031

SECTION I

SUMMARY REPORT

FOR THE

UNIVERSAL CONTROL AND DISPLAY CONSOLE

JULY, 1971

GENERAL ELECTRIC COMPANY
APOLLO AND GROUND SYSTEMS
HOUSTON PROGRAMS
HOUSTON, TEXAS

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CHECKOUT SYSTEMS SUMMARY REPORT FOR THE UNIVERSAL CONTROL AND DISPLAY CONSOLE

JULY 1971

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General Electric Company
Apollo and Ground Systems
Houston Programs
Houston, Texas

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SECTION I

PROJECT SUMMARY

1.0 INTRODUCTION

This report was prepared under Contract NAS9-11140 by the General Electric Company, Houston, Texas, to summarize the definition, design, and development of the Universal Control and Display Console (UCDC) System.

The objective of this contract was to support the development of the Unified Test Equipment (UTE) checkout concept through the development of an engineering model of the UCDC.

This effort included analysis of checkout requirements for the shuttle and space station, engineering trade-off studies to determine capability, sizing, and utilization requirements at the various test locations, and specification of the ground checkout system. In addition, hardware and software design and implementation, system test, and integration with previously developed portions of the UTE system, including the automated RF Ground Support Equipment (RF/GSE) and the simulated Thrust Vector Control (TVC) and Reaction Control System (RCS) Space Vehicle subsystems, was accomplished. Work began on this contract in July 1970 and resulted in delivery to the NASA Manned Spacecraft Center, Houston, Texas, of a complete prototype UCDC System and a documentation package in July 1971.

This report contains a brief UCDC System description, significant capabilities, significant trade-off studies with rationale and results, and recommendations related to the attainment of overall UTE conceptual goals and objectives.

2.0 DESCRIPTION

2.1 UCDC SYSTEM OBJECTIVES. Major objectives of the UCDC System in support of the development of the UTE checkout concept consist of:

- A system design consistent with an efficient test program philosophy which encompasses support for pre-installation, bench maintenance, subsystem, vendor, integrated system, factory acceptance, launch area, and refurbishment testing.

- A reduced need for special purpose test equipment through utilization of an adaptable subset of this universal system.

- The capability to interface (control and monitor) with spacecraft digital data buses.

- A system design capable of modular adaptation to support spacecraft program evolution.

- Functional and physical modularity to allow a minimum amount of checkout equipment for each checkout task and to allow flexibility to handle a wide variety of test articles and test complexities.

- Automation through closed loop testing with decision oriented display capability requiring minimal operator personnel, involvement, and training.

- Provision for utilization of a Central Data Bank (CDB) for system performance, degradation evaluation, and time history recycle information.

- Simplification of the ground checkout interfaces to the test article.

2.2 UCDC SYSTEM DESCRIPTION. The UCDC System consists of the hardware and software required to checkout and verify the proper operation of specific test articles for the Space Transportation System (STS), the Space Station/Base (SS/B), and future extensions thereof. The UCDC is a stand-alone system capable of performing automatic control and monitor functions of spacecraft subsystems with a minimal number of personnel. The console is designed for efficient use by a single operator and may be modularly expanded.

The UCDC System is capable of supporting all phases of spacecraft development test activity, unit level testing, subsystem testing, and factory acceptance and launch area testing including refurbishment. This capability includes the performance of onboard data management functions during development phases. The UCDC System can be modularly sized as dictated by test program requirements. Storage and recording elements, as well as input/output devices may be added or removed to satisfy test needs. Test management and test information can be controlled totally by the UCDC System. The UCDC System can control and monitor test configurations involving Research and Development (R&D) experiments, instrumentation, spacecraft systems, and automated GSE. Interface of the UCDC System to these elements can be achieved through Standard Interface Units (SIU's) which are customized for the application. The SIU's will provide the interface to spacecraft subsystem and GSE measurement and stimuli cells. Interface with spacecraft systems not equipped for digital data bus operation can be achieved through conventional telemetry and digital command techniques. The UCDC System consists of the following major modules: Display and Control Module (DCM) and Acquisition and Control Module (ACM).

A typical configuration of the UCDC System representative of a prelaunch test is illustrated in figure 2-1. Under the UCDC contract, system design of both DCM and ACM was accomplished with primary emphasis placed on implementation of the Display and Control Module (DCM) since it is the control element common to each UTE configuration and the principal man/machine interface. In addition to the definition and development of DCM, integration with the Checkout Systems Development Laboratory RF Test Equipment and Test Article (TVC and RCS) Simulators was achieved via a data bus.

2.2.1 Display and Control Module (DCM) Description. The DCM provides the data processing and control capability required to:

- Perform closed loop automated testing
- Display system status and multi-informative characteristics
- Permit real-time format selection and test modifications by the operator

The DCM block diagram (figure 2-2) shows the inter-relationship of the principal elements. The modular nature of the DCM allows its configuration to be tailored to the test requirements. In addition, since the equipment is compact and mobile, it can be economically moved to a new location and quickly placed in operation. The DCM is shown in photo 2-1.

