Report of the Second Computer Study Group

Submitted May, 1973[1]

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(b)(3)-P.L. 86-36

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The parts of the "Ware Report" published here include the introduction: general goals; detailed findings; discussions and conclusions: user environment, latent demand, accounting and forecasting, disadvantages of 7094(II) processing hour as a metric, long-term development plan, software plan, data access and management, some hardware development targets, performance measurement and tuning, communications requirements, computer system security, options for survivability, organizational structure and management, the economics of obtaining computer systems, strategies for getting the most computing from available budget; external environment—global, national: conditions and trends in world events, conditions and trends in the United States, impact on NSA/CSS affairs; impact of environment on computing requirements: specific implications, major design goals; the NSA computer facilities: major use areas, overview of the major NSA/CSS data processing, growth of NSA/CSS data processing—equipment and history, growth of NSA/CSS computer usage and corresponding costs; guidance and preface.

1.1 INTRODUCTION

The crucial observations from the data that we have collected are these:

- The Agency has sustained a 50% per year growth in computer power for over ten years.
- There has been a concurrent growth in demand to match the increase in capability.

[1] The table of contents of the entire *Ware Report*, as well as the Director's charge letter, guidelines (i.e., terms of reference for the study) and preface, can be found in the Appendix of this abbreviated paper. Thanks are due to Mr. Thomas A. Prugh, Commandant of the National Cryptologic School and Publisher of the *NSA Technical Journal*, for suggesting that portions of the *Ware Report* be published in the *Journal*. —Ed.

- Through the wise use of investment capital in that interval, old machines have been replaced by new and financially advantageous purchase (rather than rental) arrangements made.
- Consequently, the unit cost of computing power has declined steadily at a rate of about 25% per year.
- Investment capital in the FY73, FY74 and anticipated FY75 budgets is substantially less than has been available in the past. (It has averaged $8M/YR for the past 6 yrs. Fiscal years 73, 74 & 75 may total less than $15M procurement.)

For two reasons we feel that the Agency cannot sustain the continued 50% per year growth. The first is funding. If half again as much computing power were to be provided in FY73, the equivalent of four CDC 7600 machines would have to be procured at approximately $30M investment or $10M annual rental. Funds for procurement in FY73 approximate $3M and the increase in rental approximates $4M. This is about one-half the needed amount. A corresponding observation holds for later years.

The second reason is that families of machines are running out. The excellent actions by C Group, in recent years, to continuously upgrade capability has, in part, depended on the fact that "upward compatible" machines have been available. We note that the UNIVAC 1108, for example, has only one more step to go—the 1110—and then the family is static. Similarly, the UNIVAC 494 machines around which RYE-TIPS is implemented have no announced successors[1]. The CDC 7600 has probably only one more step in the 8600 and its future is somewhat uncertain at this time; the Burroughs line is likewise leveling out. IBM appears to be consolidating the top of its line with the 370/168 with deliveries due to begin this summer. A period of quiescence seems to be approaching in the commercial industry during which there will be a temporary lull in the appearance of significantly more powerful CPU's that are software compatible with older ones. Attention is turning to input-output equipment and total system problems.

Thus, we see the next few years as a period of consolidation during which C Group, other than continuing a policy of upgrading machines, can do little to influence the near term. It is a period in which to implement and enforce standards, to plan for the future, and to aggressively seek out those situations in which it is economic to exchange old machines for new. In contrast, however, we anticipate new families of machines to be announced in three-to-five years and we

[1]Recently, some rumors have arisen that a compatible successor was being considered by the manufacturer, but definite plans are not known and the capability improvement expected over the UNIVAC 494 has not been learned.

believe the Agency should plan for major replacements of its computers beginning at that time.

Therefore, in the coming two-to-three years, we believe that the Agency must expect a plateau in the growth of computer power and that the growth may approximate only 15-20% per year. As a consequence, it becomes extremely important to manage the computer resources carefully, with high visibility, and with specific objectives in mind. Otherwise, there is a major risk that all available computing power will be consumed by ongoing work and that new development will be seriously curtailed.

The Agency computing complex for the most part has run supply-limited for the last decade; the real demand is not known and may not be knowable. If by some luck of funding, the 50% growth rate should be maintained, it will certainly all be consumed. On the other hand, the growth can clearly be controlled by limiting the funding support; but we note this caution: we cannot say in detail what the consequences of a management-imposed lower growth rate will be, nor, at the present time, can the Agency's own internal reporting and management system.

1.2 *General Goals*

We suggest the following specific goals for the Agency computing group in the coming years:

1. Have a posture of readiness and reliability to meet the challenge of responsive on-line computer-based systems in support of SIGINT operations.
2. Reduce the labor intensification of the computing and data processing functions which support the Agency and the community.
3. Seek continued increase in computer productivity and thereby a reduction in the unit cost of computing power.
4. Establish a software posture that will expedite rapid expansion of computing services in the event of a national emergency or need.
5. Develop and implement standards and consistency across Agency computing systems which will facilitate the achievement of the other goals.

While the computer as both a tool and a technology has already penetrated quite deeply into Agency operations, and while C Group has continuously and diligently maintained, operated, and upgraded the Agency computing facilities, we believe that the situation can still be improved, and, especially in light of the anticipated budget constraints of the next several years, must be.

DOCID: 4001132

2. DETAILED FINDINGS, DISCUSSIONS, AND CONCLUSIONS

The impact of the global, national, and in-house environment on computing requirements[3] led to several specific topics that the committee discussed in detail. They have been summarized in this section of the report in order to state the committee's opinions on them and to identify specific guidance for decisions and actions that will improve the computing facility posture of NSA/CSS and help to meet the challenges outlined in other sections of this report.

2.1 *User Environment*

In addition to the traditional batch processing and RYE-type remote job entry and delivery for analyst support, NSA/CSS analytic groups have expressed a widespread need for on-line access to data and processes, much more so than was evidenced only a few years ago. Thus, a dramatic rise in this computing requirement can be expected. In addition, the delivery of finished NSA/CSS product through on-line retrieval systems could have two impacts on the processing load. One is a significant increase in demand for, and use of, on-line facilities well beyond the RYE level of capability. As a consequence, a reduction in conventional routine processing should occur as services and information become available on-line and on specific demand, rather than on a wholesale scheduled basis. Outside traffic to NSA/CSS facilities, and traffic from NSA/CSS calling on external facilities, can both be anticipated as part of the on-line load. Unfortunately, the new outside demand, the corresponding processing load requirements, and the potential shift of processing load from batch to on-line functions are not well understood nor well quantified so far as determining future computing requirements.

The demand for specific on-line capabilities may outrun the ability to build up the necessary system foundation (hardware and software) that is adequate for long-term growth. While developments done under pressure may be only temporary and have to be replaced when a general capability is established, operational experience thus gained is valuable input for building the long-term general capability. However, NSA/CSS management must understand the multiple cycles of development and redevelopment that are necessary for evolving to the direct support environment envisioned by many analysts.

2.2 *Latent Demand*

In considering the Agency's computer requirements for the next five years, we must concern ourselves with latent demand. What we see in the way of computer usage in some portions of NSA/CSS may be the tip of an iceberg with a vast requirement hidden, but preparing to

[3] Refer to Sections 3 and 4 for a detailed discussion of this topic.

surface in the not too distant future. Three areas of possible latent demand are discussed below.

The first possibility of a large latent demand is in the work of B and G Groups. After subtracting G41's dedicated use of a CDC 7600, and even though B and G Groups make some use of RYE and some batch-oriented jobs on other computers, it is clear that both could make tremendous operational and analytic improvements if they had ready access to a computer, particularly to one with interactive capability through outstations of the cathode ray tube terminal or even teletype variety. There are a great many fairly simple operations requiring some computer backup that suffer delays of days and even weeks because of the absence of on-line capability.

