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EARTH RESOURCES TECHNOLOGY SATELLITE FINAL REPORT

15. GROUND DATA HANDLING SYSTEM STUDY

PREPARED FOR

GODDARD SPACE FLIGHT CENTER
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
UNDER CONTRACT NAS5-11260

TRW
SYSTEMS GROUP

IBM
FEDERAL
SYSTEMS
DIVISION

Itek
OPTICAL
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EARTH RESOURCES TECHNOLOGY SATELLITE

FINAL REPORT

Volume 15. Ground Data Handling System Study

April 17, 1970

prepared for
National Aeronautics and Space Administration
Goddard Space Flight Center

Contract NAS5-11260
item 5a

TRW Systems Group
One Space Park · Redondo Beach
Los Angeles County
California 90278

CONTENTS

1. INTRODUCTION

The GDHS consists of two major elements OCC and the NDPF, and are organized under these two headings. There are several studies which are common to both; this volume presents these common studies.

The first study is on collocation of the OCC and NDPF. It is advantageous to collocate the two; section 2 presents the analysis of this question.

The second series of studies is on the subject of facilities, particularly in view of the stated desire by NASA for use of particular floor space. Hazardous times, cooling requirements, etc., are not unique functions of either the OCC or NDPF alone. These studies are presented in section 3.

A digital TV system has been analyzed for use in both centers; the requirements analysis leading up to it is given in section 4.

In order to select a computer of proper size, detailed studies were conducted on the capacity required for each subtask. In section 5, this study is presented. The sizing was done with respect to IBM series 360 machines. This series was selected for study convenience and represents no advance judgment on the computer selection, since a number of vendors make machines comparable to those used for baseline analysis.

1.1 FUNCTIONAL ANALYSIS

In order to determine what studies were required, and what subsystem elements would be needed in the final system, a functional analysis was performed. Figure 1-1 shows the overall flow for this analysis.

The detailed functional flows are bound as separate appendices to this volume because of their size.

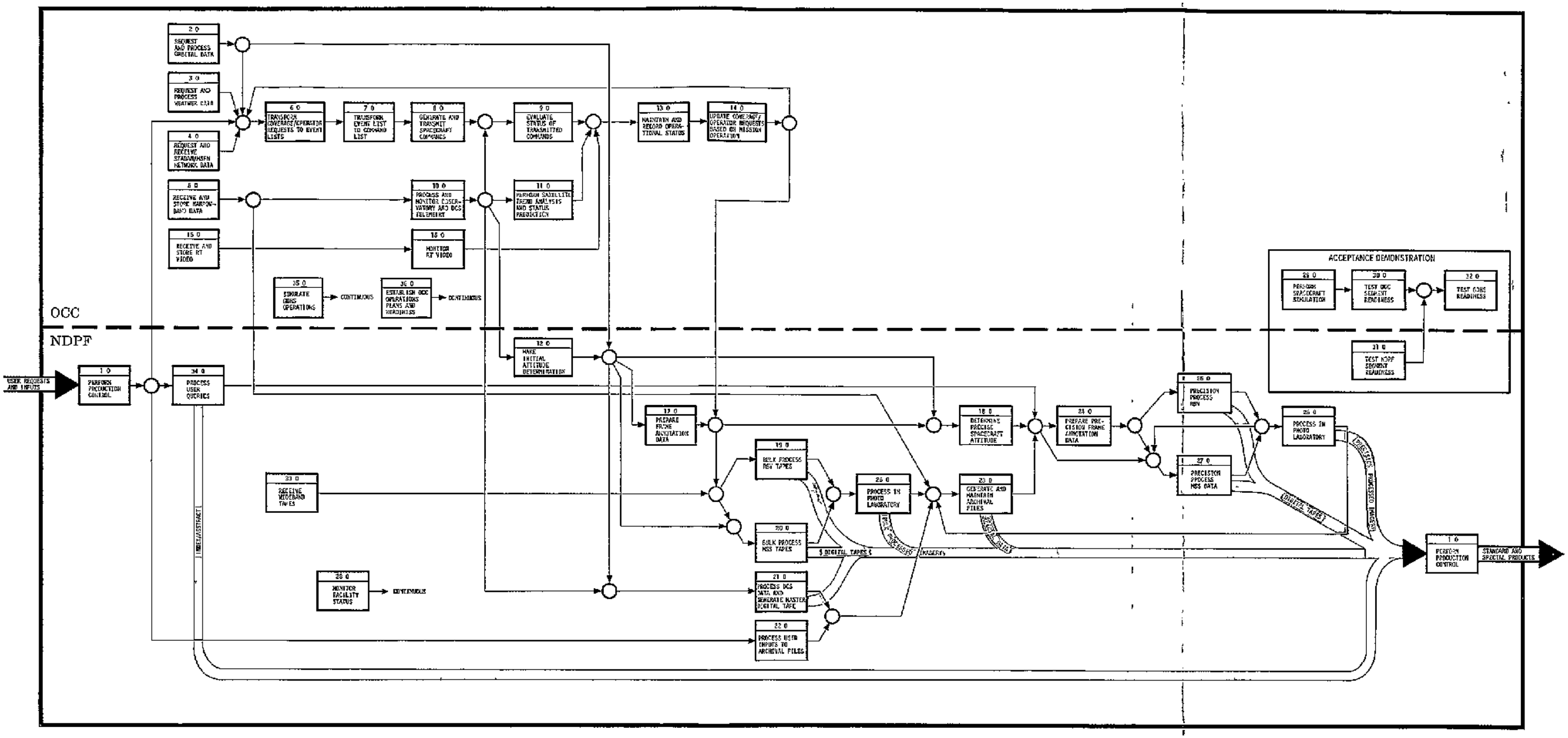

Figure 1-1
TOP FUNCTIONAL FLOW FOR GDHS

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FOLDOUT FRAME

FOLDOUT FRAME

2. OCC/NDPF COLLOCATION STUDY

2.1 INTRODUCTION AND SUMMARY

The following OCC/NDPF collocation study was performed to analyze the interface between the OCC and the NDPF and to determine the implications, in terms of hardware duplication, communication problems or performance degradation arising from a GDHS configuration wherein the OCC and NDPF are non-collocated; i.e., physically separated from one another. The analysis was performed for a dual and a single central processing unit ADPE configuration. The following basic study assumptions were made:

- For a single CPU ADPE configuration, it was assumed that the CPU would reside within the NDPF facility
- Operational philosophy and basic OCC-NDPF facility functions would remain the same for a dual or single CPU configuration.
- In a non-collocated configuration, the OCC would remain at GSFC.

The study was performed by considering the impact created by non-collocation on the following OCC/NDPF interfaces:

- Hardware interfaces
  - a) Unified display subsystem
  - b) Communications subsystem
    - (1) Intercom voice circuits
    - (2) Teletype and other communication circuits
  - c) Facilities subsystem
- Software interfaces
- Operational interfaces
  - a) User request processing
  - b) Video sensor data processing and evaluation
  - c) Personnel interfaces

- Contingency interfaces
  - a) NDPF equipment backup support to OCC
    - (1) Computer support
    - (2) Peripheral equipment support
  - b) Spacecraft sensor contingency resolution

The general conclusion drawn from the study is that the highest degree of overall system performance, with the minimum of required equipment, is attained with the OCC and NDPF in a collocated configuration. Through non-collocation of the OCC-NDPF, a requirement for more communication equipment and links is introduced, overall operational performance due to separation of the information gathering facility from the information processing facility is decreased, effective communication becomes more difficult between them, and interaction between them for contingency resolution becomes more involved.

In weighing the impact of non-collocation against a dual CPU or a single CPU configuration, a dual CPU configuration appears much more desirable. The communication links between facilities are greatly simplified with a comparable reduction in potential operational problems.

2.2 DETAILED STUDY ANALYSIS

2.2.1 Dual CPU ADPE Configuration

2.2.1.1 OCC/NDPF Hardware Interfaces

a. Unified display subsystem

1. Collocated.

   OCC and NDPF CPU's both provide format instruction and data to a single digital television display generator and buffer which drives both OCC and NDPF displays.

2. Non-collocated.

   The OCC and NDPF display subsystems will be independent subsystems, without shared components.

3. Impact of non-collocation.

   a. Separation of the display subsystems will require one additional DTV display generator and buffer.

Less complex DTV display generator and buffer units may be utilized.

b. Cross display capability between the OCC and the NDPF will be eliminated.

b. Communications subsystem

1. Intercom voice circuits

a. Collocated.

Intercom voice circuits are simple hardwire between the OCC and NDPF.

b. Non-collocated.

Intercom voice circuits utilize NASCOM lines.

c. Impact of non-collocation.

Dedicated NASCOM lines must be acquired with associated modem data adapters.

2. Teletype and other communication circuits

a. Collocated.

Incoming and outgoing communications for both the OCC and NDPF utilize a communications terminal equipment rack located in the OCC. Signal transmission internal to the OCC and NDPF is by hardwire.

b. Non-collocated.

Both the OCC and NDPF require communication equipment racks.

c. Impact of non-collocation.

An additional communications terminal rack is required with appropriate equipment. A teletype link, with accompanying modem data adaptér, is required between the OCC and NDPF.

c. Facilities subsystem

1. Collocated.

The OCC and NDPF are collocated at GSFC, Building 23, second floor.

2. Non-collocated.

The OCC and NDPF are considered separate entities located in separate facilities.

3. Impact of non-collocation.

There is no significant impact from a facility standpoint. Comparable facilities would have to be found for the separated entities. The only requirement for additional floor space may be the result of having to provide duplicate areas for tape storage, electronic spares/equipment storage, and electronic equipment maintenance.

Hardware duplication may occur in providing electronic equipment spares and maintenance equipment for the OCC and NDPF.

2.2.1.2 OCC/NDPF Software Interfaces

The GDHS design does not incorporate software which is shared by the OCC and the NDPF; therefore, no software interface impact occurs. The use of the NDPF for contingency OCC support is discussed in Section 2.2.1.4.

2.2.1.3 OCC/NDPF Operational Interfaces

a. User request processing

1. Collocated.

A user request enters the NDPF via the user liaison office, is processed as to availability of data, and transferred, when applicable, to the OCC via the unified display subsystem cross display capability.

2. Non-collocated.

The method of user request transfer from the OCC to the NDPF is via magnetic tape or punched card.

3. Impact of non-collocation.

Elimination of the unified display subsystem cross display capability introduces a change in the method of transferring user request data from the NDPF to the OCC. From an operation standpoint, this change implements a less desirable transfer method, but under normal operation there should be no significant impact. There would be introduced, however, a requirement for extensive data control procedures controlling normal request data flow and any changes to request data.

A consideration which may impede the quick response to a user request in the elimination of a personal, human interface between the NDPF user liaison office and the OCC satellite/mission planning personnel.

b) Video and PCM data processing and evaluation

1. Collocated.

Video data is received via magnetic tape at the NDPF from the Alaska and Texas ground stations. Video data from the NTTF is received in real time at the NDPF and recorded on video tape. OCC video quick look is available via the unified display subsystem cross display capability.

DCS and sensor/satellite housekeeping data are received in real time at the OCC, processed, and transferred to the NDPF as computer compatible digital data on magnetic tape.

2. Non-collocated.

Same as above except:

NTTF video data would be on magnetic tape.
OCC video quick look is eliminated.

3. Impact of non-collocation.

Under normal operation there should be no significant impact on data processing, although the data processing time will be increased due to the transfer time of OCC data tapes to the NDPF.

DCS data evaluation is not affected by non-collocation. Video data evaluation will be affected in several ways by non-collocation. OCC sensor performance evaluation will be seriously restricted by the elimination of the OCC video quick-look capability, due to absence of a cross display capability. Effective communication between OCC and NDPF personnel as to evaluation of and/or improvement of image quality is diminished by absence of OCC video quick look and OCC-NDPF separation.

c) Personnel interfaces

1. Collocated.

The capability exists for daily, personal interaction between OCC and NDPF personnel.

2. Non-collocated.

The personnel interface would primarily be by voice communication or mail.

3. Impact of non-collocation.

The capability for daily, close interactive communication between data processing/analysis personnel and satellite/mission operations personnel is eliminated. This loss of daily interaction and personal communication can degrade overall performance and efficiency in several ways. In the area of user request processing, effective communication between the user liaison office and OCC operations' personnel, which could facilitate knowledge of whether a request could be satisfied, is restricted due to the types of communication channels available. With a collocated OCC and NDPF, the opportunities for personal interaction leads to an overall higher level of personnel knowledge of ERTS objectives and the considerations and problems encountered in accomplishing them on the part of both the OCC and NDPF and provides valuable overall knowledge during contingency situations.

2.2.1.4 OCC/NDPF Contingency Interface

a) NDPF equipment backup support to OCC

1. Computer support

a. Collocated.

Assuming OCC and NDPF CPU basic commonality/compatibility, the capability exists to utilize the NDPF CPU for OCC mission operations planning and command generation functions.

b. Non-collocated.

Same as above.

c. Impact of non-colloation.

The implementation of, and the sustained operation of, the NDPF CPU performing OCC contingency support is more complicated in a non-collocated configuration. In addition to software transfer, mission planning personnel, with all required aids, must be transferred to the NDPF facility and function in a makeshift environment. In a collocated configuration, personnel would work out of their existing areas with no major disruption.

2. Peripheral equipment support

   a. Collocated.

      Both OCC and NDPF contain similar equipment; i.e., printers, strip-chart recorders, tape recorders, display equipment.

   b. Non-collocated.

      Same as above.

   c. Impact of non-collocation.

      The separation of the OCC and NDPF discourages the transfer of compatible equipment between the OCC and NDPF for resolution of an equipment problem.

b) Spacecraft sensor contingency resolution

   1. Collocated.

      Personal coordination between OCC satellite operations personnel and NDPF sensor data analysis personnel, together with quick correlation of PCM data with video data exists. OCC video quick look is available.

   2. Non-collocated.

      Video data is processed at the NDPF. PCM data is processed at the OCC and sent to the NDPF. Personnel knowledgeable in spacecraft/sensor systems and data processing must be assembled. OCC video quick look is not available.

   3. Impact of non-collocation.

      The time consumed for sensor contingency resolution increases with separation of GDHS facilities. Contributing factors are: the loss of OCC video quick look, availability time of correlated video and PCM data, sensor analyst/spacecraft operations personnel communications channels.

2.2.2 Single CPU ADPE Configuration

2.2.2.1 OCC/NDPF Hardware Interfaces

a) Unified display subsystem

1. Collocated.

   One computer providing format instructions and data to one DTV display generator and buffer which drives both OCC and NDPF displays.

2. Non-collocated.

   One computer residing in the NDPF facility which provides format instructions and data to two DTF display generators and buffers, one in the OCC and one in the NDPF. Each DTV display generator and buffer unit drives its respective display subsystem.

3. Impact of non-collocation.

   One additional DTV display generator and buffer is required. Less complex units may be utilized. A cross display capability is possible within this configuration.

b) Communications subsystem

1. Intercom voice circuits

   (reference 2.2.1.1 b.1.)

2. Teletype and other communication circuits

   (reference 2.2.1.1 b.2., with the following additional comments):

   a. Collocated.

      OCC and NDPF equipment signal lines are hardwire to the CPU.

   b. Non-collocated.

      Assuming the CPU resides within the NDPF facility, all OCC communication with the CPU must be via NASCOM links.

   c. Impact of non-collocation.