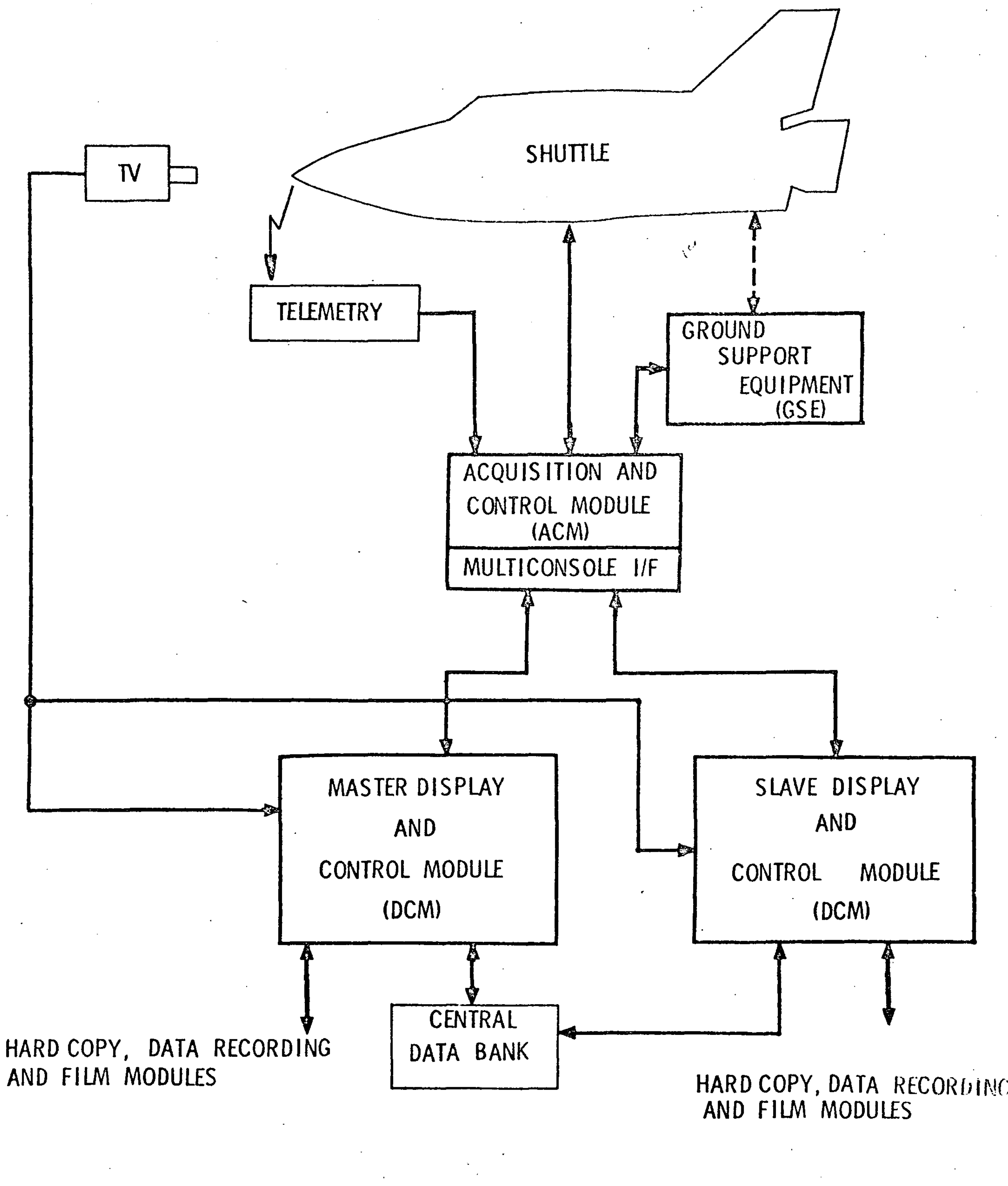


Figure 2-1. Universal Control and Display Console System

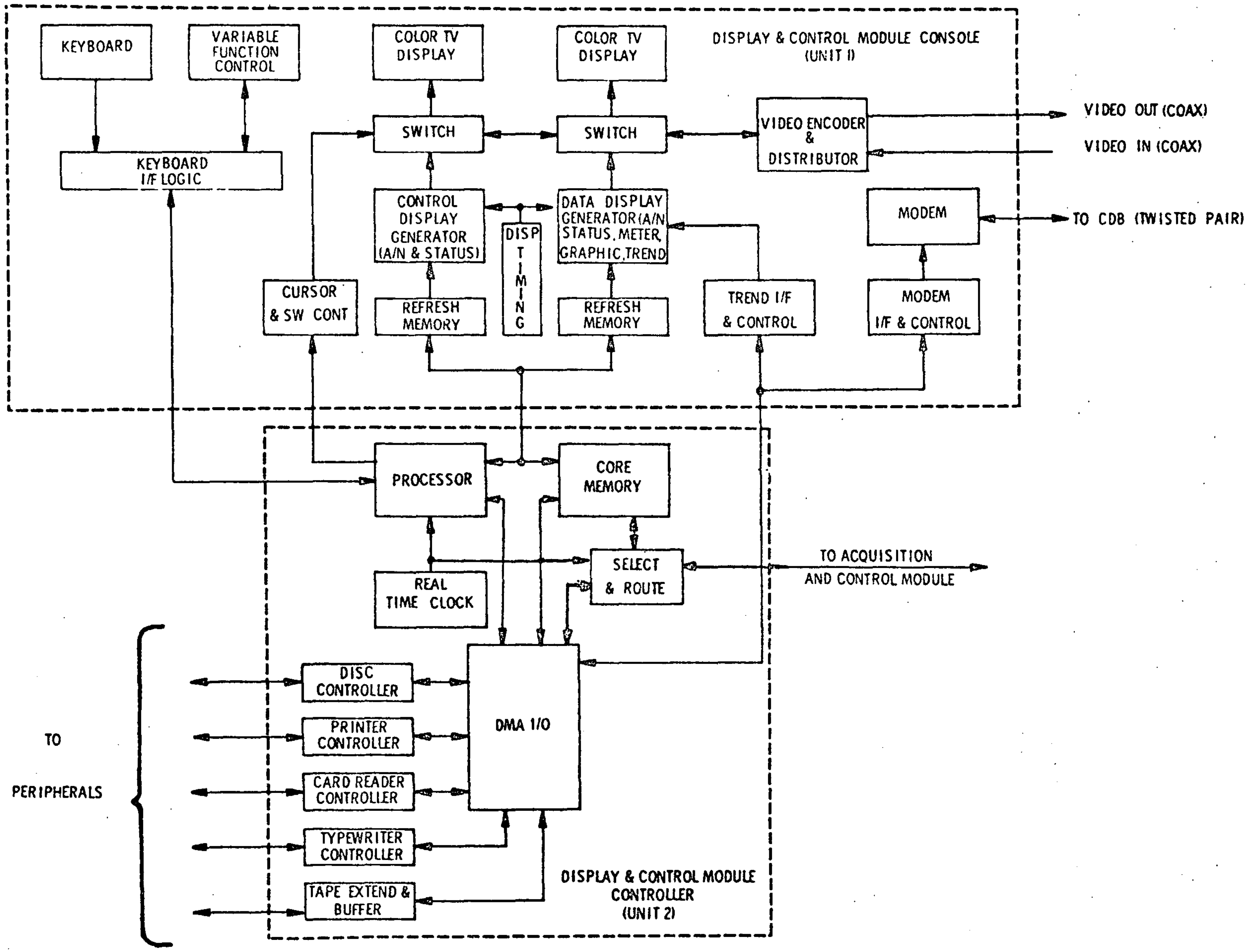
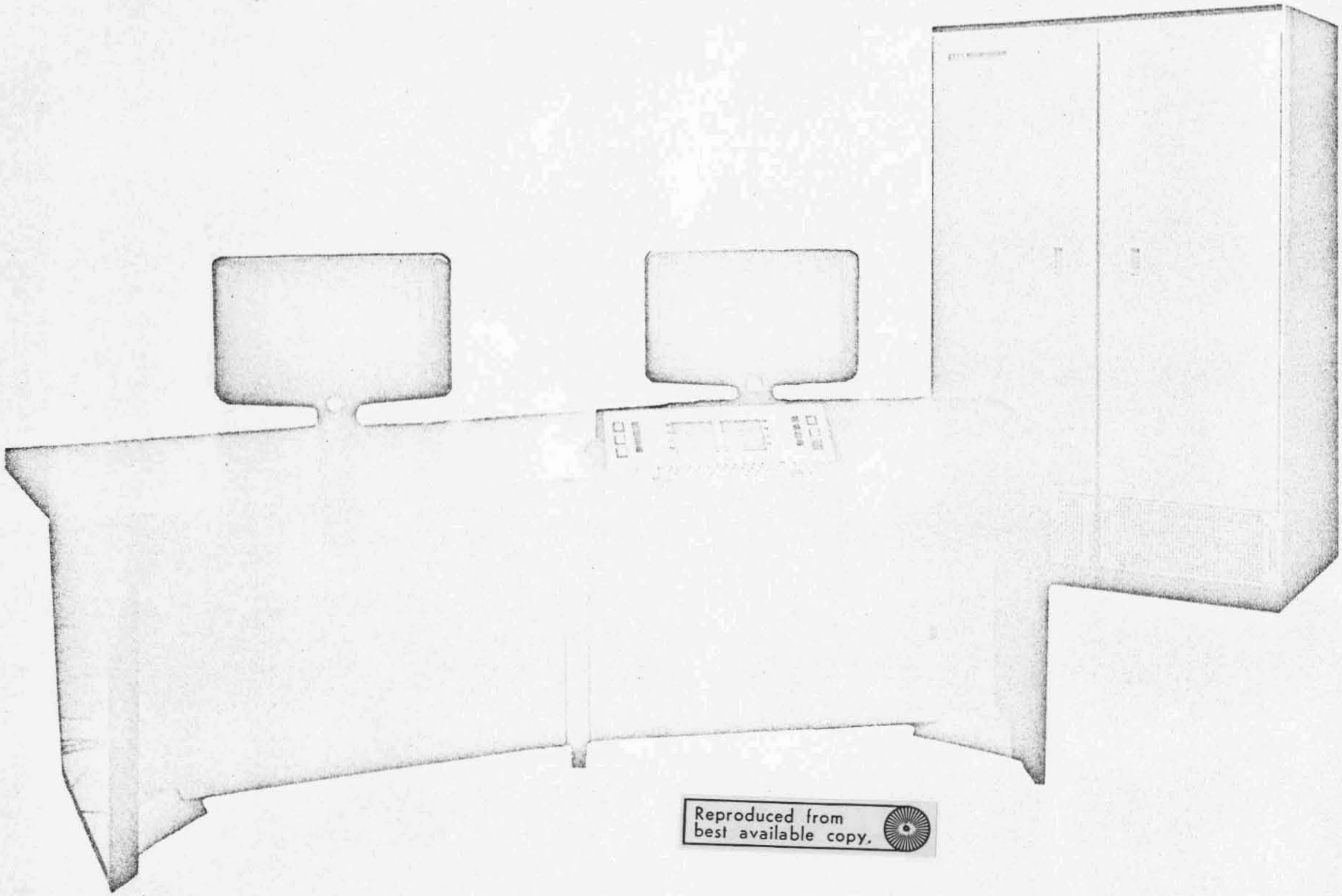


