DODDAC - AN INTEGRATED SYSTEM FOR DATA PROCESSING, INTERROGATION, AND DISPLAY

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ABSTRACT

With the DASA Department of Defense Damage Assessment Center a significant advance has been achieved in the establishment of a large-scale military data handling system which operates under real-time constraints. Although characteristics and requirements of this system are similar to those of Command/Control systems now in development, the integration of man to this configuration is of paramount concern. The DODDAC demands swift man and system interaction to elicit the information upon which decisions are based.

The system consists of a Control Data Corporation 1604 Satellite System and communication and display devices manufactured by Thompson Ramo Wooldridge Inc. The latter includes a Computer Communication Console and an on-line group display.

Introduction

The need for a damage assessment center that could rapidly handle and process extremely complex military data led to the expansion of the Defense Atomic Support Agency to include the Department of Defense Damage Assessment Center (DODDAC). Under the Deputy Chief of Staff, Damage Assessment Systems of DASA, DODDAC now provides damage assessment support to elements of the Department of Defense and the Joint Chiefs of Staff. It provides comprehensive information affecting peacetime and wartime decisions with rapidity after particular queries are received. Because of the great amount of data handled, the complexity of the processing, the comprehensiveness and the facility of output, and the fast system responses required for both man and machine, the design and implementation of the data system are especially challenging. In delivering this performance, DODDAC represents a significant advance in large scale data handling systems.

The characteristics and requirements of this system have many features common to the general class of military Command/Control systems now in development. They require, for example: large capacity random data storage devices, parallel processing of data, continual operation with near absolute reliability, real-time response, and servicing of queues formed by continual data entry and consumer requests for output.

Of paramount concern was the integration of man to the configuration, i.e., providing him with adequate tools by which he interacts with the data and the processing. In this respect especially, the design represents one of the more advanced real-time systems incorporating on-line interrogation and display.

The DODDAC system design and project management was provided by the DASA. The design was implemented by a Control Data Corporation Satellite System, a Ramo-Wooldridge Interrogation and Display System, and by programming and modelling accomplished by the System Development Corporation. This paper presents the technical aspects of the data processing and display systems, following a discussion of the mission, functions, and requirements of DODDAC.

Mission

DASA is a joint services organization with broad military responsibilities in the atomic energy field. DASA, formerly the Armed Forces Special Weapons Project, succeeded the Manhattan Project of World War II. As part of its responsibilities, DASA has for some years been performing computational studies of weapons effects, hazards, and vulnerabilities related to atomic warfare, exercised earlier by the DASA Deputy Chief of Staff for Weapons Effects and Tests and now, insofar as applications to real target systems, by the Deputy Chief of Staff for Damage Assessment Systems. Under the latter, DODDAC was established by a Department of Defense directive. On March 4, 1960, the Chief, Defense Atomic Support Agency, was designated as Executive Director of the DODDAC.

Should war occur, DASA (DODDAC) will support the Joint Chiefs of Staff and other designated military and government groups in assessing nuclear damage sustained by the armed forces and resources of the United States, its allies, and the enemy, supplementing its peacetime responsibility for appraisals of attack hazards and vulnerabilities.

Figure 1 depicts schematically the mission of DASA DODDAC by presenting the overall data flow through the system. Data comes into the DODDAC from the indicated agencies in three categories: target data, system parameters, and attack information. Target data is a comprehensive description of forces and resources, system parameters include certain data on weapon effects, and attack information is that volatile data related to a specific and unpredictable pattern of events during post attack phases.

The sources and users of data shown in Figure 1 is not an exhaustive list but a representative one. The principal user, as indicated, is the Joint Chiefs of Staff.

Functions and Requirements

A general statement of the functions of the DODDAC is as follows: perform hazard and vulnerability studies on a continuing basis, keep an up-to-date file of military forces and resources information, and in the event of hostilities, accept information quickly, process it rapidly, and provide display products suitable for top level command use.

The DASA-DODDAC has also been given the responsibility to support the war gaming activity of the Joint Chiefs of Staff. In this capacity the DODDAC works with the Joint War Games Control Group from which guidance is given leading to the development of gaming models, computer programs implementing the models, output designs and presentation methods.

More specifically, the imposing list of requirements is as follows:

1. Provide a data base of information necessary for damage assessment processing which can in the near future grow to 100 million characters.
2. Provide a means to up-date the data base on a day-to-day basis.
3. Design and implement a data handling system for handling these large amounts of data accurately and expeditiously.
4. Allow for the data transmission to DODDAC over hardened, secure, and reliable communication facilities, and devise and arrange for sources of information appropriate to the damage assessment process.
5. Accept attack data as real-time inputs and allow for their direct input to the computer system.
6. Develop damage assessment models which represent the delicate balance between comprehensiveness or realism, and speed.
7. Provide a technique for man/machine communications, allowing quick access to nearly all data in the files.
8. Provide a system for the automatic generation and presentation of high quality output products of fast response which are suitable for group viewing by top command personnel.

There is a special challenge in the last two requirements for there are few, if any, data processing systems in existence today which provide all flexible and all-purpose interrogation and display system required.

