Title: Relationship of Fully Automated Electronic Manufacturing, Automatic Electronic Testing and the FCIM Environment.

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Synopsis:

A goal for the Joint Center - Flexible Computer Integrated Manufacturing (FCIM) is the rapid delivery of small volumes of replacement circuit cards at moderate cost. While the overall FCIM program is targeted to mechanical and electronic assemblies, this paper is limited to the automated fabrication and testing of electronics. It will describe a proposed approach which can remove many of the roadblocks by unifying available tools, technologies, and standards within the acquisition and manufacturing community to form a rapid production capability. A goal which also has a direct application for the commercial world.

Overview

The proposed facility will be capable of the rapid analysis and assembly of electronic circuits with a minimum of manual intervention and no rework. The process begins with the receipt of a functional description of an operational circuit and will end when a fully tested unit meeting requirements is shipped to the requesting party. To meet FCIM goals the processing time for each fabrication step must be a minimum.

This effort will unite data handling methods, self contained fabrication and assembly routines, Computer Aided Design (CAD) and Computer Aided Software Engineering (CASE) tools, test automation and systemic improvements to processes to form a more effective and reliable manufacturing capability. The methods currently available will automatically: convert the existing circuitry, to a form fit and function (F²) unit; write a test program set (TPS) in a concurrent time frame; verify the new design and assembly approach to be economical and capable of rapid circuit adjustments in response to the real time control data

supplied by the use of on-line automatic test equipment (ATE). Fused into the assembly will be automatic online measuring and adjustment techniques plus methods to combine design, assembly and test work. The complete system will be capable of delivering a minimum of one updated F³ replacement unit within 30 days from the initiation of the order and allow fast changes in the items to be fabricated. Thus it will become a key part of the FCIM system by permitting **rapid** evaluation of received data and automate the production of necessary support documents. The methods will let subtler electronic businesses become competitive manufacturers of highly reliable units.

PROBLEM

MILITARY:

Recent political and economic events coupled with the ongoing technology explosion have forced relooks at traditional methods of electronic manufacturing. The decreasing procurement of military electronics has intensified the need for these relooks. Due to these circumstances, currently deployed, aging systems must be kept at a high state of readiness without the support of "standby" of spares. In addition, spares buys are being limited to immediate needs, vers "buying for stock". This problem is magnified by the large quantity of units built in the 1970's using now obsolete parts or which were manufactured by companies who have ceased production of the system or are no longer in business. The need to keep these old systems "online" has caused the need for rapid delivery of replacement units, a "just in time" manufacturing approach.

There exists a "data void" regarding

quantity and quality of documentation available on the existing assemblies. As many of these items were originally procured twenty or more years ago, the data may be of poor reproduction quality, outdated or just unavailable.

Commercial

There are similar commercial applications requiring quick production of small quantities of highly reliable electronic assemblies and the achievement of other concerns. These concerns are attainment of low cost, high reliability with fast availability of small lot sizes. In addition, opportunities which will allow the transition of military electronic technologies to a commercial sector are increasing. The speed and accuracy this technology transfer can be greatly improved by the adoption of the methods outlined in this paper. Moreover embracing a process which allows rapid response to market demands for new and replacement electronic products will enhance a companies posture within a highly aggressive industry.

SOLUTION

Background

Both aspects of the cited problem can be significantly resolved by the establishment of a standard, documented, automated production skill which facilitates the rapid creation and supply of economical replacement designs and assemblies within thirty days of need. To attain this goal, a new system must keep manual input to a minimum, use measured performance capabilities to logically group active electronic components, and provide the capability to rapidly accomplish dynamic "tuning" of the resulting assembly to ensure that it meets performance requirements. Additionally, all mechanical parts must have dimensional specifications verified prior to finalizing the configuration. The new system will take full advantage of commercially available tools, such as circuit simulators, and data bases for component characteristics. Thus the ability to automatically select proper F³ replacement components, run circuit

simulations on the present design and the F³ replacement prior to fabrication, automate the design verification and collect data in a reliable, repeatable manner will be established. All required data will be determined and recorded automatically. To complement the F³ development process, the testing process must also be more automatic. As the first step in this portion of the

process, the test program will be developed concurrently with the design activity by using the output of the circuit simulator. Once the design has been completed, this data will be used to form the basis of the test description for both the design verification and production acceptance test programs.

