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OFFICE OF COMPUTER SERVICES

COMPUTER SYSTEMS PLAN

FOR THE PERIOD 1971 - 1975

February 1971

DIRECTORATE OF SCIENCE AND TECHNOLOGY

CENTRAL INTELLIGENCE AGENCY

GROUP I
Excluded from automatic
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OFFICE OF COMPUTER SERVICES

COMPUTER SYSTEMS PLAN

January 1971 - June 1975

1. INTRODUCTION

This report describes a plan for extending and upgrading the computer systems in the Office of Computer Services (OCS). The emphasis of this report is on major general purpose computer systems, but there is some reference to special purpose systems and related peripheral devices. The report is concerned with OCS Computer Center services, not application development services.

This report should be viewed as a follow-on to previous reports prepared by OCS on this topic in previous years. ("OCS Computer Systems Planning Report", 17 March 1967; "Status and Planning Report for OCS Interactive Services", April 1969.)

This report is the result of analysis and planning activities within OCS and a review of past and projected requirements for computer systems support. It is intended to provide the user of the OCS Computer Center with an understanding of computer plans so that he is better prepared for changes as they occur and, more importantly, for exploiting new system capabilities as they become available.

At the outset, it is important to emphasize that this report does not address quantitative requirements nor does it attempt to justify a particular level of expenditure. Rather, the intent is to set a direction for the future; the speed with which this direction is pursued will depend on actual requirements as they arise. The justification for specific changes in computer systems will be addressed periodically during the planning period.

Our concern is whether or not we will be able to provide needed levels of data processing support, given the current pressures on dollar resources. We believe that as we move into the future, more and more requirements will be placed upon ADP systems in OCS and that growth of ADP applications should be encouraged where a worthwhile benefit can be achieved.

The past has shown a remarkable pattern of expansion. In 1963 the computers installed in OCS consisted of one IBM 1401, one IBM 1410, one IBM 7090 (operating only part of the time), and an RCA 501/301. One 360/65 is probably doing more work today than all of these systems combined. This pattern of growth has led to the installation of three IBM 360/65's, one 360/67, an RCA Spectra 70/45 and 70/35 and two IBM 360/20's.

One measure of this growth is raw computer power based on hardware specifications (but ignoring software and other considerations). We find that OCS computer power has increased 40 fold in the past eight years. In 1962, we had the equivalent of a tenth of an IBM 360/65 computer. In 1970 we had the power equivalent to nearly five 360/65's. Even with this increase in computer power, we have barely manged to keep abreast of the growth of user requirements. At times, requirements have exceeded our capacity or our ability to exploit equipment capability fully.

Assuming no basic change in this growth pattern, a simple extrapolation of capacity curves (without regard to requirements analysis) would show 19 360/65's by 1975. This is four times the 1970 computer power. To put it another way, if the rate of growth over the next five years is only half of what it was over the past five years, ten 360/65's would be needed by 1975. Should computer requirements levied on OCS demand such growth, this plan can accommodate it. Conversely, the plan is flexible enough to respond to more modest growth requirements.

Attempts to quantify OCS processing requirements for a five-year time span would not be very useful. Gathering information about OCS customer needs is most fruitful when it is considered to be a continuous process of making projections six months to a year ahead. Each division and staff of OCS, by way of frequent customer contacts, becomes aware of customer requirements as they develop. In most cases these requirements cannot be quantified very far into the future but the user and the OCS computer specialist have a good "feel" for future requirements. We have encountered very few surprises in the past with this approach.

The need for continuing growth over the next five years can be characterized by three factors.

Many projects that have been in the developmental stage are moving into production. For example, the projects from the Spectra 70/45

will be moved over to the 360's to become part of the SIPS system. ABC
and the payroll system are near-term examples. [   ] and support   25X1
to OSP programs will become operational. Several projects, such as
25X1   [   ] have increasing
processing requirements. Some of these will become peaks and valleys
in our load, but the peaks are getting bigger.

There are growing requirements for the use of resident core
storage. FMSAC has stated needs for programs in the 400,000 byte range
as a matter of general practice. Graphic support memory requirements
are increasing. A case in point is the work now going on with the IBM
2250, where the resident core module is 250,000 bytes at a very early
stage of development. There are programs now being developed on the
360/67 with core requirements exceeding 750K bytes. An example is
image enhancement software. We expect this type of requirement (for
more computer resources - not just power) to accelerate.

