INTEGRATED CIRCUITS (MICROELECTRONICS)

JOHN W. FEIST
Value Engineering Branch
Systems Effectiveness Division
Naval Training Device Center

On 14 April 1967, the office of the Secretary of Defense issued a memorandum setting forth the policies for the use of Microelectronics in military services and equipment. The Department of the Navy issued implementing instructions in the form of SECNAV Instruction 10550.4 dated 1 November 1967. The Navy Instruction disseminates and supplements the OSD Memo of 4 April 1967. As a matter of information, I will be quoting liberally from the OSD statement.

An ultimate objective of military electronics is to provide equipment which satisfactorily fulfills the military need with a high probability of no failure for the entire lifetime of the system or equipment.

The higher the equipment reliability, the higher becomes this probability and the simpler becomes the logistic support problem. The considerable improvement in reliability offered by microelectronics, the savings in space and weight and potential cost reduction, make it most desirable to promote the widest possible appropriate use of microelectronics in military systems. Further, the reliability of microelectronic circuits is sufficiently higher to warrant packaging of several or many such circuits into modules for which repair is neither practical nor effective. Such design modules would be discarded upon failure and would reduce logistic support cost.

All new research and development projects shall consider the use of microelectronics technology in their design. This policy is not intended to arbitrarily demand the use of microelectronics. Rather, it directs a continuing objective appraisal of all factors concerning the system/equipment design relative to current microelectronics technology with the view of maximizing reliability and minimizing cost, weight and space within the envelope of the other performance parameters of the design.

Microelectronic circuits shall be packaged into discrete replaceable modules of such cost and reliability that disposal-on-failure rather than module repair is the most effective and economical logistic support action. Design complexity, reliability, system life, functional use, supply support, cost and equipment availability are typical trade-off factors to be considered in determining whether the module shall have several or many microelectronic circuits.

Hybrid construction using both microelectronics and discrete active and passive electronic devices should also be considered for modularization, for reason of (1) repair through replacement and disposal as in the preceding paragraph, (2) for better accessibility, or (3) for replacement and later repair.

Several concepts for maintenance and logistic support of microelectronics equipment and modules must be considered during the initial design and followed during the ensuing phases, including the logistic support phase, in order to achieve the dual objectives of high reliability and minimum support costs. One such concept is module discard-on-failure. Another concept, stemming from the reliability improvement of microelectronic devices, is "logistic-self-support" wherein (a) built-in redundancy may substitute for replacement and repair; or (b) replacement modules, accompanying the equipment, may be procured in sufficient quantities to support the total life expectancy of the equipment. Replacement of non-plug-in microelectronics modules shall be accomplished only at higher echelon special repair activities.

The requirement of and the design of standardized microelectronic circuits and modules for broad inter-system use is not favored since (1) this can lead to undesirable constraints on the design of each succeeding specific system, (2) the design and construction of each equipment can be optimized with little additional cost or logistic support difficulty, and (3) the need and value of standardization for logistic aspects disappears when, due to the life characteristic of microelectronics, logistics-self-support can be achieved as opposed to logistic support through supply inventory.

Limited inter-system standardization may be appropriate where the system designer of a new system selects previously acceptable microelectronics design for re-use; or, where the DOD Components direct commonality of microelectronics design within two or more systems concurrently under development. Microelectronics commonality between concurrently developing systems should be a subject in each system's Technical Development Plan or other appropriate planning document.

Standardization of replacement modules within a specific equipment or system is a design objective secondary only to system optimization. This intra-system standardization will enhance the achievement of logistic-self-support with a minimum number of replacement modules required to support the system/equipment for its total life span.

General standardization of microelectronics, whether via a general military specification, standard or handbook will be restricted at this time to the areas of: (a) definition of terms; (b) parameters to be controlled for circuit characterization; (c) test levels including test methods and procedures; (d) general application guidance, design criteria and (e) preservation and packaging guidance.

Most of the standardization effort has been accomplished, or is presently "in the mill." Definitions are covered by Mil-Standard 1313. The document describing parameters to be controlled is being generated by NAVELEX and has not been assigned a number as yet. Test levels, test methods, and procedures are covered by Mil-Standard 883. General application guidance is covered in Mil Handbook 175. Preservation and packaging guidance is described in Mil-M-55565. The above numbered documents have all been released and are available upon request. One additional document has recently been authorized covering Quality Assurance provisions and is presently being generated by the Air Force (RADC).

Here at the Naval Training Device Center we have been primarily concerned with the cost and reliability of integrated circuits compared to discrete components. This slide shows the approximate effect on the cost of a gound radar system which utilized 20% integrated circuits and 80% conventional components as opposed to a system utilizing 100% conventional components. Development cost 20% less, production cost 25 to 50% less, logistic support cost - 33% less. These estimates, however, are based on production quantities. The savings realized on training devices would probably be somewhat less.

Transistor failure rates vary from .7% to 5.3% per 1,000 hours. Integrated circuit failure rates vary from .0007% to .1% per thousand hours. The low failure rates in each case correspond to "Hi-Rel" or "Minuteman" type units and the high failure rates correspond to good commercial or low grade military type devices.

Here is an example of verified system reliability for the Minuteman II. The failure rates are expressed in percent per thousand hours at .90 confidence.

