COTS/ROTS FOR MISSION-CRITICAL SYSTEMS

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ABSTRACT

Three major benefits of using commercial-off-the-shelf (COTS) products to meet defense needs are: 1) reduces overall cost of the military hardware; 2) enhances the defense supplier base; and 3) maintains technological superiority by leveraging state-of-the-art technology rapidly. However, inadequate information on realistic military operating environments, insufficient data on commercial product performance and lack of proven reliability assessment tools makes low-risk insertion of COTS components into ruggedized, mission-critical, defense applications very difficult.

General Dynamics Information Systems (GDIS) has been pursuing COTS technology, including plastic encapsulated microelectronics (PEM), for its military business for the past four years. GDIS has also joined Computer-Aided Life-Cycle Engineering (CALCE) Electronic Packaging Research Center (EPRC), University of Maryland, to participate in the research activities on PEMs, interconnect and reliability. During 1996, we successfully completed a CRAD project on PEMs, teamed with a major customer to analyze reliability of large-die-size COTS/PEMs for avionics applications, and inserted COTS into several products. In addition, we have developed several innovative techniques to convert COTS into ruggedized-off-the -shelf (ROTS) products, and applied for patents.

This paper presents an overview of development conducted at GDIS on COTS, PEMs, ROTS, and reliability. A general discussion on the analytical techniques, design modifications, design for manufacturability, manufacturing processes, accelerated life testing (ALT), non-destructive testing (NDT), and reliability assessment for high performance electronic modules will be provided. It is intended that this will broaden the base of information on COTS, PEM, ROTS, electronic materials, NDT, and reliability assessment of military and commercial circuit card assemblies. Although GDIS conducted these research activities to improve reliability of military circuit card assemblies, this technology can be used for any commercial applications requiring high reliability.

A NEW WAY OF DOING BUSINESS

Dr. William Perry, former Secretary of Defense, initiated “A New Way of Doing Business” in June, 1994, which directed the Department of Defense (DoD) to leverage best commercial practices by using the commercial/industrial base with emphasis on dual use practices, COTS and non-development items (NDI). DoD program managers are required to minimize the use of existing, outdated military standards and specifications, and incorporate, to the maximum extent practicable, commercial items and practices. The challenges facing military original equipment manufacturers (OEM) are: 1) determine what constitutes best commercial practices; 2) assess the reliability of commercial products when used in harsh military environment; and 3) determine “almost equivalent” commercial specifications and standards to replace “mil-spec type” documents. Meeting these challenges will, in effect, constitute a major cultural shift in thinking, not to mention adopting a low-cost mentality.

Pursuit of goals of achieving high degrees of quality, reliability, cost competitiveness and customer satisfaction by commitment to continuous improvement is being practiced globally by most electronics manufacturers in order to succeed. Since each manufacturer implements these "best commercial practices" differently, the OEM must assess each supplier to determine if their practices are suitable to meet the customer requirements.

Assessing the reliability of commercial products, particularly plastic components, is a major challenge. GDIS has formed a "PEM Reliability Team" and joined CALCE EPRC to address this issue. Results of our survey to determine applicable commercial standards are presented in this paper.

INTERPRETATION OF COTS AND ROTS – GDIS PERSPECTIVE

The Federal Acquisition and Streamlining Act of 1994 (FASA) initiated by the DoD to promote the use of COTS is producing major benefits by lowering cost, enhancing the available supplier base, and rapidly inserting advanced technologies. However, some confusion still exists on the interpretation of COTS and ROTS. The following paragraphs attempt to clarify the subject.

COTS - Components, modules, systems or software traded in the course of normal business operations at prices based on established catalogue or market prices [Ref 1, 2,3].
More specifically, the COTS components that meet Federal Acquisition Regulation (FAR) part 11 (Acquisition and Distribution of Commercial products) are: 1) commercial grade (0°C to + 70°C) components; 2) Industrial grade (-40°C to + 85°C) components; and 3) Standard Microcircuit Drawing (SMD) - Qualified Manufacturers List (QML) (-55°C to + 125°C) and avionics grade microcircuit. The DoD report [REF 1,2] specifically includes SMD/QML microcircuits in the "commercial" microcircuits because they meet all FAR criteria, which are: 1) listed in supplier's catalogue; 2) have established price and specifications; and 3) sold to the general public. In addition, the report recommends the use of the SMD/QML parts for non-government applications.

