ISO 9001 Registration for the Electronic Hardware Fabrication Process at the Jet Propulsion Laboratory

Dr. J. K. "Kirk" Bonner
Jet Propulsion Laboratory, California Institute of Technology

Mr. Carl de Silveira
Jet Propulsion Laboratory, California Institute of Technology

ABSTRACT

More and more companies and organizations are recognizing the benefits to be gained by achieving ISO 9000 registration. An effort is underway at JPL to become ISO 9001 registered. To facilitate this activity, the entire laboratory has been divided into processes, each one having a designated process owner. This paper concentrates more specifically on one of these processes, namely, the Packaging and Fabrication of Electronic Hardware (PAFEH), and the effort being undertaken to ensure that this process will successfully pass registration. A comprehensive approach is being utilized by the Electronic Packaging and Fabrication Section to bring this about.

KEY WORDS

ISO registration, quality management system, process modeling, IDEF0, process (activity, function), management review, ISO team, document list, gap analysis, process flowcharts, corrective and preventive actions.

INTRODUCTION

Many companies today are choosing to adhere to an international set of standards known as the ISO standards, the acronym ISO signifying Internation Standards Organization. Chief among these are the standards dealing with the quality management system of a given company or organization (ISO 9001, 9002, and 9003). In ISO parlance, quality doesn't just denote QA or QC. It refers to the entire system which enters into producing a product (good and/or service) that the customer wants and is expecting. The customer does not want products whose quality varies all over the place. He/she expects a product which will work as intended over a certain time period which the customer deems appropriate. That is, ISO standards are customer-driven, not product-driven. It used to be

that companies could say, “This is our product. Take it or leave it.” But times have changed. Now it’s the customer’s turn to say, “If I don’t find your product acceptable and suitable to my needs, I’ll buy your competitor’s product.” To produce a product that consistently meets the customers’ needs and expectations, its quality management system must be fine-tuned and be effective. This is where the ISO standards come into play. Companies adopting them have their production/quality management system documentation in place and are following it to meet and satisfy customer needs. The chief thing to remember about ISO is: Say What You Do and Do What You Say.

THE THREE ISO STANDARDS

The entire subset of ISO standards dealing with the quality management system are referred to as ISO 9000. ISO 9000 proper consists of twenty (20) elements. Depending on how many elements a company chooses to become registered to determines which particular quality standard it becomes registered under. The three quality standards of ISO 9000 are:

- ISO 9001 Design, Hardware, and Test–Company is registered to all twenty elements in most cases.
- ISO 9002 Hardware Build and Test–Company is registered to eighteen of the twenty elements (Design Control is not included).
- ISO 9003 Test and Inspection Only–Company is registered only to thirteen of the twenty elements.

NASA has made it mandatory that all NASA installations shall be ISO certified by the end of 1999. JPL is to be certified to ISO 9001 with the exclusion of Element 19, Servicing.

UNDERSTANDING THE PROCESS

To get through ISO registration, one of the chief requirements is to understand the process you’re dealing with. This can be accomplished in several fashions. Initially the Electronic Packaging and Fabrication Section utilized functional modeling using the IDEF0 technique. IDEF means ICAM DEFinition; ICAM stands for Integrated Computer Assisted Manufacturing. This was the acronym chosen by the U.S. Air Force back in the late 70s–early 80s in connection with its effort to automate aircraft manufacture. IDEF techniques emanate from the work of Dr. Douglas Ross, who originated SADT (Structured Analysis and Design Technique) to effectively deal with the management of large software projects. The SADT technique was adapted by the U.S. Air Force, with certain modifications, and utilized to model complex manufacturing systems.

The purpose of IDEF0 is in analyzing a function, or activity. The words “function”, “activity” and “process” have the same meaning in the context of IDEF0. It is important to realize that almost all processes consist of subprocesses, and each subprocess can often be further decomposed into still smaller processes. That is, a functional hierarchy exists linking various subprocesses together. IDEF0 is a structured approach which aids in analyzing a process. It accomplishes this by setting forth the various subprocesses and their correct level so that the entire process is elucidated.

Activities, or processes, are characterized by an action verb phrase. To perform IDEF0 modeling, all activities are placed in boxes. Each activity, or process, can have up to four different types of items: inputs, outputs, controls, and mechanisms. Each of of these items in the IDEF0 methodology is represented by an arrow impinging the process box in a different direction. In this model, inputs (as defined below) are categorized into several distinct types. These are:

- CONTROLS –these force the process to conform, i.e., to ensure the proper output
- INPUTS –an input by IDEF0 definition is what is physically transformed by the PROCESS (ACTIVITY) to produce the OUTPUT
- MECHANISMS (RESOURCES) –these include the people, equipment, facilities, etc., used to bring about the transformation of INPUTS into OUTPUTS. MECHANISMS are generally not transformed by the PROCESS

The IDEF0 (ICOR) model of a process is shown in Fig. 1.