The estimation of latent demand in this direction is virtually impossible. Asking those who would be served by the new methods is not very useful because they are not accustomed to thinking about their functions in the on-line environment and have no basis for separating what is difficult and costly from that which is easy to provide yet very useful or even guessing how they would do things differently. Also, a natural reaction in budget squeezes is that management protects existing personnel and retreats to well-known methodology rather than risking money on new, unfamiliar, and unproved things.

A second area of potential latent demand is the area of intercept control. The certainty of this usage is not as clear as the previous one, but there are evidences that there could be improvement of operation and a reduction in overseas personnel if computers were more extensively introduced at the intercept sites. Not everyone is in agreement with this, and some current experiments may provide more accurate insight. It is an area, however, that needs examination in response to the expected overseas environment and corresponding personnel shortages.

The third area of a possible latent demand is in connection with RYE itself as noted previously in "User Environment." RYE is a fantastically successful operation which has grown by responding to individual crises, rather than through careful top-level planning. For example, RYE originally used 490's and now uses 494's because 494 is compatible with the 490. If NSA/CSS is willing to rewrite a considerable amount of software, a careful operations analysis or management exercise undoubtedly would reveal that RYE may be upgraded by something like a factor of ten at a factor of two to four in cost. With modern technology leaping ahead, it is quite likely that in the next five or ten years, NSA/CSS will need a system that is one hundred to two hundred times as powerful in processing capacity and includes a much broader range of more responsive functions.

Changes in environment can be expected to result in more output with some reduction in the number of analytic personnel, but creating the environment may require more software people. Thus, even if a development pace can be established which prevents total staff levels from increasing and, eventually enables reduction, the required mix of staff skills would change as a result of widespread automation. This has implications for shifting staff utilization and for recruiting and training requirements.

2.3 *Accounting and Forecasting*

Good progress is being made on a difficult problem, but there is still a long way to go. Some specific comments are:

- The new dollar-based costing method being considered by C Group and which is similar to the equivalent annual rental basis used in this study is good for ascertaining the distribution of resources among various operational missions. It also aids in quantifying, for gross planning, the acquisition cost of facilities required to process an increasing load of material forecasted for future years. However, the dollar amounts do not adequately reflect the interaction of fixed and variable costs, the lower real cost of operating existing owned equipment, or specific funding strategies. For construction of real budgets, the actual acquisition plans (or alternatively, cut-back actions) must be expressed in terms of real dollar costs implied by specific plans.
- More work remains to be done in getting better measures within a computer system of how its resources are utilized by various jobs. These measures must segment resource consumption into three or four classes, e.g., processor costs, secondary (and mass) storage costs, terminal equipment costs and communication costs.
- On-line usage metrics are in poor condition. This is particularly crucial because this class of service (e.g., RYE and other online facilities) appears to be the major growth item; unfortunately, there is no useful way to quantify that demand—or even usage.
- Some relation between machine resource utilization and input and/or output work units of volume or flow is needed to aid in forecasting machine requirements as functions of intelligence target requirements.
- Study is needed to identify tradeoff factors on machine processors vs. people. There appears to be no way now to quantify the over-all cost savings that might be achieved by increasing the effort on automation. While some such tradeoff studies may have occurred in the past, we could find no meaningful cost

studies that isolated the factor. Future projects which alter the computer-personnel ratio relative to a particular information production process should be analyzed for this purpose.

2.4 *Disadvantages of 7094(II) Processing Hour as a Metric*

While we used, and found useful, the metric traditionally used in NSA for statement of computer capacity, (the 7094(II) hour[1]) it has many shortcomings. Its chief merits are that it exists, much *data* is available in the unit, and NSA/CSS has run extensive tests to calibrate a wide variety of machines in these terms.

The disadvantages are many, but they all stem from the increasing complexity of modern computer systems: multi-programming, software-managed secondary and mass storage facilities, on-line terminal access, and all sorts of automatic sharing of system resources among many processes simultaneously. The 7094(II) hour arises from the era of uni-programming (one program run at a time to completion) and total system resources were dedicated to the single program and thus easy to account for. The 7094(II) hour is really only a CPU measure and the rating for a given computer, say an IBM 370, is not stated explicity in terms of its storage size, disk capacity, input-output complement, etc.

Furthermore, the differences among machines cause wide variations in performance on various types of problems and also the sequence of jobs in an over-all work load. The IBM 7094 was a computation-oriented computer, and character stream data processing is not easily characterized in the same terms.

Thus, while the 7094(II) hour is a pragmatic and useful planning tool, it must be used with care and insight, for it fails to treat things of increasing importance. The deficiency in good metrics is an industry-wide problem; however, NSA/CSS has such a large stake in forecasting and managing its immense computer system resources that it should be among the leaders in developing and applying good capacity and load metrics.

2.5 *Long-Term Development Plan*

There appears to be no cohesive and comprehensive long-term, agency-wide plan for developing the major processing center(s) within NSA/CSS and integrating the mid- and long-range research and development efforts. Although there is much activity on facets of the necessary technology, these activities often appear to be competing, or incomplete, or toward diverging objectives. A goal-oriented processing environment needs to be established with sufficient scope, clarity, and stability that the development plan to reach it can be constructed.

[1] Defined under section 5.4.1 below.

Of course, such goals and the corresponding plans would be subject to continuous review and revision as conditions change and more is learned, but the changes must occur gradually and with a view to building on the present rather than attempting to ignore it or revolutionize it suddenly. Goal-setting and planning is not an idealistic or impossible task if it is taken seriously and the necessary experience and knowledge are applied.

2.6 *Software Plan*

The C concept of operation is expressed in terms of a "hardware plan" and is commendable in that it recognizes the necessity to plan the processing facility as a whole. The specific items of equipment listed are regarded as indicators of level, type and cost of capability needed, not necessarily final equipment selections; however, there is no corresponding software plan. Software activities generally seem to be dominated by the reaction to, and adaption of manufacturer-supplied operating systems. Some attention has been given internally to programming languages; RYE is one type of successful software activity. However, NSA/CSS should gain control of its "software destiny," especially relative to operating systems, programming languages, and data management systems. This is not to say that NSA/CSS should attempt to write all its own software—only that it be in position to specify in considerable detail the characteristics of operational software NSA/CSS will accept and use, and when standard or modified manufacturer software is not responsive, to do its own. Many of these activities, in fact, already go on at NSA/CSS. Many of the necessary skills are available, but there does not seem to be an overall firm, long-term software plan to guide the several efforts or to organize and apply the available skills. Careful identification of long-term requirements, selection of appropriate software system architecture, and a firm commitment to them are required.

Specifically, the following terms must be included as a minimum in a software plan:

- A standard communication and control protocol between segments of the processing system, input complexes, [redacted] and so forth.
- An operating system posture that includes minimum functional features and performance requirements, standard system control language(s), a user interface command language, usage accounting data requirements, security features, etc.
- Specific data access and management facilities (see item 2.7 below).
- Specific determination and identification of the on-line operating system requirements as well as the batch processing environment.

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- A determination of the specific requirements and development goals for the generation of on-line support facilities beyond that represented by RYE and its "cousins."

2.7 *Data Access and Management*

Traditionally, NSA/CSS system development has been process oriented. A major part of it needs to be more "data oriented," that part relating to the putting into, building of, and retrieval from information files and the throughput processing of large volumes of information.

