SEMICONDUCTORS AT UNIVAC

Compiled and Written by
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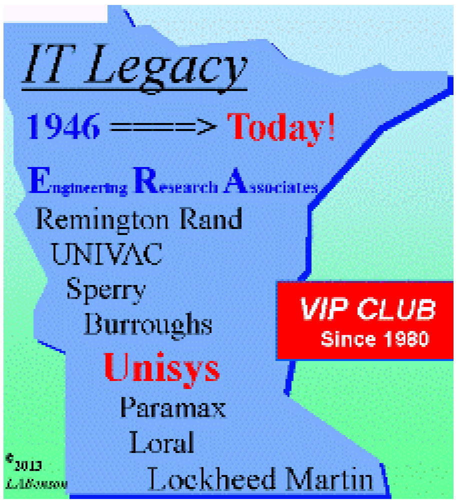

This history paper was created by Mike at the request of Dr. Tom Misa, Director of the Charles Babbage Institute at the University of Minnesota with great inputs from Larry Bolton, Ralph Kerler, David Kirkwood, and Richard 'Dick' Petschauer.

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By Bernard N 'Mike' Svendsen

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With great help from L. Benson, L. Bolton, R. Kerler, D. Kirkwood and R. Petschauer.

THE ENVIRONMENT-

The semiconductor technology race started in the late 1940's with the invention of the transistor by Bill Shockley and his team at Bell Labs. Research was extensive in materials, interconnections, manufacturing techniques and basic semiconductor theory. The end of WWII allowed the US to refocus its R & D activities towards commercial applications. Semiconductors were just leaving theory and prototyping and striving for identity in the early 1950's. There was lots of capital for startups and everyone was looking for customers and applications. Many companies began in labs, garages, and old factories. They started developing specifications and criteria for electrical, mechanical, and quality parameters. The changes in pursuit of improvement were rapid and not always based on evaluation. The knowledge about semiconductors was gained by on-the-job experience and visits to plants and not from books, classes, or formal education.

The pace quickened with the parallel realization in 1958-59 of the first integrated circuit by Jack Kilby at Texas Instrument (TI) and Bob Noyce at Fairchild. In 1965 Gordon Moore predicted that the number of transistors on a chip would double approximately every two years. It was also predicted that the overall performance [quantity and speed] would double every 18 months. The challenge was in place and it was up to the engineers to transition from tubes to semiconductors and to select what technology was best right now for their application. Their next project would be different!

The Sperry Corporation was gathering scope and size but was spread out geographically with many computing entities coming together. Eckert- Mauchly had been purchased by Remington Rand. In May 1952 they acquired Engineering Research Associates (ERA). Most of ERA's computing effort was highly classified. ERA's first commercial computer [1101] had no semiconductors, weighed 17,500 pounds, and occupied 400 square feet. In July 1955 the Sperry Corporation purchased Remington Rand and the Sperry Rand Corporation was created. The St. Paul Operations was also known as Remington Rand Univac (RRU), Military Department until January 1962 when it became Remington Rand Univac, Defense Systems Division (DSD). They were the Federal Systems Division (FSD) for a while in the late 60's, but then returned to be DSD. There were projects underway everywhere for all kinds of military and commercial customers who needed the semiconductor technology but it had to be reliable.

With the organizations coming together as noted - the people, personalities, capabilities, experience and ideas were very diverse and added to the excitement of identifying and solving problems. There was not enough knowledgeable manpower for all projects to work the issues. Standardization, centralization and communication were required. In May 1956 RRU started a companywide periodical called "Semi-Conductor Notes" which were regularly distributed to the 110 engineers and researchers in RRU. There were 29 issues [555 pages] thru February 1959 which contained semiconductor evaluation information from St. Paul with some info from the Philadelphia and Norwalk engineering centers. There are details on hundreds of transistors and diodes of all types from 45 vendors. It also showed that RRU had purchased 7.7 million diodes and transistors during that time. The Average Selling Price (ASP) in April 1957 was $0.72 for the diodes and $3.61 for the transistors. The "Notes" are an overview of all aspects of the test and evaluation of early devices. Test circuits and conditions were developed as well as the equipment to do AC and DC tests quickly and accurately under all environmental conditions.

The rapid transition from tubes to transistors to integrated circuits pushed Component Engineering and Procurement to take a stronger role in managing the interfaces between the vendors and our engineering and manufacturing personnel. The ability to get enough quality semiconductor devices at the right price and on time and to meet production schedules was very dependent on support from the industry and from within Univac. There was money to be made if it was done right - C. A. Christopher and E. E. Berg were the initial procurement leaders, while R. C. 'Red' Phillips and R. A. 'Bob' Erickson provided the engineering direction.

The semiconductor reliability required for a military or commercial computer far exceeded the observed results and the present device failure rates were not acceptable. The quality levels had to be in parts per million and not per cent defectives. Neither the time nor the methods needed to statistically determine these low failure rates were available. The Naval Tactical Data Systems (NTDS) computers would require a Mean Time before Failure (MTBF) of 200 hours; that required a transistor that would be failure free for 200 years.

The message from the Electronics Components Conference in Washington, D. C. in May 1960 was "that miniaturization is fine to a point, but after that there are diminishing returns as you make smaller parts. Also as the number of parts in a miniaturized system increases there is a rapid decrease in reliability and ease of maintenance." Univac worked very hard to prove them wrong.

THE BEGINNING

The political, geographical, organizational, professional, personal, and corporate issues of semiconductor specification and procurement were intense and amazing. The impact was tremendous and everyone was interested and affected by the results. It was never obvious what was right or what would be agreed to and it took a lot of effort by many to get it accomplished.

Travel to the vendors was a priority with face to face meetings to develop rapport with the management, manufacturing, sales, and design people. Usually multiple disciplines [procurement, quality, reliability and design] would participate from both sides in the detailed discussions. Failed parts and pictures were presented and traced to the manufacturing process for problem isolation. Results of electrical and environmental qualification testing were reviewed and specific corrective actions identified to be followed up by subsequent visits by vendors. We would gather samples of new devices [speed, power, package or process] for test and further evaluation. Vendors presented their new programs or procedures for improving quality and reliability.

The utilization of semiconductors was very dependent on the corporate, vendor and customer environment. In the 1960's standardization and consolidation within Univac was needed to bring all of the design efforts together. The technology was changing rapidly and getting more complex and the need for reliable devices was even more critical. The difference between military and commercial requirements resulted in a separation within Univac and their two operations - Data Products Division (DPD) and Defense Systems Division emerged. The worldwide growth of plants and functions in DPD reinforced the need for centralization of procurement, quality and material, so the Semiconductor Control Facility (SCF) was created in 1973. DSD had to respond to their stringent customer environmental requirements. The negotiations and contracting of government contracts and proposals made it impossible to keep DSD and DPD together in their pursuit of semiconductors. DSD therefore handled all their semiconductor activity and did not utilize SCF. The industries push to off shore fabrication and assembly was also a problem for the military. The Corporation's attempt to control its destiny in semiconductors led to the creation of the Semiconductor Division (SD) in 1980. Burroughs purchased DPD in June 1986 which created Unisys. DSD continued to be part of Unisys. SCF was dissolved in 1986 and the function moved to San Diego. The SD facility was closed in December 1987. In the middle of 1995 Loral and then Lockheed Martin became DSD's corporate identity. What follows are the semiconductor activities within those organizations.

RELIABILITY

Reliability was always of the utmost importance at Univac. George A. Raymond, Director of Reliability, and George P. Anderson, Supervisor of Failure Analysis Lab led the way. Five papers presented in 1962 thru 1964 identified basic principles:

1. "Practical Aspects of Reliability" by George A. Raymond. Purchasing and Reliability must work as a team. Successful Failure Analysis (FA) depends on imaginative painstaking detective work coupled with adequate tools and facilities. You must pay close attention to minor details with rapid communication about results.
2. "Fundamental Failure Mechanism Studies" by R.C. Phillips, G.P. Anderson and R.A. 'Bob' Erickson. We do not believe a lot is homogenous and that statistical techniques can be applied. Develop screening techniques designed with failure mode information. Gold-Aluminum Purple Plague explained.
3. "Failure Modes in High Reliability Components" by G.P. Anderson. No component approaching modest sophistication is inherently reliable if it has people and machinery involved in its design and production.

4. ”Failure Modes in Integrated Circuits and Partially Integrated Microelectronics” by G.P. Anderson and R.A. Erickson. FA along with prompt feedback to the supplier tends to remind and to motivate the vendor into a continuing product improvement and surveillance effort. The vendors appreciated the timely feedback.

5. ”Second Thoughts on Reliability” by G. A. Raymond. The object is to reduce the chance of failure. We have overemphasized mathematics, predictions and failed to put enough emphasis on FA and corrective action. There is a correctable cause for every failure. You can build a device that won't fail. You cannot test reliability in but you can test failures out.

