Tennessee.

SYSTEM DESIGN

Investigation of Available Commercial Equipment

The basic components of a workable small-scale Landsat analysis system are:

- CPU and memory;
- Disk (dual);
- Magnetic tape (dual);
- Console and interface;
- Output device; and
- Interactive display.

Figure 1 shows a block diagram of such a system.

As a result of a previous MSFC contract, some of the commercial equipment components that could be candidates for a low-cost Landsat digital analysis system were already known. However, the minicomputer market in particular has been changing rapidly with new systems being introduced almost daily. Therefore, a first step in this project was to compile a new list of available equipment that might be included in the final system design.

Letters were sent to computer equipment companies requesting brochures, price lists, and technical information. Requests were made for information on minicomputers and various peripherals. After compiling this updated list of available commercial equipment, an extensive trade-off analysis was undertaken to select the alternative components suitable for inclusion in the final system design.

The primary criteria considered in the trade-off analysis were:

- cost;
- technical performance; and
- off-the-shelf availability.

The cost of any component selected was important because a low-cost system was the primary objective of the project. Cost was not the only criterion; any component proposed for the system had to meet rigid technical requirements concerning performance with the host minicomputer.

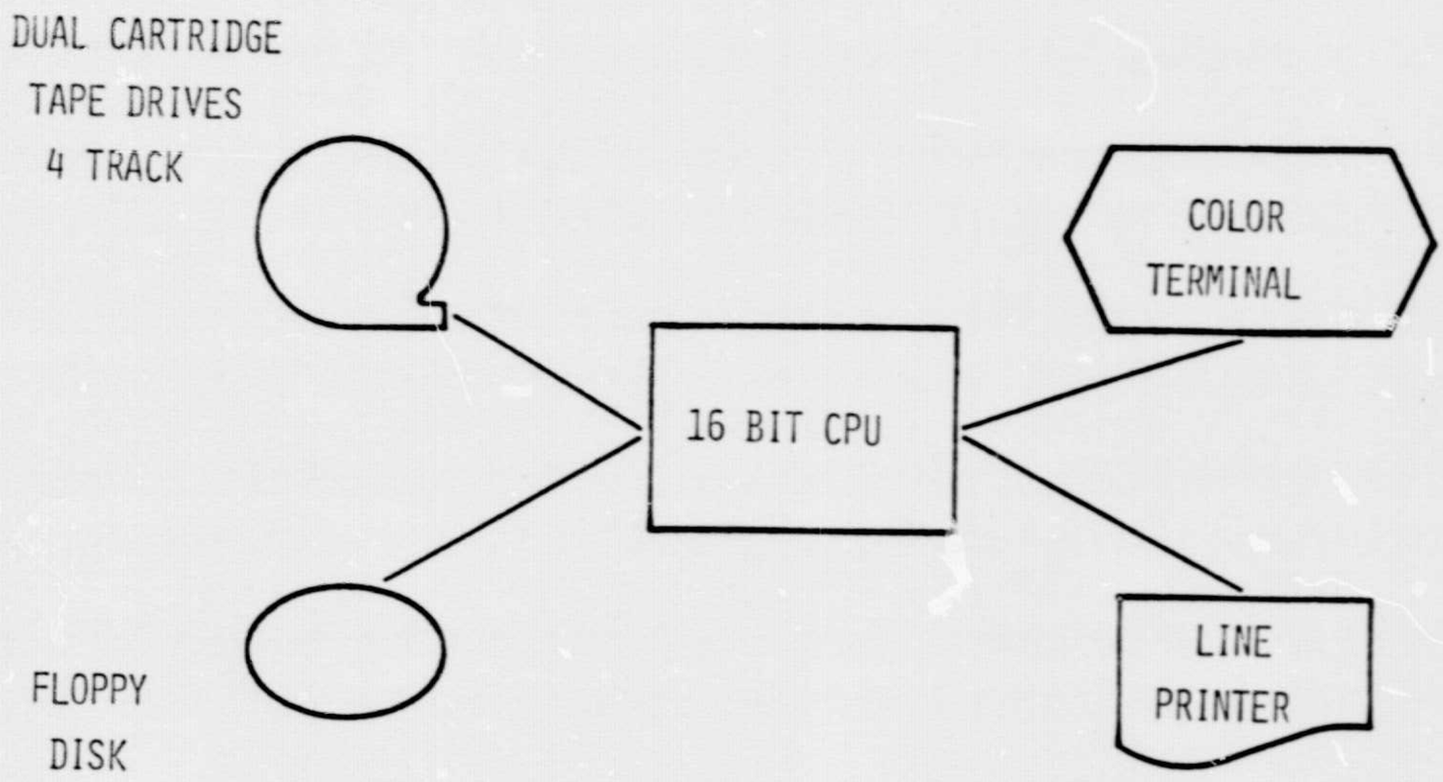

Figure 1. Block Diagram of Prototype System

Only those peripherals which met the minimum technical requirements were considered for inclusion in the system.

Finally, the components selected had to be readily available (i.e., off-the-shelf) and have existing, available interfaces for a Data General Nova minicomputer. This requirement was necessary to insure that equipment were not selected which required custom design of an interface or for which availability was unsure.

In the above trade-off analysis, several different brands of each type of peripheral were considered. For example, color displays manufactured by Grinnell Systems, Chromatics, Lexidata, Advanced Electronic Design, and Ramtek were investigated. Cartridge tape systems manufactured by 3-M, Mohawk Data Sciences, Techtran Industries, Raymond Engineering, and Data Electronics, Inc., were also considered. Finally, disk drives from Advanced Electronic Design, Shugart, and Pertec were evaluated.

In the final analysis, it was decided, for the sake of simplicity in procurement and interfacing, to specify as much equipment manufactured by Data General as possible with consideration for the cost and technical performance of each component. Thus, there were some other peripherals that might have performed adequately in the system but which were not selected.

Investigation of Cost Reduction Options

Using the list of currently available products that met the three criteria specified above, alternative equipment as well as alternative technologies were investigated to determine cost reduction options that would lower the cost of an automated system below that estimated in the previous study. For example, cartridge tape drives were selected for use in the prototype system since Landsat data for subscene areas may be transferred to a cartridge by using a cartridge system interfaced at a central computing center and because the cartridge systems are reasonable in price. The potential storage for some of the systems currently on the market exceeds that needed for a whole Landsat scene. Floppy disk systems were selected, again not only because of their reasonable price, but also because they have proven to be very reliable in micro-minicomputer applications.

The interactive color display is an integral part of a Landsat system. It is used for the location and analysis of sample training fields for maximum likelihood classification. The number of grey shades allotted to each of the three color guns determines the color resolution of the system, the refresh memory requirements, and utlimately the cost of the system.

New services and equipment which are reasonably expected to be available in the near future were also considered, e.g., direct transmission of data via a common carrier, commercial availability of fractional scene Landsat data on disks, and the possible use of video tape recorders to achieve a limited measure of automation in viewing the Landsat data.

While all of the above options were considered, the only "new" technology which was found to be available today and also compatible with the cost constraints imposed by the low-cost criterion was the cartridge tape system. Availability of these systems is relatively recent, and use of cartridge tape systems does lower the overall cost of the proposed system. Thus, the cartridge tape drives were recommended as part of the prototype low-cost system.

Definition of Prototype System

Using the above trade-off criteria and giving due consideration to the new technology now available or likely to be available in the near future, the components of a prototype system were selected. This system is shown in Table 1. Technical specifications of the components are given in Appendix A.

As mentioned previously, other peripherals were found which had the same (or greater) technical qualifications for inclusion in the system. However, when all criteria were considered, the prototype system specified in Table 1 was found to satisfy the most constraints. It is completely feasible to select other components for inclusion in this system, but additional systems engineering and trade-off analyses would be required.

Table 1. Prototype System Design

Component	Model	Approximate Cost
1) CPU	Data General Nova 3/12* w/32kw	$ 6100
2) Disk	Data General Dual Floppy Disk 1/2 mbyte capacity	3900
3) Tapes	Qantex 650 (1600 BPI - 2.88 mbyte - 4 track - dual drive) with Data General Interface	~ 4000
4) Console and Printer	Data General Console and Printer (Dasher)	1650
5) Console Interface		800
6) Color Display	Lexidata System 3400	10,000-14,000
7) Operating System	Data General DOS and Fortran IV	-
		$28,000-32,000

*Other Nova computers with similar or greater capabilities may be substituted for the Nova 3/12. In particular, the Nova 4 series may offer advantages to some users.

The prototype system consists of a Data General Nova 3/12 minicomputer with 32 kilo words of core memory, a Data General Dual Floppy Disk with a storage capacity of 0.5 megabytes, and a Data General Dasher Console and Printer. A Qantex 650 magnetic tape drive with Data General interface was chosen for input and output of Landsat data. The Qantex 650 is a 1600 bit per inch, 4 track dual tape drive with 2.88 megabytes of storage capacity.

The color display chosen for the low-cost Landsat data processing system is the Lexidata System 3400. The configuration selected includes a 256x256 pixel display with a minimum of 6 bits of information per pixel. (This is equivalent to a 64 color display.) The purchaser should specify a direct memory access to the host minicomputer - in this case a Data General Nova 3/12. The cursor option and zoom option are highly recommended as they will improve the accuracy of training field selection. A Data General Disk Operating System and Fortran IV compiler for the Nova 3/12 are supplied at no extra cost when the Data General Disk is utilized.

The low-cost Landsat data processing sysem as defined above is probably the minimum system that would prove satisfactory to any serious Landsat data user. It is possible to limit the system costs to approximately $20,000 by the elimination of the color display. However, this would adversely affect the utility of the system for operational Landsat data analyses, particularly the selection of training fields and the rapid evaluation of processing results. Consequently, it is recommended that the color display be included in any system purchased.

The prototype low-cost Landsat data processing system hardware defined in Table 1 is entirely capable of carrying out all standard Landsat processing algorithms when equipped with software such as that described in Section 3. It will perform, for example, supervised (maximum likelihood) and unsupervised classifications, training field selections, coordinate transformations, and rectification/resampling of Landsat data. Additional details of these capabilities as well as the capibilities for geographic data base creation using Landsat data are given in Section 3.

The major limitation of the prototype system is the time that it takes to process Landsat data. For example, a whole Landsat scene classified into 60 classes would take about 20 days of continuous processing to analyze completely. It is unlikely that many state agencies would be interested in processing whole Landsat scenes into 60 different classes so this time factor may not be important. However, if processing needs of this magnitude are a serious problem, the additional items of relatively inexpensive equipment which can be easily added to the basic system will largely overcome this handicap. (No additional processing capabilities are added, but all processing will take less time.)

Addition of a hardware multiply/divide unit and a hardware floating point processor to the Nova 3/12 would speed up the processing rate by a factor of 10 to 15. This would allow, for example, more rapid analysis of selected areas and/or more extensive geographic areas (e.g., one or more Landsat scenes) to be processed much more frequently than with the base system. The cost for a hardware multiply/divide unit for the Nova is approximately $2000 and a hardware floating point unit is about $6000.

The exact advantages that the enhanced systems would have for Alabama and Tennessee (or other states) would depend on the types and quantity of analyses anticipated. Since Alabama equals the equivalent of four Landsat scenes and Tennessee equals the equivalent of three Landsat scenes in land area, the time savings could be significant for processing major fractions of the state on a regular basis. On the other hand, if only limited areas are to be processed, or large-scale processing is infrequent, the prototype system should prove to be adequate.

Requirements for Input to State Information Systems

Alabama and Tennessee both have natural resource information retrieval systems to which the addition of Landsat digital data input capability is feasible. It was therefore necessary to document the required inputs to the two information retrieval systems and to assess the technical requirements necessary to have the low-cost Landsat processing system outputs feed directly into these information systems. To accomplish this coordination, liaison was established with the appropriate agencies and universities in each state. Each of the offices was requested to provide a list of any equipment already available in their state with which new equipment could be interfaced for the addition of Landsat digital processing capabilities. The cooperating agencies were also requested to identify any constraints they might have regarding new equipment to be selected.

In response to these requests, the Alabama Development Office (ADO) and Auburn University sent a joint reply describing the computer system that houses their information retrieval system at Auburn. Auburn personnel designed and operate the information system for the Alabama Development Office. Included were documentation and user manuals for the information system. The Tennessee State Planning Office (TSPO) provided a report which explains Tennessee's resource information system, and the University of Tennessee Space Institute (UTSI) provided a description of their in-house equipment for analyzing Landsat data. UTSI has previously worked with TSPO on Landsat analysis efforts. Additional details on the resource information systems and the available equipment for each state are discussed in Appendix B. The requirements for having the low-cost processing system outputs feed directly into these information systems are described below.

Alabama's system is known as the Alabama Resource Information System (ARIS). ARIS provides an automated geographic analysis and computer mapping system to aid planners and decision making personnel. In order to have the low-cost Landsat processing system outputs feed directly into this information retrieval system, Alabama officials have specified the following criteria:

- a North-South orientation of the pixels;
- a numeric data representation (e.g., croplands and pasture possibly represented by a 21 or deciduous forest land by 41, etc.);
- the UTM coordinates of the four corners of the scene (not in the data, but with it, as in a header record); and

- ARIS will view a scene as a two-dimensional array of cells (pixels) with each row containing a West to East string of pixels. ARIS expects the data to be input in row order with the northern most row input first and the southern most row input last. The only cell data to be input are the numeric values representing the territory covered by the pixel. The row and column identifiers (subscripts) are generated by the ARIS software.

