26 June 1968

MEMORANDUM FOR: Director of Computer Services

SUBJECT : Report of Time-Sharing System Selection Committee

25X1A [redacted]

2. The applications' division chiefs assumed responsibility for ascertaining projected time sharing workload. The results of these surveys are attached to this report as Attachments A, B, and C.

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4. Compatibility of the selected system with the present OCS systems was stated as an essential objective by [redacted] No 25X1A
other members of the Committee disagreed with this objective. In effect, this objective narrowed the selection to an IBM 360, or possibly the RCA SPECTRA 70/46. Attachment E contains a list of other systems reviewed

and the primary reason for rejection from further consideration. The systems studied in depth are:

a. TSMON - 50, the current OCS time sharing system.

b. TSMON-RUSH - 50, the current OCS time sharing system with LCS (large core storage).

c. ADEPT - 50, the SDC (System Development Corporation) system which is under consideration by IPRD.

d. TSMON - 65, current OCS system on a Mod 65.

e. TSMON-RUSH - 65, current OCS system with LCS on Mod 65.

f. ADEPT - 65, the SDC system on a Mod 65.

g. TSS - 67, IBM's time sharing system for the Mod 67.

h. CP - 67, a virtual machine system written by Lincoln Labs and IBM for Mod 67.

i. TS - 70/46, a system by RCA written for the Spectra 70/46.

j. Duplexed small machines such as twin Mod 40's or twin S-70/46's.

See Attachments F, G, and H for cost comparisons.

5. Widely divergent views are held by the six Committee members. A general characterization of the views is that the three applications oriented members have conservative views and wish to delay time sharing and put more emphasis on improvement of the batch system OCS is currently using. However, specific reasons, objectives, and emphasis appear to vary considerably among the above three members. [redacted] 25X1A
25X1A believe in time sharing and believe that the Agency should progress rapidly to a fully implemented system; however, these three members also have differing opinions as to specifics. These three have come closer together in views, since the favorable performance of the CP-67 on comparison performance tests and most of the specific differences are trivial as to long range implications.

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6. Since [redacted] has promised the Director of Computer Services a completion of the study and a recommendation as to future direction by 1 July 1968, and since there is little probability that a consensus of opinion will emerge, the following course of action is taken.

a. This paper is being written and includes a general discussion of the selection considerations. It also includes statistics on performance comparisons. [redacted] has other statistics and information available on systems.

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b. This paper does include a recommendation by [redacted] Committee Chairman.

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c. This paper is being presented to the Committee on 26 June 1968 for review.

d. Each member is then being asked to write for the Director of Computer Services a concurrence in the recommendation or a dissenting memorandum detailing his objections and recommending an alternate selection or course of action.

7. Objectives. The objectives of the study are those of the memo "Planning for IBM 360/50 Replacement" to CSA by DD/OCS of 26 April 1968. See Attachment I. In addition to these objectives, security compartmentation especially between files accessable to Agency users only and those accessable to non-Agency users is an overriding consideration.

8. Discussion of 10 Studied Alternatives.

a. IBM 360/65. Since the Mod 67 has hardware features such as dynamic relocation and special channel functions which are extremely desirable for time sharing and since the Mod 67 leases for less than $5,000 per month more than an equivalent Mod 65, and since the Mod 65 cannot use such time sharing software as CP, CMS, and TSS; and since the Mod 67 can run in a Mod 65 mode as Mod 65 backup, all systems which included a Mod 65 were rejected. This decision appears obvious, especially when considering the extra very skilled manpower costs required to compensate for Mod 65 hardware time sharing deficiencies.

b. IBM 360/50 - RUSH. This system requires two million bytes of LCS, will handle 90 users, but uses PL/1 only and has no query language. This system is good, but is very inflexible to adopt to known and speculative future Agency needs.

c. IBM 360/50 - ADEPT. Not operational yet, will support nine terminals on Mod 50 and 30 on Mod 65. LISP, JOVIAL, TINT (JOSS type language), TDMS (CAPRI type file management system). Requires drum - does not appear to have an effective scheduling algorithm. This system possibly could be used in an experimental environment but it was felt that OCS has advanced beyond this level. Production must be mixed with experimentation.

d. IBM 360/50 - TSMON. Several possibilities are available. LCS (Large Core Storage) could be added. However, partition sizes are limited and this relegates the customer to use languages developed by the systems programmers. Procedural languages would use excessive amounts of core in this environment. Although OCS sentiment and pride tends to bias a decision towards this system, it was felt that much more flexibility is required to meet the future unknown requirements. Also, the good features of this system could be salvaged for another system with a minimal amount of reprogramming. Maintenance of and feedback to this system depends solely on Agency effort; no other users are contributing to the research and further development.

e. IBM 360/67 - TSS. Not fully operational and performance is very poor.

f. TS - RCA 70/46. This system has many fine features. RCA has learned from the mistakes of others. RCA answers every objection with a promise of support or performance. However, RCA promises too much and shows too little which is working. Also, a technical evaluation of RCA's promises of performance and support suggests that RCA is promising the impossible, especially for the January 1969 target date. RCA promises direct compatibility or their effort to make files, programs, and hardware compatible to present systems. If these are true, it will be easy to convert to RCA (which is much, much less expensive) at a later date. The progress and performance of the RCA 70/46 should be reviewed and compared after it is running. Thus, for the present, the RCA 70/46 has been rejected. (See Attachments G and J for additional reports on RCA 70/46.)

g. Duplexed Small Systems. RCA 70/46 and Mod 40's were considered. The big advantage in these cases is binary security compartmentation. This is absolute and is approved by the Office of Security. A secondary reason is backup, however, this duplex backup would be at the expense of having both security compartments active. If the RCA 70/46 were tested in the future and approved technically as an adequate time sharing system and if the price remained as it is at present, it should be considered strongly in the future. The Mod 40's are not powerful enough to allow for any expansion or progressive time sharing development. To box the Agency time sharing efforts with such constraints is extremely shortsighted. If the Office of Security insists on separate hardware systems, consideration should also be given to a Model 40 for the COINS network and to retaining TSMON on a Model 50 for internal Agency time sharing needs. (See Attachment K for a proposed configuration.)

h. CP-67 (IBM 360/67). This system is working, is available, and meets all objectives of the study as outlined in the DD/OCS memo (see attachment I). Negative attributes are cost which is high (but within the planned budgetary limits), and the objections of the Office of Security to putting all material on one physical piece of hardware. CP-67 is running operationally at Lincoln Labs, Washington State University, and several others. All are converting rapidly to sole use of CP on the Mod 67 for their time sharing support. Most of these environments are not similar to that in OCS; however, Lincoln Labs has a similar enough load and mix to draw comparisons and conclusions. LL has 30 terminals on-line with several virtual machines in the background using OS and CMS. Terminal response time is excellent and the CP will run a number of operating systems such as CMS, OS, DOS, TSMON, ADEPT, etc. and concurrently if needed. CMS has a text editor, FORTRAN-G, ALC, PL/1, and other languages on-line. The OCS language SOLVE is a sub-set of PL/1, and SOLVE problems were run correctly under CMS by the simple addition of a semicolon at the end of each statement. This PL-1 is not an incremental compiler and thus must be compiled as an entity. For some purposes, SOLVE has advantages over the PL-1. CP-67 was previously CP-40 and its experience level dates back more than two years.

The greatest advantages are its flexibility and power for expansion. Production and experimentation can be processed concurrently. See attachments D and H for additional details.

A comparison of CP-67 characteristics with objectives of the DD/OCS memorandum follows:

a. CP-67 and its CMS is a good time sharing system with fast response. It has an excellent background processing capability which is 100% compatible with other OCS processing.

b. CP-67 comes very close to meeting a general objective of both multiprogramming and time sharing. This is not recommended at this time, but the feasibility of doing this operationally should be investigated. Multiprocessing is not available in the strict sense as of this date. CP-67 is compatible with present systems in that other systems can run under it.

c. CP-67 not only can provide a production time sharing environment by January 1969, but also an experimental one by making each a virtual system under CP-67.

d. Experimentation and extensions can be done on the same system by the virtual machine extension.

e. Costs are within the budget. Even should additional costs arise (unlikely unless to take more advantage of background capability by having more I/O devices), this system is so superior to others that justification should not be a problem. As a temporary economic saving the drum (2301) could be omitted and a performance measurement taken without it. This is only a second rate alternative, however.

f. Conversion is fairly easy. TSMON can run under CP as soon as several new peripheral support modules are finished (momentary). This probably is not desirable for the long haul, but the system flexibility does not create any extreme time constraints or pressures to convert.

g. Load - CP-67 has the power to expand greatly. Of course, every expansion will degrade background capability.

h. Manpower Resources. Many time sharing systems have been written for IBM 360. All of these systems can be tested as virtual systems under CP, and the developed packages can be extracted or run unchanged under CP-67. No other system gives us as much software flexibility, expansion as CP, and thus CP allows more human resources to be placed on solving customer problems. It is strongly stressed that CP is a large and powerful system. New devices and new functions will be desirable and will be added. OCS must plan to staff this effort with an adequate number of system programmers.

9. Security Considerations. Two separate machines for non-Agency users and files and others would give the Office of Security comfort. CP-67 does not meet this requirement in that it is one physical machine.

However, CP-67 has a new concept, "virtual machines" and it has special hardware to protect virtual machines from each other. The protection given in the virtual concept probably has a higher probability of no error than electronic communication systems which are used in Agency message handling and which the Office of Security allows to function. Expediency, i.e., data communications, has overcome Office of Security reluctance to approve. The time is approaching when a review of computers and their compartmentation security is in order. Just as in communications, the time will be reached when maintenance of separate systems will not be feasible.

However, let us assume that the Office of Security will not approve, at least at this time. It is recommended that the system service non-Agency personnel for a block two hours a day. Agency users who were not using privy Agency files could still function on-line, such as SOLVE users, program editors and conversational programmers. During the remaining 22 hours a day, Agency users could have free access, and this access could include those files which were shared with non-Agency users during the two hour block time.

As an alternative recommendation, the Mod 40 in CRS could service non-Agency users, i.e., be the COINS processor. Generally, the files on this system are those which are available to the non-Agency users of COINS. Those CRS processed files which are specially sensitive could be processed by OCS. It would seem that the administrative, management, and technical details would not provide unsurmountable obstacles.

As an alternative to replace either of the above at a future date, research should be undertaken to test ROS (Read Only Storage) as an absolute protection for one of the virtual machines. This seems feasible, especially on the Mod 67, however, it would take time to develop. Possibly, mid 1969 or early 1970 can be suggested as target dates for this evaluation.

10. Conclusion. It is recommended that the Agency lease a Mod 67 of the configuration shown in Attachment H for January 1969 to replace the present Mod 50. It is further recommended that Advanced Projects Staff put together a conversion plan for this changeover. Acquisition of such a system is a positive and progressive approach to solving Agency computation and information handling problems. Intuitively, such a step will prove to be the most economical over the future years.

It is also recommended that the letter of intent to IBM for lease of the IBM 360/67 clearly state that support for CP and CMS software must be supplied. CP/CMS software is IBM Type-3 (same type as HASP) and sometimes IBM will default on software support for Type-3 programs unless this is requested before contract negotiation.

