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BEST MANUFACTURING PRACTICES

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REPORT OF SURVEY
CONDUCTED AT

CONTROL DATA CORPORATION
GOVERNMENT SYSTEMS DIVISION
MINNEAPOLIS, MN

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DECEMBER 1986

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REPORT OF SURVEY

CONDUCTED AT

CONTROL DATA CORPORATION

GOVERNMENT SYSTEMS GROUP

MINNEAPOLIS, MN

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I. INTRODUCTION

A. Scope

The purpose of the Best Manufacturing Practices (BMP) Review conducted at Control Data Corporation, Government Systems Division, was to identify best practices, review manufacturing problems and document the results. The intent is to extend the use of high technology equipment and processes throughout industry. The ultimate goal is to strengthen the U.S. industrial base, solve manufacturing problems, improve quality and reliability, and reduce the cost of defense systems.

To accomplish this, a team of Navy engineers reviewed Control Data's Government Systems Operation in Bloomington, Minnesota to identify the most advanced manufacturing processes and techniques used in that facility. Manufacturing problems that had the potential of being industry wide problems were also reviewed and documented for further investigation in future BMP reviews. Demonstrated industry wide problems will be submitted to the Navy's Electronics Manufacturing Productivity Facility for investigation of alternatives to resolve the problems.

The review was conducted on 2-5 December 1986 by a team of Navy personnel identified on page 2 of this report. Control Data, Government Systems is primarily engaged in the design, development, and production of sophisticated electronic information processing systems for ships, ground stations, aircraft, and space vehicles.

Based on the results of BMP reviews, a baseline is being established from which a data base will be developed to track best practices and manufacturing problems. The information gathered will be available for dissemination through an easily accessible central computer. The actual exchange of detailed data will be between contractors at their discretion.

The results of this review should not be used to rate Control Data among other defense electronics contractors. A contractor's willingness to participate in the BMP program and the results of a survey have no bearing on one contractor's performance over another's. The documentation in this report and other BMP reports is not intended to be all inclusive of a contractor's best practices or problems. Only selected non-proprietary practices are reviewed and documented by the BMP survey team.

B. Review Process

This review was performed under the general survey plan guidelines established by The Department of the Navy. The review concentrated on three major functional areas: management, design engineering and manufacturing. Control Data identified potential best practices and potential industry wide problems. These practices and problems and other areas of interest identified were discussed, reviewed, and documented for dissemination throughout the U.S. industrial base.

C. BMP REVIEW TEAM

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II. SUMMARY

The Best Manufacturing Practices Survey Team evaluated management, design and manufacturing functions. Areas reviewed included Control Data's management philosophies and strategy, design and production engineering, multi-layer operation, receiving inspection, facilities, integrated testing, quality assurance, material handling, inventory control, computer aided manufacturing, and vendor selection and control. The team also discussed manufacturing problems such as vendor quality control, WS 6536 training, and electronic component standardization.

The format for this survey consisted of formal briefings and discussions on best practices and problems. Time was spent on the factory floor reviewing practices, processes and equipment. In-depth discussions were conducted to document, in detail, some of the practices and problems identified.

Several design practices reviewed were considered among the best in the electronics industry. In particular, the approach Control Data has taken to do-it-right-the-first-time by developing design guidelines that incorporate not only the requirements, but also lessons learned from previous design efforts is considered a best practices and complies with DoD 4245.7-M. The practice of collocating design and manufacturing engineering personnel provides Control Data early input in the design process while it is still relatively easy to change the design. This practice fosters cross-training of engineers.

Control Data has taken advantage of computer aided design tools in the areas of design simulation and automated generation of process sheets. This has helped improve design for producibility. To close the loop and assure maximum input, Control Data has established a team approach to design reviews. Manufacturing, engineering, and quality assurance have equal sign-off authority in the design review process.

Environmental stress screening, Just-In-Time (JIT) manufacturing, and the Total Quality Management Process (TQMP) are key ingredients to Control Data's improved production process. Stress screening 100% of all electrical components has reduced the failure rate from 4% to .2%. JIT has been very helpful in rapid problem identification and has resulted in a 33% productivity improvement. Control Data considers TQMP to be the biggest driving force in quality and productivity improvements. TQMP has the total company commitment to improve the quality of the product and to conform to the customer's requirements.