Tennessee's information system is known as the Natural Resources Planning Aid System (NRPAS). NRPAS does not yet contain land use information, but consists mostly of population data. TSPO's only specification for the Landsat data to feed directly into NRPAS is that the UTM coordinates of the four corners of a scene be provided.

The software for use with the low-cost system hardware is discussed briefly in Section 3 of this report. As can be seen from the software routines available, the low-cost system meets the objectives of Alabama and Tennessee for effectively interfacing with their natural resource information systems.

System Modifications for Alabama and Tennessee

While the primary objective of this project is to define one low-cost stand-alone hardware/software system to process Landsat data, it is also necessary to consider existing equipment available to Alabama and Tennessee. This could allow these states to achieve the capability of obtaining such a system at a cost even lower than that specified for the basic system. (See Appendix B for a discussion of each state's existing capability.)

In the case of Alabama, the only existing piece of hardware which could effectively be used in the system is a LA-36 Decwriter interactive data communications terminal. This could be used with the system in place of the Data General console and printer.

For Tennessee, the situation is considerably more complex because of the existence of a minicomputer system at the University of Tennessee Space Institute at Tullahoma. While it is possible for UTSI to use the existing hardware to process Landsat data, extensive modifications to the available software would be necessary (see Section 3). These software modifications would probably cost more than a new minicomputer. Therefore, it is recommended that the Cal Data I be replaced with a Data General Nova 3/12 or equivalent. The existing disk drives and magnetic tape units may be used, provided controllers for the Nova 3/12 are purchased. UTSI's Versatec printer/plotter can be used as an output device, if desired, and its Decwriter II terminal can be substituted for the Data General console and printer. To achieve the color display capability, it would be necessary to purchase the Lexidata color display as specified.

Other substitutions are certainly possible in the basic system (including the choice of the minicomputer). However, each substitution will probably necessitate some minor software modifications to accommodate the particular hardware device used.

Annual Operating Costs

The annual operating costs for a low-cost system such as the one specified above will vary considerably depending on the amount of use of the system. The primary recurring cost associated with the hardware would be maintenance and repair, estimated to be in the range of $1500-3000 per year. The other major operating cost would be for a computer programer and/or resource analyst to process the Landsat data. The personnel costs associated with this function would depend on the institutional arrangements whereby these services were obtained, i.e., contractor personnel or in-house personnel.

The cost for a full-time in-house computer specialist to process the Landsat data is estimated at $20,000 per year. If contractor personnel are used, the costs will probably be higher. It is unlikely, however, that a full-time computer programer would be needed immediately. Consequently, it might be possible to share the costs of a program among many agency programs and thus reduce substantially the costs for the Landsat data processing. (The same is true for maintenance and repair costs, if the system itself is used for other purposes.) In many cases, states would already have available on the payroll personnel of the type needed.

Table 2 has been prepared to assist in estimating the annual operating costs based on the fraction of time the system is utilized for Landsat data processing. (The table assumes that the system is used for other purposes when not being used for Landsat data processing. If this is not the case, the total costs are fixed independent of usage and approximate those of 100% use if a full-time analyst is employed.)

Table 2. Estimated Annual Operating Costs

Time Utilized for Landsat (%)	Maintenance and Repair	Personnel	Total
25	$ 600	$ 7,000	$ 7,600
50	1,200	12,000	13,200
75	1,800	16,000	17,800
100	2,400	20,000	22,400

SOFTWARE AND SYSTEM CAPABILITIES

Selection of Software

While numerous software packages have been developed to process Landsat data, not all of these perform satisfactorily on a minicomputer installation. Therefore, it was necessary to select a software package which is capable of performing standard Landsat data processing functions and which is compatible with the hardware system specified.

The proposed low-cost Landsat processing system is designed around a computer system that is fully compatible with the Georgia Tech Engineering Experiment Station (EES) Earth Resources Data Analysis System (ERDAS). ERDAS was designed and constructed to allow true interactive digital processing of all types of remote sensing data. The system consists of a set of four modules: (1) minicomputer subsystem, (2) input medium, (3) hardcopy output medium, and (4) display subsystem. The minicomputer subsystem consists of a Data General Nova 2/10 minicomputer with 64K bytes of core memory and a dual Diablo disk system with 5.0 megabytes of storage for programs or data.

Many software programs for the Data General Nova/Eclipse model computer are available in the public domain for analysis of Landsat data and the efficient manipulation of other geographically based data. Some of the computer programs developed by Georgia Tech EES have been documented in an EES final report to NASA/MSFC* on a previous contract. The software to a large extent is modular and only a few routines would need to be changed to accompany any changes in computer hardware. Thus, only minor program conversions (e.g., for operating the peripherals) are anticipated in making the prototype system operational.

Brief descriptions of the major software programs are given below. All programs are written in Fortran IV and currently run on a Data General Nova 2 computer. These programs are in the process of being entered into (and will be available from) COSMIC, University of Georgia, Athens, Georgia 30602.

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*Low-Cost Earth Resources Data Analysis System, by N. L. Faust and G. W. Spann, Prepared under NASA/MSFC Contract #NAS8-32397, August, 1978, CR #150838.

Landsat Processing Programs

Training Field Selection. This program provides for the display of three of the four Landsat channels of data in a color infrared composite on a COMTAL color interactive graphics system. The program is written in a user oriented keyword structure so that the user selects the desired operation from a list of options. The major options available are:

- Read image;
- Magnify image;
- Training field selection;
- Ground control point selection;
- Parallelapiped classification for one training sample signature (alarm);
- Ratio processing;
- Edge enhancement;
- Haze filtering;
- 2 dimensional plotting of multiple classes in signature space (ellipse); and
- Histogram calculation and display.

This program is an integral part of the supervised classification capability.

Maximum Likelihood Classification. This program performs the actual classification of Landsat data into various categories previously defined in the training sample selection operation. A simple table lookup algorithm is implemented which keeps track of the data values for the last 50 pixels classified and compares the new data value to the previous ones. If no match occurs, the total maximum likelihood algorithm is executed. For a large number of classes or data with low spatial variability, significant improvements in classification speed have been noted. Raw Landsat data are assumed to be input from magnetic tape and the final classified data are written to a second magnetic tape peripheral.

Linear Classification. This program performs a linear or parallelapiped classification of Landsat data. As before, signatures are assumed defined by the training field selection program. Both input and output peripherals are assumed to be magnetic tape.

Unsupervised Classification. This program classifies Landsat data into various categories without using training fields to define certain desired categories. Basically this program divides Landsat data into groups of pixels which look similar to one another. The criteria used to define similarity are specified by the user at run time. While this method does not utilize training fields as ground truth to define its categories, the ground truth must be used to determine what the groups or clusters of data mean. For example, an unsupervised classification might produce a map of ten categories over a particular area. What these categories mean in terms of ground cover types cannot be defined until some ground truth information (maps, photographs, etc.) are compared with the classification map. The unsupervised classification approach used assumes magnetic tape input and output.

Coordinate Transformation. This program computes a least squares fit of Landsat data to a given map projection, given ground control points whose coordinates have been located in Landsat data and on maps. Landsat data can thus be referenced to a UTM or latitude/longitude grid system or any other desired map projection.

Polygon Extraction. This program allows for the extraction of Landsat data within polygons such as counties assuming that the transformation matrix from pixel coordinates to map coordinates is available.

Join. This program allows the extraction of polygonal data which encompasses parts of two Landsat scenes. A mapping of categories from one scene into the next creates a general set of categories for both scenes.

Rectification/Resampling. This program resamples classified Landsat data at a user specified pixel size and performs first and second order geometric corrections. A North-South oriented image is output which is suitable for inclusion into geographic data bases.

Geographic Data Base Programs

The primary program used at the Georgia Tech EES for geographic data manipulation is NIMGRID which is an extensive modification of the Harvard University IMGRID program by David Sinton. This program is a user oriented, keyword structured program which utilizes two dimensional gridded, mapped data on a roster or line-by-line basis. By using this formulation, a user may have a geographic data base for an area limited in size only by the disk space available to the user and not the central memory required for the program to execute. Each option for the analysis of geographic data is a separate overlay in the computer so that computer central memory requirements are minimal. The primary options for the NIMGRID program are:

- Store;
- Recode;
- Update;
- Index;
- Overlay;
- Search (Proximity); and
- Matrix.

All of the above operations except search operate vertically on one to several layers of a data base (such as soils, historical, site location, topography, etc.). The search algorithm allows the inclusion of proximity information in detailed multilayer analyses.

System Capabilities

The system proposed in this study would have the capability of processing Landsat data for subscene areas on a repetitive basis. With additional hardware enhancements such as the floating point processor and hardware multiply/divide, the system could process whole scenes of Landsat data in less than two days not counting training sample selection time. Without these improvements, a full scene classification for approximately 60 classes would take about 20-25 days of constant processing, assuming no equipment malfunction or power losses. The amount of time required for processing decreases linearly with a decrease in the number of classifications desired (e.g., a full scene classification with approximately 15 classes would take about a week of constant processing).

System Limitations

Knowledge of the limitations of a system such as this are as important as knowledge of its capabilities. The major limitation relates to interface software for the Lexidata color display and for the cartridge tape drives. This software would have to be written or obtained before the system could operate. While the interface software problems do exist, it is not anticipated that a significant programing effort would be necessary to produce the required software. A competent programer should be able to accomplish the tasks required in a month or less.

The second system limitation relates to the specification of cartridge tape drives instead of the standard 9-track drives. This was done to reduce the total system cost. Thus, if the cartridge tape drives were used, some means (e.g., an interface to another computer) of transferring Landsat data from 1/2 inch 9-track tapes to cartridge tapes would be required. On the other hand, the problem could be eliminated by using standard tape drives instead of the cartridge drives. The added cost would be in the vicinity of $5000 depending on the tape drives selected.

The above limitations are not considered severe constraints on the use of a low-cost Landsat processing system such as the one specified here. Indeed, the software interfaces would have to be written if a demonstration system were assembled.

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SUMMARY AND RECOMMENDATIONS

State agencies in Alabama and Tennessee have continuing needs for a Landsat analysis capability, but neither can afford a currently available system. This report details a minicomputer-based hardware system, costing approximately $28,000, which is within the budget of many state, regional, and local agencies that previously could not afford digital processing capability.

The low-cost system designed in this study would be most beneficial to state and local users who wish to evaluate Landsat data on a small scale before committing to an extensive manpower and equipment program for operationally utilizing Landsat and geographic data on a statewide acre-by-acre basis. If a decision is made to utilize Landsat data in individual state programs, the proposed system, with the options added, could provide an instate capability for operational Landsat processing on a multiscene basis. The usage of this system would then govern the selection of larger-scale systems to handle multiple users simultaneously.

This project has taken the design of a low-cost system as far as it can go on paper. All of the tradeoffs necessary to select the specific items of equipment have been performed. What remains is the actual demonstration of such a system.

Therefore, it is recommended that the low-cost Landsat processing system described here be assembled and demonstrated to NASA and to the cooperating states. The demonstration effort would have at least two very significant benefits. First, the system as described would be proven workable. In addition to the practical utility of having a proven, working system to recommend, however, the demonstration system itself could be put to good use. It could, for example, be used for training purposes in a remote sensing laboratory or it could be mounted in a mobile van to serve as an on-site demonstration and analysis tool for Landsat technology transfer.

APPENDIX A

COMPONENT SPECIFICATIONS

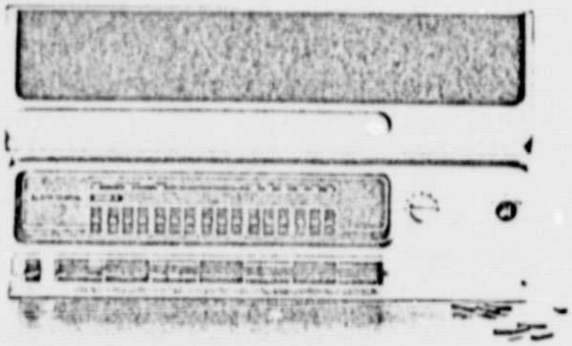
DataGeneral

NOVA 3/12 COMPUTER

PRODUCT BRIEF

FEATURES

- Economical 16K word MOS and core memory modules
- High-speed 700-nanosecond MOS memory modules
- Optional parity for MOS memory
- Optional memory expansion to 128K words
- Multi-register architecture
- Extended NOVA* line instruction set
- Wide range of standard configurations
- 12-slot modular construction
- Removable power supply module
- Large selection of peripherals, communications and I/O devices
- Options include battery backup, hardware Multiply/Divide, and Floating Point Processor
- Full operating system and high-level language support
- Complete customer support



DESCRIPTION

The NOVA 3 family of computers combines reliable NOVA line design concepts with Data General designed and manufactured components, including a MOS memory system. The result is a computer that offers speed, configurability, high-level language software, and a complete line of peripherals, all at a remarkably low price. These features make NOVA 3 well suited to OEM applications in communications, instrumentation and control, computation and data systems.