In summary the CP-67 (CMS) is recommended because:

a. It is seasoned; it has been working for two years.

b. It does handle many terminals with an excellent response time. One installation occasionally has 60-80 terminals active, and another has 20-30 active in a routine production mode.

c. It is 100% compatible with the OCS batch processing systems.

d. Its background processing capability is at least 50% of a Mod 65, and depending upon human and procedural variables, may be as high as 100% of Mod 65.

e. It does multiprogram.

f. It can be used as a production time sharing machine.

g. It can be used experimentally and concurrently with production to test subordinate time sharing systems.

h. Costs are within the OCS time sharing budget.

i. It has the best internal compartmentation hardware of any one machine, and has possibilities of being engineered to absolute compartmentation.

j. Conversion problems are minor and less than any alternative other than direct upward extension of the present system.

k. Expansion - It has the brute power to handle peak terminal loads and quadrupling of projected load can be absorbed with no serious degradation.

l. Upward compatibility - The IBM 360/67 is upward compatible, either to duplexed multiprocessing hardware or to the IBM 360/85 (a version of this machine is being equipped with time sharing hardware).

m. More software, both time sharing and batch types, is available and will run on this machine more than for any other machine.

n. Manpower requirements are less than for any other comparable system.

o. The better features developed for the OCS time sharing system can be salvaged.

The five other members of the Committee will be giving D/OCS memoranda of concurrence, comments, modifications and/or rejections of these recommendations.

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Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

Attachment "A"

13 June 1968

MEMORANDUM FOR: DD/COS

SUBJECT: Proposed SAD TSS Requirements

1. As of 1 July 1969

Application: Project Profiles

Number & Type Terminals: one 2260

DAS requirements: two million bytes

Program requirements - Core: Possibly one 15K module for one special purpose program. All other requirements can be satisfied with LINUS, TSAR, etc.

2. As of 1 July 1970

A. Application: Project Profiles

Number & Type Terminals: one 2260

DAS requirements: two million bytes

Program requirements - Core; Possibly one 15K module for one special purpose program. All other requirements can be satisfied with LINUS, TSAR, etc.

B. Application: Project MEDSTAT

Number & Type Terminals: Two 2260's

DAS requirements: Two million bytes

Program requirements - Core: No special purpose requirements. Needs TSAR, LINUS, SOLVE.

Attachment "A"

C. Application: Cartography, ANDI applications, other SAD Ad Hoc requirements.

Number & Type Terminals: One 2260, one 2250.

Das Requirements: Unresolved at this point in time. At least one million bytes for Cartography by 1 July 1970.

Program requirements: 100K for CAM. 200K for SADIG. Other requirements can generally be satisfied via existing TS programs such as LINUS, SOLVE, DESKCAL, etc.

3. The proposals listed herein assume an OCS decision to support time sharing. They do not necessarily require a time sharing environment and with the possible exception of the project profiles application might very well function better in an environment in which the expenditures were placed on decreasing turnaround time as opposed to buying and supporting a time shared system. There is a need and the justification in all cases for an RJE capability combined with the flexibility to alter source coding and data via a remote terminal device. But it is possible to incorporate these features in an MVT environment therefore providing at least a 25% decrease in turnaround time for the whole of OCS assuming a one for one dollar expenditure on equipment compatible with existing OCS hardware versus the expenditure on time sharing, while at the same time providing the flexibility on all OCS hardware of the most valuable exting time sharing systems capabilities.

In summary, the real need is for:

1. a capability to run very large programs,

2. a remote job entry capability,

3. the flexibility to alter programs and data through an on-line remote console, and

4. the ability to have output either printed in hard copy or displayed on a 2250 or 2260 display device and in the special case of the ANDI system to have pseudo real-time output as opposed to a HASP-like queued output system.

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Attachment "B"

PROJECTED TS APPLICATIONS from MSD

Estimate, TS Applications as of 1 July 1969

APPLICATION	# TERMINALS	TYPE	DASD	TYPE	CORE MAXIMUM
SANCA	3	2260	1 3	2321 2314	56K
ACORN	1	D.P.	?	2314	None outside TSAR
OCS-ADMIN	1	2260	?	2314	None outside TSAR

Estimate, TS Applications of 1 July 1970

APPLICATION	# TERMINALS	TYPE	DASD	TYPE	CORE MAXIMUM
SANCA	3	2260	1 3	2321 2314	56K
ACORN	1	D.P.	?	2314	None outside TSAR
OCS-ADMIN	1	2260	?	2314	None outside TSAR

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Attachment "C"

PROJECTED TS APPLICATIONS from ISD

Estimate, TS Applications as of 1 July 1969

1. Application: PARIS

   Number & Type of Terminals: 2 CRT for query
   1 hard copy output

   Amount of DA Storage Required: 1060K bytes

   Program Requirement - Core: 100K bytes

2. Application: CHOP SUEY

   Number & Type of Terminals: Can use same terminals as PARIS

   Amount of DA Storage Required: 1500K bytes

   Program requirement - Core: 100K bytes

3. Application: HES

   Number & Type of Terminals: one 2741

   Amount of DA Storage Required: 12,000K bytes

   Program requirement - Core: 100K bytes

4. Application: Other SAVA

   Number & Type of Terminals: one 2741

   Amount of DA Storage Required: 12,000K bytes

   Program requirement - Core: 80K

Attachment "C"

5. Application: OSR

Number & Type of Terminals: one 2250

Amount of DA Storage Required: 150,000K bytes (using Litton figures)

Program requirement - Core: ?

6. Application: FMSAC

Number & Type of Terminals: one 2250, two 2260, one hard copy output

Amount of DA Storage Required: 7,000K bytes

Program requirements - Core: 250K bytes

7. Application: NIPROD

Number & Type of Terminals: one 2260, one hard copy output

Amount of DA Storage Required: 7,560K bytes

Program requirement - Core: 100K bytes

Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

ATTACHMENT D

24 June 1968

MEMORANDUM FOR THE RECORD

SUBJECT: Report on IBM360/67 Test Using CP

STAT STAT

On 21-22 June 1968, [redacted] OCS with [redacted] IBM went to IBM, Yorktown Heights, N.Y. to use the IBM 360/67 to test the CP (Control Program) software written jointly by Lincoln Labs of M.I.T. and IBM. The 13 programs, 12 FORTRAN and 1 ALC, which OCS has used as a benchmark to test scientific processing capability and another 25 programs of PL/1 compiles, links, and GO's which (with the exception of one grinder, i.e., CPU bound) were essentially I/O bound types were used to create a mix which was meant to typify the OCS environment.

STAT

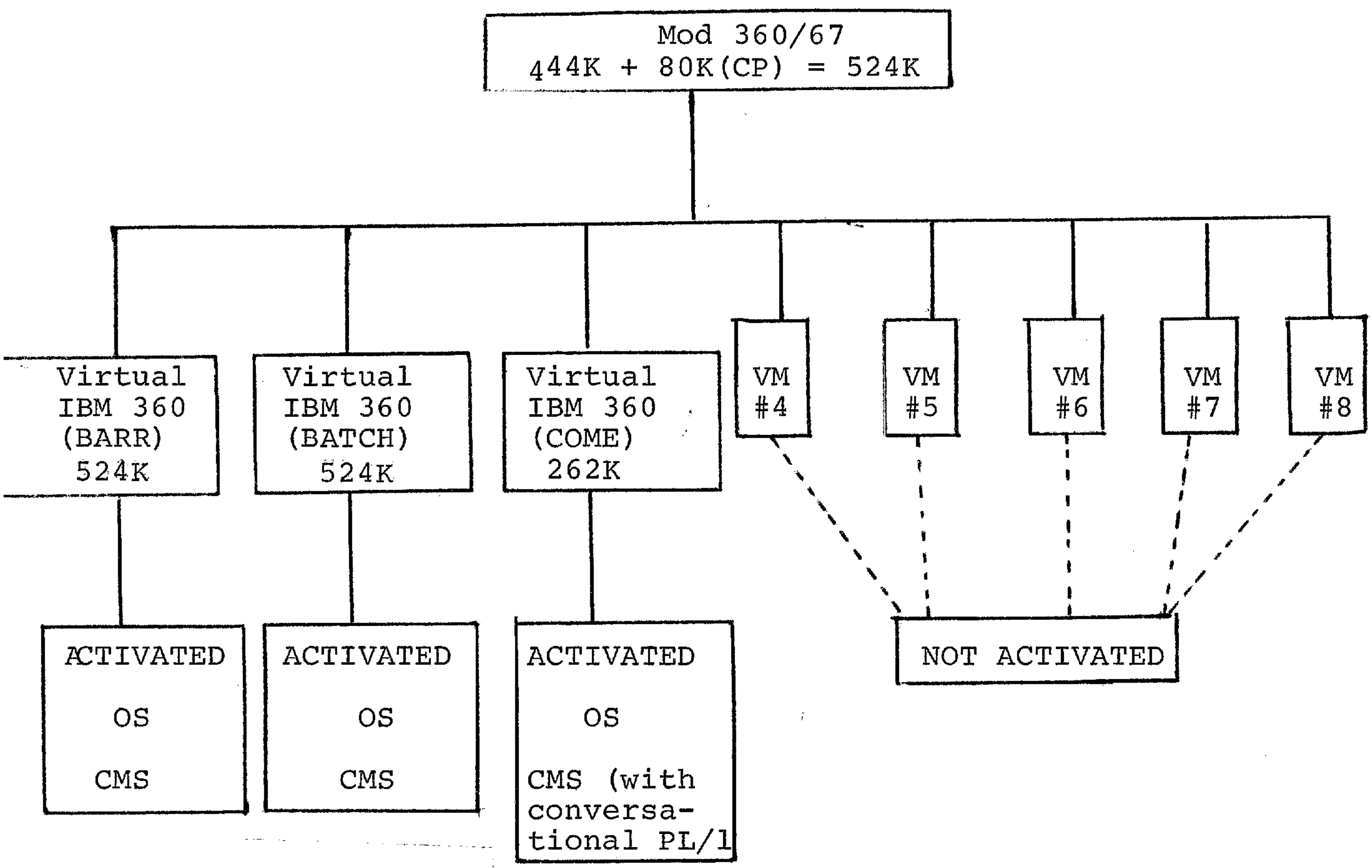
The initial two hours on the machine were a succession of errors, many human and one machine. [redacted] IBM had generated virtual machines on a tape and disk which would represent the OCS environment. His car had been broken open and the tapes and disk pack were vandalized. A substitute CP system which did not possess the recent optimization features was substituted at the last minute. The destroyed system was on 2314 disks, but unfortunately the substitute system used a combination of the 2301 drum which is faster and the 2311 disks which are slower. The tradeoffs of the two alternatives are so variable that no attempt will be made to compare their relative performances except to state that it appears that they are somewhat equivalent. This Mod 67 which was used had a very large variety of experimental components and part of the human problem was to vary the unwanted components off-line. For example, a new experimental communications controller was on-line and we had been told to disconnect it since it degraded line interleaving considerably and caused other problems. In the "virtual" confusion we forgot to disconnect it, and after disconnecting it later after running awhile, one 256K memory box gave a machine check. At this time we discovered we had used three (3) memory boxes instead of the desired two (2), and thus took the opportunity to switch out the suspected defective box and the communications controller. Sixty (60) terminals were on-line in the building and some number from external sources were also connected to the system. Unfortunately, as we were delayed to a starting time of 2326 on a Friday night, the users of the terminals no longer called in, and the terminal exercise had to be performed by the five of us who were conflictingly busy with the CP and the test measurements.

The final CP environment included a 2301 drum, 2311 disks, tapes, card reader, printer, 60 in-house terminals, an undisclosed number of external terminals, and 524K of memory of which 80K was reserved for CP. On this 444K (net) memory machine, we created eight (8) virtual 360 machines. Of these eight (8), because of lack of manpower, we were able to activate only as many as three (3) machines at one time. Virtual machine #1 (symbolic name of BARR) was given 524K bytes of core plus various peripheral space and on its library we put two (2) systems, OS and CMS (Cambridge Monitor System). Either OS or CMS could be active at one time. CMS has terminal handling capability and since it uses virtual memory, it can handle N terminals (of course, limited by lines and controllers). It also contains FORTRAN-G, SNOBOL, PL/1, and ALC, all of which can be used in batch or conversational terminal mode.