It became apparent within Univac and to our vendors that George Anderson and his Failure Analysis Team had developed industry leading techniques for determining how devices failed. The early individually packaged devices had significant internal lead bonding and contaminant failure modes which were detected by Univac failure analysis. Their micro-photography provided evidence of each failure and possible causes. Communications with the device manufacturers resulted in better processes controls. That combined with industry process improvements and continued integration of logic and memory resulted in significant reliability improvements. The vendors knew best how their devices were built but Univac worked with them to show how and why some of them failed.

All of these papers have many examples and descriptions of failures with micro-photographs of different types of semiconductors. There are also very good descriptions of the failure modes observed in devices received. A brochure - “Reliability- a Univac Product Characteristic” shows people, concepts and equipment capabilities of the organization. The electrical and mechanical test equipment along with the materials and process engineering facilities made for a very professional photographic documentation of failures. A photo library exits of the failure modes of early devices for many manufacturers.

STANDARDIZATION

The company from the beginning had always been very project driven and with the coming together of the many divisions, there was a documentation disaster unfolding. Both Military and Commercial customers helped with the confusion. In early 1961 the 1107 and 490 component engineers had the primary task of getting the electrical component [passive and active] specifications useable for production procurement. There were lots of opportunities to consolidate specifications.

They started with Allen Bradley 5% carbon composition resistors and concentrated on the documentation issues. They were not overly concerned about electrical characteristics or variations. It was a mature component and industry. They reviewed procurement records, cribs, projects, and bills of material and found 33 separate part drawings in use for the four different wattage resistors. Each drawing had a long list of dashes for the individual ohms. Eight standard specs were created with a central store for procurement, storage and disbursement. The next year there was a 30% savings in purchase cost for 4 1/2 million resistors and inventory turnover of 9. They then used this approach with other passive components in preparation for the active devices.

The standard specs were needed everywhere, but how do you implement the concept into a documentation system without a complete very costly redo? The old drawings were converted to a Montage [dummy] purchase part drawing and then superseded or made obsolete by cross referencing them to the standard part drawings. This could then be managed by the computerized bills of material. On new projects, only the standards were used. There were four different levels of specification change control utilized in St. Paul depending on Military or Commercial usage alone or joint usage with control by the largest user. In November 1962, the St. Paul Military and Commercial Operations split. In 1963 a Drawing Departure Authorization (DDA) was developed with a very tightly controlled distribution system for authorizing acceptable changes to acceptance tests, electrical/mechanical criteria, sources of supply and substituted devices.

The active devices like semiconductors took much greater effort and were more difficult to standardize because of variations in electrical specification [real and imaginary] and differences in vendors products and test conditions. Many of the early parameters were just taken from vendors' data sheets and reflected his product and not the needs of the application. Semiconductors had the greatest return on our efforts and were under the watchful eyes of everyone. One could save 10%, if we doubled the volume of a part.

On April 8, 1963 E.E. Berg, Group Mgr. of Procurement in St. Paul created a Task Force for Semiconductor Evaluation with the following objectives:

1. Promote standardization.
2. Implement engineering policies as they affect documentation.
3. Provide technical input which is necessary in the forecast of economic and price trends in the domestic as well as the foreign markets.
4. Coordinate St. Paul specifications with the rest of the Univac Division.
5. Coordinate Univac specifications with those in industry.
6. Cooperate with all design engineering groups.

C.A. Christopher, Univac Procurement in NY had directed E.E. Berg to undertake the functional coordination and procurement for some of it's more critical high usage components. "We must work for quality, delivery and price stability."

The Task Force consisted of Ralph J. Kerler, Robert M. Englund, and B. N. Mike Svendsen with Rollie M. Griep providing the purchasing support. They were to function for six months pursuing the above objectives. Their bi-weekly reports detail the efforts of sourcing, qualification, deviations, packaging, specifications and communications within Univac and with the semiconductor industry. The focus was on the top 12 high volume semiconductor usages in a computer system in preparation for combined procurement across the divisions and locations of Remington Rand Univac. Those functions were:

Function	Part #
1. Germanium Logic Transistor	4908000
2. Germanium Logic Diode - (40 nanosecond)	4907929
3. Germanium Memory Transistor - (2N1204)	4907980
4. Silicon Memory Transistor	4907974
5. Germanium High Voltage Transistor (2N398)	4907979
6. Germanium NPN Alloy Transistor (2N1304)	4907975
7. Germanium PNP Alloy Transistor (2N1305)	4907976
8. Germanium Low Freq. PNP Alloy Transistor	4907982
9. Silicon Memory Diode (1N691)	4907926
10. Germanium Drift-Alloy Memory Transistor	908980
11. Silicon 400 mw Zener Diode	4907923
12. Silicon 1 w Zener Diode	4907924

There were a total of 20 Standard specifications created at this time and they were included in the 40 devices under Coordinated Procurement (CP). If the volume was high enough or we were not able to get total concurrence by all users on the Standard Specification, the original specifications continued. The group completed its work in September 1963.

The relatively short life cycle of devices caused by technology changes and increased density of the semiconductors created a very difficult scenario for semiconductor procurement. Evaluations and qualifications were never ending. The industry also made many decisions about what business they wanted to be in. Philco exited the MADT transistor in 1963, Sylvania stopped silicon diodes in1965, and Clevite quit germanium diodes in 1966. The changes were not only in discrete devices but in integrated circuits as Westinghouse closed their Microelectronics Division in 1969.

SPERRY SEMICONDUCTOR

Sperry hired B. Rothlein in 1953 then after visiting all Sperry Divisions, he recommended starting a semiconductor operation in Great Neck, NY. They became the Sperry Semiconductor Division (SSD) in July 1956. SSD announced the commercial marketing of 17 diodes and transistors in April 1958. In May 1959, Rothlein took seven key employees and formed National Semiconductor in Danbury, CT. Sperry later [1964] sued them for breach of contract and wrongful use of trade secrets. By 1963 SSD was providing a low volume of diodes and attempting to bring up Si Planar Transistors. In 1965 SSD stopped production of silicon diodes, the only device Univac used. There was flurry of corporate activity in 1967 to determine if SSD could provide technical expertise to other Divisions, but it was too late. SSD dropped out of the industry and sold the facility to Pitney Bowes in 1969.

COORDINATED PROCUREMENT (CP)

The semiconductor coordination and procurement (CP) began in early 1963 with communication between plants about requirements. Similar discrete devices were purchased against procurement plans developed by and under the control of DSD Procurement in St. Paul. Rollie M. Griep, Procurement Manager and Dan F. Krolak, Administrator gathered requirements from St. Paul DPD and DSD as well as from Utica and Blue Bell for 40 devices. They then negotiated with the industry for price and delivery and the orders were placed from the respective plant. B.N. Svendsen joined DSD Procurement in March 1965 to direct coordinated procurement for both the DSD and DPD.

DISCRETES

The1965 history of Germanium Diode procurement shows some of the CP issues. There were three major users - St. Paul Defense, St. Paul Commercial [Roseville] and Office Machines [Utica, NY.] Each had its own specification with different approved sources and slightly different electrical characteristics but all doing the same function and produced by the vendors on the same line. The difference between monthly orders [wants] and weekly deliveries was the result of insufficient lead times and schedule changes. The total weekly demand for all three locations was about 650k devices per week but the requested delivery rate varied from 0 to 550k per week with their orders released every other month.

In 1966 the Germanium Diode plan was to release large orders under CP control to GI, ITT, and Transitron with a 30 day cancellation clause [wherein we buy the next 30 days run rate.] Changes in schedule and allocation between part numbers required 30 days notice and 60 to 90 days start up time for increases. It would have been easier if all sources were qualified on each print. These Program Procurement plans along with similar ones for other device families were submitted to Univac [Philadelphia] for corporate approval and request for timelier ordering by plants. They liked the idea but would not overrule the need for the plants to control their manufacturing schedules. The commitment of dollars by CP without requisitions was not authorized.

During 1967 TI and Motorola had shared the germanium mesa logic transistor business [6.2 million units.] Each one wanted to be the single source in order to maintain their volumes on this slowly dying technology and each offered significant price reductions. Up to this point CP had been struggling to get two or more sources on all devices so this was a major change in strategy. Motorola was selected as the single source in 1968 and TI was in 1969. We saved $781k and $95k respectively. In 1976 Motorola discontinued production of germanium transistors and it was necessary to do a lifetime buy from them.

The discrete semiconductor procurements were successfully managed without an approved CP charter. Of the following quantities about 80 to 90% were for DPD and only 33% were transistors with that percentage decreasing each year.

YEAR	QTY of Diodes & Transistors (% Trans)	Total $	ASP
1964	30.8 million (33%)	7.1 million	$.232
1965	44 million (39%)	8.4 million	$.19
1966	62.4 million (28%)	9.6 million	$.154
1967	70.9 million (24%)	7.3 million	$.103

YEAR	QTY of Diodes & Transistors (% Trans)	Total $	ASP
1968	129 million (24%)	9.4 million	$.073
1969	145.4 million (15%)	8 million	$.055

The ASP also reflects the decreasing use of transistors. In 1968 our usage was 103.7 million diodes and 25.1 million transistors. This compares to the estimated total US shipments of 920 million diodes and 840 million transistors. (Univac was 11% and 3% respectively). The US also shipped 42 million diodes and 21.2 million transistors to Japan. None of these figures included IBM usage.

