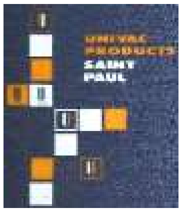
ERA/RRU ‘Electronic’ Machines

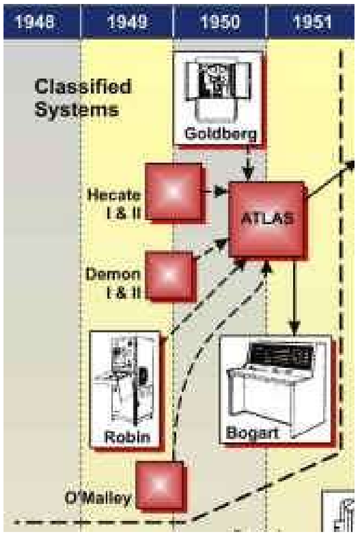
INTRODUCTION

The National Security Agency (NSA) declassified documents[1] which were written in the 1952 to 1954-time frame. Those NSA documents delve into cryptography methods from the 30’s => 50’s and the many, many machines used for code breaking. Machine manufacturers included Bell Telephone, Eastman Kodak, ERA, IBM, NCR, and RRU.


UNIVAC
PRODUCTS
SAINT
PAUL

Our Legacy Anthology includes the 279-page book UNIVAC PRODUCTS from 1947 to 1959. The foreword therein is: “In the 13-years from 1947 to 1959, the St. Paul Division of Remington Rand Univac produced over a hundred electronic and mechanical products ranging in size and complexity from large-scale data-processing systems to miniature computer components.”

This books section I introduction is: “From 1947 when Goldberg I, the electronic data-processing system with the first magnetic drum, was invented, up to 1959 when the G-40 Command Computer was developed, the design of high-speed digital, data-processing systems has been a continuing challenge to Remington Rand Univac, St. Paul, design engineers. … More than fifty different computing and data-processing systems have been developed in St. Paul, but all are not included. Specifically, the computers are referred to as “special purpose,” because they were intended for the solution of only a single type of problem over and over again.”



✓ The Goldberg Computers were developed for the Navy, for classified purposes.

✓ The Hecate Data Processors, Hecate I and Hecate II were designed and manufactured for the U. S. Navy. Their specifications are classified.

✓ The Demon series of computers was developed for the United States Navy. Three types were manufactured. Specific information regarding these computers remains classified.

✓ The O’Malley Computer is a special-purpose computing system that was designed and built for the U. S. Navy. Its specifications are classified.

✓ Robin I and II are special-purpose, analytical computers designed for military purposes. All information is classified.

✓ The Atlas Computers were among the first developed. The application of these computers is classified.

This paper extracts information from NSA documents for the ERA comparators, analyzers, and computers. Not extracted are ‘very poor’ pictures within the NSA scanned documents nor information relative to the machines from other entities. *LABenson*.

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[1] References on listed on page 21; email webmaster@vipclubmn.org for an electronic copy.

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Edited w/Microsoft Word

Ref #5, pg 25. Background

Since WW II we have seen the rapid growth of a new class of equipment both within the Agency and in the outside scientific and business world; these are the electronic digital computers. The versatility of these computers is well demonstrated by their variety of applications -- from prediction of presidential election results to aero-dynamics research; from supply inventory work to automatic translation; from number theory research to cryptanalysis.

NSA has currently, we believe, the largest computer installation in the world, a fact which we solicit your cooperation in keeping out of the newspapers. The largest outside computer installation we know of has 3 computers; the National Security Agency has five, and two more are now being packaged for delivery next month.

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[2] Click on a section title for a quick scroll thereto.

NAME	INITIAL COST	WE HAVE	DATE RECEIVED
ATLAS I	$1,300,000	2	1950, 1954
ABNER	$ 6000,000	1	1952
IBM-701	$ 33,000 (monthly)	1	1953
ATLAS II	$2,300,000	1	1953

You notice that these machines are expensive. Another indication of how expensive they are is the fact that private owners and government agencies who rent their computers to others charge from 50 to 300 dollars per hour of use.

The public press has already created the proper atmosphere of amazement about computers. The high speeds of computers allow them to do in hours what a clerk or mathematician would take years to do. They are not baffled by complexity, they can do a problem two different ways to ensure accuracy, they never get tired. Our computers are like those on the outside, so there is no need to try your patience with facts to amaze. We shall spend a few minutes considering the basic structure of any computer. After that we will examine some of the general uses which are made of our computers.

Ref #3, pg 1. Discussion

1. Purpose of analytical machines. A force of people is the most flexible and versatile of analytical agents. It follows that an analytical machine, to be worthy of consideration for our processes, must have an advantage over a force of people that outweighs its disadvantage of inferior flexibility and versatility. This advantage, it happens, is one simply of speed. Every machine in our list can perform one or more processes than could be performed by a force of people equal in size to the force required to operate and maintain the machine. This gain in time benefits operations in two ways:
    a. It saves man-hours in certain operations which would be performed anyway (at least in part), with or without machinery, and thus permits machines to replace men, with gains in effectiveness and economy.
    b. It permits certain operations to be performed which, without the machines, would never be undertaken at all, even in part, in view of prohibitive or fantastic requirements in man-hours.

Logically, the second is no more than an extension of the first, but practically the split suggests a categorization which has some application to this analysis; that is, categorization by potentiality.

2. Machines according to potentiality. By this criterion the machines fall into two categories:

a. Labor-savers and extender. Machines which replace men for operations which would be undertaken. at least in part, even without them,
b. Revolutionizers. Machines which make possible attacks which could not be undertaken without them. According to this breakdown our analytical machines line up thus: Revolutionizers now available; IBM, ABNER, ATLAS I, (GOLDBERG and CONNIE are borderline cases). Projected are NOMAD, ATLAS II. (AFSAP 1-1 is a borderline case).