      NASCOM communication links must be acquired, with appropriate modem equipment, for all OCC interfaces with the CPU.

d) Facilities subsystem

(reference 2. 2. 1. 1 c.)

2. 2. 2. 2 OCC/NDPF Software Interfaces

All software is located within the NDPF CPU, single CPU configuration, and any actual or planned software interfaces would not be a function of the physical interface.

2. 2. 2. 3 OCC/NDPF Operational Interfaces

(reference 2. 2. 1. 3)

There is no additional, unique to non-collocation, impact on this interface.

2. 2. 2. 4 OCC/NDPF Contingency Interface

a. NDPF equipment backup support to OCC

1. Computer support

   In a single CPU configuration this is eliminated.

2. Peripheral equipment support

   (reference 2. 2. 1. 4 a. 2.)

b. Spacecraft sensor contingency resolution

(reference 2. 2. 1. 4 b.)

2. 3 STUDY CONCLUSIONS

Premise: To ensure satisfying the overall ERTS objective, i. e., to demonstrate the feasibility of utilizing satellites for earth resources study applications, it is necessary to attain the maximum possible capability in overall system performance and efficiency from the GDHS.

What has been accomplished in the foregoing analysis was to examine the functional interface between the OCC and the NDPF from four aspects; hardware, software, operational, and contingency. The interface was also examined based on a dual CPU and a single CPU ADPE configuration. The conclusions drawn, based on the foregoing analysis and the above-stated overall ERTS GDHS goal, are as follows·

Hardware: It is evident that in either a single or dual CPU configuration, additional hardware will be required, if the OCC and NDPF are non-collocated. OCC to NDPF communications will require NASCOM links and associated data adaption equipment; in the single CPU configuration this requirement may be considerable. Additional NASCOM links must be provided for the NDPF, along with a communications terminal rack. Additional/duplicate maintenance equipment and spares must be provided.

Software: Non-collocation does not impact this function area, except in contingency situations which is discussed below.

Operational. In order for the GDHS to achieve its goal in supporting ERTS, it is evident that all GDHS systems will have to and should operate together in as close and cohesive a manner as possible, ensuring the maximum opportunity for coordination between the OCC (information gathering) and the NDPF (information processing) facilities.

Non-collocation of the OCC and the NDPF has an inherent self-defeating influence on performance capability and efficiency, by the elimination of close, inter-active ties between the OCC and the NDPF which would be created through daily personal coordination between facility personnel. It is felt that if both OCC and NDPF personnel acquired intimate knowledge of each other's problems and responsibilities, personnel performance capabilities would be maximized. In the non-collocation configuration, this intra-facility knowledge would be difficult to achieve.

In a non-collocation configuration, overall ERTS control would involve two distinct facilities with separate objectives rather than one prime objective in an integrated collocated facility. By the very nature of things, the facilities in non-collocation will tend to view their own function as prime rather than relate to the overall ERTS objective. Data control and handling problems also increase for non-collocation.

The capability of the OCC to effectively monitor its data collecting performance via NDPF data processing is diminished by non-collocation.

The capability to analyze methods to improve data quality through coordination between data analysts and observatory operations' personnel becomes restricted by communication channels available.

Contingency For contingency situations non-collocation presents a distinct detrimental impact. If the contingency is within the observatory sensor systems, resolution becomes involved due to separation of the commanding and image analyzation facilities and knowledgeable personnel. Common equipment contingency backup support is restricted due to considerations of equipment transfer problems between separated facilities. NDPF computer backup support to the OCC is also now a more involved procedure.

The overall conclusion apparent from the foregoing study and conclusions is that the highest degree of overall system performance, with the minimum of required equipment, is achieved with the OCC and NDPF in a collocated configuration.

3. FACILITIES DESIGN

TRW systems group performed a detailed facilities system engineering analysis of the proposed GDHS site -- the second floor of GSFC Building 23. The three main objectives of our study were to

- Determine that Building 23 is an adequate facility for the GDHS
- Determine, by tradeoff analyses, the optimum GDHS facility configuration within Building 23
- Determine general and special equipment requirements.

Some of the factors considered in our study were

a) Space utilization

b) Work flow patterns

c) Utility requirements

d) Growth and expansion capabilities

e) Equipment layout

f) Safety and pollution control

g) Economy of facility development

h) Economy of operation

i) Convenience to NASA personnel

The major conclusions reached in TRW's analysis are the result of applying systems engineering techniques to a study of the total system. These conclusions are

- Building 23 will be adequate for the TRW-proposed GDHS
- Existing facilities and utilities with modifications and additions will meet GDHS equipment and operational requirements.

A major part of TRW's analysis effort was spent in performing trade studies. The areas considered were

a) Vibration control

b) Floor seal

c) Silver recovery

d) Material handling

e) Air conditioning

f) Drain and chemical reclamation

g) Water supply

These studies are discussed in the following sections.

3.1 VIBRATION CONTROL

TRW's investigation of the GDHS facility design revealed that it will be necessary to eliminate vibration in the image processing equipment. (Other types of GDHS equipment will not be affected by vibration.) TRW studied two approaches to vibration control: 1) control of the building, and 2) control of the equipment. Both the resident vibration values and the image processing equipment vibration values had to be determined. TRW set the criteria to analyze resident vibration and GSFC conducted a vibration survey of Building 23 and established vibration values. TRW with our subcontractor, Itek, is establishing the vibration values of the image processing equipment.

TRW studied methods of controlling vibration using both of the above approaches. Based on the results of our analyses, TRW recommends control of the equipment rather than the building. This decision is made primarily on the basis of cost. The cost of dampening or control of the building equipment or structure would be prohibitive.

The decision to control vibration of equipment resulted in further study. We had to determine the best method of isolating the equipment. We studied both partial computer floor and total isolation and concluded that the latter method would be most effective. TRW's plan for vibration control is to use vibration control pads and isolation blocks between the subfloor and each critical piece of equipment. Figure 3-1 is a sketch of the proposed method.

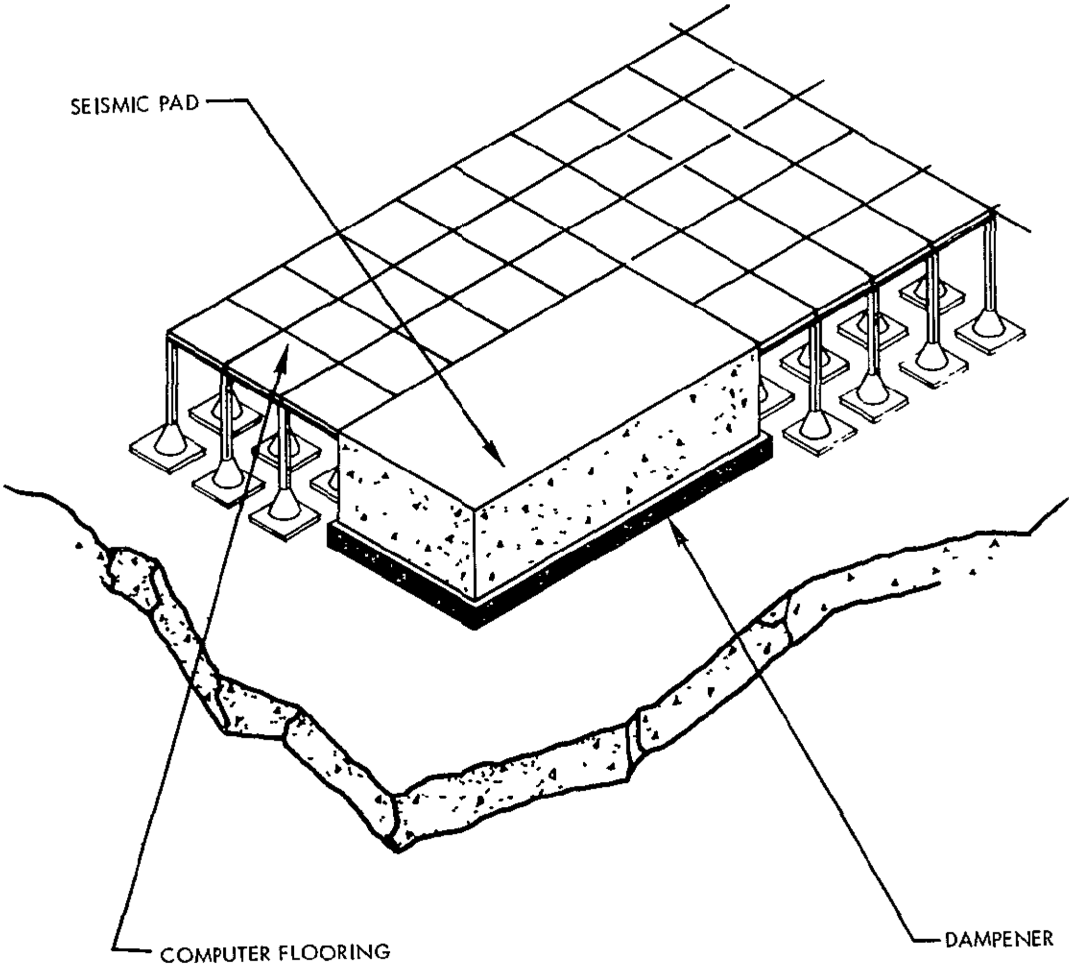


Figure 3-1

IMAGE PROCESSING EQUIPMENT in the BDHS will be protected from vibration by vibration control pads and isolation blocks.

3.2 FLOOR SEAL

TRW examined the subfloor of the TIDP computer floor area and found many penetrations and openings. We recommended that these holes be sealed so that water, chemicals, or fumes cannot escape through the floor and contaminate the DSL and the OCC areas, as well as the lower floors of the building.

In the study, TRW considered two concepts to solve this problem: 1) seal the entire TIDP area under the computer floor, and 2) seal only the rooms where wet or chemical operations will take place Figure 3-2.

TRW selected the first concept for study because all drains, water lines, and chemical areas, as well as any accidental spills or leaks, can be contained within the sealed subfloor. Also, wet or chemical operations can be expanded without further floorseal modifications.

TRW evaluated five methods of sealing the subfloor:

- 4 x 8 sections of acid resistant (RFP) material with sealed perforations (sealed with Plastisol).
- Hand layup of acid resistance RFP-80 MIL with sections of RFP sheet stock secured with fasteners and sealed with Plastisol.
- Koroseal (1/16" POC) loose liner heat sealed on floor and vertical partitions, fastened and dipped with Plastisol.
- Hand layup RFP on floor and vertical partitions with encapsulated seams and supports.
- Sprayed-in-place fiberglass coating.

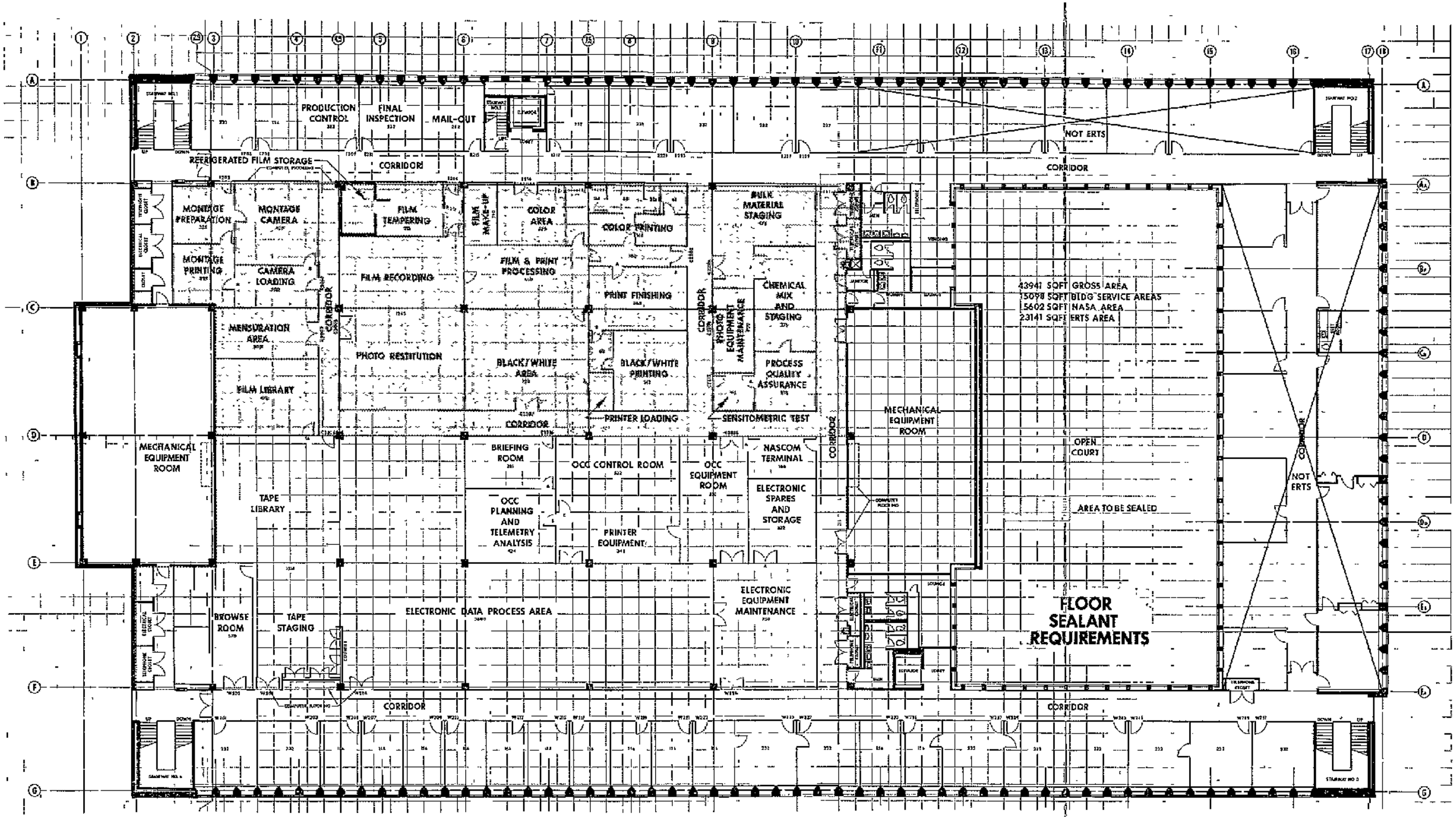
We used the following criteria to evaluate these methods of containment:

a) Resistance of seal to photo processing chemicals and water

b) Procurement lead time within schedule

c) Low cost of installation

d) Safety during installation; e.g., absence of toxic fumes in occupied area



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FOLDOUT FRAME

Figure 3-2

SHADING INDICATES THE TIDP FLOOR AREA THAT WILL BE SEALED.

FOLDOUT FRAME

e) Ease and low cost of removing seal and returning floor to original condition.

Although all five methods of sealing the floor generally meet the evaluation criteria, TRW recommends either the sprayed-in-place fiberglass or the Koroseal method. The main advantage of both is low cost. The spray-in-place fiberglass is easier to install as it can be used without removing the raised floor legs and the method has no seams. Although installation cannot take place while the area is occupied because of possible fumes, this is not a problem because the material can be installed before the area will be occupied. The main advantage of Koroseal is that the material is inexpensive. However, if Koroseal is used, the raised floor legs will have to be removed before installation and realigned after installation.

TRW also recommends that the floor seal system include a barrier between the TIDP and the DSL and OCC (in the subfloor area) for further protection of the GDHS electronic equipment (See Figure 3-3).