The NOVA 3/12 has twelve subassembly slots in a 10½-inch chassis. An optional 10½-inch rack-mounted I/O expansion chassis extends the system's capacity to 24 subassembly slots. The NOVA 3/4 has four subassembly slots in a 5¼-inch chassis.

MEMORY

Metal-Oxide Semiconductor (MOS) memory modules with 700-nanosecond cycle time are available in 4K, 8K and 16K word increments with optional parity interrupt. Data General-manufactured MOS memory chips have state-of-the-art silicon gate construction. Core memory comes in 8K-word modules with 800-nanosecond cycle time and 16K-word versions with 1-microsecond cycle time. MOS and core memory modules each occupy one computer subassembly slot. When different speed and different technology memories are mixed in NOVA 3, the effective cycle time depends on the speed of the memory module accessed.

MEMORY MANAGEMENT

Optional memory management hardware permits expansion of physical memory beyond 32K words to a maximum of 128K words with full operating system support. Two program maps are provided, each allocating logical program space in 32 1K-word blocks. Memory management also provides data channel access to two independent logical memory areas, each with a total of 32 1K-word blocks.

ARCHITECTURE

The NOVA 3/12 central processor is organized around four hardware accumulators, two hardware stack registers, and a program counter. Two of the accumulators can be used as index registers. Hardware stack registers facilitate reentrant and recursive subroutine programming. The system includes 16 memory registers that are used for auto-increment, auto-decrement operations. The multi-register architecture reduces the number of instructions necessary for execution, and simplifies programming.

*NOVA is a registered trademark of Data General Corporation.

INSTRUCTION SET

The NOVA 3 instruction set is an extended version of the proven NOVA line 16-bit, single-word multi-function instructions. Arithmetic and logical instructions execute one of eight basic functions, modify the operand, shift the result, and test the result in only one cycle. Using direct, indirect, relative, and indexed addressing modes, memory reference instructions move data between memory and accumulators, and modify program flow efficiently. Input/output instructions transfer data and control signals between the processor and peripherals, and are NOVA line compatible. Extended instructions include user-definable system trap instructions, single word PUSH/POP and multiword SAVE/RETURN stack instructions to facilitate subroutine programming, and memory management instructions for user control of more than 32K words of main memory.

CONFIGURATIONS

The NOVA 3/12 is 10½ inches high, rack-mountable, has twelve subassembly slots, and is completely compatible with the NOVA 3/4. It contains one central processor board, one or more memory boards, and space for memory management and I/O subassembly boards. The battery backup module is contained within the 10½-inch chassis. The 12-slot I/O expansion chassis is a 10½-inch high rack-mountable chassis that expands system capacity to 24 slots. It connects to the NOVA 3/12 chassis with a standard I/O cable.

MODULAR CONSTRUCTION

The modular structure of the NOVA 3/12 includes high density packaging of large- and medium-scale integrated circuitry, and a minimum of interconnections. Major subassemblies such as the central processor, memory modules, parity and major options are on a single printed circuit board, simplifying troubleshooting and repair. The power supply also occupies a single removable printed circuit board, a very important innovation for system reliability. An etched backpanel makes all interboard connections. Integral backpanel connectors are provided for commonly specified peripherals such as the diskette subsystem.

STANDARD EQUIPMENT AND OPTIONS

The NOVA 3/12 includes programmer's console, 16-bit I/O system, programmed data transfer, direct memory access, automatic interrupt source identification, 61-device addressing capability, 16-level programmed priority interrupt, hardware stack architecture, external I/O bus connector, prewired peripheral connector, and electrically isolated system memory bus. Options available include the Memory Management Unit, automatic program load, battery backup, power monitor/auto restart, turnkey console, MOS memory parity, hardware multiply/divide, high-performance floating point unit, real-time clock, and I/O expansion chassis.

PERIPHERALS, COMMUNICATIONS AND I/O

The complete range of Data General peripherals includes diskettes, fixed head discs, cartridge discs, cassettes, paper tape readers, video display terminals, industry-compatible magnetic tape units, disc pack drives, line printers, paper tape punches, plotters, and card readers. Communications hardware includes a high-speed synchronous and asynchronous multiplexor system, direct IBM 360/370 interfaces, and intercomputer connections. Input/output equipment includes A/D and D/A converters, digital I/O and general-purpose interfaces. Many of these are discountable in quantity.

SOFTWARE

Software available for the NOVA 3/12 computer includes two compatible operating systems: A Real-time Disc Operating System (RDOS), which supports more than 32K words of NOVA 3 memory, and a Real-Time Operating System (RTOS). Extended FORTRAN IV and FORTRAN 5, ALGOL, single-user and multi-user Extended BASIC, and Macro assembler are the language processors which can be used with NOVA 3/12. Utility software available includes 2780 emulator, process I/O support, sort/merge, standard and relocatable assemblers, relocatable loaders, and symbolic debuggers.

CUSTOMER SUPPORT

Available to Data General customers is a worldwide support network that offers contractual services for Application Engineers, Service Engineers and Customer Training. Also available is a Software Subscription Service and a Hardware Subscription Service. The Data General User's Group allows interchange of user programs.

SPECIFICATIONS

GENERAL

Word Length: 16 bits.

General-Purpose Accumulators: 4.

Stack Facility: 1 central processor Stack Pointer, 1 central processor Frame Pointer.

Memory Cycle Times: 700-nanosecond MOS memory, 800-nanosecond 8K-word core memory, 1000-nanosecond 16K-word core memory.

Memory Configurability: Any combination of up to eight core, MOS parity, and MOS non-parity boards. In a system with both parity and non-parity memory, the parity controller ignores accesses from non-parity memory.

Add Time: MOS memory, 700-nanoseconds; core memory, 800-1000-nanoseconds.

Accumulator Load Time: MOS memory, 1100–1200 nanoseconds; core memory, 1300–2000 nanoseconds.

Address Modes: Direct addressing of 1024 words absolute, relative and indexed modes; multi-level indirect addressing of 32,768 words to a maximum of 131,072 words with Memory Management Unit, register-based stack addressing on a Last-In, First-Out basis, and on a random indexed basis.

Memory Increments: 4K-word MOS memory, 8K-word MOS and core memory, 16K-word MOS and core memory.

Memory Capacity: 131,072 words.

Bus System: Separate I/O and memory busses.

Memory Management: Dual mapped program spaces allocatable in 1K-word increments via 32 registers in each of two program spaces. 64 data channel map registers, each addressing a contiguous 1K-word space; 32K-word physical (unmapped) program space.

Direct Memory Access Data Channel: Standard-speed and high-speed modes included; maximum word transfer rates: 1.1 MHz In, .83 MHz Out; Maximum data channel latency: 5.0 microseconds.

Input/Output System: 16-bit word length; 16 priority-level interrupt structure, 61 devices addressable; maximum interrupt latency, 11.7 microseconds.

OPTIONS

Hardware Multiply/Divide: Multiply time, 6.0 microseconds; divide time, 6.9 microseconds (successful), 1.5 (unsuccessful).

Hardware Floating Point: Worst-case single-precision (32 bit) memory-to-register multiply time, 10.9 microseconds; worst-case double-precision (64 bit) memory-to-register divide time, 22.1 microseconds.

Memory Parity: One parity bit per word; generates a parity fault interrupt upon detecting an error.

ELECTRICAL

AC Line Voltages: Four options available for all chassis types–100V, 120V, 220V, 240V, all operable within ±15%, −10% of nominal within the frequency range 47-63Hz at maximum load.

AC Power Consumption: 600 watts fully loaded.

I/O Bus Levels: Ground and +3 volts.

Battery Backup: Maintains 32K words MOS memory data contents valid for up to two hours during power failure; recharge time from fully depleted state, 24 hours during normal CPU operation.

MECHANICAL

Dimensions: 10½"H x 19"W x 23"D.

Weight: 130 lbs., fully loaded; CPU expansion chassis, 130 lbs. fully loaded.

Front Panel: UL flame-retardent and scratch-resistant plastic in gold and yellow color trim.

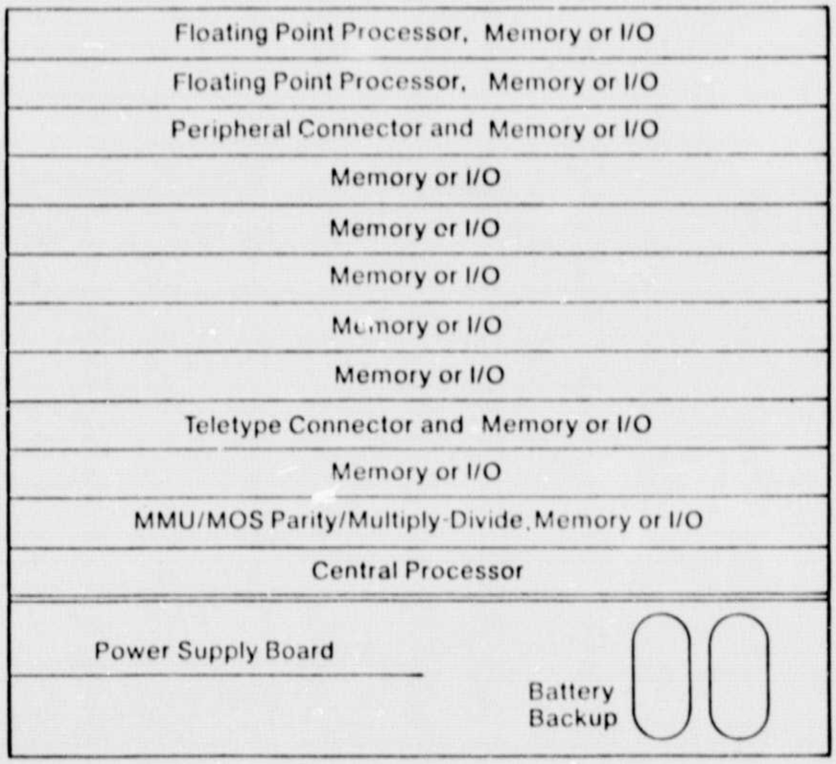
Heat Generated: 2050 BTU/hr. maximum; CPU expansion chassis, 2050 BTU/hr. maximum.

ENVIRONMENTAL

Temperature Range: 0°C to 55°C operating; −35°C to +70°C storage.

Relative Humidity Range: to 90% operating; to 95% storage.

Altitude Range: to 10,000' operating; to 50,000' storage.



NOVA 3/12 Slot Allocation. An additional 12-slot I/O expansion chassis is available.

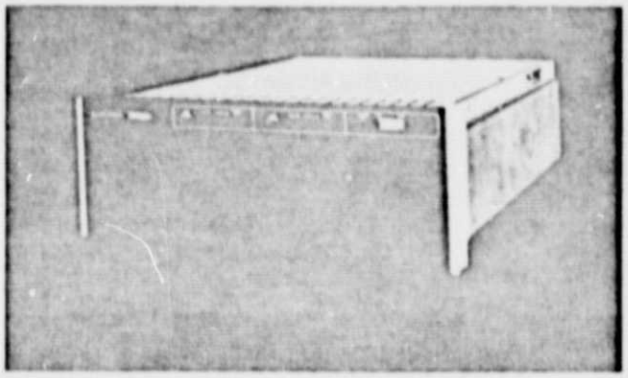
DataGeneral

DG/DISKETTE SUBSYSTEM 6030, 6031

PRODUCT BRIEF

FEATURES

- 315K bytes removable diskette storage per drive
- Uses low cost diskette recording media
- Dual- and single-drive models
- Used with any Data General computer
- Available as complete subsystem (controller and up to four drives) for NOVA® and ECLIPSE® Systems
- Can be mixed with Data General 10M byte cartridge disc subsystems on same controller
- Compact 7" high chassis, complete with power supply
- Data channel operation, sector transfer rate 31K bytes/sec.
- 260ms average head positioning time, 83ms average latency
- Comprehensive software support
- Allows file interchange with microNOVA™ Systems



DESCRIPTION

Data General's diskette subsystems provide reliable low-cost mass-storage capability for NOVA, ECLIPSE and microNOVA computers. Choose the 6030/31 series for NOVA or ECLIPSE systems and the 6038/39 series for microNOVA systems. The subsystem consists of a chassis containing power supply and drives, controller for up to four drives, and cable set. It is available in two-drive (Model 6030) and one-drive (Model 6031) versions. Expansion to four drives provides a maximum 1.2 megabyte online storage capacity. A thumb-wheel switch lets users select any unit as 0, 1, 2, or 3. The diskette subsystem uses the computer's direct memory access channel for high-speed data transfer. Typical diskette uses include software distribution and bootstrap loading, program and data exchange between Data General computer systems, offline storage in data collection and communications systems, and mass storage for small stand-alone systems. A DG/Diskette subsystem is included with all CS/20 and CS/40 computers, and is optional with all CS/60 computers.

DISKETTE MEDIA

Each diskette has a formatted data storage capacity of 512 bytes per sector, or 4096 bytes per track. Total surface capacity for a single diskette is 315,392 bytes. Diskettes are supplied pre-formatted, but can be reformatted and verified by diagnostic software. Each diskette envelope also has a write protect feature that is initially enabled. Write protection can be disabled for data recording, then enabled to ensure data integrity. In operation, the diskette revolves at 360 RPM inside its protective envelope. Diskettes are industry-compatible with 32 hard sector address verification holes for reliable sector position detection.

