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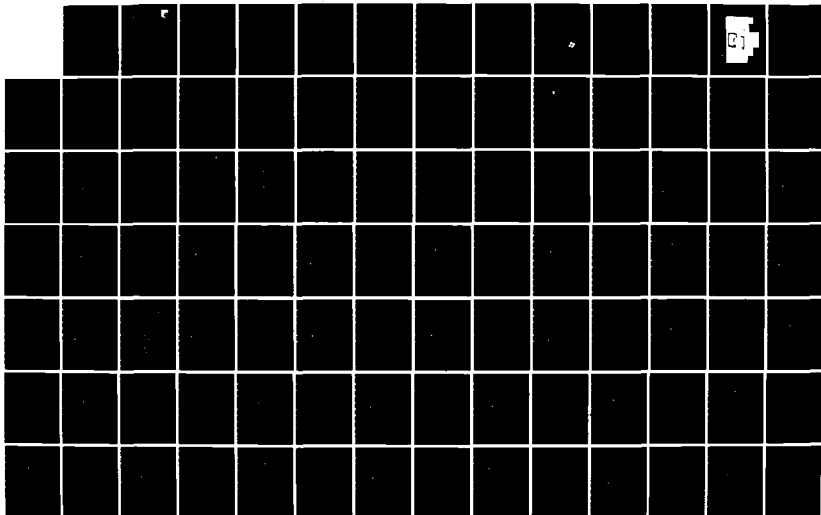
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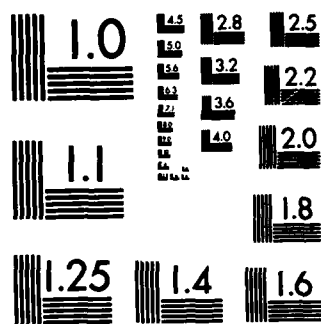
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ICAM CONCEPTUAL DESIGN FOR COMPUTER-INTEGRATED MANUFACTURING



Volume IV, Part 5

**Task D – Quality Assurance/Quality
Control/Technical Requirement/Tasks
Quality Assurance Modeling and Analysis
Architecture for Product Assurance, (TTD)**

LTV Aerospace and Defense Company
Vought Aero Products Division
Post Office Box 225907
Dallas, Texas 75265

June 1984

**Final Technical Report for Period
1 October 1981 – 29 June 1984**

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Prepared for:

**MATERIALS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
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WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433**

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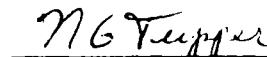
This technical report has been reviewed and is approved for publication.



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July 25, 1984
DATE

FOR THE COMMANDER:



NATHAN G. TUPPER
Chief
Computer Integrated Manufacturing Branch
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- Volume II** **Establishment of the Factory of the Future Conceptual Framework**
- Volume II, Part 1 Scoping Document (SD), SD 110512000, 25 March 1982
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 - Volume IV, Part 4 System Requirements Document (SRD), SRD110513000, 24 September 1982
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- Volume VI** **Recommendations for Factory of the Future Development Projects (TTD), TTD110510002, 29 June 1984**

FOREWORD

This Architecture for Product Assurance, was developed under Air Force Contract #F33615-81-C-5119, Project Priority 1105, entitled "ICAM Conceptual Design for Computer Integrated Manufacturing." This contract was sponsored by the Computer Integrated Manufacturing Branch, Manufacturing Technology Division, Materials Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 45433. This project was administered under the technical direction of Captain Richard R. Preston.

This document, Volume IV, Part 5, of the Final Technical Report contains the Quality Assurance Modeling and Analysis Architecture for Product Assurance.

The results of this project have been achieved by a coalition of companies organized and managed under the leadership of the prime contractor, Vought Corporation, with Mr. Don L. Norwood providing primary overall contract leadership and management responsibility (TASK A). Other Task leaders were:

1. Mr. Robert L. Moraski, Vought Corporation, responsible for leadership and management of the Factory of the Future Conceptual Framework Thrust (TASK B).
2. Mr. Frank E. Sullivan, Northrop Corporation, responsible for leadership and management of the Integrated Composites Center Conceptual and Preliminary Designs (TASK C and TASK E).
3. Mr. Robert H. Wettach, General Electric Company, responsible for leadership and management of the Quality Assurance Modeling and Analysis Thrust (TASK D).

This project was supported by a coalition team consisting of the following members:

Mr. T. R. Lee	Northrop Corporation
Mr. J. J. Page	Vought Corporation
Mr. B. R. Shepherd	General Electric Company
Mr. M. G. Stroud	Vought Corporation
Mr. W. D. Vinson	General Electric Company
Mrs. P. A. Waldrop	General Dynamics/Ft. Worth
Mr. J. P. Watkins	General Dynamics/Ft. Worth

In addition to the major coalition participants, the following companies and organizations have served as contributing and reviewing participants for this document:

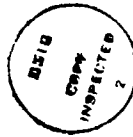
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10 January 1984

Note that the number and date in the upper right corner of each page of this document indicates that this Document has been prepared according to the ICAM Configuration Management Life Cycle Document Requirements and is a designated configuration item.

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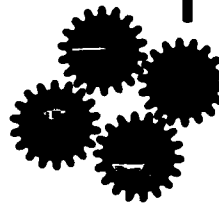
Architecture for Product Assurance

A United States Air Force Manufacturing Technology Project
Prepared For

USAF MANUFACTURING TECHNOLOGY PROGRAM

ICAM
INTEGRATED COMPUTER AIDED MANUFACTURING

Computer Integrated Manufacturing Branch
Manufacturing Technology Division
Materials Laboratory
Air Force Wright Aeronautical Laboratories
Wright-Patterson Air Force Base, Ohio 45433



Section I

Introduction

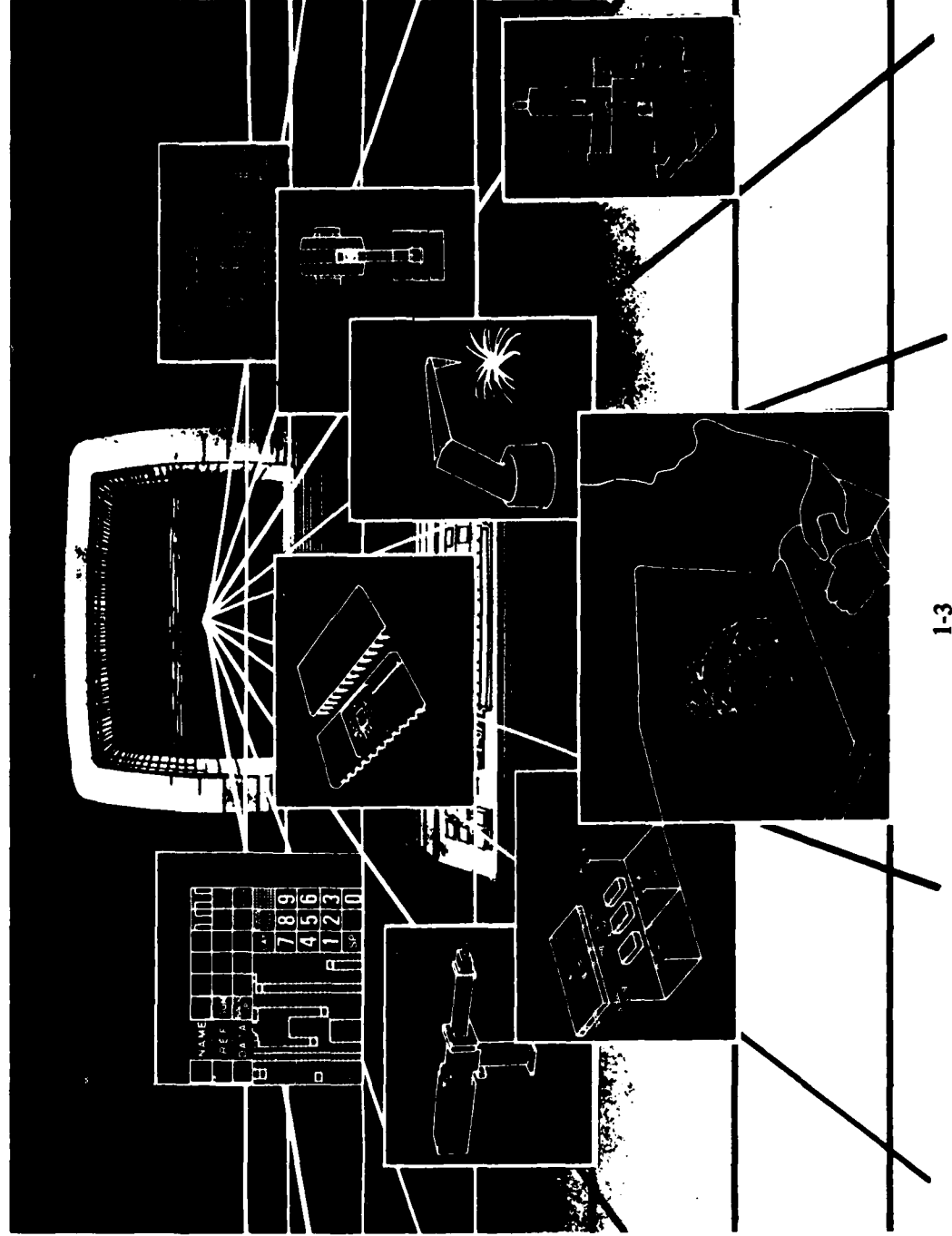
"So swiftly do new situations present themselves that, like the modern jet overhead, if we look only toward the sound, we never catch sight of the plane."

L.F. Lewis, GE Engineer

"Houston, Tranquility Base here. The Eagle has landed."

Neil Armstrong, Apollo Astronaut

Architecture for Product Assurance



Overview

In the continual struggle to change our environment for the better, we have used knowledge, creativity and intuition to evolve a single idea or discovery into a plethora of benefits to improve the quality of our lives. At no time was this more evident than when the monumental scientific and engineering achievements needed to put a man on the Moon resulted in a myriad of new technologies that have since found application in virtually every product and service that touches society.

Today it seems as if we are being "future shocked" and "megatrended" into making changes that we are hesitant to make, either because we don't understand the technology completely or because the technology accelerates so rapidly that we feel we are investing in equipment that will be obsolete by the time it is set up on the factory floor.

On the other hand, we know that we must keep pace or perish.

And that pace is being set by customers who want assurances that they are getting quality products with more reliability and maintainability at fair prices, while shareholders and top management expect continuing increases in sales and profits.

In addition, the advent of the electronics revolution has not only changed the way we manufacture, it has changed *what* we manufacture, as well. Products are becoming more exotic, more reflective of the high tech era with its focus on automation and communications.

It goes without saying that the productivity, precision and high quality inherent in electronically automated manufacturing operations is the key to survival in business today. But, however imperative the need to automate may be, there also is a need for caution.

Simply buying and installing the latest electronics equipment will not automatically mean higher quality products or more productivity. As in any business venture, the successful transition from one method of working to another will depend on a combination of realistic self-appraisal, technical know-how and timing. In other words, you must evaluate your current position, define your needs and identify the financial resources you can commit without jeopardizing your ability to compete. That basic exercise is the first important step you must take in order to establish a workable road map or timetable leading toward the total integration of automated systems into any manufacturing operation.

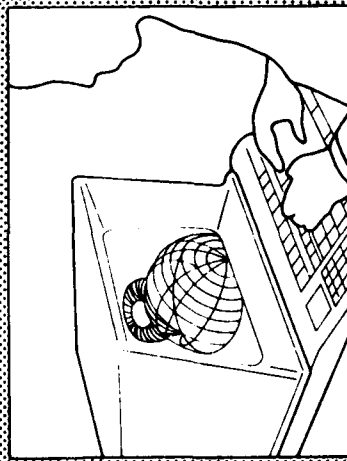
It also is beneficial to take advantage of the automation "groundwork" that has already been accomplished by other manufacturers who have "tested the waters" early and learned — through trial and error — how to get the most from their investment dollars.

Architecture for Product Assurance represents just that type of groundwork. It evolved as a result of an intensive study conducted for the Air Force by four leading manufacturers plus fifteen additional major companies served as reviewers. These companies were chosen on the basis of their successful track records and experience in integrating automation systems in a wide range of manufacturing operations resulting in cost effective quality assurance and products with high reliability and maintainability ratings. And although this report evolved from specific applications in the aerospace industry, their applicability transcends industrial boundaries. Whether you have already automated your manufacturing processes, have partially automated, or are contemplating automation, this is "must" reading.

Background

From the beginning, the aerospace industry has set a very high priority on quality, reliability and maintainability. There are very few businesses that can match the precision, endurance and performance that has become the hallmark of aerospace products. However, this self-imposed standard for excellence has also carried a high price tag.

In an effort to become more cost efficient *without* jeopardizing its high quality standards, the Air Force asked key personnel from Vought, General Dynamics, GE and Northrop to form a Coalition Team for the express purpose of identifying key areas in the manufacturing process where cost improvements could be made while maintaining quality assurance and quality control. The names of the fifteen other companies and organizations who served as reviewers of this study can be found on the last page of this document.



Integrated Computer-Aided Manufacturing

The Project Scope

This project is part of the U.S. Air Force's Integrated Computer-Aided Manufacturing (ICAM) Program, which addresses the needs and requirements related to state-of-the-art technologies, economics, design and manufacturing complexity and their respective trends with the aerospace industry.

Although the ICAM Life Cycle is a total systems approach, the Coalition Team worked on only the first phase of a four-phase approach to modernizing manufacturing quality. This first phase resulted in four documents:

- 1) *System Scope*,
- 2) *System Environment*,
- 3) *Needs Analysis*
- 4) *System Requirements*.

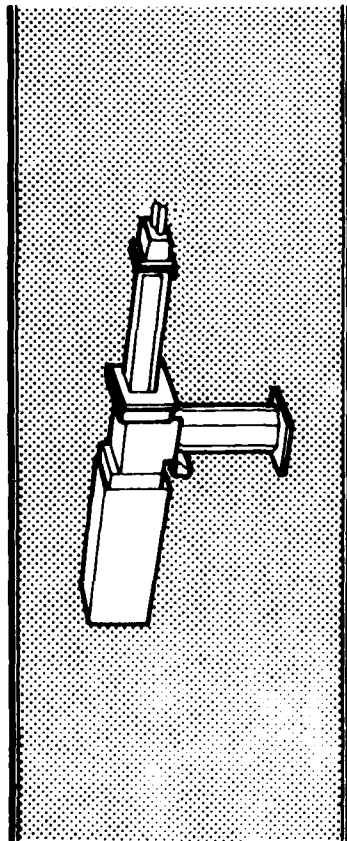
These documents detail a composite description of each team member's present Quality Assurance System; key quality/cost needs presently existing in their businesses and system requirements that must be met after solutions have been implemented.

While the information described herein relates primarily to aerospace, with little or no restructuring, it may be applied to any manufacturing facility. For example, while we use the term, "RFP" (Request for Proposal), a common government phrase, its civilian counterpart would be the submission of bids, a practice common throughout business. In other words, the name used to describe some activities may be different, but the nature of the activity is the same or nearly the same as those that confront the manufacturing community all the time.

Project Application

The ICAM "as is" (or status quo) life cycle approach provides a step-by-step method for analyzing and improving any business system.

The project documents described in the Architecture for Product Assurance provide a starting point from which you can assess your current situation, identify what your next steps should be, and determine what levels of integration are needed to assure quality and productivity increases throughout the entire manufacturing cycle, from design and engineering to finished product and field use.



Robotic Inspection

In essence this report serves as a model — or "straw man" — to use in examining your quality needs. By comparison, you can determine if your needs are similar to or different from others and if your goals and standards "measure up" with the rest of industry.

Much of the work described here has already been completed and "road tested," and will give you a detailed understanding of what must be done to assure product quality and cost effectiveness in your business. You will not only learn the answers to critical questions, you will learn how to find the answers given your

particular set of circumstances. The following are typical questions that apply to most situations:

- 1) Do we consider quality requirements and activities only after the design is finalized?
- 2) Are there voids in our quality system that, once corrected, would benefit our customers as well as the company?
- 3) Are we continuing any obsolete "quality assurance" functions?
- 4) Are we duplicating quality functions anywhere in the manufacturing cycle?
- 5) Can our present quality system accommodate proposed changes in our business, such as ...
 - the introduction of new or exotic products?
 - the addition of robots to existing automation?
 - the adoption of inventory control measures such as "just in time"?
 - the change in maintenance or repair policies?
 - the introduction of computerized design and manufacturing?
 - the switch from a centralized computer system to a distributive system?
 - the ultimate conversion to a total' paperless factory?

If you can answer "no" to the first four questions and "yes" to the applicable sections of the fifth question, then you are in a good position to surmount the challenges that are inherent in the industrial automation revolution. But that's only half the battle. Assuming you got a good grade on those questions, you're ready to answer the big one next:

Do you have *cost effective* quality assurance factored into your application of automation technology?

This Air Force project and its ICAM systems approach provides the guidelines for self-analysis that will help you answer all these questions.

The Project Documents

System Scope

The System Scope Document defines project objectives, parameters, schedule and budget constraints. It spelled out for the Coalition Team the areas to be examined, the level of detail required and how this project tied together with other ICAM projects.

System Environment

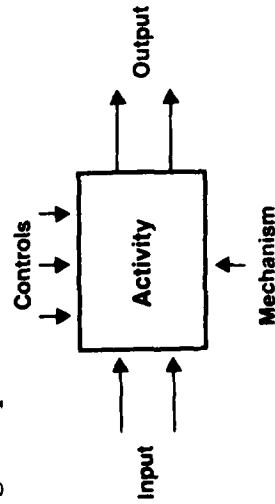
The System Environment portion of this report is divided into two sections — the first is a function model (IDEF0) that describes the "as is" activities and interfaces; the second is an information model (IDEF1) that identifies "as is" information and information relationships that must be understood before automation can occur. IDEF0 and IDEF1 are acronyms derived from "ICAM Definition Method". Each is a structured modeling method, or technique, used to record a common understanding of the manufacturing environment.

Function Model (IDEF0) — General

The major advantage of function modeling is that it forces one to think through a potential system and analyze how the pieces of the puzzle fit together and make the whole process work.

The function model is an organized sequence of diagrams that describes in sequential "telescopic" detail the work activities being modeled. IDEF0 diagrams graphically present elements or activities and their relationships.

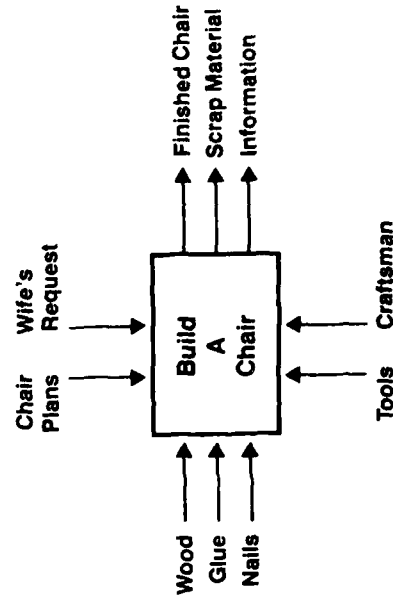
The following examples illustrate how to "read" a basic IDEF0 diagram.



A box represents the *activity* to be performed or an input that is transformed and results in an output. *Arrows*, representing objects or information required by or produced by the activity, enter or leave the box. The side of the box where an arrow enters or leaves shows its role as an *input*, *control*, *output* or *mechanism*. Inputs (always on the left) are changed into outputs (always on the right) after the activity is performed. Controls (always on the top) govern the way the change is done. Controls might be policies, requirements, demands, constraints, etc. Mechanisms (always on the bottom) indicate the resources required to perform the activity. Mechanisms might be skills, facilities, machines, etc.

Using this basic information, here is how it applies to a specific activity, such as building a chair:

Assume that the inputs for building this chair consist of wood, glue, nails, and so on, while the outputs are the finished chair, scrap material, and the data or information gathered as a result of the activity. In this case, the plans for the chair and a wife's request to have a chair built constitute the controls, while the mechanisms are represented by woodworking tools and the skilled craftsmen needed to operate those tools.



Function Model (IDEF0) — Assure Product Quality

Using the "Build a Chair" approach, the Coalition developed its function model for *Assure Product Quality*. The entire QA QC "as is" model is presented in the second section of this document. First, the tree-structured QA/QC Architecture (an index of all the QA QC activities) appears, followed by the detailed diagrams, text and glossaries describing the activities and their relationships. While some quality activities are unique to the aerospace industry, many described in the diagrams are common to most industrial operations.

As a guideline for understanding how to "read" the whole spectrum of diagrams, we have selected the following examples using "A4 - Implement QA/QC Program Plan" and "A42 - Provide QA QC Detailed Work Instructions" from the QA QC model.

IDEF0 diagrams have a family-like relationship that can be detailed through as many generations as necessary. A4, shown in Figure A, is the *parent* of all the boxes contained within it (A41, A42, A43 and A44). This numbering system, used throughout IDEF0 modeling, provides a method for tracking relationships of the activities.

"A42 - Provide QA QC Detailed Work Instructions" is a *child* of A4 with its own set of activity relationships. As detailed in Figure A, the controls that apply are 1) drawings and specifications, 2) manufacturing plan and 3) quality plan. The inputs are 1) process planning, 2) data/information and 3) request for corrective action. The outputs consist of 1) detailed QA/QC work instructions and 2) requests for change.