Figure 2-2. Display and Control Module Block Diagram



DISPLAY AND CONTROL MODULE
PHOTO 2-1

The man/machine interface is obtained through use of interactive messages, decision trees, status charts, and fixed variable function keys. The various display formats use color to emphasize significant data characteristics, minimize operator training, increase operator comprehension, and decrease operator error.

Information can be displayed in several forms utilizing two color television monitors. Internally generated displays are constructed from alphanumeric characters, status symbols, discrete value symbols, analog value symbols, special pictorial symbols, and time varying or X-Y data plots. These symbols can be combined to form an unlimited number of display pages, each of which is selectable by the operator. In addition, externally generated video from closed circuit television cameras or other consoles can be displayed.

Operator entry to the DCM is achieved through a keyboard containing three types of keys. The standard typewriter keys permit the entry of all alphanumeric information. Special fixed function keys allow rapid control of frequently used operations such as: Load, Run, Execute, and Page Call. In order to provide a universal and yet efficient means of controlling an extremely large number of commands or stimuli, variable function keys are used. These keys utilize programmable legends which are reconfigured instantaneously as the operator executes commands.

2.2.2 Acquisition and Control Module (ACM) Description. The ACM provides the command/data interface with the test article and its associated Ground Support Equipment (GSE). ACM also performs an intermediate level of test control by sequencing test instructions as a function of data received.

The ACM test article interface permits simultaneous acquisition of data from both synchronous and asynchronous sources. The test article interface is modular and expandable, allowing UCDC to be adapted to a variety of multiple data inputs including serial or parallel formats. As many as four high-rate serial data buses can be accommodated simultaneously.

Additional functions provided by ACM include the formatting of data for DCM processing and the tagging of data to denote routing for subsequent display processing, critical measurement processing, or recording.

Since the ACM is capable of being located at some distance from the DCM (e.g., a hazardous area such as the launch pad), it is required to time tag all measurement data which is to be recorded. In addition, the ACM is capable of performing closed-loop test operations such as the generation of commands necessary to accomplish subsystem safing. The ACM is programmable, which allows it to be quickly tailored to changing test requirements. Verification of all program loading operations as well as individual commands is accomplished automatically to insure validity prior to execution.

In order to obtain early evaluation of UTE concepts under this contract, the DCM was operated with an interim version of the ACM to achieve an interface with the RF/GSE and Test Article Simulators over a common data bus.