Ref #3, pg 9 decentralization.

As this philosophy applies specifically to AFSA, there is obviously both room and necessity for both central pooling and dispersion. ATLAS, NOMAD, GOLDBERG, SKATE II, the DEMONs, DELLA, SLED, and a few others obviously fall under the first compelling reason for central pooling. The ROBINs (at least in their present usage) and a large part of the IBM complex come under the permissive reason for central pooling, and therefore (since the logistics considerations always point to central pooling even when they do not compel it) need not be fought over based on the compelling reasons. CADILLAC, the frequency counters, the desk calculators, the MATHEWS (and their fellow gospelers), PICCOLO, ELKET, and such are obviously tools for the individual analysts and analytical sections, but some who need them occasionally do not have them, and there is, in our list, no coincidence selector nor digraph counter wholly suitable for decentralized use, although there is need for those. In this connection it is noted that the Machine Division has the two 70-mm general comparators, four specialized selectors (the COPPERHEADs and TESSIEs), and one simple statistical crib placer (STORK) which are not being used all, but which (except for the COPPERHEADS) are applicable to analytical problems ghat come up from time to time. The reason why these are not used is that GOLDBERG or IBM or ROBIN do the jobs more conveniently or more quickly. But it appears to me that any machine which usage figures show is not needed in the central pool is a presumptive candidate for transfer to a section that can use it.

GOLDBERG

Ref #4, Pg 4. Analytic Machines

After the war the comparator series continued to develop. The Navy product was GOLDBERG, which was the first machine designed to hold its data on a magnetic drum. The Army built CONNIE which used punched teletype tape. Both these comparators were influenced by the British war time machines called ROBINSON and COLOSSUS. In fact, the name GOLDBEUG is an American version of ROBINSON, since the cartoonist Rube Goldberg drew weird gadgets just as Heath-Robinson did. From CONNIE was developed the more special ROBIN for making round-robins, or all comparisons. The sonic delay line machine DELLA uses a new medium. sound waves in mercury, to continue the line.

Ref #3, Pg 4. Usage.

This operator has been used during one full shift of a 5-day week. Between 25% and 50% of his usage has been on selector jobs which should have been run, with less convenience and more delay (but not necessarily less efficiency), on other machines.

Ref #3, Pg 7.

This borderline revolutionizer's maintenance time runs extremely high; 35% to 50%. Disregarding this factor, which is conceivably capable of correction, its usage is of interest from two standpoints:

- It is used in only one shift, which suggests the possibility that a properly emancipated group of methods-inventors might be able to devise some uses to fill its spare time.
- With proper pressure being put on its schedule by the emancipated group of methods-inventors, it is conceivable that its present 25-50% employment as a selector would be shifted to its less versatile cousins to permit its full-time use in its higher capability as an operator.

Ref #5, Pg 1.

The GOLDBERG comparator was a general-purpose comparator of rather large scale. It was one of the first Agency machines to use a magnetic drum to store and handle data internally.

DEMON

DEMON and SKATE could be called single or multi-purpose machines. SLED advances into a new dimension, that of a general analytic machine. SLED has had many applications.in which it is more than a recognizing machine. There are two things which allow this, first, the fact that internal components can be joined together in a large variety of ways so that SLED becomes a different machine for each problem. Second, several methods of scoring results are available. Examples of problems for which the machines was not designed, but to which it has made significant contribution are those concerned with wired rotor encipherment.

HECATE

Ref #4, Pg 4. Trial Devices

Since 1946 there have been three main lines of new developments, the exhaustive trial devices, the dictionary machines, and the crypt-analytic computers. The exhaustive trial devices include HECATE and WARLOCK. They distinguish themselves by having very high operation rates, and by being large and working only by exhaustive trials.

The dictionary machines look up weights, meanings, etc. in a large memory. They are physically large and limited in their abilities. Their rates of operation are not so fast as HECATE, but are high, nevertheless.

They started with Navy's MERCURY (a war time development, long defunct) and Army's SLIDE-RUN MACHINE, and now include DEMON I, II, and III, SKATE I and II, and SLED I and II. This last can also do such operations as dragging cribs and reading depths.

Ref #4, pg 54. Hecate

HECATE (AFSAF-91, CXDD or HAGELIN CRIBDRAGGER) is a special purpose high speed electronic crib dragger for solving G-38 type Hagelin messages by exhaustive trials. Two equipment's, serials 1 and 2 were built for Navy by Engineering Research Associates, now part of Remington Rand, the first delivered 1 April 1948 and the second on 18 May 1950. The term HECATE to be sure the subproject covers the full crib dragger field and not specific equipment. Dimensions of the tape unit: 6'H x 4'L x 3'D; and of the analytic section, 6'H x 17'L x 3'D. Operation is at the rate of 75,000 trials per second, each window setting being tested in about fourteen microseconds.

O'MALLEY – Ref #4, pg 252.)

AFSAF-951 CXMY is an electronic digital calculator for finding sums of cross-products. The card reader and relay sections were built for the Navy by Commercial Controls Corporation and the electronic section by Engineering Research Associates. The one model was delivered in December 1948. ·The machine applies to problems requiring sums of products, such as flagging, inversion of large circulant matrices or matching frequency distributions with a known universe. The reader-printer is simply a two-card feed mechanism to handle multipliers and multiplicand decks, as well as the printing mechanism control panels and plugboards. Each card holds as many as 35 signed four-digit numbers.

The relay Unit stores values read. from the cards and the resultant sums of. products. An electronic unit scans these values, feeding them by pairs into counter rings and adding their products into a ring accumulator of 10^{10} capacity. These sums transfer to the reader-printer for recording. Special coding is used in the cards, and output is in printed form only. · Negative numbers are expressed as the complement of 10

Input is at the rate of 80 pairs of cards per minute and print-out is one line of 30 characters per second (20 characters for identification and a 10-digit answer). Each answer is computed and returned in 425 milliseconds. Size is two cabinets totaling 6'H x 17'L x 2'D plus reader-printer console 4'H x 5'L x 3'D, requiring 16' x 32' floor space. ·

ROBIN

Ref #3, pg 4. Usage.