DATA CHANNEL TRANSFER

Data transfer between diskette and computer memory is through the computer's direct memory access data channel. Up to eight sequential sectors can be transferred in one diskette revolution by a single command. Transfer rate is 31K bytes/second for one sector and 25K bytes/second average over several sequential sectors. The controller is quad-buffered, so data channel requests can be up to 128 μ sec apart.

OPERATION

When a read/write command is received, the head moves toward the selected track. Head loading begins just prior to reaching the selected track to minimize head/surface contact time and increase speed. Diskette timing holes provide sector position identification, and data transfer occurs. Several sectors can be transferred as required. If no activity occurs for eight revolutions (1.3 seconds), the head automatically lifts to minimize wear.

For multiple drive subsystems, seek commands can be separately issued to each drive, and head positioning will be overlapped to increase throughput. When the drive is turned on, or after loading a diskette, the drive automatically positions the head at track zero to facilitate the subsystem's use as a bootstrap device. The unit is ready for operation two to three seconds after a diskette is loaded.

DUAL-PORTING

Dual-porting is an integral part of the design of the diskette subsystem, permitting two Data General computers to share access to diskettes in a coordinated fashion. The unique dual-porting design facilitates configuring and implementing a dual computer/shared diskette using standard equipment and software. Dual-porting also makes redundant systems practical and economical for demanding applications.

The dual-porting capability can be ordered initially or added after the diskette and first computer are in use, since dual-porting is implemented simply by adding a Model 6051 dual-porting option to the second computer. The option consists of a diskette controller and dual-port cabling assemblies. Dual-porting is available for diskette subsystems consisting of one to four drives or up to four mixed diskette and disc drives. A standard hardware and software dual-port configuration is supported by Data General's Real-time Disc Operating System (RDOS).

NOVA and ECLIPSE are registered trademarks of Data General Corporation.
microNOVA is a trademark of Data General Corporation.

CONFIGURATIONS

Each diskette subsystem can be expanded to 1.2 megabytes of diskette storage in 0.3-megabyte increments. Model 6030 includes two diskette drives, an integrated power supply, controller, and cables. Model 6031 provides a similar single drive subsystem. Model 6030-A is a dual drive addition to either a single drive or dual drive subsystem, and Model 6031-A is a single drive expansion that can be used in the same way; both models include chassis with power supply and cable set.

Model 6030-B and 6031-B, respectively, are two and one drive diskette units including controls, chassis with power supply, and cable set for attachment to Models 6045, 6046, and 6047 (6031-B only) 10-, 20-, and 30-megabyte cartridge disc subsystems. Thus, up to four mixed disc and diskette drives can be configured per subsystem.

Model 6050-F is a 10-megabyte cartridge drive that can be added to an existing one to three-drive diskette subsystem.

PACKAGING

Data General's Diskette Subsystem is designed for operating ease, high reliability, and low maintenance cost. A chassis-mounted power supply with two-drive power capacity is included in each compact 7" high rack-mountable chassis. Up to four drives can be used in one subsystem. Subsystem components, including all drives, are rack mounted. Each diskette drive contains a spindle that accommodates one diskette. Diskettes are easily inserted or removed via a slot and flip-up door at the drive front. Control lights provide status information, including write lockout, head at track 0 (calibration point), and drive ready.

SOFTWARE

Diskette storage is supported as an I/O device with a compatible file structure under Data General's Disc Operating System (DOS) and Real-time Disc Operating System (RDOS). The advanced Operating System (AOS) also supports file storage on diskettes. The diskette complements main disc storage, facilitating program and data interchange between systems and file back-up for offline storage. Diskette storage is available under the Real-Time Operating System (RTOS) with file compatibility with DOS and RDOS.

The Real-time Disc Operating System (RDOS) is a modular, device-independent multitasking system which is both a powerful program development tool and a comprehensive file-oriented, real-time operating system. For real-time applications that do not require file management facilities, the Real-Time Operating System (RTOS), a compatible subset of RDOS, provides multitasking and high-speed service for peripherals. The diskette-based Disc Operating System (DOS) is an ideal development tool for stand-alone operations. Programs may be developed under DOS and executed under RDOS or RTOS.

microNOVA DOS DG/Diskette systems can exchange diskette files with NOVA or ECLIPSE systems running DOS, RDOS, or AOS. Diskette files may also be exchanged among all Data General Commercial Systems models running the Interactive Cobol Operating System (ICOS).

SPECIFICATIONS

GENERAL

Drives Per Controller: Up to 4 for attachment to any Data General computer.

Diskette Capacity: 315,392 formatted data bytes.

Sector Length: 512 bytes per sector.

Preformatting: Media is preformatted by Data General.

Recording Surfaces: One, removable.

Type of Media Enclosure: Diskette envelope.

Rotational Speed: 360 RPM.

Number of Sectors: 8 per track.

Data Transfer Rate: 31K bytes/sec. (instantaneous); 25K bytes/sec. average over several consecutive sectors.

Average Latency: 83.33ms.

Head Positioning Time: Track-to-track 20ms; Average time, 260ms; Full stroke, 770ms.

Track Density: 48 TPI.

Recording Density: 3268 BPI (innermost track).

Number of Tracks: 77.

Recording Mode: Double frequency.

Rotational Start-Up Time: 2 sec. typical.

Rotational Stop Time: Negligible.

Control Functions: Unit select, power on, track 0 indication, ready indication, write protect indication.

Voltage Requirements: 120 Vac, 60Hz; 100 or 220 or 240 Vac, 50 Hz.

Voltage Tolerance: +10%, -15%.

Frequency Tolderance: ±1 Hz.

Power Requirements, nominal (Dual): 4.9 Amps at 100 Vac; 3.8 Amps at 120 Vac; 2.1 Amps at 220 Vac; 2.0 Amps at 240 Vac.

Power Requirements, nominal (single): 3.0 Amps at 100 Vac; 2.6 Amps at 120 Vac; 1.3 Amps at 220 Vac; 1.25 Amps at 240 Vac.

Power Dissipation (maximum): 475 Watts (dual); 300 Watts (single).

Maximum Allowable Data Channel Latency: 128 microseconds.

Controller Current: 4.0 amps at +5 Vdc.

MECHANICAL

Dimensions: 7" (17.8cm) H x 19" (48.3cm) W x 23½" (59.7cm) D.

Weight: Dual unit, 67 lbs (30.5 kg). Single unit, 54 lbs. (24.5 kg).

Controller: 15"-square (38.1 cm-square) printed circuit board, occupies one slot in any Data General computer.

ENVIRONMENTAL

Temperature Range: 50°F (10°C) to 100°F (37.8°C) operating; 0° (-17.8C) to 120°F (48.9°C) storage.

Temperature Change Rate: 12°F/hour (6.7°C/hr.).

Relative Humidity: 20% to 80%, non-condensing.

Heat Generated: 1000 BTU/hr. (293 watts) dual, 600 BTU/hr. (176 watts) single, max.

DataGeneral

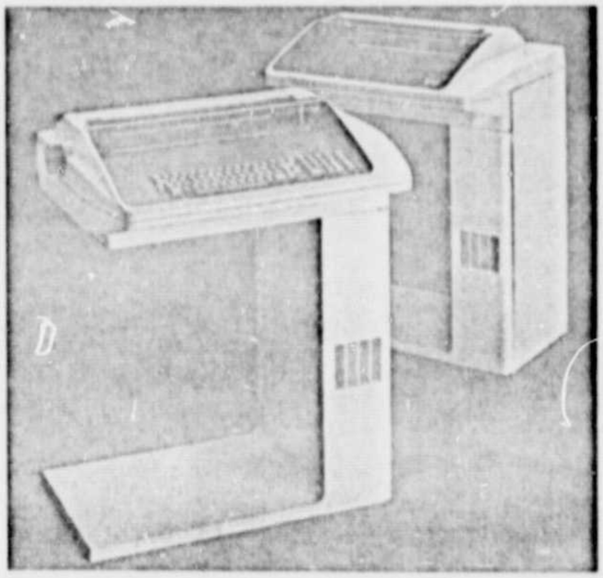
Data General Corporation, Westboro, Massachusetts 01581, (617) 366-8911

DataGeneral

DASHER TP2 TERMINAL PRINTERS
Models 6075, 6076, 6077, 6078
PRODUCT BRIEF

FEATURES

- Buffered 180-character-per-second (cps) printing
- Microprocessor-controlled, logic-seeking, bidirectional performance
- Local and remote operation via data sets (modem)
- 20mA current loop, EIA (RS-232-C/CCITT V.24) interfaces
- Communications
  - Selectable baud rates
  - True 120-cps printing at 1200 baud
  - Half- and full-duplex operation
  - Bell 103, 202 and 212A compatible
  - Parity selection and detection
- Automatic carriage return
- 132-column width at 10 characters per inch (cpi)
- Upper- and lower-case character set (96 ASCII) with true descenders, punctuation marks and underscore (international fonts available)
- Paper-fault sensing and forms-override switch
- Up to six clear, readable copies on 4"-15"-wide forms
- 6 or 8 lines per inch (switch selectable)
- 7 x 9 impact dot matrix with print penetration adjustment
- Optional alternate character set
- Longlife printhead for maximum reliability
- Plotting under software control
- Offline test feature
- Downline load facility for alternative character fonts
- Convenient operator-changeable ribbon cartridge
- Operator-selectable automatic view mode
- Models 6075 and 6077 with normal and elongated character printing; Models 6076 and 6078 with normal, elongated, condensed and condensed/elongated character printing
- Models 6077 and 6078 include typewriter style keyboard and 14-key numeric pad
- Designed and manufactured by Data General



MODEL	KEYBOARD SEND/RECEIVE	RECEIVE ONLY	CONDENSED PRINT
6077	X		
6078	X		X
6075		X	
6076		X	X

DESCRIPTION

Data General's DASHER™ TP2 terminal printers meet the needs of applications that require high-speed, high-quality hardcopy and asynchronous communications—via either a local controller or a data set (modem). All DASHER TP2 terminal printers use a built-in, 16-bit microprocessor for efficient bidirectional printing. This combines with the 180-cps print speed and Random Access Memory buffer to ensure optimum use of high-speed data communications lines without data loss or the need to issue "pad" characters (for most applications, at transmission rates up to 1200 baud). All models offer a standard selection of communications interfaces for system compatibility and produce up to six clear, readable copies on forms 4"-15" wide.

Models 6075 and 6077 DASHER TP2 terminal printers can print in either normal or elongated character widths for titles, headings, and improved report quality. Models 6076 and 6078 also allow condensed characters for printing full 132-column lines on 8½"-wide forms and condensed/elongated character widths. All variable character pitches are both switch- and software-selectable. A choice of 6- or 8 lpi vertical spacing is switch-selectable.

All DASHER TP2 terminal printers have a standard 96 ASCII character set formed by a 7x9 dot matrix that features upper- and lower-case characters with true descenders, punctuation marks, and underscore for highly readable text and high-quality report generation. International fonts and typewriter keyboards for France, Germany, Sweden, and the United Kingdom are available.

Models 6077 and 6078 DASHER TP2 terminal printers are equipped with typewriter-style keyboards. The keyboard configuration and integral 14-key numeric pad are designed for operator convenience and minimize operator retraining.

All DASHER TP2 terminal printers include a top-of-form control for variably-sized preprinted forms, horizontal and vertical tabbing for format selection and text layout and an offline test switch for verifying printer operation. They also use an extended-life ribbon cartridge, which can be changed in less than 30 seconds. Other operator-oriented features include both left- and right-adjustable tractors, fine vertical forms alignment, a print penetration adjustment to ensure consistently high print quality, master reset, and a forms-override switch.

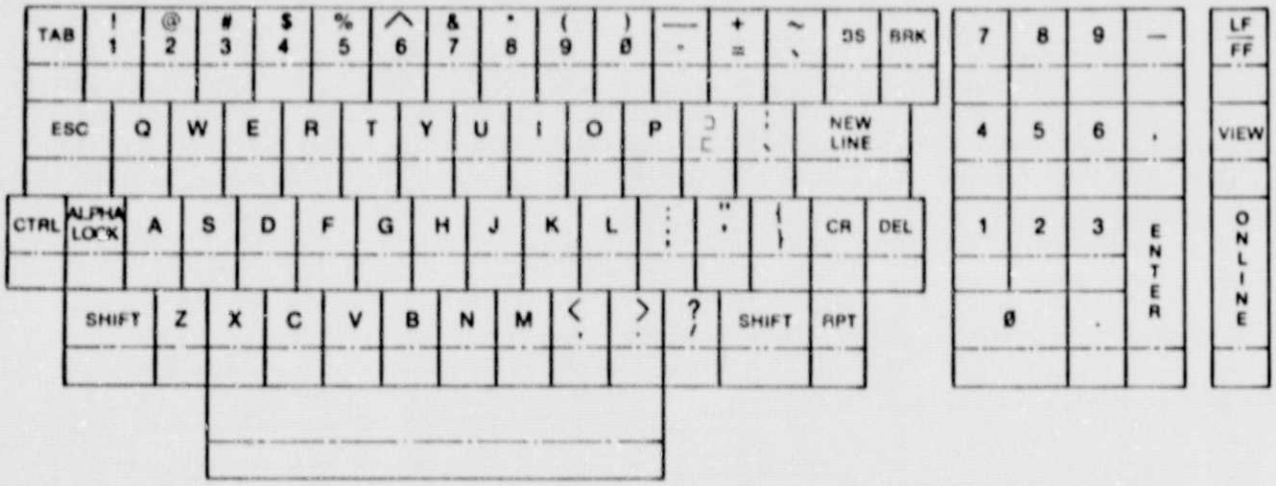
For users requiring to print from more than one character set, a hardware alternate character set is optionally available. This secondary character set can be selected by a switch on the secondary control panel or by software command. This feature is particularly useful for users generating reports in more than one language.