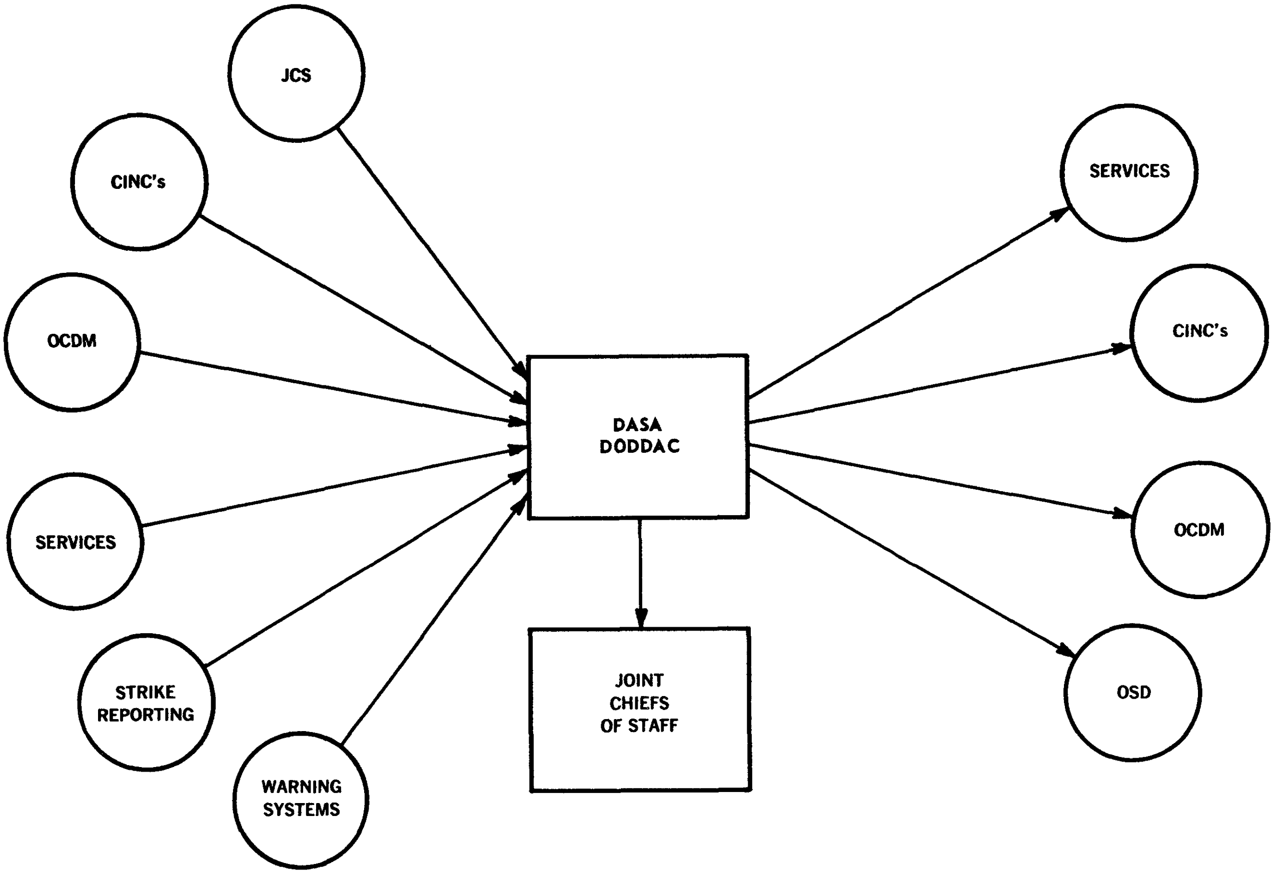

Figure 1. DASA--DODDAC Mission - Overall Data Flow

Figure 2 shows the functions to be performed by the data system. The input data, as shown, can come in through many sources: voice communications, teletype data links, specialized communication systems, and standard digital data links. The system must allow for automatic entry of data as well as manual type entry. The computations must allow for various kinds of damage assessment processes. For the various models, there must be a number of modes of operation which allow various trade-offs between comprehensiveness of the model and the speed with which results must be obtained. Standard output in terms of hard copy must be available. In addition, individual or console type displays are necessary for the individual analysis of file data.

A last requirement for output is a display for group viewing. Man/machine facilities for the input of data and for calling for requests, complete the required capabilities of the system.

Of special concern is the system for group display. In order to have the quality and comprehensibility of the group display required for command use, it was deemed necessary to have a full color display system. It was desired that this display system allow for the placing of symbols on maps and charts in full color, with no dilution of the color of the superimposed symbols. Finally, because of large amounts of information to be placed on the slides for group viewing and the fast response times necessary for their preparation, it was necessary to have completely automatic operation. This automatic operation must allow for the input of information directly from the computer, the automatic preparation of the slides, and the transportation of the slides to a projector for viewing as required.

Implementation Philosophy

In the fall of 1960 the first steps were taken toward the eventual operational DODDAC. In order to accelerate the establishment of the

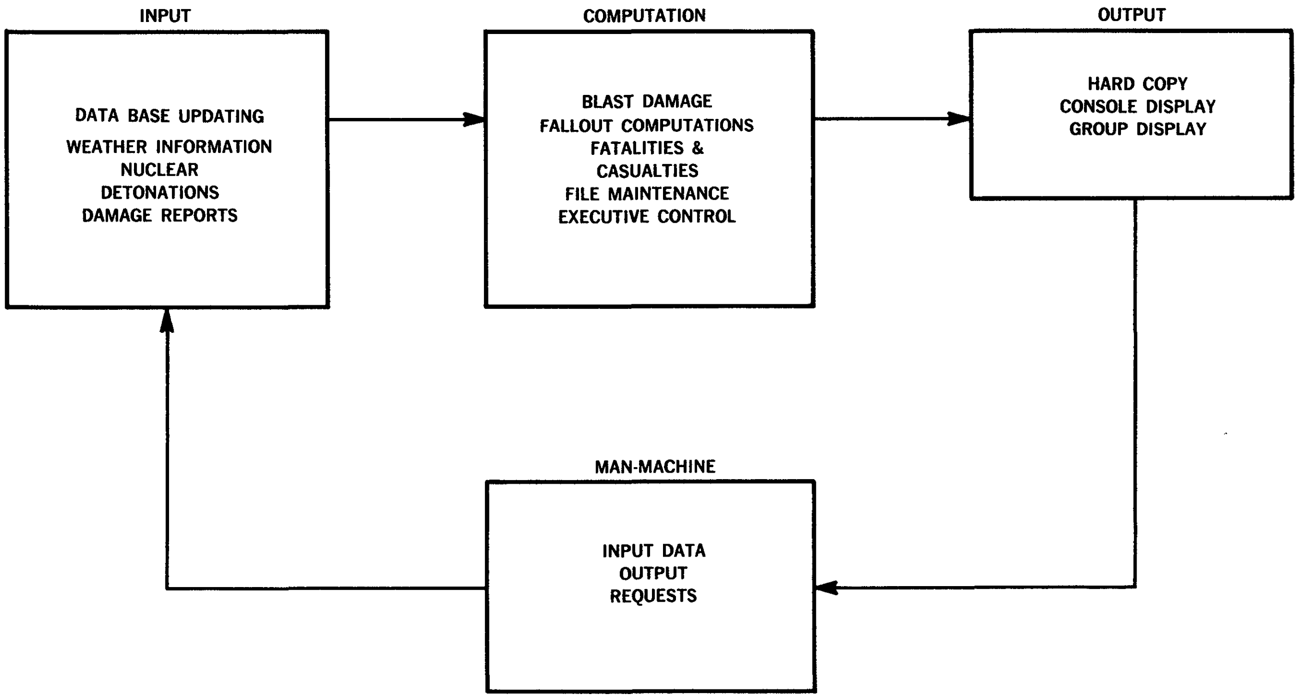

Figure 2. Data System Functions

necessary capability, an implementation philosophy was adopted which saw the following three activities in parallel development:

1. A semi-automatic manual system providing an immediate and basic capability.
2. A Developmental Center containing a simplex of equipments with which to study and test the operational DODDAC environment and requirements. This functional unit also represents a level of sophistication that fulfills many of the requirements set forth by the Department of Defense.
3. Develop a design of future systems, based on a better understanding of the problems and experience gained in operating the first two systems.

This plan allowed an early basic capability while recognizing that significant technology must evolve gradually in areas of computers, programming, and displays, with the passage of many months. It was recognized that starting immediately toward a full blown operational system would have been costly and inefficient; the plan allowed the maximum contribution to damage assessment required by national defense consistent with reasonable expenditures.

In this paper we consider aspects of the Developmental Center which is now equipped with data processing and display facilities. This system was integrated and established through the combined participation of military and industrial groups. As shown in Figure 3, the Project Management and system design was supplied by DASA which contracted the computer subsystem to Control Data Corporation, the programming data processing tasks to System Development Corporation, and the man/machine communication and display subsystem to Thompson Ramo Wooldridge Inc.

In the fall, 1961, the Developmental Center was equipped with the data handling equipments. The Developmental Center satisfies most of the requirements listed above. It is implemented with a large-scale multicomputer system and a modern man/machine communication and display system which will provide the basis for future developments of operational systems.