CORPORATE ACTIVITY

H.V. Boshea, VP of Procurement and Materials and A.B. 'Bert' Mueleners, VP of Peripherals and Component Division were the CP advocates in Philadelphia. They both worked for Paul J. Spillane, Group VP of Worldwide Development and Manufacturing in Sperry Univac. Without their help working and influencing the issues ["managing the politics"], the task would have been near impossible. CP was a function that worked across many different organizations to achieve its goals. It got devices, saved money and improved quality. CP continued to operate as in the past but was always ready to discuss areas for improvement.

In August 1966 a Sperry Corporate Electronics Components Committee was created to pursue common buying and standardization. B.N. Svendsen was appointed Chairman and visited Sperry Vickers, Gyro and Phoenix. The CP story was presented and info exchanged, but the issues within Univac about expanding CP became even larger when you tried to work across corporate boundaries. The communication channels would be very complex. Their volumes were usually much smaller and they were utilizing off the shelf devices so that there would be little advantage to add them to the program. A charter for CP was drafted in October 1966 and meetings with the interested parties started. Major disagreements existed across Univac and heated discussions about its content occurred. Little was done to change the situation and it was business as usual.

CP ISSUES

The list of issues that were hampering CP was summarized for Management in November 1967:

1. The charter for CP which was proposed in October 1966 had not been agreed to or formalized. The expansion to other components or to other parts of the corporation is not possible until there is a firm basis from which to work.

2. A method is necessary whereby upper management could approve coordinated procurement plans. Waiting for requisitions from the plant is not acceptable. At present $1 to $1.5 million is required to sustain CP and we are doing this without formal authorization.

3. The CP manpower and funding needs to be tied to the charter. Part time work is neither practical nor efficient. At present most of the effort is provided by DSD-St. Paul and their share of the procurement activity is only 10%.

4. The plants are improperly using CP as a production control tool to reduce inventory [especially at year's end] and to shorten lead times.

5. Improvements in the method of assuring device quality and reliability are not possible until direction to standardize is given. Purchasing alone can not do it. The present lot acceptance testing is too expensive and does not achieve the end result. The problem only worsens as the market becomes international and vendor manufacturing moves away from the US.

6. The first integrated circuit procurement plan for Diode Transistor Logic (DTL) is ready to proceed but "full" authority has not been given. We may have to proceed like a CP discrete procurement.

7. CP standard costs and the method and timing for developing and using them are becoming critical. Not every one uses our standards in the same way.

8. Increased cooperation is needed between the component engineering and quality control people at all participating locations as the qualification and requalification activity increases. The industry is making changes to improve and is going off shore to reduce costs.

VENDOR IMPACT

There is a significant impact of CP on the vendors. The salesman or factory representative usually gets 50% credit for negotiations and 50% for ship to address with little credit for engineering support unless it leads to more shipments. Territories are laid out either geographically, by customer type, or by customers end equipment. Univac crosses over all those boundaries. A lot of effort was expended visiting and explaining to the management at the vendors what CP was trying to do and to work issues. They had to provide engineering support to all locations, negotiate in St. Paul and then send parts to all plants. Most of the vendors set up a centralized function at the factory to manage this interface with all their product groups and CP.

INTERGRATED CIRCUIT SPECIFICATIONS

Unfortunately our past experience with discrete devices had led us to create specifications for the more complex devices that were more like subcontracts than purchase part drawings. Our general specifications relating to packaging, acceptance testing and environmental testing procedures had become very vendor specific due to negotiations and experience. This made adding or switching sources almost impossible. The vendors didn't like being told how to do their job. With our controlling general specifications, the documentation issues were costing time, money and sources. The documentation was not getting the emphasis it required. Procurement was very critical of its content since it was our only vehicle to find vendors and negotiate price and delivery. It wasn't until May 1973 that new General Specifications for semiconductors were created.

LOT ACCEPTANCE TESTING

In 1966 Procurement, Reliability, and Quality departments began a long serious debate about the usefulness of Lot Acceptance Testing (LAT). The LAT was intended to be a verification of the quality and reliability of production devices being shipped. The sample was selected from each lot and put through a battery of tests to determine its mechanical and electrical capabilities. They must pass the tests in order to ship the production lot. It took time to do and cost money. The General Specifications and purchase part drawings which described the LAT needed cleaning up by Univac and at the same time the vendors were developing their own acceptance criteria. There was seldom enough lead time to get parts for production and a 1 month delay in shipment waiting for LAT was not acceptable. Shipping prior to approval was not unusual. A review in 1965 had shown that only 7% of the 623 lots shipped were rejected. Usually it was not due to the quality of the parts, but documentation and human errors.

The semiconductor industry in 1966-67 was maturing and doing a much better job of manufacturing a quality and reliable device. In January 1967 after review of semiconductor quality assurance programs and presentations by our top 5 vendors, it was determined that our vendors were performing at our expense many unnecessary environmental lot acceptance tests. The plan was to:

1.) Avoid weekly environmental LAT for devices coming from continuously operating lines and develop a line acceptance program.
2.) Optimize testing and compliment with in-house requalification.
3.) Transfer monitoring QA from component engineering to manufacturing quality to avoid duplication and put effort closer to using organization.

In the first 9 months of 1968, we sampled 308k devices from 964 lots containing 87.9 million devices. Thirty-four lots were rejected but only three were device related [0.999 acceptable.] There was very little use of the LAT data at incoming. The samples were finally cleared for use in production and design prototyping. Alternate methods were requested to replace LAT but it appeared that it would continue. A line acceptance program was developed at the vendors for Germanium logic transistors. With the more complex and expensive integrated circuits, the cost of the devices and the tests would rise dramatically.

CP EXPANSION

In June of 1968 DSD Procurement increased the CP manpower from 1 to 5 to handle the expanding semiconductor activities in Univac and the increased importance of integrated circuits. This group was needed to place more emphasis on the problems connected with all semiconductors, not just the top 40 in CP, and to provide a repository for information about the semiconductor vendors. D.F. Krolak and R.F. Mannella would handle transistors, while R.J. Jones and E.C. Peterson would handle diodes and M.L. Feipel was assigned to integrated circuits. The integrated circuit business was growing everywhere but that was not in CP charter and was handled by each location. The plants which utilized CP at this time were: DPD Utica, NY; DPD Roseville, MN; DSD St. Paul, MN; and DSD Salt Lake City, UT.

In March of 1969 CP moved from DSD in St. Paul to DPD plant 4 in Roseville. E.D. Jorgens took over for Dan Krolak and reported to E.T. Bahre, Mgr. Procurement Roseville Operations. The discrete device volume for DSD was dwindling while DPD volume doubled and the number of DPD plants serviced had increased with addition of Bristol, TN; Blue Bell, PA; Japan; and Roedelheim, Germany.

On March 6, 1969 the Operating Charter for Semiconductor Coordinated Procurement was signed by Bahre, Lawson, Squires, Spillane, Boshea, and D.L. Heisler - VP Business Planning and Purchasing. This was the formalization of the existing CP activity and provided for expansion beyond the initial discrete devices.

There were discussions in March 1970 about a Univac Component Division but nothing happened.

All divisions could participate in CP but the Defense or Military groups were having trouble with their customer negotiations because of the inability to define and separate costs for their contracts while using the Univac standard costs which included a mark-up. Their devices also had packaging and environmental requirements which were very unique to their customers' applications. At this point DSD went its' separate way and was no longer involved in the coordinated acquisition of semiconductors within Univac.

SEMICONDUCTOR CONTROL FACILITY (SCF)

As early as December 1970 the central Semiconductor Control Facility concept was discussed which would include procurement, quality, finance and material in one place for Univac DPD. In August 1971 H. V. Boshea proposed a separate cost center to handle all aspects of semiconductors but it was rejected by Engineering. It would be September 1972 before SCF got serious and Everett T. Bahre was selected to run it. Visits to our vendors in early 1973 explained the concept and helped them prepare for their changes needed to support us. There were major logistic issues of maintaining full pipelines while changing shipment and distribution methods from vendor thru SCF to the plants. SCF may have been the initial "JUST IN TIME" distributor for electronics. In April 1973, Sperry Univac News announced SCF. They started with 24 people but by the end of FY74 had grown to 79. The facility was located in Minneapolis at 1101 Industrial Blvd. across highway 36/I35W from DPD Plant 4.

In October 1973 G.P. Anderson presented a paper on "Failure Modes in 4th Generation Processors". In it he stated: "wear out is not seen and almost all intermittent failures are caused by fabrication process control variables including workmanship. Occurrences for all failure modes tend to be cyclical." Our quality focus became the visual comparison in great detail of each lot received.