A greater share of the burden in the system development process
will be borne by the computer. One of the factors in using generalized
software systems such as OS/360, PL/1, or GIMS is that functional
capability is acquired at the cost of increased systems overhead. Meeting
a customer need with GIMS, for example, produces relatively slow
running computer programs, but the programmer should be able to get his
job on the air faster. In other words, we can increase analyst/programmer
productivity at a cost of increased power of the computer used to process
the software he develops. We believe that, in the context of our operational
requirements, this is a good trade-off -- one which will become more
significant over the next several years.

2. SYSTEM PHILOSOPHY

There are two different philosophies in data processing management
which we have considered in our planning. One concept is to attempt to
optimize computer processing for a specific project, providing that project
with the best service it can attain without regard to other projects. The
other concept is to attempt to design a computer system so that good service
is provided overall to a group of projects, but at some cost to each project
in terms of less than optimal service. The first philosophy leads to
several small systems; the second leads to a few large systems.

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We believe the latter concept to be more valid in a centralized, general purpose computer organization such as OCS. In other words, we believe OCS should continue to plan within the concept of a few large systems to meet most of its processing needs. This is not just a recitation of a previously established policy. In the analysis leading to this report, both philosophies were reviewed at some length in light of today's prospects in technology, budgets, and OCS' technical and substantive performance. There are two overriding factors that argue for the large system approach.

 - Budget. The large systems probably offer the best chance of meeting expanding needs within assumed funding restrictions.

 - Experience. We believe that we have learned how to run large systems (and are beginning to realize the so-called "economies of scale") and that users have learned to exploit the capabilities the large systems offer in a resource sharing environment (where a concern for other users is required).

There are some serious management implications of moving in the direction of few and large systems.

 - It reduces the benefits which could be derived from multivendor competition for central processors and related basic elements of computer systems. This is offset somewhat by the spirited competition for other components.

 - It involves fewer but more expensive procurement actions.

 - It is difficult for a manager to determine the effects on his computer activities when other users of the same large system make changes in their priorities, processing volumes, and computer methods.

 - Equipment or software failures have dramatic effects on production.

The first point made above - reliance on one principal vendor - needs elaboration. This plan envisions evolutionary growth within the IBM family of computers. Taken as individual steps, the changes follow an already established pattern of larger models substituted for smaller ones within the same product line. We see no justification for changing this pattern.

There are two primary factors behind the decision to recommend the continuing use of IBM equipment in OCS.

     a. OCS has a large investment in computer programs written for IBM equipment.

     b. OCS requires a very broad spectrum of computer facilities to meet its needs; no other single vendor can provide all the facilities which IBM can provide.

This Agency has a very large investment and commitment in computer programs written for IBM equipment. OCS programmers as well as user office and contractor programmers have been developing these computer programs since 1964. A conservative estimate of the Agency's investment to date is 1,200 man years. We believe that the Agency cannot afford to absorb the high cost of conversion to some other non-IBM computer system, notwithstanding vendors' claims of compatibility.

Assuming the philosophy of few large systems is valid, a single principal vendor is implied. IBM is the choice because of the facilities which it can provide. Some vendors can and do provide some or even most of the facilities. Indeed, in any given area, some one vendor can be found who has more suitable facilities than IBM (faster internal speeds, cheaper memories, a more efficient operating system, etc.). In the aggregate, however, IBM's array of facilities provides a very significant systems capability.

The following facilities now in use are considered essential. Single vendor procurement is not required, but certainly single vendor availability is highly desirable for confident planning.

     Languages/compilers:

          FORTRAN
          COBOL
          PL/1
          Assembly language
          APL

     Full range of data access techniques: direct, sequential, index sequential, telecommunications

Interactive terminal support

Full range of general utility programs

Mathematical programming system

Remote batch support

Graphics support

Extended floating point precision

Large core memories (in excess of one million bytes)

Fast central processors in the very low nano-second cycle
time range

High capacity direct access storage devices

Capability to connect the full range of peripheral equipment:

      Card readers/punches
      High speed tape drives (300 KBS)
      High speed printers (2,000 LPM)
      Interactive printer terminals
      Interactive CRT terminals
      Paper tape readers/punches
      Graphics terminals
      Remote job entry terminals

On-site, full-time, qualified technical support

We also gave consideration to the following (secondary) factors:

    - IBM is responding to market competition so that, over time,
the Agency benefits from a competitive market without having to
take on the problems of multi-vendor systems.