Data System Concept

The DASA-DODDAC's function is to provide command elements with appropriate

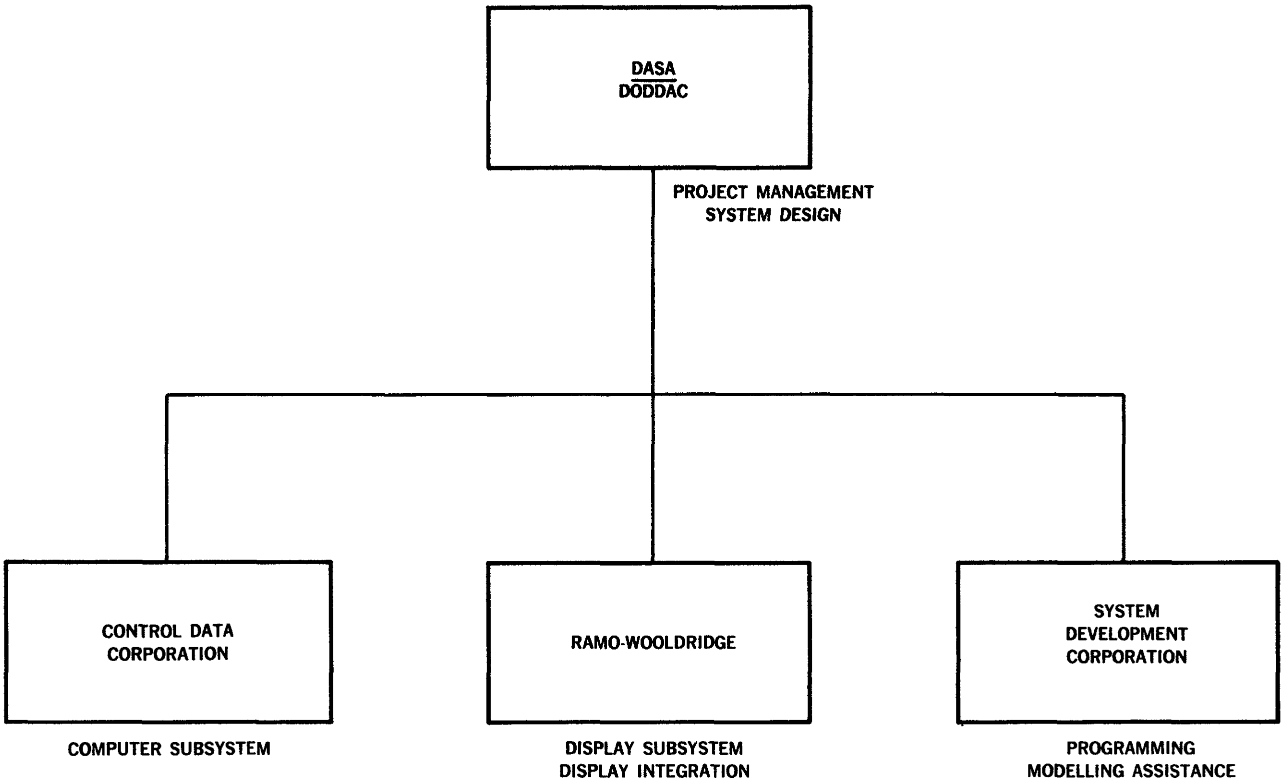

Figure 3. DASA--DODDAC - Contractor Team

information in a military environment with little delay. These requirements were translated into a data system having the following capabilities and attributes:

1. Parallel processing
2. Ease of communication interface
3. Flexibility of organization
4. Growth potential
5. High speed
6. Large, random access storage

The operational tasks were analyzed and are shown in Figure 4. Each of these areas is a functionally independent block requiring periodic intercommunication.

Computer Subsystem

The Control Data Corporation 1604 Satellite System was selected by DASA as the computer subsystem for the Developmental Center. This multi-computer system possesses attributes which meet the data processing requirements stated above. The requirement for a large, random access storage device was answered by the addition of a Bryant-320 Disc File to the CDC equipment. This unit is able to store over 30 million characters, and has a character transfer rate which ranges from 20 KC to 62.5 KC.

The complete system includes:

- 1 1604 Computer
- 2 160 Computers
- 3 1607 Tape/160 Computer controls
- 12 Magnetic tapes (Ampex FR-307, character transfer rate 30 KC)
- 1 Bryant 320 Disc File
- 1 1610 card reader, punch adapter
- 1 Card Reader (IBM 088)
- 1 Card Punch (IBM 523)
- 1 1606 Printer Adapter
- 1 High Speed Printer (Analex, 1000 lines per minute)

Each of the three computers has an associated Ferranti paper tape reader and teletype tape and punch. Also, a Soraban-modified IBM electric typewriter is included with the 1604 and one of the 160 computers.

The organization and interrelationships of the system are depicted in Figure 5. In this configuration one of the CDC 160 computers is designated to the input/output area, providing the necessary buffer and processing capabilities for data entry and hard copy output. This computer also has the function

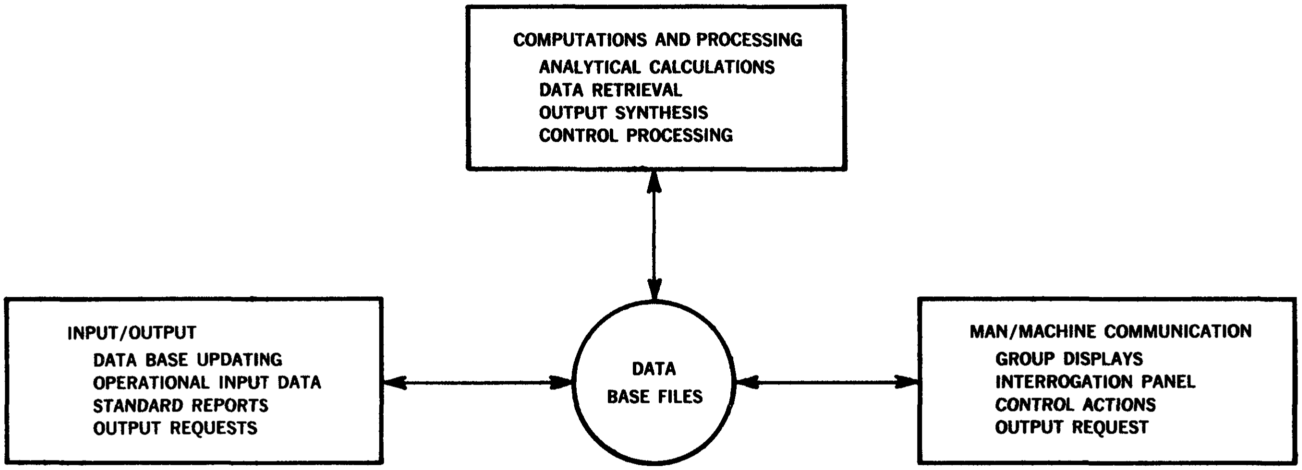

Figure 4. DASA--DODDAC Data System Functions

usually associated with off-line tape to card, card to tape and tape to printer operations.

The second CDC 160 is devoted to a time-shared operation between the three units electrically tied to itself. This includes the 1604, a communication console, and the large screen display. The latter items will be further discussed in the next section.

Finally, the 1604 computer performs the analytical and retrieval tasks. This includes the computation of the damage assessment process and the output processing. The scheduling and direction of data flow is under the executive control of a master program operating in the 1604.

It is significant that this system is completely integrated as an on-line functional unit. In this sense it is unique in adapting the satellite computers for both "off-line" type operations and as computer partners in support of the real-time processing operation.

An interesting design problem was faced in the assignment of data transfer channels to the various devices connected to the 1604. Since the computer is equipped with 3 input and 3 output buffer channels and a high speed transfer channel, a large degree of flexibility is afforded.

In the DODDAC, the 1604 has direct connection to the following:

a. Console typewriter
b. Console punch tape punch
c. Console Punch tape reader
d. Three 1607 tape systems
e. Printer control unit
f. Card reader/punch control unit
g. Disc file

Figure 6 indicates the channel assignments as established for the 1604. The rationale behind this selection was guided by the following principles:

1. Peak performance satisfaction during real-time operation
2. Accommodate individual data transfer rates
3. Avoid time sharing of high duty cycle devices
4. Provide alternate paths for reliability and back up.