Virtual Machine #2 (symbolic name of BATCH) was identical to BARR (#1), i.e., it also used 524K of virtual memory and contained both OS and CMS.

Virtual Machine #3 (symbolic name of COME) was identical to the other two but only used 262K of virtual memory. This one was to be used for our terminal testing, and its CMS also contained the conversational PL/1 compiler.

Thus, in summary, a 524K Mod 67 with a net actual memory of 444K (80K used for CP) was made to act like three (3) other machines, two of them with 524K memories and one with 262K memory. Five (5) additional but non-activated systems were also included.



Mix of Jobs Used in Test

Twenty (20) CLG (compile, linkedit, and GO) PL/1 programs were used. GO times on nineteen (19) of these were very minimal, in contrast to the compile and linkedit times. One program, P-44 was specially written as a small PL/1 grinder, i.e., a PL/1 program which was CPU bound in a tight loop. One ALC compile, three (3) FORTRAN compiles, and five (5) FORTRAN CLG's, all of which were test programs used in previous benchmark measurements and all of which were short were included. Another relatively long FORTRAN job, P-70, which was CPU bound in an infinite and medium size loop (required some paging) was used to saturate one virtual machine for the final 2-1/2 hours of 3 hour test run. No performance figures can be compared or are pertinent for this job. However, it is valid to state that this steady processing assured a good measure of a variety of programs running concurrently with another loaded virtual system/machine.

Programs used on the terminal were FORTRAN, ALC, and PL/1. The load generated by the terminal users cannot be measured or compared except to say that the third virtual system/machine was active. See Charts A, B, and C for performance and chronological running statistics.

Initializing of Virtual Machines

Initializing of a virtual machine and its system is a matter of seconds. This appears to be as simple as possible.

Compatibility with HASP

A HASP/OS system is just another system and can be loaded like any other. In our test, we did not load HASP/OS but rather just OS. CP does its own spooling and HASP is not necessary; in fact, a HASP/OS system will SPOOL to the HASP SPOOL queue and this queue will in turn SPOOL to the CP SPOOL queue. Obviously, this is redundant and inefficient. For a shop which wishes to process jobs in CP as background and yet maintain compatibility with other HASP systems in the shop, an operator command is available for the operator to ATTACH a device such as a printer or card reader to the HASP virtual machine in a "sole use" mode. Thus HASP/OS jobs can be run under a virtual machine without change if the operator ATTACHES the HASP devices to that system. This does mean extra hardware and cost. HASP jobs will run under CP without this feature, but accounting information is not gleaned from the job card. In fact in our test, this happened several times when the old HASP job card was inadvertently left in the deck. (See Chart "A", Jobs PROB45 and PROBPL.)

Efficiency of Background CP Programs

Most programs ran about four (4) times as long in the background under CP as they did under HASP (See Chart "C"). However, always two jobs were being processed concurrently while the terminal system was exercised. Thus, it can be stated that background capability on a Mod 67 is approximately one-half of the Mod 65 throughput capability when a minimal on-line interaction is performed. Degradation of background upon activation of additional terminals has not been measured. When activity is "trivial" on 10-30 terminals, a small linear degradation is evident (from Lincoln Labs trip). Number of terminals alone is not a valid comparison measurement but interaction speed, type of compute, type of query, etc. are all very complex and little understood variables and thus conclusions on degradation are risky and will not be made. It is valid to so state that on-line response is excellent in all cases observed on the previous trip. The system should be viewed primarily as an on-line system with good handling of background jobs in the remaining time.

The performance of one program, P-44, is interesting. It had the highest ratio of HASP time to CP time (18/45) and it is a grinder. However, it is PL/1 and small. Its relatively efficient performance (it was running concurrently with another grinder and with the terminal system) might be attributed to the fact that it was too small to page or to the fact that it was PL/1. Impressions gleaned from the periodicity of flashing lights supports the impression that zero paging is the chief factor. A corollary might be given that since all other measured programs which were run paged (i.e., compilers, linkeditors, and object code exceeded non-paging parameters), all other jobs were less efficient than need be. Again, this is speculation on yet another set of unmeasured variables. Tentative conclusions to be drawn are:

1. the less paging, the more efficient

2. programs can be written to be paged less and thus can be made more efficient.

<u>Optimizing Program Efficiency for Background Jobs</u>

Programs can be made to run significantly more efficiently by "packaging." None of these programs was packaged; however, P-44 inherently (accidentally programmed that way) was equivalent to a "packaged" program. Thus the 18/45 (HASP/CP) performance of P-44 very possibly is an optimum efficiency of the present CP version using two background systems.

Packaging is done by a special routine at the time programs are ready for production. The new program is executed under "PACKAGING" control and a paging optimization chart is generated. The programmer using this chart now re-packages his source deck before final compile. For overall shop efficiency it is extremely desirable to make this extra pass. Performance increases are very significant.

Jobs which run poorly

Jobs which are not modular or which have long series of in-line code can rarely be packaged efficiently. Large matrix programs would be extremes of inefficiency and packaging would help very little.

Significance of the Wait Light

On most IBM 360's the wait light is "on" most of the time while processing. Thus the CPU is idle. It is often stated that the more the wait light is off, the more efficient the system is and "turning off the wait light" many times becomes a system objective. Generally, this is a valid objective; however, this objective should be qualified in that only is it valid when the CPU is doing productive work. For example, the CPU can be tied up in "system overhead" and this is a good thing only in whether or not the net throughput is better.

For what it is worth, the wait light was mostly "on" until P-70 was loaded. This grinder turned the light off and the final 2-1/2 hours were run with the light off. Thus, it can be said that a grinder in any of the virtual machines will absorb all surplus CPU power. Also, it is suggested that if several non-CPU bound virtual systems are processing concurrently and if the wait light is "on", it is advantageous to load systems until the light is off. One can speculate on the implications of this, such as "What if a job becomes progressively more of a grinder as it processes"? "Is it valid to process a 20 minute job, - say for four (4) hours because the processing power is surplus and thus is free"? In any case, it can be stated that the CPU can be saturated so that no CPU power is wasted; however, it must be recognized that 10-45% of this power is used in overhead and not in productive work for the customer programmer.

Utility Work in the Background

At one point in the test (See Chart "A") it was required to scratch some data sets on disks. For six (6) minutes one virtual machine was used for this purpose at no loss in throughput on the other virtual machines. Operators will appreciate this capability.

At the very end of the test while the infinite grinder, P-70, was processing, another customer had priority over us and requested the machine. We processed his programs which were tape and disk utilities and which were I/O dominant type and he went away happy even though our programs were not interrupted. His programs which were small utilities (I/O and little or no paging) seemingly ran at full speed.

OS versus CMS

FORTRAN-G, PL/1, and ALC (plus others) are available under CMS. OS pages excessively and if programs are compiled under CMS rather than under OS, performance is significantly increased. All compilations in the test were under OS and thus all performance measurements are the worse case.

It is sufficient to state that improvements are available by using CMS rather than OS for certain jobs. Incompatibilities are reported non-existent or minimal, but until actual comparisons are made, reservations are in order.

Human Factor in Comparison of HASP and CP

Previously in this report, it was stated that the background of CP had one-half the throughput power of HASP on Mod 65. (See Chart "C") This statement and the times shown are extremely biased in favor of HASP. In the HASP test which was run under conditions controlled by the tester rather than by the computer operator, the CPU and/or the I/O was active 100% of the time. Measurements of actual computer performance in OCS during prime shift show that the computers are totally idle at least one-third of the time in that the machine is waiting for the operator to do something and that another significant amount of time is used for I/O during which time the CPU is idle. HASP SPOOL time would be included in the latter figure and when HASP SPOOL is the only I/O, the computer is also waiting for the operator to do something. The latter case could not be measured, but observations show that it is significant. The above measurements were taken on prime shift when supervision of operations should be optimal and when the percentage of non-set up jobs to set up jobs is highest which is also an optimal condition. All of this suggests that the usual effective usage of the Mod 65's is significantly less than the figures given in Chart "C".

Stating a conclusion from the above observations that the Mod 65's are usually only 50% effective because of human factors would invite arguments as to whether the operator and human procedural degradation is 20, 30, 40, 50, or 60%. In any case, it is significant, and in our comparison test case, it was 0%. If we assume that this human degradation of actual throughput is 50% in a 24-hour day (which appears reasonable from the above), and if we assume that an operator can keep at least one virtual machine active at all times, then the comparison performance figures will show that background processing capability of CP-67 is equivalent to the current effective throughput of an OCS Mod 65.

Thus, now background processing capability is at least 50% of a Mod 65 and effective throughput will range from 50-100% depending upon human and procedural factors.

Conclusions

The performance of the Mod 67 and the CP software was impressive. Previously, we had seen it perform terminal work with rapid response time and the objective of this test was to measure background capability. Obviously, the OS running under CP is compatible to OS on a standard 360. Reliability during the (3) hour test was perfect, even though a core box had a process check during the preliminary test time. Background throughput was measured and in the sense that this is an extra benefit, it is good.

A 444K machine which handles eight (8) virtual machines, three of them active each with two operating systems and two of these active with larger memories than the Mod 67 is impressive. Also, it is difficult to reduce the large number of variables to specific measurable conclusions. Meditation on these variables generates an infinite number of hypotheses which could be tested and obviously this alone is a strong recommendation. The system is the most flexible on the market and it can absorb or test nearly any of the many publicized IBM/360 time sharing systems available. For example, the OCS TSMON system could be run as a separate system on a virtual machine concurrently with other systems being tested. Even MVT (Multiple-variable-tasking) OS will run as a system on a separate virtual machine.

Much has been learned about time sharing over the past several years and many former notions have been discarded. It does take much raw CPU power to drive a large time sharing system satisfactorily. This power is necessary to provide excellent service at all times, even though a peak of on-line interaction may be occurring. Such power is expensive and it makes economy sense to use that power during the troughs of on-line interaction to do background processing. The Mod 67 has the power to do the above processing concurrently.