    - Compatible hardware and software systems among OCS, RID,
and CRS has been an advantage to the Agency in that we can share
experience and provide a significant degree of backup.

- This compatibility has made centralized technical training possible in the Agency and increases the flexibility of ADP personnel assignments. Systems problem-solving knowledge can be shared.

3. OBJECTIVES

The objectives of previous OCS computer systems plans remain valid: a homogeneous set of hardware and software, equipment with change and growth capability, remote terminals and interactive services, efficient software from the operator and programmer/user points of view, around-the-clock computing capability, a proper balance between batch and interactive service, and a stable environment for the user.

4. GENERAL ASSUMPTIONS

This computer systems plan is based upon the following general assumptions:

a. During the period covered by this plan, data processing requirements will continue to increase. This will come, in part, from the following factors:

--economies in certain Agency activities will be sought through further automation;

--new sophisticated Agency operational projects will require ADP services;

--advances in computer technology will provide new capabilities which in turn will generate new requirements or increased computer loads.

b. Security problems in a multi-machine, multi-security environment are soluble.

c. Off-site backup will not be cost justified, but computer backup at Headquarters for individual machine failures is requisite for production.

   d. Special purpose systems may be required in addition to the systems included in this plan.

   e. The resources required to implement this plan will be available to OCS.

   f. Changes in computer technology which may occur in the planning period will probably not have a significant effect on the plan.

   g. There will be a continuation of the major facilities of the IBM 360 Operating System.

   h. There will be no significant additional computer space made available.

5. CURRENT STATUS AND NEAR TERM CHANGES

   This computer systems plan has as its base the currently installed computer systems and the physical plant associated with the Computer Center.

   The inventory of currently installed equipment is: three IBM 360/65's, one IBM 360/67, an RCA Spectra 70/45 and 70/35, a CDC 8092/915 Page Reader, the ANDI system, and two IBM 360/20's. The Page Reader, ANDI, and the 360/20's are not discussed in this plan. It is assumed there will be a continuing need for this equipment; any changes which may be required will be handled separately.

   The two large 360/65 systems (1 and 2) are used for batch and remote job entry services. The 360/65-3 is currently used for development of several large file management systems involving remote terminals during prime shift and for batch services during the second and third shifts. The 360/65-1 has a 7090 emulator. * The IBM 360/67 is being used almost exclusively for interactive services. The RCA Spectra systems are used almost exclusively for DD/S applications. This type of work is either being converted to IBM systems or will be supplanted by SIPS.

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*An emulator is a combination of hardware and software which permits one machine to function like another machine.

Several software systems are in use. The 360/65's use the standard IBM System 360 Operating System. The 360/67 uses IBM's CP/CMS. The 7090/7094 emulator system uses IBSYS version 12. The RCA systems use the RCA standard 501 and 301 emulator software.

Several changes are planned for the near term as follows:

    a. In February 1971 the IBM 360/65-3 will be upgraded to a core memory size of 786,000 bytes; additional terminals and terminal control devices will be installed.

    b. A third storage drum will be added to the IBM 360/67 in January 1971.

    c. A COMCET Communications Processor has been installed. This device is intended for certain remote input/output functions now performed by IBM control devices on the 360/65's and 360/67. This is basically a prototype device. The Communications Processor is being handled as a developmental project.

Our current physical plant is a major factor in determining the possible moves we make. Even though the Computer Center physical space was expanded in 1969, the space is really not of the kind that easily lends itself to equipment installation. For example, building support pillars are interspersed around the room at distances of 20 feet on center. The room is odd-shaped. All equipment must be installed around these pillars and curves in the room so as to allow for operator movement, maintenance access, and aisle space.

6. LONG TERM COMPUTER SYSTEMS PLAN

The long term computer plan will proceed in several steps toward a network of computers within the Computer Center. The schematic in Figure 1 depicts the last phase of this plan, two IBM 360/195's and two 360/67's. This plan can be implemented within resources shown in the OCS FY 73-77 Program submission. The most significant change in funding occurs in FY-74, when a second IBM 360/195 is installed and the full effects of replacing previously purchased systems with rental systems is felt. (See Section 10 on funding.)

Figure I.