3.3 SILVER RECOVERY

TRW evaluated various methods of recovering silver from the NDPF processing fixing bath to determine the most practical and economical over a two-year period.

TRW studied three methods:

- Electrolytic recovery
- Metallic replacement
- Chemical precipitation

The following standards were used as a baseline:

a) 6 black and white automatic processors

b) 2 color automatic processors

c) 5000 lineal feet of 9-1/2 film (total all units)

d) the midrange of film solution, rate of flow of solution, and temperature.

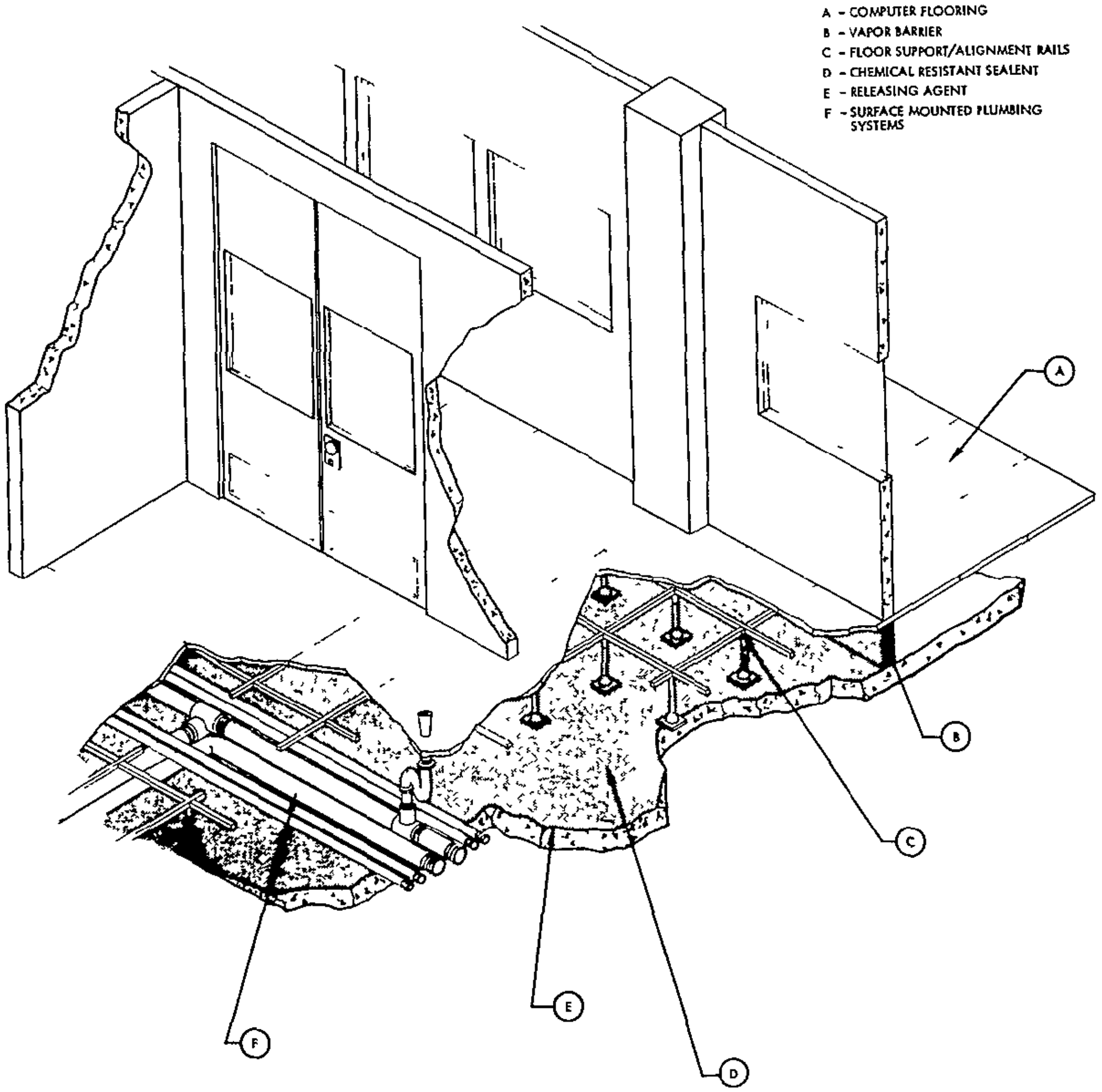


Figure 3-3

A SKETCH OF THE TIDP SUBFLOOR AREA SHOWS HOW THE FLOOR WILL BE SEALED.

The electrolytic recovery system places two electrodes, a cathode and an anode, in a silver bearing hypo. The hypo is then circulated through a filter by a self-contained pump to a separate collection tank. The tank is monitored for contaminates. The silver is removed by an electric current passing through the electrodes causing the silver to plate out on the cathode. The solution is then returned to the photo processing tank. Silver is continuously removed and the flow of solution is uninterrupted. This type of unit is currently used by the Air Force for a similar photo processing activities.

The metallic replacement system removes the silver by an ion exchange and entrapment process. The system requires a kit containing a filter, a pump recycling hose connection, a replacement canister attachment, and a testing indicator. The testing indicator requires periodic manual testing. The hypo solution can be continuously recycled. The only interruption is when the chemical recovery cartridge unit is removed and replaced. As with the electrolytic system, the metallic replacement system prolongs the life of the hypo by extracting the silver so that the hypo is reusable. A disadvantage is that the replacement canister must be sent to a refinery for silver recovery. The refining cost and shipping reduce the silver recovery value by 40 percent.

TRW evaluated several chemical systems and selected a chemical precipitation system, sodium hydroxide, to study in detail. All of the hypo must be removed from the processor. Sodium hydroxide is then added to the solution. The resulting chemical action causes the silver to become sludge which settles to the bottom of the container. The sludge is removed, dried, and sent to a refinery for recovery. Disadvantages of this system are that the hypo cannot be reused and handling is hazardous. In addition the costs of refining and shipping are as expensive as the metallic replacement.

Comparing these three systems, TRW found that the electrolytic system, among its other advantages, is the most economical over a two year period from both an operation and maintenance standpoint (Figure 3-4)--and silver recovery value. The electrolytic system returns a significant amount of silver. A preliminary estimate of silver recovery based on projected film processing is 1400 troy ounces per week.

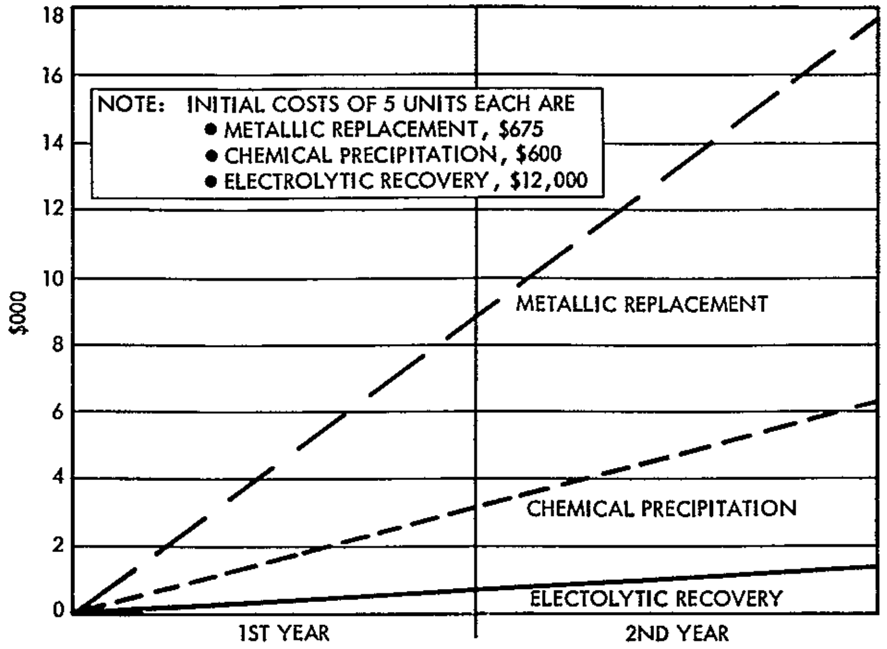


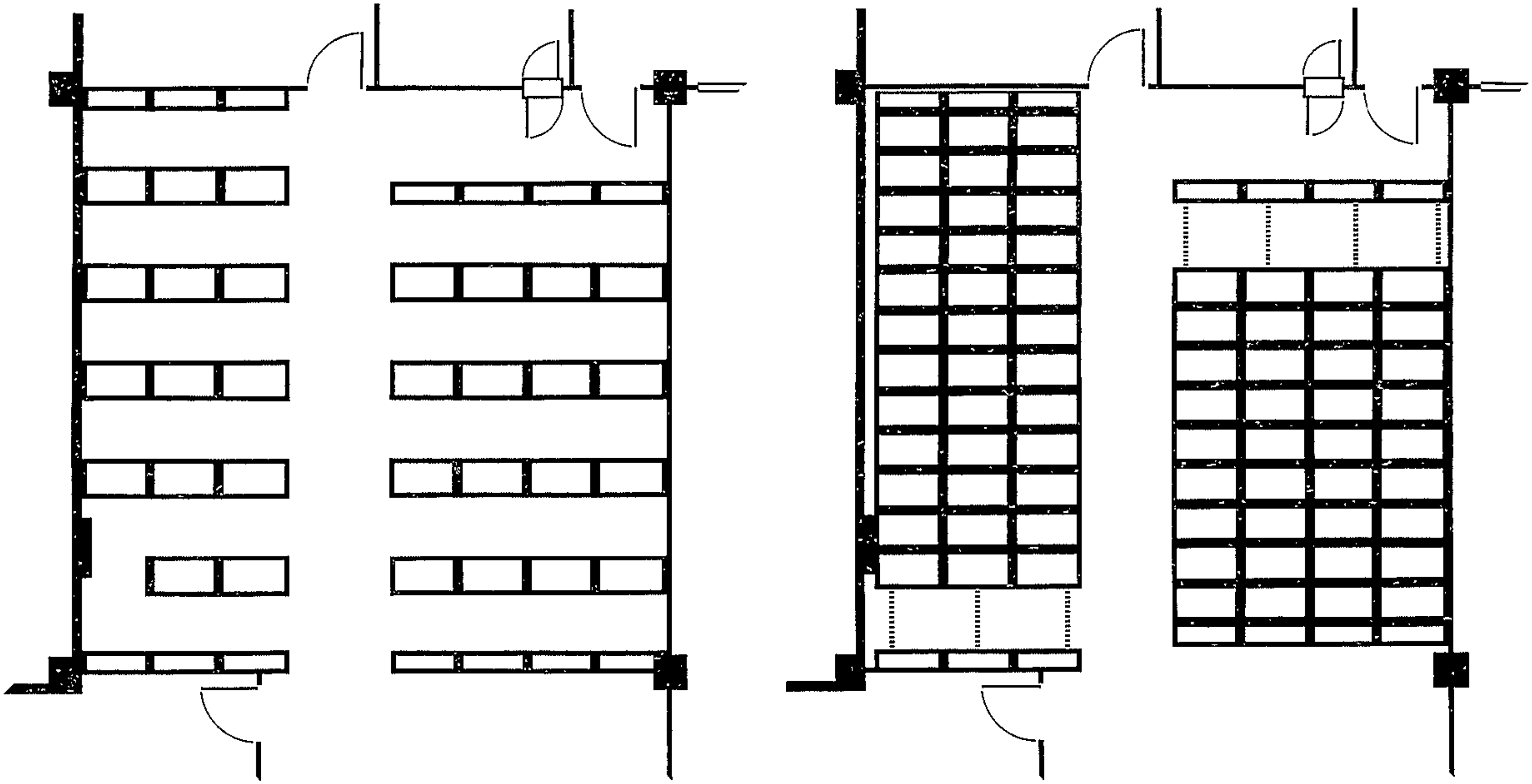
Figure 3-4
COST OF OPERATION, MAINTENANCE AND REPLACEMENT

3.4 MATERIAL HANDLING

TRW studied various methods of storing and transferring materials in the GDHS. TRW's facilities systems engineering analysis identified requirements for the following types of storage and transfer

Storage	Transfer
Tape reel	Film reel
Chemical	Raw stock and film
Finished film	Chemical
	Finished film

TRW evaluated tape reel storage requirements at program-start and for future expansion. A market survey revealed several types of storage cabinets are available that could increase capacity 100 percent over conventional cabinets in the same floor space. The cabinets are on wheels and tracks and can be easily pushed together or moved apart. Figure 3-5 compares the conventional system with the high density system. Tape reel and storage cabinets will be installed in the tape library.



CONVENTIONAL

HIGH DENSITY

Figure 3-5

HIGH DENSITY TAPE AND FILM STORAGE CABINETS have 100 percent more capacity than conventional cabinets in the same space

TRW determined that the best way to transfer and store dry chemicals is as follows. The chemicals will be transported to the second floor by elevator on a small hand pallet. They will be transferred from the elevator to the bulk material staging area, which is a short distance down the corridor. The chemical are then put into closed containers where they are held until they are mixed.

Undeveloped film will be stored in bins in a conventional refrigeration unit. Film storage of processed film will be handled in two ways. Reels will be stored in cans and flat stock will be put in protective covers. Both types of film will be placed in high density cabinets, like those used for tape reel storage. The cabinets will be installed in the film library which has a 750 cubic foot capacity. New storage space requirements are estimated at 1.5 cubic feet per day.

TRW evaluated ways to transfer mixed photo processing chemicals to the processing areas. We recommend conventional photo system piping because it is both adequate and inexpensive.

TRW considered several ways to transfer material. Pass-through windows, rollers and hand carts were given the most attention. TRW concluded that the carts are best because they are flexible and easily available. Special racks will have to be mounted on the carts to accommodate reels, tapes and film. Other nonfluid materials will be transferred by carts too. The carts can be used for staging and to deliver materials to more than one place.

3.5 AIR CONDITIONING

As part of the GDHS facilities study, TRW Systems Group facilities engineers were faced with the choice of recommending modification and balance of the present air conditioning system in Building 23 or installation of additional air conditioning equipment. After detailed analyses, we established total system compatibility requirements and subsystem, equipment, and personnel requirements for air conditioners. Further detailed analyses resulted in our decision to recommend modification and balance of the existing air conditioning system, to meet all of the requirements of the proposed TRW facility.

Some of the factors that we considered in our study were:

- Special requirements for electronic equipment.
- The need to separate chemical processing areas (TIDP) from electronic equipment areas (OCC and DSL).
- Fume control in the TIDP.