The ROBIN battery has been giving about 60% usage in one shift and 50% in a second. At the same time, the work it was provided for analysis is doing is not being pushed to completion with anything like the speed which, in the light of our mission, we should press for. As in the case of IBM, the difficulty here seems to be in the operation of the machines themselves, not in preparation.

Ref #3, pg 7. The ROBIN job.

The ROBIN program WAS pushed through as an interim measure on the basis that:

a. No already available or imminently available solution was satisfactory, even as an interim one.
b. The work could not wait for the ultimate solution (DELLA).

The second program-imposed AFSA-02 could not, of course, be challenged by anyone else. The first, however, was challenged by the then Head of AFSA-351 (Mr. Duney) and appears to me now reinforced by but not depending solely on some hindsight to be vulnerable. The ROBINs, having cost close to a million dollars, are now under scrutiny as having produced a totally unexpected lack of results. There is no reason yet to blame the ROBIN concept and the million is by no means wasted, because the ROBINs will presumably always have uses, but I am convinced that a good deal of money spent improving AMBER would have permitted us (with the help of other existing machines) at least to check out the theory and approach of the ROBINs to find whether we needed them. There may be nothing wrong with the theory,' and approach but the fact that we are even now checking those to see whether there is indication of the possibility that we crashed ahead without knowing too well where we were going.

Ref #3, pg 6. ROBIN utilization.

Putting aside the history of the ROBINs, which cannot be altered and possibly should not if it could, we turn to the day-by-day uses of these machines. AFSA-02 could not wait for DELLA. Nevertheless, with DELLA now being installed, the ROBINs have been employed at less than 50% capacity! The reason is that there are not enough ROBIN operators to man the machines at full capacity 24 hours a day. The ROBIN problem thus boils down to one of the personnel, requiring the same remedies that are needed for IBM; the Machine Division simply does not have enough people of high enough caliber.

Ref #4, pg 117. ROBIN I and II

ROBIN (OXOR, AFSAF-D/54 and AFSF-D/54-l) is a photoelectric comparator for matching tapes round robin. It was designed by 3520 and built by Engineering Research Associates, the first two (known as ROBIN I or AFSAF-D/43, being delivered in November and December 1950. Thirteen more called AFSAF-D/54-1 through 13 have since been built. The original pair and the 13th ROBIN of the second group, still in crates, are now stored.

Dimensions are 7'H x 12'L x 2'D, plus reader, punch, and power supply. Complete matching between two 20,000-character tapes take about two and a half hours. All twelve are operating at AES. At present there is considerable doubt as to ROBIN's theoretical ability to distinguish statically between random and casual situations as it was designed to do.

Ref #5, pg 7.

Many years of designing, building, and using machines of the comparator type led to a present comparator called the ROBIN, whose function is exactly that or the above problem -- to compare 2 streams of characters and count the coincidences between them. ROBIN handles its messages on punched paper tape, it looks at the characters with photoelectric cells instead of eyes, it performs its counting in electronic counters instead of by tallying. But the important thing is that it does all this at 'the rate of 50,000 comparisons per second. Thus, if we compare one ROBIN machine with people, we will seem justified in saying that it is the equivalent of the work of 50,000 cipher clerks armed with nothing more formidable than strips of paper and a pencil. The ratio is so astoundingly in favor or the machine, 50,000 to 1, that we have entered upon a new and revolutionary era. Such machines do not save labor, they create it. Let me illustrate: eleven ROBIN machines were used 16 hours a day for a period of 10 months on just one problem. ·To do the job in the same length of time by hand would have required something like 1 million people. It is not likely that we would have employed so many people for one phase of one problem. We simply would not have done it and might have gone for years in ignorance of whether the phenomenon we searched for occurred in the particular traffic being searched.

ROBIN is but one in a family of comparators. Other members of the family have contributed much to its development, and each has been peculiarly useful in its own way.

ATLAS I

Ref #1, pg 2. NSA Computers:

With the earliest design work on computers, in 1946, came the realization of the potential usefulness of such machines for Agency purposes. Quite probably this Agency's predecessors were the first to develop sophisticated analytic applications of such machines. This story is detailed later in the discussions of ATLAS I and ABNER. The use of computers by NSA has increased considerably, beginning with one of the first machines in the country, installed in December 1950.

NSA's computer installation probably ranks among the largest in the country. The chronological listing (Table 1, page 93) shows these acquisitions in the order of their installation and includes references to the page in the text where each computer is discussed.

Ref #5, pg 28. Agency Computers

ATLAS I was our first high speed computer. It was built for us by Engineering Research Associates, now a part of Remington Rand. We have two of these machines. From time-to-time modifications are made to take advantage of technological advances; for example, high speed magnetic core storage is to be added in 1955.

Ref #1, pg 7, 1101 & 1103

First, the sponsorship of the ATLAS I by NSA's Navy predecessor led directly to placing Engineering Research Associates on a firm footing as one of the country's pioneering computer firms. ERA's commercial 1101 and 1103 computers were almost identical to ATLAS I and ATLAS II respectively. With the merger of ERA and the Eckert-Mauchly Corporation into the Remington-Rand-UNIVAC organization, the 1101 and 1103 became a part of the UNIVAC line. Finally, the LIGHTNING research into ultra-high-speed computer circuits and components -- work done under contract by IBM, Remington-Rand-UNIVAC, RCA, and others -- has undoubtedly had the greatest influence in the development of new computers and other digital equipment with basic operation times measured in nanoseconds.