A downline load facility lets users print special symbols, such as foreign language characters or scientific notations of their own construction. These symbols are easily loaded into the DASHER TP2's Random Access Memory by using the appropriate command sequence prior to printing.

All DASHER TP2 terminal printers are equipped with a switch-selectable view mode that moves the printhead during printing lapses (of greater than 1 second) so users can view the text.

INPUT

For interactive operation, Models 6077 and 6078 DASHER TP2 terminal printers are equipped with standard typewriter-style keyboards and separate numeric key pads. The main keyboard, which contains the character set similar to a standard typewriter, is used to enter data into the terminal as well as for programming vertical and horizontal tab positions. There's a separate 14-key pad for numeric data entry; it's arranged for convenient operator use with all necessary function keys as a part of the cluster. Keys include the numerals 0 thru 9, comma, period, minus and enter. All keys have a multikey rollover feature that minimizes erroneous data entry when multiple keys are struck simultaneously. The capacitively-switched design of the main keyboard and separate numeric pad eliminates mechanical linkages and substantially increases reliability.



OUTPUT

Models 6075, 6076, 6077 and 6078 print 180 characters per second at a standard 10-cpi density. For headings, elongated character density is five characters per inch. On models 6076 and 6078 DASHER TP2 terminal printers, 16.5- and 8.25 condensed and condensed/elongated printing densities are also available. Users can activate these variable character pitches with a secondary control panel switch or select them under program control. A 96-character, upper- and lower-case, English-language character set with true descenders and underscore is standard with all DASHER TP2 terminal printers.

This is an example of the DASHER TP2'S printing capabilities. The text you are reading is printed using compressed width characters at 6 lines per inch vertical spacing.

This is an example of the DASHER TP2'S printing capabilities. The text you are reading is printed using compressed width characters at 8 lines per inch vertical spacing.

This is an example of the DASHER TP2'S printing capabilities. The text you are reading is printed using normal width characters at 8 lines per inch vertical spacing.

This is an example of the DASHER TP2'S printing capabilities. The text you are reading is printed using normal width characters at 6 lines per inch vertical spacing.

This is an example of the DASHER TP2'S printing capabilities. The text you are reading is printed using elongated compressed width characters at 8 lines per inch vertical spacing.

This is an example of the DASH
TP2'S printing capabilities. The te
you are reading is printed using
elongated width characters at 6 lin
per inch vertical spacing.

ORIGINAL PAGE IS
OF POOR QUALITY

OPERATOR FEATURES

The top-of-form control and horizontal and vertical tabbing capabilities conveniently permit different sized preprinted forms and report formatting. Paper loading and ribbon changing are simple and quick.

Two control panels let the operator select various print options. The primary control panel, located on the top cover, contains switches for commonly selected functions such as online/offline, line feed/form feed and view mode. The secondary control panel, which can be reached by raising the top cover, contains switches and controls for less frequently used functions such as normal/condensed print, 6/8 lines per inch, top-of-form, perforation skipover, master reset, baud rate, alternate character set select, forms override and self-test.

APPLICATIONS

DASHER TP2 terminal printers are particularly suited for a variety of local and remote applications requiring high-speed, high-quality hardcopy. Versatile formatting capabilities combined with an extensive variety of character sizes make these printers attractive in business applications. Report generation with preprinted forms of different dimensions can be accomodated for data entry terminals, computer I/O consoles, data loggers and timesharing terminals applications.

PACKAGING

DASHER TP2 terminal printers are packaged to ensure high reliability and easy maintenance. A panel on the side of the unit provides ready access to the interface, control circuits, microprocessor and power supply. Ribbon cartridge and forms tractors are easily accessed by raising the unit's top cover. The standard cantilevered pedestal maximizes operator comfort, minimizes floor space requirements and complements the office decor.

INTERFACING

All DASHER TP2 terminal printers provide a choice of standard serial interface configurations; EIA RS-232-C or current loop. The RS-232-C interface is compatible with most computers for local connection as well as with Bell 212A/type modems (data sets) for data communications. In addition, the EIA interface is compatible with CCITT recommendation V.24. Parity selection/detection is available as well as a choice of 110, 150, 300, 1200, 1800, 2400, and 4800 baud rates. Half- and full-duplex communications are available. For remote connection via modems, DASHER TP2 terminal printers will sustain "true" 1200-baud throughput for most applications. This is accomplished without "pad" or fill characters because the 180-cps print speed, combined with intelligent bidirectional operation, eliminates carriage returns and maximizes printing time, making DASHER TP2 terminal printers particularly suitable for 1200-baud timeshare networks.

SPECIFICATIONS

GENERAL

Speed: 180-cps, logic-seeking, bidirectional.

Character Set: 96 ASCII characters, upper and lower case with true descenders, punctuation marks and underscore.

Character Style: 7x9 impact dot matrix.

Character Size: (Normal width) 0.105" (2.67mm) H x 0.076" (1.93mm) W.

Characters Per Inch: 16.5, condensed (Models 6076 and 6078 only); 10, standard; 5, elongated; 8.25 condensed/elongated (Models 6076 and 6078 only).

Columns: 132, at 10 characters per inch.

Line Density: 6 or 8 vertical lines per inch, switch-selectable.

Line Feed: 33 msec.

Slew Rate: 5 inches per second.

Forms: Pin feed, fanfold; 1- to 6-part paper.

Forms Width: 4"-15" (10.2cm-38.1 cm).

Maximum Forms Thickness: 0.025" (0.625mm).

Ribbon: Fabric ribbon, cartridge-type, continuous loop (36' long, ½" wide).

Ribbon Life: Better than 4 million characters.

Format: Top-of-form control, vertical and horizontal tabulations.

Options: International character fonts for France, Germany, Sweden and the United Kingdom; alternate character set; wire paper basket.

KEYBOARD (Models 6077, 6078 only)

Keyboard: Standard typewriter layout; 3-level, capacitively switched, electronically debounced, N-key rollover (ordered by rising keystroke).

Key Pad: 14-key numeric pad.

COMMUNICATIONS INTERFACE

Transmission Type: Asynchronous.

Parity: Switch-selectable.

Modem Types: Bell 103, 202, 212A and Vadic 3400.

Line Interface: 20mA current loop/EIA (RS-232-C/CCITT V.24).

Speed: Selectable 110, 300, 600, 1200, 1800, 2400, 4800 bps.

Protocols: Half/full duplex.

MECHANICAL

Dimensions: 33.75" (85.7cm)H; (67.3cm)W; 21" (53.3cm)D.

Weight: 60 lbs. (27kg).

Power Cable: 6' (1.8m)

External I/O Cable: 25' (7.4m) standard length.

ELECTRICAL

Power Requirements: 120 (+10%, -15%), 220 (+10%, -15%), 240 (+10%, -15%) volts AC (nominal), 47-63 Hz.

Power Dissipation: Idle, 120 watts typical; running, 250 watts typical.

ENVIRONMENTAL

Temperature Range: 10°C to 40°C operating (50°F to 104°F); -40°C to 60°C storage (-40°F to 140°F).

Relative Humidity Range: 10% to 90% operating; to 95% storage (non-condensing).

Altitude Range: To 10,000' (3,048M) operating; to 50,000' (15,250m) storage.

CONTROL CODES

FUNCTION	SYMBOL	CODE	EXPLANATION
Backspace	BS	010_8	Causes the printhead to move lift one character position (online only).
Horizontal Tab	HT	011_8	Moves printhead to next horizontal tab stop.
Newline (Line Feed)	NL	012_8	Printhead moves to the beginning of the next line.
Vertical Tab	VT	013_8	Advances paper to next tab stop.
Form Feed	FF	014_8	Advances paper to top of the next form.
Carriage Return	CR	015_8	Returns carriage to the left-hand margin.
Escape	ESC	033_8	Denotes the beginning of a command sequence.

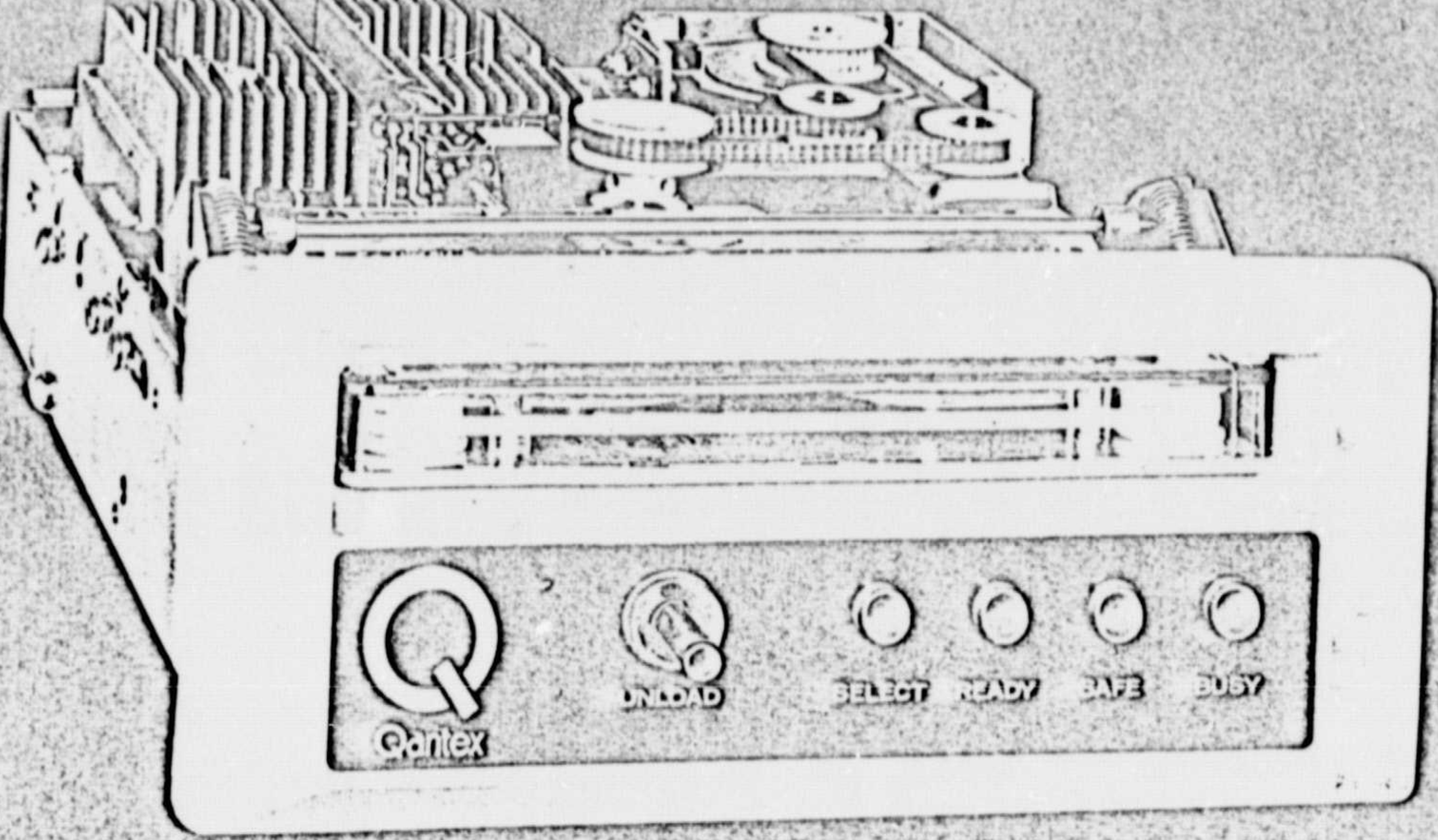
COMMAND SEQUENCE

SEQUENCE	CODE	EXPLANATION
ESC1	$033_8 061_8$	Sets horizontal tab at current printhead position.
ESC2	$033_8 062_8$	Clears horizontal tab at current printhead position.
ESC5	$033_8 065_8$	Sets vertical tab at current line position.
ESC6	$033_8 066_8$	Clears vertical tab at current line position.
ESCc	$033_8 143_8$	Master reset.
ESCa	$033_8 141_8$	Selects underscore.
ESCb	$033_8 142_8$	Deselects underscore.
ESCd	$033_8 144_8$	Selects plotting mode.
ESCe	$033_8 145_8$	Clears plotting mode.
ESC	$033_8 076_8$	Selects compressed print mode.
ESC?	$033_8 077_8$	Clears compressed print mode.
ESC	$033_8 074_8$	Selects elongated print mode.
ESC =	$033_8 075_8$	Clears elongated print mode.
ESCE	$033_8 105_8$	Sets horizontal tabs.
(ESCE) NUL	($033_8 105_8$) NUL	Clears horizontal tabs.
ESCF	$033_8 106_8$	Sets vertical tabs.
(ESCF) NUL	($033_8 106_8$) NUL	Clears vertical tabs.
ESCY (byte count, start address...data..., negated check sum)	$033_8 131_8$ (byte count, start address...data..., negated check sum)	Downline loads data (character set).
ESCN (start address)	$033_8 116_8$ (start address)	Selects downline loaded character set.
ESCO	$033_8 117_8$	Deselects downline loaded character set.