Of the nine devices connected to the 1604, the priority equipments are the disc file, the 1607 associated with the display subsystem and the 1607 servicing the input/output. Accordingly, each of these units is assigned to separate buffer channel pairs.

Secondary assignments are now made for the remaining devices. The typewriter, tape reader and card punch are all associated with the input/output channel. This has two advantages:

1. Provides high priority I/O capability for short bursts which circumvent normal queuing procedures.
2. Gives alternate paths in the event of a 1607 or a 160 failure.

The remaining element requiring assignment is the third 1607. This is tied to the channel used by the disc since these two elements were usually not to be called upon at the same time. The associated tape units also provide

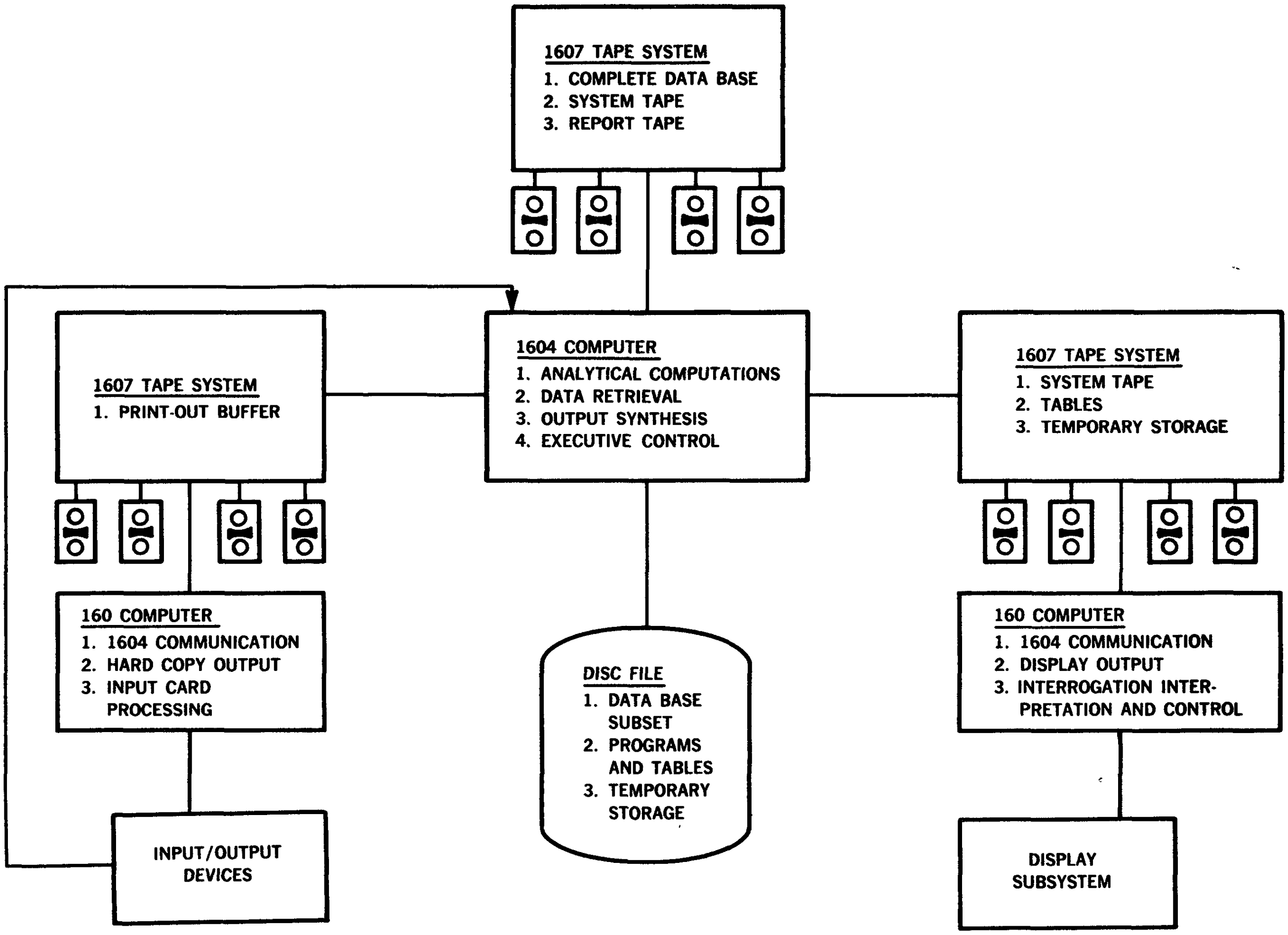

Figure 5. DSAS--DODDAC Computer Subsystem Organization

a potential backing to the disc since both devices contain the data base.

The assignments reflected above provide a clear channel for the interrogations and outputs serviced by the 160 computer attached to the display subsystem.

A design decision was made in attaching the disc file to the buffer channel instead of the high speed transfer channel. The disc information transfer rate falls between the transfer rates of the two types of input/output channels. Connection to the high speed channel would serve to slow down the effective computing capacity of the central processing; connection to the buffer channel would limit the servicing capability to the competing auxiliary devices whenever computer and data transfer is at a saturation point. The latter alternative was chosen and the executive program controls the additional channel activations whenever the disc is accessed.

Man/Machine Communication and Display Subsystem

The real-time aspect of the DODDAC requires man to dynamically interact with the system to obtain timely information concerning the status of internal information flow and data file content as they reflect the "outside world." This quest for facts is motivated by the need to make decisions which are time dependent.

In order to facilitate decision making on the part of DODDAC consumers it is necessary to provide adequate tools for summarizing and presenting data and methods by which interrogation can be readily processed.