Ref #1, pg 8. CSAW

In the summer of 1946, Moore School of Electrical Engineering, University of Pennsylvania, sponsored a series of lectures on electronic computers. Among those who attended was LCDR James T. Pendergrass, a young mathematician at Navy's Communications Supplementary Activities, Washington (CSAW). As a result of hearing the computer proposals described at that time, LCDR Pendergrass prepared a report in which he proposed that the Navy acquire such a machine. His report included a general description of the proposed machine's logic, its code of instructions, and coded examples of typical problem solutions. The design advocated was of the class known as one-address logic and was based on the I.A.S. Computer then being developed at the Institute for Advanced Study, Princeton, New Jersey. CSAW went ahead with plans for construction of ATLAS I, and CSAW personnel perfected most of the basic algorithms, or detailed machine logic for executing each instruction. The contractor, Engineering Research Associates of St. Paul, Minnesota, used MIT's WHIRLWIND I logical design to a great extent. ATLAS I was delivered on 8 December 1950 and was running before Christmas. It employed parallel circuitry, contained approximately 2700 tubes, and cost about $950,000.

Ref #4, pg 148. AFSAF-70, CXMX

ATLAS I (AFSAF-701 CXMX) is a parallel type of electronic computer to perform basic arithmetic processes and able to make conditional decisions on the basis or size and sign, modifying its own program or orders. Under Task 13, Engineering Research Associates delivered Serial 1 in December 1950 and Serial 2 in May 1953. The model is available commercially under the name ERA 1101 COMPUTER. Several peripheral equipment's have been developed: a pair or special tape punches, a HIGH-SPEED TAPE COMPARATOR consisting of two POTTER READERS (AFSAF-25) and a comparing unit, and a trio of rather non-descript devices known as OCTAL KEYBOARD, 8 KEYS, 2 OCTALS PER FRAME (AFSAF-D65), a CONTROLIER-OCTAL-TAPE-REPRODUCER CONVERTER (AFSAF-D66), a TAPE PUNCH VERIFIER (AFSAF-D67) and a CONTROLLER-OCTAL-TAPE-REGENERATOR-CONVERTER with no AFSAF number.

Operation is in parallel, simultaneous handling all bits of a word, a binary number. This makes for faster operation but more complex machinery. Each order employs one address. Data is read in from 7-level punched paper tape on a photo-electric reader at 144 characters per second and is not under program control. Output is to a CXCO regeneration typewriter and tape punch. The control unit interprets orders read from the drum (a repertory of 42 is now available) and operates the machine accordingly. The magnetic drum memory is divided into 2^{14} = 16,384 boxes or memory locations, each of which holds a 24 binary digit word, which may be either a coded order or datum. The arithmetic unit consists of a. 48-bit accumulator or A-register, a. 24-bit Q-register and a. 24-bit X-register. These together perform computations as required by the controls. Special orders have been added, including a random order, probably the most novel feature on the machine. The drum revolution time of 17 milliseconds indicates that, without planning, each instruction will take that long. But with careful planning, placing the instructions and relevant data where they will be immediately available when needed, the time per order can be lowered to as little as one percent of a drum revolution, or, at times, one fifth of one percent. The care needed to accomplish this is considerable.

The physical size of the main machine is 7'H x 40’L x 2'D plus reader, control panel, and auxiliary equipment; this requires over a thousand square feet of floor space. The pulse rate is 400 kilocycles per second and access time ranges from 32 microseconds up to 17 milliseconds (1 drum revolution). Both are in operation at Naval Security Station in room 4152.

Although the original proposal had specified that the ATLAS high-speed internal memory was to utilize Selectron tubes, a decision was made to substitute a 16,384-word magnetic drum of a type like one already placed in operation by ERA in other special-purpose equipment built for the Navy. Also, whereas LCDR Pendergrass's proposal described a machine with 36-bit words (each word containing two one-address instructions), the ATLAS I design was finally based upon 24-bit words. The drum memory was equipped with a flexible feature called "interlace," that permitted variations in address layout to be made for each program, using a plugboard setup. In effect, "lines" around the drum were renumbered by transposing certain bits of the address selection register to allow longer or shorter intervals between successive effective addresses, according to the needs of the program.

Careful programming in conjunction with careful planning of the interlace plugging made it possible to attain extremely high speeds for given programs, compared to the running time of programs written without attention to interlace. Thus, access time could be reduced to 32 microseconds under the best conditions, compared with an average of 8,500 microseconds or a maximum of 17,000 microseconds. In May 1951, a modification, the "skip" feature, was introduced that added flexibility to programming by allowing the program address counter to advance by intervals greater than one (9, 17, 33, or 65). In effect, the operation of the interlace feature was made partly automatic.

In June 1951, the installation of a "dial interlace" feature made selection of the interlace plugging simpler and eliminated the necessity of changing plugboards. Other features of ATLAS II's original design included logical multiply instruction, vector addition, several forms of ordinary arithmetic instructions, conditional jump instructions, and an elementary input-output procedure using punched paper tape. In 1952, an interesting new feature, the random jump instruction, was added. Employing a separate electronic attachment that supplied random bits of zero or one, this instruction made possible the generation of streams of random characters. The photoelectric tape-reading equipment- delivered with ATLAS I was found to be quite slow (140 characters per second) compared with ATLAS I internal speeds; nor was it under program control. It was replaced by the newly developed Ferranti photoelectric tape reader that had a speed of 300-characters 'per second'.