This is not a case for one monolithic physical information store, but we do advocate a unified set of definitions, techniques, and procedures so that data is handled uniformly throughout the system and design resources are conserved by implementing the same well-established basic design(s) on all systems. Orderly design improvement cycles should be instituted with long enough lead time and broad enough improvement in capability so that the job can be done well and can yield enough payoff to be commensurate with the development resources required.

A plan for the design of a data management and access system should include:

- Data element definition, standardization, and control (semantics).
- Data organization(s) and related maintenance techniques.
- Data representation and coding standards.
- Data logical access methods and application program interface.
- Data security (both "secrecy" and "safety" aspects).
- Data base administration(s).
- Archive management and purge criteria.

2.8 *Some Hardware Development Targets*

Generally, hardware adequate for the normal work load can be acquired commercially, and the most critical "engineering" attention now needs to be on software; however, a few hardware areas must receive continuing attention and effort.

- Special-purpose equipment for specific cryptanalytic and other special processes has long been an area of NSA/CSS need and expertise. No change in the requirement to maintain that expertise is seen; if anything it may need to be enhanced.
- Continuing long-term attention is needed on very large capacity storage (equal to or exceeding 10^{12} bits). The NSA/CSS requirements are among the few which will push that technology.

- Intermediate storage, above 10^{10} bits but below the [redacted] size (approximately 10^{13} bits) is needed. Even if available from commercial sources, integration into the NSA/CSS system is necessary. A continuing reduction in the cost of such storage is also necessary.
- High capacity, high data-rate automated transfer of data among major processing components should be implemented. Electronic equipment exists for this purpose, but over-all system design and engineering are necessary. Using a combination of direct channel-to-channel interconnections and [redacted] mailboxes should be regarded only as stopgap techniques.
- The attention within NSA/CSS on "universal terminal" design and communication should be broadened and encouraged. Electronic technology per se is satisfactory and is improving rapidly, particularly in lowering of cost, but the specific devices for the NSA/CSS complex need to be determined and the equipment acquired and/or developed with the intent to have it be a stock equipment inventory item at NSA/CSS.

2.9 *Performance Measurement and Tuning*

A team should exist for the sole purpose of measuring computer performance and making studies of computer effectiveness, providing "meters" to measure performance, and generally relating performance and costs to one another. In a time of declining budgets and with demands exceeding availability, it becomes imperative to obtain the most cost-effective equipment and software. Measures must be developed to determine reprogramming costs so that they can be properly considered when changing to new systems. Today, there are at best guesses as to what such costs may be. No consideration can be given to the value of added new features or more efficiency that may be provided as a consequence of reprogramming.

Typically, by the time a complex software system is successfully debugged and operating correctly, the scarce personnel resources skilled in such areas are needed on other critical projects; no time is available for tuning to improve efficiency; and no one wants to disturb a production operation. This phenomenon is true throughout the software industry. In view of the hardware environment of today and the future involving cache memory and virtual memory computers, it is particularly important to monitor software performance and to tune it.

Careful selection of highly utilized programs for performance tuning can yield high dividends for the effort expended and can provide one source for additional computing power to satisfy latent demands. C

Group has recently strengthened and formalized its efforts of this type.

2.10 *Communication Requirements*

Clearly, as direct communication with the field increases for both input and output and as more automatic interlinkage of processes within NSA/CSS develops, the need for increased communication capacity increases, especially for data transfer. The software to manage such communication becomes an item for system-wide treatment. Traditionally, the boundary between computer and communications technologies and operations (nationally and world-wide) has been a source of technical and administrative problems. NSA/CSS must manage this interface to minimize such problems.

2.11 *Computer System Security*

It is axiomatic that the pervasive use of highly automatic information production lines, of large integrated storage facilities, and of user terminals for access to computing capacity require the solution of the technical and administrative problems of the security of multi-compartment computer systems. NSA/CSS has extensive experience in operating systems which have been effectively secure (i.e., RYE, TIPS, COINS) and has organized R&D expertise on the topic. It should be in a good position to make progress on these very difficult problems.

2.12 *Options for Survivability*

We have noted that the increasing centralization of activities at Fort Meade due to pressures both to withdraw facilities from the field and to provide enhanced field support because of the power of the skills and facilities at NSA/CSS headquarters is simultaneously creating a significant vulnerability. This needs explicit attention in management planning. Various measures should be investigated to include alternate site arrangements for highly critical time-sensitive services and for storing and maintaining full, up-to-date documentation of all operational systems and procedures. Documentation must be produced anyway because it is a tool for routine development and management of operations, but in addition, all program libraries and critical data files necessary for the processing system to be able to operate on new input must be provided.

2.13 *Organizational Structure and Management*

Specific functions and characteristics that must be included in any organizational structure and management strategy for providing the necessary information processing facilities are as follows:

- For effective operation of all facets of the processing system, the major elements of the facilities must be tightly coordinated, i.e., communications, data input and conversion, processing, major storage and retrieval facilities, and output (including massive volumes of report printing). The more automated the facilities and the entire processing flow, the more integrated their design and management must be. Facilities should be installed and operated on a "utility basis."

- The main facility components (hardware and software) should be designed, selected, and installed on the basis of a long-term consistent plan and according to a carefully designed system architecture. The present (and historical) approach has been to build various islands in uncoordinated ways and then patch them together.
- Software professionals must have a common background training and adhere to the NSA design standards and techniques. Innovation must always be sought, but introduced only on a controlled basis. The computer professionals should establish and enforce design standards for NSA/CSS, whether adopted from industry or developed internally. They must also be responsible for the "core software" of the overall system, provision of common software user capabilities to be used in various applications, testing and tuning of designs for operational efficiency, and consultation and assistance as necessary.
- Maintenance and all facility support should be under a unified management.
- Application programming is best staffed by people who are trained in the application, as well as the programming. The present enviornment ranges from complete "open shop" programming to complete "closed shop." In an activity as large and varied as NSA/CSS, striving toward homogeneity of organizational placement of such staff is probably not desirable.
- While there always seem to be shortages of skilled personnel, NSA/CSS has a very large cadre of computer science and data processing personnel experienced in all aspects of hardware and software design, application design, and operations. To make optimal use of this cadre is both a challenge and an opportunity for management.

2.14 *The Economics of Obtaining Computer Systems*

The Government purchases (or leases) a very large number of computers of all types during the market lifetime of the systems. Some agencies such as NSA, AEC, and others receive early delivery of new systems and often are upgrading to even newer systems while other departments of the government are still acquiring the computers still marketed. A mechanism exists for the redistribution of such surplus

equipment within the government so that it can be acquired for whatever needs it can satisfy. Unfortunately, this does not work as well as it could or should. Within the AEC there is somewhat tighter control on the hand-me-downs so that they stay within the AEC family until there is no further need for them. Certainly, such a scheme should be used within other large agencies as well. The Department of Defense should be encouraged to work with NSA/CSS so that computer systems that are being replaced can be moved into other portions of the DoD.

The amortization period for a leased computer system is of the order of three to five years. If a system is to be retained for at least such a period (and it should be, if one considers the inertia of software investment and its total life, including transfer to other users within NSA/CSS) it should clearly be purchased. The buyer can almost always obtain a better deal than the lessor. With computers serving useful lifetimes of up to 10 years, the savings incurred are large. Even if there is a shortage in capital acquisition funds, it is possible to arrange purchase option plans such that operational money can be used to pay off the total purchase price over a reasonable period of time and to obtain title to the computer with the final payment.