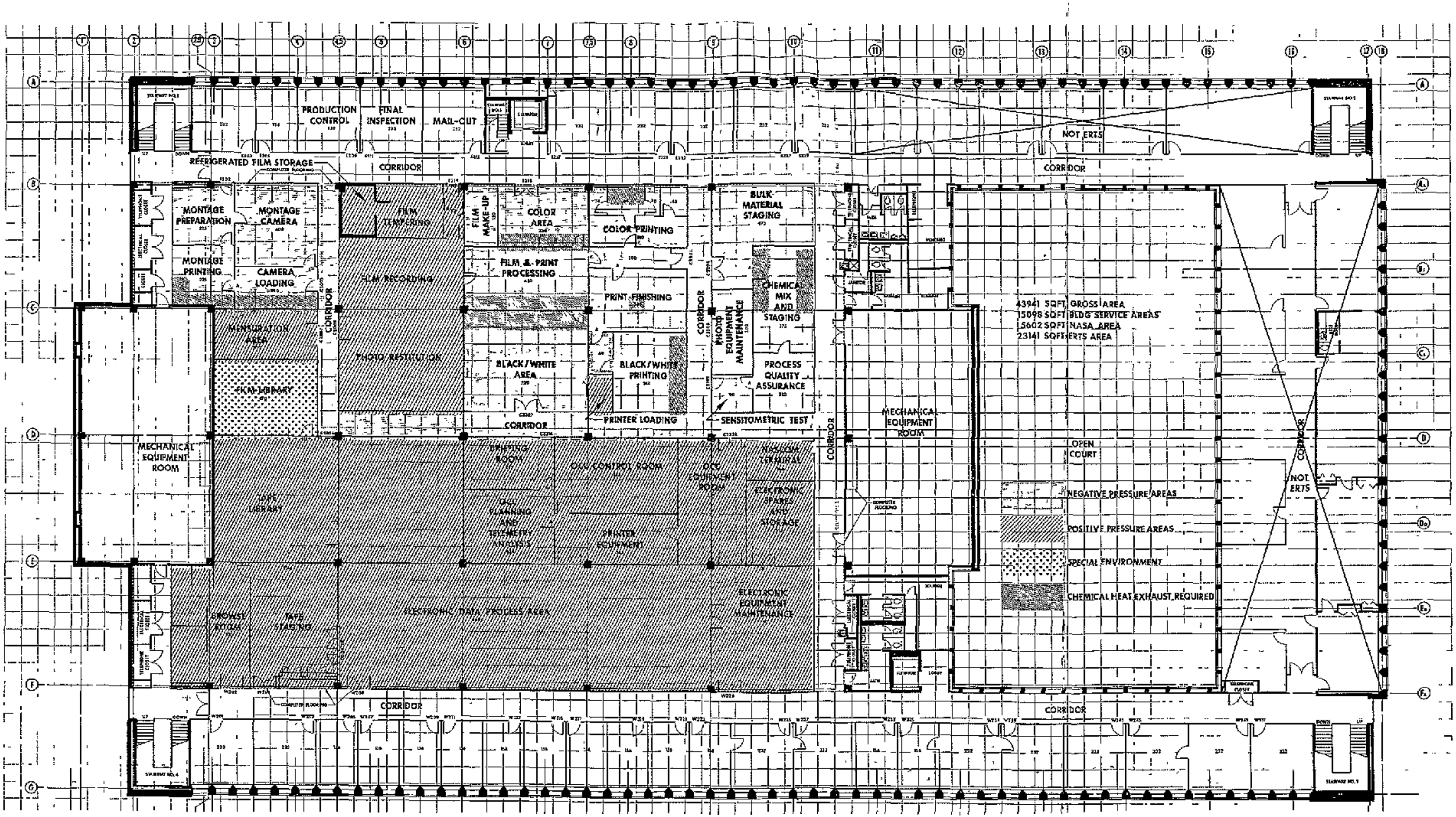
Details of the recommended system are described in the following paragraph.

The raised floor system should be divided into two areas because of the chemical processing in the TIDP. The separation should be made between the TIDP and the electronic equipment areas (Figure 3-6). The TIDP will be on negative pressure, except for the area below the computer floor which does not require an air supply. All the electronic areas, OCC and DSL, will be on positive pressure, including the sub-floor, ensuring that fumes from the chemical processing areas cannot contaminate electronic equipment. The film recording room and viewing/mensuration room, which contain electronic equipment, will be on positive air pressure. Modification and balance, in the positive areas, will also meet electronic equipment requirements. This balancing and modification, together with the floor seal installation discussed in section 3.2, will ensure contamination-free electronic equipment. Further modifications will have to be made in the TIDP to control fumes. Direct exhausting through the roof to the exterior of the building will be required in fume-producing areas, to prevent introduction of these fumes into the GDHS facility environment.

3.6 DRAIN AND CHEMICAL RECLAMATION

As part of the GDHS facility study, TRW studied possible water pollution problems that could be caused by disposing waste chemicals in the TIDP. TRW identified the types of waste materials that will have to be discharged through drains and determined how many and what types of drains will be needed.

The types of materials that will be disposed can be grouped into two categories: (1) chemical compounds that can be diluted or neutralized to prevent water pollution and (2) chemical compounds that cannot be diluted or neutralized to prevent water pollution.



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FOLDOUT FRAME

Figure 3-6

SHADING DIFFERENTIATES THE AREAS THAT WILL BE ON POSITIVE OR NEGATIVE AIR PRESSURE AS WELL AS THE AREAS WITH SPECIAL REQUIREMENTS

FOLDOUT FRAME

TRW's preliminary findings are that two drainage systems will be required to dispose of waste materials and prevent pollution.

- The primary system will include a water clarifier that will dilute chemical compounds so that they will not be pollutant.
- The secondary system will be closed and will collect those chemicals and compounds that cannot be diluted or neturalized with water. The chemicals will be collected in the system and held for disposal or reclamation. TRW is conducting further studies to establish the feasibility of reclamation.

TRW surveyed various materials that could be used for both drain systems and be fully resistant to all the full-strength processing solutions that will be used in the TIDP. In particular, we investigated plastics, such as polyethylene, polyvinyl chloride, polyvinyl dichloride, and polyester fiberglass. These materials can be fabricated into drain pipes of all ordinary sizes and have excellent corrosion resistance and adequate mechanical strength. TRW recommends that polyvinyl-dichloride be used in both drain systems, as it is not only easy to work with and inexpensive, but has a greater heat resistance than the other plastics.

3.7 WATER SUPPLY

Refined water will be required for special photo processing in the TIDP. TRW established the water system requirements for the utilities and equipment in the TIDP. We considered such factors as purity, temperature range, reuseability, and disposability. TRW then studied various methods of modifying the existing hot and cold water supply to meet these requirements. We selected two systems to compare and study in detail. Both use the existing domestic hot and cold water system for the water source.

1) Closed loop system: A reverse osmosis process requiring a water processing unit and a holding tank.
2) Open loop system: A clarification process that requires a vacuum type distillation unit; the existing building steam can provide its processing energy.

In comparing the two systems, we used the cost of the domestic water (25 cents per 1000 gallons) at the rate of 39,000 gallons per 8 hour shift as a baseline. To this we added the cost of buying the processing units, the cost of filtering and heating the water, the cost of maintenance, and space requirements.

The conclusions of TRW's study is that the open loop system is better than the closed loop system because it requires little space and maintenance and because it is not a boiler--require no operator. Also, over a five year period, the closed loop system is much more expensive as shown in Figure 3-7. The proposed system will require a 120 gph units with a 1000 gallon retained tank in the equipment room.

Additional study will be necessary to establish special water requirements such as filtering, distilling and polishing.

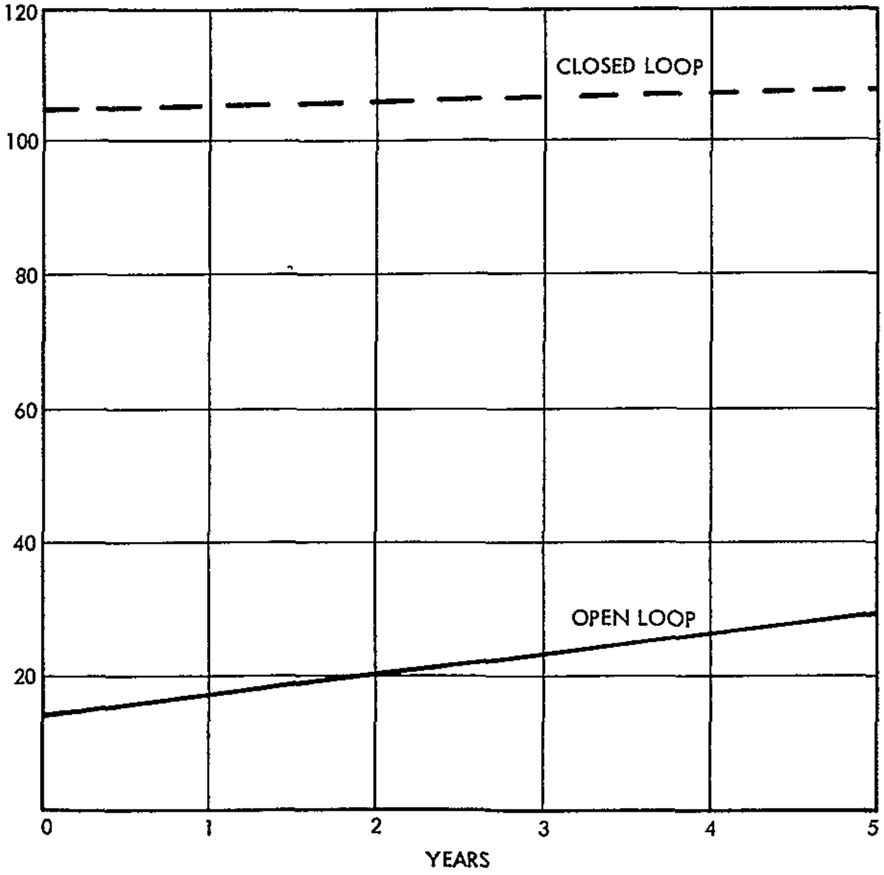

Figure 3-7

COMPARISON OF COSTS between open and closed loop refined water systems shows that the open loop is more economical to operate.

4. DISPLAY SYSTEM ANALYSIS

4.1 INTRODUCTION

The GDHS has a number of display needs; e.g., vehicle status in the OCC, and viewing images in the NDPF which have been stored in digital form. The range of such needs is fairly wide, however, it appears that there are enough common elements to make a unified display system feasible.

If such a unified display were proven feasible, then it would be most desirable from the points of view of flexibility and ease of support. With this possibility in mind, an analysis was made of the requirements. The result of this analysis, presented in the following sections, has led to the identification of a digital RV system suitable for common display needs.

Before proceeding into the analysis, it is useful to examine the system environment.

- There will be two data processors in the system. Backup concepts require that either processor be able to drive OCC displays.
- There are many points in the system where interactive displays are required, i.e., there will be a number of personnel on-line most of the time.
- Within this environment, four basic operational requirements have been identified; and four primary system requirements have been imposed by the system architecture.

4.1.1 Basic Requirements

The basic unified display system requirements are GDHS peculiar (e.g., system operation as opposed to NDPF or OCC operations) and include:

a) Interface capability and flexibility

b) Growth potential

c) Cost per unit

d) Input/Output capability and availability

4.1.1.1 Interface

A two computer system has been configured for the GDHS. To provide operational flexibility the display system should be capable of interfacing with either computer data base. The interface will be sequential via computer data base on request. The software to perform this function should not be complex.

4.1.1.2 Growth Potential

For system growth, the display system should have the capability of expansion at a cost commensurate with the initial system cost. Areas of potential growth include the addition of closed circuit television, a large screen (3' x 4') RBV and MSS projection device, and a spectral analysis console with color capability.

4.1.1.3 Cost

Cost per unit must be commensurate with overall system total, without geometrical cost increases for expansion.

4.1.1.4 Input/Output Capability

The Input/Output system requirements will be evaluated for availability and capability in meeting the Input/Output requirement posed by the GDHS operations concept, which requires multiple input devices.

4.1.2 Primary Requirements

The primary UDS requirements are imposed by NDPF and OCC design and operations concepts. These requirements include:

a) Classification of presentations

b) Quality of presentation

c) Quantity of data presented

d) Number and loading of console stations

4.1.2.1 Classification of Presentations

Three major classifications of presentations have been determined from the OCC and NDPF; formatted alphanumerics, graphics (line drawing), and pictorial (video) imagery.

Formatted Alphanumerics

The OCC requires the utilization of large quantities of formatted alphanumeric characters for the presentation of:

- Observatory instrumentation list
- Satellite command sequence
- Satellite command history
- Stored command programmer contents
- Contingency message
- Satellite trend data
- Spacecraft command status
- Payload command status
- Ground swath
- Sensor event list

The NDPF requires similar alphanumeric presentations including:

- Scheduling
- Inventory control
- Status monitoring
- Work load forecasting
- Process user requests
- Program development
- Program modification

Graphics

Although graphic requirements are not severe, graphic presentations can enhance the interactive capability. The OCC graphic requirements are concerned mainly with trend analysis and ground swath prediction.

The NDPF graphic requirements support:

a) Imagery annotation
b) Cloud area delineation
c) Ground swath (predicted coverage)
d) Map reference data and coordinates (e. g., Georefs)

Pictorial Imagery

The requirements for pictorial imagery support both the system image processing function (NDPF) as well as providing OCC usable imagery for "quick-look" analysis of sensor, recorder and related transmission operations. Requirements for pictorial imagery within the NDPF are concerned with: (1) verification of imagery selected for precision processing; and (2) selection of sub-areas (in bulk mode) for processing as well as rapid cloud screening.

Prior to precision digital processing of an image, it may be desirable for the operator or the requester to view the video image prior to processing. This would primarily be to assure that the correct image is processed. A high resolution terminal is required for displaying the actual RBV/MSS imagery.

Prior to precision processing in the bulk mode, there is a requirement to select sub-image areas by the use of a cursor the areas to be further processed. This requires a line graphic capability for delineating cloud or water areas, and it could be used to select 25 x 25 and 50 x 50 mile areas within the 100 x 100 images.

Pictorial imagery requirements for the OCC are concerned mainly with sensor and recorder status analysis and control by a "quick-look" capability. The "quick-look" capability requires a 1050-line resolution capable of providing resolution of 1/4 of the available RBV line structure for the full frame. Two magnifications should be provided functionally at each console which permit: (a) any 50 x 50 nautical mile area selected by cursor control) to be displayed on the full screen at 1/2 resolution, and (b) any 25 x 25 nautical mile area similarly selected to be displayed at full resolution. By means of central hard copy generator, any displayed quick-look frame may be documented for later examination and/or annotation. Utilization of the display system for imagery quick-look for rapid sensor evaluation requires high quality imagery.

4.1.2.2 Data Quality

The quality of the presentation includes those characteristics which directly influence the operator's capability to view a given presentation without fatigue and to obtain required information rapidly and efficiently.

These characteristics include flicker, character size, resolution, contrast, and intensity.

Flicker

Flicker can cause viewer fatigue and is not tolerable. It is a requirement that GDHS display shall be free of apparent flicker. Most versatile displays in use currently are regenerative systems; competent design will provide stable images.

Character Sizes

Minimum character sizes are based upon several considerations; the distance between user and screen, visual angle of the viewer's eyes in relation to the display screen. In order to differentiate between subclasses of data and provide emphasis (contingencies, priorities), two distinct character sizes are warranted.

Resolution

Resolution requirements for the viewer are directly related in many respects to the character sizes, and have a definite effect on the efficiency of operator functions. If the viewer cannot visually distinguish between adjacent display elements (at a given distance and visual angle) which compose a given image or character, the resolution of the presentation meets basic user requirements. Higher system resolution is required, however, to provide the video imagery presentations without a serious degradation of video imagery quality and provide a direct magnification capability. (Section 4. 1. 2. 1.) Based upon the higher imagery requirements, coincident with the provision of better appearing characters, a relatively high (1, 000) line display requirement is apparent.