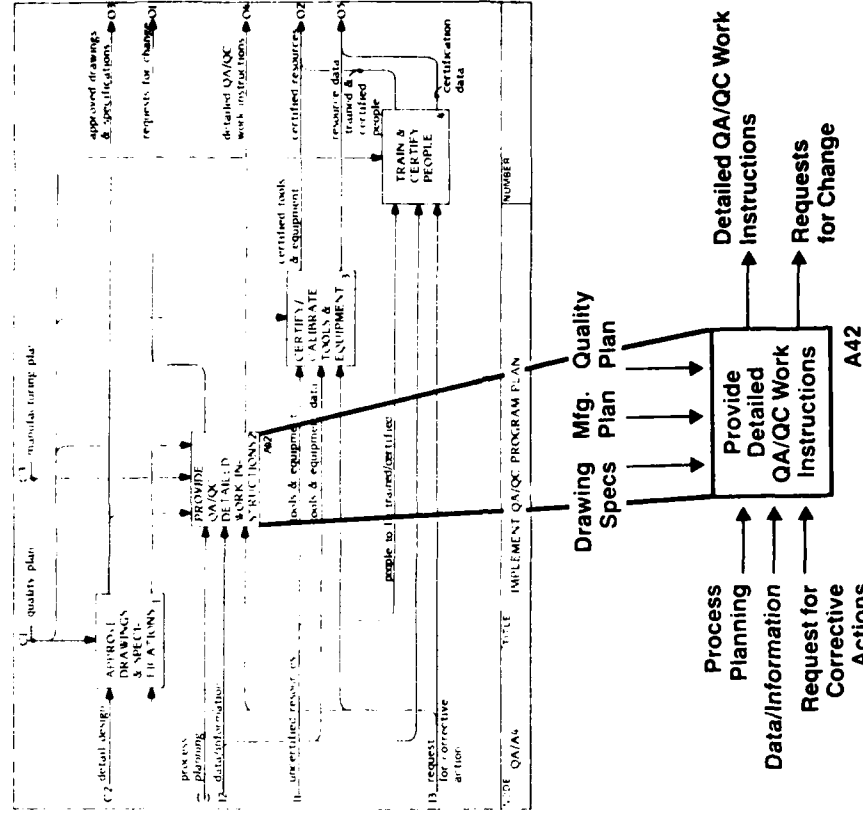


Figure A. Parent IDEF Diagram

Specific activities relating to A42 are shown in Figure B. These include the following:

- 1) Determine Critical Quality Characteristics
- 2) Review Manufacturing Sequence
- 3) Identify Test/Inspection/Control Points
- 4) Select Existing Test/Inspection/Control Instructions
- 5) Determine New Test/Inspection/Control Instructions
- 6) Integrate Instructions with Process Plans.

Just as in reading any road map, it is a good idea to look at the entire route. In reading the A42 example, first scan the parent, A4, to orient yourself with the sequence of events — the preliminary as well as subsequent requirements that relate to the diagram being studied.

Two resources, TI + E facilities equipment and QA QC experts are required to perform all the quality activities. These are shown on the first IDEF0 diagram, QA/A-O, Assure Product Quality (Context). Rather than repeating the same resources on every diagram, a technique called "tunneling in" was used. "Tunneling in" of resources is indicated by placing brackets around the arrowheads on the first IDEF0 diagram. The reverse, known as "tunneling out," can be used when specific types of resources need to be mentioned on a diagram. Examples of emerging resources are shown on QA/A5121, Inspect Sheet Metal and Extruded Parts.

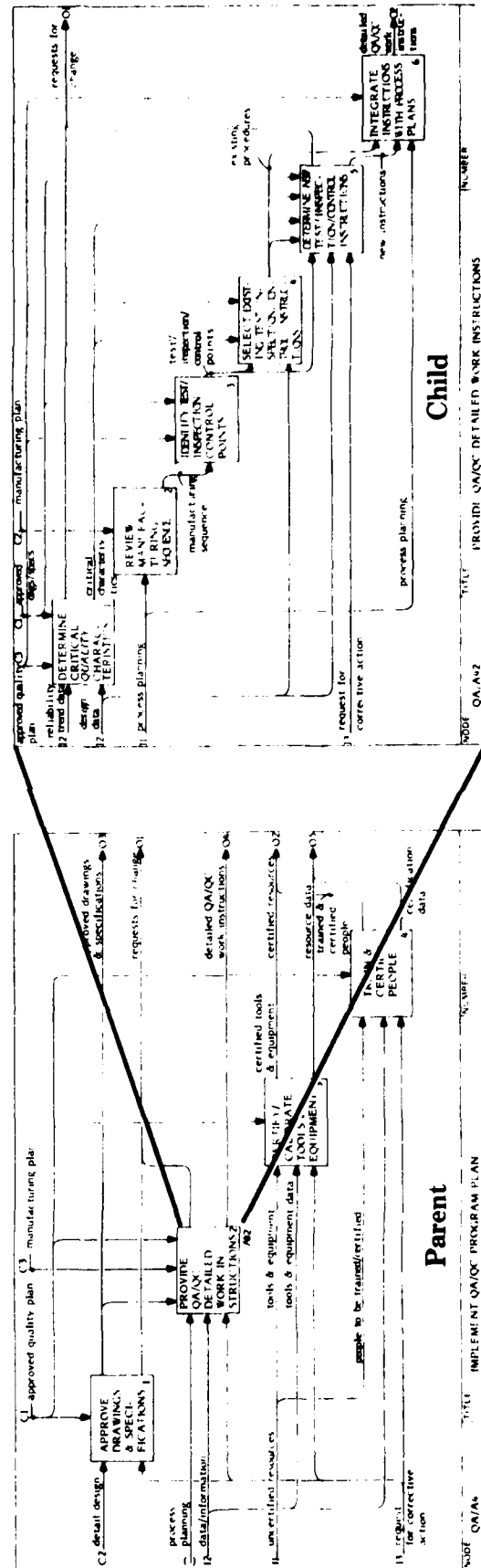


Figure B. Parent-Child Diagram Example

How To Apply The Function Model

The primary objective of the QA/QC function model is to provide a baseline understanding of how product quality is assured and to help you identify the key requirements and relationships associated with particular functions.

As we have mentioned earlier, modification of these documents to "fit" specific needs and operations in a wide range of industrial applications is a fairly straightforward undertaking.

However, there may be instances when other quality activities are necessary — in each case these documents and drawings will still serve as a valid model from which to formulate your own standards. For example, if a major portion of your business involved the manufacture of small motors, various quality activities associated with casting, stamping, winding and assembly would be detailed on an activity diagram. The amount and level of detail for your new activity diagrams is purely a "judgement call" on your part. However, one rule of thumb is to go no deeper than the level at which problems are perceived.

In many cases you'll find that while the activities may not change, the associated inputs, outputs, controls and/or mechanisms may be different. These elements should be carefully reviewed since the identification of duplication, omissions, or unnecessary procedures may lead to key areas of productivity improvement within the quality system.

Information Model (IDEF1)

The second ICAM model is an Information Model. It identifies information and shows the relationships that exist between classes of information that are used to assure product quality. The

understanding that is gained can be used to improve efficiency and effectiveness of the entire quality management system while developing a computerized data base.

The information model (Figure C) shows the relative relationships between entities (things) and their attributes (descriptions). For example, take the role of inspector within the quality architecture. The inspector's job is to inspect parts, components and assemblies to assure conformance to specifications. IDEF1 identifies three types of inspection activities that require different information.

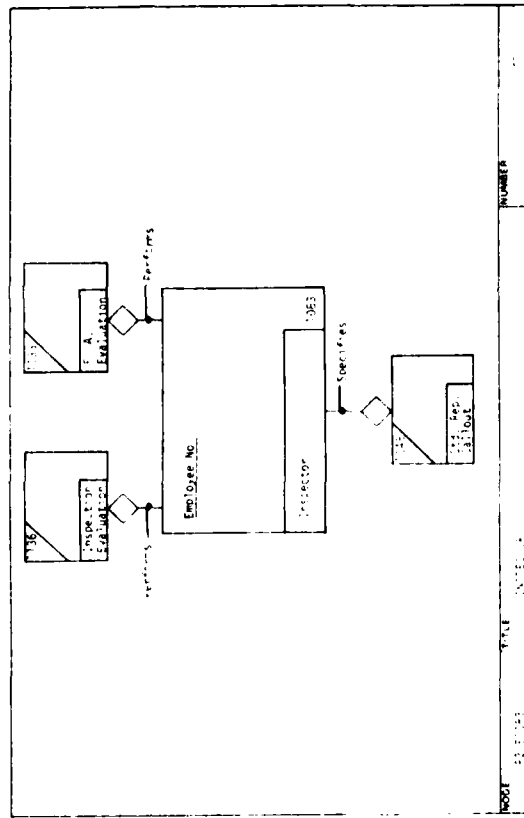


Figure C. Information Model Example

First, the inspector performs the "normal," day-to-day activities associated with incoming, in-process and final inspections of parts and assemblies. *Second*, he does a much more detailed inspection on any parts that are being submitted by a vendor for the first time. This detailed inspection is known as "first article evaluation" and generally involves a complete dimensional, physical and material analysis for conformance to specification. *Third* is the standard repair call-out which refers to those instances when the inspector makes a judgement of what standard repair procedures can be performed.

The IDEF1 model also contains the attributes unique to each entity. For example, in this case the inspector is the entity and his employee number is the attribute. So that there is no misunderstanding as to terminology, definitions are an integral part of the model, including name, label on diagram, definition and any frequently-used synonyms.

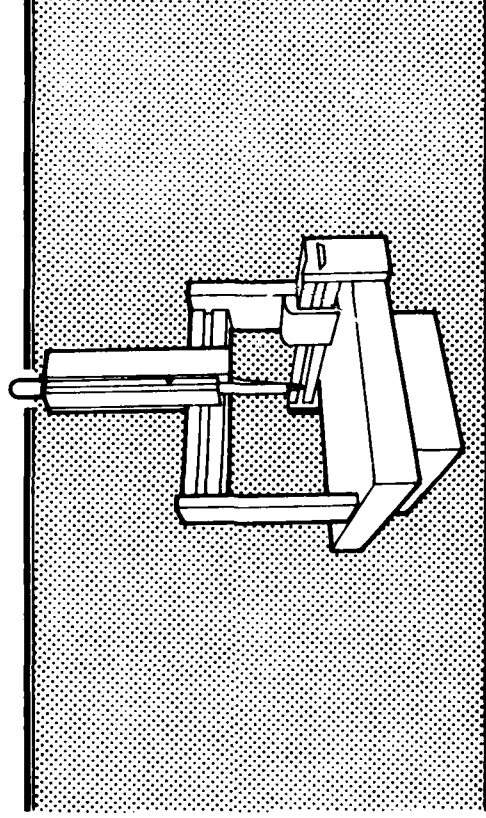
While the Coalition Team covered only the following areas, they are fundamental to any quality system within most manufacturing environments:

- 1) Inspection Planning
- 2) Process Control
- 3) Inspection, Test & Evaluation
- 4) Vendor Contact
- 5) Material Control
- 6) Material Review Board

An overview of this information model, complete with entity classes and relationship between classes, is shown in the third section of this document.

How to Apply the Information Model

Unlike the function model, an information model must *exactly* represent the business informational requirements in developing a computerized data base. This information model can be used as a guide for one to use in developing his own. It should prove useful as a "straw man" for examining and documenting one's own information system.



Automated Inspection Machine

The Needs Analysis Document identifies key weaknesses and improvements needed in any system in order to reach a more effective level of quality assurance performance.

The team developed an approach using a "Structured Needs Matrix" (Figure D) which relates each work activity identified in the function model against those elements critical to its support. These elements were classified into five categories:

- 1) Competency in Technical Skills
- 2) Organizational Interface Requirements
- 3) Adequacy of Information and Information Systems

[illegible]

1-13

- 4) Sufficiency of QA/QC Tools, Methods and Facilities
5) Other — a constant reminder to question whether or not any critical elements have been overlooked.

Each activity in the IDEF0 model was tested against these elements by members of the Coalition (by interviewing experts in their own companies) to determine if any deficiencies existed. These interviews elicited specific information about problems (Figure E), taking into account the source of information, ability to translate the problem to what was needed, any cost drivers associated with needs, human resource considerations and estimated benefits (both tangible and intangible) resulting from meeting the perceived need.

SUBMIT		AUTHOR	TASK & QUALIFICATION	DATE	REV	WORKING DRAFT	READER	DATE	CONTEXT				
		PROJECT ICM 1105		1	2	3	4	5	6	7	8	9	10
NODE NUMBER:		SOURCE:											
PROBLEM:		NEC											
COS* DRIVERS		HUMAN FACTOR CONSIDERATIONS / Positive & Negative											
BENEFITS / RISK*		Intangible											
Spendable													

Figure E. Needs Identification - Survey Sheet

Systems Requirements

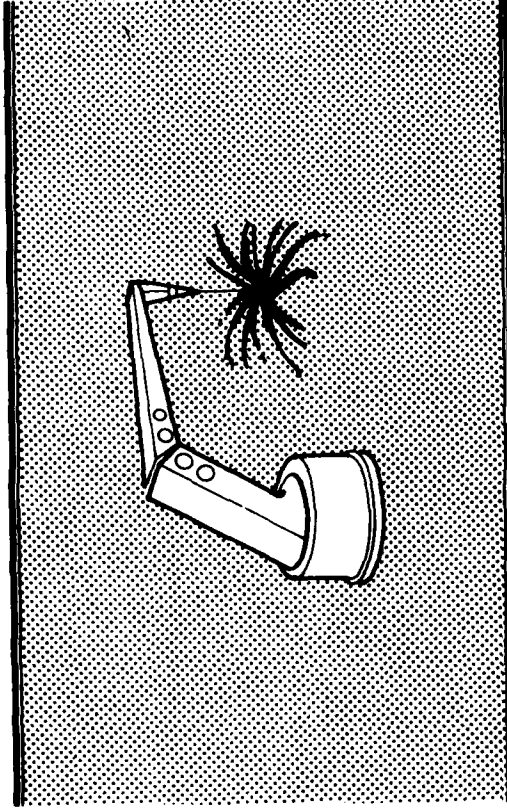
The Coalition Team compiled a set of systems requirements based on the preceding Needs Analysis section. Each key area of need was examined in detail to determine what was required to meet the need. Potential improvement concepts were reviewed against these requirements from which the system requirements were developed. These system requirements express what must ultimately be satisfied.

For each key need perceived by the coalition team, the following set of questions apply:

- 1) What requirements must be met to fulfill the need?
- 2) How can each requirement be met from an improvement concept and still serve our best interests?
- 3) What is the state-of-the-art status for each improvement concept? (Interestingly, the team found that the state-of-the-art is presently available to achieve 83% of the total benefits identified.)

The following tabulated information (Figure G) reflects a summary of the systems requirements and potential areas of improvement for the Coalition Team's aerospace industry business.

If you tabulate your information in a similar manner, it should provide you with a better perspective of your needs and more relevant problem-solving guide for your business or organization.



Robotic Welder

	KEY AREAS OF NEED NEED	SYSTEM REQUIREMENT REQUIREMENT	IMPROVEMENT CONCEPTS CONCEPT	STATE OF THE ART	
				AVAILABLE	NOT AVAILABLE
I.					
A	Early prevention/detection of design/production/manufacturing problems and capitalizing on quality opportunities.	<u>THE EARLY INTEGRATION OF FUNCTIONAL ACTIVITIES</u> Early integration of Marketing, Engineering, Manufacturing and QA/QC.	1) A structured, collaborative approach linking: o Potential Market Requirements o Concept Design Logic o Anticipated Manufacturing Process o Quality Assurance Plan and utilizing information contained in the integrated data base. 2) A multifunctional integration of goals	X	
B	New QA/QC technology compatible with future design concepts and factory-of-the-future manufacturing innovations.	Early integration of Product Concept planners, Factory-of-the-future planners and QA/QC Test and Inspection planners.	A structured, collaborative approach linking: o Product Concepts o Factory-of-the-future Concepts o QA/QC Test and Inspection Concepts Working design reviews before design is finalized that allows for trade-offs between Product Design, Process Design and T&E Design.	X	
C	Early availability of Design and Manufacturing requirements for Test and Inspection planning and Equipment requirements.	Early integration of QA/QC Test, Inspection and Evaluation (TIE) planners with Product Designers and Process planners.		X	
II.					
A	Inspections of internal integrity of composites.	<u>PROVIDE FAST, RELIABLE INSPECTIONS</u> Fast, reliable inspection of internal integrity of parts fabricated from composite material.	Automatic, high-speed inspection equipment capable of inspecting for voids and delaminations in composite parts and the evaluation of the structural integrity of a bonded joint.		X
B	Composite dimensional inspections.	Fast, reliable inspection of internal composite dimensions.	Integration of the inspection function with tape and cloth lay-up to assure, rather than just inspect for, tape orientation and spacing. This would be a part of the automated lay-up program.		X
C	Detailed machined part dimensional inspection.	Nondisruptive inspection techniques for machined components.	Automatic, in-line means for verifying dimensional accuracy of machined parts.	X	
D	Electrical wire harness inspection.	Early detection of electrical defects in components. Fast, reliable inspection of completed harnesses.	Automatic testing of harness components during assembly and final check of completed harness assembly.	X	
E	Sheet metal blanking inspection. Eliminate excessive material handling and lengthy manual inspection of sheet metal parts.	Sheet metal inspection techniques that provide rapid, in-process inspection without need for hard tooling.	Expand use of optical, laser and other flexible tooling for inspection of sheet metal parts.		X

Figure G. QA/QC System Requirements

KEY AREAS OF NEED		SYSTEM REQUIREMENTS		IMPROVEMENT CONCEPTS		STATUS OF THE ART	
NEED		REQUIREMENT		CONCEPT		AVAILABLE	
F	Automated, on-line electronic circuit QA/QC equipment. Increased accuracy/decreased time.	Fast, accurate inspection of electronic circuit fabrication.		Automated, on-line electronic circuit inspection equipment.			X
G	Reduce the need for QA/QC skills where they are in short supply.	Reduce dependence of manufacturing processing and QA inspection on QA/QC skills that are in short supply.		1) Introduce advanced automatic equipment that replaces the need for QA/QC skills in short supply. The equipment should be carefully selected so as to not create a need for other QA/QC skills that might be in even shorter supply. 2) Improved control of the manufacturing processes so that there is less need to call out nonconforming products.			X
<u>THE TIMELY TRANSMISSION OF DATA</u>							
A	Provide QA/QC field information for early identification and solution.	Reliable, timely transmission of Quality data from the field to appropriate organization functions.		1) Field representatives utilizing portable terminals at major field locations to relay analysis and acceptance/problem data to field offices and factory locations. 2) Utilize an effective data management system.		X	
B	Minimize present Product problem data in future designs and change proposals.	Reliable, timely transmission of Product problem information to Design and Application Engineers.		Perform a detailed analysis of Product problem data and establish a close link for communicating the information to Design and Application Engineers.		X	
C	Improve the collection, processing, storage and retrieval of shop floor inspection data.	Inspection data system that provides reliable and up-to-date data, easily accessible for retrieval and analysis with minimized input time and effort.		Install an integrated, automated data handling system for shop floor inspection.		X	
D	Secure useful incoming inspection data in a timely manner.	Receiving inspection effectively integrated into the material flow plan.		1) Automated, real-time material flow data system that contains inspection data. 2) Effective vendor control and certification programs.		X	
E	Submit a quality plan in response to the RFP that utilizes demonstrated strengths.	Reliable, timely transmission of past performance Quality data to those responding to the RFP.		Provide the RFP team a summarized, historical record of Quality performance results for appropriate Quality plans. List areas of strengths and weaknesses.		X	
F	Ensure correct inspection programs are loaded in on-line inspection equipment when the Part arrives.	Establishment of fail-safe techniques Program loading of on-type inspection equipment.		Provide a direct link between inspection program files, on-type inspection equipment and production control of parts flow in the shop.		X	

Figure G. QA, QC System Requirements (Continued)

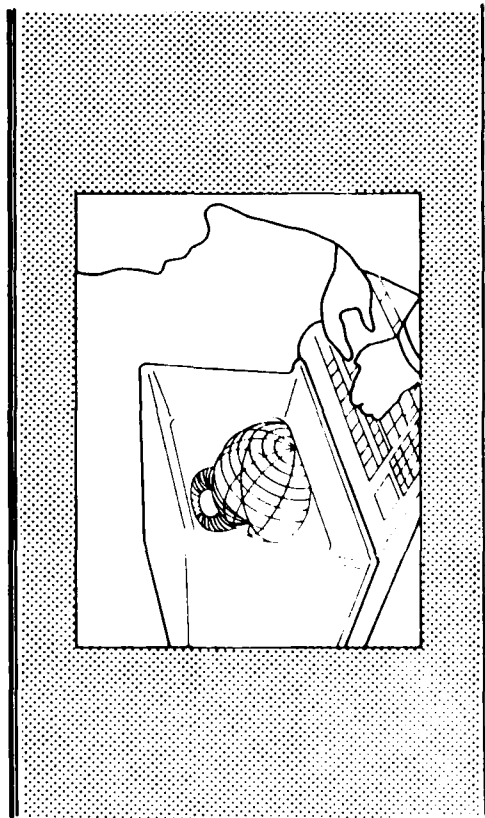
	KEY AREAS OF NEED	SYSTEM REQUIREMENTS		IMPROVEMENT CONCEPTS	STATUS - COMMENTS
		NEED	REQUIREMENT		AVAILABLE NOT AVAILABLE
G.	Provide only current, relevant inspection data to the shop floor.		Selective, timely transmission of inspection data to the shop floor.	Provide access to only current, relevant inspection data at each station requiring such information.	X
H.	Reduce the time and cost to incorporate repetitious QA/QC information in the response to the RFP.		Ability to store and recall standard QA/QC statements and descriptions used in response to RFPs.	Utilize word-processing equipment for response to RFP.	X
IV			<u>MORE EFFECTIVE PERSONNEL PRACTICES AND RESOURCE ALLOCATION</u>		
A.	Provide for QA/QC skills where they are in short supply.		Improved training in QA/QC skills that are in short supply.	Improve training of QA/QC skills in short supply.	X
B.	Provide a closer match between QA/QC personnel and position skill requirements.		Better selection process and procedures in filling QA/QC positions.	1) Establish better definition of skills required on a job along with improved techniques for assessing individual capabilities. 2) Reduce forces that mitigate against proper selection.	X
C.	Reduce QA/QC resource inefficiencies associated with project organizations.		Improved utilization and productivity of QA/QC resources.	Include in master plan allowance for level-load sharing of resources between project organizations.	X
V.			<u>ADDITIONS TO THE "AS IS" QUALITY SYSTEM</u>		
A.	Software Quality Assurance Needs: o Design requirements o "Process Control" procedures o Design change/configuration control o Validation o Audits		Software Quality Assurance at acceptable quality/cost levels.	1) Software documentation guidelines and standards for Quality Assurance. 2) A software requirement definition procedure. 3) Test/verification programs matching software against requirements. 4) A software design change/configuration control system.	X
B.	Provide Quality Assurance audit measuring the adequacy of the system to assure Product Quality.		An audit that measures the economic effectiveness of the Quality Plan and supporting procedures in producing products that meet quality integrity requirements.	Use a team of technically competent engineers representing the design, the process and quality assurance to audit the quality plan and procedure being followed that will identify areas for improvement.	X

Figure G. QA/QC System Requirements (Continued)

Conclusion

In conclusion, we have shown how this project can be of benefit to you. We recognize there are no pat answers or tailor-made guides for individual industrial businesses that can be referred to for obtaining instant solutions to quality and productivity problems. But this report does simplify the process considerably by providing a logical process to sequence events, prioritize those operations that merit your attention, eliminate replication of procedures, and establish a pattern or road map that is designed to be pertinent to your applications while at the same time flexible enough to adapt to any given situation.