2.15 *Strategies for Getting the Most Computing from Available Budget*

Faced with the implacable pressures of budget limitations and rising demands (some of which are generated by increased use of computers to save on personnel costs), the NSA/CSS computing facility must seek ways to further reduce the unit cost of computing and to ferret out and eliminate any wasteful uses of present capacity. Appropriate actions include:

- Continue and extend the existing practices to arrange low-cost procurements, with emphasis on purchase rather than lease.
- Seek out old technology in use which is uneconomic because of poor performance and/or costly operating support. Replace with new equipment.
- Make systems operations more automatic. Establish operating systems in which work streams can be automatically scheduled and files automatically staged either from file systems local to the computer systems or from [redacted] (b)(3)-P.L. 86
- Eliminate unnecessary processing. As on-line facilities are implemented in response to demands for more direct support to analysts, identify routine batch processing that can be eliminated. The costs of developing and providing the on-line services must be balanced against personnel or computer costs avoided, or else the net benefits sought will not occur. This

may mean that it is not sufficient to shift only part of the demand for a batch-produced "wholesale" product. It all must be shifted, or the "wholesale" product cannot be eliminated.

- Examine regularly scheduled products to see if lengthening the periods between successive issues would yield significant savings in computing costs without seriously affecting the utility of the results.
- Identify and examine the demand-limited segments of NSA/CSS computing resources for possible diversion of capacity to supply-limited areas. Doing this requires solution of severe administrative problems.
- Conduct an agressive program of performance measurement and tuning of operational programs, giving priority to those which are on newly acquired facilities and which use the largest portions of available capacity.

It must be noted that these actions will not happen spontaneously. Conscious and deliberate management attention is required to implement them.

3. EXTERNAL ENVIRONMENT—GLOBAL, NATIONAL

3.1 *Conditions and Trends in World Events*

In the coming decade, a number of conditions and trends in world events over which the intelligence community has no control may directly influence the National Security Agency/Consolidated Security Service and strongly affect the nature of the information systems that it must have to support its SIGINT mission. These conditions include the following:

3.1.1 *The nature of future local military confrontations.* A common scenario envisions the United States becoming involved in a succession of limited actions. Whether the U.S. role in such localized military engagements remained limited to materiel aid, or support of indigenous forces, or whether it entailed active participation of U.S. personnel, NSA/CSS might be obliged to perform in a wide variety of geographical locations and to deal with a large number of natural languages.

3.1.2 The recently concluded Strategic Arms Limitation Treaty (SALT). This agreement will influence NSA/CSS affairs for at least the next five years. [redacted]

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3.1.3 The increasing volume of communications throughout the world. Since the launching of the first international communications satellite in 1965, the number of operational earth stations has grown to over 80 (located in over 60 countries), and the number of circuits is approaching 6000. Moreover, in each country of the world, especially emerging ones, the installation of [redacted] tropospheric scatter, and satellite links is increasing. Thus, the volume of traffic in which NSA/CSS has a potential interest appears to have no limits.

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3.1.4 The growing volume of encrypted communications. Apart from communications that relate to national interest and governmental affairs, ordinary business traffic and computer communications are also being encrypted. Due in part to the emergence of remote access time-sharing computer systems, the number of commercial encryption devices available for various baud-rate circuits is growing.[5] As the U.S. continues its treaty relations with various allies, it can be expected that this country will furnish communications security (COMSEC) equipment and expertise to such countries as part of the treaty obligation.

3.1.5 The steady increase in sophistication and cost-effective performance of electronic technology. Therefore, transformations on natural language are becoming cheaper and easier to do. One can expect that even in relatively primitive countries or emerging nations, the sophistication of communication security techniques will advance more rapidly than historical evidence would suggest.

3.1.6 The rapid change of general communications techniques. Dictated both by national needs for survivable systems and by general needs for higher reliability and error-free systems, new communication technology is being introduced into daily use. [redacted] Other signals growing rapidly in volume include secure voice channels and the data links between computer systems or between sensor/data acquisition systems and their processing centers.

3.1.7 *The political change in the world itself. New countries appear;* coalitions of old countries form to yield new ones; new countries develop or acquire significant military capabilities; weapons technology makes significant strategic capabilities available even to small countries.

[redacted]

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(b)(3)-50 USC 403
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3.2 *Conditions and Trends in the United States*

Just as events of the world are creating an environment in which NSA/CSS will have to function, so coming events in the U.S. will also strongly influence the future of the SIGINT effort. Among these are the following effects:

3.2.1 The best estimate about the future of the military budget is that it will continue to decrease. This will be especially so as the world moves into an era in which a strategic balance among the major powers promises to minimize the risk of nuclear warfare. Recent political discussions between this country and the U.S.S.R. and the People's Republic of China (PRC), coupled with the development of industrial and trade relations between these countries all serve to minimize the apparent risk of international warfare. Such events will help maintain pressure to continually decrease the military share of federal spending.

3.2.2 As military budgets decline, there will be mounting pressure to reduce manpower and increase efficiency of all military operations, since the largest single part of the military budget goes into salaries and manpower support costs.

3.2.3 The U.S. is committed to an all-volunteer military force. The implications of this policy are not yet entirely clear, but possible consequences include a reduction in both the quantity and quality of manpower available, and a decline in the dedication with which this manpower performs its job. Mutual balanced force reductions or international balance of payments will lead to curtailment of overseas military bases and manpower billets. In its own national interests, the U.S. is almost certain to "pull in its horns" and attempt to do as much as possible from the Continental United States.

3.2.4 There may be further changes in the organizational structure of the Department of Defense and/or within the intelligence community itself. Events such as the recent Consolidated Security Service reorganization imply change for NSA, e.g., new national missions, more responsive support of the executive branch, closer coupling to operational military forces (especially general purpose forces), and a deeper involvement in operational military affairs.

3.2.5 New strategic missions for NSA/CSS are certain to emerge as the U.S. deals with world politics and shifts in international power and seeks to stabilize the competition between major powers by treaty and/or alliances. One prominent example is that of being a major contributor to the monitoring of SALT. Whatever treaties or agreements this country may become concerned with, if these agreements entail a policing or monitoring aspect, NSA/CSS will probably be heavily involved.

3.3 *Impact on NSA/CSS Affairs*

As these world events and the related or independent changes within the U.S. take place, what impact might they have on NSA/CSS affairs? Here are five examples.

3.3.1. There is bound to be a transfer of work load from the field to NSA/CSS headquarters. The reasons for this are many. The over-all job can clearly be done more efficiently at one site than at a number of widely separated sites which are difficult to manage efficiently. From the technical standpoint, the problem of selecting traffic or items of interest from a large volume of material can be done more efficiently, more carefully, and more thoroughly in one location than at widespread locations. The cost of maintaining personnel at remote sites on foreign soil will inevitably bring pressure to return people to this country. The cost of communications to outlying stations may also act to drive the work load back home.

3.3.2 Local military situations will require extensive support of military field forces, either U.S. forces alone, indigenous forces alone, or mixed forces. Thus, there is an implication that special equipment, special systems, or special operational elements may be required for deployment on short notice. They would have to be capable of functioning in a very ill-defined and possibly confused environment with an uncertain natural language overlay. Depending upon how various forces act to distribute work load between NSA/CSS, its field sites, and perhaps regional processing centers, there might be a greater than projected growth in demand for communications. There is a variety of reasons why this may happen.