In October 1974 B.N. Svendsen became Director of the Semiconductor Control Facility, replacing E.T. Bahre who went to Cupertino, Ca. to run Integrated Storage Systems (ISS). With SCF having responsibility for all Commercial semiconductors it was necessary to identify and gather information weekly from all locations about their device usage. DSD was not involved. In November 1975 Electronic News noted "that the creation of SCF avoids the need for an internal facility." A computer communication system [using the MAPPER software tool] was utilized to gather requirements from all users. Mapper was a powerful software tool developed by Roseville Manufacturing and widely sold to our system customers.

In 1976 and 1977 SCF discussed this supply concept with Northern Telecom, NCR, Collins Radio, and Burroughs.

DEVICE QUALIFICATION STATUS

MAPPER was also used as the data base for information about the devices used within Univac - who was qualified and where the product was processed and assembled. The qualification status of each part was shown along with its industry standard part number. The SCF qualified production facility file showed the fabrication, assembly and test locations across the world with descriptions of packaging and material variations. SCF engineers developed procedures, equipment and staff to analyze the incoming quality. The Quality Verification Test (QVT) was implemented to evaluate visually and electrically each lot as it arrived to compare it to previous receipts. By this time "Appearances were not deceiving in semiconductors - if it looks good it probably is." In all 168,000 QVT tests were performed at SCF.

FIELD VENDOR SURVEILLANCE

A Field Vendor Surveillance organization was developed to help with communication. People were stationed on the East and West coasts and in the Southwest. They had ready access to plants and were treated as employees. This was a relationship which they earned by their professional involvement in problem solving. Dave Anderson, Merle Oestrich, Bob Collins, Hal Cutting, Bruce Madden, Arden Hendrickson, and Andy Clawson grew up with the industry. The annual reviews, the constant communications and the many plant visits required someone onsite to help with continuity. The group grew to nine in June 1975 with one in the Far East. They also flagged potential issues that were found by the vendors' in-house quality programs. The vendor programs were rapidly improving and demonstrating timely control of their quality.

FINANCIAL

SCF would have a large impact on the financial statistics of Univac manufacturing and its plants during its 13 year existence. Univac's fiscal year went from April 1 to March 30, i.e.

FY 74 ended on 3/30/1974. The Univac plants were measured monthly and quarterly over their fiscal year. The semiconductor industry is a monthly issue over the calendar year. The setting of standards, the measuring and value of shipments, inventory and commitments and the determination of Purchase Price Variance (PPV) were all very date sensitive. Univac and the industry were not always supportive of each other.

STANDARDS-PURCHASE PRICE VARIANCE (PPV)

A very high priority task was to set cost standards each fiscal year and track PPV. The objective of setting standards was to have zero PPV at year end. You would start the year in the negative and then watch its slope each week to project the end of year outcome. Our major tool was the Program Procurement Plan (PPP), wherein we forecasted requirements, quoted vendors and selected run rates to support production. The FY'75 process started in Sept. 1973 to provide standards for April 1, 1974 thru March 31, 1975. We combined similar devices to make it attractive for vendors. The biggest issue was always how many and at what rate did we need parts. The vendors would project learning curves based on volume and time. The assumption was always - no quality or technical issues and that our needs would not change, which was never the case. We attempted to spread the planning effort out over the total year but the numbers had to be submitted in October. If there were a major issue we had to justify and modify the standard during the year. The net favorable PPV over 13 years was $42.5 million.

MARK-UP

The cost of SCF was absorbed in a mark-up to the standard device cost and was earned with shipment to the plants. For the first two years it was 4% and thereafter was 6%. In 1985 when the demand disappeared the mark up was raised to 12% to help cover costs. The semiconductor portion of the box cost was valued using these standards and depending on the plant ranged from 5.3% to 22.1% [13.3% average] of the total box cost in 1981. If you throw in our delivery and quality responsibility, SCF had a major impact on each plants performance and therefore attended most of their quarterly reviews. If there was any problem with semiconductors, SCF wanted to be the best resource to solve it quickly. "Don't waste time finger pointing and looking for the guilty party". Their knowledge about the industry and the devices combined with the relationship with the vendors needed to be outstanding. Every performance parameter was watched and plotted continuously for SCF, the vendors and the plants, in an effort to catch or correct a trend. As a byproduct we had major insight into how the plants were running.

HERMETIC VERSUS MOLDED PACKAGES

During the last 5 years of the 70's the hermetic versus molded package debate was nonstop. The low cost and uniformity of molded was desired. The protection of the semiconductor surface was a challenge as was the impact of temperature change on the package materials. Terminology within the industry [vendor and customer] and the many experiments and process changes being evaluated everywhere resulted in too much information. The failure rate variation was very small so that identifying improvement was difficult. It also began to have a major impact on availability as the vendors switched over to molded packages. The customers were not convinced that there were no reliability problems. The military customer with their temperature extremes held out the longest. The analysis of failures in molded devices required a major improvement in failure analysis techniques and skills to get through the plastic without destroying the device. The vendors' improvements and demonstrated device reliability eventually led to molded everywhere.

WORK STOPPAGE IN ST. PAUL

The Union labor contract negotiations were to occur in St. Paul in June 1979 and about 1/3 of the SCF personnel belonged to the Union. Univac could not afford to interrupt the flow of semiconductors to the plants worldwide. SCF therefore duplicated their capability in a warehouse in Mt. View, CA and SCF WEST went into operation for the summer. The vendors' ship-to was changed to California and the Material Control and Quality functions moved there. Shipments to the plants were made with the assistance of the two corporate jets which were put at their disposal. The vote was to strike and negotiations continued into July before settlement. SCF returned to normal in Minneapolis in August 1979 after an outstanding effort to maintain the flow of semiconductors.

GOLD SURCHARGE

At the end of 1979 the cost of gold was $200 per ounce. It climbed rapidly to over $825 per ounce during 1980. The industry panicked since gold was inherent in most of the processing and setting a fixed device price was next to impossible. Working with each vendor the amount of gold per device was determined and separated from device cost. Each month the surcharge was negotiated separately for the device volume shipped. Gold settled back down to about $400 per ounce for the next 25 years. Gold was removed from most of the processes but the issue must have returned as gold climbed to $1,900 per ounce in 2011.

FORECASTING DEMAND

The projection of semiconductor requirements was always a high priority but it was becoming super critical as we approached the 1980's. In 1979 the semiconductor part number file had 7000 parts with the following different device commodity codes:

• IC or LSI Families	25
• Transistors-Switching & Power	30
• Diodes- Switching & Power	23
• Memory Types, not Bit Variations	14
TOTAL	92

There were 140 vendors or suppliers listed utilizing 183 package types.

It is interesting that even though the logic was converted to Gate Arrays for improved computing performance the rest of the hardware still used a lot of "STANDARD" devices. If the volume of a unique function became high enough, the industry would build it and we would use it. Almost every type of memory device and bit count was procured, but we did not do the programming of PROMS.

The total volume was climbing, the number of devices and their complexity were increasing, the number of locations was growing world-wide and the resultant impact on the bottom line was crucial. The SCF MAPPER system gathered the plants requirements based on their orders but a longer range look was necessary. Major coordination meetings were held with all locations in order to gather forecasts of systems and their use of semiconductors. The initial review by Roseville DPD was completed in June 1980 and showed requirements for FY81 thru FY86 for 13 products. The commodity codes were expanded to describe the newer technology devices.

In late Nov. 1980 we also added site representatives for our customers to aid in communicating. On the East coast at Blue Bell was William Roberts and on the West coast was Gary King at Mini-Computer Organization - MCO.

Even with the use of more complex logic and memory devices these reviews showed projected device volume would double in the next six years from 16 million to 35 million. There were 28 device families represented and only a few of the very old technologies declined. The actual shipments from SCF did continue to increase each year until 1985. Then the large-computer industry changed with the arrival of distributed processing and personal computers. Univac started closing plants worldwide and the SCF customer base disappeared with little warning leaving them with open orders and inventory. There is little documentation about 1985 and 1986 SCF activity. A comment in early February 1985 that “Univac needs only 10% of what is coming in this year” indicated the seriousness of the situation. The SCF mark-up was increased to 12% to help offset cost issues, but that only added to the plants problems.

Burroughs had set up a function called CEPO (Component Engineering and Procurement Organization) very similar to SCF in San Diego, CA. In 1986 when they purchased Univac and created Unisys, SCF was shut down and moved to San Diego. Memory devices went first and then the other parts and test equipment. Don Grittner retired and some Minneapolis people went to CEPO.

SEMICONDUCTOR CONTROL FACILITY – HISTORY

LIFE	13 years - established 1973 and dissolved in 1986.
SHIPMENTS	Ranged from $27M to $186M per year. Averaged $.5M to $3.8M per week. Productivity of $256K to $1,045K per person. Inventory level between $4M and $68M.
VOLUMES	77 million to 160 million pieces per year, total volume was 1.38 billion pieces. Volume by commodity yearly:

- Diodes 105M to 18M
- Transistors 35M to 5M
- IC's 25M to 72M
- LSI's 0 to 3.1M

QUALITY

Combined defect rate for all commodities improved from:

- 12% to 1500 parts per million (ppm).
- Over 60% of parts met 100 ppm.
- Over 1,200 qualifications performed- about 150 per year.
- Performed 168,000 Quality Verification Tests (QVT). Highest year was 18,600.