SCHEMATIC

OCS COMPUTER CENTER PLAN

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Terminals

Remote
and
Local

Printers

Readers

Punches

Hardware
Switches

Interactive
360/67-1

Storage

Interactive
360/67-2

Storage

Shared
Storage

Batch &
Interactive
360/195-1

Storage

Batch &
Interactive
360/195-2

Shared
Storage

Storage
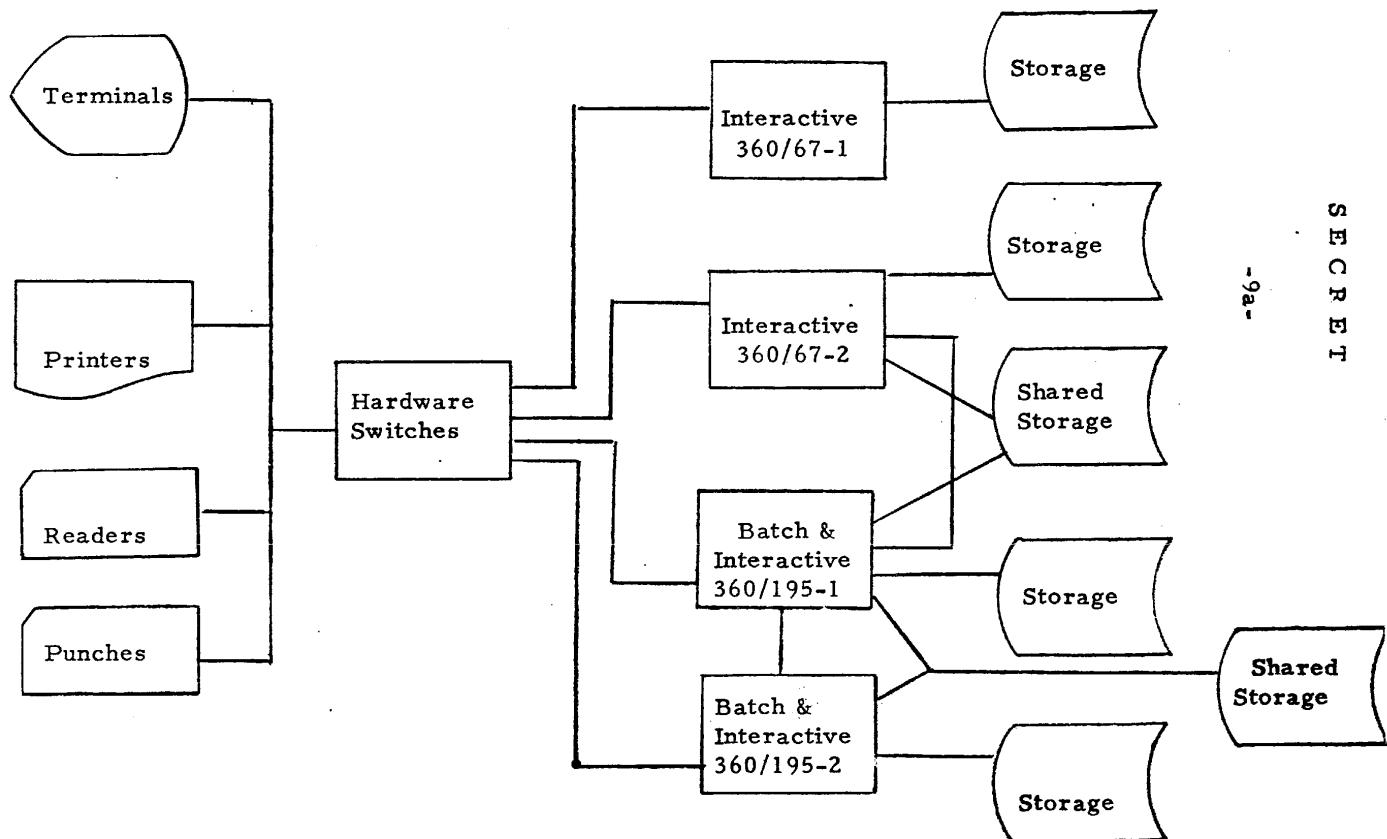
The plan calls for the large Model 195 computers to utilize software known as ASP (for Attached Support Processors) or LASP (for local ASP). This software system provides for automatic scheduling of jobs on systems based upon job characteristics, resources available, and indicated priorities. It includes automatic load leveling. The 360/67's will continue to use the virtual memory concept (paging) of the CP/67 variety and more than likely will be that system for some time to come. Other software, such as TSS, is under continual review, and one of them may prove to be more suitable.