The volume of production at Control Data, Government Systems does not justify total automation. However, automation has been integrated into key inspection, manufacturing, and assembly areas. Automated optical inspection and robotic pick and place are two best practice applications documented in this report. Control Data is also considered to be one of the leaders in artificial intelligence and has a captive integrated circuit foundry featuring Tempest shielding and submicron sizes.

Employee problem solving teams and an employee advisory resource staff are two best practices utilized by Control Data's management. They have also developed automated data tracking and collection systems to better manage the overall facility. Their computer integrated manufacturing plan provides a foundation for current and future company investments and improvements. This system will include cost estimating, material requirement planning, production control, technical data and configuration management, artificial intelligence, and operations research.

Most of the problems identified by Control Data are similar to those identified by other companies surveyed by the BMP team; i.e., component solderability, cleaning under leadless chip carriers, design change approval cycle, part marking permanency, WS 6536 training, and field performance feedback.

The best manufacturing practices and problems identified at Control Data will be evaluated and reviewed by the Navy team during future BMP surveys. Those practices identified as being among the best in the electronics industry will be documented in a central data base for dissemination throughout the industrial base. Industry wide problems will be investigated by the Navy in an effort to develop alternatives for their resolution.

III. BEST PRACTICES

The practices listed in this section are those identified by the Navy BMP survey team as having the potential of being among the best in the electronics industry. This judgment is based on experience from previous BMP surveys and expertise gained by team members through years of working relationships with industry.

A. Design

MECHANICAL DESIGN GUIDELINES

Control Data is in the process of developing mechanical design guidelines. The guidelines resulted from a TQMP (Total Quality Management Process) recommendation for reducing the number of mechanical design errors (engineering change orders) and to produce more consistent design quality. The document enables mechanical engineers to do-it-right-the-first-time. It is a formal framework for a disciplined design process as well as a training curriculum for new engineers and a method to beef up design reviews and to document corporate knowledge.

A sample of key sections are:

- Design process
- Aerospace specifications and standards
- Component/material selection
- Human factors
- Mechanical tolerancing
- Product assurance
- Reliability and maintainability
- PCB design and documentation
- Thermal
- Structural
- Manual and automated assembly
- Electromagnetic interference(EMI)/Radio frequency interference (RFI)
- Mechanical computer aided design (MCAD)
- Test
- Finishes

New sections are to be added to cover other necessary topics. Sections are authored by field experts and reviewed by peers, managers, and consultants. Revisions are made the third quarter of each year following a training session for new mechanical engineers.

Collocation Of Engineering Personnel

Control Data has a policy in place to collocate manufacturing engineering personnel and procurement and software specialists with the design engineering group on all new programs. Mid-level personnel are assigned to the design team and act as points of contact for their organizations.

Since, it is more difficult to change a design once it is finalized, this procedure enhances the opportunity for other organizations to effect changes before the design is firmed up. The primary benefit, according to Control Data, is that manufacturing engineering and other input is provided very early in the design process while it is relatively easy to change the design.

This procedure has been observed by the team at other firms. The consensus is that it is an effective method for ensuring producibility and testability.

ENGINEERING CAREER ENHANCEMENT

Control Data has initiated a formal program titled "Engineering Career Enhancement" that provides engineers with cross-training between its engineering and manufacturing departments. In this program, which was implemented in 1986, engineers are "traded" between departments on a one-for-one basis for a period of 15-18 months. During this period, they are monitored by the human resources department to assure timely return to their original departments. The program is voluntary and involves engineering interns, new hires (after nine months), and experienced engineers. The qualifications of candidates and directions for administering this program are contained in a policy and procedure letter. The intent of this program is to broaden the experience base of the design and manufacturing organizations by cross-training and to improve communications and cooperation between these organizations. This should result in developing higher quality products and processes in less time and at lower cost.

DESIGN TOOLS AND SIMULATION

There are various integrated design tools and simulation packages which enable design engineering to produce quality designs utilizing VLSI technology. The architecture simulation packages, written in N.2, enable verification of the design of all parts of a module. Placement and routing of the integrated circuit is also done at the workstation with the tests being created automatically. Final masks are given to the integrated circuit foundry in tape format.

Simulation and verification of the module design can be accomplished on both the firmware and gate hardware. For the firmware simulation, the design is verified through execution of the complete instruction set. At the gate level, the hardware is verified at its operational speed using the ZYCAD system. Use of these architecture and lower level simulation packages enables engineering to create a verified design without actually constructing and then testing the design.