PROCUREMENTS

Ranged from $33M to $185M per year.
Total disbursed over 13 years was $900M.
Purchased Price Variance (PPV) ranged from a negative $7.7M to a positive $10.4M per year.
Net favorable PPV over 13 years was $42.5M.

MISC.

Started with 29 people- at year end ranged from 79 to179.
Space went from 14,000 to 35,000 sq.ft.

CASTING

Directors: Ev Bahre, Mike Svendsen, Don Grittner.
Procurement :Gene Jorgens, Wally Lyslo, Corky Roberts, Doug Tanner, Dick Brunsell, Bob Mattson.
Materiel: Gene Roeller, Bert Meuleners, Gary Martinson
Quality: Don Grittner, Dave Oines.
Controller: John Griffin, Bill Karnes, George Coons, Herb Blumentritt, Tom Karner.

OTHERS

Best in the Company.

SEMICONDUCTOR OPERATIONS

At the Sperry Univac Management Conference in October 1976 in Sea Pines, SC, the strategy concerning Large Scale Integration (LSI), semiconductors and microprocessors was presented by Ralph Kerler and Joe DiGiacomo. The top 90 Sperry Directors attended the panel discussion. The needs of the corporation were presented and the pros and cons of possible solutions discussed. The recommendations were:

1. Continue to develop in-house prototype/design facilities.
2. Buy standard product when competitively available.
3. Maximize potential for success by negotiating technology agreements with key vendors.

The acquiring of semiconductor technology had always been difficult and usually very expensive. For a long time the semiconductor industry feared Sperry Univac as a potential competitor and was very cautious about helping them to get started. In August 1968 we tried very hard to create a joint Emitter Coupled Logic (ECL) development program with TI, Motorola, and Fairchild with statements of work worth $100K each. The DPD need for the higher speed was delayed and DSD did not need speed, so the effort was delayed. It may have been naive to think that was enough money and that the three vendors would be willing to compete. Several meetings took place but no action resulted.

LSI LAB

DSD located in Eagan, MN was working in the early 70's with the Sperry Research Center in Sudbury, MA on the use of Metal Nitride Oxide Silicon (MNOS) for non-volatile memory devices. Sperry had started the process development in 1968 funded by the Department of Defense (DOD) and internal research money. The first application was for a 32K Block Oriented Random Access Memory for the All Application Digital Computer (AADC) {Editor's Note: The AADC became the Navy's AN/UYK-20.} By 1974 DSD was building MNOS devices in prototype quantities. A 6-chip set was built for use as a router in the Distributed Communications Processor (DCP-10) in Salt Lake City. The laboratory was staffed by DSD engineers with process support from Sudbury. DSD had invested $3 million of capital in the LSI Lab for photo mask, MOS wafer fabrication, and hybrid packaging and LSI test. Another $2 million was planned for bipolar fabrication by the end of 1977. Assembly capability was very limited and was mostly outsourced. An internal hybrid capability was created and used extensively.

DSD's first outside hire from the semiconductor industry was Howard Lawrence in mid-1975. Over time it became apparent that additional experienced semiconductor process engineers had to come from that industry. Ted Malanczuk for MOS and C.A. Ladas for BIPOLAR were hired in 1977. This was a very competitive environment and head hunters were necessary to stay aggressive on salaries and benefits. In 1979 Dr. J.C. Vesley was hired for his MOS/CMOS expertise.

The constant device and technology improvements put industry wide pressure on engineers, capital equipment, and management and it was a challenge to find, hire and retain the aggressive and knowledgeable people needed. This was especially true when business was good and the industry book to bill ratio was greater than 1.It was high reward and high pressure for everyone. Univac needed to make these investments to insure the best devices for their new hardware.

PHOTO MASK

The vendors had the device processing capability and Univac had the Computer Aided Design (CAD) skills. In 1975 an internal photo mask shop was created to bridge the gap from main frame computer circuit design to packaged integrated circuit chips. Univac's technical leadership in CAD was critical to this new operation. It was located in the Defense

Systems Eagan plant with Nick Garaffa from Roseville CAD as leader. Initially their masks supported Roseville machines but they soon would be used by Fairchild to build their devices to Univac's logic design. They supplied MNOS masks to the prototype MOS wafer fab in Eagan and when SO expanded into Bipolar processing, they provided those masks. The mask shop also supplied other corporate groups - Gyroscope, Flight, Sudbury and Blue Bell. They provided masks to RCA, Motorola, and CDC/Sea Gate. The Sea Gate masks were submicron technology for its flying head technology. They demonstrated their ability to provide competitive state of the art masks.

Some of their accomplishments from FY83 through FY87 were:

- Increased from 600 to 2,200 layers delivered
- Productivity doubled
- Turnaround time cut to 1/3rd
- Mask yield increased 50%
- Returned layers reduced by a factor of 10
- Revenue increased from $2.2 M to $5 M.

The mask shop was shut down in 1987 as part of the closing of the Twin Cities Semiconductor Operations.

SEMICONDUCTOR DIVISION

It became apparent in the late 1970's that the in house prototype lab was not adequate to meet internal military and commercial needs for both MOS and Bipolar technologies. The merchant vendors were still not interested in providing prototypes for the unique devices required for our advanced hardware.

At this time, of the top 50 electronic companies World-Wide; 1/3 were semiconductor vendors, 1/3 had captive semiconductor capability, and the remaining 1/3 had limited or no semiconductor expertise. The number of captives had increased rapidly over the last few years and some were entering the merchant market. The foreign competitors backed by government funding and policies were growing exponentially. Already 40% of the memory devices were coming from Japan.

A Blue Border proposal was submitted in December 1979 and approved in early 1980 for a $42 million 145,000 sq. ft. semiconductor facility to be built adjacent to Plant 8 in Eagan, MN. This document is missing. It was a comprehensive review of the industry and the justification for Sperry to enter this arena after many years as a customer.

The Semiconductor Division (SD) was created in March 1980 with Robert A. Erickson as V.P. reporting to Paul J. Spillane, President of Sperry Univac's Product Division. The mission statement for the Semiconductor Operation (SO) was "Provide for early availability of essential semiconductor technology for the Sperry design centers and manufacture cost effective unique and proprietary devices to enhance product differentiation in the marketplace". The challenge would prove to be formidable especially to be cost effective at the relatively low volumes needed within Univac and the Sperry Corporation. The ground breaking for the new facility was on October 28, 1980.

With the creation of the new division, SCF now reported to SD instead of Philadelphia and the SCF Directors office was moved to Eagan in April 1981. SCF operations remained in Minneapolis. SCF was also given the responsibility for the quality of product from SO.

An overview of the new Semiconductor Division was presented to the Sperry Univac Board of Directors in July 1981. The presenters - R.J. Kerler, Dr. J.C. Vesley, D.L. Kirkwood, C.L. Church, C.A. Ladas, and B.N. Svendsen covered Process Technology, Design Tools, Device Development, Production Requirements, and Industry Status. There was strong endorsement and wide support from the Board, but also an understanding of the challenge. In August 1981 B.N. Svendsen left SCF and became the Director of Bipolar Operations. Donald A. Grittner became Director of SCF.

The next 2 years involved constant pressure to meet the increasing commitments to our customers, build the new building, select and install state of-the-art processing equipment, buildup and retain manpower and continue to improve processes. We lacked the expertise and volumes to optimize the transition from prototype to production and thereby reduce the cost per function on the chips. It also became apparent that the need for more highly specialized capital equipment was driving the costs up. The new facility was occupied in May 1983.

Management concern about SD performance resulted in an outside consultant being hired in July 1983. David C. Turcotte of Rydell Associates spent several weeks reviewing the SO operation. Those reviews and his feedback to D.R. Neddenriep - Group VP of Product Division- resulted in the reassignment of R.E. Erickson. D.C. Turcotte became VP of SD on October 27, 1983. B.N. Svendsen left for a sales opportunity at Motorola. Paul Davis was hired from the industry on March 12, 1984 as Director of Bipolar Operations.

It is difficult to summarize the overwhelming technical and business challenges within SO. By 1985 there were 9 MOS and 5 BIPOLAR technology families developing and producing gate arrays and standard cells for customers across the corporation. This also required an extensive packaging effort for the increasingly more complex devices. Initially the logic designs came from Roseville, Salt Lake City, DSD, and Sperry Flight; but interest was growing across the corporation. The front end engineering support was huge and the volumes were small. There was no sales force and the operational people were doing double-duty. There was no corporate directive to use SO, so they competed directly with merchants. All the customers wanted the state of the art device which is coming and under development. There were over 30 projects in process and the customer list now included 10 locations. Semiconductor Operations also pursued second source and foundry agreements with the industry as protection against a catastrophe.