2.3 TYPICAL UCDC TEST OPERATION. A typical test operation, such as the Thrust Vector Control (TVC) subsystem test, begins with "Operator Identification" as shown in photo 2-2. This initial display, presented on the control (right-hand) TV monitor, requests the operator to identify himself by typing a predetermined code word on the keyboard shown in photo 2-3. After correctly identifying himself and depressing the execute key, the variable function display is configured as shown. In addition, the control display indicates the mode selection decision tree seen in photo 2-4. Depending on the activity the operator chooses, additional decision trees may be presented until sufficient choices have been made to reach the operating or working level. For each decision tree, a corresponding variable function display is generated to facilitate the operator's input. Photo 2-5 shows the control display presentation after the TVC subsystem test is selected and initiated. This presentation is a test status display indicating subtest sequence and subtest status as well as overall test status. Color is used to denote test condition as follows:

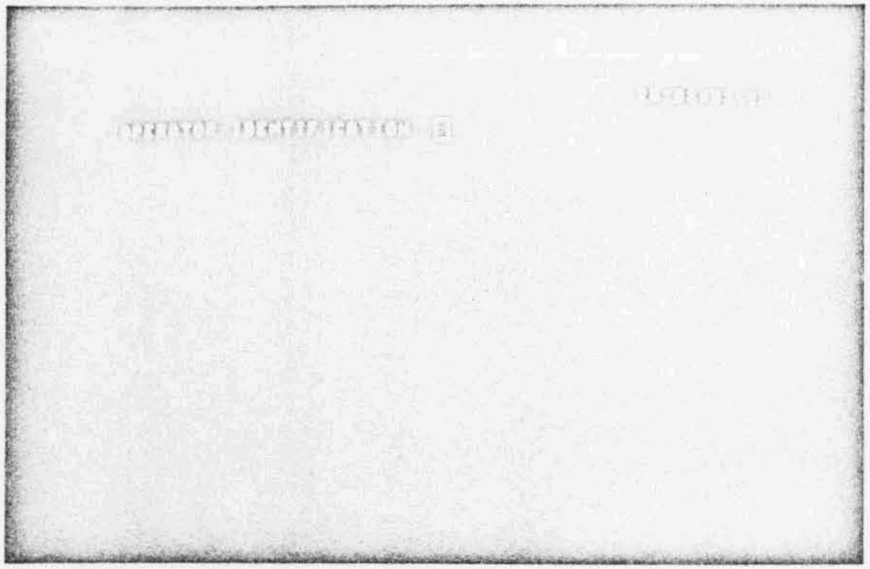
Black — No test

Cyan — Test in process

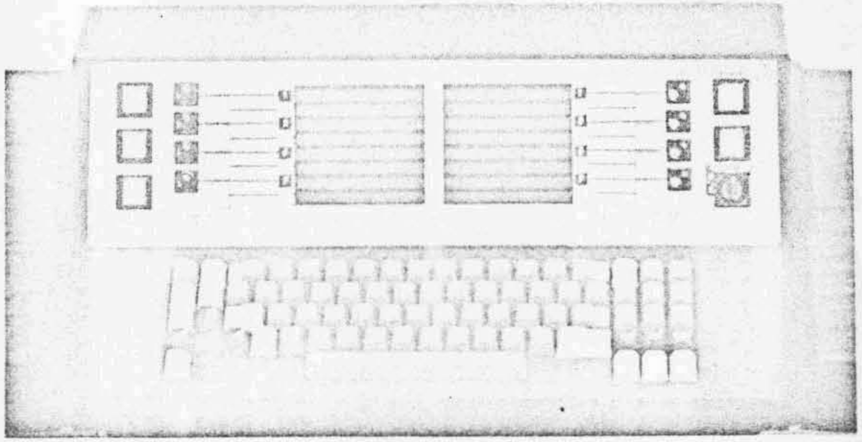
Green — Test completed satisfactorily

Red — Test unsatisfactory

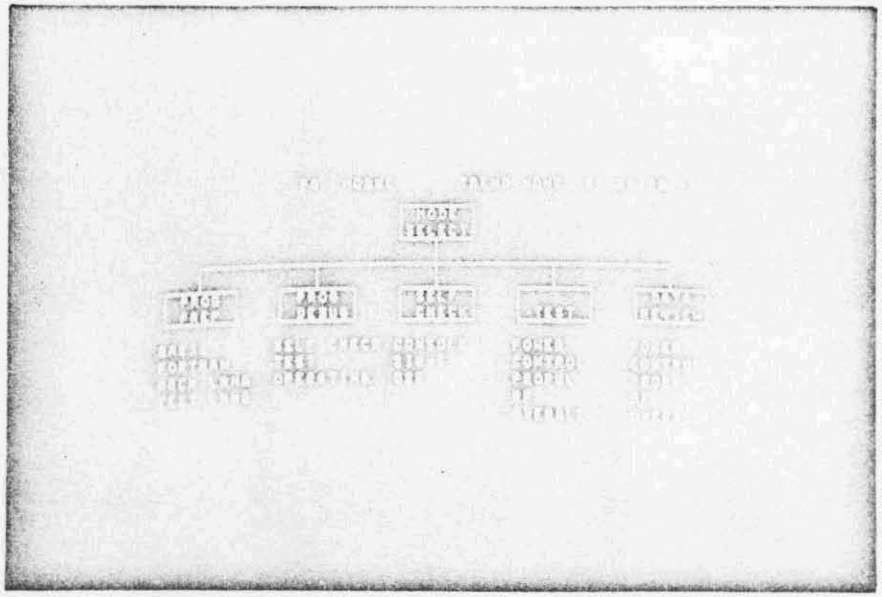
Photo 2-6 shows the keyboard variable function display as it appears during the TVC test. Note that the cursor is positioned to the left of CYCLE, which allows the operator to verify that the processor has correctly received his command prior to execution. The data (left-hand) TV monitor is used primarily to display data which may be useful for detailed analysis or troubleshooting. Photo 2-7 shows a typical display of analog and discrete data. The length



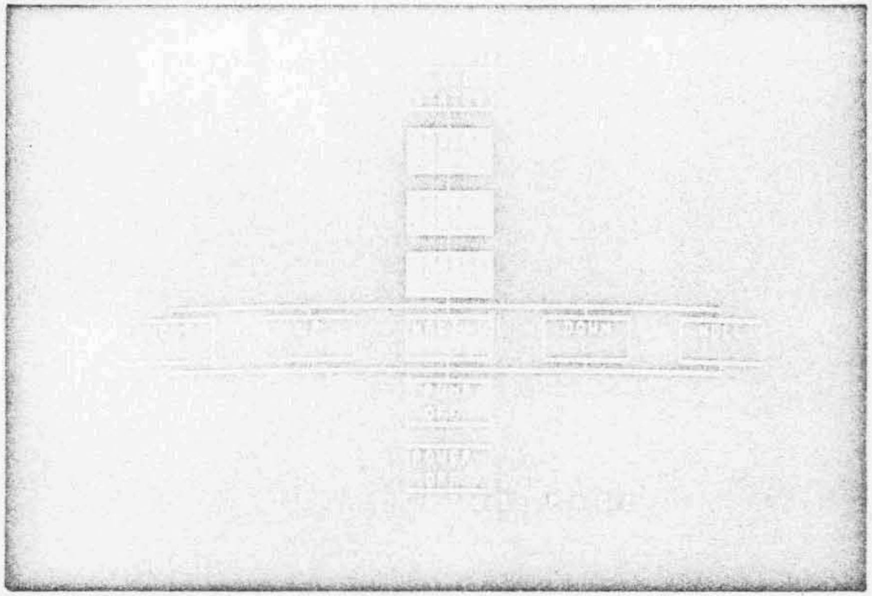
OPERATOR IDENTIFICATION
PHOTO 2-2



KEYBOARD WITH MODE SELECT FUNCTIONS
PHOTO 2-3



MODE SELECTION DECISION TREE
PHOTO 2-4



TVC TEST STATUS
PHOTO 2-5

of the meter bar is proportional to parameter value and the color indicates tolerance as follows:

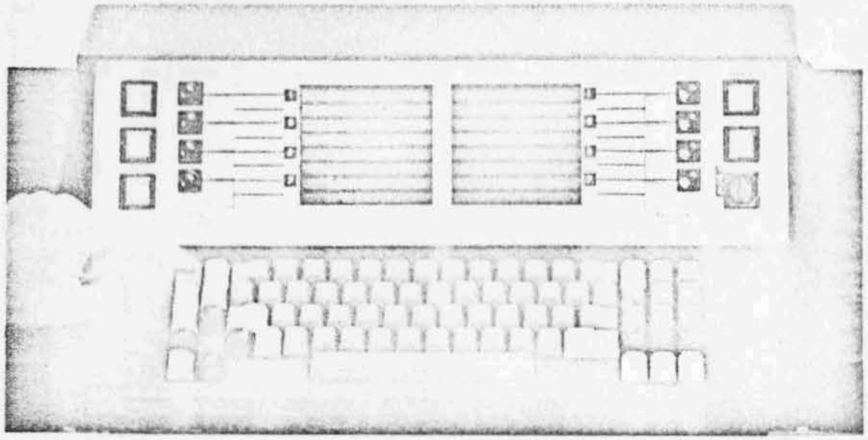
Green — In-tolerance

Yellow — Marginal

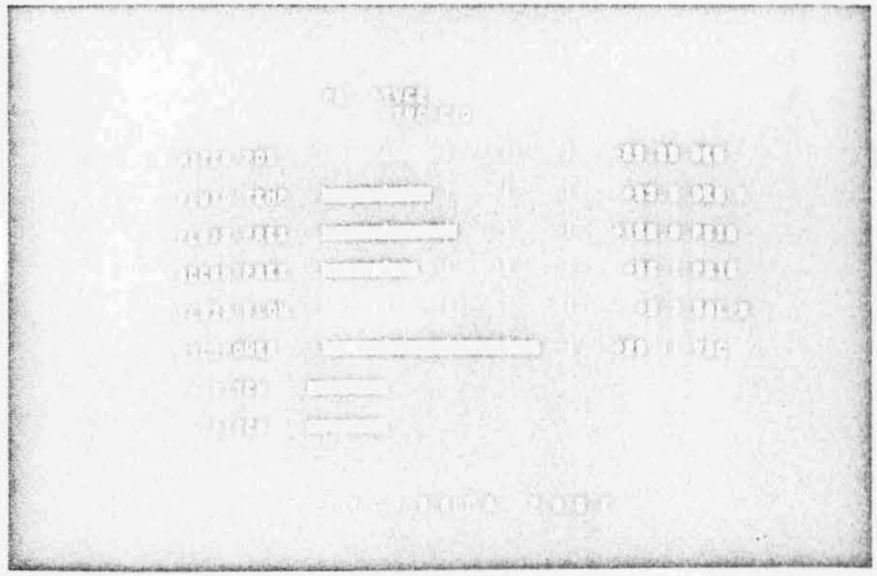
Red — Out-of-tolerance

Data trends, which may be plotted as a function of other data or time, can be continuously updated with real-time values. Photo 2-8 shows multiple plots and the use of color to differentiate the curves.

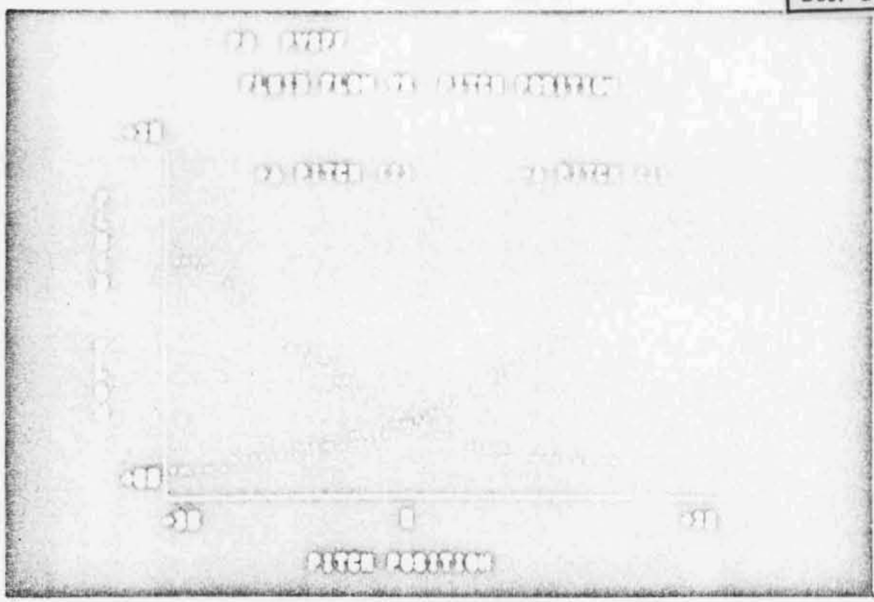
Special graphical displays can be created to aid operator comprehension, as the example in photo 2-9 illustrates.



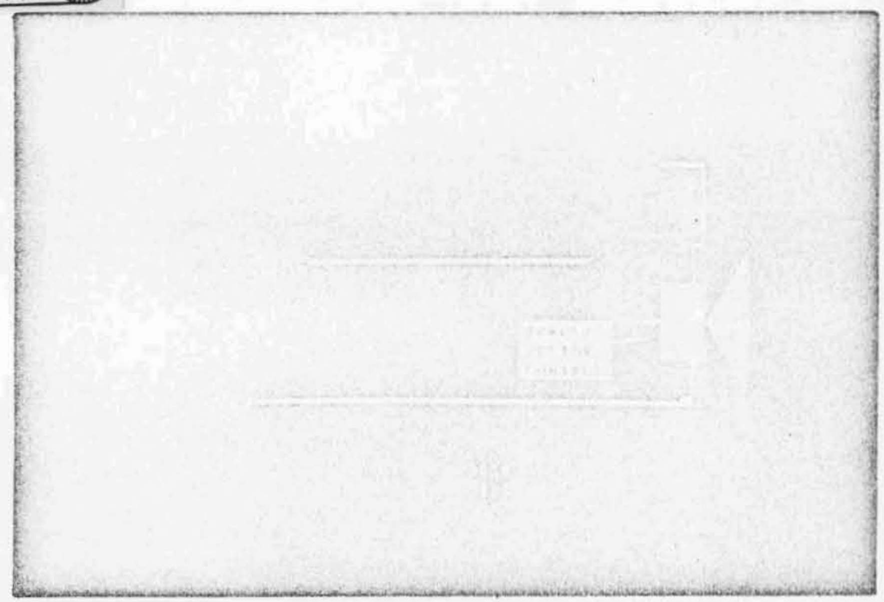
KEYBOARD WITH TVC TEST FUNCTIONS
PHOTO 2-6