We all know that if money were no object, the highest quality products would be rolling off every assembly line in the world every day. But money is the object — in terms of raw materials, manpower, overhead, production, quality control and test, and in terms of staying profitable. The basic guidelines set forth in this



document are designed to help you achieve the quality and cost efficiencies you want while remaining healthy and growing profitably in a high technology future.

In addition to the four major companies who participated in the coalition (Northrop, Vought, General Dynamics and General Electric), the following companies and agencies served as reviewing participants:

- Boeing Aerospace Company
- Boeing Commercial Airplane Co.
- Boeing Military Airplane Co.
- Cincinnati Milacron
- GE Aircraft Engine Business Group
- Grumman Aerospace
- Lockheed-Georgia
- Lockheed Missiles & Space Co.
- McDonnell Aircraft
- Rockwell International
- Sikorsky Aircraft
- HQ AFSC, Product Assurance Office
- ASD, Quality Assurance Division, Directorate of Manufacturing
- AFPRO DET 27, Quality Assurance Division, General Dynamics, Ft. Worth

The Quality Assurance Coalition — General Dynamics, Northrop, Vought and General Electric — was established under the auspices of the U.S. Air Force and technical work performed under the direction of ICAM Project Manager, Richard R. Preston, Captain, USAF. Any questions or comments that may arise during the use or potential use of this report should be directed to:

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Ohio, 45433

References

<u>Final Technical Reports</u>		<u>ICAM Life Cycle Documents</u>	
AFWAL-TR-81-4023	ICAM Architecture Part II Vol. III - Integration Using Architecture	SD 110513000	ICAM Conceptual Design for Computer-Integrated Manufacturing, "Scoping Document" for Task D, 28 January 1982
AFWAL-TR-81-4023	ICAM Architecture Part II Vol. IV - Function Modeling Manual (IDEFO)	NAD110513000	ICAM Conceptual Design for Computer-Integrated Manufacturing, "Needs Analysis Document" for Task D, 24 June 1982
AFWAL-TR-81-4023	ICAM Architecture Part II Vol. V - Information Modeling Manual (IDEF1)	SED110513000	ICAM Conceptual Design for Computer-Integrated Manufacturing, "System Environment Document" for Task D, 31 August 1982
AFWAL-TR-81-4023	ICAM Architecture Part II Vol. VII - Composite Function Model of "Manufacture Product" (MFGO)	SRD110513000	ICAM Conceptual Design for Computer-Integrated Manufacturing, "System Requirements Document" for Task D, 24 September 1982
AFWAL-TR-81-4023	ICAM Architecture Part II Vol. VIII - Composite Function Model of "Design Product" (DESO)	IDS1502120000E	ICAM Documentation Standards, 31 May 1982

Section II

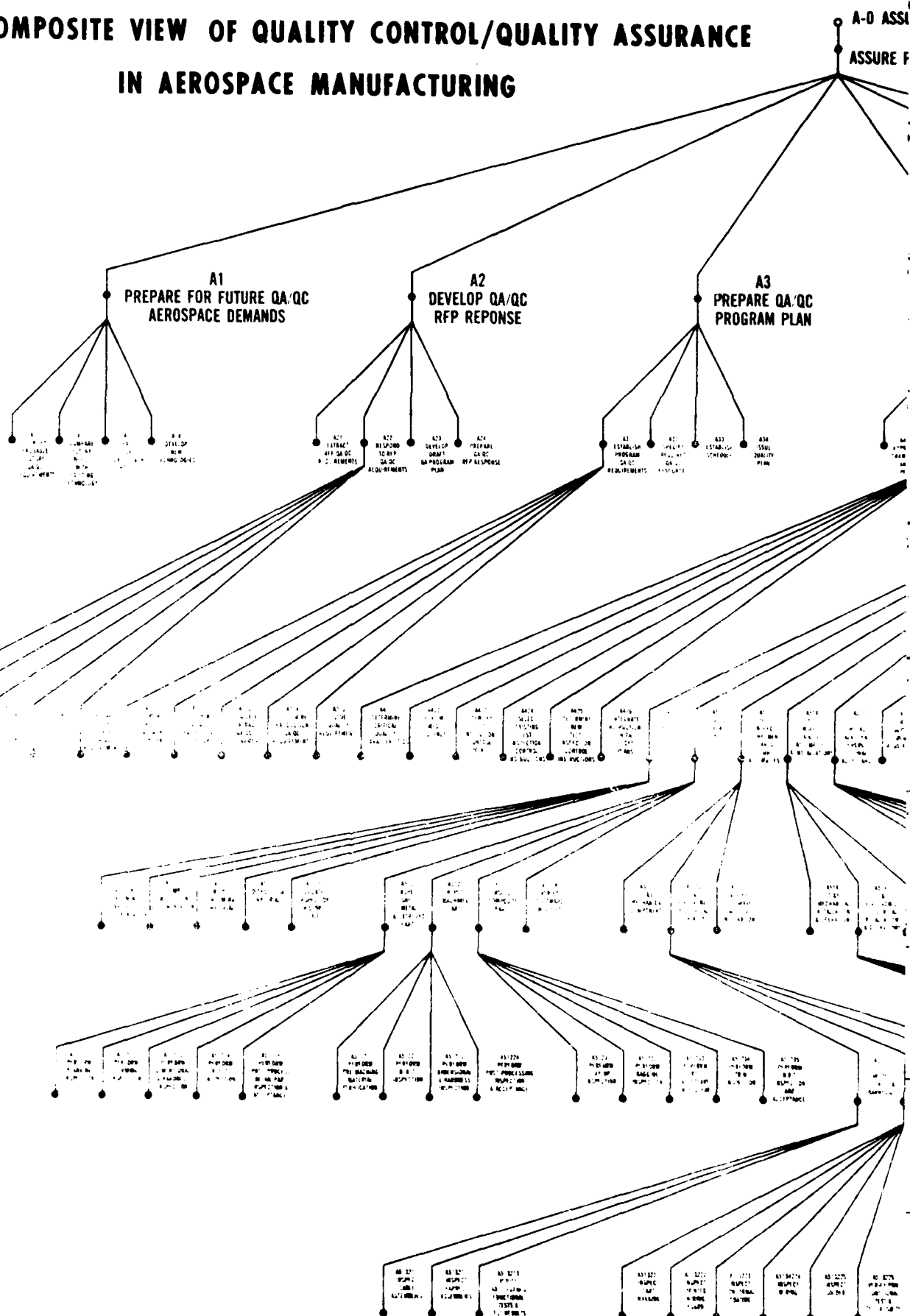
Function Model [IDEF0]

For Assure Product Quality

This second section of the Architecture for Product Assurance presents the Function Model (IDEF0) for *Assure Product Quality*.

The tree-structured QA/QC Architecture is presented first and provides an index of all the QA/QC activities. It is followed by the detailed diagrams, with associated text and glossaries describing the activities and their relationships.

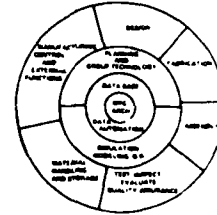
ICAM COMPOSITE VIEW OF QUALITY CONTROL/QUALITY ASSURANCE IN AEROSPACE MANUFACTURING



①

SURE PRODUCT QUALITY (CONTEXT)

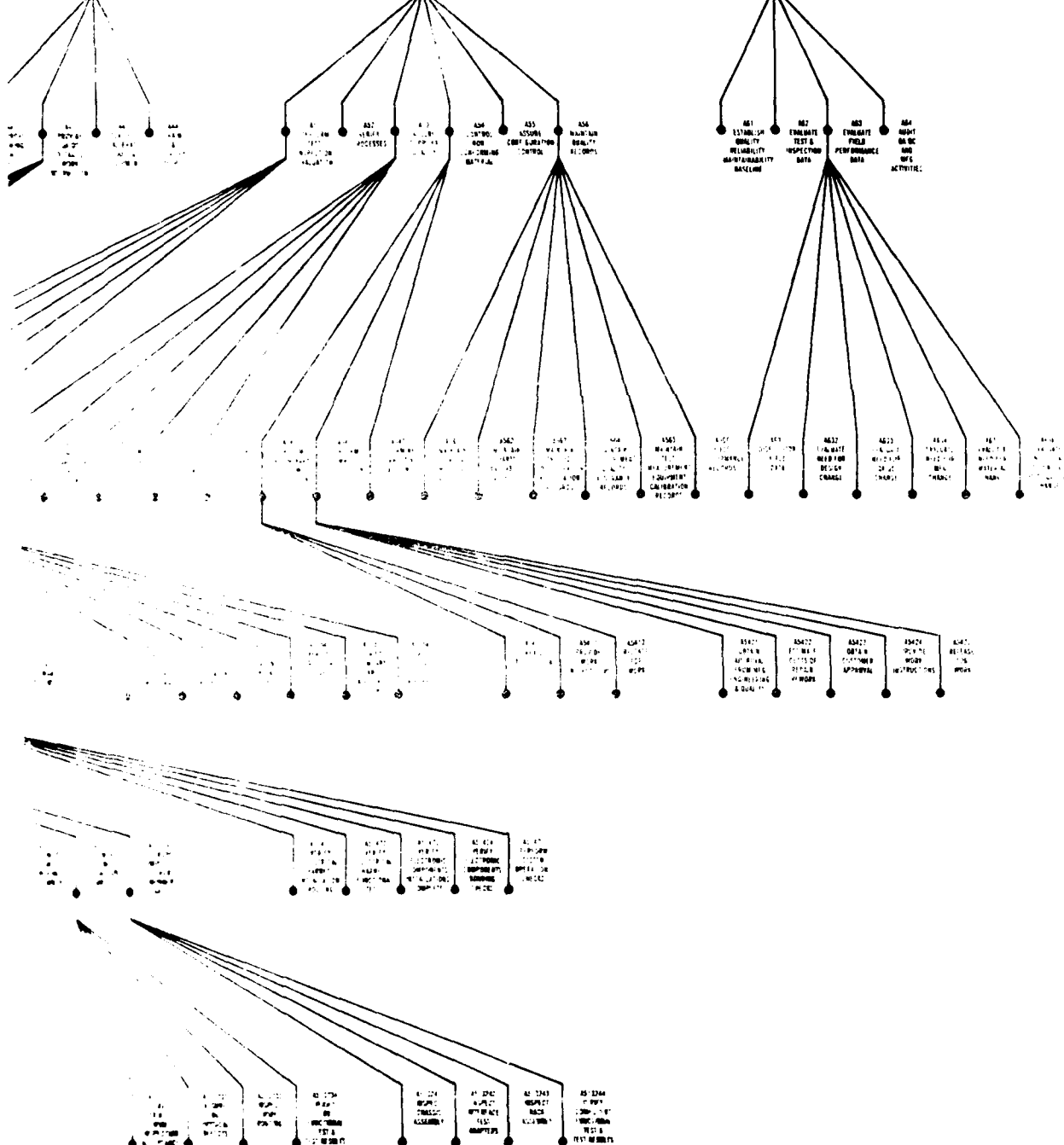
A0 PRODUCT QUALITY



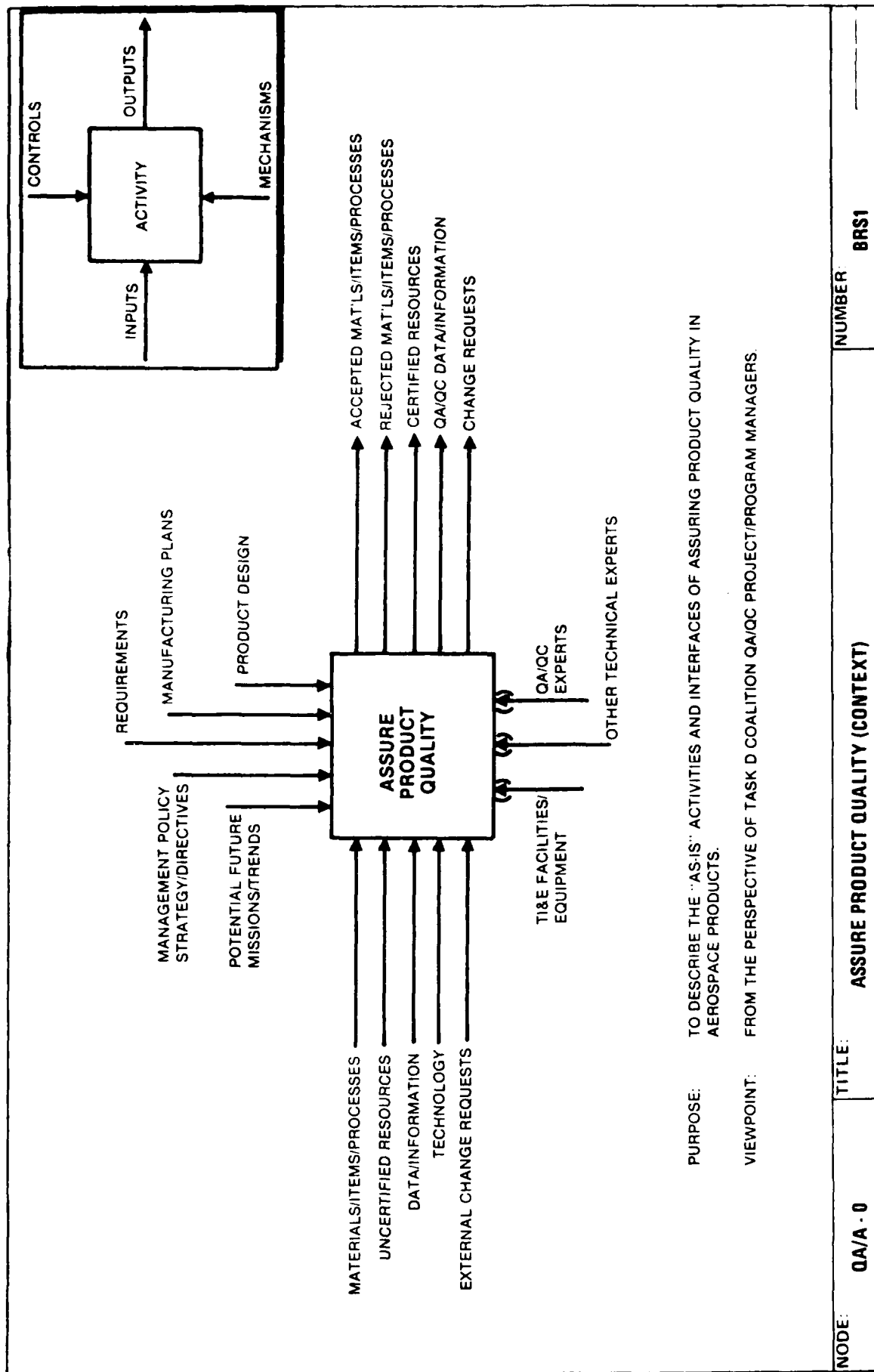
A4 IMPLEMENT QA/QC PROGRAM PLAN

A5 PERFORM TO QA/QC PROGRAM PLAN

A6 EVALUATE QA/QC EFFECTIVENESS

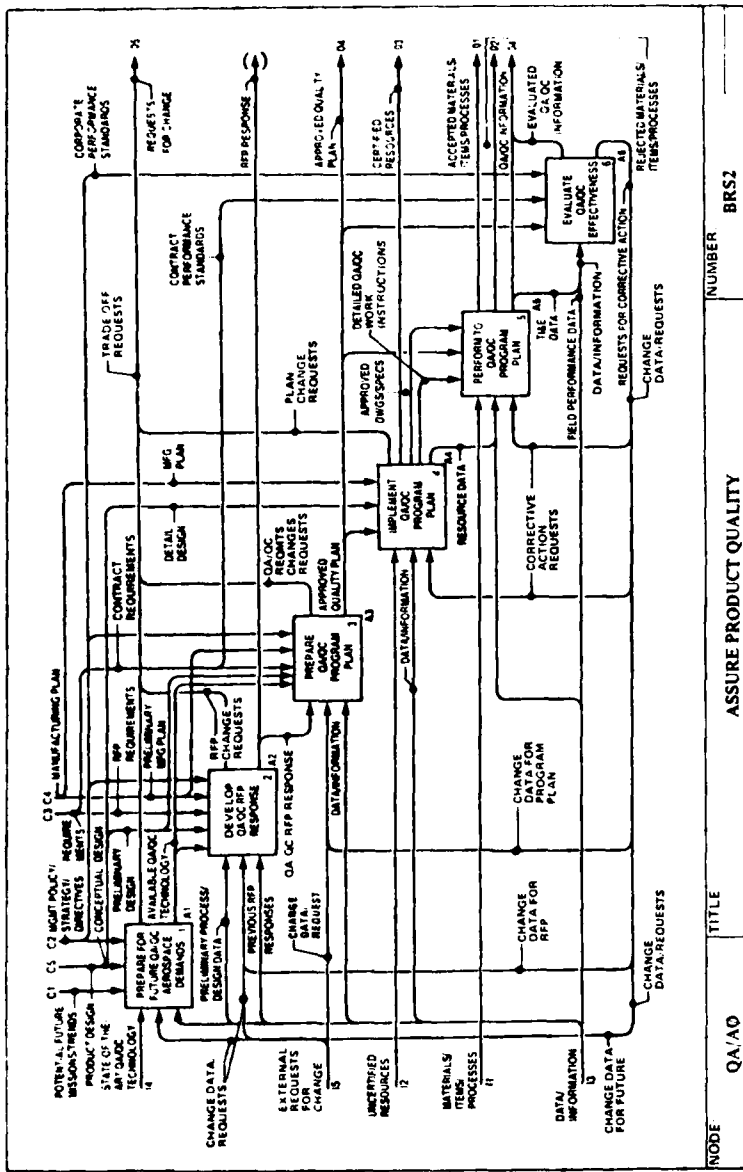


Function Model [IDEFØ] For Assure Product Quality



Glossary - A-0 Assure Product Quality (Context)

Accepted Materials/Items/Processes Those materials/items/processes which have been deemed acceptable for use/operation.	Items component parts, subassemblies and assemblies.	Rejected Materials/Items/Processes Materials, items or processes that have been deemed unacceptable for use.
Certified Resources Includes certified QA/QC people, inspection equipment and inspection tools.	Processes a series of actions pertaining to the manufacture of an item.	Requirements Conditions which are imposed on a function to assure that objectives are met satisfactorily.
Change Requests Requests for alteration in the configuration of an item delivered, to be delivered, or under development after formal establishment of its configuration identification.	Other Technical Experts People in all other phases of the business (besides QA/QC) who are also responsible for the quality of the product.	Technology The applied scientific knowledge used in manufacturing and Quality Assurance.
Data Information All information and data previously generated which is pertinent and useful in assuring Product Quality.	Potential Future Missions/Trends Includes both trends and potential future products with specifications for use of the products (what it is to be; what it is to do).	TI&E Facilities/Equipment The equipment and facilities used in the test, inspection and evaluation of materials, items and processes.
External Change Requests includes all requests for change which are imposed from other functions.	Product Design All drawings and specifications required to define a unique aerospace product.	Uncertified Resources Resources such as people, equipment, facilities requiring certification in order to fulfill contractual requirements.
Management Policy/Strategy/Directives the governing principles forming the basis for the actions of a corporation.	QA/QC Data/Information Includes, but is not limited to, the following types of information: market research, information on quality, product design test data, prototype quality information, reliability predictions, receiving inspection data, vendor rating information, process control data, process capability data, in-process test and inspection data, final product test and inspection data, field performance data.	
Manufacturing Plans overview plans including flow sequence plans, manufacturing schedules, item and station charts, item indentures, facilities and equipment requirements, manpower requirements, tooling requirements, material requirements, etc.	QA/QC Experts Certified inspectors, QA/QC engineers and other personnel qualified to perform activities associated with quality assurance and quality controls.	
Materials/Items/Processes Materials the raw materials which will be used to produce higher level parts.		



A0 Assure Product Quality

Quality Assurance is active throughout all phases of an aerospace product life cycle. QA/QC activity in today's aerospace industry begins with the "front-end", pre-contract even RFP phase. Using trend data to identify probable future missions, Engineering and QA/QC interface to assure that the technologies required to Assure Product Quality are either available for design inclusion/consideration or will be developed to enable the contractor to "Prepare for Future QA/QC Aerospace Demands" (Box 1).

During the RFP phase, Quality interfaces with the proposal team to provide the estimates and supporting rationale of required QA/QC tasks, and the information necessary to "Develop (the) QA/QC RFP Response" (Box 2). The QA/QC RFP response normally includes the "Draft QA/QC Plan".

After the contract has been awarded, the Quality Assurance Quality Control/Program Plan is refined and approved (Box 3). This Quality Plan provides the roadmap to assure that the procedures, processes and product quality requirements will be met throughout the life of the product.

"Implement (the) QA/QC Program Plan" (Box 4) is the activity required to ensure that the required QA/QC resources are specified and/or in place. The resources include work procedures, certified test and inspection equipment, tools, quality documentation records, facilities and people. These activities begin during the pre-production phase of the product life cycle.

Most of the traditional Quality Control functions take place in Box 5, "Perform to QA/QC Program

Plan". The actual performance of the activities required to assure quality during the production and post-production phase is accomplished at this point.

Finally, an "Evaluation of QA/QC Effectiveness" (Box 6) is made, not only during the post-production phase in terms of field performance of the product, but also during the production phase in the form of audits and other evaluations. This process may result in change data to conceptual, preliminary and detail Engineering designs as well as requests for corrective action to current manufacturing processes.

The involvement of Quality Assurance in the total life cycle of a system helps assure that the aerospace product will have the quality necessary to fulfill its mission.

A0 Glossary

Approved Drawings/Specifications

Engineering drawings and specifications that have been approved from the QA/QC point of view.

Available QA/QC Technology

Technology (usually TI&E equipment) currently available to assure product quality.

Approved Quality Plan

An approved plan which establishes standards for manufacturing materials, related production resources and the product being manufactured for compliance with customer requirements, company policies and product specifications.