Shortly after the completion of the ATLAS I design in 1949, a decision was made to construct a relay analog of the equipment, to assist in training programmers and to "debug" its programs (at least logically) before it was delivered. ABEL was designed and constructed by CSAW personnel in about four months. Logically it was identical to ATLAS I, but its memory drum capacity was 2,047 words instead of 16,384, and its relay circuitry made it several hundred times slower. After an initial period of perfecting operational and maintenance techniques, ABEL proved to be quite reliable. It was used not only for programmer training but also for generating various statistical tables. Principally because of the great difference in capacity of the memories of ATLAS I and ABEL, the latter could not be effectively used to debug large-scale ATLAS programs. After ATLAS I began operating at CSAW, ABEL was dismantled and transferred, through the Office of Naval Research, to the Navy Logistics Project at George Washington University where it went back into service. After operation on the Navy Logistics Project for a time, it was presented to the George Washington University School of Engineering. Finally, in 1963, GNU presented ABEL to the Albert Einstein High School in Silver Spring, Maryland. Here upon the advice of Agency representatives, it was dismantled for the last time.

Several months before the delivery of ATLAS I, an order was placed with ERA for the construction of another almost identical machine; it was delivered in May 1953. In 1956, both machines were modified by the addition of high-speed core; storage in the amount of 4,096 words. This addition modernized the machines and eased the programmers' burden; for before the addition of the high-speed magnetic-core memory, the extra effort required of programmers in putting instructions and constants in those locations in-the memory best adapted to maximum use of the interlace feature was often excessive. In 1957, both ATLAS I's were moved to Fort Meade, and in November 1959 both machines were taken out of operation. ATLAS I, Serial 1, was salvaged, and the components used for other purposes; in March 1960 Serial 2 was shipped to the Anti-Submarine Research Center, SACLANT, NATO Forces, at La Spezia, Italy.

From a maintenance point of view, both machines performed extremely well. Although periods of down time for modifications and additions were necessary, the machines were usually operational above 90 percent in the reporting period. Many useful programs were written for ATLAS I, particularly for statistical and mathematical problems. Although the instructions were well-balanced for statistical and analytic uses, and the machines were designed and built for reliable operation, ATLAS I could not be used for problems demanding the handling of large volumes of data because of the lack of a magnetic tape facility.

Ref #3, pg 3: revolutionizers.

ATLAS I has been manned during six dayshifts five evening-shifts, and five mid-shifts per week. This 128 hours per week is 76% of total available time (168 hours per week). During the first three months of calendar 1952, because of light usage in the mid-shift, ATLAS I was used or under maintenance or alteration only 52% of available time. This was increased to 72% during the second three months of the year, very nearly full utilization during manned shifts.

ATLAS II

Ref #5, pg 37.

ATLAS II is another ERA product and will shortly be joined by a second machine. The second machine will have a magnetic core storage system, which is the newest fast, compact, and reliable method of storing information.

Ref #1: Tasking

Several months before ATLAS I was delivered, a new task was established that provided for the design of a successor. ATLAS II and ATLAS I differed in the following respects:

1. Storage -- Whereas ATLAS I had only drum storage, ATLAS II had, in addition, high-speed electrostatic storage for 1,024 words.
2. Word Size -- The word size on ATLAS II was 36 bits. ATLAS I word size was only 24 bits.
3. Instruction Logic -- ATLAS II used two-address instruction logic; ATLAS I, one-address.
4. Order Code -- Instruction sophistication was increased on ATLAS II.
5. Input-output -- ATLAS II trolled input-output instructions. A lack of this capability was a serious drawback for the ATLAS I.

Two-address instruction logic was unique among computer projects. In some instructions, the two addresses specified the locations of two operands - in other instructions, one of the addresses was an operand and the other a destination location. Among the more sophisticated new instructions were the repeat instruction, several modular-arithmetic instructions, a scale factor instruction, and an index jump instruction.

Ref #4, page 153 - 1103.

ATLAS II (AFSAF-70A, AFSAF-70B) is an electronic parallel type of computer with all the functions of ATLAS I but with additional types of memory which result in greater speed and capacity.

Serial 1 was delivered by Engineering Research Associates, now a subsidiary of Remington Rand Corporation, in September 1953. Serial 2, a model change, is expected by August 1954. The machine is available commercially- under the name or ERA 1103 COMPUTER. The auxiliary equipment is the same as for ATLAS I, the ERA 1101 COMPUTER.

Operation is in parallel - all bits or a word {number) are operated on simultaneously. word size is 36 bits, 6 for address and 30 for two 15-bit addresses or data. Initial input is by-7-level paper tape read photoelectrically at 144 characters per second. Four magnetic tapes under program control during operation serve as input, output, and an auxiliary memory. In addition, a CXCO regeneration typewriter or tape punch is available for output. In addition to the intermediate speed magnetic drum which holds 2^{14} or 16 ,381 words and the magnetic tapes just mentioned, there is a primary high-speed electrostatic storage (Williams tubes in serial 1, AFSAF-70A, and magnetic cores in serial 2, AFSAF-70B) capable of storing 2^{10} or 1,024 words. Both the electrostatic and drum memories are fully addressed. The arithmetic unit consists of a 72-bit accumulator, a 36-bit X register and a 36-bit Q-register. The control unit functions the same as in ATLAS I. Programming or sequencing of orders, uses a 2-address system and is not very difficult.

Several special orders, such as modular arithmetic, a scale factor order and repetition, are built in routines. This last one is the outstanding feature which differentiates the machine from other computers and contributes most to its cryptologic usefulness.

The device consists of 6 cabinets each measuring 7'H x 18'L x 2'D, plus peripheral equipment, and requires about 1200 square feet of floor space. The pulse rate is 500 kilocycles per second. Access time for electrostatic storage is about 12 to 18 microseconds, and tor data on tape or drum is not great since one drum revolution takes 34 milliseconds. It operates at Naval Security Station in room 4152.

The second ATLAS II differed from the first only in that it had a high-speed ferrite-core memory rather than an electrostatic tube memory. Originally the plan was to equip ATLAS II with Raytheon magnetic-tape drives using a data representation of one character per frame. However, a change was made to a conservative scheme for data representation involving two positions per information bit, resulting in three tape frames per character. Subsequently, this latter representation was felt to be too inefficient for most large problems. With the objective of achieving tape interchangeability and speeding up magnetic-tape operations, a redesign effort was undertaken. However, this modification never reached operational effectiveness.