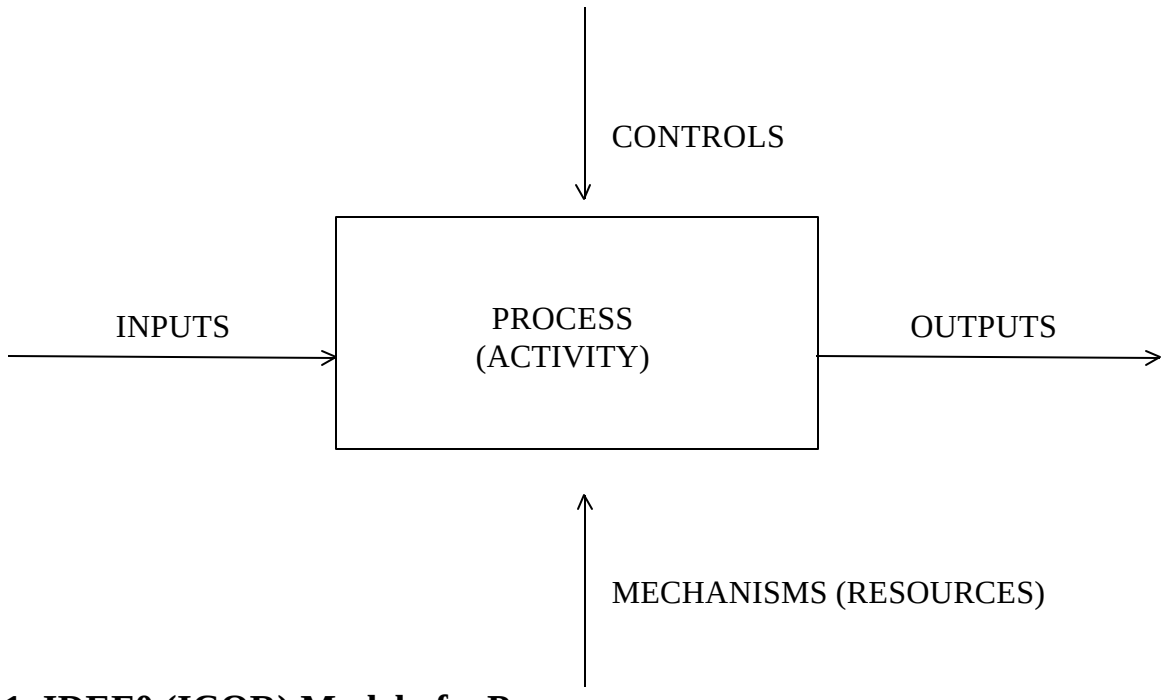


Figure 1. IDEF0 (ICOR) Model of a Process

This setting forth of the various subprocesses making up a given process and the corresponding assignment of the various subprocesses at their correct level is known as structural decomposition or hierarchical decomposition. The decomposition can be continued down to the lowest desired level. When a diagram is decomposed into several lower level diagrams, the original diagram is known as a parent diagram and the lower level diagrams into which it is decomposed are known as child diagrams.

Once the IDEF0 modeling was accomplished, the various major subprocesses fell out. These were:

- Electronic Packaging Design and Development
- Advanced Electronic Packaging Design and Development
- Electronic Fabrication–Manual and Automated
- Cable Fabrication
- Hybrid Fabrication
- Optical Fabrication.

Once the various subprocesses had been delineated using IDEF0, a somewhat simpler approach was used to define these subprocesses. Each subprocess was examined as to what were considered INPUTS and OUTPUTS. Each of the six subprocesses given above is based on a simplified model of a process, namely, everything entering the process is considered an INPUT, and everything leaving the process an OUTPUT. The INPUT is everything employed to produce the OUTPUT. Fig. 1 displays this model.