Change Data/Requests

Requests for and data related to changes to an RFP (includes corrective action requests).

Conceptual Design

Those drawings, sketches and specifications needed to provide a concept of the end product.

Contract Performance Standards

Standards of performance as required by a contract for products and services.

Contract Requirements

All government or customer quality requirements contained in a contract incumbent on the contractor for conformance.

Corporate Performance Standards

Standards of performance as set by a corporation for its products and services.

Corrective Action Requests

Requests to both the implementation and execution of the quality plan made as a result of evaluating QA/QC effectiveness.

Detail Design

The drawings and specifications which complete the Product Design by defining all of the details required to produce the item.

Detailed QA/QC Work Instructions

QA/QC instructions including procedures.

Evaluated QA/QC Data

Data that has been critically examined for possible further application in assuring quality.

Field Performance Data

Information about the performance of the end item that results after its delivery, installation and usage by the customer.

Plan Change Requests

Requests for change to the Quality Plan made as a result of problems in the implementation of the plan.

Preliminary Design

Drawings and specifications which define an end item in terms sufficient for the design to be understood and analyzed. Complete definition is frequently not a part of the Preliminary Design.

Preliminary Manufacturing Plan

A draft manufacturing plan drawn up in advance usually for the purpose of presenting initial ideas to be used in trade-off studies.

Preliminary Process/Design Data

Data associated with both the design and the process used to produce the design.

Previous RFP Responses

Historical information used to help in the preparation of new RFP responses.

QA/QC Requirements Change Requests

Requests for change to the program requirements made as a result of making the quality plan.

QA/QC RFP Response

Reply to Request for Proposal.

RFP Change Requests

Requests for change to an RFP made as a result of responding to the RFP.

RFP Requirements

Any requirements incumbent on a contractor in order to respond to a Request for Proposal.

Resource Data

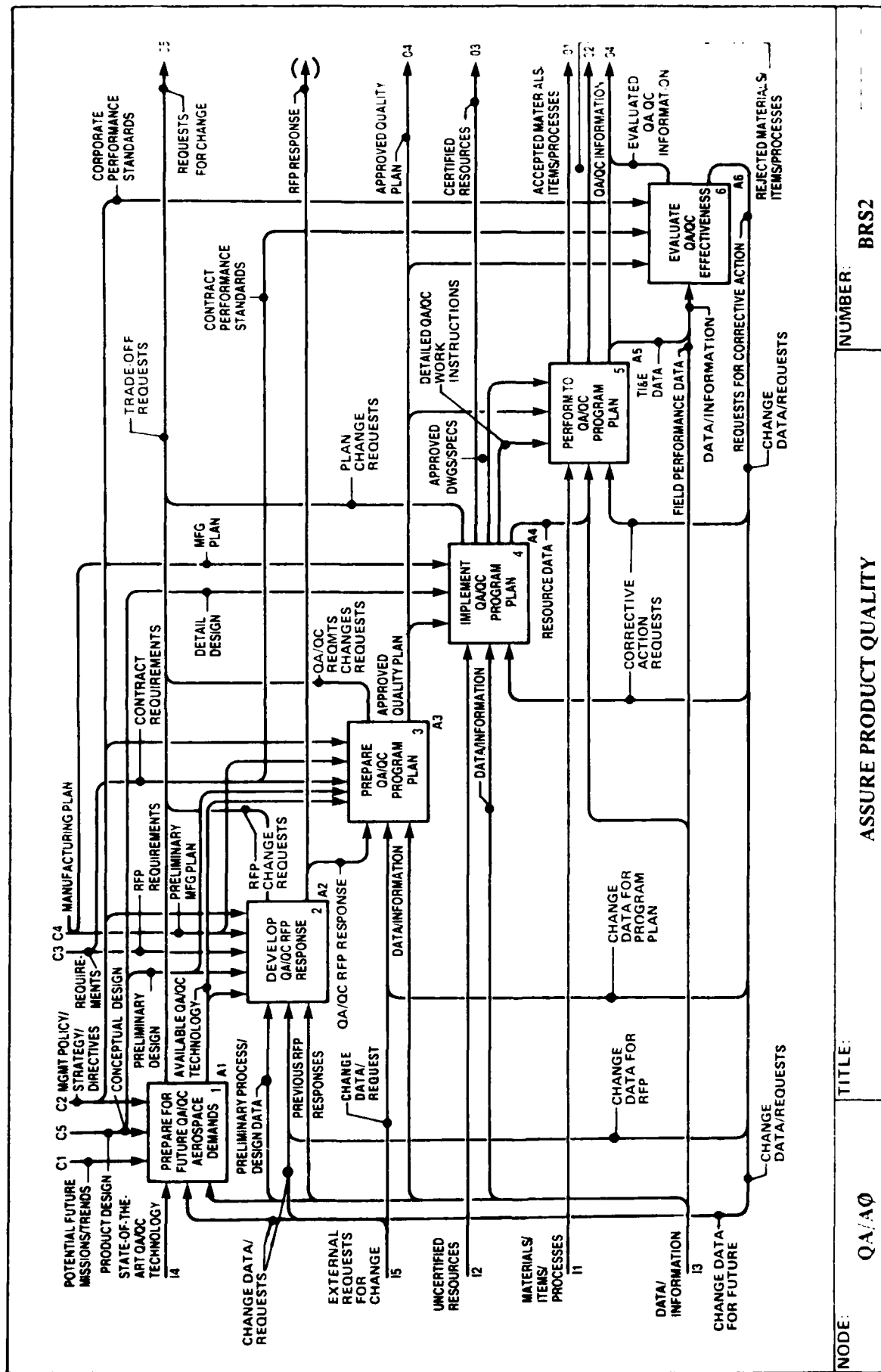
Information on resources including technology, materials, supplies, tools, people, equipment and facilities necessary to perform QA tasks.

State-of-the-Art QA/QC Technology

The latest QA/QC technologies that are available for application.

TI&E Data

The data that is collected, analyzed and reported in conjunction with the Test, Inspect and Evaluation functions.



QA/AO

The QA/AO diagram *Assure Product Quality* provides the basic overview for six broad activities required in an Aerospace Quality Assurance System. The diagram starts with node A1. *Prepare for Future QA/QC Aerospace Demands* and ends with node A6. *Evaluate QA/QC Effectiveness*. Each of the six nodes are exploded, or telescoped, downward in subsequent diagrams to provide additional details. The QA/AO diagram and subsequent diagrams can be used by others as a baseline or starting point for building a new or examining an existing quality assurance system.

To help one assess the relevancy of these nodes to a specific business, a brief explanation of each major node follows.

QA/A1 This node, *Prepare for Future QA/QC Aerospace Demands* identifies four major quality activities that take place within the aerospace industry in anticipating and preparing for future QA/QC demands. These activities extend from identifying what will be required in the future to the development of new technologies to meet these demands. These activities are relevant to businesses having to prepare for future quality requirements.

QA/A2 *Develop QA/QC RFP Response* details those activities required to prepare the QA/QC response to a formal Request for Proposal. While Requests for Proposal (RFP's) are generally only associated with government contracts, there are counterparts in the private sector such as the submission of bids. After some change in nomenclature, these work activities should be similar for companies who periodically submit bids.

QA/A3 *Prepare QA/QC Program Plan* outlines the work activities involved in preparing and issuing a quality program plan. The first node QA/A31, *Establish Program QA/QC Requirements* is oriented toward an industry having a formal contractual statement of work supplemented with explicit written deviations to these requirements. Even though many businesses do not deal with product deviations on a formal basis, they should be considered if the delivered product is at all different from what was originally expected by the customer.

QA/A4 *Implement QA/QC Program Plan* is described by four nodes. These are:

QA/A41 Approve the Drawings and Specifications;
QA/A42 Providing Detailed Work Instructions for the Test/Inspection/Control of Critical Quality Characteristics;

QA/A43 Certifying and Calibrating the Quality Information Tools and Equipment and;

QA/A44 Training & Certifying the People Performing Quality Activities.

QA/A5 *Perform to QA/QC Program Plan*, describes the quality assurance activities generally associated with the shop or manufacturing function. It contains inspection activities and is broken down into many detailed diagrams. Node QA/A5 has more diagrams than any of the other nodes in the *Assure Product Quality* model. These diagrams describe the specific activities associated with military airframe manufacture and assembly. These detailed diagrams are included since they should help provide ideas for the design of a quality system for other product lines.

QA/A6 *Evaluate QA/QC Effectiveness* describes the work activities associated with the assessment of the effectiveness of the QA/QC plan. These include:

QA/A61 Establishing the

Quality/Reliability/Maintainability Baseline from which the Test, Inspection and Evaluation Standards for acceptability are derived;

QA/A62 Evaluate the Test and Inspection Data to determine where changes in Design,

Manufacturing Processes, Inspection Procedures or Product Configuration are warranted;

QA/A63 Evaluate the Field Performance Data to appraise the product performance against its design specification (for many businesses field performance is measured directly against customer satisfaction);

QA/A64 Audit the QA/QC and Manufacturing activities.

Evaluation of performance is an essential ingredient to the success of any system.

particularly for a multi-functional system such as quality. Consequently these work activities should apply to all businesses.

From an analysis of trends in Government or (other) customer missions and strategies, probable future QA/QC needs are identified. Engineering, Manufacturing and Quality Assurance interface to assure that the technologies, equipment and techniques capable of inspecting/controlling new designs currently exist. An example of this interface would include QA/QC involvement in the Conceptual Design Review process. This interaction can result in trade-off requests where appropriate. Where technology voids do exist, selected development projects may result in new systems for controlling and assuring quality in future aerospace products.

Acceptable QA/QC Technology

Future Concepts/Designs Data

Future QA/QC Requirements

Leading Edge Technologies

Those technologies which are at the forefront. Generally, not quite ready for application. (See State-of-the-Art Technology.)



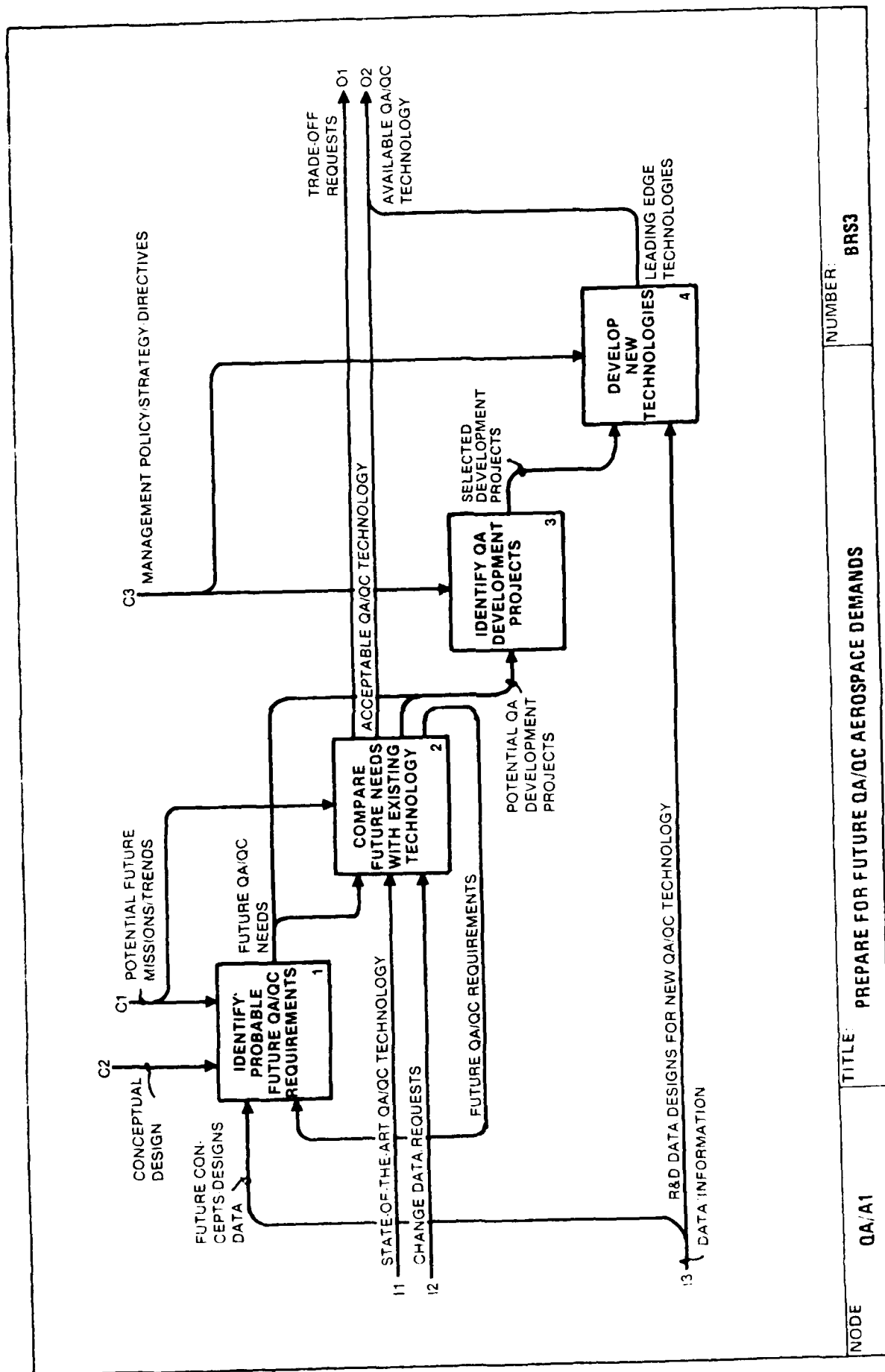
R&D Data/Designs for New QA/QC Technology

Selected Development Projects

Those projects selected for development as chosen by management decision.

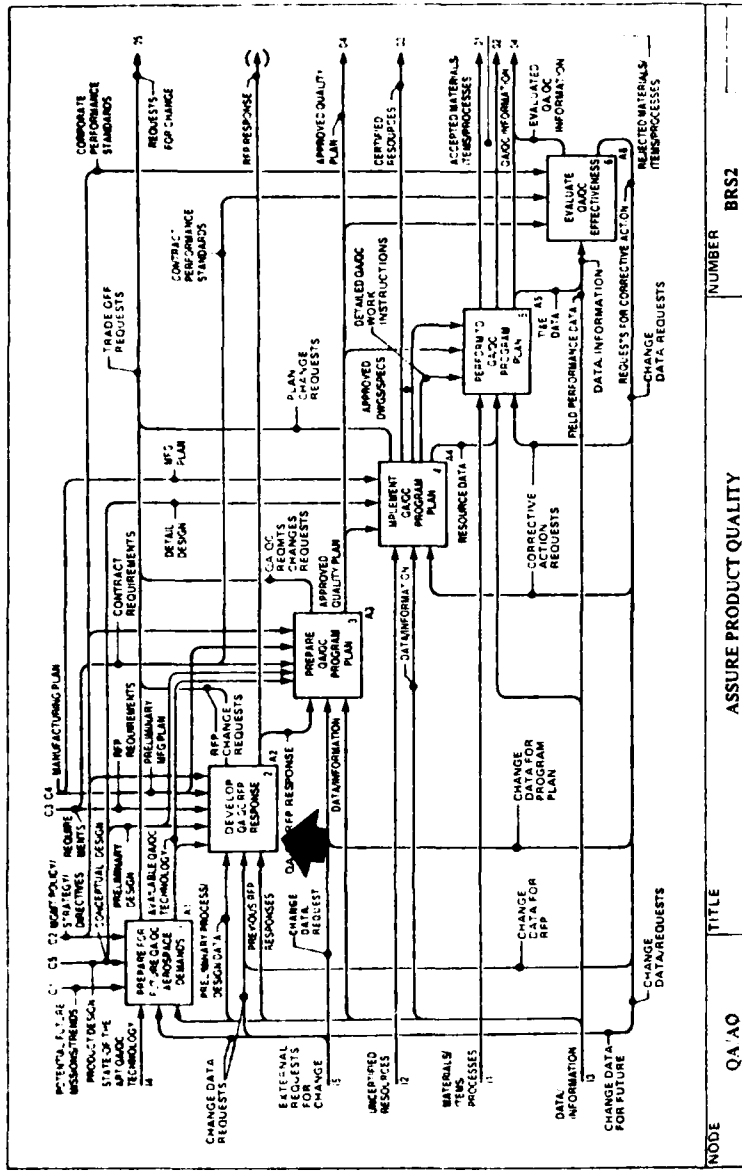
Those technologies which are new and ready for application.

Includes the interactive process of going back to potential clients for discussion of trade-off to evaluate alternatives in the quality control process.



A2 Develop QA/QC RFP Response

The Request for Proposal (RFP) is analyzed for the QA/QC requirements. All affected departments provide estimates and supporting rationale of task and information in accordance with proposal formats and requirements. Drawing on previous proposal efforts, a draft QA Program Plan (which may include a QA Program Management Plan), is prepared. The draft QA Plan is based on RFP requirements and draws heavily on previous proposal efforts for content. Requests for change to the RFP also may result, causing an iterative process to occur. The QA/QC response to the RFP includes the Draft Quality Plan.



Glossary

Acceptable QA/QC Requirements

That portion of the QA/QC requirements which is acceptable.

Draft QA Program Plan

A preliminary QA program plan done to enable a QA/QC RFP response to be initiated.

RFP QA/QC Requirements

That portion of the entire RFP requirements that is directly applicable to QA/QC.

RFP Requirements

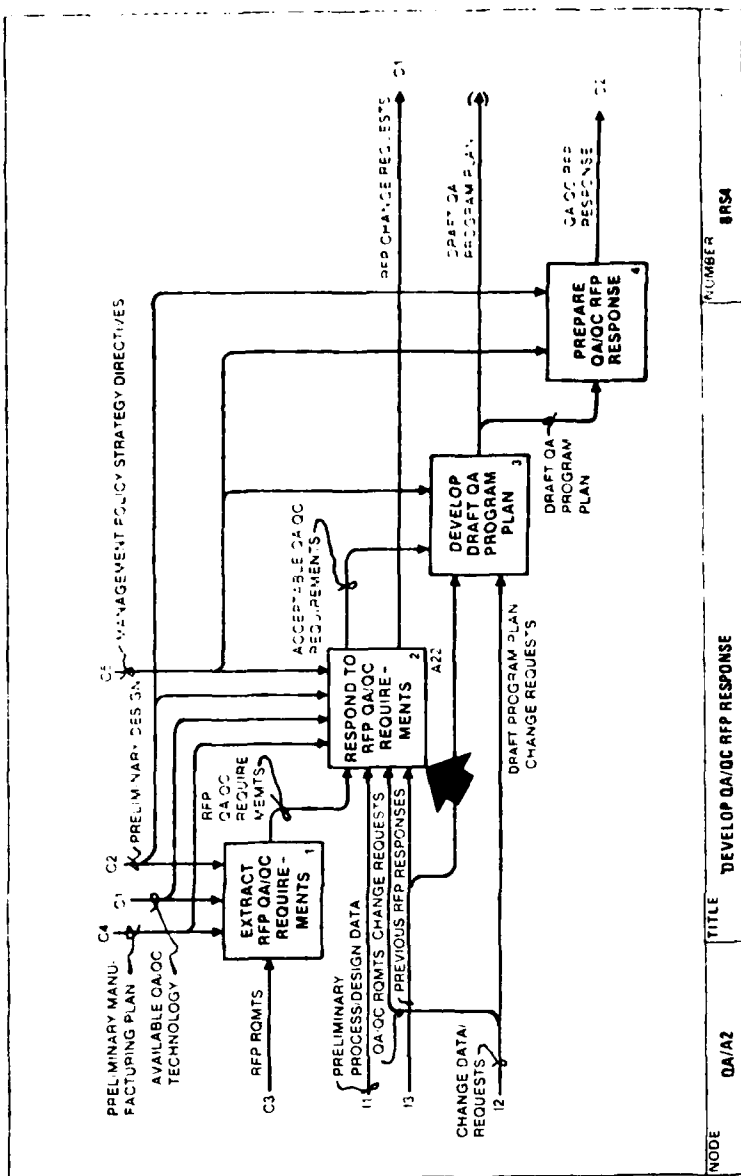
Request for Proposal requirements.

A22 Respond to RFP QA/QC Requirements

Preparing a response to a Request for Proposal consists of evaluating the RFP first from the aspect of its technology requirements. The preliminary process and design data generated for the response are reviewed for their QA/QC technology requirements.

Requirements that can be met with available QA/QC technology are identified along with potential problem areas.

Similar evaluations are made for cost and schedule requirements. Alternatives are defined for the potential problem areas where appropriate. The acceptable QA/QC requirements, as well as requests for change to the RFP where required together, comprise the QA/QC response to the RFP. Request for change may take place in the RFP, design, manufacturing plan, etc.