PRODUCIBILITY

Control Data utilizes a standard format for review and analysis of product design for producibility. Two of the main drivers for producibility are: (1) the Control Data TQMP (Total Quality Management Process) and (2) the "Design Rules for Product Assembly" concept as promulgated by Boothroyd and Dewhurst. The product design rules for robotic assembly are in an internal document prepared by the manufacturing engineering department. It clearly states the design rules that should be adhered to in order to ensure a more producible product.

The producibility review forces interaction between the design engineers and the manufacturing, production, and industrial engineers. The producibility analysis considers manual, robotic, and fixed automation for product assembly. The formatted producibility analysis creates a tangible baseline for a design change or "freeze" for both the design engineers and the manufacturing engineers and provides for a "corporate memory" for the project.

SYSTEM DEVELOPMENT TEAMS

Various program management elements such as in-house design reviews are accomplished through system development teams. A program manager is responsible for overall program management and all interaction with the customer and company upper management. Other members of the team are from the areas of manufacturing, engineering, and quality assurance. All of the team members attend the design reviews with sign-off required for the final design release. Guidelines and checklists are used to validate the design process and design quality. In this way, a quality product design is assured with this up-front interaction and communication.

B. Production

CONTINUOUS FLOW LINES

Control Data has implemented three Just-In-Time (JIT) cells, which they refer to as continuous flow lines. These flow lines were established for single sided boards (12 people), double sided boards (13 people), and for power supplies (16 people).

The continuous flow lines are basically balanced assembly lines, in which the product is pulled through rather than pushed through. There are pre-established parameters for minimum and maximum work-in-process (WIP) between stations. When the WIP ahead of a station exceeds the maximum, the previous operation is halted. This procedure results in substantially lower levels of WIP.

There are several benefits resulting from the continuous flow line concept. The primary benefit is the rapid identification of problems. For example, the severity of the component solderability problem apparently did not surface until the introduction of continuous flow lines. Other benefits are a 33% productivity improvement resulting from a paced operation and a reduction in flow time from nine weeks to two to three weeks.

TOTAL QUALITY MANAGEMENT PROCESS

Total Quality Management Process (TQMP) is a total company commitment to improve quality of the product and conform to the customer's requirements. TQMP was started three years ago with the establishment of the Operations Effectiveness Office. This office reports directly to President of the Government Systems Group. The philosophy towards quality is that it is a process and it must be managed personally by each individual to make TQMP a success. TQMP has four primary concepts. The first concept is that the cost of quality is categorized as cost of conformance or cost of non-conformance (failure). Cost of conformance is divided into prevention (training, planning) and appraisal (make sure specifications are met). The second concept recognizes that quality has to be managed. The third concept states that everyone has a customer and the fourth concept identifies the process (TQMP) as that of continual improvement.

Control Data has developed an objective methodology to find the cause of problems and make sure problems never return by applying a closed loop corrective action process. Each department (manufacturing, engineering, etc.) has a resident TQMP representative. In the aggregate, Control Data estimates that the cost of quality is 25-40% of revenue, which calculates into \$750 million per year. Government System's Cost of Quality Index has been reduced to less than half this percentage.

Control Data has developed six questions to facilitate problem solving. They are: (1) What goes on in the activity?; (2) What are the big problems; (3) What are the causes of the problem?; (4) What does past data show?; (5) What are the causes and effects relationship?; and (6) What does current data show about the activity in question? This methodology is applicable to all departments and has been successful in problem identification and resolution.

ENVIRONMENTAL STRESS SCREENING

Control Data has had an environmental stress screening program for ICs in effect since 1981. This program consists of 100% electrical test and 100% temperature test. The temperature test is very thorough, ranging from +125°C to -65°C. Although this is very costly, Control Data feels the reduction in failure rate from 4% to .2% has proven the program to be cost effective.

AUTOMATED OPERATION SHEET GENERATION

Control Data is now generating operation sheets automatically. This capability has been achieved by integrating design engineering drawing data from the CAD system with a PC based word processing system to produce operation sheets for factory use.

The system includes intermediate steps which generate modified drawings based on design engineering drawings in their larger CAD system, processing of the modified drawing data through a neutral plot file, and finally, combining the modified drawings with appropriate verbiage from a PC system. Datacopy hardware and software is used for integration of the drawing data with the PC data to produce the final operation sheets.