The "*COTS Module*", a frequently used, misused and confused term in DoD electronics generally implies the overall trend of military equipment manufacturers toward using commercially available products in systems designed for deployment in a battlefield environment. It also indicates either stand-alone or embedded computers designed for operational military forces. However, benign environment office computers, used by DoD are not necessarily COTS. Three variants on ruggedization of "COTS Modules" are: 1) commercial for benign environment; 2) industrial for relatively harsh environment; and 3) mil-spec grade to meet unique, harsh environmental requirements. The "mil-spec grade" modules are being commercially marketed by some companies. One of the most popular COTS architecture is Versa Module Eurocard (VME). The VME COTS modules are now available in all three categories of ruggedization.

ROTS - Two categories of electronics that do not meet the FAR criteria for COTS are as follows: 1) products manufactured to military-OEM-specific "source controlled drawings" (SCD) and non-military OEM-specific requirements. Typical examples include components for automobiles which are often manufactured and tested to "non-standard, customized criteria"; and 2) products purchased as COTS, and subsequently modified, burned-in, tested, used outside the supplier's specification limits, and/or identified differently to perform under adverse environmental conditions [REF 2, 4]. These products may be considered ruggedized-off-the-shelf (ROTS).

During 1996, GDIS successfully developed compliant leads to convert COTS ceramic ball grid array (CBGA) into ROTS compliant leaded grid array (CLGA). This technique has enhanced solder joint reliability of circuit card assemblies [REF4, 5] such that reliable performance is obtained in harsh environments over the lifetime of the platform.

UPRATING OF COTS TO ROTS

The definition of uprating per Dr. M. Pecht, CALCE[REF 6,7], is as follows:

> "Uprating is the process which is used to reduce the risk involved in using the components and/or systems outside the manufacturer's environmental specifications or any design modifications."

Uprating of COTS may be necessary due to unavailability or diminishing supply of high-temp, MIL-SPEC parts. Several helpful guides for uprating parts, presented by at least fifteen organizations in four workshops, are summarized [REF 8, 9, 10, 11] as follows:

- Determine the "real environment" of the system.
- Maintain maximum margin (safety factor) during design optimization.
- Select and certify a supplier.
- Do not count on receiving any help from the commercial suppliers.
- Use supplier's test data or actual test data to determine the capabilities of the parts.
- Analyze design rules - they may not be the same as the spec sheets.
- Use the same manufacturer, same fabrication, and same date code when possible. Just-in-time is not necessarily compatible with uprating.
- Do not burn-in.
- Resistors in plastic packages change value when thermal cycled.
- Involve customer and suppliers early in design.
- Marking of screened parts is important for field repair.
- Control environmental impact through external means.
- Take full ownership of the product.

Contrary to the upgrade approach practiced by several organizations, DoD contends that a COTS component tested beyond the limits of the manufacturer's data sheet or SMD does not qualify as COTS. In addition, the test stresses the component beyond the manufacturer's test environmental limits, voids warranty and may create latent reliability problems. The OEM using the components may be held legally responsible for the performance [REF 2].

PLASTIC ENCAPSULATED MICROELECTRONICS (PEM)

A large number of books [REF 12, 13], reports [REF 14,15,16] conference proceedings [REF 17,18,19] and papers have been published on this subject. Most technologists are expected to be familiar with this subject. This section will describe some of the important issues associated with PEMs.

Affordability

Currently, the $ 1 billion military market is less than 1% of the worldwide microcircuit (approx $ 150 billion) market. The majority of commercial microcircuits, offered in plastic packages known as PEMs, offer a significant cost advantage over traditional military, hermetically sealed ceramic packages mainly due to higher production volume, highly automated processes, raw material cost and elimination or reduction of non-value added efforts.

State-Of-The Art-Technology

During the 1980s and 1990s, commercial microcircuit technology expanded exponentially worldwide, mainly due to the computer, telecom and consumer market. Insertion of newer technology provides higher gate density, lower supply voltage, improved product performance, high density and lower weight at a significantly lower cost from more global sources.

Technology Trends

The component geometry scaling is expected to continue from ".35 to .25 microns" in 1997 to ".18 microns" by 2000 [REF 24], and I/O count of a logic device will reach as high as "2000" by 2001 from "750" in 1995 [REF 20,21,22, 23].

Currently, most PEMs are available in leaded configuration; however, future PEM packages will include ball grid array (BGA), chip scale package (CSP) and multichip module (MCM) in higher quantities to accommodate higher I/O count.