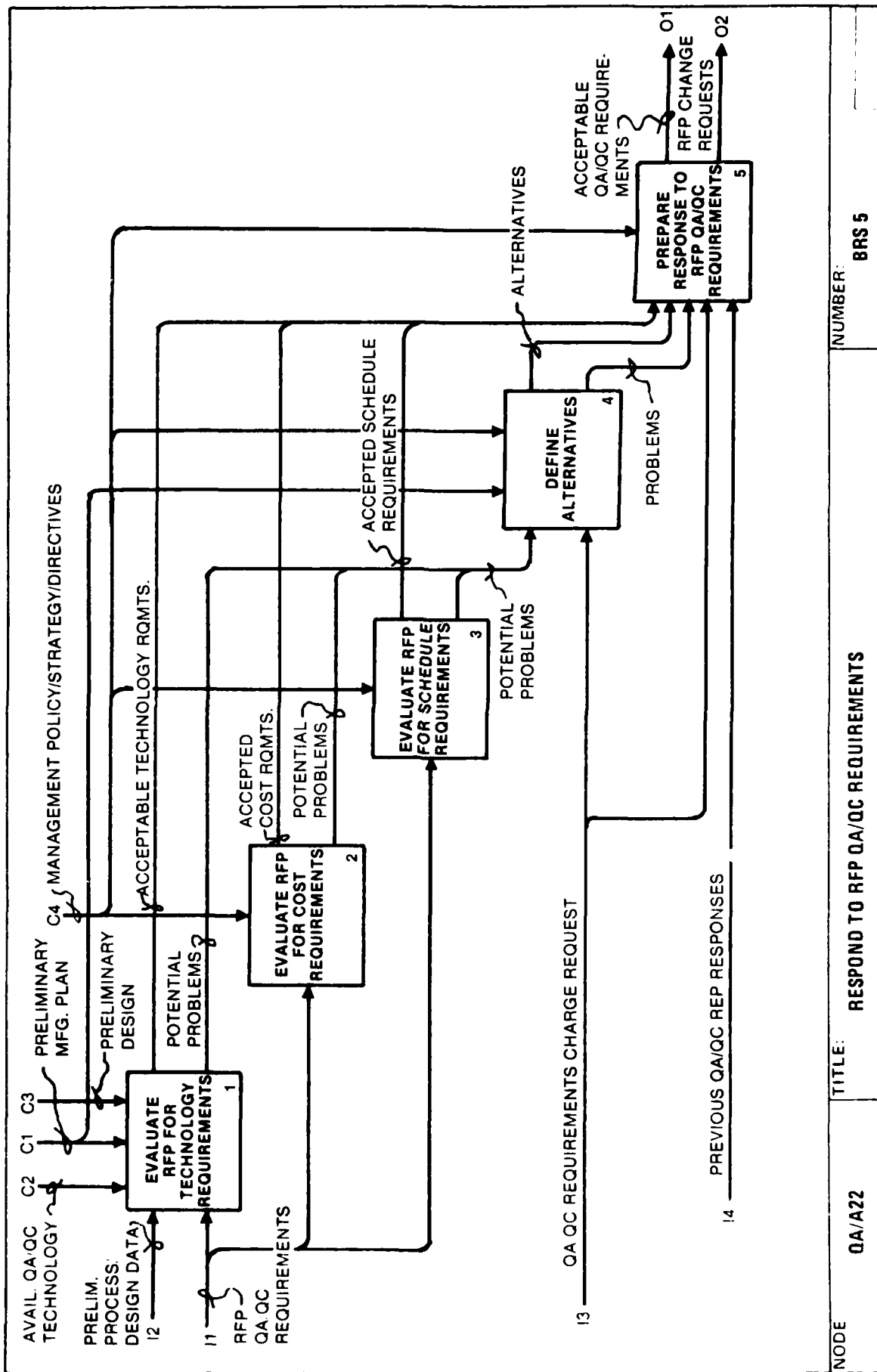
Glossary

Acceptable Technology, Cost, Schedule Requirements

Those particular areas of the RFP that are considered acceptable from the QA/QC viewpoint.

Alternatives

Options that could be used in the preparation of the RFP QA/QC response.



NUMBER: BRS 5

TITLE: RESPOND TO RFP QA/QC REQUIREMENTS

QA/A22

NODE

A3 Prepare QA/QC Program Plan

After the contract has been awarded, its Statement of Work is compared with the proposal for any changes. A review of the contract requirements for unique and special controls, processes, equipment, skills and manpower is conducted. Integral to the Quality planning process is consideration of: 1) QA Resources such as testing and measuring equipment, Q personnel and the training plan necessary to support a production program; 2) Defined Schedule and Timing, e.g., determination of the inspection points in the manufacturing cycle. The sequence of inspection and specific wording of instructions are provided for integration into the manufacturing process plans; 3) Defined responsibilities of all interfacing departments and organizations connected with the contract, including the inputs to Design/Manufacturing for the "preventive nonconformance additions" for up-front QA enhancements. Finally an approved Quality Plan is generated to document product quality objectives that are consistent with company policies, customer requirements and product specifications.

Glossary

Design/Manufacturing Resource Data

That data which is necessary in order to specify the QA/QC resources required to implement the quality plan.

Resource Capacity/Availability

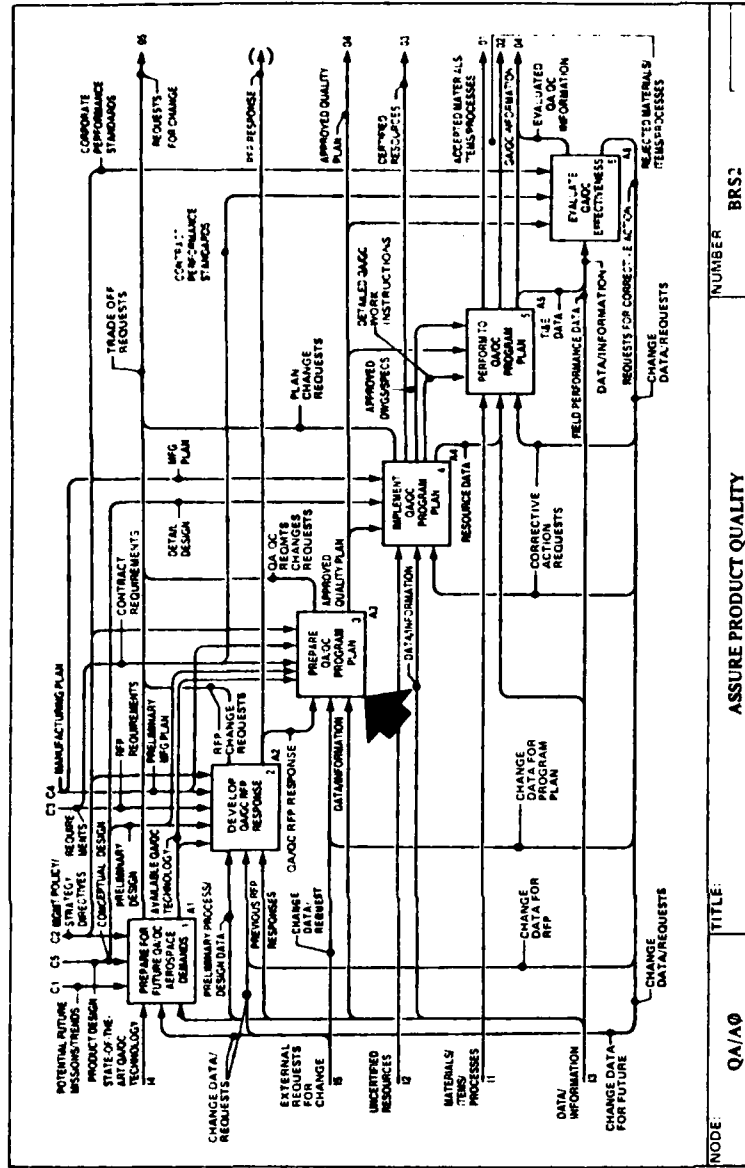
The capacity and availability of all resources, i.e., personnel, equipment, tools, etc. needed to assure Product Quality.

Resource, Schedule, Plan Requirement

Requirements for those particular areas necessary to issue a quality plan for the program.

Sequenced Schedule

That part of the QA Program Plan that addresses the timing requirements for the program.

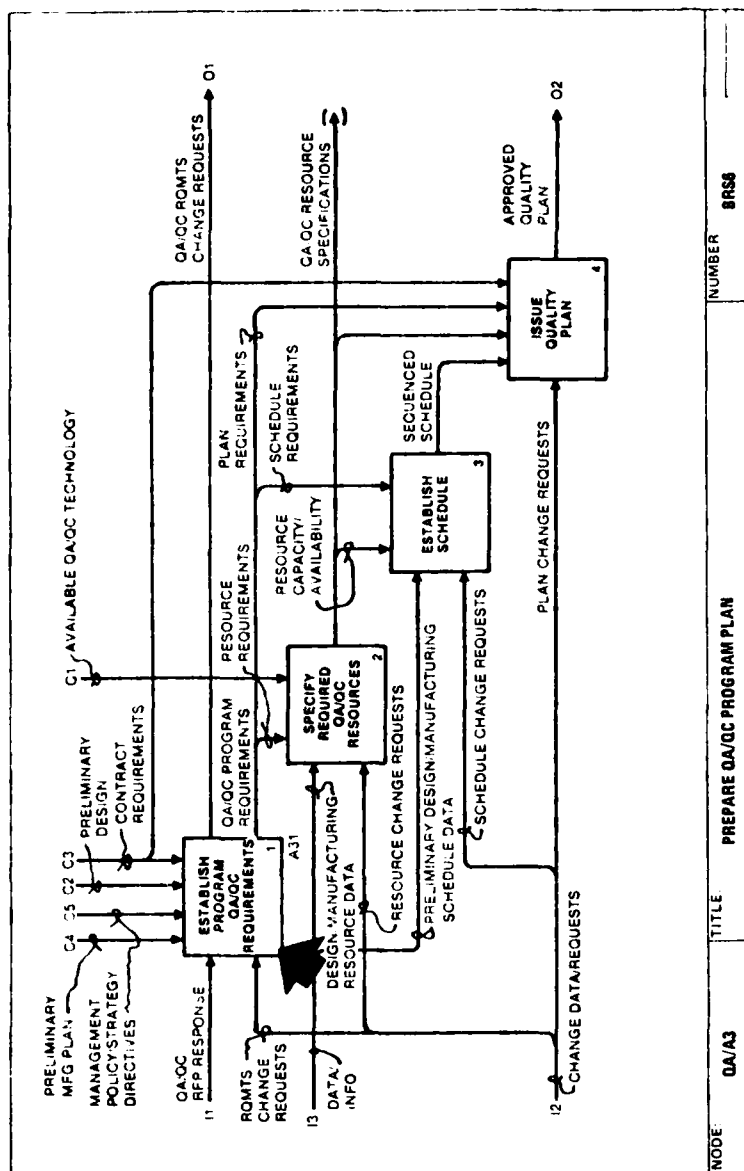


A31 Establish Program QA/QC Requirements

The sequence of activities required to Establish QA/QC Program Requirements consists of first comparing the QA portion of the contract Statement of Work with the RFP response to identify any changes in requirements. Requirement deviations may result in requests for change to the preliminary design or manufacturing plan or to the Draft QA Plan.

The evaluation of the awarded contract is performed by Quality Assurance personnel who identify the document requirements specified or referenced in a contract to define the minimum acceptable level of quality and to assure adequate controls, criteria and measurement throughout all areas of contract performance. A preliminary QA contract analysis results from this activity.

This analysis is distributed to engineering operations, affected program offices, AFPRO, AFQA, QA department heads, etc., to assure that all parties understand the contract quality requirements and the methods to be used in work inspection, material review, change verification, nondestructive testing and other actions to ensure continuing production of a satisfactory end item. Detailed QA/QC Program Requirements are then issued.



Glossary

MIL Specifications/Standards

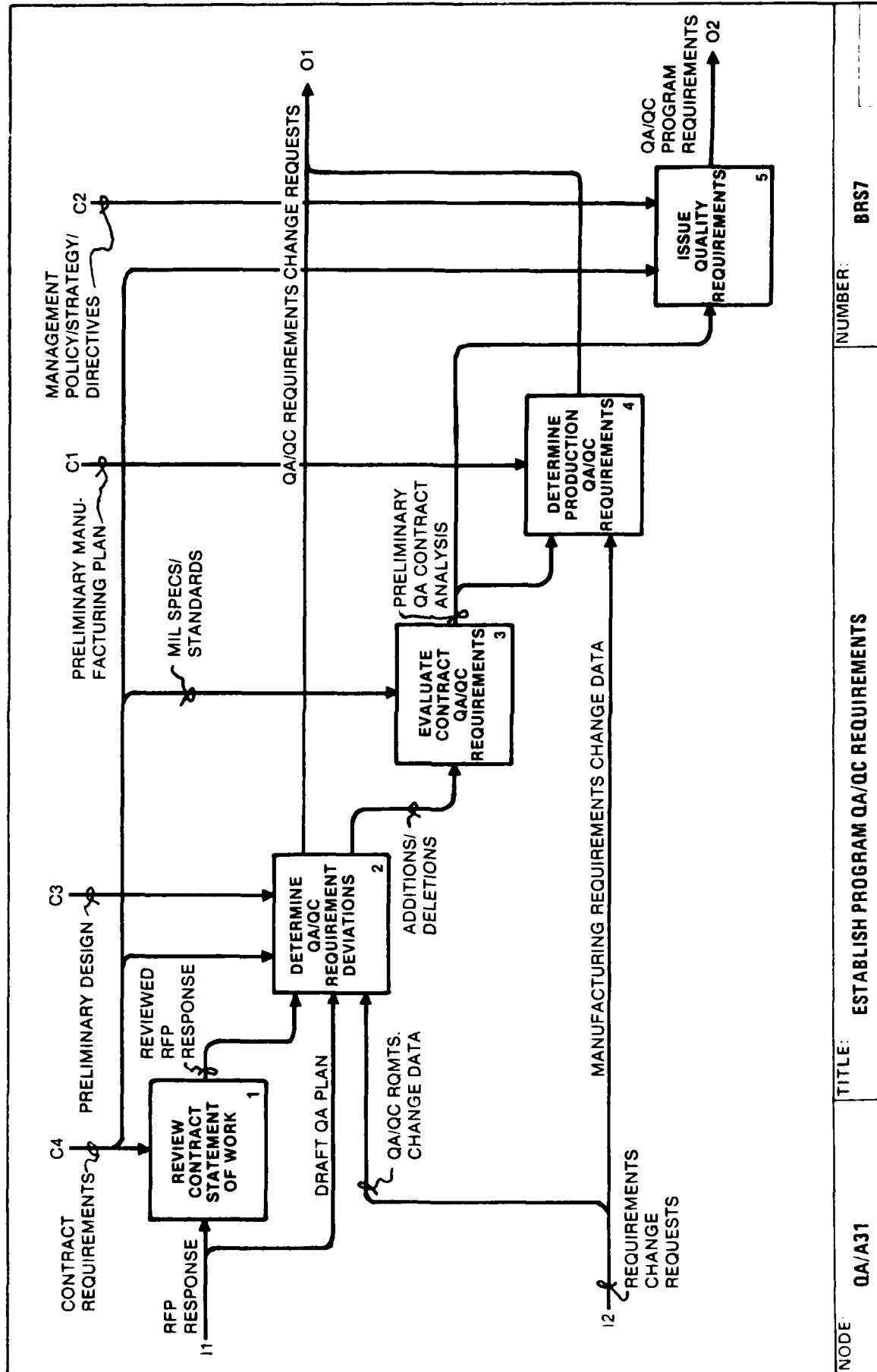
Military Specifications and Standards.

Preliminary QA Contract Analysis

The result of an examination of that portion of the contract applicable to QA/QC.

Reviewed RFP Response

The result of a re-examination of the RFP response to assure that the RFP requirements are being properly addressed.



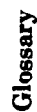
2-22031

QA/A31

ESTABLISH PROGRAM QA/QC REQUIREMENTS

NUMBER: BRS7

The established QA/QC program is implemented by providing work instructions to manufacturing and inspection. Certified tools, equipment, facilities and personnel are provided to perform QA/QC activities. Tools and equipment are checked at regular intervals to maintain required accuracy. Training and certification of personnel addresses critical processes, special tests, government/industry specifications, non-destructive testing and skills updating.

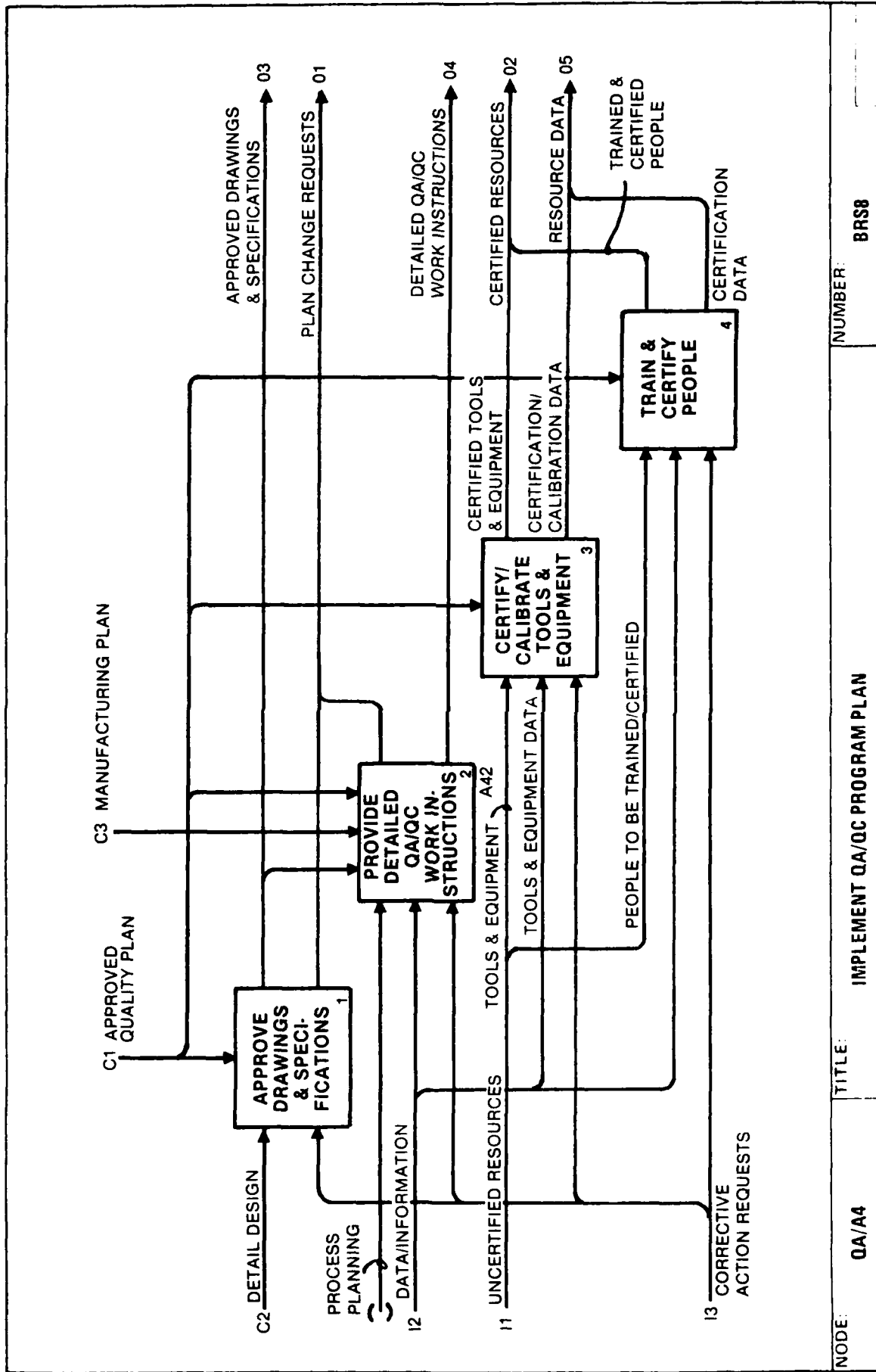


Data which documents the certification of people, tools and equipment.

Tools and equipment that have been certified for use.

The planning activity required to permit the fabrication, process and assembly sequence to take place.

People trained for, and where required, certified to perform QA/QC functions.



NODE:

QA/A4

TITLE:

IMPLEMENT QA/QC PROGRAM PLAN

NUMBER:

BRS8

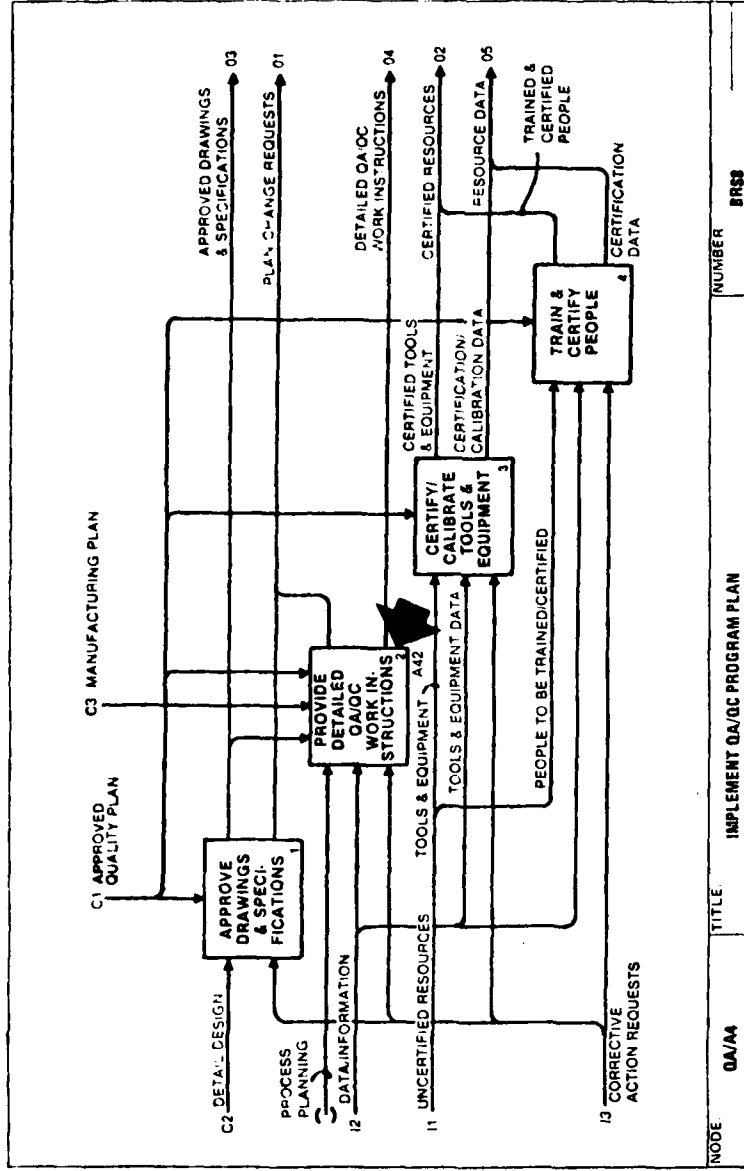
2-22031

A42 Provide QA/QC Detailed Work Instructions

Critical quality characteristics are determined by reviewing design drawings for QA inputs and related specifications. Recommended changes to design specifications are made by QA based on trends and experience.

Production process planning is reviewed to determine critical-to-quality test, inspection and control points.

Existing test/inspection instructions are selected where appropriate and new instructions are generated where required, the result being detailed QA/QC work instructions integrated with the manufacturing process planning.



Glossary

Critical Characteristics

Those characteristics of a product that are deemed critical-to-quality.