Data Quantity

The data quantity refers to the number of symbols (discretes) which the display must be capable of presenting. The quantity of information which must be presented to OCC operations personnel is based upon the total data received into the OCC, and the pre-processing or data filtering functions (on pre-set limits), provided within the data processing function, preventing nominal data from overloading the operator/monitor with data not requiring crew intervention.

It is estimated that as many as 500 parameters and subfunctions could be available with uncontrolled output functions, which would limit the effectiveness of the operator.

Using the limits provided by software (from operator inputs) the number of parameters which are required for display will vary between 30 and 128, depending on command lists activated and specific limits set. It is estimated that 200 display frames will be required for each 24 hours of operation. These presentation frames have a maximum character base of approximately 100/line at 50 lines.

The NDPF requirements for display presentations are less than those presented for the OCC, nominally 50-60 characters/line at 30-40 lines. Consequently, quantity capabilities for the OCC would meet NDPF requirements.

4.1.3 Contrast and Intensity

Both the NDPF and OCC will have similar levels of light ambience; their luminance requirements would be similar. Basically a luminance of 40 foot lamberts, adjustable for operator preference (0-40) at a 20:1 contrast ratio (white to black) will meet requirements.

4.2 DISPLAY APPROACHES

In general, the display requirements for the OCC and NDPF are similar (requirements for one occasionally exceeding the other and vice versa). Consequently, a single display configuration will suffice for both.

In summary, GDHS basic requirements include:

a) Two processor data base interfaces
b) Efficient system expansion
c) Purchase efficiency
d) Input/Output capability for multiple inputs from each console

The primary requirements include:

a) Alphanumeric presentations, multiple formats, 80-100 characters per line, 50 lines per frame
b) Graphics - typically lines and curves
c) Pictorial imagery capability
d) Flicker-free, stable images
e) Adjustable luminance

4.2.1 CRT Based Interactive Configuration

Several devices capable of providing computer generated displays are readily available, impact and electro-optical printers, electro-mechanical plotters, CRTs and electro-mechanical readouts. These devices with the exception of the CRT based system are not efficient interactive channels. The basic design of the OCC requires an interactive system whereby efficient control of the system is provided by the operating crew employing an advanced data processing system as a management tool. Consequently, devices capable of both versatile computer input as well as display output are required. Recorder/plotters, readouts and printers do not have the interactive function. Limited interaction is possible by associating an input keyboard with either a printer or readouts. This technique is inefficient due to the response time differential between the keyboard, computer, readouts and printer. In addition, graphics, imagery or closed circuit television techniques cannot be utilized.

The NDPF requirements for display interaction are similar to the OCC. In addition, many more information queries, direct and indirect process control actions as well as on-line program implementation and modification are required.

The NDPF and OCC both require imagery display; the OCC for "quick-look" mission assessment, and the NDPF for several aspects of image processing.

4.2.1.1 Character Generator

The character generator is the "heart" of the CRT display system; in that system costing, peripheral configurations, and system flexibility revolve around the type of character generator being used.

Two major types of character generation are: beam writing and raster scan. In addition, beam extrusion (charactron) techniques were considered, but eliminated for a lack of flexibility.

The beam writing techniques include: stroke, Lissajous, and programmed dot. For this analysis the stroke-writing technique was chosen as a representative method of this type of character generation.

Stroke-writing techniques are a series of line segments to define particular characters. Each stroke is generated in sequence by switching between appropriate voltage levels, causing the CRT electron-beam movement.

Characters are formed by varying combinations of x and y voltages to deflection circuits causing vertical, horizontal, and diagonal strokes. Intensity control signals are varied depending on stroke lengths. Individual character control sequences are stored in digital or analog form.

Digital television is the presentation, on TV monitors, of an artificially digitally composed television raster. Digital data, received from a computer, is converted in memory to an image of the desired display. Each TV line is divided into specific number of picture elements and one bit of storage is provided for each element. The memory is then read out sequentially in synchronism with the television sweep to present a picture on the monitor.

4.2.1.2 Tradeoff

The two display systems utilize the same general components; however, the technique of applying these components to achieve a similar result is different. In the stroke-writing system, the refresh memory which cycles to refresh the CRT precedes the display generator, whereas the refresh memory succeeds the display generator in the digital TV system. This means that the symbol and vector generators of the stroke system must recreate the entire display every refresh cycle, whereas in the digital TV system the display generator can stand idle during CRT display refreshing. The digital TV display generator then operates only during updates, and then only on the portions of the display which change.

Both display generator techniques support display systems which fulfill most of the basic display system requirements. As an example, both techniques interface with any computer system on the TRW procurement list. Growth potential is provided for in both types of systems although the related costs vary, and will be discussed. The Input/Output capability is satisfied in most cases by both systems with respect to display generator requirements, consoles, large screen capability, and hardcopy generators. There are differences, however, which are considered in the following sections.

Stroke Writing

The stroke-writing capabilities compared to the functional requirements listed in this study are as follows:

a. The capability to interface with a computer exists, however, small modifications may be required to match required word length depending on the systems selected. Also, a demultiplexer arrangement will be required to enable two or more controllers to be driven from the same computer.

b. The growth potential of stroke generation techniques are limited. Additions of light pen or trackball are easily accomplished; however, increased numbers of consoles, imagery presentation capability, or the additional monitors (repeaters) is not possible.

c. The stroke technique provides for all of the man-machine interface requirements of the GDHS with the exception of video mixing and polarity reversal. Other deficiencies or required modifications were noted in previous paragraphs relating to growth potential. The stroke technique offers the following Input/Output capabilities:

    1) Alphanumeric Keyboard programmed function keyboard interfaces.

    2) Lightpen or trackball interfaces.

    3) Alphanumeric characters — 2-4 sizes are available depending on the specific device chosen. The character fonts are hardwired and they are not readily changeable. The characters are very pleasing to the eye as the stroke-writing technique provides for rounding of corners. The symbol and vector position registration, however, is degradated compared with the display resolution because of the use of analog signals. As an example, resolution may be one part in 1, 024, but registration error of a display to a background map may be 1 percent or worse.

4) Full length vectors are available.

5) Flicker-free presentation — Because the entire display is recreated every refresh cycle, the refresh rate can fall behind the critical fusion frequency (CFF) when the display generator is placed under the strain of producing very large numbers of analog vectors or symbols.

6) Blinking character and vector capability.

7) The stroke-writing monitors utilize large consoles because much of the sophisticated logic involved for display generation is contained in each console. Additionally, the use of analog techniques requires frequent adjustments.

8) The MTBF is relatively high, since each channel may have its own generation logic. Thus, if one channel fails, the others remain active.

Digital TV

The digital TV capabilities compared to the functional requirements listed in this study are as follows:

a. The digital TV technique interfaces with computers via an Input/Output buffer located in the data processing units of the video system. Distribution to TV monitors is accomplished by distributing the digital video output signals to each individual monitor.

b. The growth potential of the digital TV with respect to the expansion areas described in this study is one of the prime advantages of this technique. This digital video output to a video large screen projection display system can be made without conversion. The digital TV generator provides color capability by utilizing a group of three channels, one each for the primary colors, and outputs these channels are mixed within a color TV monitor. Lightpen or trackball capability can be adequately interfaced with the scan technique. Video signals from other sources such as background slide file and video tape can be mixed with digital computer output to provide a "video mix" presentation.

c. The digital TV technique provides for the man-machine interface requirements for GDHS operations, including those not available with the stroke technique. The digital technique offers the following Input/Output capabilities:

1) Alphanumeric keyboard and programmed function keyboard interfaces.

2) Lightpen or trackball interfaces.

3) Alphanumeric characters — variable sizes may be presented. The character fonts are stored in the digital TV and may be program changed by the computer to add new or modified characters or symbols. The character fonts are constructed by dot patterns and may tend to display square corners. The display registration of dynamic data to referenced background maps, grids, tables, etc., is essentially perfect since all symbol or vector elements are generated by the same high precision digital circuits. This is one of the major advantages of the digital video system.

4) Full length vectors are available.

5) Flicker-free presentations — The individual channel display processing time does not affect the refresh rate as individual refresh buffers are provided for each channel insuring an adequate refresh rate to prevent flicker.

6) Blinking characters and vector capability.

7) The monitors are standard high precision TV monitors and are easily and compactly mounted on consoles.

8) Signal distribution is much less costly for analog systems and can be done over long distances without introducting symbol jitter.

9) Video polarity reversal is available, which is particularly important for high resolution map displays. The presence of a large number of white symbols on a black background causes a "dazzle" effect, which can be eased by reversing the polarity. Similarly, a few white symbols or vectors on a background is often preferred.

10) The addition of repeater, or slave displays, can be accomplished at a very low cost.

11) The MTBF is moderate to high depending on the frequency that the system is intentionally shut down. All channels may share a single display generator.

4.3 CONCLUSION

Table 4-1 compares the two types of video generation techniques in terms of basic and primary requirements. Both systems have basic display capabilities; however, the digital TV technique has additional capabilities that are desirable in the GDHS. These include video mixing, polarity reversal, higher registration, video mixing, and the growth potential in the desired areas. Figure 4-1 shows cost trade off for multiple channel systems.

4.4 RECOMMENDATIONS

The digital video display system is recommended, based on a relatively large cost differential per channel, the additional capabilities of this type of system with respect to high registration, video mixing, and the growth potential. It will meet all current system requirements for the OCC and NDPF.

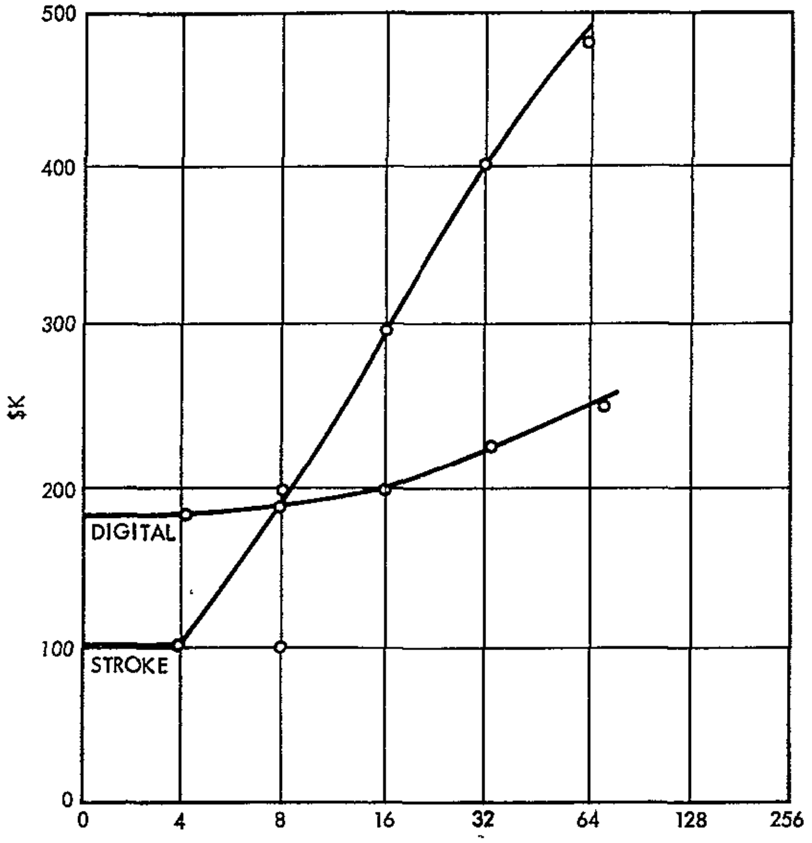

Figure 4-1
COST TRADEOFF FOR MULTIPLE CHANNEL SYSTEMS

Table 4-1. Comparison of CRT Display Systems; Digital vs Stroke

	Processor Interface	Growth	Cost/Unit	Input/Output
Basic requirements				
Digital	excellent	Relatively inexpensive additions	Initially high increased numbers decreased unit cost	good
Stroke	excellent	Expensive, system duplication	Initially low, very expensive over 4-8 terminals	good

	100 x 50 Characters	Graphics	Flicker Free	Imagery	Contrast and Intensity	Resolution for Imagery
Primary requirements						
Digital	Yes	Partial or fully random	Yes*	Yes	0-40 30:1 variable	1000-1500 TV lines
Stroke	Yes	Random	When refresh* buffer permits	No	0-40 30:1 variable	NA

*Digital video systems are intrinsically flicker free and independent of displayed data density when the correct frame rate/phosphor combination is selected. Stroke writing systems are data dependent since frame time is a function of data density (per frame).

5. COMPUTER REQUIREMENTS ANALYSIS

5.1 INTRODUCTION

In order to recommend a computer configuration for the NDPF it was necessary in the phase B/C study to size the system based on the central processing unit (CPU) and unoverlapped* input/output (I/O) times for each basic computer function.

Section 5.2 includes the timing and sizing analysis for each function, and section 5.3 uses the sizing figures to configure the base system. The detailed sizing and computer configuration figures are found in appendix A.

All figures associated with image processing in case B are based on eight images per set, three RBV and five MSS, in order to approach the worst case throughput rates of ERTS B, case B. Elsewhere in the study, other volumes, there are references to statistics and figures e.g., images per day, etc. which are based on seven images per set.

5.2 TIMING AND SIZING ANALYSIS

The objective of this analysis is to identify and recommend those computer configurations that can adequately perform the NDPF workload. The normal criteria for judging whether a configuration can do the job is the CPU utilization and the elapsed time. As will be evident further in this section, the elapsed time rather than the CPU utilization becomes the prime criteria due to the extensive amount of unoverlapped input/output. The elapsed time utilization indicates that several systems configurations which have attractive CPU utilizations had to be discarded as unable to address the job due to elapsed time. In order to judge the systems identically, all configurations were given the same auxiliary equipment. As a result of this analysis, two configurations are recommended for detail analysis. One configuration satisfies the requirements for processing the bulk imagery with no correction. The second configuration satisfies the requirements for processing the bulk imagery with some corrections. These are defined in the discussion below.

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*Unoverlapped input/output (I/O) occurs when the time to read in (or write out) data from (to) an external device is greater than the CPU time required to process it.

5.2.1 Methodology

The methodology employed for this analysis was to:

a) Identify each major function that the NDPF may be required to perform.

b) Reduce this function to its basic data processing requirements e.g., core storage area, instruction processing (CPU) time, input/output area, rates, etc.

c) Determine the requirements, hardware and software, and tradeoffs associated with the performances of the function.

d) Develop the hardware configuration, with tradeoffs, which potentially meets the collective NDPF requirements.

e) Test the configuration for the various operating modes.

The last step is actually an iterative process whereby cumulative totals of the major functions, e.g., telemetry and DCS processing, were timed and sized to a specific mode of operation and hardware configuration. Each change in a basic data processing requirement for any given function, due to either hardware or software modifications, new assumptions, or improvements, necessitated a new iteration to determine the effect on each given mode of operation.

The methodology employed in this analysis brought many tradeoffs to the forefront, and caused "new looks" to be taken time and again at basic design factors. Consequently, this resulted in numerous configuration design changes and contributed considerably to the optimization and improvement of the overall NDPF design concept.

5.2.2 Worst Case Evaluation

During this analysis, it became necessary to make the following assumptions:

a) When any function had several different options available to the user, it was assumed that he always chose the worst case.

b) When the number of images to be processed for a specific function varied, the largest number, or worst case, was again used.