These requirements are met by the Computer Communication Console (CCC) and an

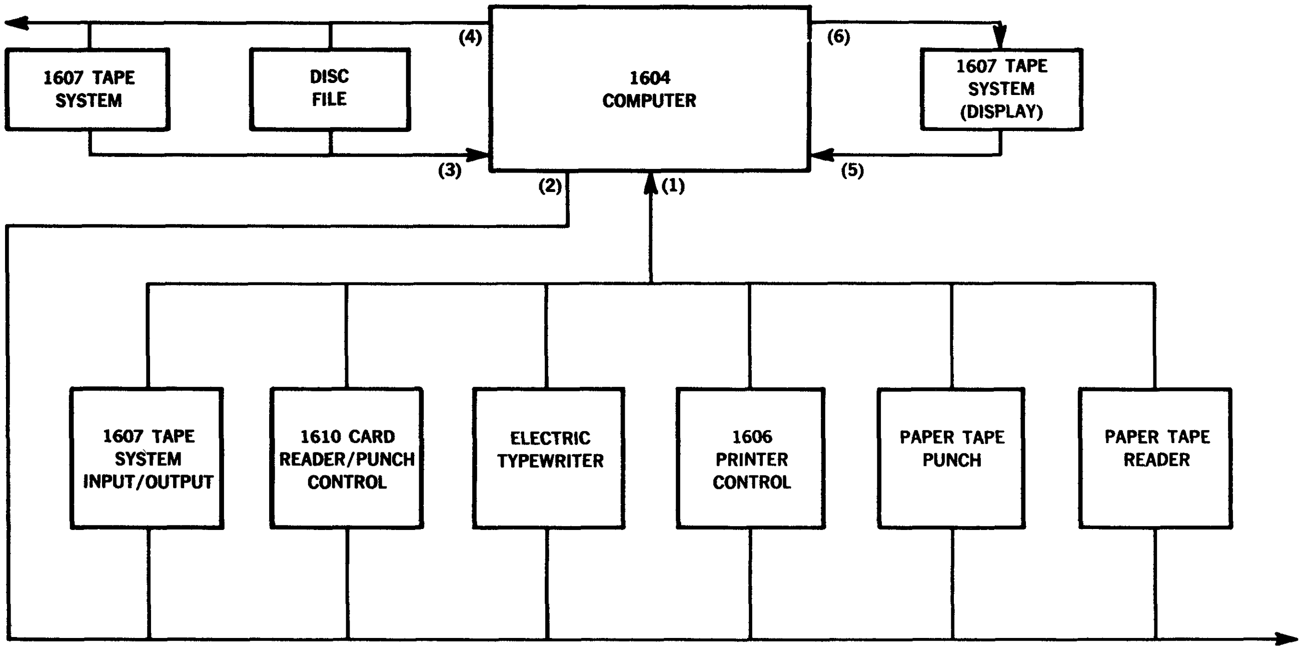

Figure 6. Buffer Channel Assignment in the DODDAC

on-line group display supplied by Ramo-Wooldridge. These items form the basis of the DODDAC Presentation Room. The CCC is a single operator device (see Figure 7) providing the ability to initiate interrogation and system control via a keyboard, or to display system status by use of a CRT read out. The group display generates film chips which are automatically delivered to a projector for large screen, full color viewing.

The CCC is a general purpose console facilitating communication between a human analyst/operator and a computer system in the performance of:

Data entry
Data analysis
Information retrieval
Display
System control.

These features are summarized as follows:

1. Control buttons on a console keyboard
2. Status lights for indicating system action
3. Alpha/numeric keys for data entry
4. CRT displays for alpha/numeric displays
5. Removable keyboard overlay for changing the problem orientation of the console.
6. Complete program control of all console keys, lights and displays.

Of particular significance are the CRT and the overlay. The electronic display permits the presentation of up to 720 symbols out of a font of 62 alpha/numeric and graphic symbols. Options are available for either outputting a full display of 720 characters or any number of symbols at selected grid points of the 20 row by 36 column display matrix. The refresh rate is under program control and is usually performed at 45 times per second in order to avoid flicker.

The overlay (see Figure 8) is the feature which gives the console application flexibility and user oriented characteristics. It consists of a plastic form which fits over a bank of 30 buttons designated as the Process Step Keys. When in place, the overlay supplies an associated labor for each button Thus, by properly engraving the overlay, the Process Step Keys become functionally tied to a particular job or operation.

There are 63 overlays possible, each one being identified to the computer, when in keyboard position, by a code generated by one to six prongs present on the underside of the plastic. Each overlay typically will have associated computer programs which are activated when buttons are pressed. Removal of an overlay and insertion of another effectively changes the orientation of both the console and the computer.

Each label and button of the Process Step Keys have associated illuminators whose state is under program control. These lights are utilized to indicate to the console operator current operating position by lighting the proper button, and next allowable steps by lighting selected labels. Sequential illumination of these lights, as a function of buttons pressed, serve to guide the operator through a particular process. Using these keys together with the data entry and CRT response capability, the console can outline and lead the operator in carrying out specific operations.

The on-line group display system produces photographic transparencies for immediate full color projection. The slide is a single, composite 70 mm film chip containing three images formed by a color separation process. These images are projected through the lenses of a special projector and recombined to give the color presentation. The slide content represents a combination of previously prepared backgrounds (such as maps, charts and photographs) with timely, computer-generated annotations.

The attributes of this display system are:

1. SPEED: The time lapse between the generating of annotation data and the

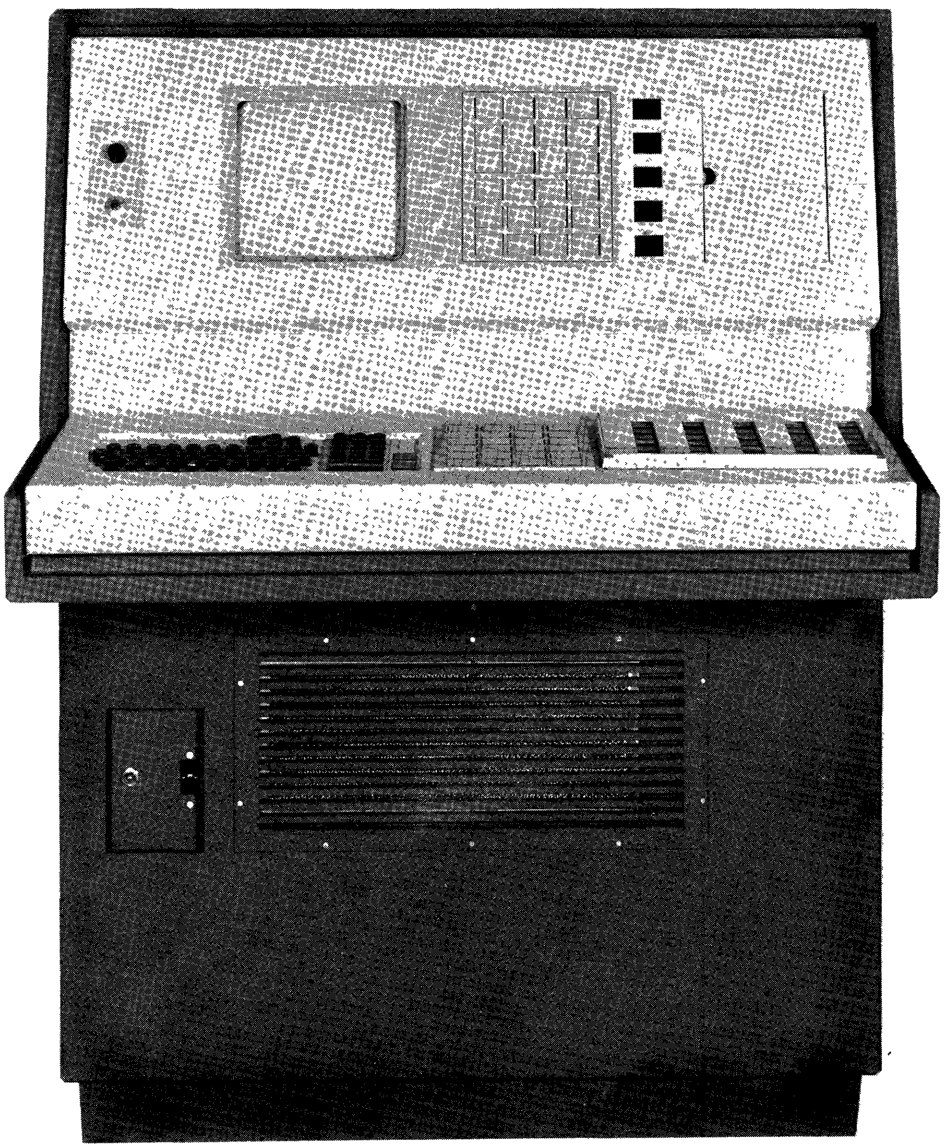

Figure 7. Computer Communications Console

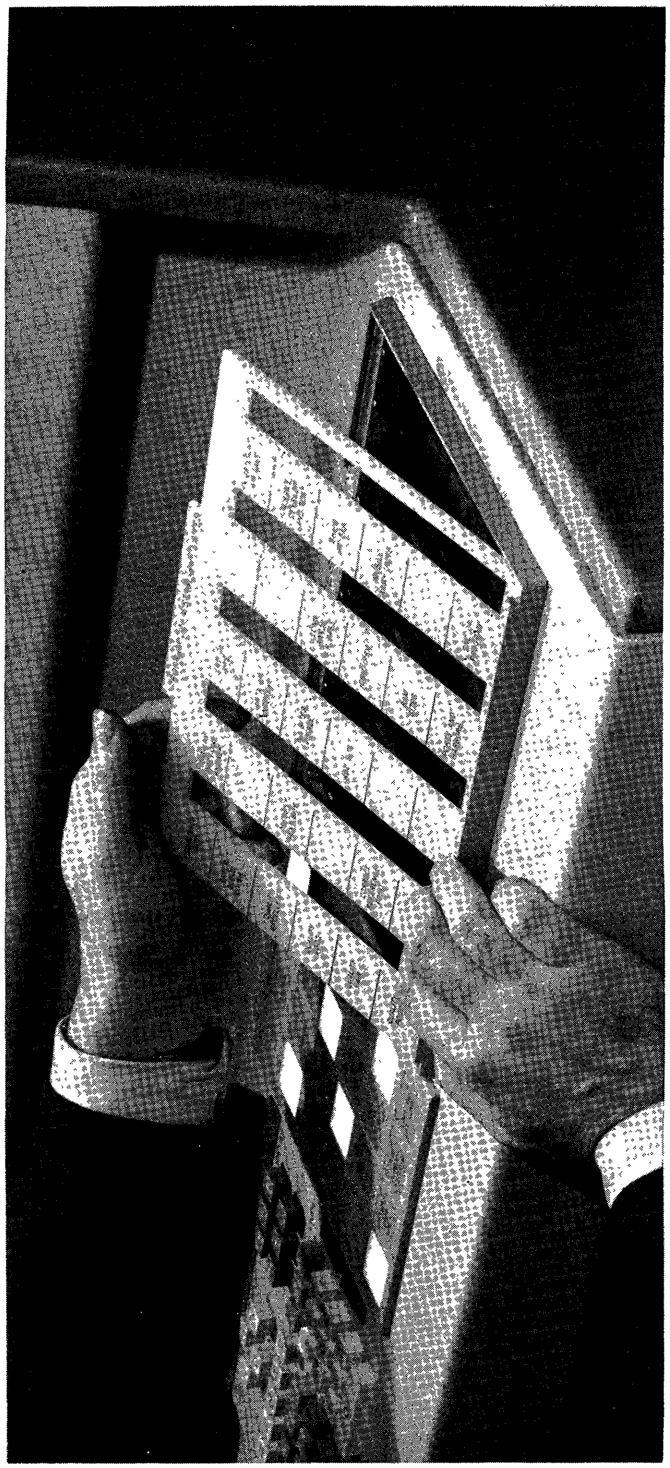

Figure 8. Console Overlay

projecting of the typical display chip is 30 to 60 seconds.

2. INFORMATION CLARITY AND DENSITY: The annotations appear as highly legible alphanumeric characters, lines, curves, or special symbols in any of eight fully saturated colors (including black and white); the background colors (full range) are equally well saturated. Background and annotations can thus be extensively color-coded.
3. INFORMATION PERMANENCE AND ACCESSIBILITY: Display chips constitute a permanent record easy to store and retrieve; individual chips are automatically selected from random access, 200-chip file magazines.
4. AUTOMATIC OPERATION: The film chip generation, processing and delivery is under complete program control.

These advantages are made possible by the use of various special techniques. The high overall response time is due largely to the high speed of photographic developing (1-1/2 seconds) resulting from a combination of two relatively new photographic techniques. One is that of color separation to create a color image from black and white film. The second contribution came from the use of Kalvatone film, which is a special type of black and white film that can be developed by heat instead of chemicals.

The legibility and color saturation of the displays derives from a "masking" technique that enables the annotations to be inserted into rather than superimposed onto the background so as to eliminate color mixing and weakening.

Convenient storage and retrieval derives from the unit record film chip. This slide can be projected on large screens or individual consoles. Slides can be duplicated and used for multiple projections or processed to standard color transparencies for dissemination or hard copy printing.

The equipment used to create the full color displays consists of four main units:

1. The Control Programmer, which receives display data and instructions from the computer and stores them temporarily for subsequent use by the Display Generator.
2. The Display Generator, which produces the actual display chip by obtaining the necessary instructions from the Control Programmer. According to these instructions, a display chip is sequentially exposed with particular sets of annotations, in given colors, and inserted in the desired space of the background specified. (This background can be any of 200 stored in the Display Generator's random access file.) It then develops the chip and, if requested, makes duplicates before passing it on.
3. The Monitor/Analysis Console, which is an operational viewing station used to perform quality control check on the production chips and maintenance control on the entire system.
4. The Display Projector (or projectors) receives finished chips from the Display Generator and projects them for individual or group viewing.

In the DODDAC these communication and display devices are electrically tied to the CDC Satellite System via one of the 160 computers. The relevant parts of this subsystem are shown in Figure 9. The 160 computer provides a satisfactory interface and is time shared between the following competing tasks:

1. refreshing of CCC's CRT display
2. control of CCC illuminators
3. monitoring of CCC output register
4. monitoring of 1604 communication
5. data output to the control programmer
6. message interpretation and composition
7. display subsystem control.

The display subsystem, however, entails more than the connection and operation of these equipments. The organization of data within the computer, the programming concerned with the retrieval of this information and the techniques employed in the requesting of data, are all integral parts of the man/machine communication. Because of the versatility of this display subsystem, the user is not restricted to a few standard displays from which he must deduce all the information required in the numerous situations he will encounter. Rather, he may request information for presentation in such a fashion that each display is tailored to the specific problem which exists at the time. Extraneous information is deleted from any display, leaving only that data which is pertinent to the situation at hand.

Accordingly, a great deal of flexibility is desired in making output requests. The CCC