TVC DATA DISPLAY
PHOTO 2-7



TVC DATA TREND PLOT
PHOTO 2-8



SPECIAL GRAPHICS DISPLAY
PHOTO 2-9

3.0 SIGNIFICANT CAPABILITIES AND CHARACTERISTICS

3.1 CONTROL

Interactive Man/Machine Interface

Single Operator

Variable Function Control [16 keys with programmable legends (plasma display)]

Fixed Function Control [78 keys consisting of A/N characters, special graphic symbols, and control functions]

Color Selection

Video Selection

3.2 DISPLAY

Control Display Capability

- A/N Characters
- Status/Event Symbols
- Cursor Symbols
- Mixed and Superimposed Symbols
- Unlimited Pages
- Operator Formattable
- Real-Time Update
- Utilizes Independent Refresh Memory and RGB Color TV Monitor

Data Display Capability

- A/N Characters
- Status/Event Symbols
- Meter Symbols
- Special Graphic Symbols
- Trend
- External Video (Camera or Film Data)
- Mixed and Superimposed Symbols
- Unlimited Pages
- Operator Formattable
- Real-Time Update
- Utilizes Independent Refresh Memory and RGB Color TV Monitor

Display Characteristics

Alphanumeric Characters —

- 64 Character Repertoire
- 8 x 10 Character Font
- 52 Characters Per Line
- 25 Lines Per Page
- 8 Colors
- Automatic Contrast Control [character vs. background color]

Status/Event Symbols (Discrete Value) —

- 5 Fixed Length Rectangles Per Line With Annotation
- 8 Colors
- Variable Height Rectangles
- Selectable Interconnect Lines With Rectangle Outline
- Up to 25 Lines Per Page
- Rectangle Color Can Be Controlled by Parameter Status [i.e., black - no activity, cyan - in process, green - completed satisfactorily, red - fault]

Meter Symbol (Analog Value) —

- 1 Meter Symbol (Bar) Per Line With Annotation
- 25 Meter Symbols Per Page
- 8 Colors
- 5 Evenly Spaced Reference Marks
- Variable Horizontal Bar Position
- Bar Length Proportional to Analog Value
- Bar Color Can Be Controlled by Parameter Condition [i.e., green - in tolerance, yellow - marginal, red - out-of-tolerance]

Special Graphic Symbols —

- 32 User-Specified Symbols with 4-Position Symbol Rotation
- 25 Symbols Per Line
- 12 Lines Per Page
- 8 Colors

Trend —

- 3 Independent Parameter Plots Per Page
- 256 Points Per Curve (Plot)
- 128 Possible Values Per Point

8 Colors Used to Differentiate Between Curves or to Highlight Curve Characteristics [i.e., out-of-limits]

3 Selectable Plotting Formats [i.e., moving window interval, fixed interval, and repeated interval]

Selectable Time Base

Selectable Grid Format and Position

3.3 PROCESSING

General-Purpose Processor

Alterable ROM Instruction Set (2K)

135-Nanosecond ROM Instruction Cycle

Real-Time Clock with Millisecond Counts to 30 Days

Emulates IBM 1130 Computer with Augmented Instructions

1-Microsecond Core Memory Cycle

Expandable 16K x 18-Bit Core Memory

3.4 DATA ACQUISITION/CONTROL

Design Capability

Up to 80K 32-Bit Words Per Second

Multiple Data Inputs and Outputs

Asynchronous Data [i.e., data buses and digital commands]

Synchronous Data [i.e., PCM telemetry]

Hardware Routing, Formatting, Data Compression, Limit Checking, and Closed-Loop Operation

Remote or Hazardous Environment Operation

Multiple Console Interface

Implemented

Data Bus Interface (video pair cable)

Operation with up to 31 Standard Interface Units (SIU)

Up to 22K 32-Bit Words Per Second

Up to 4K Unique Asynchronous Parameters

Up to 4K Unique Commands

3.5 EXTERNAL VIDEO INTERFACE

Remote Cameras and TV Monitors
Hard Copy
Film Data

3.6 PRODUCT DESIGN

Desk Furniture Appearance
Adjustable Display Monitors
Integrated Keyboard
Modular Design
Mobile Construction
Self-Contained Cooling System
Wirewrap Interconnection with DIP Logic
Built-In Maintenance Aids
Conventional Power (120VAC - 5000 watts)

4.0 SIGNIFICANT STUDIES AND RESULTS

Analysis and tradeoff studies were performed to arrive at a UCDC definition and design based on NASA/EB-5 UTE conceptual objectives. This section contains a brief summary of the most significant studies which were performed.

4.1 SYSTEM DEFINITION STUDIES. In order to define UCDC, it was necessary to analyze actual and anticipated operational requirements and determine the optimum approach to fulfilling these requirements. To support the various test configurations envisioned for the shuttle program, the use of specialized test equipment versus universal test equipment with standardized test article interfaces was considered. An approach utilizing modular universal test equipment was chosen because of the cost savings which can be expected through reduced equipment inventory and improved manpower utilization. Studies indicated that automation of the checkout process would further enhance manpower utilization by reducing the time required to prepare and conduct tests.

Analysis of shuttle program requirements led to the definition of various configurations showing how the UCDC modules could be economically applied to perform a wide range of tasks varying from factory tests to integrated or preflight checkout of the complete vehicle.

A study of the checkout display requirements included experience gained with use of Acceptance Checkout Equipment - Spacecraft (ACE-S/C) in the Apollo Program and an evaluation of the System Performance Evaluation Console (SPEC) which is an engineering feasibility model designed under a separate contract. Two displays were specified, one for text information concerning the test status and console control, and one for actual test data and results (bar graphs, events, trends, video).

Acquisition and command requirements were defined after study by a special NASA/GE task force. These front-end functions included address compression, data compression, multiplexing, command sequencing, data formatting, and time tagging.