These worst case situations were subsequently evaluated for the three modes of operation defined for use as the NDPF configuration sizing criteria namely:

- Mode 1 - Bulk mode 1
- Mode 2 - Bulk mode 2 with analog image processing
- Mode 3 - Bulk mode 2 with digital image processing

Mode 1 operation consists of the functions listed in Table 5-1. Mode 2 and mode 3 operation consists of the functions listed in Table 5-2.

The major functions that must be performed by the NDPF are shown in Table 5-3, NDPF Basic Functions, together with the basic assumptions made with regard to case A and case B for each function using eight frames, three RBV and five MSS, as the ERTS B, case B worst case. The core capacity and instruction counts required per execution are also defined for each function. Table 5-4 shows the number of images to be processed for both case A and case B. The information from these two figures was used to generate Table 5-5, which presents the total elapsed time for each function of case A and case B on system 360 model 65, 75, and 85 computers.

See Appendix A for a detailed breakdown of CPU time and unoverlapped input/output time. The system 360 model 65 was used as the base machine, with an execution capability of 2.4×10^9 instructions per hour. The model 75 was considered to be 1.5 times faster than the 65 and the model 85 to be 4.5 times faster than the 65. Each machine was configured the same and was considered to have 1×10^6 bytes of processor storage space for image information. The input or output of images is accomplished at 800K bytes per second for 20 seconds.

The most evident conclusion to be drawn from the information tabulated in Appendix A and summarized in Table 5-5 is that, as a result of the image input/output times, all the configurations are subject to a significant amount of unoverlapped input/output since the core limitations of the model 65 and 75 computers does not permit telemetry processing and image processing to run concurrently. It is not possible to reduce the computed input/output rates by any appreciable amount. Such is not the case for the model 85. While the figures for case A show that the model 85

Table 5-1. Mode 1 Functions

Mode 1 Functions	
Function	Task
Process control	Control the operation of the RBV, MSS bulk line control units and high density tape drives Provide annotation and shading/gain control information to the bulk line control units.
Calibration	Input calibration images and compute the shading/gain control.
Precision mode 1	Correct selected images using single point radiometric and four point interpolation geometric corrections
Precision mode 2	Correct selected images using precision mode 1 corrections plus MTF and coherent noise removal corrections.
Digital images	Provide selected digital images on 1600 BPI computer tapes.
Telemetry process	Do computations on the PCM, DCS, and time reference data Generate the image annotation information, master digital tape, and DCS tape.
Information management	Maintain files such as index/abstract and respond to queries from production control

Table 5-2. Mode 2 Functions

Function	Task
Mode 2	
Bulk mode 2 (analog)	Compute corrections for and interface with the PPR's
Mode 1 functions	
Listed in Table 5-1	
Mode 3	
Bulk mode 2 (digital)	Compute corrections for all RBV images using single point radiometric and point shift geometric techniques.
Mode 1 functions	
Listed in Table 5-1	

Table 5-3. NDPF Basic Functions

Function	Assumptions		Instructions Executed/Function		Core Required (K Bytes)
			Case A	Case B	
Operating system	(1) MVT Environment (2) 100K Bytes core for nucleus (3) 50K Bytes core for RDR, WRTR, etc.		1.20×10^{9}	3.6×10^{9}	150
Telemetry processing	(1) Analog to digital not included (2) Computer readable input tapes		6.12×10^{9}	10.69×10^{9}	400
Information management	(1) Batch - estimates based on 2% CPU per 8 hour day for 5/360/75 (2) Terminal - estimates based on 2 minutes of CPU per 8 hour day for 5/360/75 or 200 uses per day (terminal support included)		0.72×10^{9}	1.2×10^{9}	200
			Cases A and B		
Process control	(1) Bulk image processing only (2) All images - geometric correction-interpolation		0.15×10^{6}		020
Calibration	(1) RBV images only - shading correction		0.046×10^{9}		800
Precision process mode 1	(1) Reseau detection on RBV images only (2) All images - geometric correction - interpolation (3) Blemish removal - RBV	MSS	0.197×10^{9}		800
		RBV	0.312×10^{9}		800
Bulk mode 2 (analog)	(1) Reseau detection		0.1×10^{6}		300
	(2) Image correction computation (includes PPR support)		0.114×10^{9}		075
Bulk mode 2 (digital)	(1) Reseau detection (2) Geometric correction - point shift - single point		0.023×10^{9}		800
Digitize images	(1) 1600 BPI tapes	Bulk images I/O overlapped	0.0333×10^{6}		200
	(2) 9 Track tape	Precision images I/O unoverlapped	0.032×10^{6}		200
Precision process mode 2	(1) Reseau detection on RBV images only (2) All images geometric correction - interpolation, modulation transfer function, coherent noise removal	MSS	1.30×10^{9}		800
		RBV	2.08×10^{9}		800

Table 5-4. Images for Case A and B

Images		ERTS A, Case A	ERTS B, Case B*		
			5 Days	6 Days	7 Days
Process control		441	1841	1534	1315
Digitize images		37	156	131	109
Calibration		38	38	32	27
Precision mode 1	MSS	13	57	48	41
	RBV	9	35	29	25
Precision mode 2	MSS	4	8	8	8
	RBV	3	6	6	6
Bulk mode 2 (analog)		63	231	193	165
Bulk mode 2 (digital)		189	693	578	495

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*Includes eight image frames per set (3 RBV, 5 MSS)

Table 5-5. NDPF Computer Time Requirements

Computer / Function	Case A (5-day)			Case B (5-day)			Case B (6-day)			Case B (7-day)		
	360/ 65	360/ 75	360/ 85	360/ 65	360/ 75	360/ 85	360/ 65	360/ 75	360/ 85	360/ 65	360/ 75	360/ 85
Image-Processing												
Mode 1	8.39	5.81	2.43	22.05	15.59	6.97	20.03	14.10	6.21	16.77	13.02	5.64
Mode 2	11.74	8.19	3.45	31.78	24.69	10.84	30.77	21.70	9.43	27.85	14.52	8.40
Mode 3	11.83	8.88	4.83	34.66	26.85	15.77	30.54	23.49	13.54	27.57	21.06	11.92
Non-Image Processing	4.60	3.48	2.00	7.70	5.61	2.72	7.70	5.61	2.72	7.70	5.61	2.72

NOTE. Times are expressed in hours and tenths of hours has approximately 49 percent of unoverlapped input/output, it can be expected that by increasing the core storage of the model 85 from one megabyte to two megabytes will permit concurrent operation of all functions and a resultant decrease in unoverlapped input/output.

When the model 65 or 75 computer could not do the specified functions in the allocated time, the splitting of the functions between a model 65 and a model 75 was addressed. The model 75 was considered to be dedicated to image processing while the model 65 was to perform the telemetry processing and information management functions.

This, as Table 5-5 shows, would permit case A mode 1 image processing to take place on the model 75, but would not permit either of the mode 2 or mode 3 operations to fit into the eight hour time restraint.

Case B, however, because of the extra shifts, does permit the use of a 75/65 combination in a seven day three shift operation to satisfy the mode 2 operation, 19.52 hours elapsed time, and the mode 3 operation, 21.06 hours elapsed time. The elapsed time for this configuration in case B, mode 2 and mode 3, is greater than 75 percent of the total daily time available and is not recommended.

The model 85, while marginal for case A, 6.83 hours elapsed time, can easily handle the case B load for either mode 2 or mode 3 operations in a five day week, 3 shift operation.

The marginal case A problem on the model 85 can be eliminated by the addition of a second direct access storage device for image data and, as mentioned previously, an additional one megabyte of processor storage to permit concurrent program operation.

These additions, however, cannot be made on a model 65 or 75 due to system limitations.

As the result of the analysis of the information in Table 5-5, the following recommendations are made for performing the modes defined in 5.2:

a) Mode 1

A model 75 dedicated to the image processing task and a model 65 to handle the information management and telemetry processing functions. The model 75 CPU for case A would be approximately 73 percent, utilized with an elapsed time of 5.81 hours in an eight hour day. The model 65 CPU would be approximately 42 percent loaded with an elapsed time of 4.60 hours in an eight hour day. For case B, the same configuration would do the mode 1 operation in a five day three shift work week. The model 75 would have a CPU utilization of 55 percent and an elapsed time of 15.59 hours out of 24 hours. The model 65 would have a CPU utilization of 27 percent and an elapsed time of 7.70 hours out of the available 24 hours.

b) Mode 2

A model 85 dedicated to all the NDPF functions is recommended. For case A the model 85 would have a CPU utilization factor of 40 percent and an elapsed time of 5.45 (3.45 + 2.00) hours out of the allotted eight hours. For case B, the same computer would do the mode 2 functions in a five day two shift work week. The CPU utilization would be 54 percent and the elapsed time would be 13.56 (10.84 + 2.72) hours of the 16 hours.

A model 75 dedicated to image processing cannot do case A but could do case B in a seven day three shift work week. The CPU utilization would be 71 percent and elapsed time per day would be 19.52 hours. It is not recommended however, due to the long elapsed time.

c) Mode 3

A model 85 dedicated to all NDPF functions is recommended. For case A the model 85 would have a CPU utilization of 36 percent and an elapsed time of 6.83 (4.83 + 2.00) hours out of the allotted eight hours. For case B, the same computer would do the NDPF functions in a five day three shift work week. The CPU utilization would be 31 percent and would use 18.49 (15.77 + 2.72) hours per day.

In summary, the model 85 is recommended to perform all NDPF functions. Although the elapsed time is greater than 75 percent, these can be reduced, to less than 65 percent by adding a second megabyte, 1 million bytes, of core storage capacity. These added equipments are not available for either the model 65 or 75.

A configuration equal to less than a model 85 is marginal at best and will not afford the capability for expansion and growth available with the model 85.

5.3 SYSTEM CONFIGURATION

The base system can be configured using the information generated in the previous section on timing and sizing. The unique hardware requirements for each task are then added to the base configuration. The first consideration is the systems core requirements. The next item to be considered is the input/output requirements for each task. This may cause an increase in the core requirements to reduce the amount of unoverlapped input/output. The final item to be considered is unique equipment required in the performance of any task. These considerations are interactive and cause many iteractions in configuring the optimum, cost effective, expandable system. The salient features for each item of equipment shown in Figures 5-1, 5-2 and 5-3 are described in Appendix A.

5.3.1 Mode 1 System Configuration

As a result of the timing and sizing analysis, a system/360 model 75 is recommended to handle the image processing and a system/360 model 65 is recommended to handle the telemetry processing and information management. It may be possible for the model 65 to also perform the OCC tasks, but no attempt was made to address that consideration here.

5.3.1.1 Model 75 Configuration (Figure 5-1)

A 1 megabyte core was selected since the image processing requires an 800K byte region. The biggest problem in image processing is the amount of data that must be handled. In order to reduce the time for input and output of the image two high speed channels, 2 and 3, were configured in the system for image data transfer. Each channel operates independently at 1.2×10^6 bytes per second. The actual input and output rate, however, will be at 800K bytes per second. The reason for this is covered in the following paragraphs.

It is possible to store the image on a disk pack on the 2314 direct access storage facility, however, this would limit the image input/output rates to less than 312K bytes per second and drastically increase the time to read in an image. Data is written on these drums at channel speeds, 1.2×10^6 bytes per second, however, due to rotational delays and system input/output handling requirements, the image input rate is reduced to

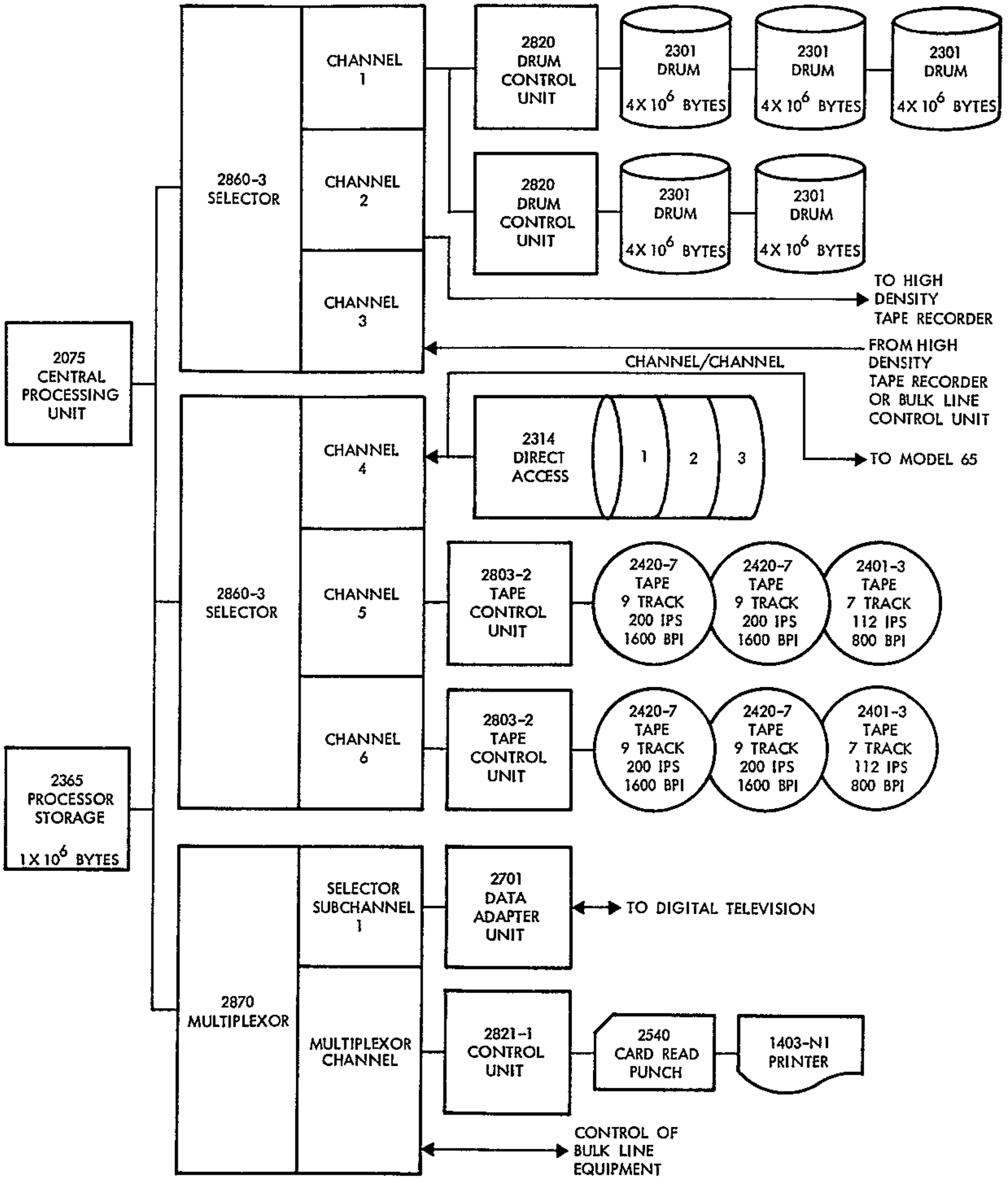

Figure 5-1
MODEL 75 CONFIGURATION

800K bytes per second. This provides the system with a comfortable margin and precludes the loss of image data, due to overrun. Five drums, each storing 4 x 10^6 bytes of data, were required to store an RBV image.

The 2314 direct access storage facility was configured in the system to store the operating system libraries and for scratch storage. Scratch storage would contain such things as annotation data, etc. Only a 3 disk pack capability was used because of the limited amount of data storage required. Each pack is capable of storing 29 x 10^6 bytes of information.