- First, as dependence on NSA/CSS product increases, and military commanders appreciate the significance of the information available to them, there may be increased communication requirements to support the field, which includes both NSA/CSS sites and military forces or sites. To provide adequate response to field military forces, such forces must have full and current information about the local situation. NSA/CSS, as the source of such data, would require high-rate, high-volume communications links with field forces.
- In the strategic context, high-rate, high-volume communications may be required to support strategic missions such as SALT monitoring. For example, an action by the U.S.S.R. which suggests a SALT violation might require access to an enormous amount of related and collateral information in order to judge whether the event is significant or not.
- Depending upon how the international balance of power evolves, it is possible that the United States could find itself

in a joint operation with a country historically considered an enemy. For example, should the PRC rapidly develop a major missile threat against both the United States and the U.S.S.R., one aspect of a SALT agreement might be an antiballistic missile force based in Russia, operated jointly by the United States and the Soviets, and protecting both against Chinese attack. Under such a novel circumstance, it would be inevitable that the U.S. forces deployed in such a situation would need extensive and timely support by NSA/CSS.

- All of the above military situations imply significantly increased communication demand; however, as was noted earlier, the total volume of communications throughout the world is growing, not only in terms of circuits, but also in terms of data rates. Even if the collection system were to remain essentially status quo, the volume of information to be processed will increase independently and therefore require more and more communications.
- Finally, as NSA/CSS moves into a larger role in the strategic posture of the country, it will have to expand simply to link itself and its information systems efficiently to those of other agencies, and to various consumers throughout the government.

3.3.3 In its role as a major monitor of communications affecting world affairs and the political balance between this country and the world, NSA/CSS must have a posture both of readiness and reliability. It will have to be ready with information systems, personnel, collection apparatus, and operational procedures for a wide variety of possible situations. It must also be prepared to conduct continuing routine surveillance functions as well as quick-response "fire fighting" tactical functions responsively and with highly reliable systems and over-all performance.

3.3.4 NSA/CSS will have to produce more and more output from each dollar of its budget, and it may have to do this with a declining work force. Given the steadily increasing cost of manpower and the anticipated continuing decline in the military budget, NSA/CSS may be unable to afford its present labor-intensive work posture. The only way that it may be able to accommodate a growing work load is through extensive and deliberate automation of its operations.

3.3.5 If some or all of the events suggested above do result in centralization of business at Fort Meade, as opposed to limited decentralization through field activities, the United States, in a literal sense, would be putting all its SIGINT eggs into one basket. The headquarters area would be a vulnerable target of immense and growing mili-

tary significance. To paraphrase recent statements by the President, there must be national options other than pushing the button that would bring about mutual annihilation of this country and an attacking enemy. The national strategy is now swinging away from the historical spasmodic type of SIOP (Strategic Integrated Operations Plan) war toward controlled interchanges, perhaps limited to military targets, even if nuclear weapons are involved. Traditionally, survival of the United States has been considered as dependent upon survival of the strategic forces of the country and the command and control structure that governs their usage. Thus, should the National Command Authority be faced with fighting any level of nuclear war, the survival of the national SIGINT system would be crucial to the ability of the United States to function successfully during and after a "controlled war" situation. SIGINT inputs to national decisions are more timely, more insightful, and more comprehensive than other sources, but at the same time, complement other sources. Thus, deliberate planning for strategic survival of NSA/CSS is a crucial item. The steady progression toward centralization of activities at the Fort Meade site amounts to acceptance of a steadily increasing national vulnerability.

4. IMPACT OF ENVIRONMENT ON COMPUTING REQUIREMENTS

4.1 *Specific Implications*

World events influence the behavior, posture and planning of NSA/CSS as an organization and also strongly affect the design, implementation and operational readiness of SIGINT information systems. Listed below are some of the implications of this environmental influence.

4.1.1 There will have to be more regularly scheduled, comprehensive "information production lines" modeled after the AG-22 system designed and now operated by B Group to monitor the People's Republic of China. It is apparent that a number of the information processes of NSA/CSS have quite stable characteristics, and with industrial engineering methods applied, can be thoroughly automated and monitored for efficient performance like a production line.

4.1.2 There will be more requirements for production lines that produce information on demand similar to AUTOLINE. Such systems also can be highly automated but must be designed for responsiveness and to accommodate load conditions with wide variations between peak and average load.

4.1.3 With pressures to move toward a reduced labor force, it is inevitable that the analyst will require more extensive support from computer-based tools. One can look forward to information production lines that contain an analyst-machine combination that is conceptually just short of a fully automated production line.

4.1.4 Extensive exploitation of on-line computer systems will be needed. Uses will include:

- Updating the query files. In some instances, file updating can be automated.
- Message editing, correcting and degarbling.
- Developing computer programs.
- Cryptanalytic diagnostics.
- Providing computer-based aids to analysts, such as special dictionaries; cryptanalytic diagnostics which are callable from a personal console; specialized data bases or product reference files tailored to the needs of one or a few analysts.

4.1.5 There will be more and more on-line data bases that can be referenced through on-line terminals both within NSA/CSS headquarters and at remote sites. Many will be of substantial size and may include semiautomatic features such as summarization periodically, or aperiodically in connection with certain events.

4.1.6 High reliability will be mandatory and will have to be a design goal of all information systems. Internal users and consumers will not be able to tolerate conditions in which the system is not operating for an extended time. Backup will have to be provided for the most critical missions and for the most critical information production lines. To guard against unexpected anomalies in information systems, computer programs will have to be validated. Higher reliability of the computer operating system software and application programs is essential. As much as possible, the design of the system will have to exclude people, especially computer operators and other operational personnel. Heavy reliance on commercially produced machines that are in current production will hedge against catastrophic destruction of processing capability and will also minimize the lead time for the acquisition of new processing power.

4.1.7 There will have to be a comprehensive solution to the matter of computer security. Information safeguards must be adaptable to any emergency and readiness situations that may arise. The safeguards cannot be such that information systems overload at crucial times and delay access to needed information.

4.1.8 Since the thrust for efficiency and a reduced labor force imply automaticity and production-line-like systems, computer programs are likely to need frequent revision to maintain efficiency. Certainly, those programs that are components of a production line will have to be monitored for performance, tuned and modified as required. This implies that a whole new function is needed.

4.1.9 Similarly, computer equipment configurations will have to be monitored and tuned to maintain their efficiency in the face of changes

in workload. Notably, any computer configuration that is part of a production line will especially need to be monitored and tuned.

4.1.10 Software development, especially large efforts, will have to be comprehensively managed to assure that all such developments meet the reliability and readiness requirements, fit into the over-all operational concept of the Computing Center, present proper interfaces to users, conform to SIGINT standards for information systems, are adequately automatic in operation, etc. The net effect of this point and the two immediately preceding ones is that a capability like that in industrial engineering for implementing and operating information systems must be available continuously on the NSA/CSS computing scene.

4.2 *Major Design Goals*

In summary, the future NSA/CSS information system, from collection to consumer, must meet three major design goals:

1. Extensive, if not complete, automaticity;
2. A posture of readiness to support a wide variety of operational contingencies;
3. High reliability, especially on those missions considered crucial.

These three specific requirements are essential parts of the general issue that NSA/CSS as a whole, and its information system in particular, must have a posture of strategic survival and continuity of operation for crucial national missions in the event of national emergency or catastrophe. *The present trend of centralization at the Fort Meade site is in direct opposition to this goal.*

5. THE NSA COMPUTER FACILITIES

5.1 *Major Use Areas*

The NSA computer facility has expanded tremendously since its first application to the SIGINT mission. Today, we find that computers are used in nearly every aspect of the NSA/CSS operation at home and in the field. This section will identify, characterize and measure this valuable resource, second in importance only to the knowledge and skill of the NSA/CSS staff.