Some direct access storage devices will be shared (a) between a 360/67 and a 360/195 for passing data sets from one machine to the other, and (b) between the 360/195's to store common program libraries and data sets. The technology for this limited sharing is already available and is operational in some installations. Management of storage could develop into a bottleneck in the network. We believe a "back-end" storage processor, analogous to the "front-end" communications processor, is a feasible concept. We will begin to investigate its use in the network, but do not anticipate operational use in the planning period.

Most user terminals will be connectable to any computer system and its data sets in the Computer Center through a patch panel or a communications processor.

7. SYSTEM DESCRIPTION

Jobs or data may enter the computer network in any of the following ways:

- over the counter (through local readers)

- over telecommunication lines (Remote Job Entry - RJE)

- over telecommunication lines in near realtime

- from the interactive user.

Which processor actually supports the user could be determined (a) on command from the user, or (b) automatically by the software system based

upon the load leveling algorithm or upon the function to be performed.
Over-the-counter job submissions will be handled as a normal function
of the network. The system would be sufficiently flexible to handle
special or priority requirements.

The 360/195 systems will process both batch and interactive work
and will accommodate the four basic kinds of inputs noted above. The
batch work, both over-the-counter and RJE on the 195's, will be controlled
by the Attached Support Processor (ASP) software. The interactive work
on 195's will be controlled by standard Operating System (OS/360) software.

The 360/67 system will process interactive work and also provide
the interactive user with a link to the 195's for tasks which can be better
handled by those systems. For example, he may want a 195 to do a long
computation program on data he selected using the interactive facilities
of the 67. This is our current mode of operation, using CP/67 and CMS
software on the 67 and a link to one of the 360/65's.

The relationships between these computers and the controlling
software is illustrated in Figure 2. This diagram shows the possible
input paths from user to his processing function via the controlling soft-
ware elements. Reversing arrows would depict flow from processing
function back to the user. The batch and interactive processing functions
are described in more detail below.

7.1. Batch Processing

The IBM ASP software will be installed to allow the batch work to
be handled by a network of computers regardless of the number of
processors involved. We hope to derive two benefits from the ASP
approach:

    - Enhance the operating environment of the computers using
OS/360 by automating many of the operator functions.

    - Optimize the scheduling of the batch workload. ASP has the
potential to reduce resource contention (CPU, Core, and input/
output); and it employs an efficient algorithm to automatically
allocate system input/output data sets, which can increase utiliza-
tion of available space while maintaining reasonable access times.

Figure 2.