PRODUCT ANALYSIS AND TRACKING HISTORY

Product Analysis and Tracking History (PATH) is a computerized data collection and analysis system in which each part is tracked during the entire building process. The goal of PATH is to weed out failing elements. The data is stored in a large database for a period of one year. There are 600 computer entries per day. Control Data is in the process of bar coding the components for automated data entry. The data is used for analysis, work-in-process, tracking, and history. Two thousand parts are tracked at a time. The benefits of PATH are many. There are only 17 failures per computer during the final test. The system can isolate the failing elements at the environmental conditions. PATH provides automatic system configuration, identifies and resolves failure trends, aids in troubleshooting, tracks WIP, and performs statistical and component failure analysis. Automatic data validation is performed by PATH. The system is easily expanded for new products, requires minimal user training, and has powerful report generation capabilities.

COMPUTER INTEGRATED MANUFACTURING

Control Data made a decision in 1985 to develop a new corporate strategy and master plan for the application of state-of-the-art computer technology to all manufacturing related operations. This effort consists of a phased approach which takes into consideration those previously computerized areas supporting production. The areas included CAD/CAM, manufacturing engineering, industrial engineering, production engineering, production and quality assurance, etc. Automation in these areas had been implemented on a limited basis without a centralized corporate strategy or plan.

A master computer integrated manufacturing (CIM) plan was developed by Control Data. The first phase of the CIM plan orchestrated the "front end" of the business to provide a solid foundation for networking the operations together in the proper sequence to effect CIM. A unique organizational team of experienced Control Data personnel was established to develop and help implement the CIM plan. The team consists of three design engineers, three manufacturing engineers, a management representative, and two consultants. The plan developed outlines the resources required to establish CIM at Control Data. The resources included those personnel, equipment, and facilities necessary to implement, in a phased manner, various project efforts to support, operate, and manage manufacturing.

Completion of phase I will allow simultaneous capture, featuring 15 projects, of existing computer automated operations. It will also establish a standard factory automation base for future related modernization efforts which would be in consonance with the Control Data business plan. Phase II will lead the way toward specific manufacturing process and support improvements. These improvements will be related in that all will be integrated into an ETHERNET system using a "C" developed CIM database and management information system (MIS). Some examples to be included involve: cost estimating, material requirements planning (MRP), production control, technical data and configuration management, engineering, artificial intelligence, operations research, etc.

C. Transition Plan

TRANSITION FROM DESIGN TO PRODUCTION

Control Data is "totally committed" to compliance with DoD 4245.7-M, Transition From Design to Production. Due to this commitment, Control Data has personnel from different areas (i.e., engineering, design, manufacturing, quality, etc.) working together in early stages of programs to achieve a better transition to production.

Control Data, Government Systems, has written transition plans, although not a contractual requirement, for three current programs: P³I, MADS, and A6-F. Government Systems is convinced that up-front planning of a program, via a transition plan, is an efficient, common sense method to plan for a program. This is an expensive planning process to inject in a program up-front, but Government Systems feels that it is very cost effective as the program matures.

D. Facilities

AUTOMATED OPTICAL INSPECTION

Control Data uses a Hughes Opti III automated optical inspection (AOI) cell to verify line widths and spaces of circuit paths. The machine is capable of processing 0.0031 inch line spacings. It operates at a rate of 1.5 square feet per minute, but a planned upgrade will increase the scan rate to approximately 3 square feet per minute.

Ten different machines were evaluated during the selection process. The Hughes Opti III was chosen on the basis of its low frequency of false calls (7% of total calls on panels that ran through aqueous solution) as well as on the basis of its cost and ease of operation.

The system, which operates on three shifts, is capable of taking parts directly from the inner layer plating and cleaning line. The inspection is based on a comparison to design rules, as opposed to a comparison of product specific data. This type of comparison is inherently simpler. It enables the system to inspect, with minimal set-up, 2000 different part numbers, involving different configurations and materials.

Control Data's evaluation of the Hughes Opti III indicates that it found all of the defects detected by an operator plus some defects that the human operator missed. The machine accomplished its task 30% faster than the human operator. Also, the machine was in operation on the same day that it was installed.

ROBOTIC PICK AND PLACE

Control Data has installed a WT Automation/ADEPT 1 robot for use in its printed wiring board assembly facility. It performs pick and place operations for installation of leadless ICs on AN/AYK-14 circuit boards.