Manufacturing Sequence

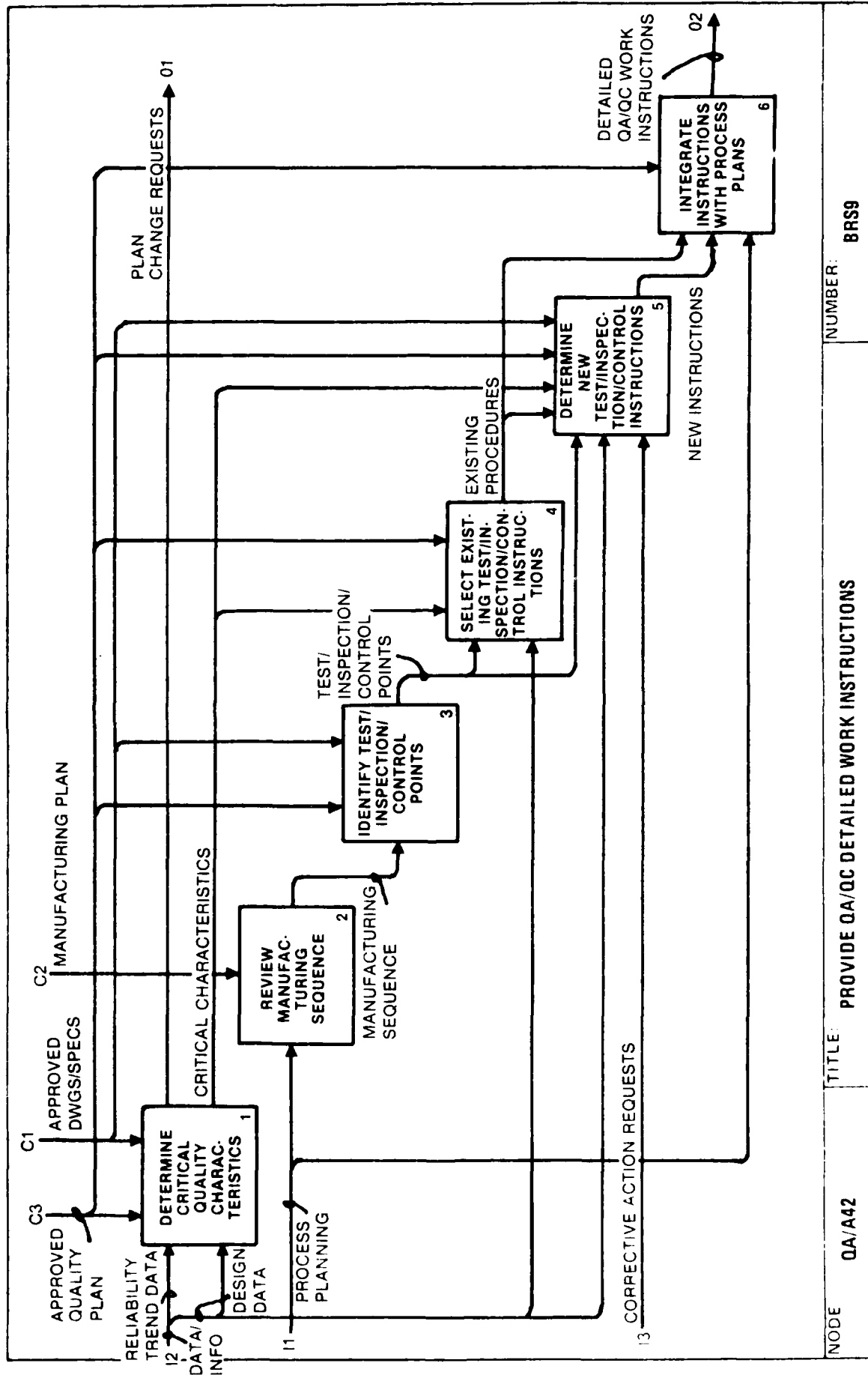
The flow of material through the production process.

Reliability Trend Data

Data which indicates trends in the reliability of a product.

Test/Inspection/Control Points

Those points in the manufacturing sequence at which tests, inspections and evaluations will take place for the purpose of applying quality control.



NODE

QA/A42

TITLE

PROVIDE QA/QC DETAILED WORK INSTRUCTIONS

NUMBER

BRS9

A5 Perform to QA/QC Program Plan

In performing to the QA/QC program plan, Test, Inspect and Evaluation TIE activities functions control the integrity and conformance of materials and items throughout the manufacturing process. Manufacturing process capabilities are verified and controlled. Quality Assurance verifies that supplier materials, competency and performance adhere to the quality and technical specifications of the contract. Nonconforming materials are evaluated and dispositioned. Product configuration is assured through monitoring drawings release and change control systems. A system for recall of drawings and documents for updating or change is maintained. Quality records: 1) provide evidence of design conformity; 2) assure that proper sequence of manufacture is followed; 3) show that all required inspections and tests were accomplished; 4) properly document acceptance or rejection and 5) verify and document completion of progressive manufacturing steps.

Glossary

Configuration Management Plan

The plan which outlines how the documentation required to produce a product will be managed (see DOD-STD-480A).

Configuration Problem Reports

Documentation which outlines problems occurring during the maintenance of configuration control.

Disposition Data/Corrective Action Reports

Data which documents the disposition of nonconforming materials and the subsequent corrective action taken.

Engineering Drawings/Specifications/ECN's

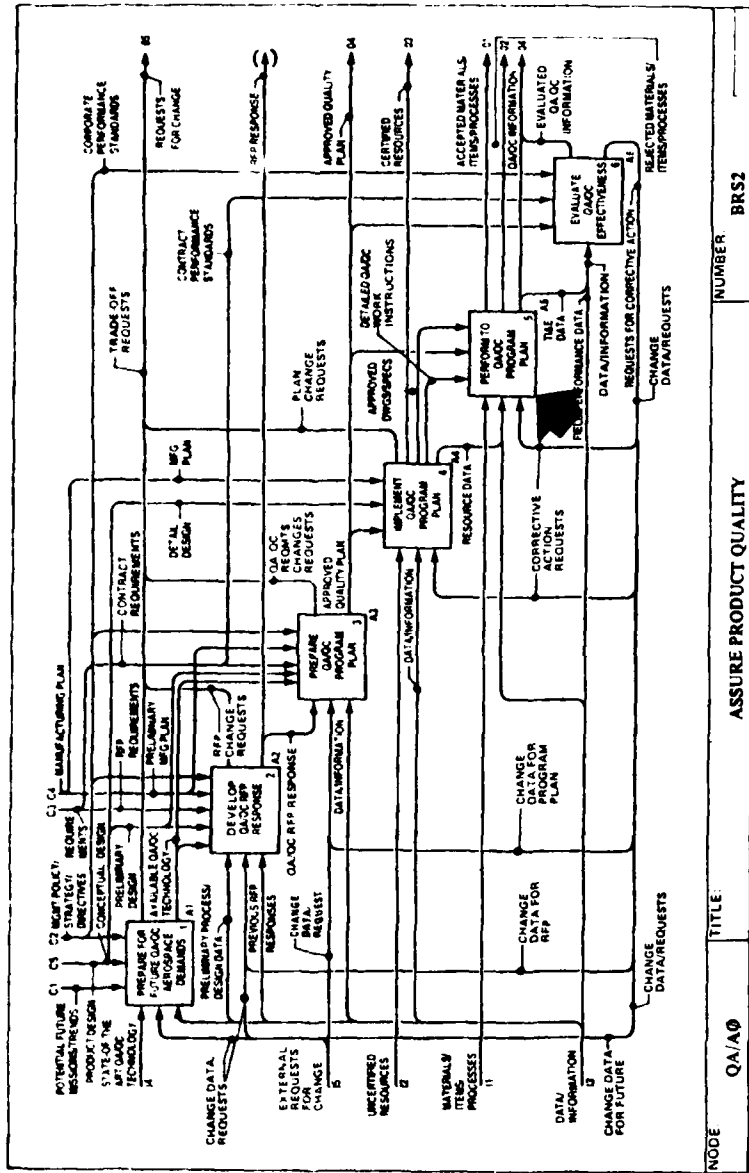
The documentation of the engineering designs (conceptual, product, detailed) including the specifications and the changes to those designs.

Nonconforming Material Plan

The plan which outlines how the nonconforming material will be controlled (see MIL-STD-1520B).

Process Control Plan

The plan which outlines the controls which will be imposed on the manufacturing process.



Process Data

Data generated as a result of measuring the output of various manufacturing processes.

Procured Item/Supplier Data

Data related to both the purchased material itself as well as the vendor who supplied it.

Quality Information System Plan

The plan which outlines how the required quality information will be collected, analyzed, displayed and reported.

Supplier Control Plan

The plan which outlines the controls which will be imposed on the suppliers (subcontractors).

TI&E Data

Data generated as a result of performing tests, inspections and evaluations.

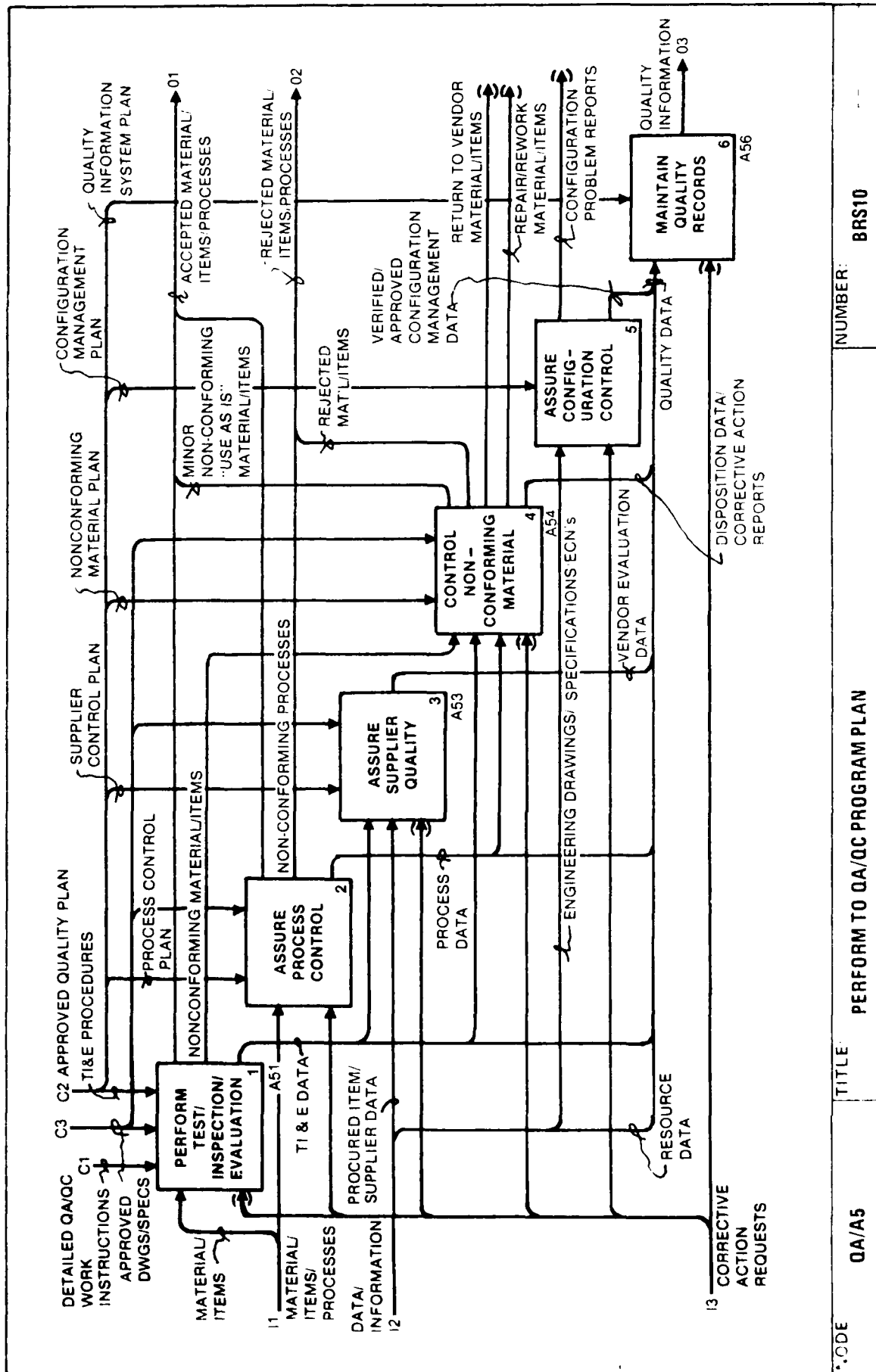
TI&E Procedures

The written actions necessary for an inspector to verify a product's compliance with its design specifications.

Vendor Evaluation Data

Data used in evaluating the effectiveness of a vendor in supplying material.

Verified/Approved Configuration Management Data Configuration management information and data which has been verified and approved according to the Configuration Management Plan.



*.CODE

QA/A5

TITLE

PERFORM TO QA/QC PROGRAM PLAN

NUMBER

BRS10

A51 Perform Test, Inspect & Evaluate

The Quality Assurance Plan provides the guidance required to control the integrity and conformance of materials, items, parts and assemblies during the life of the contract. This guidance takes the form of approved drawings and specifications, detailed work instructions and test, inspect and evaluation procedures.

These control procedures are used during the production phase. Test, inspection and evaluation results (in the form of trends in nonconformances, failure modes, rejection rates, etc.) are collected to establish data bases for reliability and maintainability considerations and subsequent corrective action.

Glossary

Final Product

The final product (end item) as specified by a contract.

Component Parts (Subassemblies)

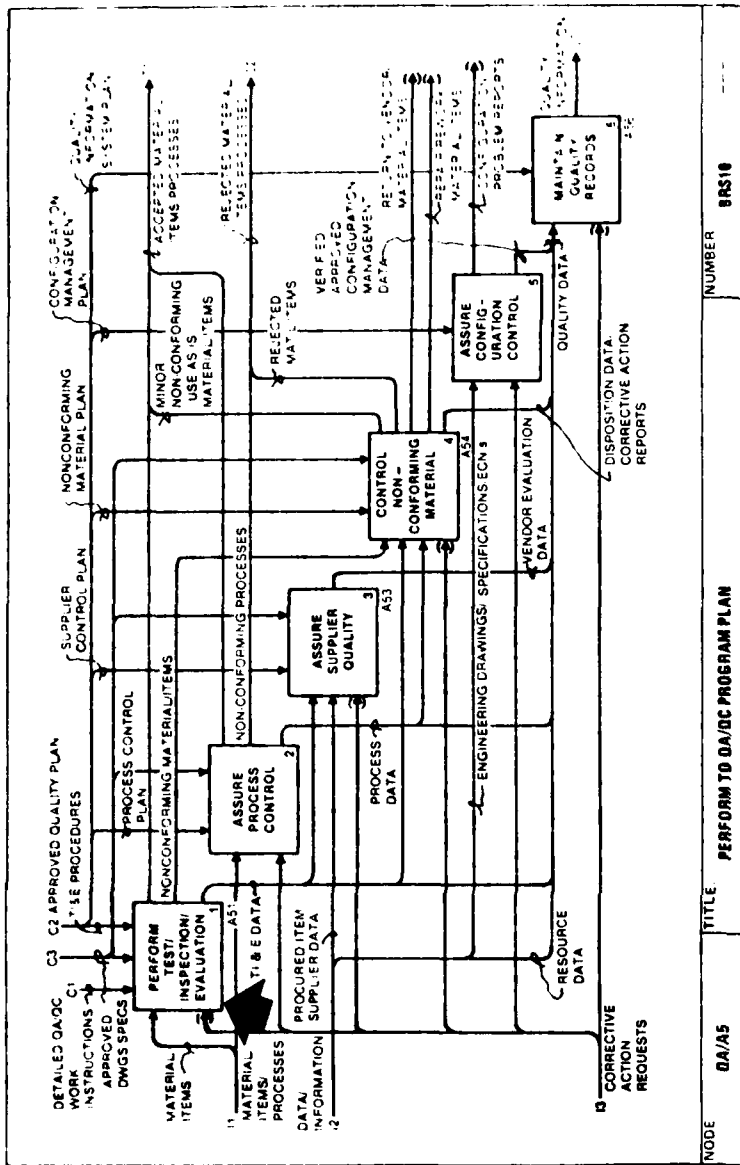
Parts which are used as a component of another part.

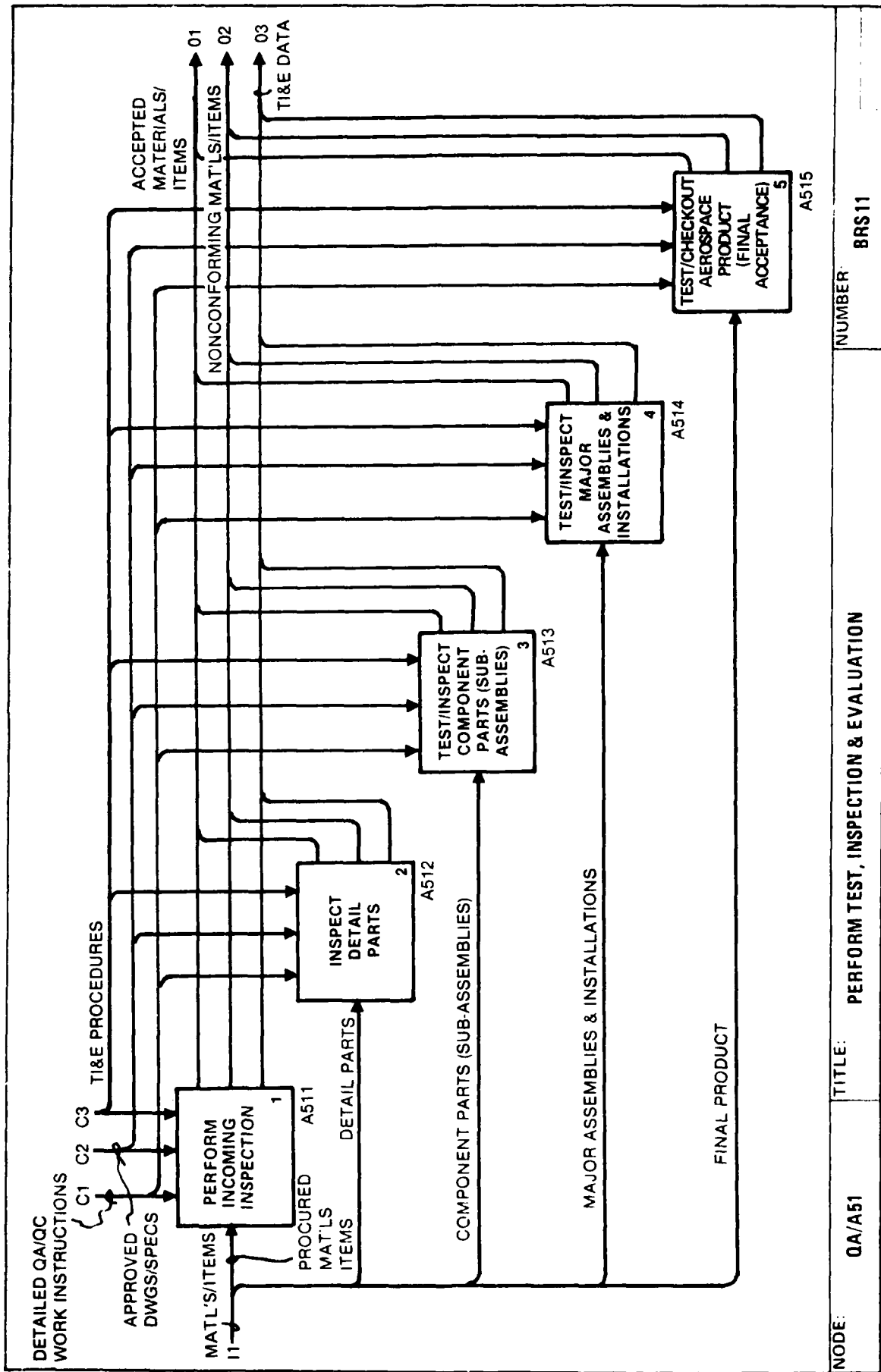
Detail Parts

Items that will become part of a higher level part.

Major Assemblies & Installations

Component parts (subassemblies) assembled into still higher level parts, i.e., wing, fuselage.