The Agency accounting systems for computer usage currently recognize seven basic applications for work run on equipment at NSA/CSS. These are:

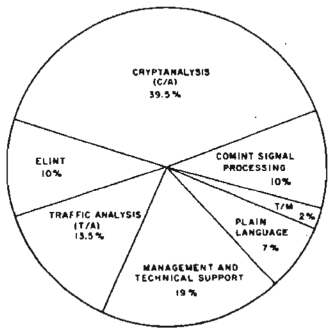
- Management and Technical Support
- Plain Language Processing
- Traffic Analysis (TA)
- Missile and Space Telemetry Processing
- ELINT Processing

- Cryptanalysis (CA)
- COMINT Signal Processing

There are several items of equipment which, at this time, do not provide data in adequate detail (principally the UNIVAC 494's) and the usage on these machines is not reflected in the following chart. Since the 494's represent only about 10% of the total hourly computer usage and tend to be used for a wide variety of tasks, this omission should not significantly alter the distribution. This does not detract from the importance of the functions carried out using the 494's. It simply reflects the inability to quantize adequately their allocation to the various purposes.

Figure 1 illustrates the distribution of hourly[5] usage among the seven application categories for NSA during FY 72.

DISTRIBUTION OF COMPUTER* USAGE BY PROBLEM CATEGORY



*DOES NOT INCLUDE RYE OR SPECIAL PURPOSE EQUIPMENT

Figure 1

The rather large percentage shown for the Management and Technical Support category is primarily due to a lack of understanding on the part of most programmers and users of the intended meaning of this functional category. Originally, only those jobs supporting administrative report generation, COMSEC and equipment studies were to be assigned to this category. We note that about one-half of the jobs assigned to this category should properly be allocated to one of the others.

[5] As defined in 5.4.1 below. "Hours," for the purpose of this report, are the "7094(II) Processing Hours."

5.2 *Overview of the Major NSA/CSS Data Processing Systems Today*

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[redacted]

5.2.4 Processing of Plain Text—Two UNIVAC 1108 systems provide the processing support necessary for [redacted] plaintext scanning and distribution function and [redacted] signals conversion activities.

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5.2.5 On-line Remote-Access—The RYE complex consists of a [redacted] random access storage. The system provides cryptanalytic support for those requirements not met by the two main systems mentioned under 5.2.3 above and provides a file maintenance and retrieval capability for various end-product and technical files that may be accessed *from* any RYE terminal (some of which are outside NSA/CSS headquarters).

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A second UNIVAC 494 system (TIDE) supports the Time Dependent processing and reporting functions. This system receives high priority reports from the field, determines the processing sequence required, performs the processing, and reports the data to internal and external consumers automatically. The system consists of two UNIVAC 494 [redacted]

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5.2.6 Data Communications—Several systems together furnish the data communications handling function. Briefly, these are the Internal Data Distribution Facility (IDDF) located in TCOM, and [redacted]

The Internal Data Distribution Facility (IDDF) is responsible for storing and forwarding CRITICOM messages to and from NSA/CSS. The system provides for the receipt, transmission, correction, retrieval/retransmission and distribution of this traffic. It is composed of two parallel SIGMA 5 CPU's and interchangeable peripherals including four rapid access disk units, large central disk storage and six Uniscope 100 terminals.

5.2.7 Research and Development Support—The NSA/CSS Research and Development (R&D) organization has a dedicated facility for its

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use. [redacted]

5.3. *Growth of NSA/CSS Data Processing Equipment—History*[7]

5.3.1 General Data Processing and Computing—On 8 December 1950, the ATLAS I electronic computer was delivered to the Navy's Communications Supplemental Activities, Washington (CSAW). This was NSA's first digital computer. [redacted] The ATLAS I [redacted] A second ATLAS I was installed in May 1953.

In September 1951, the ABNER Computer was completed. This machine was noteworthy in that it was designed and constructed by ASA engineers, and many of its features became models for later

[7]Most of the material in this section has been excerpted from the excellent 1964 monograph by Samuel S. Snyder entitled, "History of NSA General Purpose Electronic Digital Computers." In this section we are attempting to briefly describe the ancestry of each of the major systems in place today. For a more extensive treatment of the early years, the reader should refer to Snyder's work.

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designs. A second ABNER was acquired several years later for a total cost of approximately $1.35 million for both machines.

By June 1955 NSA had acquired [redacted] digital computers at a total cost of approximately $10 million; these included two of the first IBM machines, the 701 and 702. The 701 provided only crude input-output capability [redacted]

The arrival of these early IBM machines can be viewed as the genesis of today's large-scale information processing system. In 1956 the 701 and 702 were replaced with the IBM 704 and 705 machines; they were to become the workhorses of NSA in the next decade. By the end of 1957, NSA had acquired three 704's two of which were operational until mid-1963. Similarly, four 705's had arrived by the end of 1957 and the last three were retired in 1964.

In the early 1960's more modern versions of the 704 and 705 were acquired. The first IBM 7090 to replace the 704 arrived in 1962; by 1968, four IBM 7094 (a later version of the 7090) machines were operational. One is still in full-time use today. These machines continued to be used principally for mathematical and scientific jobs. In 1960 a transistorized version of the IBM 705, called the IBM 1401, appeared. In the following four years [redacted] were obtained.

In early 1968 the first IBM 360/65 was installed to begin the gradual replacement of the 7094 and 1401 (and other later machines). In addition, many smaller system 360's were also obtained. By mid 1971, the Central Data Processing Facility consisted of two IBM 360/65's and two 360/85's plus many smaller 360/20's and 360/30's. In 1972 the 65's and 85's were replaced with four 370/165 machines.

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5.3.2 ELINT Processing—It became apparent in 1966 that the IBM 7094 did not have the capabilities needed to process the increasing volume of ELINT data being collected. A machine was needed with a large word size and extremely rapid arithmetic unit; a CDC 6400 was installed in December 1966 to satisfy this need. This machine is still operational today as part of the [redacted] Complex which now includes three CDC 6600's as well.

5.3.3. Cryptanalytic Support—In the late 1950's another project began that was to prove of great importance to NSA throughout the following decade and into the present one. This was the development of the HARVEST System, in its day the most powerful and unique computer system. In many respects this is still true, more than ten years after it began operation.

The HARVEST concept grew out of the separate desires of IBM, AEC and NSA to develop an advanced system having special features that would help each satisfy its needs:

—The AEC required a very rapid arithmetic unit;
—NSA required the ability to handle very large volumes of data and to be able to perform complex logical operations on two data streams at high speeds; and
—IBM required a marketable system.

The NSA version of this system was to comprise the following basic components:

—IBM 7030 (STRETCH) CPU
—High Speed Streaming Unit
—TRACTOR Tape System
—786,000 Bytes of Main Core Storage
—16,000 Bytes of High-Speed Core Storage

The official contract for the system was signed in April 1958. The system was delivered in January 1962 and has been in constant use ever since. In addition to cryptanalytic support, it has been used extensively in plaintext processing.

HARVEST is one example of the need to stimulate the commercial environment to produce data processing equipment that is sufficiently advanced to attack the many highly complex problems at NSA. Another case involved Remington-Rand Corporation in 1954 and the development of the BOGART machine, of which five were obtained. They were used extensively for the compilation of data from many sources into a compatible form for more efficient processing by the large processors. A variation of this type of effort created the [redacted] Complex. In this instance, NSA chose to use computers already available commercially (from Control Data Corporation) and to contract for special-purpose attachments to perform specific logic and arithmetic functions in a highly parallel and rapid manner to aid in the attack against high-speed, sophisticated cryptosystems. In many cases the cost of these attachments exceeded the cost of the host computer several times over. The early systems used CDC 1604 computers, and later ones used CDC 3600's in addition to many smaller models. Eventually over 20 separate systems were to be part of what was eventually called "the SHEARMAN area."