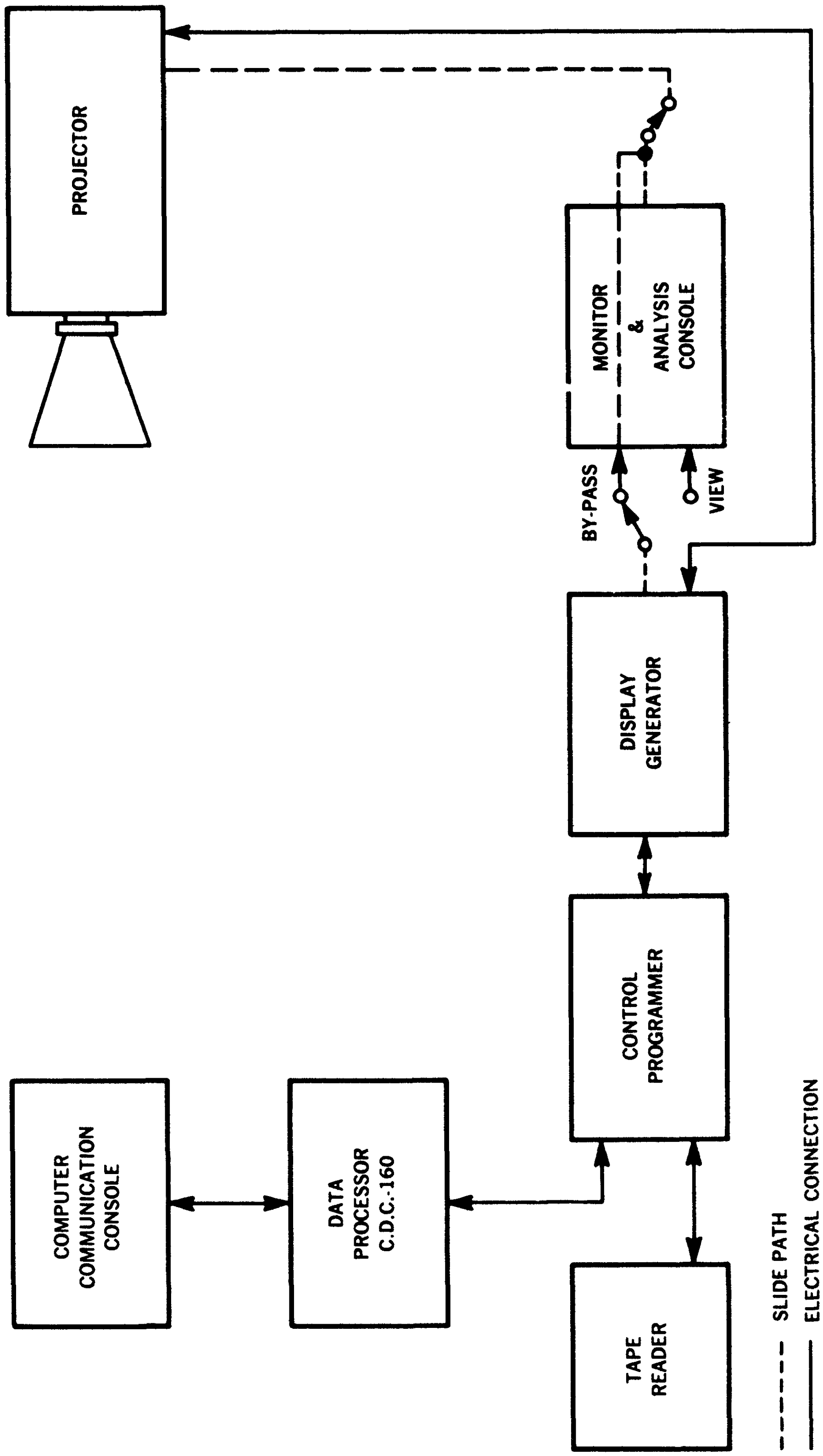

Figure 9. Full Color System Diagram

and the group display serve as the input and output elements for this process. In fact, the system user completes an information flow loop when he wishes to obtain data from the system as a result of viewing an output. This information flow is shown in Figure 10.

The output request overlay is instrumental in performing the interrogation. A suggestive implementation of such an overlay is given in Figure 11. After pressing the start button and registering the overlay to the computer, label lights are sequenced as a function of pressing each button. This sequencing is demonstrated in Figure 12.

Pressing any one of the keys will in addition to setting up this sequencing, also cause a CRT display to appear. These displays will generally be of two types. One allows the operator to make multiple choices of category items or alternatives. A second type will require data parameter inputs as specified in a form presented to the operator. In all cases, the parameters entered serve to set limits for the data retrieval and output processing programs.

DASA DODDAC Status and Developments

The integration of equipment, computer programs and man was initiated in the fall of 1961. In addition to having operational stature, the installation will be used to test the adequacy of damage assessment models, output displays, personnel requirements and general system design. Of particular concern is the establishment of communication interfaces and data input techniques.

Whereas the Developmental Center is located at the Pentagon, plans have been formulated for eventual DODDAC operation in other appropriate military environments. One of these is already installed and operating: the semi-automatic system at the Alternate Joint Communication Center the hub of which is an augmented IBM 1401 system.

As stated previously, we believe the Developmental Center System to be among the most modern large-scale data systems for real-time. The experience in using the system in the Center will add greatly to the design of future DODDAC systems which are responsive to the considerable requirements of the military mission.