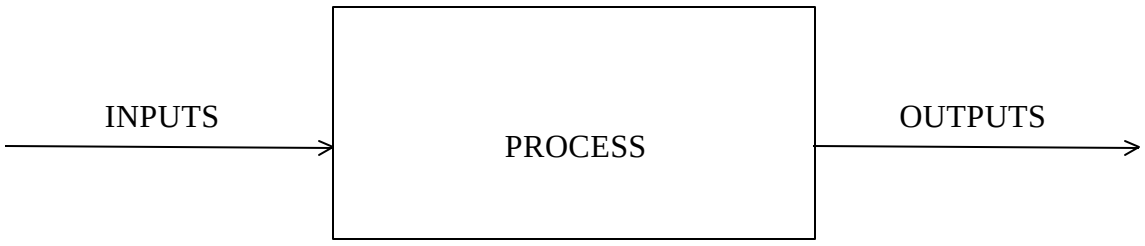


Figure 2. Simplified Model of a Process

An example of how this simplied model was used to analyze one of the six subprocesses is:

Electronic Fabrication–Manual and Automated

Inputs (What's Used To Produce End Product)

Trained process/fabrication engineers
Certified technicians/fabrication personnel
Computer systems & appropriate software
D-8208
FP513414 and other assembly procedures as appropriate
Released print set (drawings, AIDS or fabrication plan)
Other specifications as required by customer
Travelers (record of work performed)
Build materials such as printed wiring boards and components (piece parts)
Process expendable materials such as fluxes, conformal coating materials, cleaning agents, etc.
Controlled facilities (building, dedicated rooms, HVAC, etc.)
Process equipment, e.g., soldering irons, tweezers, lead forming device, tinning pots, lead forming device, automated tinning equipment, solder reflow equipment, automated pick-and-place equipment, semiautomated cleaning equipment, rework station
QA inspectors + QA specifications (Section 506 personnel and procedures)

Outputs (End Products)

Fully fabricated and inspected assemblies **(chief end product of this activity)**
Engineering change requests (ECRs) (feedback to design engineering)
Suggested changes to D-8208/FP513414 (feedback to documentation control)

DEVELOP A PLAN TO ACHIEVE ISO REGISTRATION

A plan was developed for the Electronic Packaging and Fabrication section for achieving ISO registration. The chief items highlighted in the plan were:

Establish a ISO 9001 Team within Electronic Packaging and Fabrication section. This team is composed of the following individuals:

- Kirk Bonner (Section 349 management representative)
- Robert Graber (Microelectronic Hybrid Assembly Processes)
- Paul Baca (Electronic Fabrication Processes)

- Pat Westerlund (Cable Fabrication Processes)
- Atul Mehta (SMT Electronic Fabrication Processes)
- Charles Kaczinski (Packaging and Advanced Packaging Design Engineering)
- Joan Coggins (QA)

Have an all-hands meeting to inform everyone in the Electronic Packaging and Fabrication section that the section'll be going through the ISO registration process. This helps familiarize people with what ISO 9000 is and what it isn't. Without total "buy in" by everyone in the section, it's much more difficult, if not impossible, to achieve the objective. This meeting emphasizes to all section members the seriousness and total commitment to the quality system.

The ISO Team should meet every week to review progress, and a record must be kept of each meeting. Once progress is moving forward, the meetings should include corrective and preventive actions. The purpose of such meetings is to discuss the ISO 9000 system, its implementation throughout the Electronic Packaging and Fabrication section, and its being understood, at least in broad outline, by every section member. Progress toward ISO 9001 registration should be reported on once a month at section staff meetings regarding progress.

DEVELOP FLOWCHARTS AND A MASTER DOCUMENT LIST

Each member of the ISO team responsible for one of the subprocesses within the Electronic Packaging and Fabrication section was asked to develop a detailed process flowchart for his/her process. These process flowcharts were developed and proved very useful.

Concomitant with the above effort of developing flowcharts, the Electronic Packaging and Fabrication section began consolidating all relevant guidelines, procedures, and work instructions into three working documents. The intention is that there be two chief technical documents of the Electronic Packaging and Fabrication section and a third document covering the system procedures required by ISO 9001. These documents are:

- D-8208, Spacecraft Design and Fabrication Requirements for Electronic Packaging and Cabling
- FP-513414, Manufacturing Processes and Procedures for Assembly and Wiring of Electronic Equipment and Assemblies (detailed work instruction)
- Procedures covering the PAFEH process as a system. These procedures are necessary to meet the needs of ISO registration. Examples are Document and Data Control, Handling of Norconforming Product, and Training.

PERFORM A GAP ANAYSIS

Once the chief documents have been determined and the process flow charts elaborated for each subprocess, each block in each flow chart was examined to ascertain if it had a match in one of the above documents on the master list. This activity is known in ISO parlance as performing a "gap analysis". That is, there is a gap between what is actually being done on the floor and what the documentation claims is done. Remember the chief caveat for ISO is: Say What You Do and Do What You Say!