The robot is equipped with a vision system that employs two cameras. One camera is used to identify the proper component orientation. The other camera, which is mounted on the Z axis, is used for circuit board location alignment. The robot utilizes a specially designed end-effector that contains four different vacuum pick-ups. Each pick-up is a different size and is used for a different component size. This arrangement allows the robot to pick and place a variety of different components without changing end-effectors.

The direct drive ADEPT 1 robot offers cost effective population of circuit boards. The system has reduced processing time of PWBs, component placement defects, and both calibration and maintenance times when compared to previous manual or gear driven robot operations. Control Data also believes the ADEPT 1 robot system offers more reliability and flexibility than conventional dedicated pick and place machines.

IC MANUFACTURING

Control Data has recently invested significantly in VTC Incorporated, an IC manufacturing facility. Located within a few blocks of the Control Data Aerospace facility in Bloomington, Minnesota, VTC has the capability to design and manufacture production quantities of standard, semi-custom, and custom ICs using both CMOS and bipolar technologies for LSI and VLSI applications.

VTC is also in the process of an extensive facility update which will provide circuit manufacturing capability at the submicron level. This capability will provide the Control Data and VTC team with a nearly vertical VHSIC capability in the near future.

ARTIFICIAL INTELLIGENCE

Based upon their awareness of Mr. Willoughby's concern for component level diagnosis, CDC submitted a successful manufacturing technology proposal for a feasibility study in the area of applied artificial intelligence (AI). The specific scope of the feasibility study was to diagnose failures in the General Processor Module (GPM) of the AN/AYK-14 computer to the component level. The ten month (50 man-month) study will be completed in January 1987. The study featured the development and evaluation of a prototype expert system which performed component-level diagnoses.

The expert system was developed using "LISP" software language to run on IBM PC compatible systems. Three expert diagnostic technicians were interviewed to develop the knowledge base used within the expert system. The use of three experts ensured a multi-opinion approach to the task. Approximately 250 hours were spent interacting with the expert technicians in order to build the expert system prototype. Three areas of expertise were established for observing and interviewing expert technicians: (1) product specific expertise, (2) troubleshooting expertise, and (3) good problem solving (fixing) expertise.

The expert's knowledge of General Processor Module hardware and software was integrated via a computer model, and through evaluation reiteration, a prototype was developed and tested in eight months. A friendly user interface was developed for prototype, such that no manuals or training was required to use the prototype.

The prototype was tested by two expert and two novice technicians from CDC. The testing was based upon four cases using four pairs of embedded failures (eight total failures). Each of the four technicians performing the tests attempted to "fix" the first failure of each pair on his own, without the aid of the expert system. Each technician then attempted to "fix" the second failure in each pair with the aid of the expert system. The failures in each pair were selected to fail in a similar manner, but due to a different cause.

The results proved to be encouraging. In many instances, technicians were able to make a diagnosis and fix quicker with the aid of the expert system than without. Not only was the feasibility of AI proven, but in application on realistic problems, measurable success was accomplished.

Further work is being planned to refine the expert system by categorizing generic and product specific attributes. The generic troubleshooting knowledge will be acquired from expert technicians "on the floor," and the product specific knowledge will be acquired from the product designers. Future integration with the module test computer control unit is envisioned. Since this project was funded by the Navy Manufacturing Technology (MT) Program, the technology is available to other firms through the MT program office.

E. Management

MAKE THINGS BETTER TEAM

A group of individuals called Make Things Better (MTB) Team can be assembled at any level within the organization to solve problems. The team is composed of the most

knowledgeable engineers and workers familiar with the problem. The team stays in existence until the problem is resolved. The benefits derived from the team are process improvements.

EMPLOYEE ADVISORY RESOURCE (EAR) STAFF

Control Data has an Employee Advisory Resource (EAR) staff comprised of 40 counselors to help all employees with personal and work related problems. The staff is trained in counseling, clinical psychology, social work, and industrial relations. All discussions are strictly confidential. The organization is independent and reports to the corporate VP level. This staff can advise management in situations that the manager may be unfamiliar with. The staff also markets its services outside the company.

IV. PROBLEM AREAS

A. Production

CLEANING UNDER LEADLESS CHIP CARRIERS

Control Data, along with other companies using leadless chip carrier (LCC) technology on their PWBs, is having difficulty adequately removing solder flux from beneath the LCCs after soldering.