SYSTEM INPUT FLOW

over-the
counter

RJE

RJE

batch
input

ASP

OS/360

CP/67

CP/67

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OS/360

CMS

CMS

user
processing

user
processing

user
processing

user
processing

195-1

195-2

67-2

67-1

interactive
and
real-time

interactive
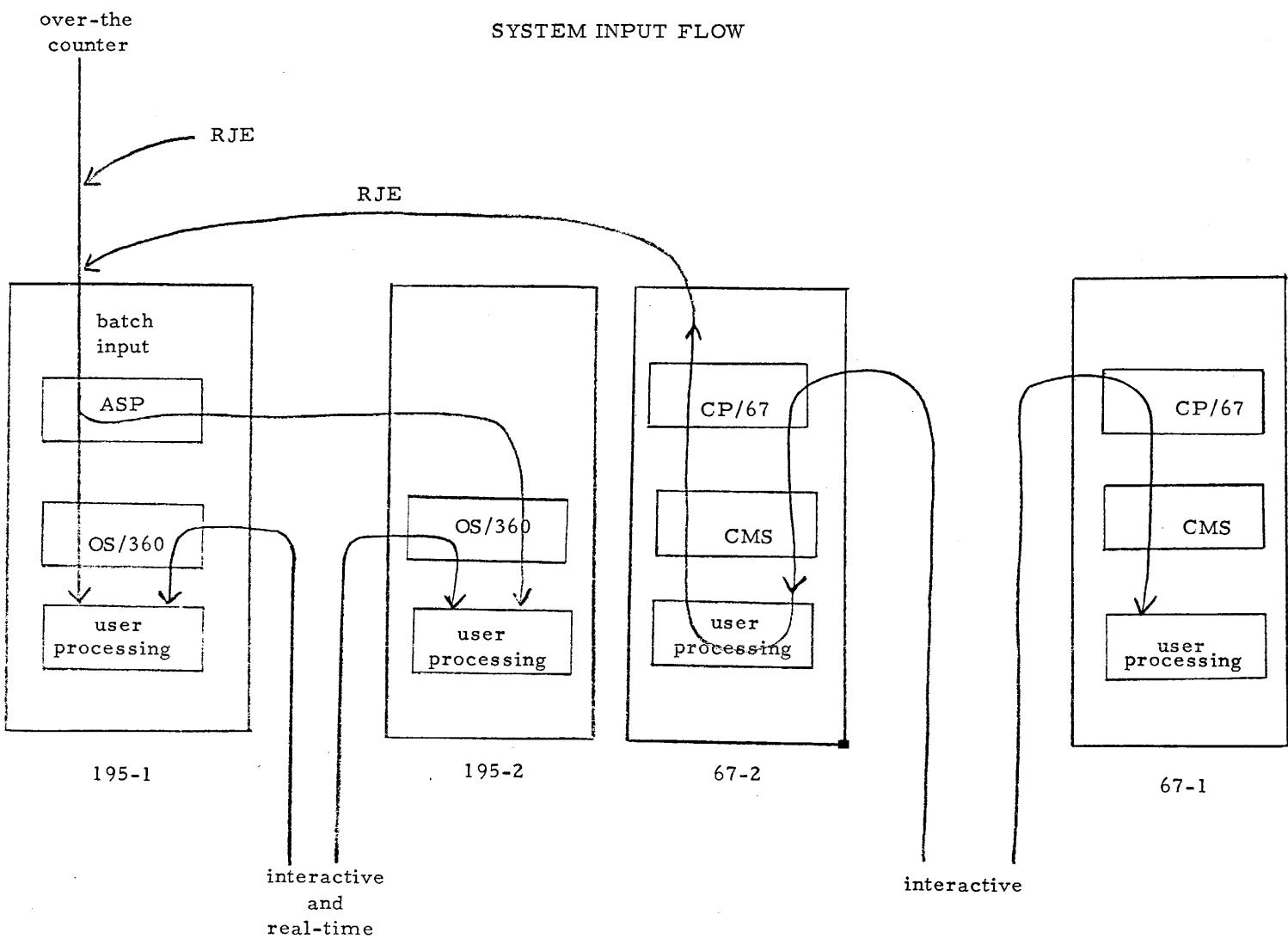
In addition, ASP permits intermixing of 7090 emulation programs in an OS/360 jobstream, it provides telecommunications support for transmit and receive terminals, and it permits peripheral support and other background jobs to be processed directly, reducing OS/360 overhead. Consoles can be located at strategic locations in the Computer Center to allow information exchange between the system and the operators, tape librarian, control point, system manager, etc.

At system start-up time, either 195 could be assigned the ASP function (shown as 195-1 in Figure 1) or each processor could be operated independently. All printers, card readers/punches, telecommunication equipment and the necessary secondary storage would be switchable between processors so that both processors could be assigned the necessary hardware to assume the ASP function.

Special processors, if necessary, would probably stand apart from ASP, but in some cases may be connected to ASP so that it can assume some of the system burden.

7.2. Interactive Processing

Interactive work (from terminals with keyboards requiring fast response) would be handled both by the 195's and the 67's. The system to be used depends on several factors. Interactive work on the 195's will have one or more of the following characteristics:

- several concurrent users of a given file;

- medium-sized or large files;

- close relationship between interactive and batch activities for the application;

- relatively modest core requirements;

- designed for OS/360 operation.

Conversely, interactive work on the 67's will tend toward the following:

- individual, personal use;

- small files;

- loose coupling of interactive and batch activities;

- large core requirements;

- designed for CP/CMS and "non-standard" operation.

It is important to emphasize that these distinctions are necessary not primarily because of differences in user requirements but because of factors in software and hardware technology such as memory organization and input/output methods. Therefore, the choice of computer system and related control software may be based on criteria which are artificial or irrelevant to the user. *

The 67's will function in much the same way they do now: the user will have access to one or more virtual machines, invoking CMS functions or simulating other 360 systems. (See "OCS Interactive Services User's Guide," 1 December 1969, for a description of the CP/CMS software.) Coupling of the two 360/67's is not contemplated in this plan, but duplexed versions of TSS and CP are available and will be reviewed. The central processor on the installed 360/67 is not designed for direct coupling; a replacement of this purchased component would be required.