PERFORM INTERNAL AUDITS

Another item that should arise rather quickly in the ISO Team meetings is that of internal quality audits. As the various internal documents defining the quality system (the term "quality system" is used in its broadest sense; see ANSI/ISO A8402-1994 "Quality Management and Quality Assurance–Vocabulary") are set forth, quality audits should be conducted on a periodic basis, the purpose of which is to assess the variance between the system as defined by the documentation and the actual practice that is taking place. The idea, of course, is either to amend the documentation, if appropriate, or to close the gap between what ought to be done regarding quality (the quality system) and what is in fact being done (actual practice). All action items emanating from the ISO Team meetings automatically become agenda items at the next meeting.

TAKE CORRECTIVE ACTION TO PREPARE FOR THIRD PARTY AUDITOR

Once management reviews and quality audits have begun, then corrective and preventive actions should be initiated on an as-needed basis. These actions are designed to close the variance between the ISO 9000 system and actual practice as conducted within the section. The corrective actions take place first. They are reports generated by internal auditors which are then turned over to the ISO Team to correct. These become agenda items and must be addressed, hopefully before a third party audit takes place. Once the quality system is in good shape and a third party auditor has granted registration, it is necessary to perform preventive actions to ensure that the quality system remains in good working order and doesn't degenerate. Obtaining and keeping ISO registration is an ongoing process. It is an achievement worth shooting for.

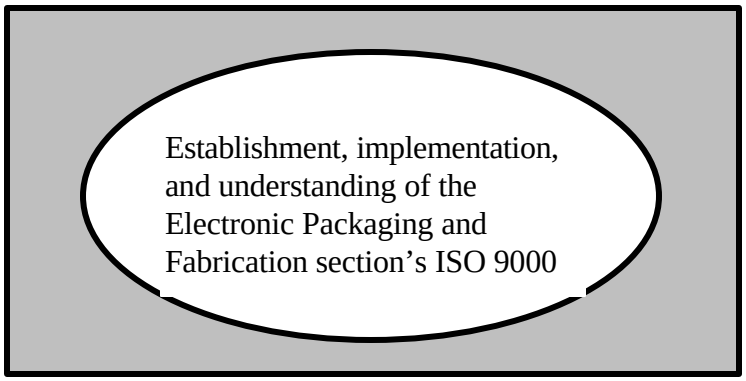
CONCLUSION

In summary, for the Electronic Packaging and Fabrication section the four drivers for ISO registration are:

- ISO Team meetings and reviews
- Necessary documentation
- Internal quality audits
- Corrective and preventive actions.

These four items ought to drive the establishment, implementation, and understanding of the quality system. This fundamental idea can perhaps best be captured by a pictorial diagram as shown in Fig. 3 below.

ISO Section Team Reviews **Necessary Documentation**



Internal Quality Audits **Corrective and Preventive Actions**

Figure 3. Four drivers of Electronic Pkg. and Fab. in achieving ISO registration

ACKNOWLEDGEMENTS

The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. Funding for revising the chief technical documents used by the Electronic Packaging and Fabrication section was provided by the Jet Propulsion Laboratory's Technical Infrastructure fund. The authors wish to thank Mr. Charles H. Shinbrot for his support. In addition, they wish to thank the individual members of the Electronic Packaging and Fabrication section's ISO Team, who are listed above, and all the personnel of the section.

REFERENCES

American National Standard: Quality Systems—Model for Quality Assurance in Design, Development, Production, Installation, and Servicing. ANSI/ISO/ASQC Q9001-1994. Milwaukee, WI: American Society for Quality Control, 1994.

International Standard: Quality Management and Quality Assurance Standards—Part 1: Guidelines for Selection and Use. ISO 9000-1.

American National Standard: Quality Management and Quality Assurance—Vocabulary. ANSI/ISO/ASQC A8402-1994. Milwaukee, WI: American Society for Quality Control, 1994.

American National Standard: Quality Management and Quality System Elements—Guidelines. ANSI/ISO/ASQC Q9004-1-1994. Milwaukee, WI: American Society for Quality Control, 1994.

Breen, Michael; Jud, Bob; Pareja, Pablo E. An Introduction to ISO 9000. SME Blue Book Series. Detroit, MI: Society of Manufacturing Engineers, 1993.

Hoyle, David. ISO 9000: Quality Systems Handbook, 2nd ed. Oxford, UK: Butterworth-Heinemann, 1994.

Patterson, James G. ISO 9000: Worldwide Quality Standard. Menlo Park, CA: Crisp Publications, 1995.

Sprow, Eugene. “Insights into ISO 9000.” Mfg. Eng., Sept. (1992), 73-77.