Even though somewhat handicapped by the lack of an effective magnetic-tape system, both ATLAS II's contributed considerably to the solution of many problems. Reliability was high for both machines, but Serial 1 required somewhat more maintenance attention than Serial 2 because of the electrostatic tube storage. ATLAS I and ATLAS II were forerunners of the first two in a commercial line of Remington-Rand computers, the UNIVAC 1101 and 1103 respectively.

Also, ATLAS II was the logical model for the first transistorized computer, SOLO. ATLAS II, Serial 1, was taken out of operation in February 1960 and donated to the University of Texas; Serial 2 was turned over to the Second Army for disposal in May 1962.

Ref #2: Planning for ATLAS II

1. The delivery date of ATLAS II will be approximately one year hence. In Order to adequately prepare for the use of this machine a great deal of planning, programming, and training needs to be done.

2. Test Routines: In Order to help with the testing of the machine, test routines should be written by experienced programmers who are familiar with the details of the machine. Sufficient information is available here to develop tests to cover every order and. subcommand in the machine. More detailed information can be obtained on visits to ERA. Tests of electrostatic storage are especially important since these tests will determine the limits set on the repetitive reading ratio. Tests of the magnetic tape storage can test magnetic tapes as well as the MT storage system. Tests like those used on ATLAS I will be needed for the magnetic drum storage. Planning and writing these test programs should take approximately 160-man hours.

3. Programmer Training: The training of several programmers is a project which should be initiated soon. Programmers with training on both ATLAS I and ABNER should be able to learn ATLAS II rapidly. Programmers with experience on only one machine will have to learn the different techniques "borrowed” from the other. Since all available programmers are at present quite busy on machines in use or nearing completion, it will be necessary to train new programmers for ATLAS II. This process of training will take three months and should be initiated as soon as possible, since many of the new people will have to be hired. Time for training experienced personnel has been found to be about 2-months or about 100-man hours for instruction and assistance. Inexperienced programmers require at least another month or training or a total of about 150-man hours of instruction and assistance.

4. Training Aids: Certain training aids are helpful in training programmers and in instructing people who have a casual interest in the machine. A detailed instruction code of orders will be necessary to explain the Operation or the Orders and the special features. A training manual will lessen the time which is required to explain details to students. It has been found that sample routines are a help in training programmers. These training aids will take a great deal of time to prepare and should be available at least as soon as training of new programmers is initiated.

5. Operator Training: Operators familiar with ATLAS I should have very little trouble with ATLAS II. There is one big difference from the operator’s point of view, however. This is in the care and use of magnetic tape. Training in this phase should be started as soon as the tape machines are checked out and ready for use.

6. Maintenance Training: No experience is available at present for the maintenance of electrostatic storage systems. For this reason, personnel should be assigned to study the experimental equipment available at ERA. It is suggested that the tube test (5 digit) units could be used to train maintenance personnel until the pilot model has been tested. Later additional personnel could be assigned to gain experience on the pilot model. This training should be initiated in November 1952 if possible to allow time for new personnel to become thoroughly familiar with the equipment.

7. Operational Programs: A few large-scale programs have been written for ATLAS II. These programs were written to determine the characteristics of the machine and to compare against other machines. These are mostly of academic value at the present time. Operational programs may be initiated as personnel are trained and suitable problems are determined. At the projected rate of training, it will require at least 6 new full-time programmer-trainees to have six large-scale programs ready to run on ATLAS II when it is delivered.

8. Programming Studies: Programming Studies are used to determine the optimum programing techniques and to gain experience in determining the types of problems which are suitable for the machine. Studies or the machine characteristics are necessary to determine the times of operations, especially the inter-relat1onship between electrostatic and magnetic drum storage. These studies also bring out “tricks” which can be performed with the orders. ·

BOGART

Named after John B. Bogart, famous city editor of the New York Sun.

Ref #1, pg 31:

In Chapter 1, page 4, the problems attending the preparation of input data for computer treatment have been touched on. The difficulties inherent in Agency activities -- lack of control of source material, variations in communications practices, rigid formatting requirement of computer programs -- had resulted in the construction of many different types of conversion equipment. In 1952 and 1953, suggestions were made for using specially designed digital computers for data conversion and editing and to clean-up raw data for input to larger computers. During the NOMAD development, for example, one proposal for the solution of its anticipated massive data preparation, conversion, and formatting requirements was to build an additional computer for these purposes.

In December 1953, a proposal for the design and construction of such an "editing" computer was approved. The purchase description of BOGART specified-a- logical design based upon 7-bit words and provided for magnetic core and magnetic drum storage, punched paper-tape input, punched paper-tape and card output, and a flexible set of 3-word instructions.

In July 1954, Engineering Research Associates Division of Remington Rand was awarded a contract to build two of these machines. The decision was made to use diode and magnetic core logic for arithmetic and control circuitry, the basic memory cycle time was to be 20 microseconds.

Several months of programming experimentation showed that the small, 7-bit word size and the awkwardness of handling 3-word group for every instruction caused much difficulty for programmers and put a strain on the memory capacity. In July 1955, a modification was made that provided for several index registers and larger word size (24 bits), with flexibility in dealing with 9-bit portions of any-word. Now, also, four machines instead of two were to be constructed and equipped with IBM Type 727 magnetic-tape drives. Serial 1 was delivered in July 1957; Serials 2 and 3, in November 1957; and Serial 4 in January 1958. Subsequently, the pilot model was utilized as the central computer for the remote-operated system ROB ROY, so that five BOGART machines in all were delivered to the Agency.