Eventually, the cryptanalytic organizations in A and G Groups required capabilities beyond the 7094 and HARVEST. Late in 1969 each group received its own CDC 6600. In 1971, A Group added a CDC 7600, and in 1972 G Group replaced their 6600 with a 7600.

5.3.4 Remote Access Facilities—In 1954, another significant segment of today's computing facility began. It was recognized at that time that

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the individual cryptanalyst needed a computer terminal in or near his own work area. In 1954 R/D undertook a study of this problem and in 1955 defined a system using an ALWAC III-E computer and four remote stations. The system was delivered and began operation in 1956 and continued in use as a remote access system until late 1959. In 1957 R/D issued a proposal for an advanced ALWAC system that would simplify operation, overlap input-output and computation, increase storage capacity and instruction flexibility. The system was dubbed ROB ROY, its development started in 1958, and by 1960 it was in full operation with five remote terminals. It was soon apparent that the demand for this service far exceeded the available capacity. By mid-decade the replacement system (RYE) with two UNIVAC 490 central processors and over twenty terminals was in operation. This system has since grown into a configuration of four UNIVAC 494's and over 200 terminals.

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In early 1972, it became apparent that the requirements for quick-reaction tactical support processing on the 494's were becoming large enough to warrant a dedicated facility. To satisfy the need, another UNIVAC 494 was obtained and combined with one of the RYE machines to form the TIDE System (for Time Dependent).

5.3.5 Data Scan and Selection—By the middle 1960's, the Agency was being overwhelmed by the volume of intercepted [redacted] communications (both cipher and plain text). Some mechanism had to be developed to scan these data rapidly and detect those sections which were of sufficient interest to warrant further processing. The UNIVAC 1108 was selected to perform these functions; the first delivery was in 1968, and eventually five 1108's were acquired for this function, of which four are still operational today.

5.3.6 Data Communications—Historically, most intercept data received at NSA headquarters from the field were recorded on punched paper tape. The relatively slow speed of this technique and the increased demand for intercept required that a considerable effort be expended to gist the intercept at or near the point of intercept before it was forwarded electrically. It was also necessary for NSA to expend considerable resources to convert the large volumes of received paper tape into a form more compatible with the data processing equipment. To partially automate this process, in 1965 C Group installed a device called [redacted] that recorded incoming data directly on digital magnetic tape in a form suitable for follow-on processing. This system was later replaced by a more advanced version called [redacted]

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As a result of the reduction in overseas personnel, much of the data that previously had been gisted before being forwarded to NSA began to be transmitted in entirety. In addition, much of the processing that

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had been accomplished in the field to support site operations would have to be done at NSA and the results transmitted back to the field in a timely manner, thus further increasing the communications load and the requirements for responsiveness and reliability. This led to the specifications for the [redacted] two UNIVAC 494 computer systems operating in parallel and with direct communications links to several of the major follow-on processors to reduce tape handling. This system has been in operation since 1969 and now handles over [redacted] (incoming and outgoing).

5.3.7 File Storage—The growth of computing at NSA was naturally accompanied by a similar growth of data files stored on magnetic tape. By 1965 the central tape library contained approximately 75,000 reels of magnetic tape that stored over 40,000 individual files, and was growing about 20% annually. In light of this enormous storage problem (i.e., total cost, space, and response time), the R&D organization and C Group undertook a study of alternative storage media that might replace the tape library, reduce cost and improve response time. This study lead to the proposal of the [redacted] System, equipment that would provide over 10^{12} bits of on-line storage simultaneously to a number of widely separated computer systems. Two storage media were to be employed: the Ampex Terabit Memory System for transient data and the IBM 1360 Photo-Digital for archival storage. In addition, two PDP-10's and two PDP-9's would provide the necessary control functions. The system is undergoing testing and should be operational in the near future.

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5.4. *Growth of NSA/CSS Computer Usage and Corresponding Costs*

5.4.1 Units of Measure—To quantify the growth and distribution of computer usage at NSA, it is necessary to develop units of measure which are independent of equipment manufacturer and machine type. The present measure is the 7094(II) equivalent hour. In order to use it, one must determine a performance factor relative to the IBM 7094 (II) for all items of equipment in the inventory. This can be done by running a representative job mix on all machines and noting how long it takes to complete it, relative to the same job on the 7094(II). The CDC 6600, for example, has a ratio of 4.0. Given these ratios, one may then accumulate total computer usage of all machines each year, measured in equivalent 7094(II) hours. There are some disadvantages to this approach (discussed in section 2.4), but it is the only comparable unit in which historical data are available.

A second approach, useful for gross planning purposes, determines the equivalent annual rental for each equipment—whether leased or owned—based upon a current GSA price schedule. The portion of the rental attributed to each user on each equipment item is taken as the

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percent of the hourly usage of each charged to that user. We may then accumulate the equivalent rental dollars of all machines for each user. Furthermore, we may allocate to each user a portion of all other operating costs (salaries, etc.) corresponding to each user's share of the equivalent rental cost and thereby obtain an equivalent annual operating cost. Such data do not reflect actual expenditures, since not all machines are rented; nor do they take into account advantageous purchase or leasing arrangements available to Government agencies, but serve as a rough guide to the growth trend over several years. One important use for this approach is to measure the cost per unit of computing. Given the hourly usage described first and the equivalent annual operating cost, the ratio of the two will indicate the degree to which *technological advancement has changed* the cost of computing.

5.4.2 Growth in NSA/CSS Computing—Given these preliminary definitions, the growth in computing is depicted in the following charts[a]. First, the annual Agency computer utilization from 1960 to the present is shown measured in 7094(II) hours (see Fig. 2).

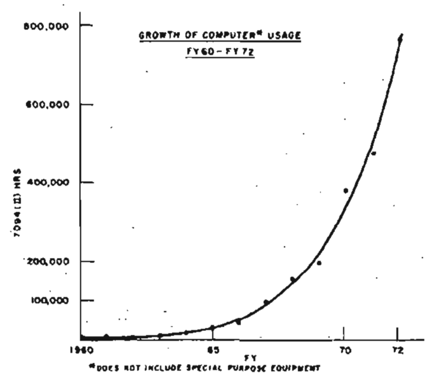

Figure 2

[a]Data used to plot these charts, and all subsequent ones, are those available through FY 72.

A Logarithmic Scale for the vertical axis is often more convenient than a linear one because a straight line represents an exponential growth or a constant precentage change per year. The following logarithmic plot (Fig. 3) clearly depicts the exponential nature of the growth of computing at NSA since 1960.

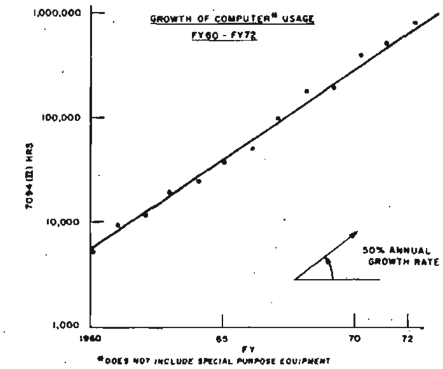

Figure 3

In a similar fashion, the equivalent annual operating cost growth since 1960 is shown; in Fig. 4 the cost scale is linear and in Fig. 5 the scale is logarithmic. In addition, Fig. 5 displays the actual expenditures for computing equipment and personnel. The equivalent annual operating cost was computed for the years FY 67 and FY 72. These two points determine the straight line plotted in Fig. 5.