STAT

Chart "A"

PROCESSING LOG from CP TEST

JOB	Time in	Time out	Elapsed Time	Virtual Machine	Comments
L3D406	1126	1130	4	Batch	FORTRAN
PR0B09	1127	1132	5	BARR	PL/1 Job interrupted to set u disks (1 minute?)
L3D400	1130	1131	1	BATCH	FORTRAN or ALC
L3D40A	1131	1141	10	BATCH	ALC or FORTRAN
PR0B10	1132	1138	6	BARR	PL/1
PROB11	1138	1142	4	BARR	PL/1
PROB12	1142	1146	4	BARR	PL/1
--	1141	1144	3	BATCH	not used, operator behind
L3D405	1144	1150	6	BATCH	FORTRAN
PROB15	1146	1150	4	BARR	PL/1
PROB13	1150	1154	4	BARR	PL/1
L3D440	1150	1157	7	BATCH	FORTRAN
PROB14	1154	1158	4	BARR	PL/1
PROB-70	1157	--	-	BATCH	FORTRAN, program was a grinde in an infinite loop and at 0243 was terminated.
PROB15A	1158	0004	6	BARR	PL/1
PROB17	0004	0009	5	BARR	PL/1
TERMINAL	0005	0104	59	COME	FORTRAN, ALC, PL/1 programs run by various customers.
PROB18	0009	0012	3	BARR	PL/1
PROB37	0012	0017	5	BARR	PL/1
PROB31	0015	0025	8	BARR	PL/1
PROB33	0025	0030	5	BARR	PL/1
PROB44	0030	0115	45	BARR	PL/1, was a grinder and backe to grinder 63D451
PROB45	0115	0115	0	BARR	Dupe JOB card, ignored, same as L3J270
L3D270	0115	0126	11	BARR	PL/1
TERMINAL	0117	0205	48	COME	PL/1, FORTRAN, etc.on termina
PROB51	0126	0128	2	BARR	PL/1
PROMMA	0128	0133	5	BARR	PL/1, short grinder
PROBPL	0133	0133	0	BARR	Dupe JOB card, ignored, same L3J265
L3J265	0133	0138	5	BARR	PL/1
UTILITY	0138	0144	6	BARR	Vir Machine used for 6 minute for utility work
PROBCN	0144	0144	0	BARR	PL/1, JCL error because of change in system. Not sub-sequently run.
PROB08	0144	0148	4	BARR	PL/1
L3D404	0148	0158	10	BARR	FORTRAN
L3D403	0158	0200	2	BARR	FORTRAN
L3D407	0200	0206	6	BARR	FORTRAN
L3D402	0206	0219	13	BARR	FORTRAN
PROB01	0219	0223	4	BARR	PL/1
UTILITY	0226	0240	14	BARR	Various disk & tape utilities were run for other customer

COME quiesced at 0205
BARR " at 0223
BATCH " at 0243

Chart "B"

PROCESSING LOG from HASP TEST

HASP Job Name	CP Job name	Time (minutes)
PROB #1	PROBO1	.98
SCHOOL	PROBO8	1.40
EXERCIZE	PROB09	1.16
START	PROB10	1.35
START	PROB11	1.16
PROB #12	PROB12	0.90
PROB #15	PROB15	0.92
GP2	PROB13	0.96
A	PROB14	1.01
A	PROB15A	1.15
PROB #17	PROB17	0.94
PROB #18	PROB18	0.88
PROB #37	PROB37	1.16
RANDOM	PROB31	1.87
MAJIC33	PROB33	1.07
MAJIC44	PROB44	18.34
BIN-TEST	PROB45	1.08
CLOCK	PROB51	0.99
MALTA	PROBMA	1.35
PLOT	PROBPL	1.34
		40.01

Chart "C"

TIMING COMPARISONS of HASP versus BACKGROUND[a] on CP

Job	Type		(Minutes) HASP Mod 65	CP-Background[b]
400	ALC	C	0.25	1
40A	FORTRAN	C	2.46	10
402	FORTRAN	CLG	2.70	13
403	FORTRAN	C	0.31	2
404	FORTRAN	CLG	2.79	10
405	FORTRAN	C	1.34	6
406	FORTRAN	CLG	1.49	4
407	FORTRAN	CLG	1.40	6
440	FORTRAN	CLG	1.98	7
P-1	PL/1	CLG	.98	4
P-8	PL/1	CLG	1.40	4
P-9	"	"	1.16	5
P-10	"	"	1.35	6
P-11	"	"	1.16	4
P-12	"	"	.90	4
P-13	"	"	.96	4
P-14	"	"	1.01	4
P-15	"	"	.92	4
P-15A	"	"	1.15	6
P-17	"	"	.94	5
P-18	"	"	.88	3
P-31	"	"	1.87	8
P-33	"	"	1.07	5
P-37	"	"	1.16	5
P-44	"	"	18.34	45
P-45	"	"	1.08	11
P-51	"	"	0.99	2
P-MA	"	"	1.35	5
P-PL	"	"	1.34	5
			54.73	198

a. Foreground job consisted of more than 60 terminals on-line but during test only one was active on which was processed conversational PL/1, FORTRAN, and ALC. No measurement possible for foreground tasks.

b. Two jobs were running concurrently in the background. Thus an effective measure of background power suggests that all CP times could be halved for comparison purposes.

Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

HARDWARE SYSTEMS REJECTED UPON PRELIMINARY INVESTIGATION

A number of time-sharing systems other than IBM's were investigated (CDC, GE, UNIVAC, SDS, DEC, RCA) but were not seriously considered primarily because they were not compatible to the Computer Center production systems (IBM 360/65) and could not be used as back-up to the batch workload. In addition to the compatibility problems none of these systems could completely satisfy our TS processing objectives. Some of these systems were not operational yet and others were felt to be lacking in one or more of the following areas:

- CPU processing power
- Adequate direct access storage devices on-line
- Query language
- Terminal response time
- Information retrieval package
- Software security
- Shared data sets
- Scheduling algorithm
- CRT support

SDS - 930/940	Supports 16 terminals, response poor, lack of adequate on-line storage capacity, no query language or IR package.
PDP - 6	JOSS type language only.
GE - 645	MULTICS - not completely operational, performance poor.
GE - 265/235	BASIC only.
GE - 635	Time sharing system to be implemented under GECOS - not operational yet.
CDC - 6000	RESPOND system editing and remote batch capabilities only.

Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

Attachment F

COMPARISON OF HARDWARE COSTS
(In Dollars)

	Model-50			Model-65			Model-67
	TSMON[1]	TSMON RUSH	ADEPT	TSMON[1]	TSMON RUSH	ADEPT	CP/CMS
CPU 1052-7, 512K byte core, 2 selector channels 1 max channel (models 65 and 67 include 1 sort selector channel)	22,290	22,290	22,290[2]	38,692	38,692	38,692[2]	42,682
Drum (2820 control unit - 2301 drum)			4,620			4,620	4,620
LCS (one million bytes)		6,500			6,500		
Peripherals	19,679.50	19,679.50	19,679.50	19,679.50	19,679.50	19,679.50	19,679.50
	41,969.50	48,469.50	46,589.50	58,371.50	64,871.50	62,991.50	66,981.50

1 Current system

2 Additional cost for RPQ on this system not included here.

ATTACHMENT G

Price of RCA 70/46

Processor (262K)	$16,446
Peripheral Units	4,705
Random Access	12,253
Communications Devices	3,876
	$37,280

Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

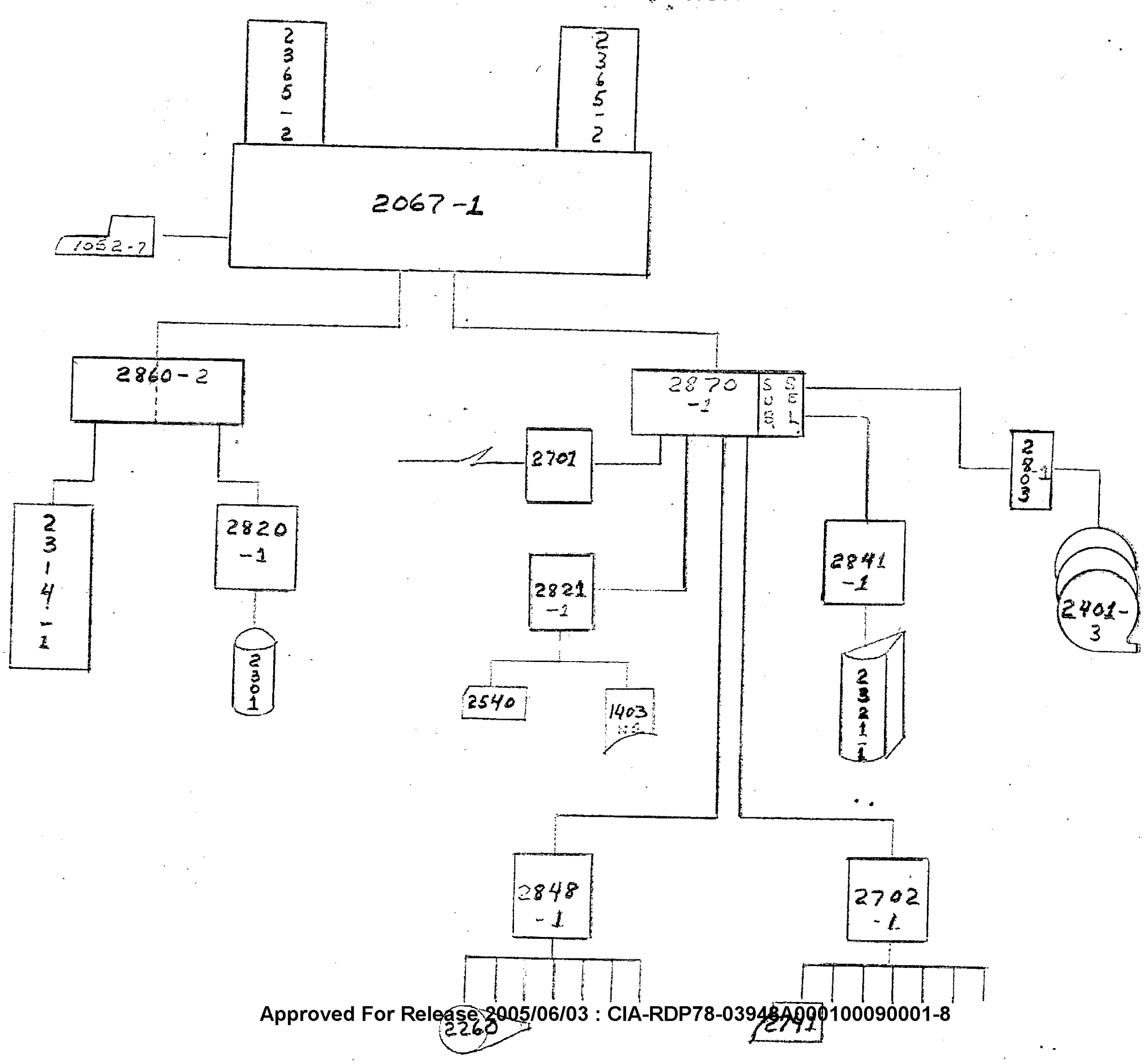
IBM 360/67

SYSTEM CONFIGURATION

		Lease per Month	Purchase
2067-1 Processing Unit		17,585	711,490
#4434 Floating Storage Addressing		25	1,100
#7920 1052 Adapter		232	10,545
2365-2 Storage Unit	2 @ 9,530	19,060	795,400
#7123 7 Bit Storage Protect		N.C.	
#8035 2067 2067 Attachment		N.C.	
1052-7 Console I/O Keyboard		65	2,725
2860-2 Selector Channel		3,090	143,750
#9502 1st Channel on Buss		N.C.	
2870-1 Multiplexor Channel		2,265	106,700
#6990 Selector Subchannel		410	17,940
2314-1 Direct Access Storage Facility		5,410	244,440
2820-1 Storage Control		2,370	108,930
2301-1 Drum Storage		2,250	96,000
2821-1 Control Unit		1,000	45,100
#3615 1100 LPM Printer Adapter		77	2,910
2540-1 Card Read Punch		680	33,950
1403-N1 Printer		900	41,200
#8640 Universal Char Set - Mod 3 W1		10	450
1416-1 Inter Changeable Train Cartridge		100	3,000
2701-1 Data Adapter Unit		206	9,410
#3815 Expanded Capability Feature		25	1,200
#3855 Expansion Feature		82	3,640
RPQ F1804A M25697 CK Polynomial Qty 2		90	3,600
RPQ F18049 M24802 Intr Processor Comm Adapter Qty 2		480	19,000
RPQ F1804B 816190 Full Duplex 188B Interface		118	4,130
2848-3 Display Control		435	18,530
#4787 Line Addressing		10	450
#5340 Non-Destructive Cursor		10	430
#3859 Expansion Unit		46	1,890
#5341 Non-Destructive Cursor Adapter	4 @ 5	20	860
#3357 Display Adapter For Mod 3	4 @ 103	412	15,520

2260-1 Display Station		31	970
2841-1 Storage Control Unit		540	26,430
#4385 Scan		36	1,360
#6118 Record Overflow		10	400
#8079 2321 Attachment		180	6,790
2321-1 Data Cell Drive		2,885	132,400
2803-1 Tape Control		670	31,620
2401-3 Tape Units	3 @ 810	2,430	110,280
2702-1 Transmission Control		875	39,580
#4615 IBM Terminal Control Type I		36	1,575
#3233 Data Set Line Adapter		20	950
#3853 Expansion Base		N.C.	
#7912 Telegraph Term Control Tpy II		36	1,575
#4635 IBM Line Adapter 4W Limited	5 @ 23	115	5,425
#8055 2741 Break		10	450
2741-1 Communication Terminal		82	3,100
#4635 Line Adapter 3W		3	135
#4708 Interrupt		2.50	115
		$65,424.50	$2,807,445

SYSTEM CONFIGURATION



Description of IBM 360/67 and CP/CMS Software

The IBM System 360/67 was specifically designed to overcome the problems encountered in programming and operating a time-sharing application. The following features are considered necessary in an on-line computing environment:

1. CPU Speed - The 200 nanosec internal cycle time assures a fast response to console users. The necessity of a high-speed CPU in this environment is not to handle a few staggered demands for service, but to insure that when multiple instantaneous user's demands exist, the apparent terminal response is not degraded. Most computer systems designs are built around a turnaround criteria of hours; and job load averages in this spectrum of time can be analyzed to determine the best CPU cost vs. time tradeoff. In a time-sharing system this same system design technique is invalid. The on-line system which uses only response as a measure of its acceptability requires a high-powered CPU, a CPU which is excessive in regard to the computing demands of the on-line users. Any inefficiency in this type operation suggests that the system also accommodate another class of user, the background job. This low priority work must be available to absorb the excess CPU capability.