Reliability ISSUES

The reliability issues associated with PEMs are summarized [REF 31, 32,14, 19] as follows:

- *PEM Defects* - Typical defects found in PEMs are: 1) *thermomechanical defects* - cracks and delamination; 2) *die defects* - all defects normally associated with semiconductor wafer fabrication and PEM unique defects, i.e., passivaton cracks and metallization deformation; 3) *die attach defects* - poor die-to-support adhesion, voids, inadequate filleting; 4) *encapsulation defects* - voids, delamination, die paddle shift and wire shift; 5) *leadframe defects* - overetching, stamping, skewed leads, bent leads, plating defects, solderability; and 6) *wirebond defects* - lift-off, contamination, shearing and fracture.

- *Failure Modes* - Predominant failure modes are: 1) corrosion; 2) popcorning; 3) bondpad cratering; 4) die cracking; and 5) metallization deformation.

- *Accelerated Life Test (ALT)* - Some of the frequently used ALT methods are: 1) highly accelerated stress testing (HAST); 2) thermal cycling with various profiles; 3) temperature/humidity testing with various profiles with or without bias; 4) high/low temperature operating; 5) high temperature storage; and 6) thermal cycling with vibration.

  Reliability assessment techniques for PEMs, particularly those with large-die-size, used in harsh environments need to be developed. GDIS has initiated a limited effort to analyze delamination of PEMs using a C-Mode Scanning Acoustic Microscope (CSAM) and correlate the results to reliability. Several PEMs with large-size-die have been CSAM'ed, and the delamination problems have been identified. Additional development effort is needed to determine appropriate ALT, develop affordable non-destructive test (NDT) methods, assess accuracy and repeatability of NDTs, conduct tests, correlate data and develop reliability models. While much can be leveraged from resources such as CALCE, internal development effort is still required to apply these techniques to GDIS products.

Major Concerns

- Thermal characteristics - Plastic encapsulants have relatively lower thermal conductivity and higher thermal coefficient of thermal expansion (CTE) than alumina used in ceramic packages. Inadequate thermal dissipation in high power devices could cause functional instability and reliability problems. High CTE difference among the encapsulant, leadframe and die restricts operating and storage temperature range.

- Handling and Storage - Proper care must be exercised to protect PEMs during shipping, storage, assembly and handling to prevent "popcorning" (REF 26,27,28,29,30). Depending on the factory environment and storage condition, high temperature baking of parts and assemblies may be required prior to assembly and/or rework.

- Standard processes and procedures - Most of the PEMs, including BGAs are being fabricated in foreign countries. Very little standard documentation pertaining to processes, materials, and quality control is made available for applications requiring high reliability users.

- Field experience - There is very little field experience with PEMs in high reliability, mission critical electronics.

- Non Hermetic Package - Despite improvements made in the wafer passivation processes, encapsulating materials, fabrication processes, PEMs are always susceptible to moisture. Bake-out drives out moisture and creates microscopic openings for vapor ingress and egress.

MIGRATION TO INDUSTRY STANDARDS

The specification and standard reform is demanding transition from outdated, entrenched, rigidly controlled military standards to relatively simple, commercial standards which can support an exponential growth rate in electronic device and assembly technology. Since July 1, 1994, over 4,400 military specifications and standards have been canceled, and over 2600 documents have been inactivated for use in new weapon system designs. Over the same period, DoD adopted over 7500 non-government standards and over 5900 commercial items descriptions, comprising nearly 25% of all the specifications and standards listed in the DoD index (REF 34). Major difficulties experienced in locating equivalent commercial standards are: 1) many of the military specifications are being canceled, or replaced by guidance documents; 2) commercial standards are generated by several organization; 3) exact equivalent commercial standards do not necessarily exist; 4) lack of assistance from qualified technical resources; and 5) the commercial standards change relatively fast.

We conducted literature (REF 35, 36) and internet searches for standards primarily related to "hardware design and manufacturing issues" in March, 1997. The results are briefly described in the following paragraphs. Since the commercial standards change rapidly, technologists are advised to search web sites for revisions.

- **TABLE - l** shows some of the organizations associated with generating and supplying standards associated with electronics. Additional organizations can be found on the internet.