The corporation had invested almost $200 million in SO and it was costing $100 million a year to operate. The revenue projections at best were $50 to $70 million. They had shipped 544k devices worth $49 million in FY85. None of the Sperry programs had the necessary volume of 10k to 100 k devices per year to provide a solid financial base. The merchant competition had demonstrated a learning curve that doubles the complexity every 2 years with the device cost staying the same. SO couldn't make it up with volume. The headcount in SO rose rapidly to 500 in April 1983 and reached a peak of almost 1400 by January 1985.

THOMAS GROUP AUDIT REPORT

The cost and performance pressure continued to build on SO. The Thomas Group Inc. was hired In August 1985 to analyze the circumstances at SO, present findings and conclusions, and where appropriate, recommend action that would reduce the deficit at SO. "Is Sperry getting its money's worth from SO?" The 118 page document compares SO with the industry in technology, capacity and financial parameters.

In technology - "SO has reached parity with the merchant market in both MOS and BIPOLAR but the cost of maintaining it or even pulling ahead of the competition may be prohibitive. As a captive supplier SO may have difficulty achieving and maintaining the production volumes and cycle times required to achieve the required number of cycles of learning to establish a competitive manufacturing technology."

There was excess capacity - "2 to 4 times the demand over the next 5 years with the resultant under absorption. Doing both MOS and Bipolar along with development at the same time is difficult. It is the poorest FAB performance TGI has seen."

SO was spending $104 million per year with total revenue of only $73 million. The financial reporting system needed improvement with better standard costs and tracking like a semiconductor manufacturer.

They also looked at the organization and compared it to the industry. They presented areas of consolidation by function as well as pulling the two technologies together.

The following alternatives were discussed but shutdown was recommended:

1. Operations remain as is with greatly improved spending controls - NO!

   With the annual spending of only $100 million the industry will pass you by. The capital needed to keep up is huge.

2. Operation stays the same size but get outside business - NO!

   It is a major distraction and the competition is fierce. Semiconductor Operations even created a business plan for a NEWCO.

3. Substantial downsizing of greater than 20% - with 1185 people the reorganization of the 2 technologies will lead to loss of key people - NO!

4. Discontinue operations and return to merchant market- DO IT!

From that point on it was apparent that the end was inevitable and the focus was on cost reduction, internal reassignments and gradual layoffs. The headcount had dropped to 812 by February 1987.

UNISYS

In June 1986, when Univac was purchased by Burroughs, it became UNISYS. There were now two semiconductor facilities - Eagan, MN and Ranch Bernardo, CA. Both had MOS capability while Eagan also had bipolar skills. Motorola and Intel had been involved with Rancho Bernardo while Eagan had developed their technologies on their own with some early help from Sperry Research. The facilities began a run off competition to build a MOS gate array, but the decision to shutter Eagan was mostly financial and the result of the huge tax benefit for the acquiring corporation-Burroughs.

The closing was announced on February 6, 1987 with a planned eleven months to shut down. A reducing workforce led by D.L. Kirkwood did an outstanding job of meeting device commitments for lifetime buys for 17 products. Most of the process engineers hired from the industry were able to return with promotions. The actual shutter date was December 11, 1987. The building was vacant for almost 3 years and finally sold to NWA for $6 .6 million in Oct. 1991. NWA then spent $20 million converting it into their computer center.

RISE and FALL of SEMICONDUCTOR OPERATIONS

Semiconductor Division Established	March 1980
Blue Border for New Facility Approved $42 M	April 1980
Let Design Contract and Long Lead-time Capital	2Q1980
Ground Breaking	Oct. 1980
Facility Construction Done and Moving In	May 1983
<u>Qualify Facility</u>	
First Production Devices Shipped	1Q1984
Operational Audit by Thomas Group	3Q1985
Possible Sale for $160 Million Falls Through	1985
Burroughs Purchase of Univac - Becomes UNISYS	June 1986
Announcement of Facility Closing in 11 months	Feb.1987
Shutter Production Facility	Dec. 1987

Put Up for Sale- $25 Million	June 1988
Dismantled Equipment	Late 1988
NWA Purchased for Computer Center ($6.6 Mil)	Oct. 1991

SEMICONDUCTOR COMPLEXITY TIMELINE

Description	# of Equiv. Gates	Chip Size	Year
Discrete-Diodes & Transistors	1		1950
IC-SSI- Small Scale Integration	1 to 10	50 x 50 mil	1960
IC-MSI-Medium Scale Integration	11 to100	100 x 100 mil	1968
IC-LSI-Large Scale Integration	101 to 1000	125 x 125 mil	1974
Gate Array* (GA)	~ 350	100 on 2" wafer	1977
IC-VLSI-Very Large Scale Integration	>1000	250 x 250 mil	1978
WSI-Wafer Scale Integration- Trilogy**		Total Wafer	1983
Standard Cell			1989
GA-Gate Array	9000		1992
Sea of Gate Arrays***	318,000	15x15 mil	1993

*A unique chip with 2 layers of metal connecting a common set of transistors/resistors

**Leave logic functions on a complete wafer and connect those avoiding defects) (Library design is not limited to fixed transistor size or placement. Ten layers of metal interconnect rather than just 2)

***Combination of Standard Cell Design and Gate Array Fabrication

DATA PRODUCTS DIVISION (DPD)

Semiconductor and commercial computer technology fed off of each other. The rate of change was phenomenal and led to tremendous improvements in performance at reduced cost. The challenge was to stay ahead of your competition and get to market first. The computer development time was longer than the time it took to create the next generation of semiconductors. The pace never slackened and the competition was fierce in both industries. Univac was a leader in the design systems for back panel and PC board interconnection of gates while the semiconductor industries were specialists in the processing needed to create the gates. To be successful each had to learn more about the others' skills. Although the LSI needs across the corporation are diverse, they have many important similarities. Over half the time and cost of custom circuits was in the front end design and that was not the strength of the semiconductor vendor or his desired use of resources. Sperry needed to be able to handle the logic on semiconductors in the same manner it was presently done on printed circuit boards. This required Univac to develop expertise in semiconductors and in the interface of their design tools with the semiconductor industry. This activity was also very beneficial to the semiconductor vendors who would learn about Univac's Computer Aided Design tools.

INDUSTRY PARTNERS

During 1975 the DPD system studies showed a need for a significant performance improvement for the1100/90 with its planned delivery in 1983 [8 years.] Univac was concerned that the semiconductor industry was more interested in high complexity CMOS than very high performance logic we needed. An agreement was made with Tom Longo and Fairchild to obtain their ECL mask design rules, which would allow Univac to do a complete design of the LSI chips for the 1100 architecture. This would include the diffusion set, mask set and Univac Printed Circuit (PC) boards. This effort was handled by DPD-Roseville with no involvement of SCF. The speed of ECL led to the need for precision multilayer boards and back panel technology with controlled impedance. Fairchild would manufacture the chips on their standard process. By the middle of 1977 the basic chip designs were complete and the first test parts received in early 1978. There were about 100 devices on a 2" wafer. The chips were assembled into a dense custom package.

Univac started a major evaluation of Trilogy's wafer scale integration in June of 1983 with an option to license the technology for design and manufacture. It was determined by 1985 that the implied cost and performance goals could not be met and the manufacturing risks were high. Electronic News (EN) reported that after spending $50 million, Univac was aborting the effort with a substantial write-off.

In July 1986 EN reported that Hitachi would co-develop Sperry's next generation of Central Processor Units (CPU), both subassemblies and circuits. A fast response by Unisys was necessary because of the time lost evaluating Trilogy. This is just 7 months before the announcement that SO is closing. Unisys mapped the 2200 Processor System Design to Hitachi's high performance ECL gate array and their compatible PC boards. The package was a 54 pin on 50 mil centers requiring liquid cooling. This was different than the earlier agreement with Fairchild in which Unisys did the complete design and build of the gate array diffusion set, related mask sets and the PC boards.

During the 1990s the Univac 2200, A and V Series computers were ranked 1, 2 and 3 in computer reliability in the US. The high performance semiconductors in these systems were designed by Ranch Bernardo engineers using Motorola process and design rules. The Ranch Bernardo fabrication shop made the prototypes and pre-production devices and Motorola built the production semiconductors.

According to EN [2/3/92] Unisys entered into an agreement with Motorola under which Motorola would take over the production of both existing and future custom CMOS and Bi-CMOS circuits. The deal includes joint development of future process and design technologies. Unisys would phase out its CMOS and Bipolar fabrication lines in Rancho Bernardo, CA over the next two years. All CMOS and Bi-CMOS circuits currently being made there would be transferred to Motorola. The estimated value was $15 million per year. The small amount of Bipolar would simply go out of production. James Unruh, Unisys Chairman and CEO stated: “The alliance confirms our commitment to focus our resources where we add unique value and team with industry leaders in other disciplines.”

SEMICONDUCTORS in 1100/2200 SYSTEMS

The following provides a timeline and highlights the semiconductor technology utilized in the Univac 1100/2200 Systems. Most of the information comes from R.J. ‘Dick’ Petschauer paper “History and Evolution of 1100/2200 Mainframe Technology” presented at the Fall 1990 USE Inc. Conference in Seattle, WA.