2. Dynamic Relocation - This feature on the Model 67 insures the security of user data and programs which co-exist in the same real memory. It also provides the control programs with the hardware necessary to overcome the core fragmentation problem; therefore, only programs and data which are actually in use require residence in high-speed memory.

3. Channel Architecture - The channels in Model 67 are self-contained; that is, they are not part of the CPU as they are on the less powerful models of the System/360. This arrangement has two advantages--first, a hardware error in the channel does not bring the system down completely; second, when this architecture is further extended by the inclusion of a channel controller IBM 2846 in the system configuration, the probability of interference between the channel and CPU memory demands is reduced.

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4. Reconfiguration - In the Model 67 system equipped with a configuration console, the probability of extended system outage is considerably reduced. The operator need only switch out defective components and gracefully degrade system performance.

The real advantage of any computing system is, of course, its software. In this respect, the System 360/67 is unique. The CP/67 which is the time-sharing part of the system program has evolved from an earlier system CP/40 which was operational over two years ago.

The CMS (Cambridge Monitor System), which is one of the on-line programming systems available to the terminal user, is the same system that operated with CP/40 and therefore has benefited through two years of use.

The specific advantages of the CP/67 come from its creation in a dynamic sense of many "virtual computers." This technique allows the terminal user to regard his console as an operator's console, 1052, and he programs as if he is running on a 360 computer by himself. This organization permits the individual terminal user a multitude of already existant programs and lowers the cost of converting to an on-line programming environment.

The CP/67 system has the following attributes:

1. Compatibility - Most significantly by being able to run OS, it is completely compatible with the rest of the installation.

2. Openended - CP/67 allows execution in a virtual machine any 360 programs which are not timing dependent nor have data driven I/O.

3. Security - The virtual machines are accessed through a password scheme and since all memory and I/O references invoke mapping by hardware and software, the security of the individual's data is nearly absolute.

4. Maintainability - The system is easily maintained for two reasons; first, because it is relatively small; second, because it is very modular and the individual modules have very little dependence on one another.

5. Proven System - The system has been over two years in operational development and has been successful in operation in a customer site (Lincoln Lab) for over a year where it currently supports 30 terminals.

Questions and Answers on Model 67 and CP

1. What is CP?

   A Time-Sharing System for the Model 360/67 hardware.

2. What does it do?

   This software system, working in conjunction with the hardware, creates a unique environment called the virtual machine.

3. How does it compare with MFT and MVT?

   There is a functional difference between CP and other current operating systems. In CP, the common user functions usually called data management are separate from those functions necessary to perform multi-programming. Under the other systems, multi-programming and data management are combined and usually user directed.

4. Under CP on the Model 67, how many virtual systems can be "sysgenned" into the system?

   This is limited by the amount of space, I/O, and secondary storage which are available.

5. What is a virtual system?

   Virtual system is a simulated 360 environment in which all inter-user conflicts are resolved through mapping by either software of hardware, or both.

6. What systems can be operable under CP? (OS, CMS???)

   Any non-timing dependent/360 program is operable in a virtual system.

7. What is the limit to the number of users on line at the same time under CP?

   The limit on the number of users depends on the load conditions but currently there are 30 on-line users at the Lincoln Laboratory. Plans call for another control unit and then the number will double.

8. When are the bounds of each virtual system defined? Can they be altered at any time?

   The bounds of each virtual system are defined in the user directory. It can be altered by creating a new directory before start-up.

9. What device support is available under CP?

   A. 2260
   B. 2250
   C. 2741
   D. Disk drives 2314, 2311
   E. Drums 2301, 2303
   F. Large core storage is being implemented at Washington State.
   G. Printers--No restriction as to the number of printers.
   H. Card Reader-Punch--no restriction as to number.

10. Can one use RJE's with this system?

    Yes, current plans include 1130 support as an RJE terminal.

11. Would it be practical?

    yes

12. Is there much degradation to the system if they are all on at once?

    Degradation in a time-sharing paging environment is a function of the load of the terminals. In a correctly operating system, degradation should be linear as the load.

13. Can any one virtual system interfere with any other virtual system? Even deliberately?

    No

14. If data is written on a disk or other I/O device by one virtual system, can it easily be accessed by another virtual system?

    Access to I/O data is only achievable through the directory. Therefore, users can be prohibited or permitted access to one another's data by altering the directory before start-up.

15. Can remote terminals be used with this system?

Yes

16. Can the remote terminals be on-line with the batch?

Yes

17. Is there any chance that one remote terminal may retrieve data from another area other than the area he is using?

No

18. Does the remote terminal degrade much from batch performance? Even with a compute bound job?

Degradation in the time-sharing system is severe for jobs which misuse core even in a batch system. Jobs which are written to run well in the batch environment tend to perform well in the time-sharing environment.

19. What is CMS?

CMS is the Cambridge Monitor System. It is the Operating System used by the terminal user. It provides on-line capabilities such as FORTRAN, PL/1, context editing, SNO BOL.

20. How does it compare with OS?

In comparing CMS with OS, with CMS we have a subset of the OS data management functions and a subset of the languages available under OS and no multiprogramming facilities. CMS is comparable to FMS (Fortran Monitor System) for the IBM 7090.

21. Which types of jobs, I/O or compute bound, run best under the CP system?

I/O bound jobs tend to run best under the CP system.

22. Why?

Because there is a greater amount of time available for multiprogramming with these type jobs.

23. Is there a significant increase in performance with faster data rate I/O (2311 vs. 2314 vs. 2303 vs. large core)?

System performance with regard to the I/O system depends heavily on the ratio of core space and CPU demands to I/O demands.

24. With only 444k bytes of physical core available, how can the machine act as if it has 1 meg. bytes available?

By the use of a hardware relocation device which maps all storage references, those pages (i.e., 4096 bytes) which are not in core are brought in from secondary storage and the relocation device is updated.

25. What is paging?

Paging is the artificial division of a user program's address space. In the 360/67, this space is divided into 4096 byte pages. Addresses generated by the CPU pass through and are acted upon by a hardware relocation device before reaching the execution store. Those pages which are not in the physical core store are retrieved from secondary storage devices (drum, disk). The entries for the relocation device are changed to reflect the swap from drum to core.

26. Is only part of the program stored in core at any one time?

The part of the program required for execution is in core.

27. If so, where is the rest of it?

On some secondary storage device (drum or disk).

28. If two small programs are operating under two virtual systems, might everything remain in core from both systems at the same time?

Yes, if the sum of the two active page requirements is less than or equal to the number of available pages in a physical core.

29. Under CP and the concept of virtual systems, how large can a program be before it runs out of core?

16 million bytes, i.e., the number of bits in the address field.

30. If one virtual OS systems fail, does it bring down the whole system?

    No

31. If CP fails, does it bring down the whole system?

    Yes

32. Does CP have both input and output spooling?

    Yes

33. How can the output from separate jobs be kept separate?

    By prefixing the printed output with a user ID.

34. Is there a way to direct certain job output stream to a certain printer?

    This facility is currently being implemented.

35. From the same system input device (i.e., card reader-punch) how does the input go to the intended OS virtual system?

    By preceding the user input cards with a user ID card.

Approved For Release 2005/06/03 : CIA-RDP78-03948A000100090001-8

ATTACHMENT I

26 April 1968

MEMORANDUM FOR: Computer Science Advisor

SUBJECT : Planning for IBM 360/50 Replacement

1. I would like you to form an ad hoc group within the Office to study the alternatives and recommend a course of action regarding the replacement of the 360/50 in the Computer Center. As you know, this computer will be moved to the DD/P in January 1969.

2. In analyzing the alternatives, the following factors should be considered:

a. The system will be used principally in the time sharing mode. Background processing for efficient computer utilization is desirable but not mandatory.

b. I do not believe we can plan to move into a completely integrated software system including multiprocessing, multiprogramming, and time sharing as the standard Operating System in the Center. Compatibility with the software and hardware used in the Center is certainly desirable, particularly if main frame connections are feasible for passing tasks back and forth.

c. We should assume that by January 1969 the customer requirements and our experience with time sharing will be such that a stand alone <u>production</u> time sharing environment will be feasible and desirable.

d. Movement toward a production environment will make system experimentation and extension more difficult than it is now, but through judicious planning (and perhaps the use of IPRD facilities), we should be able to continue experimentation at a reasonable pace.

e. Costs must stay within current budget estimates. Supplementary funding could be justified only if major new requirements were surfaced.

f. Conversion to the new equipment should be as painless as possible.

g. We have no firm basis for projecting load other than what we know about existing applications and informal requirements. We should assume that the known requirements will constitute the minimum load to be expected.

3. The above factors tend to reduce the number of hardware alternatives that must be considered seriously. In my view, the following are the more obvious ones (in no particular order, with no comment):

a. A 360/50 starting with the configuration identical with the current one but expanding as needs arise (LCS, AMCS, 2314's, etc.).

b. Two stand alone 360/40's, one for Agency sensitive data, the other for everything else.

c. A 360/67 using a minimal configuration needed for TSMON (with or without CP67).

d. A 360/65 configured for time sharing.

e. A Spectra 70/46.

4. Software alternatives are perhaps the more difficult to evaluate. Some random thoughts: We have to assume that the programming talent that can be applied to time sharing software and related application services (in quality and quantity) will always be less than optimal. But I think the "shoe string" effort thus far can be expanded over the next year because we have encouraging tangible results. We should concentrate on building and expanding services peculiar to our installation, perhaps at the expense of building monitors or spending time making them more efficient. As the system becomes saturated, our first question should be whether modest increases in hardware would keep the system going rather than to immediately task our available programming manpower to squeeze more from the existing hardware. Only when serious overload is expected should we look to improved or new monitors. In this way, I would hope that we could keep the system going until efficient monitors that meet our needs become available from the outside, using our people in the meantime to build more and better application services.

5. Your findings should be available by 1 June so that a decision can be made and an order placed with sufficient lead time.