An important factor in defining UCDC involved the trade-off between hardware and software implementation. In order to obtain the best utilization of the available controller and active memory capacity and to simplify system programming, the UCDC System was defined so that as many repetitive functions as possible could be implemented using hardware techniques.

4.2 CONTROLLER SELECTION. To implement the system requirements, it was necessary to select a controller that could handle both the data acquisition and command requirements of four serial data buses operating at five megabits per bus and to handle the processing requirements of a fully automatic checkout system. The necessity of adding or altering special instructions was stressed because of the desire to implement a test language in the final system. The ease by which the controller could be interfaced with nonstandard devices such as the data bus also was stressed, as was maximum utilization of the core storage using multiported banks of memory designed for simultaneous access. Other important controller considerations were small physical size, ability to operate on standard power and in a normal working environment without special air conditioning, and cost.

With these broad requirements in mind, a task team was formed to further define the requirements for a controller that would serve both as a display processor and acquisition and command processor.

The outgrowth of the task team was a plan for evaluating all possible controllers against the requirements. Information was solicited from 26 computer vendors on 30 controllers. The requirements were translated into a weighted formula for grading each potential controller. The formula took into account each separate hardware and software characteristic as well as cost, environmental, and support considerations. A typical test/checkout algorithm was timed on each promising candidate. Eight controllers emerged as possible candidates, and a detailed study of these controllers resulted in the top four vendors being asked to submit bids on the specific system application.

Final evaluation of the four bids submitted resulted in the selection of the Digital Scientific Corp. META-4 Controller for use in the UCDC.

4.3 OPERATOR ENTRY TECHNIQUE. Analysis of the operator entry technique used in the SPEC and ACE-S/C indicated the need for both fixed and variable function keys. Major considerations in the selection were flexibility of arrangement, acceptability of character coding, reliability, and simplicity of power interface. The Honeywell "Micro Switch" solid state keyboard was selected for the fixed function entry device after a survey of available devices.

The variable function entry technique centered about evaluation of methods of selecting large numbers of functions. Discrete assignment of switches was prohibitive because of quantity. Experience with SPEC indicated the desirability of relieving the operator of the logistical problems associated with overlays or other hardware modification techniques. It was determined that a small number of powerful functions should be made available to the operator and that these should be fully identified by software. Display devices were evaluated in terms of capacity, brightness/contrast, interface suitability, and adaptability to incorporation of switches. Light emitting diodes (LED), CRT, and projection displays were rejected in favor of the Burroughs "Self Scan" plasma panel with adjacent pushbutton switches. The 256-character panel was divided into a 15-character legend for each of 16 pushbuttons located eight on either side of the panel.

4.4 DATA DISPLAY SELECTION. The data display device is required to convey information of various types in a meaningful manner. Analog, discrete, and symbolic presentations are desirable in an integrated display along with the ability to distinguish and accent individual display elements. Hard copy production and display of external data sources must be accommodated.

Four flat panel displays were considered. Ferroceramic displays were rejected on the basis of the experimental nature of the technology, high cost, and speed. LED, plasma, and electroluminescent displays are single-color displays which are not available in a desirable size except as custom designs entailing high development costs. For these reasons, they were not considered further.

The color CRT approach used in SPEC provided a powerful solution to the data display requirements. However, the Conrac monitors utilized in that program did not realize the full resolution and color capabilities of the shadow mask CRT. Alternatives were evaluated including: random beam positioning, Sony Trinitron, Ball Brothers RGB monitor and beam penetration tubes; the last three being raster scan devices.

Raster scan systems are superior to random beam positioning systems in cost, color capability, compatibility, registration, and simplicity. Among the raster scan systems, penetration tubes were rejected because of associated high development costs and inferior color switching time. The Trinitron has desirable resolution features, but is available only as a TV receiver from a foreign manufacturer.

The Ball Brothers RGB monitor is a precision device compatible with digital video signals. Its convergence tolerance ($\pm 1/2$ line) is half that of the Conrac monitor. It has a 4.7-MHz, 0-db response point compared to the Conrac 3.58-MHz, 0-db response point. It can display composite black and white or color video from commercial standard composite sources with the addition of a video decoder. The three digital signals used to drive it can be encoded for transmission to remote standard 525-line monitors. Therefore, the Ball Brothers RGB monitor was selected as the UCDC Data Display Device.

4.5 DISPLAY SYMBOLOGY. The alphanumeric repertoire was selected on the basis of the essential A/N characters plus desirable characters totalling 64. Limited pictorial generation was added by providing a separate modular special symbol library.

Five A/N fonts (5 x 7, 5 x 8, 5 x 10, 10 x 12, 10 x 16) were evaluated under the conditions imposed by the 14-inch, 525-line monitor. The 8 x 10 font was selected as ideal based on trade-offs between memory size, single-field flicker considerations, speed, and character legibility.

The special symbol library was selected to allow a limited pictorial presentation capability utilizing 32 basic symbols which are rotatable on horizontal and vertical axes to yield 81 unique symbols.

4.6 REFRESH MEMORY SELECTION. Evaluation of the SPEC revealed that the refresh memory required by the data display requires synchronous access by the display generators as well as random access by the processor. The optimum configuration is an extension of the processor memory with ports dedicated to the display generators. Consideration of the speed, reliability, and volatility desired led to selection of the Intel 3102 bipolar solid state memory elements as the refresh memory building block.

4.7 TREND GENERATION. The trend display incorporated in SPEC was generated by a storage tube scan converter capable of generating one single-color curve. The drawbacks to this system, characteristic of analog scan conversion, became evident during the console evaluation. Flicker, poor registration, lack of resolution, and the need for periodic adjustment were unacceptable to UCDC. The desirability of multiple simultaneous curve plotting also was indicated during the evaluation.

A digital trend generator was devised, based on a binary algorithm of single-valued functions. By considering the CRT capacity and useable resolution, three simultaneous multicolored curves of 256 data points per curve (each with an amplitude of 128 adjacent field lines) formed the design specification for the UCDC trend display. The result is a flicker-free display with perfect registration.

4.8 REAL-TIME CLOCK SELECTION. A real-time clock study was performed to evaluate timing needs, availability, and cost. In view of the UCDC size restrictions, the relatively high cost of available timing devices, and the unique requirement to display time only on the CRT, it was decided that the real-time clock would be designed and fabricated as part of the system. Real-time is derived from the 60-Hz ac line frequency in the form of days, hours, minutes, and seconds. The addition of a 10-MHz crystal oscillator provides millisecond counts for more precise command timing and measurement tagging.