- **TABLE - ll** shows a list of the IPC standards approved by the DoD. IPC has been providing news of new standards and documents. The information can also be obtained by contacting 847-509-9700 or IPC's web site "http://www.ipc.org".
- **TABLE - lll** shows the DoD adoptions of IPC test methods (based on MIL-P-13949 - Plastic Sheet, Laminated, Metal Clad) in progress.
- **TABLE - IV** shows DoD adoptions of IPC test methods and standards under consideration.
- **TABLE - V** shows some of the useful ANSI/EIA standards.
- **TABLE - VI** shows transition of military to *almost equivalent* commercial standards. Technologists are advised to *study and compare* these standards carefully prior to application. The IPC standards are also changing, as indicated by the list of drafts.
- **TABLE - Vll** shows changes in the Military Standards applicable IC procurement.

Further information is available from the Electronics Manufacturing Productivity Facility (EMPF), Indianapolis, 317-655-3673, www.empf.org, who have experts on this subject, in addition to IPC.

DESIGN AND MANUFACTURE FOR RELIABILITY USING COTS

Designing for reliability should include the following items:

- Define operating environment. This includes electrical, mechanical, storage and weapons deployment/combat environmental conditions.

- Use MIL-HDBK-179A guideline to select the least expensive components for the products to be designed.

- Establish lifetime requirements of the products.

- Use reliability models, if available, to estimate lifetime under the environmental conditions applicable to "deployment or field application". If appropriate models are not available, an appropriate ALT must be conducted to determine expected life.

- If the system requires components that must operate beyond the manufacturer's published data sheet, available options for the OEM are: 1) uprate commercial parts after assessing risk and legal liabilities; 2) use non-commercial components; 3) convert COTS into ROTS; and 4) design external means or "ruggedized enclosure" to minimize environmental impact.

- The life span of a military electronics system (from design, qualification, production to deployment) is typically 15 to 20 years. Select components with the longest available expected production life cycle.

- Qualify component suppliers, qualify components and purchase large lots, if possible, to complete the entire program. Financial risk of purchasing large lots is fairly high due to parts problems or design changes. However, the risk associated with the small lots is even higher because the commercial suppliers can change parts any time without notifying the "insignificant OEM" customers.

- Currently, most COTS-PEMs are being manufactured in Asia. Most "insignificant OEM" customers do not have any control on the processes and materials used during the fabrication of the components. Purchasing must pursue distributors to obtain important data.

- Handle COTS-PEMs per manufacturer's instructions. Optimize assembly processes [REF 12, 13, 27, 28, 29] for COTS-PEMs.

- Maintain reliability database using test and field data.

- Conduct Destructive Physical Analysis (DPA) per MIL-STD-883 Method 5009 with modifications to analyze modern PEM components. The modification includes C-SAM, X-RAY analysis and decapsulation.

SUMMARY AND CONCLUSION

Since 1996, GDIS organized two teams - COTS Planning and PEM reliability - and joined CALCE EPRC to understand various issues associated with COTS-PEMs. Currently, COTS-PEMs are used on some of the production programs. In addition, technologies to convert COTS into ROTS for ruggedized applications are being developed.

Additional development effort is needed in the following areas:

- It is necessary to develop NDT technologies for COTS components and modules. Currently, C-SAM is being used by some OEMs to inspect for delamination. Infrared imaging (IRI) techniques [REF 38] also look promising. However, these techniques often require highly trained operators to interpret results. It is necessary to assess accuracy and repeatability of these techniques.

- The reliability assessment techniques for COTS.

- Development effort is needed to determine appropriate ALTs for harsh environments.

- The reliability models for COTS-PEMs with high-pad-count, large-size die must be developed and customized for GDIS products.

TABLE - l
STANDARDS GENERATING/SUPPLYING ORGANIZATIONS

- The Institute For Interconnecting and Packaging Electronic Circuits (IPC)
- Accredited Standards Committee (ASC)
- American National Standards Institute (ANSI)
- Defense Standardization Program (DSP)
- Communications Standards Review (CSR)
- Data Interchange Standards Association (DISA)
- Department of Energy (DOE)
- Electronic Data Interchange Standard (EDIS)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Fire Protection Association (NFPA)
- National Institute of Standards and Technology (NIST)
- National Standards Systems Network (NSSN)
- Optical Society of America (OSA)Institute of Electrical Engineers (IEE)
- Underwriters Laboratory (UL)
- National Electrical Manufacturers Association (NEMA)
- VITA (VME bus International Trade Association) Standards Organization (VSO)
- FOR MORE INFO: http://www.eia.org/eng/linksdo.htm
  http://www.acq.osd.mil/es/std/stdhome.html