25X1A

Deputy Director of Computer Services

cc: D/OCS
TRC Members

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26 June 1968
ATTACHMENT J

MEMORANDUM FOR THE RECORD

SUBJECT: Trip to RCA on Spectra 70/46

1. On 17 June 1968 [redacted] went to Cherry Hill, New Jersey, to test the Spectra 70/46 and talk to systems personnel. (See attached for a description of Spectra 70/46 as written by Totaro of Auerbach and distributed by RCA.) STAT

2. Meinstein, RCA, stated RCA's time sharing objectives as follows:

a. "To provide concurrent service to a large number of users at remote points."

b. "To supply the user with immediate access to a computer so that it appears to him that he is the only user."

He gave an overview description of the hardware which is included in the attachment. He explained that 524K of memory was rejected because of cost and thus the S-46 was a 262 byte machine. System design programs are separated into two classes.

Class 1 - that which is brought over, must be loaded in entirety, must be loaded contiguously, must use private volumes, must never be paged, and memory is not to be relinquished.

Class 2 - Program is created on S-46 with TDOS compilers, pages are pageable, certain pages are not to be moved, only the page with an entry point must be loaded to start, may share public and/or private volumes.

In data management, SAM and BDAM are available on all devices except RACE. BTAM (Basic Tape Access Method) is available. ISAM is available on all DASD except on RACE.

All code is re-entrant. Is this because of insufficient memory size? Is it worthwhile? This was rather unusual since there is a trend to forget re-entrant code on paging hardware. Cataloging is available by name.

JCL and TCL (Terminal Control Language) are a single language which is an excellent feature. The operator can designate number of pages limited to a class 1 program.

3. Performance Tests. In order to demonstrate that the S-46 works, an unofficial demonstration was given. One typewriter terminal was activated and then 39 copies of another program were simulated by attaching a S-45 to the S-46. Performance and response were impressive. However, as most time sharing implementers have discovered, a synchronous and perfectly interleaved load is not the same as humans asynchronously interacting with a system. Whether RCA really has a better time sharing technique than others could not be determined. If a machine as low powered and with as small memory as the S-46 can handle 40 users with 1-2 second response time, RCA has a winner. In conclusion, I am willing to go on record with my personal opinion that RCA is in for a rude awakening on performance. In my opinion, RCA on the S-46 will not provide 40-48 users with adequate response time. When load peaks and especially with complicated queries or calculations, I believe the response time will degrade to many seconds, or even minutes and customers will be dissatisfied. Unfortunately, RCA's system cannot be adequately exercised and measured.

4. Device support.

Data Cell. RCA offers its RACE; and even though direct access is not supported under S-46, they offered to help move SANCA over to the RACE.

Fast Direct Storage. RCA will not have its own large disk until 1970, but they offered to interface with a 2314.

2250. They can interface through an 1130. They have no comparable piece of equipment manufactured by RCA.

5. Language Support. RCA supports FORTRAN and COBOL. The statement was made that a S-46 could handle jobs as fast as the Mod 65, even in FORTRAN. OCS is supplying them with the 13 jobs from the benchmark test so that they can compare their times with a Mod 65. Several similar statements were very disconcerting and reminded me of performance claims for the S-70/45 before delivery. However, if what they are claiming is true (or even partially), OCS should immediately substitute RCA equipment for all IBM gear. Just to satisfy all parties concerned, RCA must complete the comparison testing of the FORTRAN programs.

6. Summary. Very interesting. RCA has very impressive technicians. They are making many ambitious claims. If these are really true, they should be given strong consideration in new time sharing equipment selection.

STAT

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This profile of RCA's new time sharing system and other recent developments in the Spectra 70 line is extracted from a new 250-page analysis of the RCA Spectra 70 hardware and software in AUERBACH Standard EDP Reports, *an analytical reference service published by AUERBACH Info, Inc., of Philadelphia.*

time sharing spectra 70 style

By J. BURT TOTARO
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AUERBACH CORPORATION

When the RCA Spectra 70 series of computers was announced in December 1964, RCA entered head-to-head competition with IBM and its System 360. From the beginning, RCA promised to provide more computing power per dollar than IBM.

Spectra 70 indeed offered much: a family of five generally compatible computer systems, a high degree of source and object program compatibility with the IBM System 360, extensive use of monolithic integrated circuitry, three levels of integrated operated systems, and an extensive line of peripheral equipment.* But the System 360 offered more—a greater variety of hardware and, especially, more "third generation" software facilities, such as random-access-oriented operating systems, source-language control of random access devices, automatic data management systems, comprehensive data communications control systems, and support of time-shared processing.

*For a detailed review of the Spectra 70 family of computer systems, see "RCA Spectra 70—A Compatible Competitor," by J. B. Totaro, *Data Processing Magazine*, June 1966, pages 54-61.

Recognizing these problem areas, RCA quietly set about closing the "facilities gap" between itself and IBM. During the past year RCA has added new and impressive peripheral units to its Spectra 70 line and has greatly increased the capacity and scope of its software systems. Most recently, on May 4, 1967, RCA announced the long-rumored Spectra 70/46 Time Sharing System, a development that serves to plug the only remaining gap of any significance in RCA's battle to match the processing capabilities of IBM in the small-to-medium-scale computer market.

Spectra 70/46

The Spectra 70/46 Time Sharing System includes a new Spectra 70/46 central processor, a new 70/567 high-speed magnetic drum unit, and a specially-designed software system called the Time Sharing Operating System (TSOS). Both hardware and software for the Spectra 70 Time Sharing System are scheduled for first delivery during the third quarter of 1968.

The 70/46 marks RCA's entry into the time-sharing computer market, joining such competition as the GE-645, IBM System 360/Model 67, and SDS Sigma 7 computer systems. However, RCA has designed its time-sharing system with more modest goals than those of GE and IBM. RCA's apparent intention is to remain competitive in all areas of the small-to-medium scale commercial computer market without enduring the frustrations of the more ambitious pioneers in the large-scale commercial time-sharing business.

The monthly rental of an RCA Spectra 70/46 Processor with 262,144 bytes of core storage is $14,125. RCA estimates that typical 70/46 system configurations will rent for between $25,000 and $30,000 per month. Contributing to the relatively modest prices of planned Spectra 70/46 systems are the facts: (1) that the 262K-byte 70/46 Processor is basically an expanded version of the $11,125-per-month Spectra 70/45 262K-byte Processor, (2) that only single-processor systems have been announced to date, and (3) that a maximum of 48 on-line remote terminal units can be controlled by the system.

According to its design goals, the Spectra 70/46 Time Sharing System will be an efficient batch processing system with advanced multiprograming capabilities; remote, conversational time-shared operations in time-sliced mode will be a powerful available facility that may, in some installations, consume only a limited amount of the system's total processing capacity. The more expensive GE-

645 and IBM System 360/Model 67 systems, by contrast, are designed primarily for time-shared processing.

Noteworthy features of the 70/46 Time Sharing System include:

- Hardware logic within the processor to facilitate program paging and segmentation, providing simultaneous system access for up to 48 users at remote terminals.
- Up to 2,097,152 bytes of virtual memory available to programers.
- A fast associative memory for translation of all virtual memory addresses to real core storage addresses.
- A conversational FORTRAN IV compiler with interpretive execution capability.
- Full compatibility with the systems programs and language processors of the RCA Spectra 70 general-purpose Tape Operating System (TOS) and Tape/Disc Operating System (TDOS), both of which are used with Spectra 70/35, 70/45, and 70/55 computer systems.

Configurations

Spectra 70/46 system configurations (and their costs) will closely approximate those of Spectra 70/45 systems. Any Spectra 70 peripheral device that can be used with the 70/45 can also be used with the 70/46 (and in generally the same numbers). The few configuration differences include the 70/46's required use of a 70/567 Drum Memory Unit and, if remote terminals are expected to be used on-line, a multi-line communications controller. Spectra 70/46 systems are currently restricted to the use of a single processor and 262K bytes of core storage.

In addition to the 70/567 Drum Memory Unit, a minimum Spectra 70/46 configuration will include at least two 70/564 Disk Storage Units and two magnetic tape units for use by the system's software. The 70/46 Time Sharing System is designed to take advantage of the processing efficiencies made possible through the use of a hierarchy of system storage devices that range from magnetic tape units to disks, drums, and finally to main core memory.

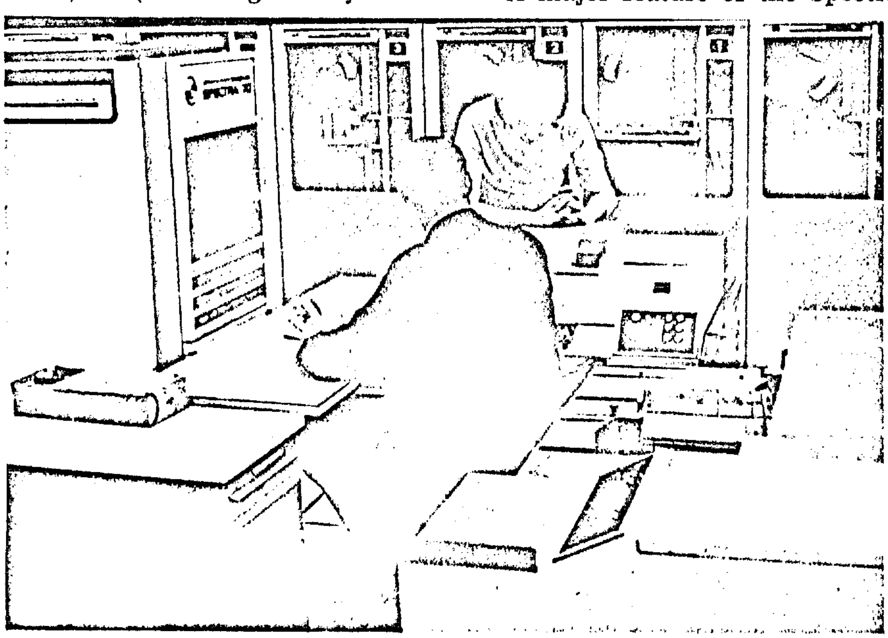
Storage

Spectra 70/46 magnetic core memory is available in a single block of 262,144 bytes. Memory cycle time is 1.44 microseconds per 2-byte access. Each byte consists of eight data bits and one parity bit. Bytes can be grouped into 4-byte, 32-bit binary words. This data structure is identical with that of the Spectra 70/35, 70/45, and 70/55 systems (and, therefore, with the IBM System 360).

A major feature of the Spectra 70/46 Processor is its read-only control memory unit. This unit has a memory cycle time of 480 nanoseconds per 54-bit access. Read-only memory (ROM) is provided in three banks, each of which contains 2,048 54-bit words (or "Elementary Operations"). The Spectra 70/45 Processor, by contrast, provides only a single bank of read-only memory, which is used exclusively for the emulation of other computers, such as the IBM 1401 or RCA 301.

Spectra 70/46 systems cannot use the emulation technique. Read-only memory in 70/46 systems is instead used to implement several features that facilitate time-shared operation. The first bank of read-only memory is used to provide the microprogramed routines that will permit the 70/46 to operate in the Spectra 70/45 processing mode. The second bank is used to implement an address translation table (in a section called the Translation Memory), an interval timer, and other hardware features used by the 70/46 in its paging and time-sharing operations. A portion of the second bank and all of the third bank are used to implement specialized functions, such as translation table manipulation, paging interrupt handling, etc., that would normally be performed by software. A special Spectra 70/46 processor instruction, Function Call, is provided to call for and execute these microprogrammed routines.

The new 70/567 Drum Memory Unit is currently offered for use exclusively with the 70/46 Time Sharing System. In this system, pages of user programs will be stored in on-line disk storage units, from which they will be called to main memory for execution. Once in main memory, program pages that must be temporarily dumped to make room for higher-priority pages are sent to the Drum Memory Unit, where they await rapid retransmission to core when main memory space again becomes available. Also residing in the Drum Memory Unit will be the most frequently used control routines of the 70/46 Time Sharing Operating System (TSOS).