Subsystem Test	-	.05
System test	-	.02
Field operations	-	.007

It is interesting to note that the system reliability appears to improve with age. Contrary to conventional components, integrated circuits have not exhibited wear-out characteristics. It has been stated by several authoritative sources that with extensive testing, screening, and burn-in, a great majority of the "marginal" components can be weeded out, leaving for the most part only good units.

Here are some other samples of verified system reliability. The Apollo Guidance Computer .0017, the IBM system 360 - .003, the Mirage I Digital Radar Display has a verified MTBF of 5,000 hours.

Figure 167 pretty well shows the story of integrated circuits from 1965 to the present time. Military shipments have increased from 61 million dollars in 1965 to 109 million in 1967. The total integrated circuit factory shipments have increased from 84.6 million to 253.8 million dollars in 1967, with projected total shipments for 1968 to 355 million dollars. On the surface, it appears as though the Government only utilizes about 44% of the total Integrated Circuit factory shipments. It should be noted, however, that the Government presently owns or operates 4 billion dollars worth of computers and as you all know, virtually all of the present day computers utilize integrated circuits and these devices would not be reflected on the "military shipments" chart.

The average price of the military type integrated circuit has dropped rapidly since 1965 from $10.50 to $4.55 in 1967. This $4.55 price is actually a little on the high side, since it is made up of an average of several quarterly price quotations. The present average price is probably $4.00 or less.

I might also note that the increase in shipments and reduction in military price have exceeded the estimates predicted a year ago by EIA and the U. S. Dept. of Commerce.

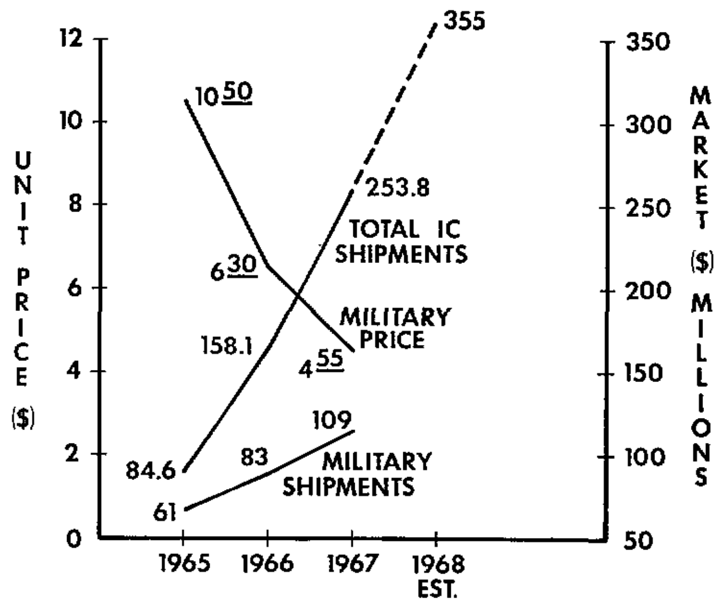

Figure 167. Comparison of Military Shipments 1965-1968 and Unit Prices.

In summary, I will state that NTDC is implementing the DOD and Navy policy in several ways. A committee has been established by the Technical Director to make recommendations regarding the application of integrated circuits in training equipment. The committee will consider such factors as system partitioning, reliability, maintainability, and life cycle cost. It will also be a goal of this committee to generate guideline documentation regarding screening and testing of integrated circuits, modular construction and discard at failure guidelines.

DESIGN DATA DOCUMENTATION (ENGINEERING REPORTS)

C. R. FORD
ASW Tactics Trainers Division
S. KOTEEN
Visual, Space, and Aviation Trainers Division
Naval Training Device Center

Engineering and logistic support data for any given trainer development program may require a minimum of formal documentation or may represent a significant amount of paperwork. The criteria that establish the quantity of design data documentation that must be furnished to produce successfully an acceptable trainer varies, of course, with the complexity of the trainer. For a most complex trainer, documentation in the form of reports, lists and drawings would be necessary to satisfy both engineering and logistic support requirements. Each of these data items is intended to serve a specific purpose. For our discussion today, we will only concern ourselves with the area of engineering reports.

The primary mission of the Naval Training Device Center is to contribute to the Navy's operational readiness by developing training devices for training agencies and other Fleet activities. The fidelity of the simulation of a training device is ultimately appraised by the user activity. For training devices which simulate actual operational equipment, the appraisal consists of an assessment of the degree of learning that has been imparted to the trainees through utilization of the training device as compared with the operational equipment. This assessment effectively evaluates the degree of success by both the contractor and the Naval Training Device Center in meeting the stated needs of the user activity.

The Naval Training Device Center engineering project team has the responsibility for transforming the Fleet requirements into the quantitative technical language that forms the basis for mutual understanding between the contractor and the Government for the development of a training device. As so often is the case, the development of a training device parallels the development of the operational hardware. In such cases it is not possible to convert Fleet requirements into the necessary total quantitative requirements for a contractor to construct the training device.

In the normal course of events related to a negotiated type of procurement for a typical weapons system trainer, the NTDC project engineer will prepare a procurement package utilizing the data available at the time. Pertinent data available from the operational equipment