TABLE - ll
IPC STANDARDS APPROVED BY DoD

- IPC-T-50 Terms and Definition
- IPC-PC-90 General Requirements for Implementation of SPC
- IPC-EG-150 Specification for Finished Fabric Woven from Aramid for PWB
- IPC-SG-141 Specification for Finished Fabric Woven from “S” glass for PWB
- IPC-A-142 Specification for Finished Fabric Woven from Aramid for PWB
- IPC-QF-143 Specification for Finished Fabric Woven from Quartz for PWB
- IPC-MF-150F Metal Foils for PWB Application
- IPC-FC-231C Flexible Bare Dielectric for Use in Flexible Printed Wiring
- IPC-FC-232C Spec for Adhesive Coated Dielectric Films for Use as Cover Sheets for Flex
- IPC-FC-241C Metal Clad Flex dielectric for Use in Fab of Flex
- IPC-D-275 Design Standard for Rigid PWB and Rigid PWA
- IPC-NC-349 Computer Numeric Control Formatting for Drilling and routing Equipment
- IPC-D-350D Printed Board Description and Digital Form
- IPC-D-351 Printed Board Drawings in Digital Form
- IPC-D-352 Electronic Database Description for Printed Boards
- IPC-D-354 Library Format Description for Printed Boards
- IPC-DW-425A Design and End Product Requirements for Discrete Wiring Boards
- IPC-QL-653 Qualification of facilities that Inspect/Test Printed Boards
- IPC-SM-840B Qual and Perf of Perm Poly Coating (Solder mask for PWB)
- IPC-HDBK-001 Handbook and Guide to Suppliment J-STD-001

TABLE - lll
IPC TEST METHODS - DoD ADOPTIONS IN PROGRESS (BASED ON MIL-P-13949)

- IPC-TM-650-Method 2.1.6 Thickness of Glass Fabric
- IPC-TM-650-Method 2.1.6.1 Weight of fabric reinforcement
- IPC-TM-650-Method 2.1.10 Visual Inspection for undissolved Dicyndiamide
- IPC-TM-650-Method 2.1.8 Workmanship
- IPC-TM-650-Method 2.2.18 Determination of Thickness of Laminate by Mech Measurement
- IPC-TM-650-Method 2.2.18.1 Determination of Thickness of Metallic Clad Laminate by C/S
- IPC-TM-650-Method 2.2.19.1 Length, width & Perpendicularity of Laminate panels
- IPC-TM-650-Method 2.3.7.2 Alkaline Etching Method
- IPC-TM-650-Method 2.3.16.2 Treated Weight of Prepeg
- IPC-TM-650-Method 2.3.17.2 Resin Flow of No-flow Prepeg
- IPC-TM-650-Method 2.2.8.3 Peel Strength of Metallic Clad Laminate at Elevated Temp
- IPC-TM-650-Method 2.2.13.1 Thermal Stress of Laminate

TABLE - lV
IPC TEST METHODS & STANDARDS - DoD ADOPTIONS UNDER CONSIDERATION

- IPC-TM-650-Method 2.2.2 Conductor Width and Spacing
- IPC-TM-650-Method 2.2.3 Conductor Edge Definition
- IPC-TM-650-Method 2.3.4 Chemical Resistance - Marking Paints and Inks
- IPC-TM-650-Method 2.4.18 Tensile Strength and Elongation
- IPC-TM-650-Method 2.4.21 Terminal Pull Strength, Rigid PWB
- IPC-TM-650-Method 2.4.21.1 Bond Strength, Surface Mount Lands Perpendicular Pull
- IPC-TM-650-Method 2.4.26 Tape Test for Additive PWB
- IPC-TM-650-Method 2.6.4 Outgassing Multilayer PWB
- IPC-TM-650-Method 2.6.5 Physical Shock Multilayer PWB
- IPC-TM-650-Method 2.6.7 Thermal Shock and Continuity, Flexible Printed Wiring
- IPC-TM-650-Method 2.6.7.2 Thermal shock Rigid PWB
- IPC-TM-650-Method 2.6.8 Thermal Stress Plated Thru Hole
- IPC-TM-650-Method 2.6.9 Vibration Rigid PWB
- IPC-TM-650-Method 2.6.10 X-Ray, Multilayer PWB
- IPC-TM-650-Method 2.4.22.1 Bow and Twist - Laminate
- IPC-CF-148 Resin Coated Metal for Printed Boards
- IPC-CF-152 Composite Metallic Material for PWB
- IPC-D-249 Design Standards for Flexible Single and Double-sided PWB
- IPC-D-317 Design Guideline for Packaging Utilizing High Speed techniques
- IPC-D-300 Printed Board Dimensions and Tolerances
- IPC-D-322 Guidelines for Selecting PWB Sizes Using Standard Panels
- IPC-D-325 Documentation Requirement for PWB
- IPC-SM-782 Surface Mount Land patterns