5.4.3 Unit Cost of Computing—The change in the unit cost of computing by NSA/CSS is shown as the ratio of the data in Fig. 4 to that in Fig. 2 (or Fig. 5 to Fig. 3). Again, using both linear and logarithmic scales we present these data in Figs. 6 and 7.

In summary, the total annual usage has been growing about 50% per year, but the equivalent annual operating cost has been growing only at a 15% rate due to a decrease in the unit cost of about 25% per year.

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5.4.4 Portion of NSA/CSS Budget Devoted to Computing—From a corporate investment viewpoint, NSA/CSS not only has generally increased its absolute expenditures for computing each year, but has devoted a larger portion of the total annual expenditures to computers. Figure 8 depicts this trend for the last ten years. We see that at present expenditures for computing equipment and personnel exceed 15% of the total NSA annual budget (not including SCA's) and over the past ten years this ratio has increased by 50%.

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Figure 4

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Figure 5

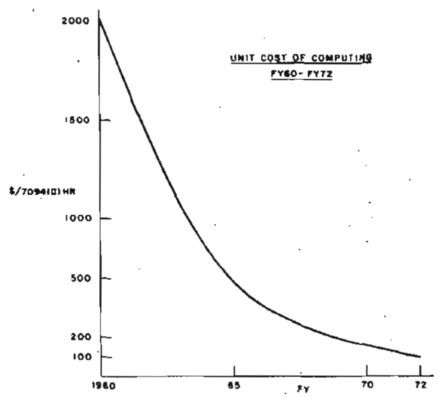

Figure 6

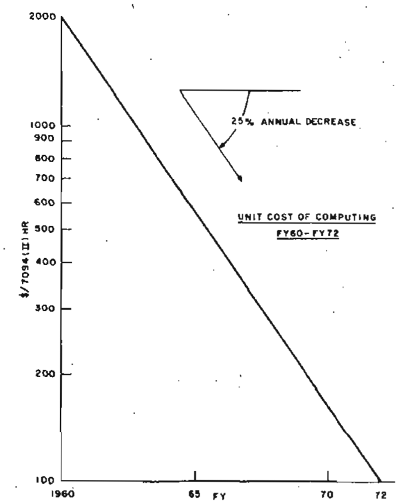

Figure 7

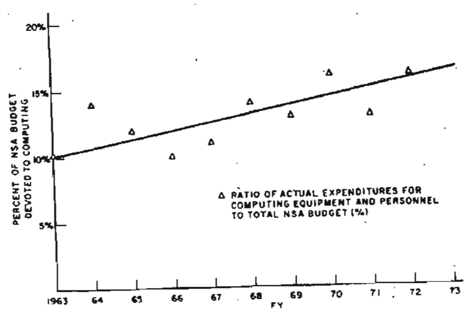

Figure 8

APPENDIX: PERTINENT PARTS OF THE WARE REPORT OTHER THAN THE TEXT PROPER

PREFACE

An earlier 1966 NSA Computer Study was commissioned because, at the time, there had developed a debate over the Agency's forecast funding needs for computers. The report investigated the planning and projection methodology in use at the time and supported it as an appropriate means. It also touched on a number of other questions relevant to NSA's computing facility and suggested a number of recommendations for action.

By contrast, the present study was undertaken to see what had happened since 1966, to assess the present status of computing within NSA, and to project a best estimate of how computing support will develop in the next few years. We hope that our work can serve as the broad basis for managing, updating, expanding and extending computer support in the Agency for perhaps three to five years.

In the course of the study, we have collected much data that has not been previously available and we have been able to assemble a broad overview of how computing has fitted into Agency affairs. Since an inescapable aspect of any discussion about funding support for computers, especially if there is some growth, is "what's it being used for?", we have also included much supplemental material to make this report a complete picture of past, present, and projected future with the expectation that it can be used as an informative document for both internal and external government officials. In addition to the specific recommendations based on our work, we have also included a short history of computing at NSA, many-year growth curves, a summary of the 1966 report, and an estimate of the national and international forces that will affect the Agency.

The study group consisted of:

Dr. Willis H. Ware
The RAND Corporation

Dr. Ronald L. Wigington
Chemical Abstracts Corporation

Dr. Henry S. McDonald
Bell Telephone Laboratories

(b)(3)-P.L. 86-36 [redacted]
Institute for Defense Analyses

Dr. Sidney Fernbach
Lawrence Radiation Laboratory

We functioned under the sponsorship of the Director's office, and were supported through the Office of the Assistant Director for Science and Technology, Mr. Thomas A. Prugh. Our full-time and very able staff support was [redacted]

I would like to note especially the very important contribution of Dr. Wigington, who functioned as Vice Chairman and carried a major part of the load in committee activity.

Willis H. Ware
May 1973

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~~SECRET~~

NATIONAL SECURITY AGENCY
FORT GEORGE G. MEADE, MARYLAND 20755

Serial: N 0885
10 August 1971

Dr. Willis H. Ware, Vice President
for Project RAND
The RAND Corporation
1700 Main Street
Santa Monica, California 90406

Dear Willis:

My staff informs me that several meetings, relating to a second computer study, have been held and that things are shaping up well. I think it is time to get the show on the road. Here are some of my thoughts on this subject.

Initially, I believe a review of the first study and actions taken as a direct result should be the jumping off point. This will provide a valuable measure in determining the effect of the original study and also serve as a refresher for the group. Second, the previous study needs updating to provide an overview of the Agency computing capability, to reflect it as it now is and project it into the next 5 - 10 years.

You should also consider factors such as centralization, decentralization, budget limitations, the advancement of communications, and the field support role.

Inclosed is a more definitive description of the specific areas your group should consider in the report. If you agree to the ground rules, I trust you can get started in September.

Tom Prugh will continue to keep you informed. I look forward to seeing you and discussing this study in the near future.

Warmest regards,

Noel G.

NOEL GAYLER
Vice Admiral, U. S. Navy
Director

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4 August 1971

GUIDELINES FOR SECOND COMPUTER STUDY

1. The computer study will provide an overview of the NSA computing stituation. This overview must include both the NSA internal operations and a consideration of the external influences such as field conversion and processing and future on-line data reporting.

2. The study will include an inventory and description of the present Agency capabilities and their application. These many different computing capacities will be converted to a common base, i.e., equivalent hours of a common machine. This will provide a measure of capacity applied to target requirements and also related to functional activities such as file maintenance, cryptanalytic problems, etc. This will be the basis for forecasting future requirements.

3. The predicted workload in a number of functional areas can partly be determined from previous experience. However, changes in community operational concepts and new technology may significantly impact the predictions in other areas. Some of the factors that must be considered as possibly impacting the predictions are listed below:

a. Changing requirements. These may not change the over-all workload, but may shift the resources to new targets.

b. The shift of many conversion and processing functions to field activities. These include large processing operations using CDC 6600 [redacted]

(b)(1)
(b)(3)-P.L. 86-36

c. The changes to the collection posture. Implications of site reductions and of new collection concepts must be considered.

d. Improved communications and a shift to electrical forwarding of data from the field.

e. The increased use of interactive terminals in analytic areas at NSA and at remote locations to provide on-line data exchange.

f. The security requirements caused by the use of remote terminals and shared files.

g. Possible new services that might be required.

4. Other factors must be considered as a part of the recommendations for handling the predicted workload. These factors include:

a. New computer technology such as mainframe architecture, new logic approaches, storage devices, etc.

b. Software support required and the management of this support.

c. A management system to monitor work flow and measure performance and to optimize allocation of resources.

5. The above statement of factors to be considered in the study should not be considered complete or limiting but should define the general scope of the study.

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