A51F Perform Test, Inspect & Evaluate (FEO)

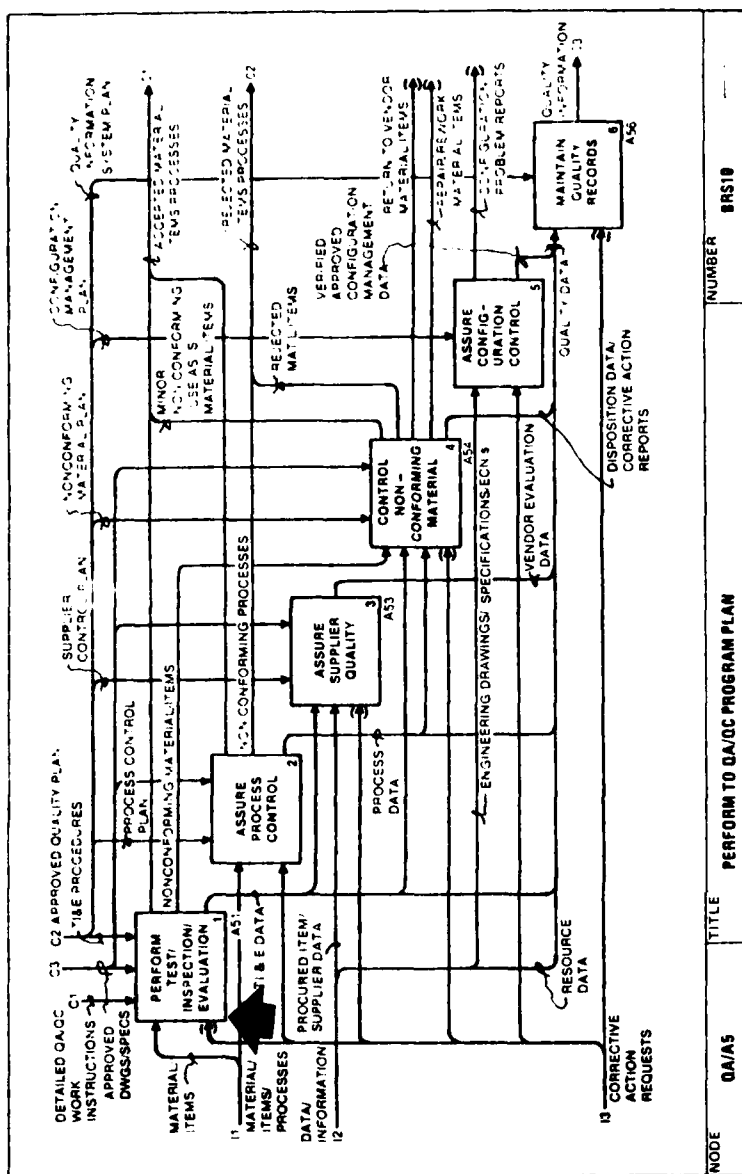
For the purposes of clarifying the distinction between:

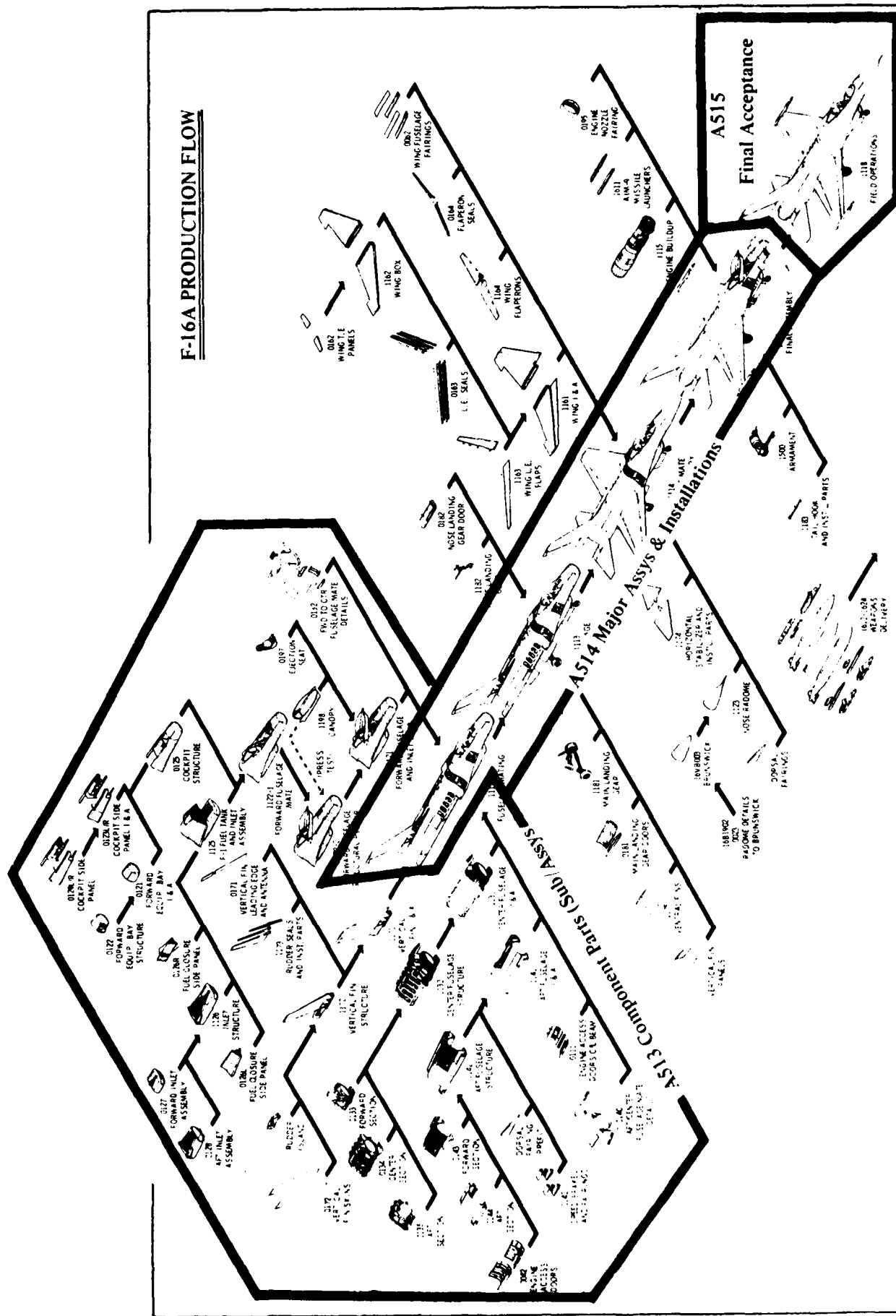
A513 - Component Parts
(Subassemblies)

A514 - Major Assemblies and
Installations

A515 - Final Product Acceptance

The production flow sequence for the F-16 is shown with those areas ballooned. It must be noted that this distinction is used only for purposes of clarifying the model and furthermore, are only approximate even within this context.



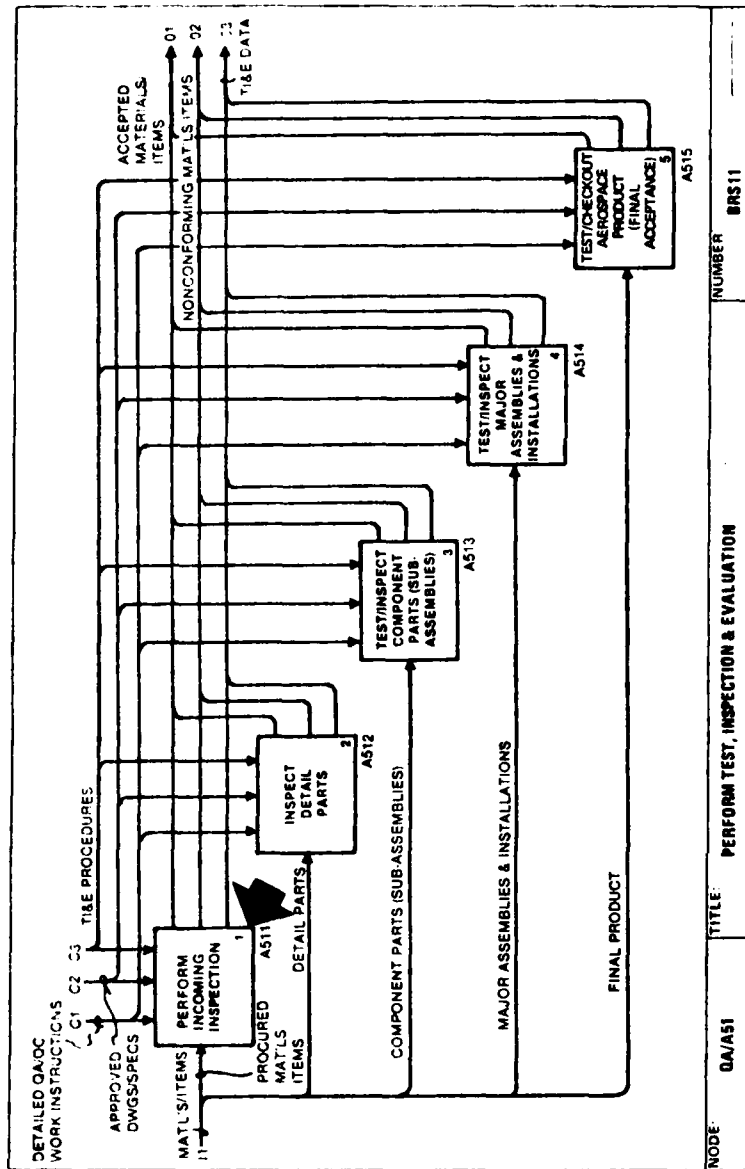


F-16A PRODUCTION FLOW

CODE	TITLE	NUMBER
QA AS1F	PERFORM TEST, INSPECT & EVALUATE (FEO)	BRS12

A511 Perform Incoming Inspection

Materials and items, along with corresponding receiving documentation including Certificates of Compliance (for vendor performed inspections), are screened for completeness. If incomplete or incorrect, the material is forwarded to a "hold area" for subsequent action. Otherwise, the material is forwarded to the inspector, along with a TI&E Work Package consisting of all the documentation required to perform the inspection. This documentation includes the work instructions, inspection procedures and a history file. The history file includes level of inspection required (100% inspection, sampling inspection, ID and cursory damage checks, etc.) or other special checks that may be required. Material is either accepted or declared nonconforming with supporting documentation for disposition by Preliminary Review or by the Material Review Board (MRB).



Glossary

Inspection Results

Data which presents the results of an inspection, i.e. acceptable or unacceptable for use.

Receiving Documentation

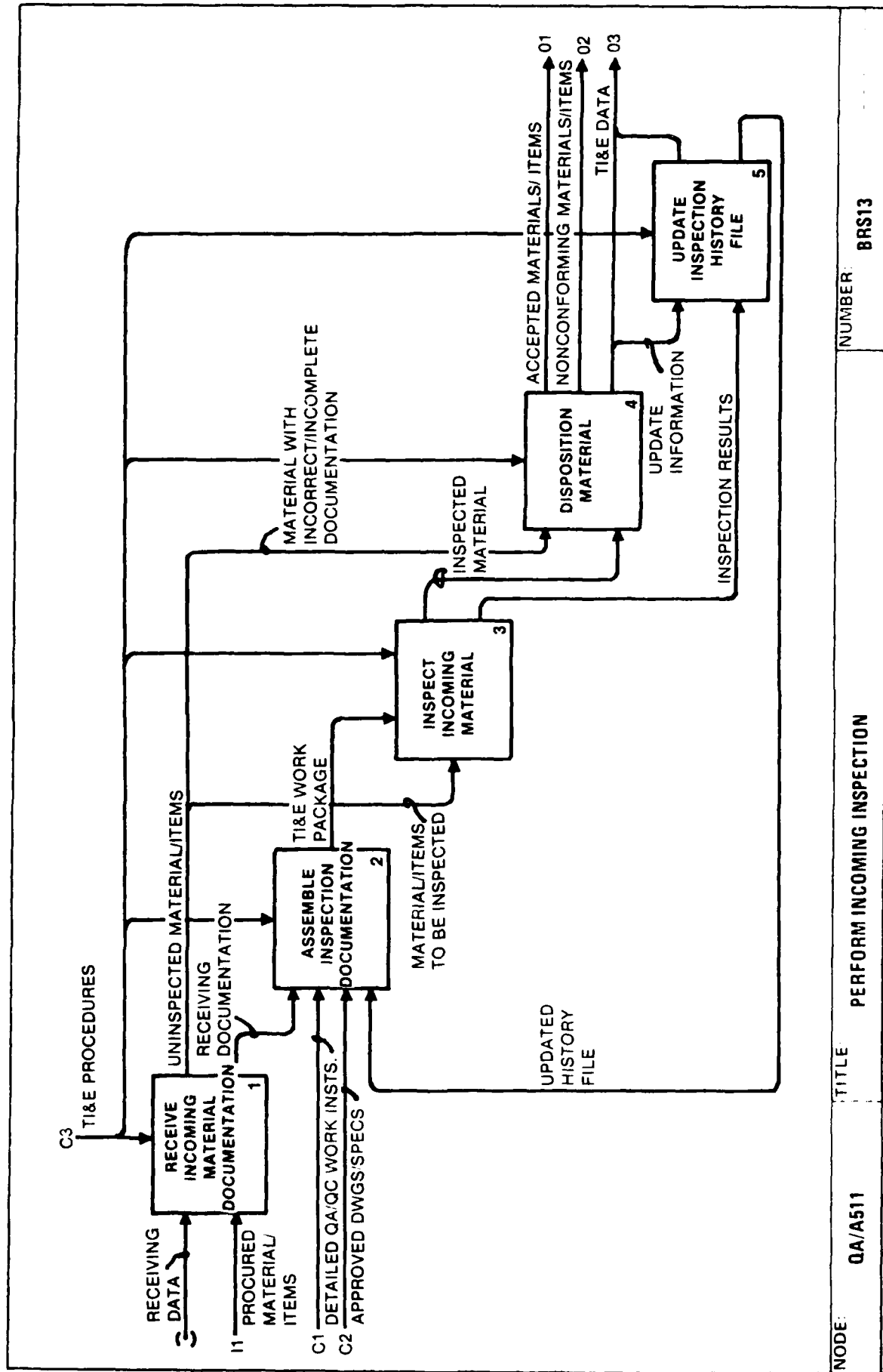
Documentation including incoming receipts, receiving reports and Certificates of Compliance.

TI&E Work Package

All the documentation the Inspector needs to perform an inspection including general work instructions, sampling plan, specifications, etc.

Updated History File

A file of inspection data to which the results of the most recent inspection have been added.



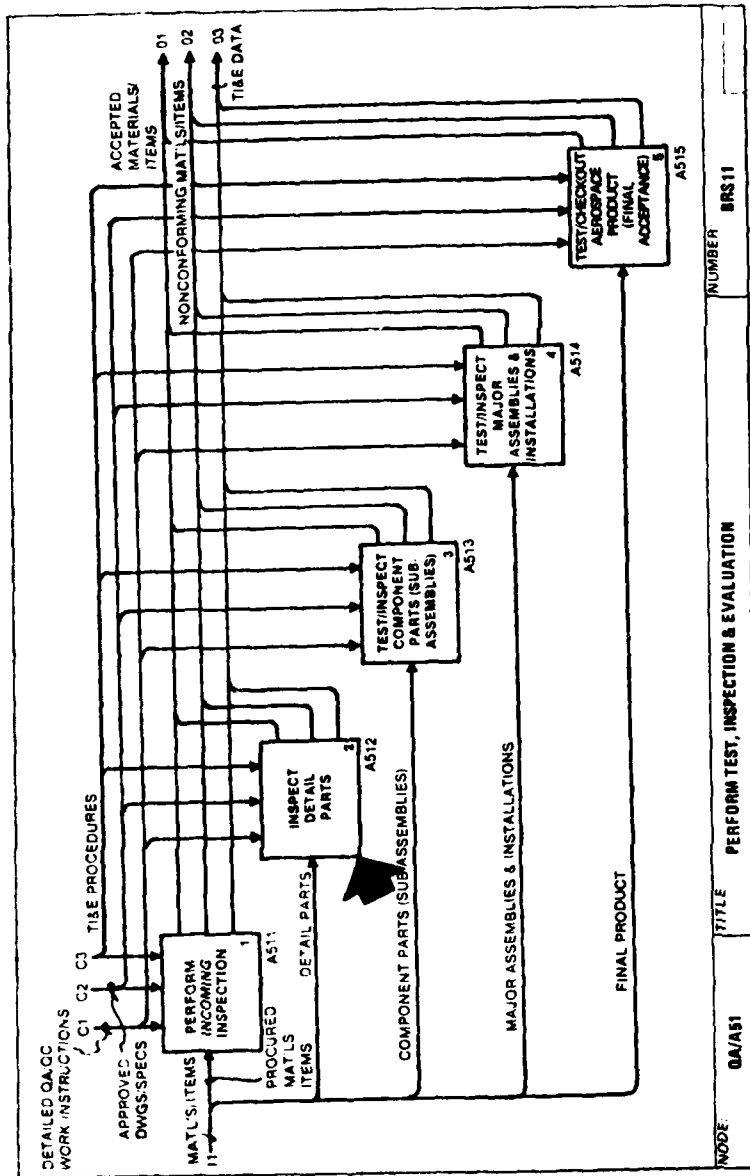
NODE: QA/A511

TITLE: PERFORM INCOMING INSPECTION

NUMBER: BRS13

A512 Inspect Detail Parts

Detail Parts are inspected to assure compliance with requirements. The parts are either accepted or declared nonconforming for subsequent Preliminary Review or MRB action. TI&E data is collected for analysis and potential corrective action.



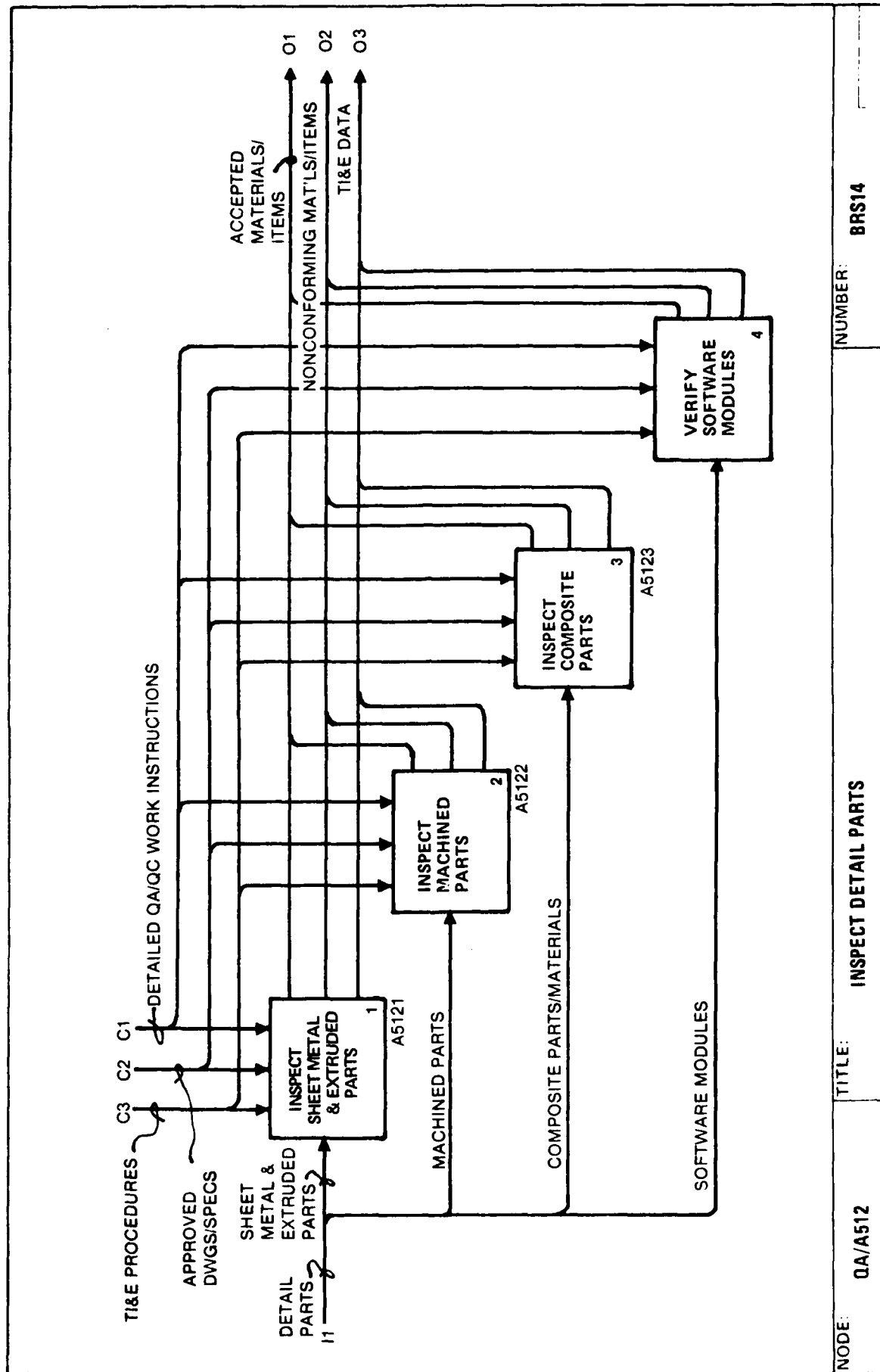
Glossary

Composite Parts/Materials

Composite material is made up of various compositions which have the basic characteristics of high strength and light weight. The composite material is formed into a composite part by layering the material with appropriate binders to produce a laminated structure.

Software Modules

A unit of software which can be tested and inspected separately prior to shipment to the customer.



NODE: QA/A512

TITLE: INSPECT DETAIL PARTS

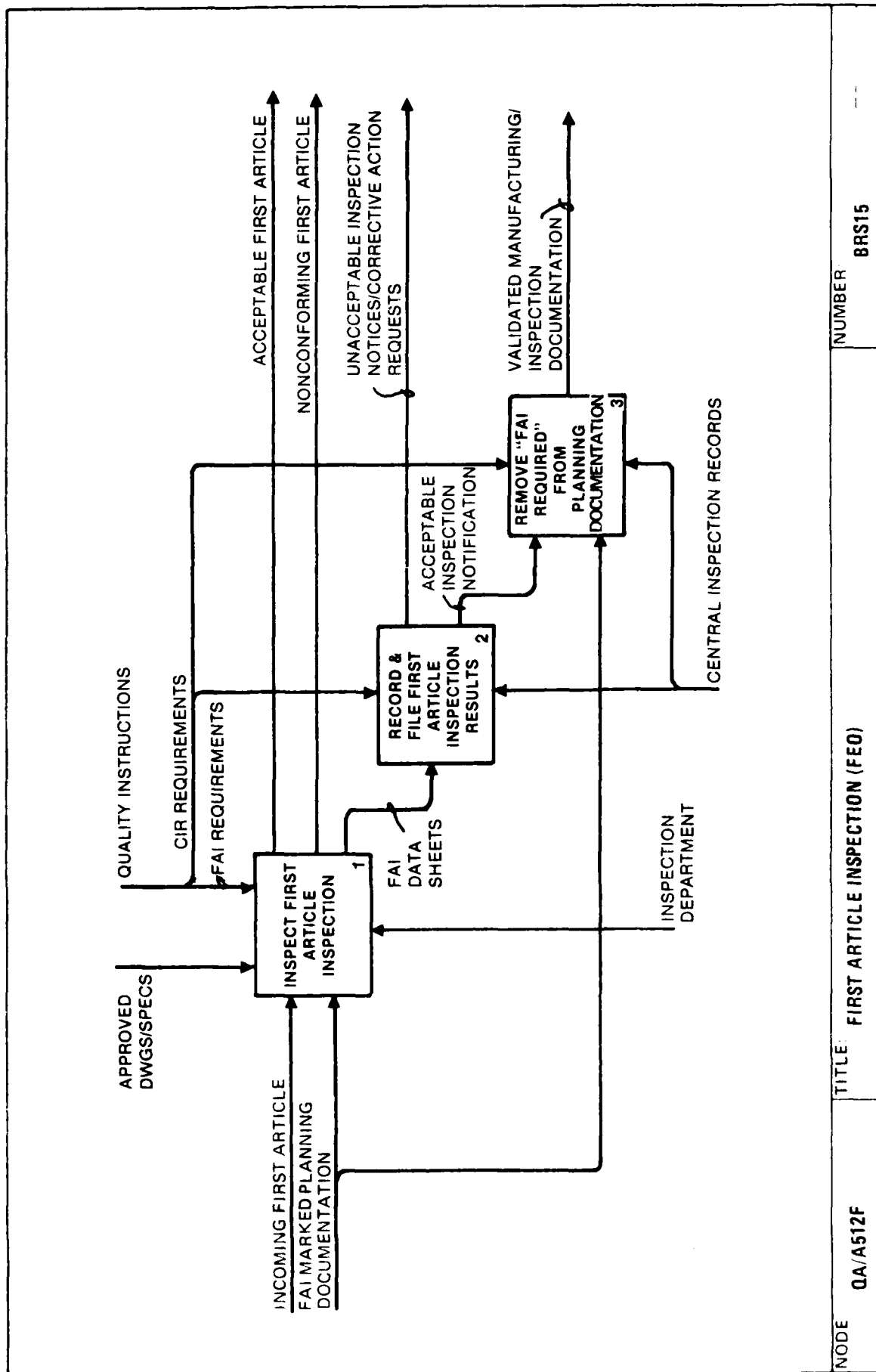
NUMBER: BRS14

The objective of First Article Inspection is to assure that the first piece considered to be representative of a larger part lot, which is to follow, meets prescribed quality objectives. Assuming the first piece passes this inspection, the remainder of the parts are released for manufacture. (Also, sometimes called First Piece Inspection or Set-up Inspection.)