BOGART has operated extremely reliably. It has been in great demand for many jobs other than pure editing and data conversion. In 1957, an assembly program, SLAVE, was created, and in 1959 BARN OWL, an executive routine, was introduced. Later, BARN OWL was refined and expanded to include some compiling functions. As an operating system it became known as PHOENIX. The BBC Compiler, based on the ABC Compiler for the IBM 704, is also available.

OTHERS

In Mr. Snyder’s 1964 document (declassified in 2004) there are several UNIVAC computers used by NSA after the initial ATLAS machine/computer.

Ref #1, pg 36. UNIVAC 1224A (CRISPI)

UNIVAC 1224A is a name applied by the Sperry Rand Corporation to the computer that the company built for CRISPI, a baud-signal receiving and processing system being developed by an R&D engineering and design group. The UNIVAC 1224A is the heart of CRISPI, and its organization and instruction repertoire are directed toward the concurrent manipulation of 16 or more independent data-streams. Features descriptive of the UNIVAC 1224A are:

- Word length: 24 bits plus 2 parity bits
- Memory' size: 16,384 words
- Memory cycle time: 4 microseconds
- Number of instructions: 28 single-address
- Number of index registers: 31 (one live, others in memory)
- Input: up to 16 independent data-streams
- Output: variety of outputs (hereafter described)
- Number of circuit cards: approximately 1000
- Physical dimensions: 24" wide, 27" deep, 72" high

- Power requirement: approximately 1,000 watts
- Specifications: designed to meet MIL-E-16400
- Mean time between failures: 1,200 hours (estimated)

The logic of the input/output portion of the UNIVAC 1224A provides for communication with several external devices.

To prevent simultaneous access to memory by more than one external device, a priority system regulates access by prorating them fairly. Present external devices include paper tape input/output device, printing facility, magnetic-tape unit, on-line communication line, and one to four operator consoles. The paper-tape input/output device provides a minimal capability and consists of a 300-frames-per-second photo- electric reader and a 11O-frames-per-second paper-tape punch.

The printing facility uses a one-way-only flow of data and can be any device that will match the computer's electrical and logic interfaces. The device presently used is a printer control unit designed to distribute up to 64 output streams to paper-tape punches on one-at-a-time page printers.

A bidirectional interface on the magnetic-tape facility permits data to be transferred from computer to tape or from tape to computer but not concurrently. The magnetic-tape control unit is designed to handle up to four transports. The tape format is compatible with IBM Type 729 low-density tapes. The on-line input/output facility permits bidirectional data exchange between two computers or between one computer and some other asynchronous device such as a communication center. The operator console is the critical, on-line interface equipment between the signal tuning equipment (receivers, demodulators, and the like) and the computer. The console allows the operator to control the flow of data to the computer and to monitor the activity in the computer. The logic interface between the console and the computer is such that a variety of operator consoles may be used. To date, four different consoles have been constructed.

Two UNIVAC 1224 computers have been put into use, the first in June "1963 "and the second in July 1963. Performance has been excellent. Four more are under construction for delivery early in 1964. Procurement of ten more for other purposes is being initiated.

Ref #1, pg 88 – ROB ROY (BOGART)

In February 1957, another report was prepared by the research group that contained recommendations for a final ROGUE system. Among the comments on the ALWAC operating experience, the following disadvantages were cited:

1. Slow speed (1 to 17 milliseconds per order)
2. Limited addressable memory (128 words)
3. Extremely slow input-output (10 char./second)

However, recognizing the overall success of the ALWAC experiment and the enthusiasm of the analytic groups, the report recommended an improved system that included the following principal features:

1. A BOGART computer
2. A buffer system for magnetic tapes
3. A buffer scan unit
4. Auxiliary storage (magnetic drums)
5. A high-speed paper-tape reader

The report also recommended the initiation of a development effort aimed at perfecting a practical, high-speed, output printer (200 characters per second).

In April 1958, the research group was requested to proceed with the construction of a remote system substantially as described in the 1957 recommendations. It was called ROB ROY. The proposed system used BOGART Serial 5 as its central computer, with a Ferranti high-speed paper-tape reader (200 frames per second) at each of four outstations, transmitting data to the central computer over telephone cables. At the computer site the character rate is stepped up by means of a buffer system and written onto IBM Type 727 magnetic tape for computer input. Output results follow a similar path, with a 60-characters-per-second punch and. an off-line Flexowriter at each station to produce hard copies as desired. The input and output core buffers and outstation consoles were constructed by Vitro Labs. In January 1959, a fifth outstation was provided for, and in December 1959 the ROB ROY system was installed and checked. The installation at first had power line noise and long lead pick-up. These difficulties were eventually eliminated by Agency engineers.

In February 1960 the ROB ROY System was placed in regular operation. The total cost was $219,000, of which $152,500 covered the equipment furnished under the Vitro Labs contract. The cost of the BOGART computer is not included in these figures.

The experience gained in operating ROB ROY has been even more useful than that of ALWAC. More sophisticated runs have been possible, including large analytic and data processing jobs. The speed of ROB ROY is greater than ALWAC's by a factor of several hundred. The principal operating advantages over ALWAC are the following:

1. Elimination of any elaborate switching system for control of outstation operation. The BOGART supervisor program calls for a program from the library tape, assembles new programs if necessary, and logs records of system operation.

2. Actual, effective overlap of input from outstations, computer operation, and output. This is made possible by the use of core buffers at input and output, together with use of two magnetic tapes for temporary storage of data and results.

3. Greater storage capacity and instruction flexibility of BOGART, plus availability of three additional magnetic-tape drives for storage of intermediate results and for other purposes. These add tremendously to the system's usefulness.

The demand for ROB ROY has been much greater than its capacity to accommodate as a remote-operated system. The result has been an arrangement -for many jobs to be run nights and weekends. In such cases, there is an effort to "batch" jobs. But the practical limitation in the number of outstations and the increasing demand for more and bigger runs have led to plans for a successor to ROB ROY.