LCCs leave only .002 inch clearance between the chip carrier and the PWB surface after soldering. Single pass, and even multiple pass, cleaning using the existing degreaser equipment has been unable to completely remove the entrapped solder flux as required by current military specifications.

Control Data is working closely with the manufacturer of its degreaser equipment (Detrex) to develop improved degreaser jet angles and higher power jets to improve cleaning under the LCCs. Further experimentation to increase the thickness of the solder mask, under the corners of the LCCs only, is also in process in the hopes that the increased clearance will allow thorough cleaning. No clear solution to the problem exists at this time.

SOLDERABILITY OF COMPONENTS

Poor component solderability is a major concern of Control Data, who reports that 15% of all incoming electronic components are rejectable for solderability problems. Fairchild's Indonesian components and Cypress' Korean components have been particularly troublesome.

Control Data has spent considerable effort working with component vendors to try to improve the quality of components when received. Notable improvements have been made as vendors have switched to a hot solder dip process for tinning of component leads.

To further aid solderability, Control Data uses an outside facility to re-tin all rejected ICs. Control Data retins 95% of all components again immediately prior to installation on PWBS to enhance solderability. This avoids the cost of conducting solderability tests on components which have been in storage for 120 days or more. Even though solderability is still a significant problem, Control Data's solder defect rate is now relatively low.

PART MARKING

Control Data has similar concerns as other contractors about maintaining part markings after components go through numerous required cleaning cycles. The problem has been noted at each company surveyed. Solutions developed by industry have had minimal success. A recommended cure could be a requirement to use a more permanent ink in part marking. However, the current specifications do not require such an ink.

ENVIRONMENTAL STRESS SCREENING

Stress screening is a contractual requirement in most cases. A problem associated with 100% screening is that Control Data is usually duplicating a test that the supplier has performed before shipment. To alleviate this, Control Data would like to receive permission from the Government to use statistical process control to determine the percentage of screening to be performed.

B. Logistics

FIELD PERFORMANCE DATA

One of the best ways to improve the quality and reliability of a product is to identify failures and incorporate changes. Most contractors make this a part of the manufacturing process. This works for those changes that appear during the manufacturing and assembly process. However, contractors seldom hear about the failures that occur in the field. Field performance feedback would be invaluable to a contractor interested in improving his product. Control Data believes this problem is worthy of the Navy's attention.

WS 6536 TRAINING

Ever since WS 6536 has been enforced, there has been a problem in obtaining the required training. Contractors required to produce to WS 6536 specifications have experienced a six month to one year wait to obtain the training. To complicate this matter, the training does not include surface mount technology. This poses a real problem to those contractors required to produce to WS 6536 using surface mount technology.

C. Management

DESIGN CHANGE APPROVAL

The change approval cycle has been identified by most of the contractors surveyed as a problem in doing business with the Government. Normal approval time exceeds that available under a contract to deliver. Often a contractor is forced to take the risk of incorporating a change prior to approval. The system needs to be streamlined to shorten engineering change approval cycle time.

V. CONCLUSIONS

The review conducted at Control Data, Government Systems, yielded many best practices and more detail on industry wide problems already documented during other surveys. One of the more prominent best practices is the focus Control Data puts on quality control. Systems have been developed to collect and document data that are used to analyze problems and provide the basis for solutions. The team approach is another key ingredient of Control Data's success in quality and productivity. Personnel at all levels and functional areas are made aware of problems and teams are established to solve them.

Another example of success through applying the team approach can be found in the design area. Engineers are exchanged between design, manufacturing, and quality for periods of time to provide cross-training in these areas. This helps identify design problems prior to going into production. This approach has also helped develop solid and complete design guidelines.

Even though automation in the manufacturing and assembly areas is not high on the list of priorities because of the low volume of defense deliverables, Control Data has automated selected areas. These areas include computer aided vision inspection, robotic pick and place assembly, and IC manufacturing. Control Data's efforts in the IC area are considered to be leading the defense industry.

Many of the practices employed at Control Data, Government Systems are in compliance with DoD 4245.7-M, Transition From Development to Production. An effort is being made to analyze this document and other technical guidelines for defense production in more detail and apply the practices that are suitable to Control Data.

The problems discussed during the survey were similar to those discussed at other companies. More information was obtained to document the depth of the problems. Some discussions revolved around possible solutions to identified problems.

Both the best practice and problem information are forwarded to the Electronics Manufacturing Productivity Facility in China Lake, California for further test, evaluation, and research.