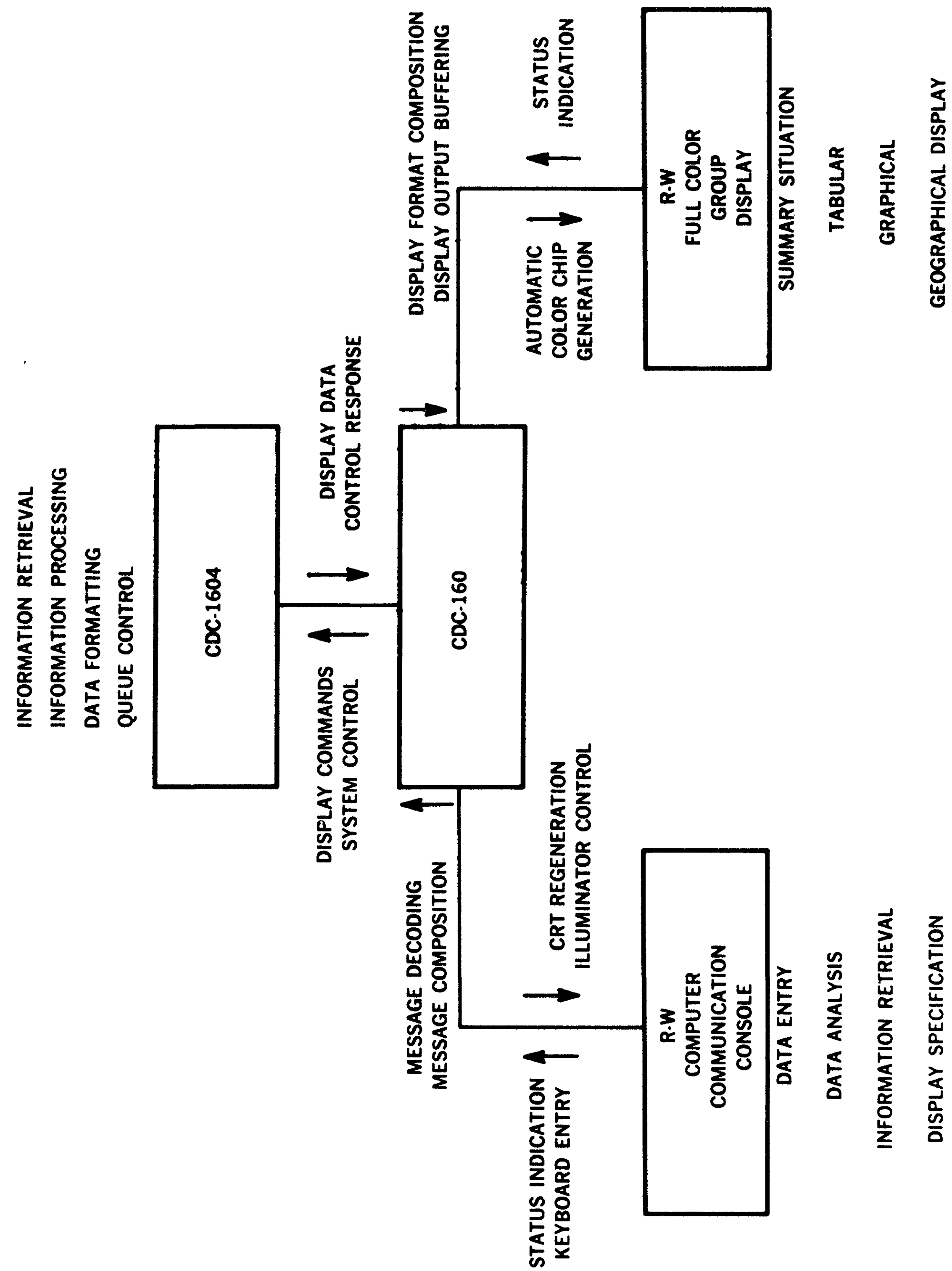

Figure 10. DODDAC Display Data Flow

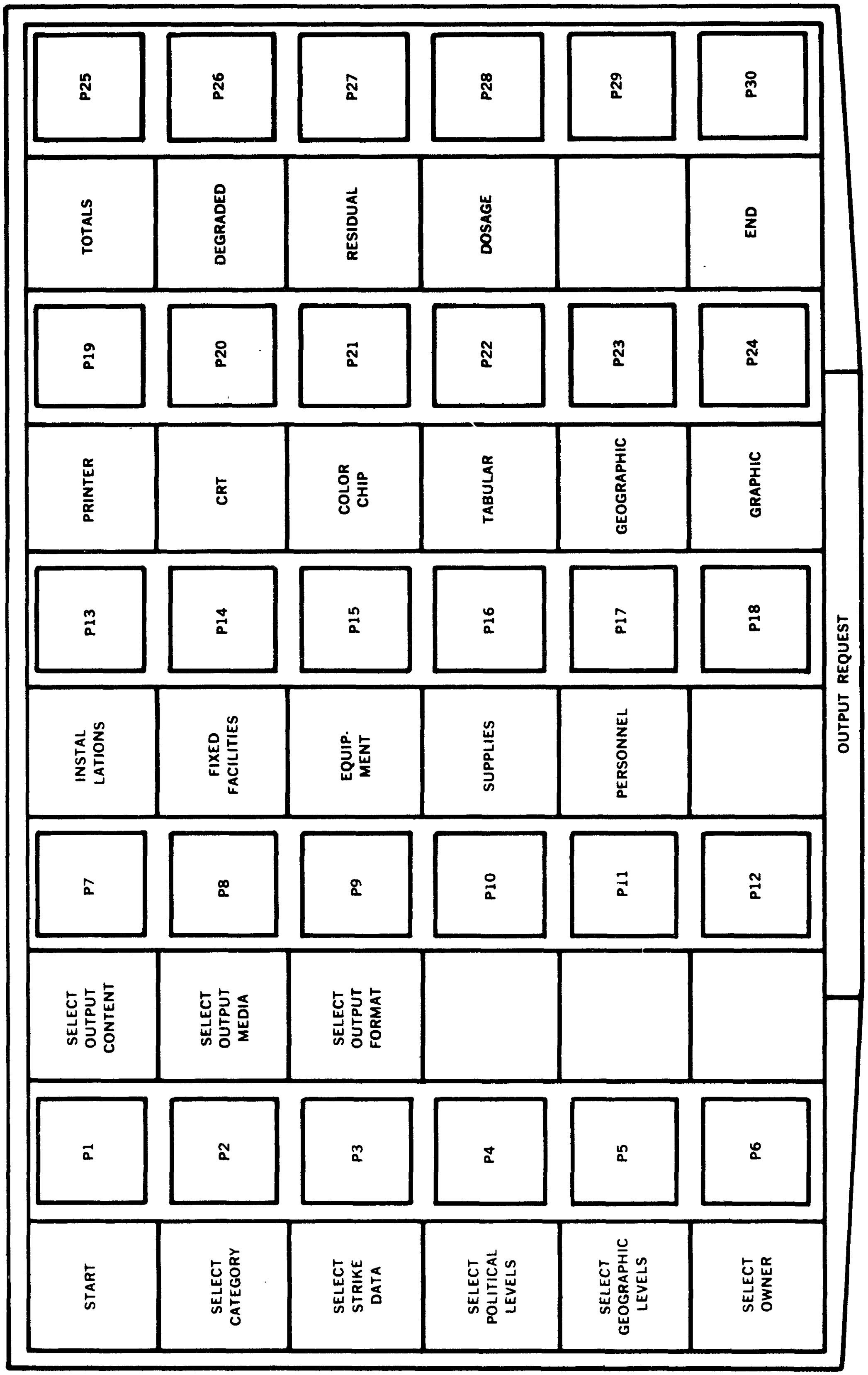

Figure 11. Process Step Key Overlay for Output Requests

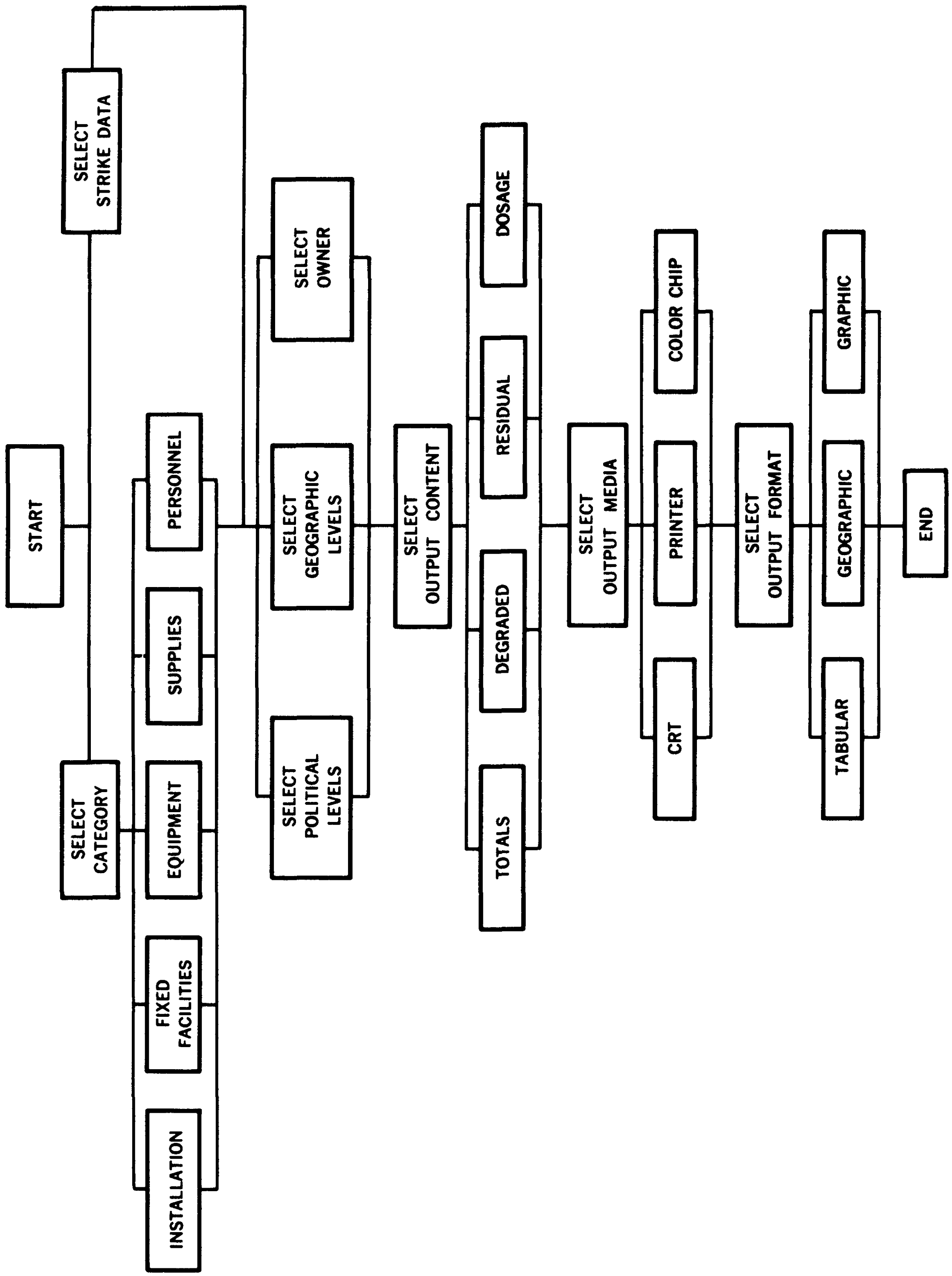

Figure 12. Sequence in Making Request for Data