Data General

Data General Corporation, Westboro, Massachusetts 01581, (617) 366-8911

MODEL 650
CARTRIDGE TAPE DRIVE



- SMALL SIZE
- LOW COST TAPE DRIVE
- USES 3M DATA CARTRIDGE

Qantex

The Qantex Model 650 Tape Drive utilizes the 3M Data Cartridge (DC300A) to provide a magnetic tape storage capability with the performance specifications of a compatible 1/2" tape drive *but* at a fraction of the cost.

The Model 650 is designed to be an OEM system component. It's flexible design offers a wide range of options to allow the system designer to choose both the control parameters and mechanical mounting configuration best suited to his system design concept and application.

The Qantex Model 650 is available in a wide variety of configurations. In its simplest form, a "mechanism only with intimate electronics" is offered. The "intimate electronics" are the optical tachometer and servo power amplifier electronics. In its most complete configuration, the Model 650 is offered with all electronics, including many housekeeping functions, status displays, and a bezel which may be readily customized with the user's logo type. Many variations between these two extremes are available to meet the OEM's most desired configuration.

A small front profile, 3-1/8" high by 7" wide (excluding customized bezel) makes the Qantex 650 Drive an ideal choice where front panel space is at a premium.

HEAVY-DUTY MECHANICAL DESIGN

The Qantex Model 650 Cartridge Drive was designed for the original equipment manufacturer. Realizing a major requirement is reliability, the mechanical design provides both data reliability and hardware reliability with all mechanical parts fabricated for strength and durability.

The Model 650 provides a true three-point suspension of the data cartridge to reference it accurately to the magnetic head, thus insuring data interchange and compatibility. Once the data cartridge is inserted into the Qantex 650, it is physically locked in place, thus preventing inadvertent removal while the tape is being driven.

APPEARANCE

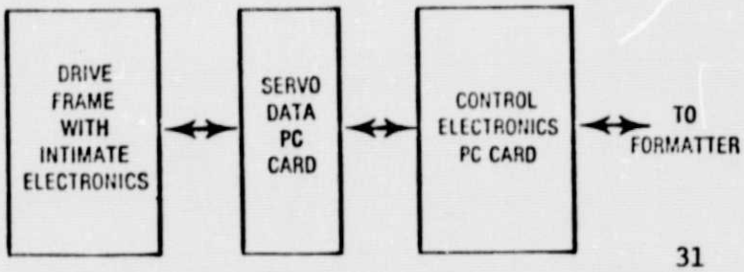
The molded bezel directs the entry path of the data cartridge for a smooth and guided insertion. In addition, the bezel covers the tape drive mounting screws. It also holds the status display.

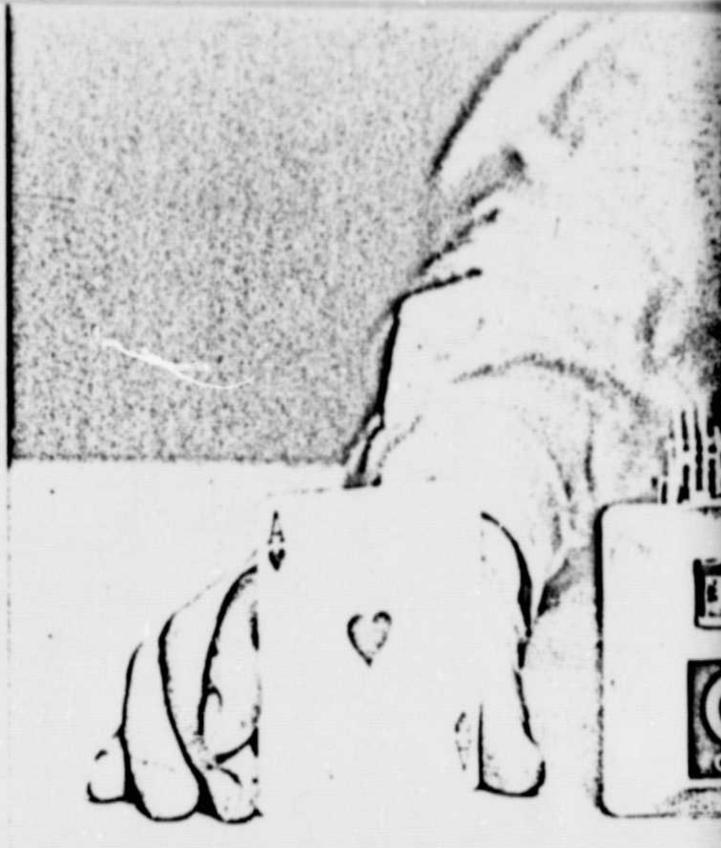
The recessed area in the bezel (approximately 6-1/4" x 1-3/8") provides room for a printed insert with the OEM's logo and color choice. The standard insert is offered with horizontal or vertical legends. Bezel color may also be selected.

CONFIGURATION

The Model 650 is available in the following configurations:

- Mechanism only with intimate electronics
- Mechanism with Servo/Data electronics
- Complete tape drive with control electronics
- Rack mounted versions i.e., 2200, 2400
- Portable tape drive systems, 2710
- ANSI Formatter available, Model 86008





ANSI/ECMA COMPATIBLE

The Qantex Tape Drive meets the requirements of the proposed ANSI/ECMA specification for information interchange of ¼", 4-track data cartridges. Data is written at a density of 1600 bpi, phase encoded (3200 FCI), at 30 ips. This results in a data transfer rate of 48,000 bps. High-speed bidirectional search is accomplished at 90 ips.

DRIVE OUTPUTS

The control and data signals from the Qantex Tape Drive are open collectors to simplify the buss wiring in a multi-drive configuration. Each bussable output is controlled by the respective SELECT signal. Up to eight Model 650 tape drives can be bussed together.

DATA ELECTRONICS

The basic data electronics provide for "transparent" operation, i.e., "data out" is a replica of "data in". The electronics have been optimized for the ANSI specification: 1600 bpi phase-encoded, 30 ips.

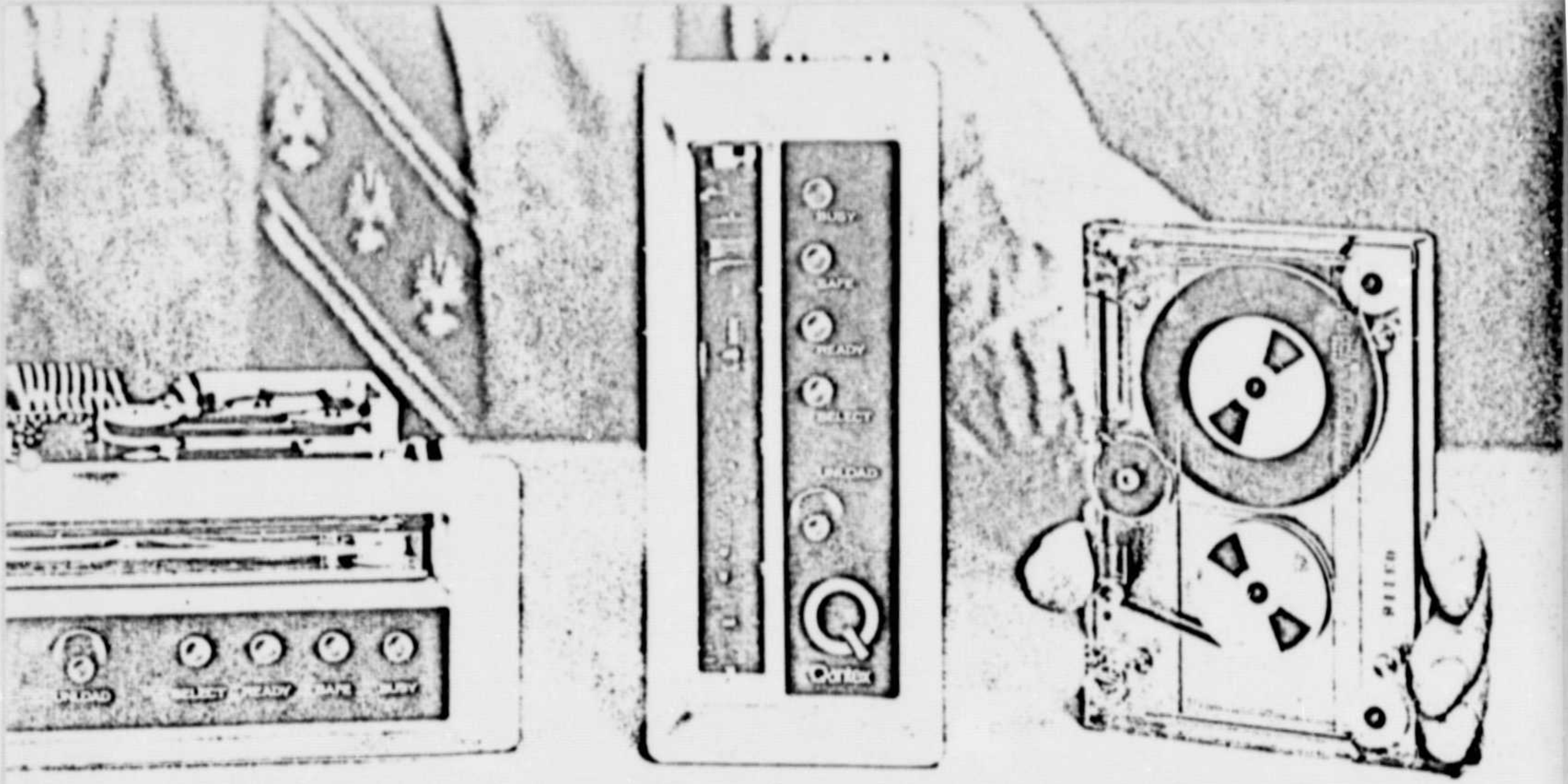
CARTRIDGE REMOVAL

Removal can be accomplished by energizing the EJECT line (immediate ejection) or commanding an UNLOAD operation (high-speed rewind to BOT followed by automatic ejection). The Model 650 also features a manual UNLOAD button, the operation of which can be factory-installed to provide one or more of these ways:

- Allow data cartridge ejection only under controller command.
- Allow manual data cartridge ejection when power is off.
- Allow data cartridge ejection when not selected.

PROTECTIVE INTERLOCK

The motor cannot be driven unless a data cartridge has been loaded, the tape drive *SELECTED* and *READY*.



CONTROL FUNCTIONS & SEQUENCE

The Qantex 650 control electronics include all necessary circuitry to simplify the system interface. The OEM-oriented functions are:

REWIND — The tape drive reverses to BOT (90 ips), then moves forward (30 ips) to the Load Point.

UNLOAD — The tape drive reverses to BOT (90 ips) then automatically ejects the data cartridge.

LOAD — The tape drive moves forward to the Load Point (30 ips)

READY — Shows the data cartridge is in place and and internal LEDS are on.

FILE PROTECT — Shows the data cartridge file protect ring checked as "SAFE". Writing is inhibited in "SAFE" position.

AUTO LOAD — The tape drive automatically advances to the Load Point upon data cartridge insertion. This is a programmable function.

WRITING — This operation is automatically inhibited with the tape drive in reverse.

BOT — After detection of BOT, the tape drive automatically advances to the Load Point (except when commanded to UNLOAD).

EJECT — This allows user to command immediate data cartridge ejection.

PHASE DECODER OPTION

The Phase Decoder option provides a clock pulse associated with Read Data to enable the user to strobe NRZ data out of the drive. It detects and strips the preamble and also provides ALLOW DATA and DATA PRESENT signals. This circuitry allows reading tapes whose density varies by more than ±15% from the standard. This option is not required when utilizing the Qantex Tape Formatter.

STATUS DISPLAY

The optional status display provides four indicators to give visual indication of the current status of the Qantex 650 tape drive:

SELECT — Indicates the tape drive has been selected by the controller.

READY — Indicates the data cartridge is properly inserted and internal LEDS are on.

SAFE — Indicates an inserted data cartridge is file protected.

BUSY — Indicates the tape drive is Writing or Reading or is performing an internal operation, i.e. Loading/Unloading, Starting/Stopping or Rewinding.

MAINTENANCE

The Model 650 is totally "connectorized" to facilitate servicing. The electronics is contained on two printed circuit cards within the drive.

Qantex
DIVISION

NORTH ATLANTIC
INDUSTRIES, INC.

SPECIFICATIONS

Model 650 Tape Drive

Speed	30 ips, write, bi-directional read 90 ips, bi-directional search and rewind
Recording Density	1600 bpi, phase encoded, 3200 fci
Number of Tracks	1, 2, or 4
Transfer Rate	48,000 bits/second @ 30 ips
Head Type	*Standard*—Dual gap, read after write *Optional*—Selective erase
Start-Stop Time	At 30 ips, 30ms At 90 ips, 75ms
Start-Stop Distance	At 30 ips, start = 0.58″, stop = 0.16″ At 90 ips, start = 3.15″ nom., stop = 1.4″ nom.
Long-Term Speed Variation	±3%
Interface	DTL/TTL, Low True
Power	+5VDC ±3%, 1A, max. ± 18VDC ±5% 250mA idle, 1.3A run (optionally ± 12V, changes spec.)