DEBUGGING AT THE console of a prototype Spectra 70/46 Time Sharing System.

Vital statistics on the new drum include a storage capacity that ranges between 4.1 and 16.4 million bytes, an average access time of 8.6 milliseconds, and a peak data transfer rate of 333,333 bytes per second.

70/46 Processor

The RCA Spectra 70/46 Processor is basically a 70/45 Processor with additional features to facilitate time-shared operations. All features of the 70/45 Processor are also included in the 70/46. The principal features added to the 70/45 in designing the 70/46 Processor include:

- Two additional banks of read-only memory.
- Virtual-to-real address translation logic.
- An interval timer with a 100-microsecond resolution.
- Hardware control of paging and segmentation.
- Interrupt capabilities for interval timer run-out, paging errors, and page queuing.
- Six microprogramed operators to control use of the translation Memory, interval timer, and page queuing.
- Capacity to add up to four high-speed selector I/O channels (as compared to a maximum of three medium-speed selector channels with the 70/45).
- Memory protection that includes both Store and Fetch Protect features. The Spectra 70/46 Processor has been designed to facilitate serving multiple users with multiple programs. To understand this design, it is necessary to consider the concept of paging.

Paging

The Spectra 70/46 core storage unit is divided into many blocks of equal size called "pages." The basic page size is 4,096 bytes, but 2,048-byte page lengths can also be specified through the software. Spectra 70/46 programs are compiled in blocks of 4,096-byte pages, and only a limited number of pages of each program need be in core storage at any given instant of program execution.

The purpose of so fragmenting core storage and programs is to permit a large number of programs (or program segments) to reside concurrently in core storage in a manner that permits execution control to be passed easily between the resident programs, either on an interrupt basis or a time-slicing basis. Thus, even modest-sized core memories can accommodate the processing needs of a large number of users, since only a limited number of pages of each requested program require use of core storage at any one time.

Program pages not immediately required for execution in a Spectra 70/46 system are stored in random access secondary storage—typically a 70/564 Disk Storage Unit. When these program pages are called for execution, they are relocated by the Time Sharing Executive routine to any available page in core storage. If active resident pages must be displaced by higher-priority program pages, they are temporarily dispatched to the system drum unit, from which they can be quickly called and reinstated in any available page of core storage.

The 512-word Translation Memory is used by the software when assigning and relocating program pages to specific blocks of core storage. The Translation Memory sets a limit of 512 pages as the maximum number of uniquely addressed program pages that any program can contain. This means that every Spectra 70/46 program can be written as if 2,097,152 bytes of core storage were available for its use, even though the actual core storage unit provides only 262,144 bytes of real storage. The Spectra 70/46's provision of about two million bytes of virtual core storage could be expanded to eight million bytes without substantial hardware change, but RCA has not indicated that such an expansion is forthcoming.

Address Translation

Before executing instructions in program pages that are dispersed randomly through core storage, the 70/46 Processor must translate each non-I/O instruction and operand address from its virtual address form to the corresponding real address that is relative to the current location of the page in core storage. Virtual-to-real address translation takes place automatically in the Spectra 70/46 Processor, and generally without any increase in instruction execution time. (Instruction execution times for the 70/46 Processor are generally equal to those of the 70/45 Processor.)

When the Spectra 70/46 Processor is operating in the time-sharing mode, 24-bit virtual addresses are translated to 18-bit real addresses by means of an associative table-lookup search through the Translation Memory portion of read-only memory. The 12 low-order bits (i.e., the "displacement" field) of the virtual address are used intact as the 12 low-order bits of the real address. The next 11 bits of the virtual address represent the segment and page number of the program address. These bits are translated via the Translation Memory to a 6-bit real page address which is combined with the untouched 12-bit displacement field to form an 18-bit real address that is capable of directly addressing up to 262,144 bytes of core storage.

Processor Modes

Two processing modes are available for users of the 70/46 Time Sharing System. If a specific bit is set in the processor's Interrupt Status Register and a corresponding bit is set within the virtual address of an instruction or operand, automatic virtual-to-real address translation takes place and the various microprogramed operations of the Function Call instruction can be utilized. This processing mode is called the 70/46 or time-sharing mode. All user programs compiled by the Spectra 70/46's Time Sharing Operating System (TSOS) software include virtual addresses with the translate bit set.

The other processing mode is called the 70/45 mode. In this mode all object program addresses are treated as direct addresses, and no address translation occurs.

It will be possible to execute all Spectra 70/45 object programs, including the TOS and TDOS software control routines, in a Spectra 70/46 Processor operating in the 70/45 mode, with results identical to those obtained in a 70/45 Processor.

Instruction Set

The Spectra 70/46 Processor includes the full instruction repertoire of the Spectra 70/45 Processor, plus two new instructions; Test and Set, and Function Call. The Test and Set instruction can be executed in either the 70/45 or 70/46 mode. This instruction is used for bit-testing anywhere in main memory. The Function Call and its several microprogramed operations (called Special Functions) can be executed only in the 70/46 processing mode, and an attempt to execute them in the 70/45 mode results in an interrupt.

The purpose of the Special Functions is to reduce overhead times normally associated with time-sharing systems by implementing in hardware (i.e., read-only memory) functions which are usually performed by relatively slow software control routines. This approach to reducing the overhead delays associated with software operating systems has been widely discussed but rarely used to date. A similar use of read-only memories to implement emulators for achieving program compatibility with unlike computers has been successfully accomplished by RCA and IBM, and is currently being developed by several other manufacturers.

I/O Capacity

Like the Spectra 70/45 system, the 70/46 Time Sharing System can concurrently execute one machine instruction, one input-output operation on each of the installed selector channels, and one data transfer operation on each of the eight subchannels included in the standard multiplexor channel. Up to 256 low-speed I/O devices can be connected to a 70/46 system via the multiplexor channel.

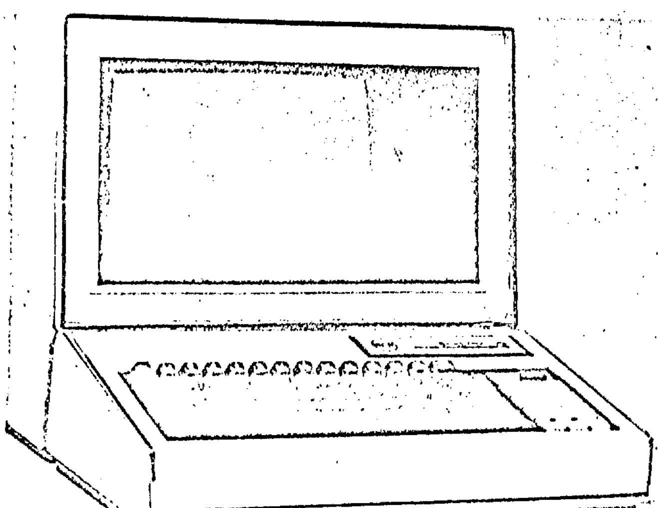
Selector channels are optional equipment, and two, three, or four such channels can be installed. Each selector channel has two trunks, permitting two I/O control units to be connected. Input/output data is transferred into and out of core storage in 2-byte blocks over the Selector Channels, and the 70/46 Processor is delayed a maximum of 1.44 microseconds for each block transferred. Thus, the I/O throughput capacity of the 70/46 system is 1.4 million bytes per second. (The 70/45 Processor, by contrast, is delayed 1.44 microseconds for each single-byte I/O transfer, resulting in an I/O throughput capacity that is half that of the 70/46.) The maximum data rate possible over a single selector channel is 465,000 bytes per second.

Time-Sharing Software

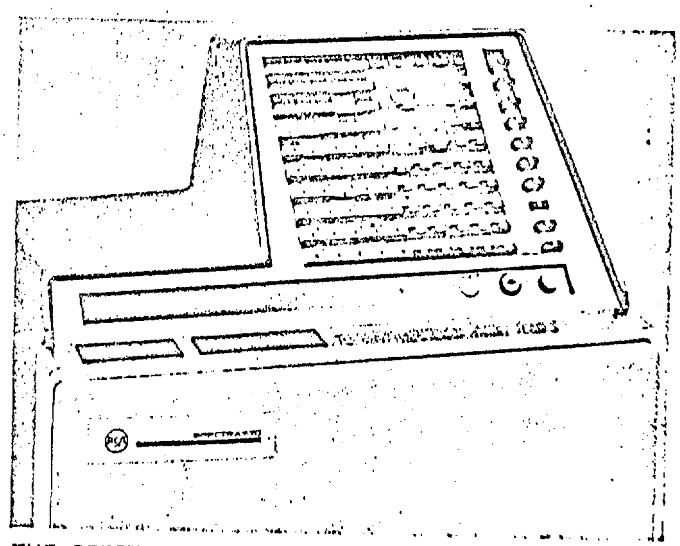
To complement the promising hardware design of the Spectra 70/46, RCA has announced an impressive software package called the Time Sharing Operating System. TSOS promises an efficient random-access-oriented multiprograming operating system plus capabilities for providing up to 48 users at remote terminals with immediate, conversational access to the central 70/46 computer. Included in the software package will be a complete range of batch and conversational language processors, remote syntax checking, debugging and file editing systems, an extensive data management system, and a powerful executive control program. RCA plans to deliver the entire Time Sharing Operating System during the third quarter of 1968.

The nucleus of TSOS is its network of system control programs used in the "privileged" mode by the central Spectra 70 system. The principal control programs include: the resident Executive program; the File Control Processor (FCP) for catalog, file, and data management; an interactive data communications input-output system; an interactive software debugging system; and hardware diagnostic routines.

The chief components of the



RCA's NEW SPECTRA 70/552 Alphanumeric Video Data Terminal provides keyboard input and CRT output facilities.



THE SPECTRA 70/630 Data Gathering System transmits data from input stations such as this to a Spectra 70 computer.

Executive program will be the following:

- Task Scheduler, to maintain a single task queue from multiple input sources, including remote terminals, and to schedule on a priority basis the concurrent execution of as many programs as the system resources will allow. The Task Scheduler will also include a time-sharing algorithm to control responsive time-shared operations.
- Memory Manager, to control the dynamic allocation of program pages and to manage the use of the more than two million bytes of virtual storage available to the programmer.
- Device Allocator, to manage the pool of input-output devices available to the system, and to assign free I/O devices to the programs' device-independent I/O requests.
- Peripheral Input-Output, to provide optional buffering of punched-card input files and printer-destined output files on random access devices or magnetic tape units.
- Job Control, to accept user-specified Job Control Language statements used to enter and define batch processing jobs at the central 70/46 computer center.
- Command Language Control, to enable users at remote terminals to communicate with the central system in either conversational or batch mode. The Command Language is an extension of the Job Control Language. It permits the users at remote terminals to identify themselves, to specify the tasks the system is to perform, and to monitor the execution of these tasks. Command Language procedures can be prestored for efficiency of operation.

Data Management

A major system control program in the Time Sharing Operating System is the File Control Processor (FCP). The FCP provides comprehensive file management and data management systems. In the area of file management, the FCP maintains catalogs of all files in the system and provides facilities for indexed sequential access to files stored on random access devices. Options available to the user include the capability to specify file names and characteristics at execution time rather than at assembly or compilation time, and the capability to share files among users through the use of passwords.

Also controlled by the FCP is the TSOS Data Management System. Two types of file organization are supported: sequential and indexed sequential. The Data Management System provides facilities for manipulating either type of file by means of the following functions: describe, create, access copy, change, and delete. A file protection system prevents unauthorized reading and writing of files in a dynamic time-shared environment.