Ref #1, pg 89. – RYE (UNIVAC 490)

When the decision was made to 'plan a remote-operation system as a successor to ROB ROY; bids from four possible contractors were solicited, and their proposals were evaluated according to a set of stringent requirements. The UNIVAC 490 was selected, and orders for two systems were placed. The first 490 was delivered in August 1963; the second is to come in January 1964. Both are planned to operate in a master-slave relationship and be fed by 30 remote stations (eventually possibly 50) using two communication multiplexers and the lines of the existing secure telephone system. The UNIVAC 490 system has the following features:

1. Main memory of 32,000 30-bit words with 6-microsecond cycle time.
2. Twelve Uniservo-IIIC tape drives, IBM 729-compatible.
3. One high-speed magnetic drum, capacity 786,000 words, average access time of 17 milliseconds.
4. One Fastrand mass storage magnetic drum, capacity 13 million words.
5. One high-speed printer, speed 600 lines/minute.
6. One modified Model 28 Teletype, with console, keyboard, and printer.
7. One high-speed, paper-tape reader and punch, speeds 400 and 110 characters per second respectively.
8. Various communication line terminals to accommodate various outstation requirements.

The philosophy of outstation operation presumes 24-hour data and requests simultaneously and being serviced with a minimum of delay according to a priority system under automatic system control. Three classes of outstations are planned, differing primarily according to class of input/output and display equipment. A general station will consist of a Model 35 Teletype only; a class II station will also have a BOSTIC, or high-speed, paper-tape reader and punch device, class I stations will have Teletype and BOSTIC, and, in addition, a UNIVAC 1004-line printer and other high-speed equipment as needed. One station will ·be equipped with an x-y plotter, connected to the 490 through a data-channel. Programs will normally be limited to 30 minutes of running time.

An executive program, REX, regulates the operation of programs from the various stations. RYE, the Agency's real-time program, places programs in proper priority order, considering actual assigned priority. The system will keep operations records for all jobs, permit interruptions for high priority jobs, and supervise debugging aids to programmers. Also, several General utility Programs (Guppies) will be available to users of the RYE system.

The two 490 computers will be operable either together in master-slave relationship to provide extra capacity for extraordinary-capacity jobs, or as separate computers. In the latter situation, the second 490 can be used for debugging or other operations while the first serves system needs. If either 490 is out of operation, the other can become the master and take over. The RYE system is expected to become operational around 1 April 1964.

Ref #1, pg 93. Install dates.

Dates of equipment from RRU, NSA, IBM, Librascope, Technitrol Inc., Philco-Corp., Logistica Research Inc, and CDC are listed in a three-page table. Listed here are RRU units.

Model	date	page
ATLAS I (1)	Dec 50	8
ATLAS 1 (2)	MAR 53	12
ATLAS II (1)	Oct 53	13
ATLAS II (2)	Dec 54	13
BOGART (1)	Jul 57	31
BOGART (2)	Nov 57	33
BOGART (3)	Nov 57	33

Model	date	page
BOGART (4)	Jan 58	33
BOGART (5), ROB ROY sys	Dec 59	33, 88
1224A (1)	June 63	36
1224A (2)	July 63	39
Univac 490, RYE system	Aug 63	89

EPILOGUE

Thanks to Keith Myhre who found the last four NSA declassified documents. This paper reduces 536 pages of NSA documents onto these 21 pages. Parts of the NSA documents are written as if the author was trying to cover or defend his 'backside' should the expenditures and decisions be challenged. A lot of reading for those not familiar with cryptographic methods or not familiar with the NSA use of 'code words' for equipment or projects. The NSA renting of IBM equipment since 1932 was a bit of a surprise and explains why IBM contracted with ERA for a drum-based card-reader computer design in the early 50s.

References:

Ref.	NSA #	Pub Date	Declassified	Title
1	A41023	1964	2-9-2004	History of NSA General-Purpose Electronic Digital Computers – 106 pages.
2	A60163	7-14-1952	1-23-2014	Planning for ATLAS II – 6 pages.
3	A60166	8-15-1952	1-23-2014	Analytical Machine Employment – 20 pages.
4	A60928	5-30-1953	6-14-2014	Cryptanalytic Machines in NSA – 365 pages.
5	A66701	9-28-1954	11-13-2013	Machines in the Service of Cryptanalysis – 41 pages.

- https://vipclubmn.org/Documents/UNIVAC%20Products%20Saint%20Paul%20-%201947%20to%201959.pdf.
- https://vipclubmn.org/CP24bit.html#Classified.
- https://vipclubmn.org/BitsBakUp/BOGART%20Programmers%20Manual%20(July%201957).pdf.
- https://vipclubmn.org/CP24bit.html#CP818.

Crypto comments:

A few words about cryptography for those who do not do the occasional newspaper Crypto Quiz (CQ). CQs use the simplest one-for-one letter substitution and include a one letter clue, i.e. *y* of an encrypted message equals *o* – a 10-character shift:

Code 10: **k** l m n o p q r **s** t u v w x **y** z a b c d e f g h i j.
Normal: **a** b c d e f g h **i** j k l m n **o** p q r s t u v w x y z.

So, an encoded CQ character stream “S vsuo dy cyvfo k qyyn nksvi zejjvo.” decodes to “I like to solve a good daily puzzle.” After the one given letter substitution, the 1st CQ decoding hint is that **a** and **i** are single letter words in the English language,. These must be the encrypted **k** and **s**, but which is which? The 2nd hint is to count letters; in this CQ; s3, v2, 1u, o3, k2, q1, y4, n2, z1, e1, j2, d1, and f1. The most used letter in the English is E, 2nd is T, 3rd is A, O, N, R, I, S, H, D, L, U, and the 13th is C. Then some guess work looking for word spellings.

<u>Hindsight comment</u>: this paper would have flowed a bit better had I extracted info in the declassification date sequence. ☺ *LABenson*