4.9 MODEM SELECTION. To provide a data link to and from a central computing complex, a market survey of data communication MODEMs was conducted to determine a cost effective approach to allow long distance exchange of information and programs. It was important that the MODEM selected be compatible with as much existing equipment as possible in order to gain the flexibility of communications with a large number of possible central computing complexes. The Bell System (Series 200) MODEMs are widely used and provide for maximum handwidth utilization over dial-up telephone lines. The Sangamo Electric Co. Model T201A3/4SA MODEM was chosen based on economy versus performance and half-duplex operation (allowing transmission in one direction at a time at 2000 baud). This MODEM also has provisions for interfacing with the automatic call and answer control units available on lease from the Bell System.

4.10 CONSOLE DESIGN. Major requirements for the console design were that it possess excellent human engineering qualities, be aesthetically appealing, provide room for seating two operators, be mobile and have cooling provided by ambient air. The specification that the console provide for mounting two TV monitors and a keyboard had a direct effect on the physical design.

Full-scale mockups were used in reaching satisfactory solutions for the two major requirements of aesthetic appeal and good human engineering design. These mockups were preceded by numerous human factors studies and analysis including surveys of keyboard heights and artist sketches of proposed designs. The mockups were evaluated both from an aesthetic and human factors viewpoint to factually demonstrate the operator interface with console displays and keyboard.

The solution arrived at was a console with a high quality "executive office furniture" character; i.e., wood grained work surface, warm textured finish for the electronic enclosure, and close attention to details such as rounded corners, subdued trim, and high quality finish. This approach is a departure from the sterile, aluminum-trimmed straight-line design prevalent in the electronic/computer field. The physical shape consists of a semi-circular work surface supported by a truncated shaped under carriage. The TV enclosures, with their rounded corners and subtle curved top of simulated leather, blend into the design character. Each of the TV monitors is provided with an adjustable shield over the CRT to reduce reflection from over-head ceiling lights. Numerous viewing positions are afforded by the vertical tilt and horizontal swivel features of the monitors.

The keyboard is recessed into the work surface to place it at an optimum operator height for ease of operation. Ample leg room is provided under the work surface and mobility is provided by 6 casters mounted under the console.

4.11 OPERATING SOFTWARE SYSTEM. The Operating Software System requirements dictated development of rapid, comprehensive operator interface techniques. The operator must be provided a large selection of tests; each test comprising those control routines, process routines, and associated parameters required to allow initiation, control, and monitoring of the test. The memory required to store large test selections and associated back-up data led to use of a disk operating system for memory extension. The disk memory provides intermediate storage for programs and parameters, limiting residence in core memory to those elements needed to meet current processing requirements.

The operating software system was developed using basic assembly language and special sequences available through use of firmware programming. The major system elements include:

a. Basic operating system supervisor including the following functions:

   Executive Routines
   Service Routines
   Display Format Routines
   Disk Monitor and Control Routines
   I/O Routines
   Operator Interface Routines
   Display Process Routines

b. Processing routines to provide the following functions:

DCM Communications
Data Bus I/O Control
SIU Load and Verify
Command Formatting
Response Formatting
Select and Route

Support programs utilized or developed include:

a. Vendor software, modification and additions

b. Special utilities not available from the vendor

c. Special assemblies for UCDC applications

d. Hardware debug support routines

The Variable Function Keyboard and CRT provide the primary operator interface, identifying all options available. This approach removes the requirement to use off-line documentation or to rely on memory to accomplish activity selections.

In keeping with NASA UTE philosophy, the software system is modular to provide flexibility for additions and change requirements.

4.12 RF/GSE INTEGRATION. To effectively demonstrate and evaluate the UCDC System, it was necessary to apply the system to an actual checkout task. It was established that checkout of a Collins Variable Omni Range/Instrument Landing System (VOR/ILS) Receiver using the existing RF/GSE would be a representative bench test application. The RF/GSE consists of basic RF test equipment controlled by a Ground Standard Interface Unit (GSIU) which in turn has been loaded and activated by UCDC. Since test procedures for automatic checkout are established by the test engineer much the same as for manual checkout, a determination of the desired test criteria was performed.

Studies were performed to determine the best method of accomplishing the required test sequences. Consideration of operator skill and reaction led to display definitions which utilize the symbolic and graphical representations provided by the UCDC System.

The automated VOR/ILS Receiver test which was implemented includes measurement of receiver performance characteristics such as audio and RF sensitivity, Automatic Gain Control (AGC) flatness, and bearing accuracy. This checkout application is provided with status and data displays adequate to determine test progress, test results, and receiver performance.

5.0 RECOMMENDATIONS

The objective of this UCDC contract was to define and construct an engineering model of a Universal Console to be used in evaluating the UTE concept and suitable for use in an operational prototype ground checkout system. While this objective was successfully accomplished, the experience gained provides the insight necessary to improve the design and to identify areas requiring additional attention.

Further study is required to define the optimized system which provides cost effective sizing for both minimum and expanded test requirements. Analysis and evaluation of the modularity approaches should evolve requirements for overall improvement of future units. Specific recommendations follow:

a. The actual capability of the UCDC System depends to a very large degree on the software system available. Continuing development of the initial basic system is mandatory to realize the full benefits of the UCDC System. In addition to the basic operating and support software, development of a test language, including on-line and off-line compiling, should be pursued actively in order to enable UTE to be easily and efficiently used by the engineering personnel responsible for actually performing shuttle and space station checkout.

b. In order to establish the correct interface relationship between the UCDC and other elements of an operational ground checkout system, it is necessary to develop the other elements. Implementation of the ACM and the Multiple Console Interface are particularly important as much of the operational checkout philosophy is established through these elements. In addition, implementation of a Central Computer capability allows the interface to be established between Checkout System and a common data base such as may exist for the shuttle. The addition of Hard Copy and Film Data capabilities will assist the operator considerably in utilizing the Checkout System for test article analysis and troubleshooting.

c. A small, high-speed memory should be added to the controller to allow interrupts to be handled efficiently, thereby increasing the processing throughput. Presently, many core memory cycles are required to store and retrieve register contents when interrupt servicing is performed.

d. Since the disc memory is an integral part of the Universal Console philosophy, providing the operator with a large selection of test options, the disc should be included in the minimum console enclosure. In addition, use of the head-per-track type disc memory in lieu of the moving head type will decrease access time, decrease space required, and will result in more reliable operation.

e. By packaging the controller (Unit 2) and the console (Unit 1) equipment in a single enclosure, considerable size and cost reduction can be affected by elimination of line drivers, bulkhead connectors, and external cables. Power supply minimization, optimum packaging techniques based upon cost effectiveness studies and selection of console functions applicable to the minimum test level (vendor factory subsystem tests), should allow all the required functions of the DCM to be contained in an enclosure approximately the same size as Unit 1 (console).