DATE	SYSTEM	QUANTITY	SEMICONDUCTOR CONTENT	
			LOGIC	MEMORY
1962	1107 & 490	38 & 60	Germanium Diodes & Transistors	Thin film & Core
1965	1108	1000 by Nov. 1979	Silicon Diodes & Transistors	Core & Semiconductor
1969	1106			All Semiconductor 1K MOS
1972	1110	>400	TTL 16 pin Dip	Last to Use Magnetic Main Memory- Later Replaced with Semi-Conductor Memories
1975	1100/10, 20	1000		1106, 08 & 010 Upgraded with Semi-Conductor Memories
1976	1100/80	>1000	ECL 16 pin Dip 1000	4K then16K MOS
	First System with Controlled Impedance PC Cards & Multilayer Packages In December 1976 the 1100th 1100 System was shipped.			
1979	1100/60 & 70 “Vanguard”	4000	ECL chips in 36 bit Microprocessor	4K then16K MOS
1983	1100/90“Cirru	1200	350 gates ECL-54 pins 90% LSI with 2000 LSI (40 Types) & 4000 MSI Devices FAIRCHILD	64K MOS
1984	System 11 “Chaparral” “Mapper 10”	100% LSI for Logic	1000 Gates - .25x.25 chip 1.4 x 1.4 in. Package 45 Types	256KMOS
1985	“Trilogy”- Did not work technically and cost performance goals not met.			
1986	2200/200 “Swift”	1000	CMOS VLSI- 6 chips averaging Over 100k transistors-.375x.375 224 lead 2in.x 2in. package	
	Basic MICRO 1100 CMOS Chip Set Was 4 Parts that Performed All 1100 Functions. M -1 Chip Set Added 2 devices			
1988	2200/600		ECL VLSI -300 unique GA with 2500 gates of logic- 850 LSI Types	

DATE	SYSTEM	QUANTITY	SEMICONDUCTOR CONTENT	
			LOGIC	MEMORY
1989	200/400 "Centurion" (ECL) "Liberty" (CMOS)	>1000	MICRO 1100 Chip Set became M - 2 with 9 Circuits & Doubled Speed MOTOROLA	1 MEGABIT
1990	2200/100		M -1 Chip Set	
1990	2200/600ES 1100/90 follow-on		I/O Uses CMOS of 2200/400	
1992	2200/900 Series A16/A1		4 Gate Array Diffusion Sets All on Motorola ECL Product Lines-9000 Logic Element GA	4 MEGABIT
1993	2200/500		CMOS Sea of Gates-318,000 Equiv. Gates on Motorola H4C Process-7 GA with RAM	16 MEGABIT

There are extremely detailed shadow boxes in the Unisys Roseville, MN facility depicting the logic, storage and interconnection methods for the 16 Univac Computer Systems built from1955 to 1996. There are also 7 shadow boxes showing Engineering highlights for FY'79 thru FY'84. Each of these large displays has hardware examples, detailed descriptions and photographs of the artifacts. It is an impressive overview of Univac-DPD's technology.

In 1990 SCF reappeared in Unisys but this time it was the System Control Facility for the 2200/900 and had little to do with semiconductors. The SCF Console supported many functions ranging from basic operator control to system maintenance, environmental monitoring, configuration management and unattended operation. A very close working relationship was required between the support, software and hardware engineers to develop this system.

DEFENSE SYSTEMS DIVISION (DSD)

After WWII and into the 1950s the utilization of computers in the military increased. The first all transistor computer built by Sperry was the Athena missile guidance system designed for the Air Force in 1956-1957 with 26 built. The emphasis then turned to smaller size, lighter weight and lower power. The vacuum tube computers could not meet those needs and the semiconductor technology showed great promise. The volumes required for military contracts and their ability to help pay for development induced most semiconductor manufacturers to support these activities. The quality and reliability testing and evaluations were beneficial to both customer and manufacturer.

DSD was part of the initial semiconductor coordinating activities within Univac, but in 1969 they returned to negotiating their own contracts and handling all aspects of acquiring semiconductors. This was mainly due to their customers' requirements.

There is very little discussion herein about diode and transistor activity at DSD, but they used standard devices in the majority of their applications.

LOGIC

In late 1962 the CP667 computer was designed with multiple chip microcircuits from Motorola – an intermediate step before integrated circuits. There were 8 devices containing active and passive chips assembled onto a 10 pin TO-5 transistor header which was hermetically sealed. The devices were to be Qualified and Acceptance tested to full Military Specifications and Motorola planned to sell them as such. The assembly and test issues were never fully resolved and even though we made three computer systems, it was neither cost effective nor reliable enough to continue.

The initial integrated circuit design was the special circuits for MMRBM in early 1963. DSD developed this first IC family of 15 circuits [6 DTL for logic, 7 for memory and 2 for Input/Output.] They were manufactured by Westinghouse and Raytheon. Seventy-five systems were built for the Air Force Aerospace programs - 1824, Titan III, MMRBM, and SABRE. Westinghouse also created a standard family [800 Series] with military specifications.

In December 1964, two high speed custom DTL circuits were specified to provide IC logic for the next generation of systems with both a Military and Commercial test temperature version and in a variety of packages. The reliability and quality specifications were the same. Development contracts were given to 5 vendors - Westinghouse, Motorola, Signetics, Texas Instrument, and Fairchild for a quad 2 input NAND and a dual 4 input NAND. Samples were received in March 1965. Westinghouse devices were okay and Motorola and Signetics were marginal. The others failed. Each vendor had utilized their technology to implement the functions and all were different. Papers by Ralph J. Kerler and Larry D. Bolton relate the challenges of developing and sustaining qualification of a unique design in this rapidly changing high technology environment. The government and military customers were not interested in new technology after they had completed field and sea qualifications of a system. They had maintenance and logistic pipelines to maintain with training and spares and they wanted no change. The vendor base, however, was ever changing as they closed facilities, ran out of capacity, increased wafer size, or modified or obsolete technologies. Motorola, Raytheon, National, and Fairchild also supplied these devices during the life of the family. In 1994 a last time buy was made. Lansdale has acquired the rights to the Fairchild design if more are needed. Standardization paid off with millions of devices supplied to Univac DSD resulting in extremely reliable computer systems for the military. These were the only custom logic IC's to be used jointly by military and commercial. The commercial use was very short lived [490 System] as DPD pursued speed and system performance with custom arrays.

In August 1965 the DSD Standardization Group published a chart of "available" IC families. The devices had extended temperature ranges in 10 and 14 lead flat packages with limited speed and electrical characteristics shown. The vendors were Westinghouse, Raytheon, Signetics, Motorola, TI, Fairchild, and Sylvania using DTL, TTL, RTL and ECL technologies.

In August 1965 V.E. 'Val' Herzfeld and G.G. 'Gerry' Probst created a DPD/DSD task force led by George Raymond to select a single Univac Standard IC. They evaluated the physical, electrical and logical characteristics along with the procurement and Univac experience of 5 device families [DTL, DTTL, TTL-series 54, TTL-SUHLII and CTL.] They also compared the vendors who built them. In November 1965 they recommended standardizing on 2 families, DTTL for the peripheral equipment and DTL for applications requiring higher speed. DSD would use the two DTL Standard devices for over 30 years. The Task Force detail reports provide an important and detailed snap shot of the IC industry in 1965. It also showed the computer criteria that were important in selecting an IC.

In order to get early computers to run reliably over a wide temperature range and to optimize performance, electrical characteristics of diodes and transistors were tightly controlled and tested for at the vendor and in receiving inspection. The vendors' standard products usually did not meet our needs or varied between vendors. This practice continued with the early ICs until 1970s when the market finally settled on families of devices which were designed for common digital and linear applications and were specified and tested as such. This standardization also helped create multiple sources.

Samples from multiple vendors were subjected to a battery of electrical and environmental tests for qualification. Initially all devices were tested, but when the volume increased, they were grouped for testing into families based on technology or assembly location. The environmental lot acceptance tests and burn-in were performed to assure reliable processing of each lot shipped. These quality and reliability programs implemented by Univac at the beginning had positive results. In March of 1981 the Navy did a Fleet wide assessment of Univac's tactical computer reliability with the following MTBF results: CP642@ 4,128 hours, AN/UYK-7@ 2,528 hours and AN/UYK20@ 12,096 hours.

During the 1970's the vendors started to move packaging and even wafer assembly to off-shore facilities, initially to Mexico and then to the Far East. The U.S. Government was very concerned about their semiconductor sources being dependent on foreign factories.

MIL-SPECIFICATIONS

The Military created MIL-M-38510 to define requirements for devices that were fully qualified by the Defense Electronic Supply Command (DESC). These devices were defined on military detail specifications [slash sheets.] Military contractors had to justify why they could not use these devices. DSD needed state of the art devices and could not use these older technology parts that were qualified. The DSD SB specifications mirrored the military specification in many ways but only required that devices be equivalent to MIL-STD-883-Class C or Class B. This included screening and quality conformance sampling but not qualification. Vendors offered many more devices as Class B. Most DSD devices were procured as MIL-STD-883, Class B as specified by SB213 or SB222. This continued into the mid-1990s when DSD converted to mostly Commercially Available Off-The-Shelf "COTS" devices.