Most interactive users of the 195's will use functions which are specialized to their application (for example, manipulation of graphics or file maintenance), but more general software packages may become available for economical use on these systems. The difficulty here is OS/360, which in its current form requires that programs for interactive users remain in core memory. IBM's Time Sharing Option (TSO) software will provide memory swapping services under OS/360. This and other methods of improving the flexibility of the system for interactive users will be investigated.

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*A major design concern during the planning period will be whether a more rational approach to interactive tasking is possible. Given the goal of homogeneous systems, we will continue to seek a method of handling all or most user interactive needs economically on the machine used for batch work. The continuation of both OS/360 and CP/CMS systems in this plan implies a judgment that this goal is probably not realizable by 1975.

7.3. Communications Processor

When or if a communications processor is included in the network, the appropriate functions will be gradually transferred to it, hopefully with no impact on the user.

The communications processor would have the basic function of handling telecommunication lines for both interactive and batch processing terminals. The function is shown in its simplest form -- switching -- in Figure 1.

All terminals (interactive and non-interactive) and remote computers would enter the OCS Computer Center via the communications processor. This would eliminate the need for a number of line adapters attached to each processor as well as the requirement for software in the main processors to handle the communication lines. The central computer software system would be required to handle only the lines to the communications processor. Any type of terminal could be made accessible to all main processors without changes to the computer system software.

The communications processor would handle the lines in a store-and-forward mode and a conversational mode. In the store and forward mode, blocks of data from each telecommunications line would be accumulated on secondary storage and then passed, together with data from other lines, at high speed to the proper system as one large block. In the conversational mode, data would be passed immediately to the computer, but multiplexed with data from other lines. All interactive terminals would be handled in this mode.

8. MAJOR STEPS TOWARD IMPLEMENTATION

Changes described here will be made as user requirements arise. They are shown as the fewest number of steps to get to the network shown in Figure 1. We believe this plan is flexible enough so that we can choose alternate sub-paths as changes occur or where problems develop without affecting the long term goal.

This section should not be considered definitive; its main purpose is to indicate that it is possible to get there from here. Our immediate objective is to begin a course of action toward detailed analysis and implementation of this plan. We have indicated approximate dates for

each step. These dates should be considered illustrative only; they are based on assumptions about major factors such as increased computer load, new functional requirements, the availability of the hardware/ software, the time it takes for implementation, and the availability of funds. The steps are summarized in Figure 3.

Step I: Second Quarter CY 1971

- Install ASP on 360/65-1 and 2.

Step II: Third Quarter CY 1971

- Install large core storage (LCS) on one of the 360/65's.

- Install 360/67-2 as a replacement for 360/65-3.

- Release 360/65-3 when its functions are absorbed by 360/67-2.

Step III: First Quarter CY 1972

- Install 360/195-1.

- Install ASP system on the 360/195, 360/65-2, and 360/67-2. (360/67-2 may be used part-time as an Interactive System.)

- Release 360/65-1 when its functions have been absorbed by the other computers.

Step IV: CY 1973

- Install IBM 360/195-2 and make operational within ASP control, removing batch load from 360/67-2.

- Begin implementation of IBM 360/67-2 as an interactive system.

Figure 3.

COMPUTER SYSTEM PLANNING CHART

By Calendar Year Quarter

	1971 1st	2nd	3rd	4th	1972 1st	2nd	3rd	4th	1973 1st	2nd	3rd	4th	1974 1st	2nd	3rd	4th	1975 1st	2nd
360/65-1																		
360/65-2																		
360/65-3																		
360/67-1																		
360/195-1																		
360/67-2																		
360/195-2																		
RCA 70/45/35																		
360/20's																		