The tape on channels 5 and 6 were configured in the system due to user requirements for images on digital tape. The 2420 model 7, 1600 bytes per inch drives were chosen because of their high transfer rate, 320K bytes per second. The 2401 model 3 drives were added to provide the user, who did not have 9 track, 1600 bytes per inch capability, with image data.

The channel to channel adapter was included on channel 4 to permit intercomputer communication between the model 75 and model 65.

Each of the channels on the two 2860-2 selectors, which operate at speeds up 1.2 megabytes per second, were required to handle the data rates of the devices attached to them.

The 2870 multiplexer was configured in the system to interface the printer and card read punch. Only one card read punch and one printer was put on the system because of the limited card and printer requirements of image processing. These devices are required more for maintenance than for the NDPF workload. The multiplexer channel also interfaces with the bulk line equipment and controls the operation of each device involved in bulk image processing.

A selector subchannel was added to the 2870 multiplexer to permit communications with a digital television. The subchannel operates at speeds up to 180K bytes per second. The 2701 data adapter unit interfaces the subchannel to the digital television.

5.3.1.2 Model 65 System Configuration (Figure 5-2)

As recommended, the model 65 would perform the non-image processing functions of the NDPF. Because the core requirements of the

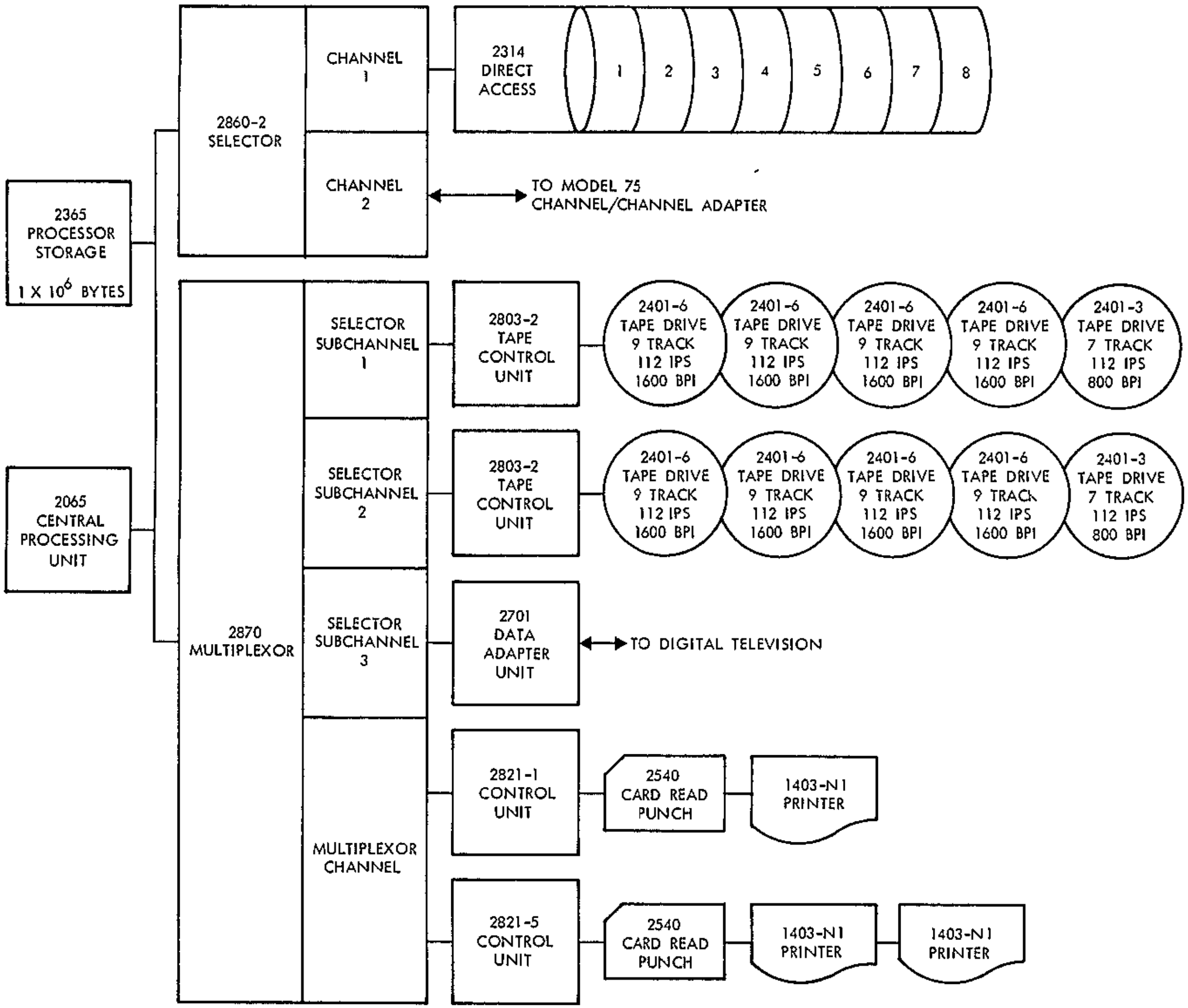

Figure 5-2

MODEL 65 CONFIGURATION

operating system, information management and telemetry processing, all of which must operate concurrently, a 1 x 10^6 byte processor storage was configured. Information management is one of the functions of this system, therefore a 2314 direct access storage facility, with a full complement of disk packs (eight), was configured in the system. Each disk pack is capable of storing 29 x 10^6 bytes of information. System estimates are that five full packs will be used for file information. The additional packs were added for work space. The 2860-2 selector is used to handle the 2314 and to interface with the model 75 image processing system.

The 2870 multiplexer is configured in the system to interface the tape, printers and card readers to the computer. Selector subchannels 1 and 2 are dedicated to tapes. The two channels are necessary to permit reading on one tape, while writing in another. Telemetry processing has a requirement for a various number of tapes dependent on the task being performed. Preprocessing, for example, requires three input and one output tapes. Others require various combinations of input and output tapes. To limit the amount of unoverlapped input/output telemetry processing has a requirement for tape drives that can read while back spacing. The 7 track tape drives were again added for users who do not have 9 track, 1600 BPI tape drives on their systems.

Subchannel 3 of the 2870 is used to interface the digital television to the system via the 2701 data adapter unit.

The printer and card read punch requirements, of the model 65, are much more extensive and resulted in 2 card read punches and 3 line printers being configured in the system.

5.3.2 Mode 2 and Mode 3 Systems Configuration

As the result of the timing and sizing analysis, a system/360 model 85 computer system was recommended. In this configuration all of the NDPF functions will be performed in the same system. This is possible because of the speed of the processor and the amount of available storage.

5.3.2.1 Model 85 Configuration (Figure 5-3)

From the tables in the sizing and analysis section, the core requirements to permit concurrent operation of telemetry processing,

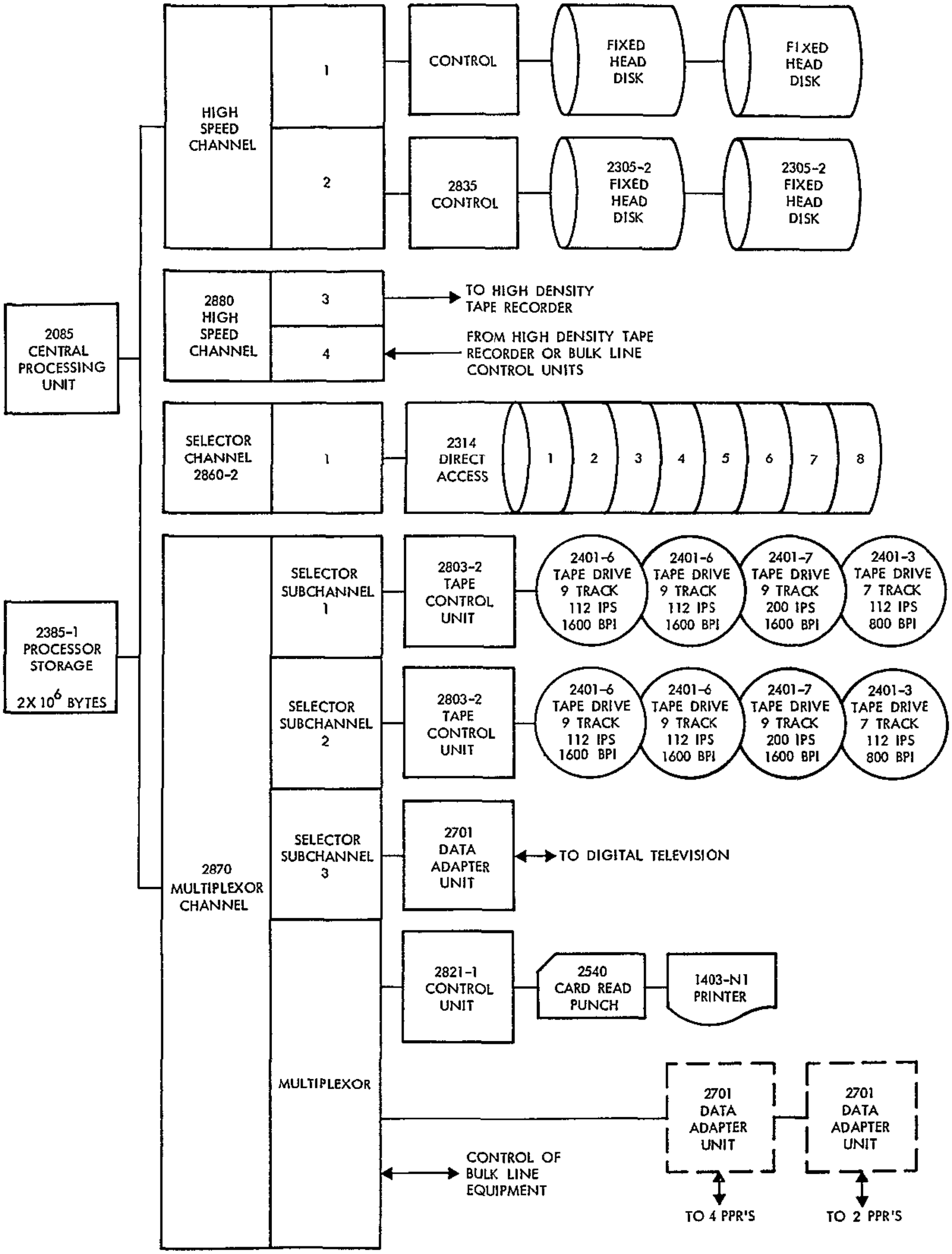

Figure 5-3
MODEL 86 CONFIGURATION

information management and image processing is about 1.6 x 10^6 bytes of storage. Because of this a 2 x 10^6 byte processor storage was specified.

A 2880 model 2 high speed selector was specified to permit the attachment of two channels of high speed direct access storage. Each channel operates at speeds up to 3 x 10^6 bytes per second. Four 2305 model 2 fixed head disks were specified, two on each 2880 channel, for image storage. Each disk stores 11 x 10^6 bytes of data and transfers at 1.5 x 10^6 bytes per second. By using two channels the image input/output times for case A and case B operation should be approximately half of those specified in the timing and sizing analysis figures.

A 2880 model 2 high speed selector is used for the input/output of image data.

A full complement 2314, 8 disks, on selector channel 3 is used for operating system libraries, information management system files and work space.

Two 2420 model 7 tape drives, on selector channel 4, for generation of image tapes.

The 2870 multiplexer, tape drives, data adapter unit, printers and card read punches have been configured in the system for the same reasons as they were on the model 65 in the bulk mode 1 configuration.

The two 2701 data adapter units, shown in phantom, are used to interface with the precision photo restitutors should the bulk mode 2 with analog processing be selected for implementation.

APPENDIX A

APPENDIX A

DETAIL COMPUTER CONFIGURATION DESCRIPTION AND DETAIL SIZING ANALYSIS FIGURES

1. INTRODUCTION

This appendix contains a detailed description of the salient features of the IBM 360 Models 65, 75, and 85 described in the system configurations described in Section 5.3; and a detailed breakdown of the computer sizing analysis that was described in Section 5.2.

2. COMPUTER DESCRIPTIONS

The NDPF computer systems described in Section 5 were configured according to the equipment in the following paragraphs.

During the study, it was most natural that IBM develop the NDPF system hardware configuration based upon IBM equipment. The important characteristics of the various subsystems and units are described. These are summarized from IBM 360 System Summary, Form A22-6810.

2.1 IBM System/360 Model 65

The System/360 Model 65 offers powerful performance with exceptional versatility in large system applications.

The Model 65 has a maximum main storage capacity of 1,048,576 bytes. Two-way interleaving increases speed of operations by substantially reducing the effective access time.

2.1.1 System Components

Central Processing Unit: 2065 Processing Unit

- Basic Machine Cycle Time: 0.2 microsecond (200 nanoseconds)
- Instruction Set: The universal instruction set is standard with the Model 65.

Main Storage: 2365 Processor Storage Model

- Storage Size:

Capacity (Bytes)	Model	Storage Units	Type of Interleaving
1,048,576	J65	Four 2365-2's	Two-way

- Storage Cycle Time: 0.75 microseconds
- Storage Access Width: Eight bytes (one double word)
- Protection Features: Both store and fetch protection are standard features.

2.1.2 Storage Control Unit

The storage control units handle all processor and channel references to main storage. The storage control unit operates in parallel with, and is effectively independent of, both the processor and all channels. Its function is to handle all requests for use of storage and to determine action to be taken in case of simultaneous requests either between channels or between channels and the processor. It is designed to minimize the number of storage references made by the channels or processor and to permit overlap of storage references, whenever possible.

2.1.3 Checking

Extensive checking capability is built into all units of the Model 65 based largely on a byte parity check. All data transfers are checked for correct parity both within and between units of the system. All storage references in the 2365 Processor Storage are checked for proper parity within the unit itself.

The 2065 Processing Unit includes checking of data transfers, arithmetic functions, as well as performing a parity check of the ROS control words.

2.2 IBM System/360 Model 75

The System/360 Model 75 is a significant step higher in efficiency and speed of internal processing than the Model 65. The primary advantages of the Model 75 are its shorter instruction execution times (approximately two times shorter than the Model 65) and its overlapping of processing, in which two instructions are processed currently. The Model 75 has a maximum main storage capacity of 1,048,576 bytes.

Standard Features

- Universal instruction set
- Storage protection (both store and fetch protection)
- Attachment for 2870 Multiplexer Channel
- Attachment for 2860 Selector Channel
- Direct controls (includes external interrupt)
- Timer (line-frequency type)

Optional Features

- 2870 Multiplexer Channel
- 2860 Selector Channel (as many as two units, providing as many as six selector channels)
- Selector subchannels (as many as four)

2.2.1 System Components

Central Processing Unit: 2075 Processing Unit

- Basic Machine Cycle Time: 0.195 microsecond (195 nanoseconds)
- Instruction Set: The universal set is standard with the Model 75.

Main Storage: 2365 Processor Storage Model 3

- Storage Size:

Capacity (Bytes)	Model	Storage Units	Type of Interleaving
1,048,576	J75	Four 2365-3's	Four-way

- Storage Cycle Time: 0.75 microsecond
- Storage Access Width: Eight bytes (one double word)
- Protection Features: Both store and fetch protection are standard on the Model 75.

2.2.2 Storage Control Unit

The storage control unit handles all processor and channel references to main storage. The storage control unit operates in parallel with, and is effectively independent of, both the processor and all channels. Its function is to handle all requests for use of storage and to determine action to be taken in case of simultaneous requests either between channels or between channels and the processor. It is designed to maximize the number of storage references made by the channels or processor and to permit overlap of storage references, whenever possible.