Note: 3.5A surge required during start and stop time from either plus or minus supply voltage, ± 18V.

Dimensions	*With Electronics* 3-1/8" H x 7" W x 10" D *Without Electronics* 3-1/8" H x 7" W x 8-1/4" D *Bezel Dimensions* 3-3/8" H x 8" W x 5/8" D

Data Cartridge (3M DC 300A, ITC TC-2000, WABASH Quadronix)

Tape	Computer grade magnetic tape—length 300′ (91.44m) of useable storage
Recording Density	1600 bits per inch, phase encoded or 3200 flux reversals per inch.
Number of Tracks	4 — Data is recorded serially on one track at a time
Capacity	2,880,000 bytes (8 bit per byte) of non formatted data
Tape Position Sensing	Holes are provided in the tape for optical sensing of BOT (Beginning of Tape), Load Point, Early Warning and EOT (End of Tape)
File Protect	Screwdriver or fingernail activated window provided
Temperature	+5°C to +45°C
Humidity	20% to 80% non-condensing
Operating Life	5,000 passes (BOT to EOT) typical
Construction	High impact plastic cover over heavy gauge metal base plate
Size	4 x 6 x 0.665 in. (101.6 x 152.4 x 17 mm)
Weight	8 ounces (266.8 g)

HOW TO ORDER THE MODEL 650

For standard Cartridge Tape Drive order: Model 650

Ordering Number:

For Cartridge Tape Drive with options, review the following section and complete the ordering number with no blanks.

Model 650-XT/XXX-XPC-XE-XB/XD-XL-XS-XT-XP

-XT (Number of Tracks)
Specify 4T (std)
2T
1T

/XXX (Type of Head)
Specify /DGH—Dual Gap Head (std)
/DGE—Dual Gap/Erase
/XXX—None

-XPC (Electronics)
Specify 1PC—Servo/Data PC Board
2PC—Servo/Data & Control PC Boards (std)
XPC—None

-XE (Type of Ejection)
Specify 1E—Manual eject only
2E—Manual and Controller eject (std)
3E—Controller eject only

-XB (Bezel)
Specify 1B—Standard Bezel (horizontal label) (std)
2B—Standard Bezel (vertical label)
3B—Standard Bezel (horizontal label—no Q)
4B—Standard Bezel (vertical label—no Q)
5B—Standard Bezel (custom label)
XB—None

/XD (Status Display)
Specify 1D—4 Indicators (std)
2D—3 Indicators (i.e. no *Select*)
XD—None

-XL (Auto Load)
Specify 1L—Tape to LP (std)
XL—None

-XS (Unit Select Coding)
Specify 1S—Factory Programmed
2S—Built-in Programming Switch (std)
XS—None (customer must jumper program)

-XT (Terminator)
Specify 1T—Terminator Socket w/Network (std)
2T—Terminator Socket w/o Network
3T—Factory-Wired Terminator Network

-XP (Phase Decoder)
1P—Provided
XP—None

Connecting Cables:
Power Cable P/N 786009-1
Data Cable P/N 786009-2 (If Model 650 is used with Qantex Formatter, use Formatter Connecting Cables, P/N 786010-1 through -8.)

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Qantex DIVISION
NORTH ATLANTIC INDUSTRIES, INC.
60 PLANT AVENUE, HAUPPAUGE, NEW YORK 11787
516-582-6060 • CABLE: NOATLANTIC • TWX: 510-227-9660

FEATURES

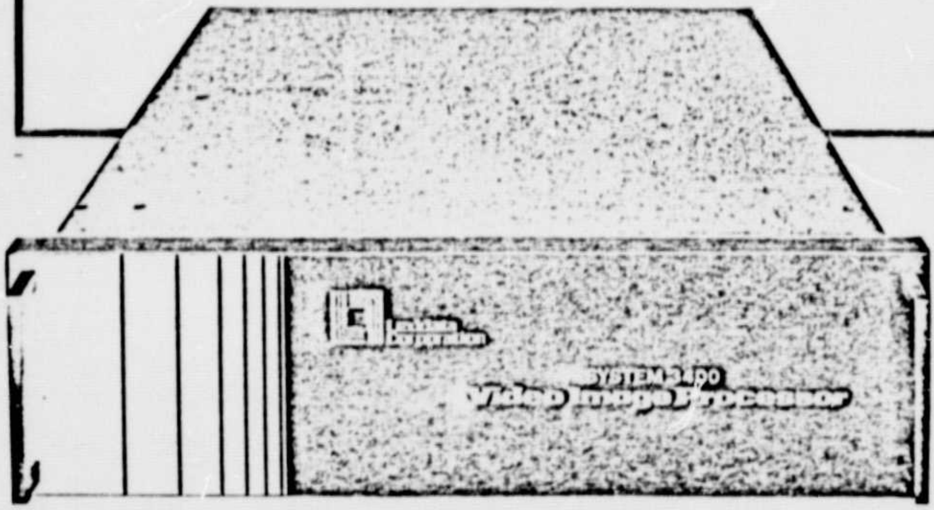
- Resolutions up to 1280 x 1024 pixels
- Interfaceable to any 8, 16 or 32 bit host computer
- Command I/O, DMA and RS-232 to host computer
- Self-contained 80 nsec cycle time microprocessor for applications programming
- Composite video outputs
- Grayscale look-up table; display 256 simultaneous gray levels selected from 4096 levels
- Color look-up table; display 1024 simultaneous colors selected from more than 16 million combinations
- Either 30 Hz interlaced or 60 Hz non-interlaced refresh
- Very high speed random pixel updating; memory is x, y addressable
- Up to 8 different simultaneous monochrome outputs
- Cursor size and shape are user-definable
- Alphanumeric character generator
- Special characters and symbols
- Gamma-corrected grayscale video output
- Instantaneous, non-destructive zoom; 2x, 3x, 4x, 5x . . . up to 16x selectable
- Selectable margins
- 4-directional scrolling
- Memory readback
- Housed in its own compact chassis with power supply

FAST RANDOM DISPLAY PROCESSING

The Lexidata System 3400 offers uniquely flexible and powerful Image/Graphics processing for low, medium and high resolution raster-scan requirements. Combining very fast (750 nsec/pixel) random updating via a separate dedicated memory controller with a fully programmable 80 nsec cycle time microprocessor, the 3400 is the perfect answer for ultra-high speed applications. For the first time ultrasound and nuclear scanning, weather radar, flight simulation, color graphics, etc. can be handled fast enough by raster-scan technology.

Fulfilling its role as a very intelligent peripheral, the 3400 operates with a minimum of host CPU interaction. Compact packaging provides a single-chassis design with self-contained power supply and cooling. Interfacing the 3400 is a matter of plugging in a standard cable connected I/O card into the user's host computer.

SYSTEM 3400 VIDEO IMAGE PROCESSOR



Lexidata Corporation

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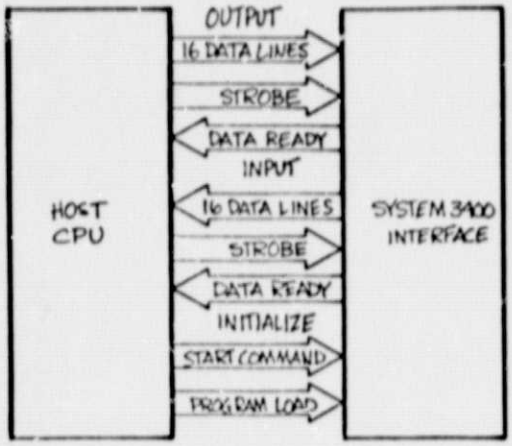
POWERFUL IMAGING FUNCTIONS

Design Considerations

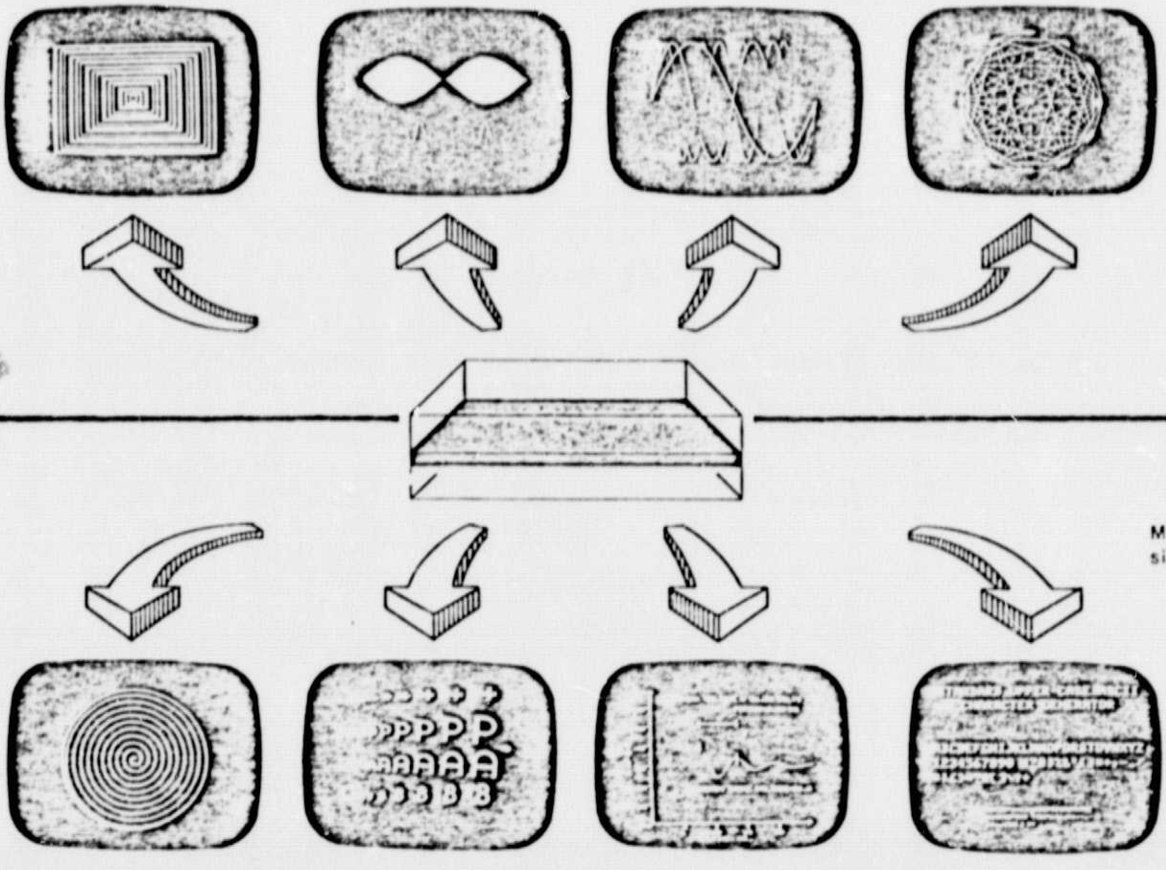
The System 3400 will interface to any 8, 16 or 32 bit host computer over DMA, Command I/O or RS-232 links. It can accept data rates as high as 2 megabytes/sec which is faster than most minicomputer data output. Its memory is organized in logical planes of 320 x 256, 640 x 512 or 1280 x 1024 pixels. Each memory plane may be configured to be part of the Graphics/Image Memory or the Overlay Memory. The system allows up to sixteen 320 x 256 or 640 x 512 memory planes for color or black-and-white viewing. The system also allows up to four 1280 x 1024 planes for color or black-and-white viewing. All memory is x, y addressable.

Functions such as blinking between two or more images to aid comparison, automatic cycling between multiple stored images to create movie picture, multiple magnitude zoom, scrolling, or image manipulation through look-up tables, make the System 3400 a versatile tool for convenient display of Image and Graphics data.



Standard High Speed Interface: suitable for I/O to DEC, DG, Interdata and other popular cpu's.

Software support for the System 3400 includes a set of FORTRAN callable subroutines. These routines all run in the 3400 microprocessor and thus require minimal processor overhead in the host computer. In addition, users can custom-program the system in a powerful microprocessor ASSEMBLY language to meet format, process, storage, retrieval and output demands.