Processing Programs

In addition to the network control programs. TSOS provides a large set of processing programs available for use by the system and problem programmers. The TSOS processing programs include language processors and utility or service programs. Both the processing programs and the users' programs are executed in the "nonprivileged" mode under control of the TSOS control programs.

Language processors are supplied in conversational and batch form. The conversational language processors include an interpretive FORTRAN compiler that uses a FORTRAN subset language, and syntax checking programs for source-level FORTRAN, COBOL, and assembly-language programs. The more conventional language processors that operate in batch mode are a FORTRAN IV compiler, a COBOL compiler, a Macro Assembler, and a Report Program Generator.

Utility programs are also provided in both conversational and batch modes. The two conversational service programs are the Desk Calculator and Text Editor programs. Using the Text Editor, the remote user can create, modify, and display files on a line-at-a-time (i.e., single record) basis. The Text Editor should prove of great value in maintaining symbolic programs and their associated data files. The batch utility programs include a sort/merge program, a file maintenance routine for system and user programs, and a test data generator.

All software comprising the Time Sharing Operating System is currently scheduled for delivery during the third quarter of 1968.

In summary, the Time Sharing Operating System and its many components represent RCA's answer to the large-scale, random-access-oriented software systems offered by IBM with its Operating System 360 and the Model 67's Time Sharing System. TSOS supplants the long-discussed Disk Operating System in the RCA Spectra 70 software line. Because TSOS includes not only time-sharing facilities, but also impressive multiprogramming and data management facilities, it is likely that the Spectra 70/46 Time Sharing System (including TSOS) will prove attractive to some users whose processing requirements do not include remote, time-shared processing.

Compatibility

The Spectra 70/46 Time Sharing System is compatible with the RCA Spectra 70/35, 70/45, and 70/55 systems to the extent that all instructions, character codes, interrupt facilities, and special features available in the nontime-sharing systems are also available in the 70/46 system and function in the same manner. Therefore, when operating in the 70/45 mode, the 70/46 system will be able to use the TOS and TDOS software systems and execute object programs compiled for 70/35, 70/45, and 70/55 systems, provided that the programs are timing-independent and system optional features are identical.

Functioning in the 70/46 mode under the specialized Time Sharing Operating System, the 70/46 will be able to compile all source programs originally written to function under TOS or TDOS in 70/35, 70/45, or 70/55 systems.

The Job Control Language (JCL) used with the Spectra 70/46 Time Sharing Operating System is an expanded version of JCL as used with the Tape and Tape/Disc Operating Systems, but is not fully compatible with the latter.

Because of the high degree of compatibility between the 70/46 and the general-purpose Spectra 70 computer systems, users of the 70/35, 70/45, and 70/55 systems should be able to upgrade to the more advanced facilities of the Time Sharing System with a minimum of conversion-time difficulty.

Like the RCA Spectra 70/35, 70/45, and 70/55 systems, the Spectra 70/46 in 70/45 mode is largely compatible (both in terms of programs and data) with the general-purpose models of the IBM System 360 computers.

Performance

A prototype Spectra 70/46 system is currently operational and being used by RCA for software development, but no detailed performance estimates are available to date. As a preliminary performance indication, RCA states that the system will provide a maximum response time of eight seconds for each of 48 interactive remote terminals, assuming that all terminals are concurrently active and that four background programs are also being processed concurrently.

The Spectra 70/46 hardware/software combination as specified is impressive and deserving of further scrutiny by the industry as its implementation progresses. The 70/46 Time Sharing System is not startlingly revolutionary in its design nor extravagantly bold in its goals (and, as such, may not appeal to the industry's confirmed innovators). Yet, the 70/46 may work. It appears to combine the better features of efficient multiprograming systems with more advanced remote data communications and time-sharing facilities. Its approach to time-sharing is evolutionary—a natural, continuous progression from the time-tested batch processing facilities to those that may be better suited to cope with the processing needs of the future.

Table 1. Profile of the RCA Spectra 70/46 Processor

Core storage cycle time, microseconds	1.44
Bytes accessed per cycle	2
Core storage capacity, bytes	262,144
Selector channels	0, 2, 3, or 4
Multiplexor channels	1
Selector channel capacity, bytes per second	465,000
Multiplexor channel capacity, bytes per second	465,000
Maximum combined I/O data transfer rate, bytes per second	1,388,888
Processor speeds, microseconds*	
Fixed-point binary	
$c = a + b$	25.2
$c = a \times b$	81.9
Fixed-point decimal	
$c = a + b$	42.2
$c = a \times b$	127.0
Floating-point (short)	
$c = a + b$	37.4
$c = a \times b$	67.6
Floating-point (long)	
$c = a + b$	52.6
$c = a \times b$	211.5

*The fixed-point binary and short floating-point operations use 32-bit binary operands; long floating-point operations use 64-bit binary operands. The fixed-point decimal times are based on signed 5-digit (3-byte) decimal operands.

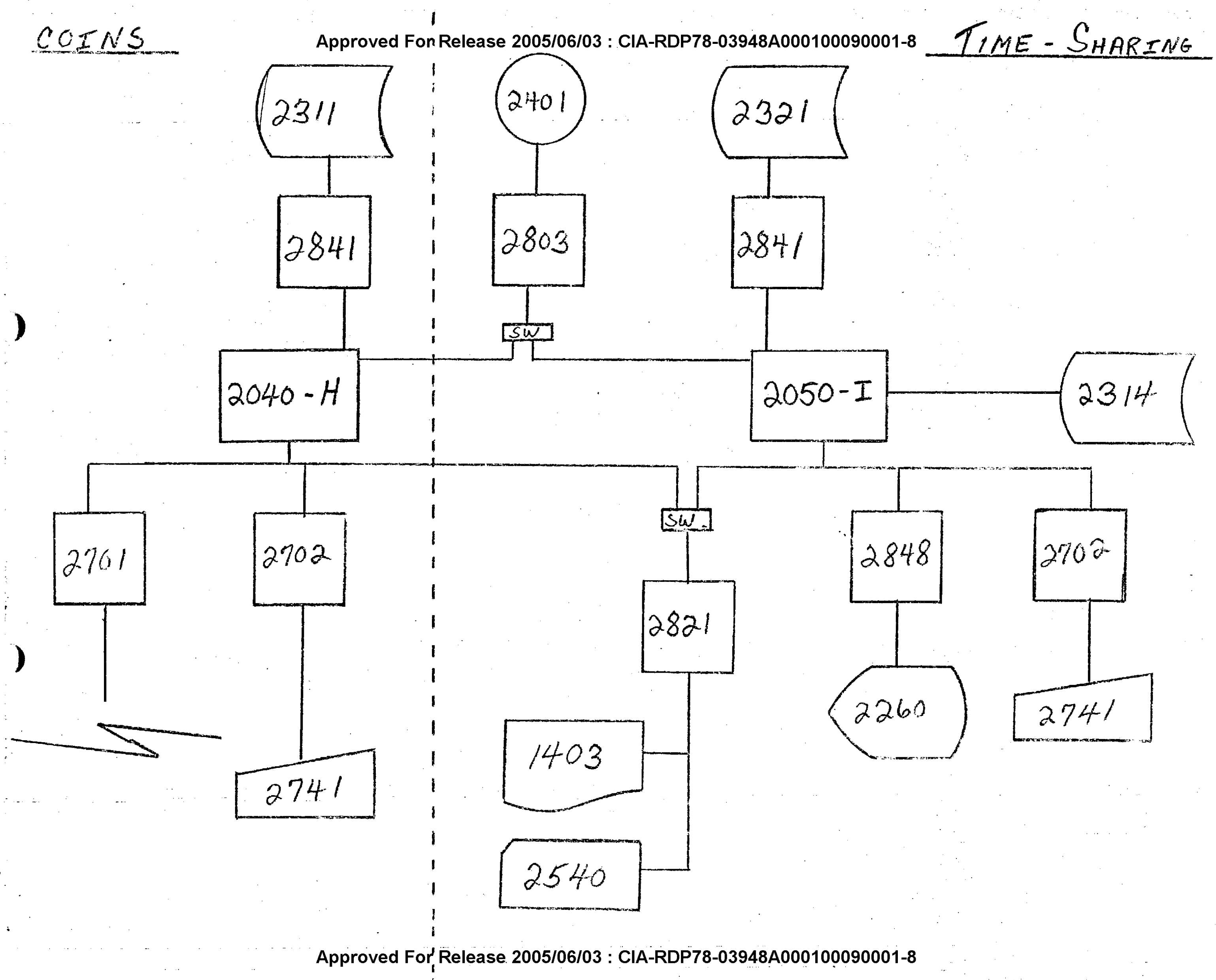
New Hardware and Software

In addition to the 70/46 Time Sharing System, RCA has expanded and improved its product line in other areas during the past year. New hardware products include a controller for Burroughs, IBM, or NCR MICR sorter-readers, a high-speed (1,000 cps) paper tape reader, "quietized" printers with 96-character sets, an improved CRT display device, and 7-track magnetic tape units that provide tape compatibility with earlier RCA 301 and 501 systems.

More specialized hardware systems of recent development are the Spectra 70/510 Voice Response System, which delivers recorded human-voice responses to on-line inquirers at Bell System Touch-Tone telephones, and the Spectra 70/630 Data Gathering System (DGS), designed to gather information at remote, point-or-transaction input stations (such as badge readers, card readers, etc.) and transmit it to a central Spectra 70 computer system.

Software improvements have centered on adding random access device capabilities to the Spectra 70 language processors and expanding the support of data communications devices. Also, the Spectra 70 Basic Time Sharing System (BTSS) is being developed as an all-software approach to limited time-shared processing with Spectra 70/45 systems.

By means of these developments, RCA has improved its position as a worthy competitor of IBM in all areas of the small-to-medium scale computer market. RCA has accomplished this feat with the aid of a maturing market and product planning philosophy that does not attempt to match in every detail the vast facilities of the IBM System 360, but instead attempts to analyze the demands of the market place and to implement whatever facilities are required to remain competitive, but on a scale that is feasible and potentially profitable. The hardware and software design of the new Spectra 70/46 Time Sharing System is an excellent case in point.


COINS
TIME - SHARING
2311
2401
2321
2841
2803
2841
SW
2040-H
2050-I
2314
SW.
2761
2702
2848
2702
2821
2260
2741
1403
2741
2540

TIME SHARING SYSTEM

2050-I			20,550
	1052	Adapter	232
	6980	Selector Channel 1st	720
	6981	Selector Channel 2nd	720
1052-7			65
2821-1		Control Unit	1,000
	3615	1100 LPM Printer Adapter	77
	1990	Column Binary	103
	8637	Univ Char Set Adapter	15
1403-N1		Printer	910
1416-1		Inter Changeable Train Cartridge	100
2540		Card Read Punch	680
2848-3		Display Control	435
2260-1		Display Station (8 @ 51)	408
2702-1		Transmission Control	1,075
2841		Storage Control	766
2321		Data Cell Drive	2,885
2314-1		Direct Access Storage Facility	5,410
2803-1		Tape Control	670
2401-3		Tape Units (3 @ 810)	2,430
			39,251

COINS

2040 - H		10,505
1052	Adapter	232
6980	Selector Channel	360
1052-7		65
2702-1	Transmission Control	1,075
2741-1	Communication Terminal (5 @ 87.50)	437.50
2841	Storage Control	540
2311-1	Disk Storage Drive (6 @ 590)	3,540
2701-1	Data Adapter Unit	1,001
		17,755.50

COINS System	17,755.50
TS System	39,251.00
Switching hardware	1,000.00
	$ 58,006.50