2.2.3 Instruction Unit

The I unit contains the registers, arithmetic units, and controls necessary to handle instruction sequencing, address preparation, and execution of some instructions. The I unit also contains the general registers, the PSW register, and the CPU clock.

2.2.4 General Registers

The general registers are used in address arithmetic and as accumulators in fixed-point arithmetic and logical operations. Each general register has a capacity of four bytes. General registers are implemented in active elements and have a cycle time of 200 nanoseconds per four bytes. For some operations, two adjacent registers can be coupled providing a doubleword capacity. When appropriate, such coupled registers have a cycle time of 200 nanoseconds per eight bytes.

2.2.5 Execution Unit

The E unit performs arithmetic and logical functions. It contains the registers, arithmetic units, and controls for execution of fixed-point, floating-point, and decimal arithmetic instructions, and for execution of logical operations. The four 8-byte registers in the E unit are working registers; they are not addressable.

Floating-Point Registers. Four floating-point registers are available for floating-point operations. These registers are two words (eight bytes) in length and can contain either a short (one word) or a long (two word) precision floating-point operand. The floating-point registers are implemented in active elements and have a cycle time of 200 nanoseconds per eight bytes.

2.3 IBM System/360 Model 85

The System/360 Model 85 provides increased precision, speed, and storage capacity beyond that of the Models 65 and 75. The precision of scientific computations is significantly increased by extended-precision floating-point arithmetic; the speed of operations is increased by four-way interleaving, the high-speed multiply feature, and a unique high-speed buffer storage. The maximum main storage capacity of 4,194,304 bytes, four times that of the Model 65 or 75, makes the Model 85 well-suited for effective and efficient multiprogramming.

The performance of this system is further enhanced by notable reliability features, such as the instruction retry feature, the Recovery Management Support (RMS) program, and the main-storage error-checking and correction circuits.

Standard Features

- Universal instruction set
- High-speed buffer storage (16,384 bytes)
- Extended-precision floating-point arithmetic
- Instruction retry
- Error checking and correction
- Storage protection (both store and fetch protection)
- Byte-oriented operand
- Attachments for 2860 Selector Channel and 2870 Multiplexer Channel
- Direct control (includes external interrupt)
- Timer (line-frequency type)
- Microfiche document projector and viewer

Optional Features

- 2880 Block Multiplexer Channel
- High-speed multiply
- Buffer storage expansions (as many as two, each with 8,192 bytes)

- 2860 Selector Channel (as many as two units, providing as many as six selector channels)
- 2870 Multiplexer Channel
- Selector subchannels (as many as four)
- Channel-to-channel adapter

2.3.1 System Components

Central Processing Unit: 2085 Processing Unit

- Basic Machine Cycle Time: 0.08 microsecond (80 nanoseconds)
- Instruction Set: The universal instruction set is standard with the Model 85.
- High-Speed Buffer and its Expansions: This unique storage feature permits a reduction of the effective system storage cycle time to as little as 80 nanoseconds if the desired data has already been transferred to buffer storage. Total buffer storage available (with expansions) is 32,768 bytes.
- Overlapped Operations: The operations of the CPU's instruction and execution units are overlapped, allowing execution of instructions to proceed while the instruction unit prepares for later operations.

Main Storage: 2385 Processor Storage Model 1

- Storage Size:

Capacity (Bytes)	Model	Storage Units	Type of Interleaving
2,097,152	K85	One 2385-1	Four-Way

- Storage Cycle Time: 0.96 microsecond for the 2385 Model 1. (The effective storage cycle time is sharply reduced if the data has already been transferred to buffer storage.)
- Storage Access Width: Sixteen bytes (one quad-word)
- Protection Features: Both store and fetch protection are standard.

2.3.2 Channels

Channels provide the data paths and direct control for input/output control units and the input/output devices attached to the control units. Channels relieve the CPU of the task of communicating directly with the input/output devices and permit data processing to proceed concurrently with input/output operations.

Data is transferred one byte at a time between an input/output device and a channel. Data transfer between a channel and the storage control unit are parallel by eight bytes for both selector and multiplexer channels.

A standard input/output interface provides a uniform method of attaching input/output units to all channels.

A 2860 Selector Channel and the 2870 Multiplexer Channel are available for Models 65, 75, and 85, and a 2880 Block Multiplexer Channel is also available for the Model 85.

2.3.3 2860 Selector Channel

The 2860 Selector Channel provides for the attachment and control of burst mode input/output control units and associated devices. The 2860 is available in three models:

a) Model 1 - provides one selector channel

b) Model 2 - provides two selector channels

c) Model 3 - provides three selector channels

The selector channel permits data rates of 1.3 million bytes per second. Input/output operations are overlapped with processing and depending on the data rate, all selector channels can operate concurrently. A full set of channel control and buffer registers permits each channel to operate with minimal interference.

A maximum of eight control units can be attached to each selector channel. Each channel may have more than one unit connected to it, but only one device per channel may transfer data at any given time.

2.3.4 Channel-to-Channel Feature

The adapter permits the communication between two System/360 channels, thus providing the capability for interconnection of two processing units within the System/360. The adapter uses one control unit position on each of the two channels. Only one of the two connected channels requires the feature. There can be a maximum of one channel-to-channel adapter per channel.

2.3.5 2870 Multiplexer Channel

The 2870 Multiplexer Channel provides for the attachment of a wide range of low to medium speed input/output control units and associated devices.

The multiplexer channel provides up to 196 subchannels, including four selector subchannels. The basic multiplexer channel has 192 subchannels; it can attach eight control units and can address 192 input/output devices. The basic multiplexer channel can overlap the operation of several input/output devices in multiplex mode or operate a single device in burst mode. One to four selector subchannels are optional with a 2870. Each selector subchannel can operate one input/output device concurrently with the basic multiplexer channel. Each selector subchannel permits attachment of eight control units for devices having a data rate not exceeding 180 K byte/second. Regardless of the number of control units attached, a maximum of 16 input/output devices can be attached to a selector subchannel.

The maximum aggregate data rate for the multiplexer channel ranges from 110 to 670 K byte/second depending on the number of selector subchannels installed. Selector subchannels 1 through 3 may each operate concurrently at up to 180 K byte/second; selector subchannel 4 has a maximum data-rate of 100 K byte/second. Each selector subchannel in operation diminishes the basic multiplexer channel's maximum data-rate of 100 K byte/second.

2.4 2880 Block Multiplexer Channels

The 2880 operates in either the selector channel mode or the block multiplexer mode. Selector channel mode is functionally equivalent to the 2860 selector channel operation. The block multiplexer mode permits the concurrent operation of up to 64 input/output devices on a single channel by multiplexing blocks of data on the single data path of the channel. New reliability features provide for extensive checking, of channel and control unit operations, and on certain failures, provide automatic hardware retry of malfunctioning operations.

Additional data buffering provides lower system interference. The basic 2880 is capable of data rates up to 1.5×10^6 bytes per second.

2.5 Direct Access Devices

2.5.1 IBM 2301 Drum Storage; IBM 2820 Storage Control

The IBM 2301 Drum Storage provides direct access storage of approximately 4 million bytes at a data rate of 1.2 megabytes per second. The high data rate is achieved partially by increasing four track in parallel rather than a single track, thus the common reference to this as a "parallel file." The data are recorded on and read from the rotating drum serially by half-byte; first the four high-order bits of the byte, then the four low-order bits.

The IBM 2301 records data on 800 tracks, divided into 200 addressable groups of four tracks each. Each such conceptual track can contain a single record of 20,483 bytes. Data records can be of variable length and can overflow from track to track. Seek time is zero; rotational delay to any record ranges from 0 to 17.5 milliseconds, and averages 8.6 milliseconds.

The IBM 2820 Storage Control provides the capability of attaching up to four IBM 2301 Drum Storage units to a System/360 channel, for a total on-line direct access capacity of more than 16 million bytes or 32 million packed decimal digits and signs per 2820 attached.

The IBM 2820 interprets and executes all control orders received from the channel, and checks the validity of the data transferred to or from the storage devices.

2.5.2 IBM 2314 Direct Access Storage Facility Models 1, A1, and A2; IBM 2844 Auxiliary Storage Control

The IBM 2314 Direct Access Storage Facility contains a control unit and up to eight independent disk storage drives. A ninth drive is provided to be used if one of the eight normally addressed drives requires preventive or emergency maintenance.

The maximum, average, and minimum access times for the IBM 2314 are 130, 60, and 25 milliseconds. Average rotational delay on all models is 12.5 milliseconds. Each drive in the IBM 2314 operates independently. The IBM 2314 use the removable disk pack method of storing data. The data rate of the IBM 2314 is 312,000 bytes per second.

Each disk pack in the IBM 2314 has a capacity of 29.17 million bytes (or 58.35 million packed decimal digits and signs). Each of the 20 disk recording surfaces is divided into 200 concentric tracks; each track has a capacity of 7,294 bytes.

The conceptual cylinders of the IBM 2314 are composed of 20 tracks, one on each disk surface. With 7.294 bytes per track, 145, 880-bytes are available under each of the access mechanisms in an IBM 2314. Within a cylinder, multiple records can be read or written by command chaining, without rotational delay between records.

The eight removable and interchangeable IBM 2316 Disk Packs required by each 2314 provide a total of 233.4 million bytes of on-line disk storage and practically unlimited off-line storage.

File scan and record overflow are standard features. File scan permits a comparison on selected bytes (in effect, a search through the file for a specific record or condition). Record overflow increases the utilization of storage by allowing a record to overflow from track to track to the end of the cylinder.

2.6 2305 Fixed Head Storage Facility and 2835 Storage Control

The 2305 Fixed Head Storage modules physically consist of a non-removable rotating media and multiple element recording heads. The recording media consists of six disks revolving in an environmentally controlled air system. The 2305 Model 2 has 768 tracks, each with its own read/write head and a maximum capacity of 14,660 bytes per track.

Record overflow, multiple track operation, multiple requesting and rotational position sensing are all standard features. The rotational position sensing function enables the channel to seek to an angular track position. It permits channel disconnection during most of the rotational latency period and thus contributes to increased channel availability.

A two module 2305 model 2 fixed Head Storage Facility has the ability to store 22×10^6 bytes of information.

2.6.1 2835 Storage Control

The 2835 Storage Control provides the capability of attaching two 2305 Fixed Head Storage Facilities to a 2880 Block Multiplexer Channel for a total on line direct access capacity of more than 22×10^6 bytes. The 2835 interprets and executes all control orders received from the channel and checks the validity of the data transferred to or from the storage devices.

2.7 Tapes

IBM 2401 Magnetic Tape Unit Models 3 and 6

IBM 2803 Tape Control Model 2;

The IBM 2401 Magnetic Tape Unit reads or writes nine tracks across half-inch wide, heavy-duty magnetic tape at a density of 800 or 1,600 bytes per inch (bpi). Each byte contains one letter or special character, or two four-bit decimal digits, or one decimal digit and a sign, or eight binary bits, etc., and a ninth bit used for parity checking.

The model numbers designate the type unit speed in bytes per second, which is directly related to two factors: tape speed in inches per second and data density in bytes per inch of tape.

Model 3	90,000 bytes per second at 112.5 ips at 800 bytes per inch
Model 6	180,000 bytes per second at 112.5 ips at 1,600 bytes per inch.

Model 6 uses the technique of "phase encoding" for its advantages of high speed and automatic single-track in-flight error correction.

2.7.1 Tape Controls

The 2803 controls as many as eight tape units and are in two models. Model 2 is primarily for control of the 1,600 bytes per inch units in 2401 Models 4-6, but may also control 800-bpi tape units if either the nine-track compatibility feature or the seven and nine-track compatibility feature is installed. (Also, each 2401 Model 3 attached to Model 2 of the 2803 must have the mode compatibility feature.)

Controls attach to a selector or multiplexer channel and operate in the burst mode. A 2803 requires a control-unit position on the channel.

2.7.2 Seven Track Compatibility

An optional seven-track compatibility feature enables a 2401 Model 3 to write or read seven-track tape at 200, 556, or 800 characters per inch; this provides tape compatibility with devices such as IBM 729 and IBM 7330 Magnetic Tape Units. The seven-track compatibility feature can be installed on any tape control and is required if any attached tape unit has the seven-track head. As part of the seven-track compatibility feature, a code translator feature is included to translate the BCD interchange code to the System/360 code (EBCDIC).

2.7.3 IBM 2420 Magnetic Tape Unit Model 7

The IBM 2420 Magnetic Tape Unit Model 7 is the highest performance tape unit available for the System/360. Incorporating a new tape transport technology, it has a write time of 2 milliseconds and a tape speed of 200 inches per second, providing a data rate of 320,000 eight-bit bytes per second. It also corrects single-track defect errors during operation without impairing tape performance with the result that most corrections are made without interrupting the reading process.

The 2420 reads and writes nine phase-encoded tracks across 1/2-inch magnetic tape at a density of 1,600 bpi. These tapes can also be used on 2400-series magnetic tape units Models 4-6. The command structure for the 2420 is the same as for the 2400-series single density phase-encoded tape units.

The 2420 is attached to the System/360 via the 2803 Tape Control Model 2 with the 2420 attachment feature installed.

2.8 IBM 2701 Data Adapter Unit

The IBM 2701 Data Adapter Unit provides for the on-line connection to System/360 of a variety of local and remote systems and devices.

Eight 2701's can be attached to a System/360 channel, each occupying one control unit position.

Each 2701 provides for the attachment of up to four parallel data acquisition devices (word width of 16 to 48 bits).

All necessary bit-byte and word-byte conversions, interface matching, and data control for the attachment of specific terminal devices is accomplished by the 2701.

2.9 IBM 2540 Card Read Punch

The IBM 2540 Card Read Punch reads cards at a maximum rate of 1,000 per minute, and punches cards at a maximum rate of 300 per minute. The card reading and punching sections are separate entities, and reading and punching can take place simultaneously.

2.10 1403-N1 Printer

The Model N1 operates at higher speeds through the use of the universal character set.

The Printer is controlled and buffered by the 2821 Control Unit, which also provided the attachment to a System/360 channel. One or two 1403's can be controlled by each 2821, depending on the 2821 model.

The Model N1 uses an interchangeable chain cartridge adapter. The cartridge adapts the 1403 for quick and convenient changing of type fonts or character arrangements for special printing jobs.

Characters are printed ten to the inch, and lines are spaced either six or eight to the inch under operator control. Auxiliary ribbon feeding feature is standard.

The 1403 Model N1 features sound-absorbent covers extending to the floor, power-operated front and top covers, and a newly designed forms cart.

2.11 2821 Control Unit

The 2821 Model 1 and 5 control units interfaces 2540 card read punches and 1403-N1 printers to the System/360. It interprets and executes all control orders received from the channel. The 2821 Model 1 controls one 2540 card read punch and one 1403-N1 printer. The 2821 Model 5 controls one 2540 card read punch and two 1403-N1 printers.

3. TIMING AND SIZING ANALYSIS

Table A-1 presents a detail breakdown of the computer timing analysis for case A and case B for the IBM 360/65, 75, and 85. This chart shows the CPU time, unoverlapped input/output time, and elapsed time required to perform the indicated NDPF requirements that are imposed on the computer system. The table presented supports the analysis described in Section 5 of this report.