The product had also greatly improved in quality. By the 1980's the vendors' internal quality programs and defect levels had improved to the point where it was deemed unnecessary to qualify each device and shipment. It was assumed that the devices met the vendor data sheet. It had become impossible and too costly to verify the quality of every device shipped. DSD was a contributor to the standardization of testing procedures thru the Electronic Industries Association (EIA) G-12 subcommittee of Defense Contractors.

APPLICATION SPECIFIC ICs (ASIC)

The first DSD Gate Array (GA) was a 112 gate I/O device from Fairchild for the AN/UYK-20/ATC. It was followed by a 132 gate dual I/O device from IMI for the same program. The GA's were programmed with a custom mask for the metal interconnection.

Two gate arrays were developed by the Semiconductor Operations for DSD. They were both about 1300 gate capacity using Schottky bipolar for the AN/UYK-43 computer and using CMOS for the AN/UYK-44 computer. It was a device similar to that used in DPD for Chaparral. When SO shut down in 1987 a lifetime build was made for both. An effort was made to get a merchant to build the 20 bipolar devices. Raytheon agreed but it was not long before they also stopped production of this old process. At this point all devices were converted to a compatible CMOS gate array built by LSI Logic at a cost of almost $100,000 per function. The semiconductor process technology was advancing at a very fast rate and the vendors were not interested in wasting effort on an old process. LSI wanted to upgrade every few years at our expense which was not acceptable and again lifetime buys were made.

Over 125 ASICs were designed by DSD and they usually required several modifications to meet system requirements. Most were gate arrays with some macro cell arrays and a few totally custom. The largest was a 354K gate, 60K RAM gate array in a 596 BGA package developed in early 2000s.

With the long duration of defense programs, Univac and the government could not tolerate the need to update and change design every few years. The lifetime buys were not an answer because the forecasted demand was never accurate.

Shortly after the development of the bipolar fusible link PROMS, Monolithic Memories developed a series of programmable logic elements called PALS. Device complexity increased to where Atmel, Xilinx, and Altera had devices large enough to compete with gate arrays. Some were RAM based and were reloaded every time power was applied and others EPROM or EEPROM based. The use of mask programmed gate arrays stopped in favor of user programmable devices.

The need to put different technologies into a single package led to hybrids and the creation of the facility in DSD. They designed and built hundreds of line drivers as well as fiber optical transmitters and receivers.

The first memory device used was a bipolar 16 bit memory cell developed for Univac in 1960's and was followed by 64 bit. As the SRAM and Dram density doubled every couple of years Univac would design them in. The need for performance and lower cost could always be utilized. The first programmable device was a 512 bit bipolar PROM. Initially they were programmed by electrically blowing a fuse for each bit. Those fuses were not always equal and would grow back. A high temperature burn-in was performed after programming and the program rechecked. These bipolar PROMS were used up to 64K bit density on the AN/UYK-43 and AN/UYK-44. After that we switched to CMOS EPROM and EEPROM devices which had no fuses but relied on small electrical charges stored on floating gates. Today FLASH EEPROMS are used.

PACKAGING

The early devices were in hermetic flat packs with 10 or 14 leads and later in hermetic Dual-in-Line (DIP) packages. The AN/UYK-44 was the first to use a Leadless Chip Carrier (LCC) surface mounted package with up to 84 pins on a ceramic substrate card. The AN/UYK-43 gate arrays were in 139 pin Pin-Grid- Array (PBGA) packages soldered thru holes in a PC board. In the 1990's a Ball-Grid-Array (BGA) was used with pin counts over 500.

From 1971 until 1987 the Hybrid Assembly Operation utilized every possible interconnection scheme as the technologies shrunk and the pin count went up. Whenever different technologies were needed in a single package, they did the assembly. They did the prototyping of gate arrays but production went off-shore to Kyocera or Annam.

Prior to 1990 almost all the semiconductors DSD used were in hermetic packages with temperature ranges of -55C to +125C and were individually burned-in prior to use. Each device was fully electrically tested to specified requirements. In 1994 Mr. Perry of the Department of Defense directed that all future Defense equipment be designed using commercially available off-the-shelf (COTS) devices. The COTS directive supposedly resulted from publicity about $1,000 toilet seats built to military specifications. There were many interpretations of COTS: from no special requirements beyond vendors' data sheet to plastic packaged devices with 0C to 70C characteristics. The vendors were quick to support the approach and discontinued devices with military ratings. It even resulted in DSD offering a lower cost AN/UYK-43 with plastic commercial devices.

FINAL MINNESOTA CHAPTER

On November 18, 2010 Lockheed Martin announced that the Eagan, MN ‘DSD’ facility would be phased out and closed by 2013. That has now happened, many history documents were transferred to the Charles Babbage Institute. Some hardware artifacts have been transferred to the Dakota County Historical Society’s Lawshe Museum.

ACKNOWLEDGEMENTS

During 60 years, semiconductor technology has gone from a single gate to over a half million equivalent gates in a device, with no end in sight. Gordon Moore’s prediction was right on. Univac has been involved in all aspects of the technologies growth and contributed significantly to its becoming a mature industry. It was very exciting and rewarding to be involved and I hope this has given the readers an overview of the Univac participation.

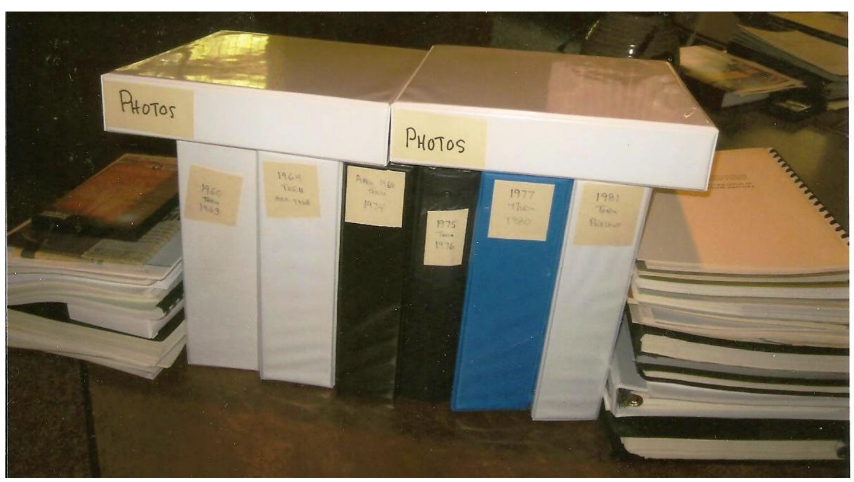
I want to thank the following people for being part of the story and for their help in gathering and presenting information: Lowell Benson, Larry Bolton, Ralph Kerler, Dave Kirkwood, and Dick Petschauer. I also would like to pay tribute to all those people at Univac and our vendors who helped make semiconductors one of the major technologies of the century. It is amazing that semiconductors are this successful considering their shaky beginning.

I have compiled over 600 documents, memos, presentations, and actions from this time period which are listed in Appendix A. They will be archived along with this document at the Charles Babbage Institute at the University of Minnesota.

Bernard N. “Mike” Svendsen.

Appendix A -

Semiconductor references are stored at Charles Babbage Institute, University of Minnesota – and not copied as a part of this on-line paper.



LEXICON

AC Alternating Current
ASP Average Selling Price
CAD Computer Aided Design
CEPO Component Engineering and Procurement Organization
CMOS Complementary Metal-Oxide Silicon
COTS Commercial off the Shelf
CP Coordinated Procurement
CPU Central Processing Unit
D. C. District of Columbia
DC Direct Current
DCP-10 Distributed Communications Processor
DDA Drawing Departure Authorization
DESC Defense Electronic Supply Command
DIP Dual-in-Line
DOD Department of Defense
DPD Data Products Division
DSD Defense Systems Division
DTL Diode Transistor Logic
ECL Emitter Coupled Logic
EIA Electronic Industries Association
EN Electronic News
ERA Engineering Research Associates
FA Failure Analysis
FSD Federal Systems Division
GA Gate Array
IC Integrated Circuit
ISS Integrated Storage Systems
IT Information Technology
LAT Lot Acceptance Testing
LCC Leadless Chip Carrier
LSI Large Scale Integration
MNOS Metal Nitride Oxide Silicon
MTBF Mean Time before Failure
NTDS Naval Tactical Data Systems
NWA Northwest Airlines
PC Printed Circuit [boards]
PPP Program Procurement Plan
PPV Purchase Price Variance
QVT Quality Verification Test
R & D Research and Development
RRU Remington Rand Univac
SCF Semiconductor Control Facility
SSD Sperry Semiconductor Division
TI Texas Instruments, Inc.
US United States
WWII World War Two