TABLE V
SOME OF THE USEFUL ANSI/EIA AND IPC STANDARDS

ANSI/EIA-186-1E thru 14E	Environmental Testing - Humidity, Moisture Resistance, Salt, Thermal Shock, Vibration, Dielectric Test, Heat Resistance, etc.
IPC-SM-7101	Classification and Floor Life of Desiccant Components (PEMs)
FOR MORE INFO	http://www.eia.org/eng/catalog/catindex.htm

TABLE VI
SPEC TRANSITION - FROM MILITARY TO *ALMOST* EQUIVALENT COMMERCIAL

SUBJECT		MIL SPEC	TO COMMERCIAL SPEC
Quality		MIL-Q-9858	ISO-9000 & ASQC-92 Series
Inspection System		MIL-I-45208	ISO-9000 & ASQC-92 Series
Design -	Rigid	MIL-STD-275E	IPC-D-275 (draft -IPC 2221/2222)
	SM Land Patterns	-	IPC-SM-782A
	Flex Circuit	MIL-STD-2118	IPC-D-249 (draft - IPC 2221/2223)
	Rigid Flex	MIL-STD-2118	IPC-D-249 (draft - IPC 2221/2223)
	MCM Laminate	-	IPC-MC-790 (draft - IPC 2221/2225)
	Documentation	MIL-STD-130 & 275E	IPC-D-325A
	Rel Des Guideline SM	-	IPC-D-279
	Perm Solder Mask	-	IPC-SM-840C
Fab -	Rigid PWB	MIL-P-55220E	IPC 6011;6012 (draft)
	Flex & Rigid/Flex	MIL-P-50884C	IPC-RF-245 (draft - IPC 6011/6013)
	MCM	-	IPC-MC-790 (draft - IPC 2221/2225)
Assembly -	Rigid, Flex, Rigid/Flex	MIL-C-28809B	IPC-CM-770D (OLD)
	Soldering	MIL-STD-2000A	J-STD-001B
Components Handling		MIL-D-3464	IPC-SM-786A (OLD) J-STD-020A
Comp -	Solderability	MIL-STD-202	J-STD-002
	PWB Solderability	MIL-P-55110	J-STD-003
Fluxes		MIL-F-14256	J-STD-004
Solder Alloy		QQ-S-571	J-STD-005
Conformal Coating		MIL-I-46058 MIL-STD-2000A	IPC-CC-830 (OLD) IPC-CC-830A J-STD-001B

NOTE: IPC STANDARDS ARE ALSO CHANGING.
CONTACT: http://www.ipc.org FOR CURRENT INFORMATION ON STANDARDS

TABLE VII
CHANGES IN MILITARY STANDARDS RELATED TO IC PROCUREMENT

- MIL-STD-454 Standard and General Requirements for Electronics Equipment
  CANCELED AND REPLACED BY A MILITARY HANDBOOK
- MIL-STD-970 Specifications and Standards, Order of Preference for
  CANCELED. (Was used to permit choosing commercial parts)
- MIL-STD-975 NASA Parts Control
  CANCELED AND CHANGED INTO A HANDBOOK
- MIL-HDBK-179A Microcircuit Acquisition Handbook and Reliability Toolkit
  PUBLISHED IN 1995 TO HELP EVALUATE COMMERCIAL PARTS
- MIL PART LIST THE USERS OF MILITARY PARTS WILL USE THE FOLLOWING:
  MIL-STD-1562 List of Standard Microcircuits
  MIL-BUL-103 List of Standardized Microcircuit Drawings
  MIL-STD-983 Substitution List for Microcircuit
- OTHER SPECS **APPLICABLE, IF CALLED OUT IN THE CONTRACT**
  MIL-PRF-38535 IC Manufacturing
  MIL-STD-883 Test Methods and Procedures for M. D.
  MIL-HDBK-217 Reliability Prediction
  MIL-STD-1835 Microcircuit Case Outline

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