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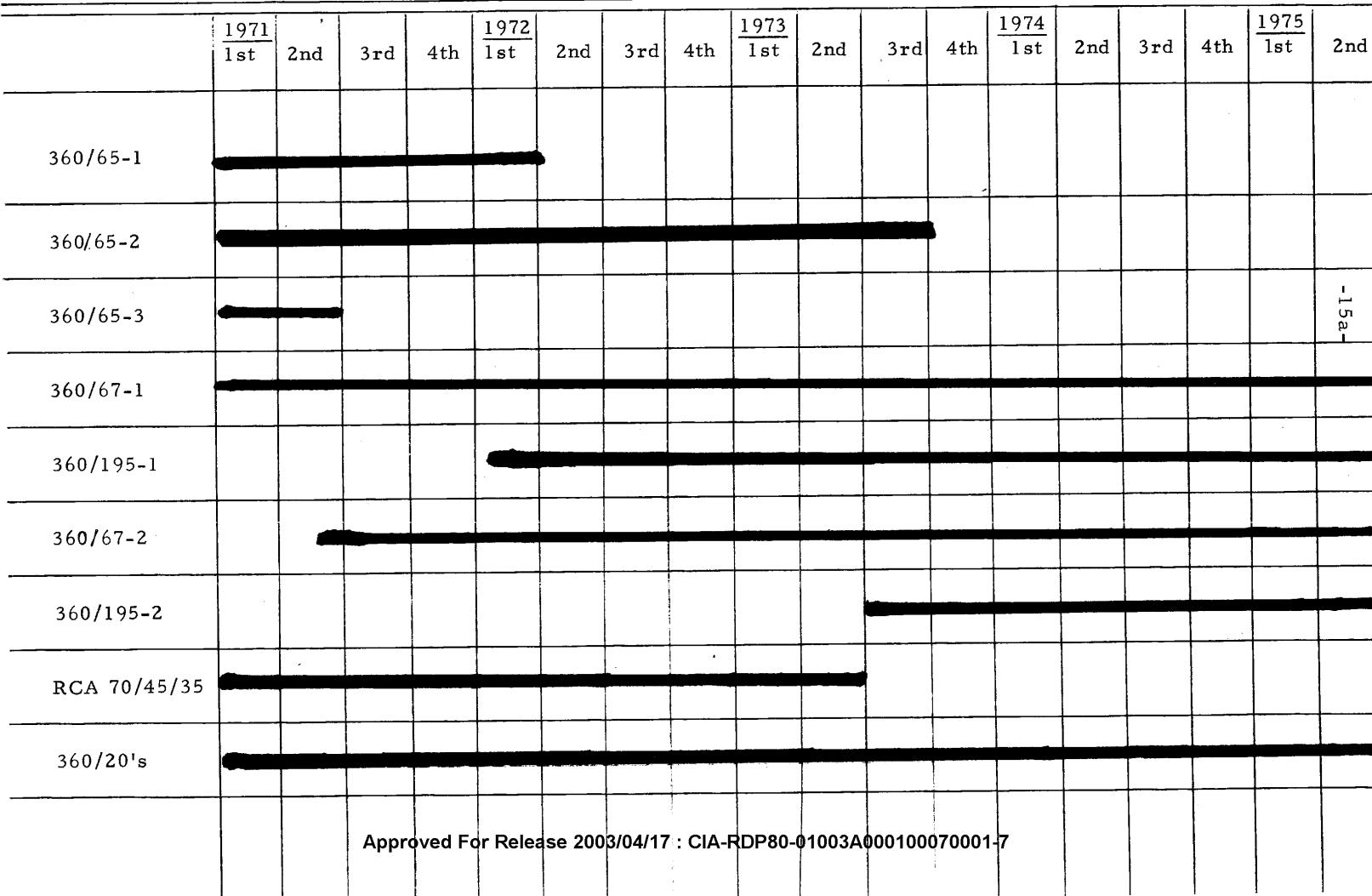
- Release RCA 70/45 and 70/35 when its functions are absorbed by IBM computers.

- Release 65-2 when its functions are absorbed by 360/195-1 and -2.

9. PROJECT CONTROL AND DESIGN REVIEW

A necessary ingredient to this computer systems plan is a method to control an otherwise ever increasing workload. We need to establish procedures and mechanisms for review before a computer project is initiated and at certain milestones to insure that progress on the project is appropriate and proper. At these milestones and at other opportunities, we believe we also need to undertake technical design reviews to insure that the design of computer applications takes into account any opportunity for efficient use of computer resources.

We intend to develop and establish a specific project control and design review methods. These goals will probably require organizational recognition of the review functions. Some ideas now being examined:

- For project control we could charge users for their use of OCS resources; we could require project approval from higher authority at project initiation time, and we could require that project cost estimates be made and then reviewed by management at certain established milestones.

- For design review we could establish a technical review group which would establish design standards and review projects during development, measuring them against the standards, or we may require review by a third party.

We plan to have the first draft of our ready for coordination with the Information Processing Board in early 1971.

10. BUDGET AND FUNDING (RENTALS)

The attached table shows projected equipment rental funding for the period 1971-1977 as submitted in the OCS Program.

Assuming a progression of changes and upgrading which is responsive to user need on one hand and is paced so as not to overtax OCS resources on the other hand, we believe we can accomplish the goals outlined in this planning report within the established estimates.

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