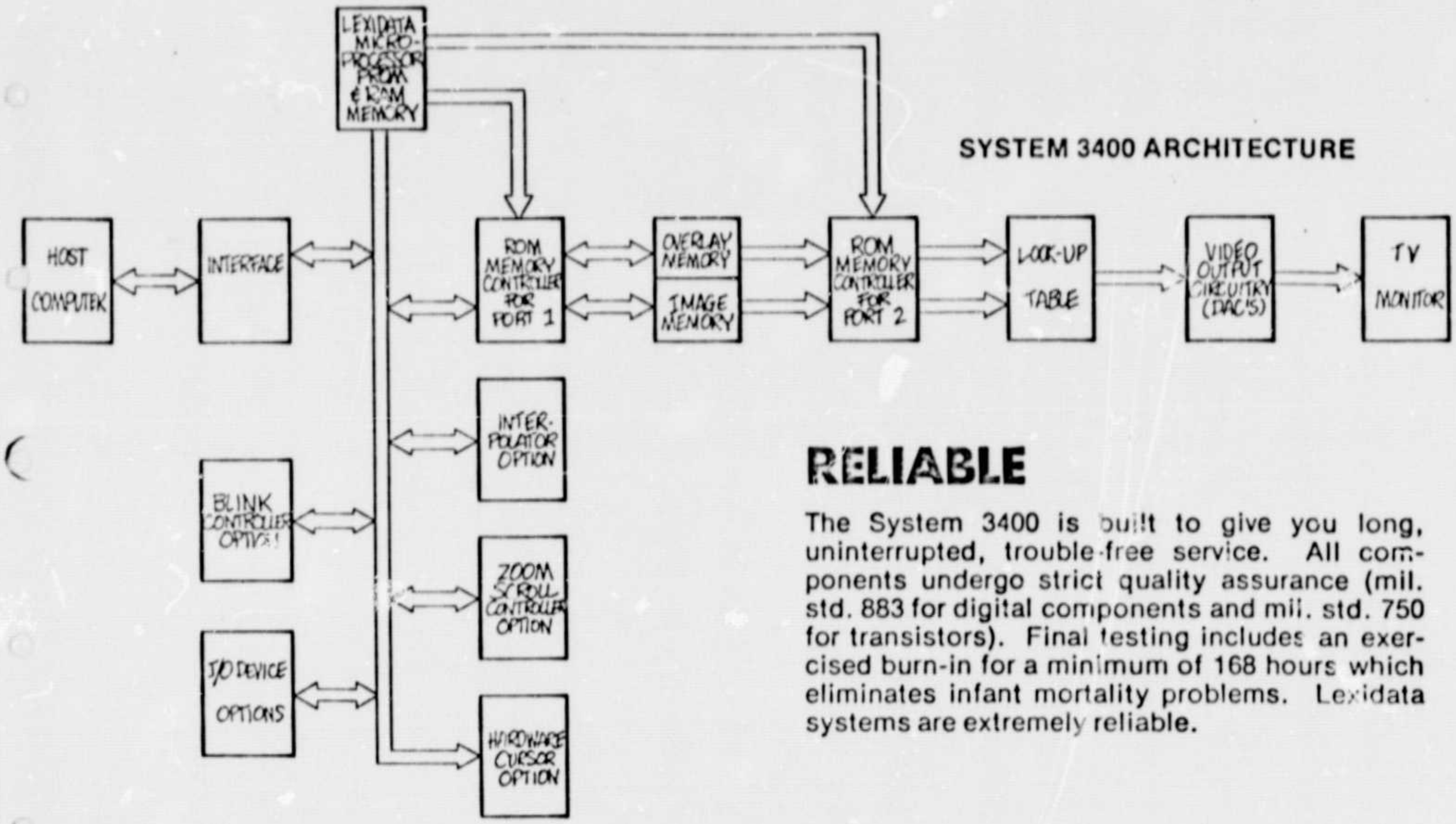


Multiple Monit
simultaneous n

FLEXIBLE ROUTINES

The System 3400 resident Interactive Display Operating System (IDOS) incorporates the following FORTRAN callable subroutines:

Set Display Margin (MARGIN)
Display Zoom (ZOOM)
Display Movie (MOVIE)
Generate Look-Up Table Ramp (LUTBL)
Look-Up Table Block Write (LUTWT)
Look-Up Table Block Read (LUTRD)
Clear Display (ERASE)
Select Display Channels (CHSEL)
Display Vector (VECTOR)
Random Write (POINT)
Display Rectangular Limits (RTLIM)
Send Data To Display (SEQW)
Get Data From Display (SEQR)
Random Pixel Read (RANR)
Set Alphanumeric Display Parameters (SAO)
Display Text (TEXT)
Echo Data From Host (ECHO)

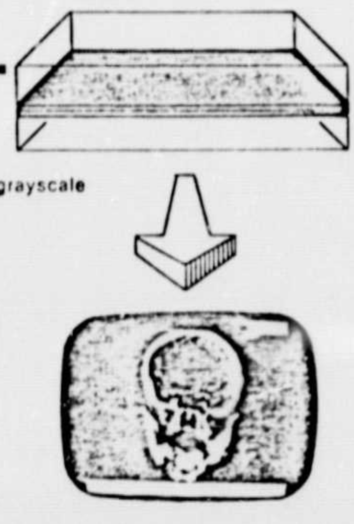


SYSTEM 3400 ARCHITECTURE

RELIABLE

The System 3400 is built to give you long, uninterrupted, trouble-free service. All components undergo strict quality assurance (mil. std. 883 for digital components and mil. std. 750 for transistors). Final testing includes an exercised burn-in for a minimum of 168 hours which eliminates infant mortality problems. Lexidata systems are extremely reliable.

ement: up to 8 different
..me outputs.



Single Monitor arrangement: grayscale or color output.

SPECIFICATIONS

Video Output: Standard RS-170, or RS-343A or any non-standard composite sync and blanking. 0 to -1 Volt into 75 Ohms. Max horizontal frequency is 33.5 KHz.
Refresh Rate: Either 30 Hz interlaced or 60 Hz non-interlaced. Also for overseas 25 Hz interlaced or 50 Hz non-interlaced available.
Alphanumerics: Standard 5 x 7 (inside 8 x 8 box) gives 80 characters per line by 64 lines for 640 x 512 resolution. Special character options available.
Cursor (Option): Size and shape of non-destructive cursor is user-loadable within 64 x 64 matrix. Also full screen cross-hair cursor selectable.
Grayscale Look-Up Table (Option): Program controlled mapping of either 10, 11 or 12 bits of intensity data to 8 bits of grayscale video output. Up to 256 levels of gray can be displayed simultaneously, selected from up to 4096.
Color Look-Up Table (Option): Program controlled mapping of 10 bits of intensity data to three 8-bit video outputs, one each for the red, green, and blue guns of a RGB color monitor. Up to 1024 colors can be displayed simultaneously, selected from 2^{24} -1 combinations. A grayscale look-up table may be operated in parallel to a color look-up table.
Picture Memory: Standard Configurations

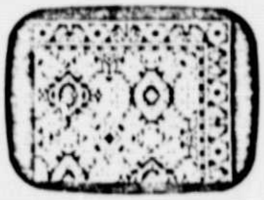
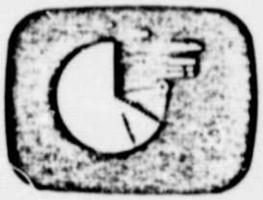
256 x 256 pixels	1 to 16 bits per pixel
320 x 256 pixels	1 to 16 bits per pixel
640 x 256 pixels	1 to 16 bits per pixel
512 x 512 pixels	1 to 16 bits per pixel
640 x 512 pixels	1 to 16 bits per pixel
1024 x 1024 pixels	1 to 4 bits per pixel
1280 x 1024 pixels	1 to 4 bits per pixel

Input Device Options: Interfaced via host computer or 3400 — Joystick, Trackball, Keyboard, Light-Pen, Data Tablet, Video Camera, RS-232.

Interpolator (Option): Hardware implemented linear interpolation on 2x or 4x zoom.
Pixel Update Times: Based on average time to update System 3400 Picture Memory from new data in host computer memory —
Random or Sequential Update; 750 nsec/pixel
Random or Sequential Readback; 1 μsec/pixel
Vector Drawing Time: Set-up: 10μsec;
Drawing: 2 μsec/pixel.
Zoom (Option): 2x, 3x, 4x, 5x, 6x . . . up to 16x selectable over screen area without destroying original stored image in refresh memory.
Scrolling (Option): 4-directional scrolling of image without host interaction.
Blinking (Option): User-programmable blinking rate.
Interfaces: DMA, Command I/O or RS-232 Interface options to any 8, 12 or 16 bit parallel link; a 32 bit minicomputer will operate with the System 3400 through a modified 16 bit parallel interface.
Software: FORTRAN callable subroutines as described earlier are provided with each System 3400 purchase. Custom software programming is also available from Lexidata.
Data Transfer Rate: Up to 2 Megabytes per second from host computer.
Gamma Correction (Option): Factory programmed to user specifications.
Power Requirements: 110/220 VAC, 50/60 Hz, 2.5A at 110 VAC.
Power Consumption: 300 W average.
Environmental Requirements: Temperature 0° to 55°C operating, -35° to 70°C storage;
Relative humidity to 90% operating, to 95% storage (non-condensing);
Altitude to 10,000 ft. operating, to 50,000 ft. storage.
Dimensions: 5¼" high x 19" wide x 25¼" deep.
Weight: 50 pounds including power supply.

Applications are many, varied and increasing:



Lexidata Corporation

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APPENDIX B

DESCRIPTION OF NATURAL RESOURCE SYSTEMS AND AVAILABLE EQUIPMENT IN ALABAMA AND TENNESSEE

APPENDIX B

DESCRIPTION OF NATURAL RESOURCE SYSTEMS AND AVAILABLE EQUIPMENT IN ALABAMA AND TENNESSEE

Alabama and Tennessee both have natural resource information retrieval systems to which they wish to add Landsat digital data input capability. These systems and the existing equipment available in each state are discussed below.

Alabama

Alabama's system is known as the Alabama Resources Information System (ARIS). ARIS provides an automated geographic analysis and computer mapping system to aid planners and decision making personnel. The system is built around a computer accessible, uniformly structured, and self-indexing data base. A decision maker, using both ARIS software and a complete description of the resources area (data base), can develop the proper relationships which lead to possible alternative approaches to a problem. Iterations consisting of varied sets of views of the geographic and other resource information, coupled with an analysis of the importance and relationship of the information components, can lead to feasible solutions.

The ARIS project is housed at Auburn University, Auburn, Alabama. ADO has access to ARIS by means of a Digital Model LA-36 Decwriter II hardcopy terminal installed at ADO's Montgomery office. Major ARIS processing is performed at Auburn on an IBM 370/158 computer (to be replaced with an IBM 3031 or 3032 sometime during the middle of 1979). Peripheral equipment includes model 3330 and model 3350 disk drives, model 3400 nine channel tape drives, a number of remote and on-site line printer/card reader/computer controlled printing card punch centers, and an extensive network of time sharing option terminals. In addition to printed and CRT output displays, an electrostatic printer/plotter is connected to the system.

The need exists for some mode of inputing data from the proposed digital Landsat processing system directly into ARIS. A Wang minicomputer at Auburn which is connected to their main IBM computer may provide the link between ARIS and the Landsat analysis process. The Wang is a model 2200 minicomputer which presently consists of a CPU having 12k bytes of RAM memory, a 100 lpm printer having a 120 character line width, a double flexible disk drive utilizing single density read/write heads, and several interfacing units. Among the several interface units is one which will permit interconnecting the Wang through the time sharing option system with the IBM 370/158 computer. Data transfer through that connection will be slow, but feasible. The Shugart disk drive is double in that two diskettes can be simultaneously used and can store 256k characters on each diskette. Record length is fixed at single sector addressing with each sector storing up to 256 bytes.

Tennessee

Tennessee's resource information system is known as the Natural Resources Planning Aid System (NRPAS). NRPAS is based on a software system known as MINIS (Multipurpose Interactive NASA Information System). MINIS was developed at MSFC, Huntsville, and later relocated to the University of Tennessee, Knoxville, where it was modified to run on UT's DEC-10 (Digital Equipment Corporation's Model 10 computer). It has since been relocated to the University of Tennessee, Nashville. Access to the system by TSPO is afforded by the installation of two remote terminals (DEC-VT 52 CRT and DEC LA-36 printing terminal) in the TSPO Nashville office with connection via telephone lines to the host computer.

The MINIS is an on-line, generalized data management system and will accommodate fixed length records with up to 500 data fields and as many records as the host computer's mass storage will permit. The system is constructed of interactive modules with each major function being invoked by user requests in the Data Base Access Language (DABAL). The DABAL provides the capability to construct sets, perform calculations, define new variables from combinations of data base fields and other variables, sum a variable or field within a set, and summon any of the other system modules. The modular structure of the MINIS, which is an efficient means of supporting the features and functions of the system, establishes a base to which additional features are readily adapted.

If TSPO should decide to access UTSI's digital processing capabilities rather than a stand-alone system, the following equipment is available. The UTSI digital capabilities are centered around a Cal Data I Computer System, a 16 bit machine with a cycle time of 850 nanoseconds. All peripherals on the Cal Data are attached to a bidirectional bus shared by all elements of the system. The present configuration supports 48K words of mapped memory. An extensive instruction set allows for extra manipulation of floating point numbers including hardwired multiply and divide.

The random access storage devices for the system consist of two Wangco 100 TPI series T magnetic disk drives and accompanying controller. Each drive incorporates a permanent disk as well as a removable cartridge of the IBM 5440 type. Each plotter has a capacity of 2.5 megabytes and is treated as a separate device by the system. Thus, the maximum on-line disk storage provided is 10 megabytes.

A Digi-Data 1730 magnetic tape unit and controller provide the ability to work with large sequential files as well as to archive such data as maps or photos. The unit operates at a speed of 45 inches per second and can read and track IBM or DEC-formatted magnetic tape at either 800 or 1600 bits per inch.

A Versatec 2160A Matrix electrostatic printer/plotter carries out most of the system's production of maps. The system console is the Decwriter II. This terminal allows on- or off-line operation at a rate of 30 characters per second (300 band).