SYSTEM SPECIFICS

Overall Description

The major operating areas of the proposed system are;

- a. Data Exchange
- b. Automated Design and Fabrication,
- c. Automated Testing, and
- d. Automated Reporting.

Data Exchange

The key element to any successful automation process is the ease and flexibility with which data is processed both within the system as well as its proposed system must accept a variety of inputs ranging from technical, financial and logistical and multiple formats emphasis must be placed in the creation of this capability. It is anticipated that compliance to the existing and emerging Computeraided Logistics (CALs) standards will aid heavily in this regard.

To deal with the current data problems and to avoid reoccurrence in the future, mechanical and electrical information will be captured or created in an electronic format for storage and transmission to manufacturing sites and other interested parties by electronic means. Since the use of paper as the medium to transmit data is prone to errors and delays it will not be used. The use of a standard electronic medium across high-speed modems Local Area Networks (LANS) or Wide Area Networks (WANS) will speed the data transmission process and improve the long term accuracy of the data. In doing so, Government agencies and manufacturers alike will be able to review the current data in "real-time" thus reducing administrative and procurement lead-time while enhancing and improving the level of standardization.

Automated Design and Fabrication

The automated design and fabrication capabilities of the system will harness the capabilities of commercially used tools which posses the capability to design and create ceramic carriers with custom dielectric values and thermal coefficients equal to those of the

circuit substrates, ensure mechanical and thermal bonding integrity, deposit circuit conductor paths with varying widths and depths, position discrete components and integrate circuits in the most efficient locations, and provide for "tuning" of the design to meet optimum performance. The proposed system will also be capable of interfacing with a number of commercial and Government data bases which contain data relative to component availability, component characteristics, costs, National Stock Numbers, etcetera.

Automated Testing

The goal of the test section of the system is to reduce the overall time required for acceptance testing. It will be accomplished by two separate ways the first is to reduce the number of tests to the minimum required and the second is to use in-line testing to monitor the actual production process. Historically, test sequences have been created for design verification versus production acceptance. In addition ATE and test programs were created to test specific electronic assemblies within a closed architecture leading high cost and lengthy lead times. Many of the present systems perform "end-offline" serial testing to detect failures but do not locate or cite the cause of failure. The proposed system will be designed to test the assembly at critical points in the production process as well as verify the functional aspects of the unit when it is completed. The use of in-line testing will enable the manufacturer to more closely monitor the production process and take immediate corrective action if a problem exists.

Reporting

In addition to the usual production data which is reported, (e.g. production quantities, number assembled, number accepted, reasons for rejection, etc.) the use of automated fabrication and testing processes provides access to other data which can be used to further enhance the process. In addition to empirical data such as how an assembly failed(marginally out of tolerance, shorted traces, etcetra), other data

including time of day, date, ambient temperature, and so on can be collected automatically and analyzed as it is generated and used to improve production methods, quality control, and cost control.

SUMMARY

Some of the techniques cited in the

paper were partially created or were demonstrated on previous successful Army programs. These are listed below. The aim of this project is to integrate the techniques and create new capabilities meeting FCIM and commercial goals. To this end, the methods employed in this system will:

1. Automate the process of converting aging, obsolete electronic circuits to uniform F³ replacements units.
2. Automate the process for creating test programs (TPS) concurrent with the design process which are capable of verifying the ability of the replacement assembly. These TPS are to perform in a minimum time period, and are to equipment independent
3. Create an Automatic Test System based on a VXI format that can be merged into the facility using an open architecture.
4. Ensure that the system can be rapidly tuned to compensate for manufacturing tolerances values in response to real time control data supplied by in-line Automatic Test Equipment.
5. Establish and maintain a data format for the storage and retrieval of electronic design data, results, etc. in concert with ongoing Department of Defense (DoD) initiatives(e.g. CALS).

REFERENCES

Data on the supporting projects can be obtained from the usual sources by citing the following contracts.

Project No.	Contractor	Contract No.
		DAAB07-
A2893192	M/A-COM	89-C-A008
A2893200	PA State U	89-C-A065
A2903069	Giardano Assc	90-C-A024
A2903223	PA State U	90-C-A033
A2769773	Harris (PRD)	76-C-8106
A2789773	Harris (PRD)	78-C-2015
A2853111	Westinghouse	85-C-K584
A2859289	M/A-COM	85-C-K513
3193	PA State U	-----
A2779808	RCA	77-C-0585
A2719353	RCA	71-C-2641