First Article Inspection

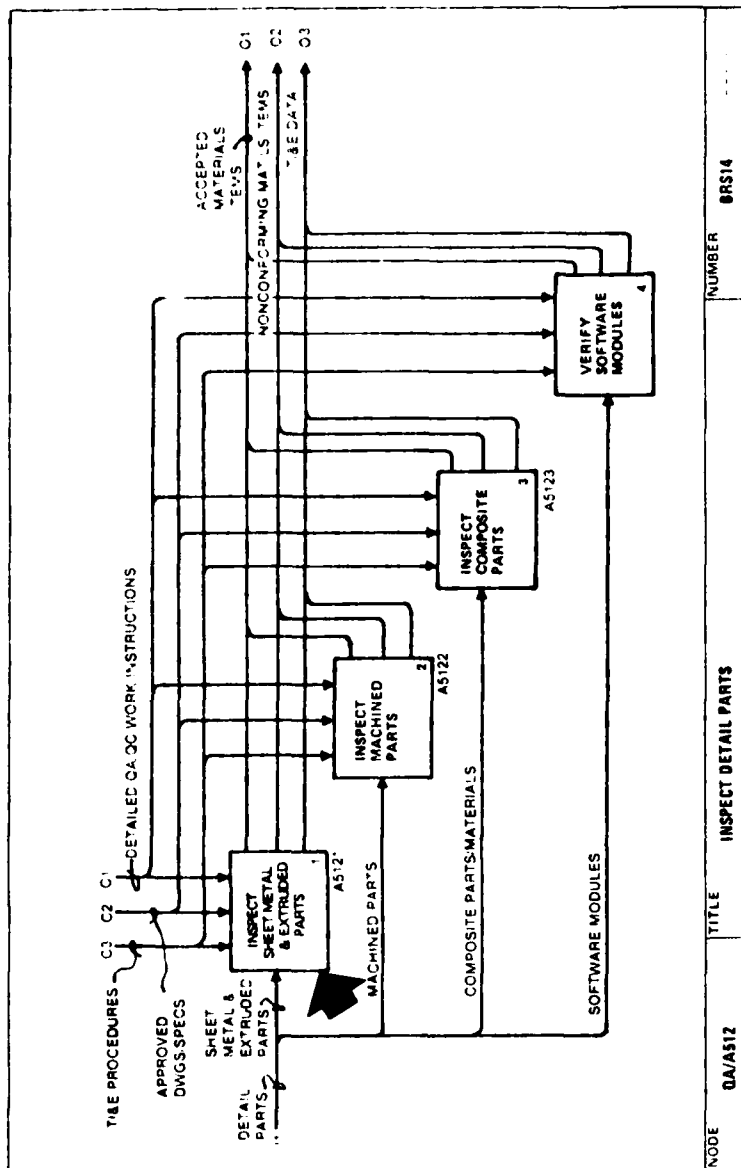
The detailed inspection of the first article produced; used to verify/approve a process for subsequent manufacture.



NODE	QA/A512F	TITLE	FIRST ARTICLE INSPECTION (FEO)	NUMBER	BRS15
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A5121 Inspect Sheet Metal & Extruded Parts

Blanked parts are inspected for outline shape; formed and drilled parts are inspected for bends, folds, etc. Critical dimensions and Rockwell Hardness are verified, x-ray and dye penetrant non-destructive tests are performed on completed detail parts. Finally, post-process operations (prime, paint and identification markings) are inspected.



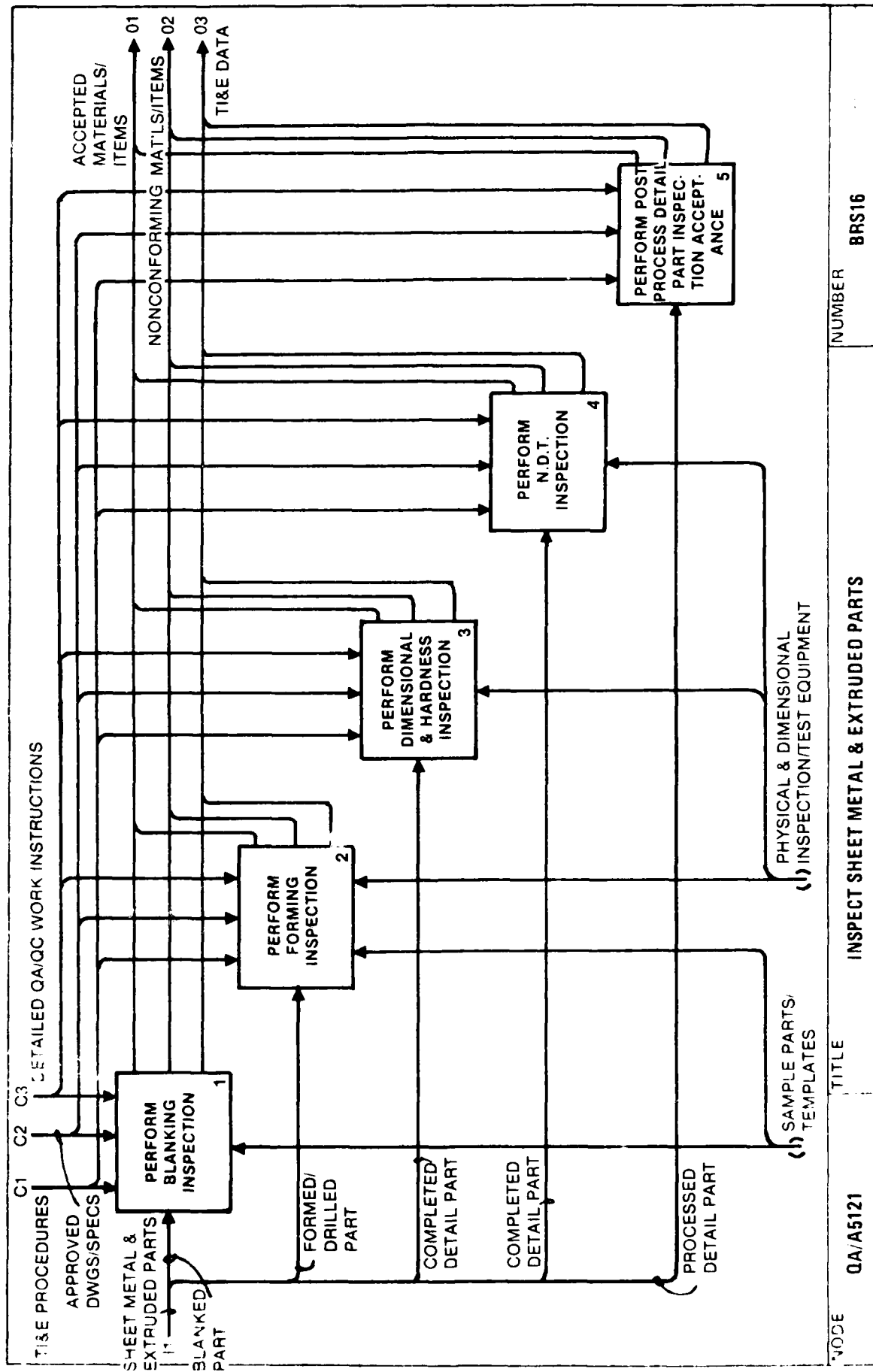
Glossary

Non-Destructive Testing (N.D.T)

The methods used for the detection or measurement of the significant properties or performance capabilities of materials, parts and assemblies by tests which do not impair their serviceability.

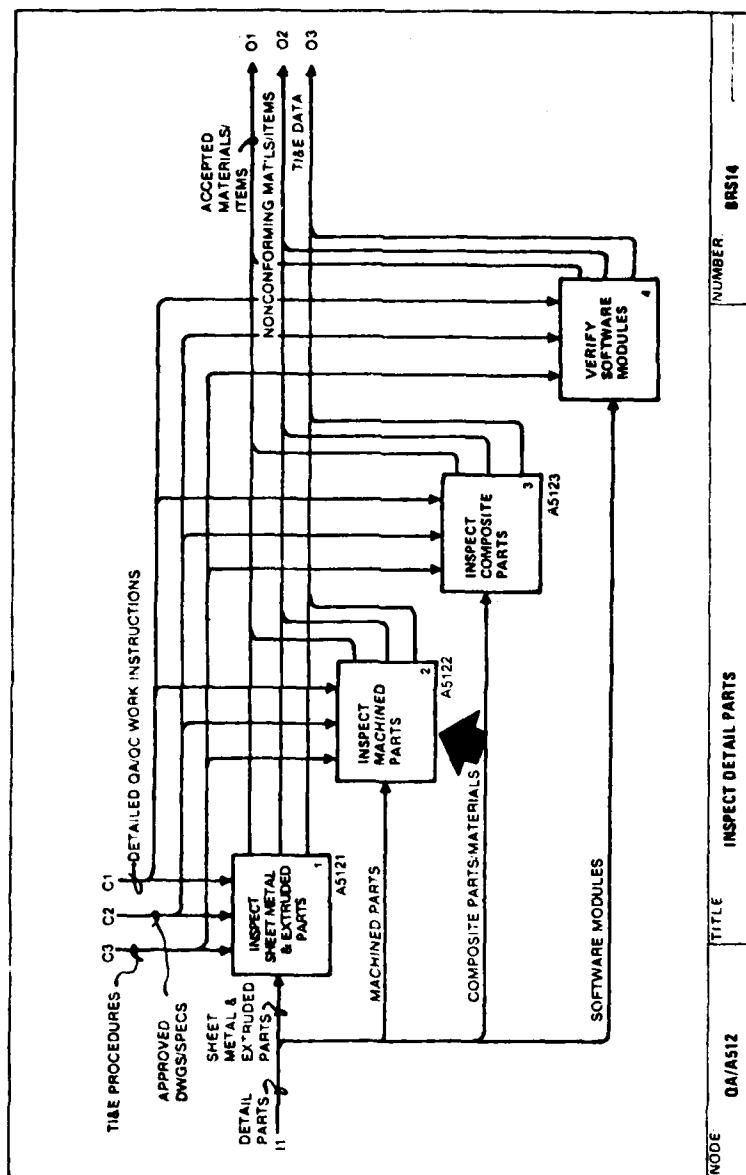
Processed Detail Part

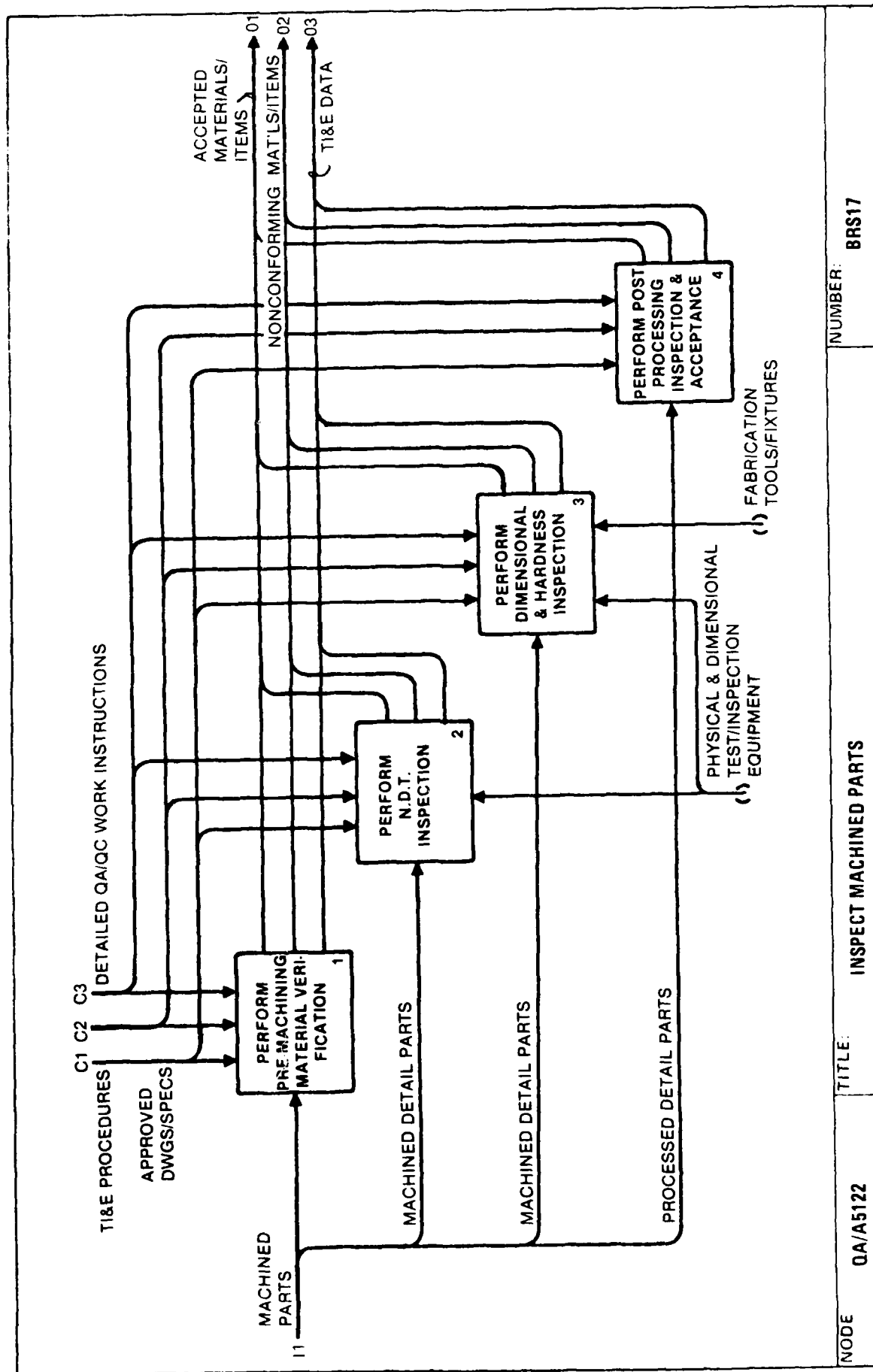
Those parts which have been subjected to a change in their physical or chemical properties (i.e. welding, heat treating, etc.) as contrasted with a change in their dimensions or shape.



A5122 Inspect Machined Parts

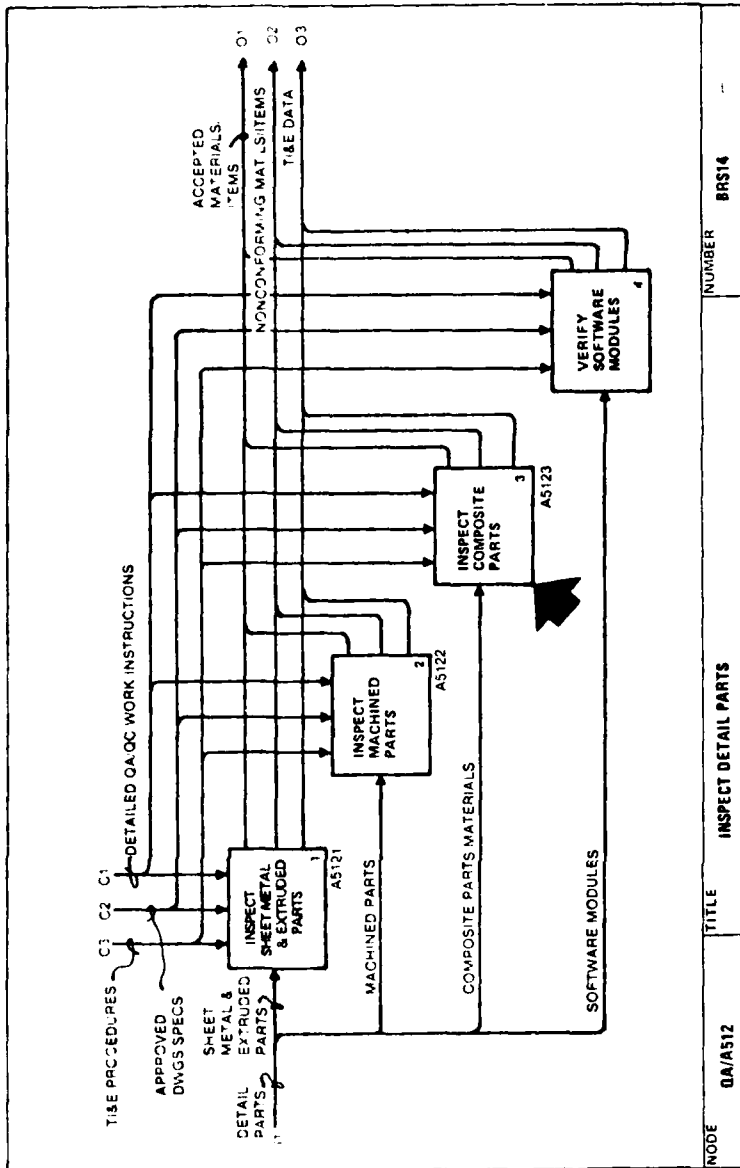
Correct material type is verified prior to machining, finished machined parts are non-destructively tested for cracks or other flaws and dimensionally verified. Post-processed parts are inspected for finish and markings.

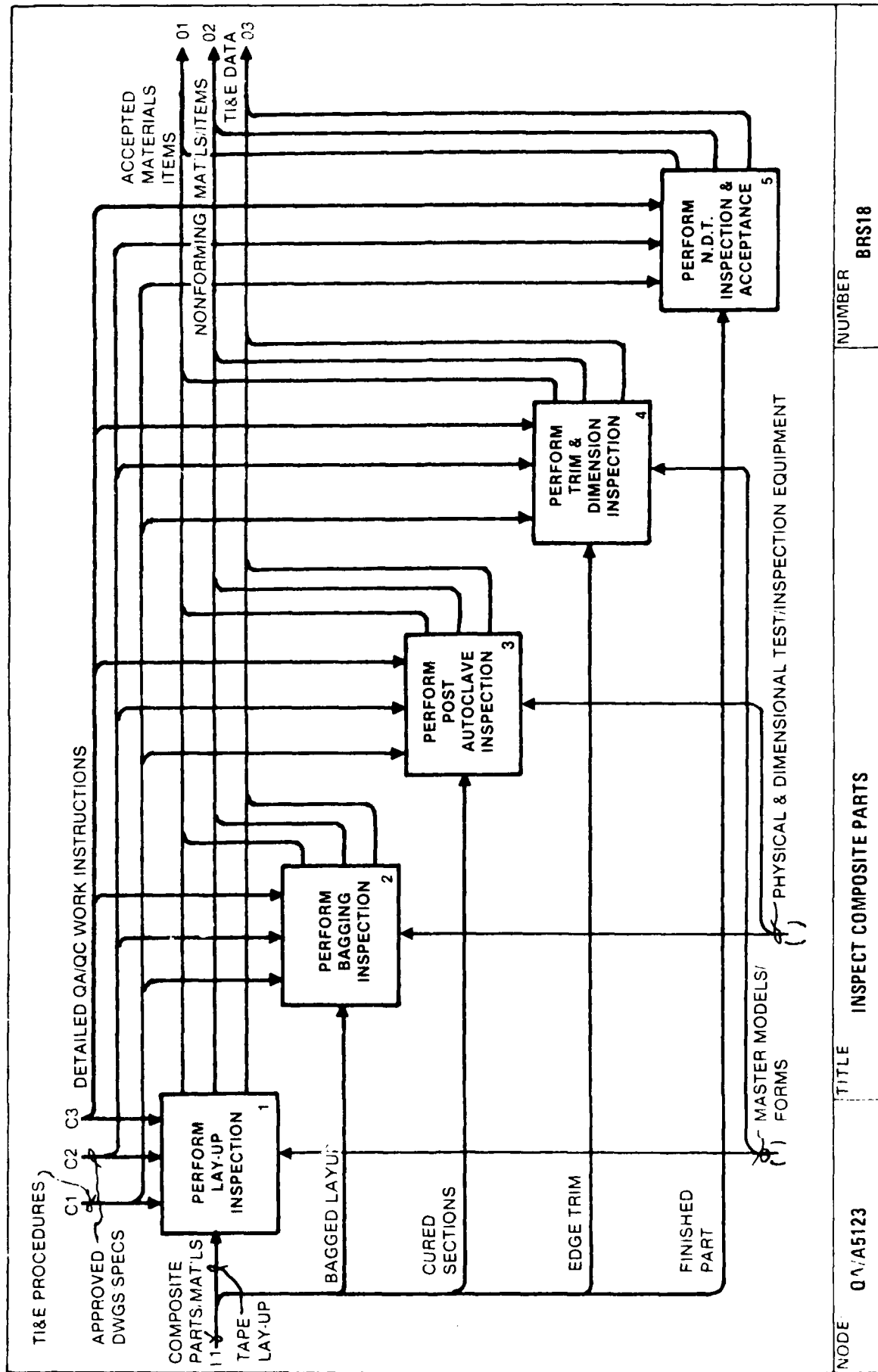




A5123 Inspect Composite Parts

Each layer of tape is inspected to verify the angle and spacing of the lay-up. Bagged lay-ups are checked for leaks. The finished lay-up is inspected for proper cure. After trimming, edge inspection takes place. Finally, the finished part is subjected to x-ray and ultrasonic tests for voids or delaminations.

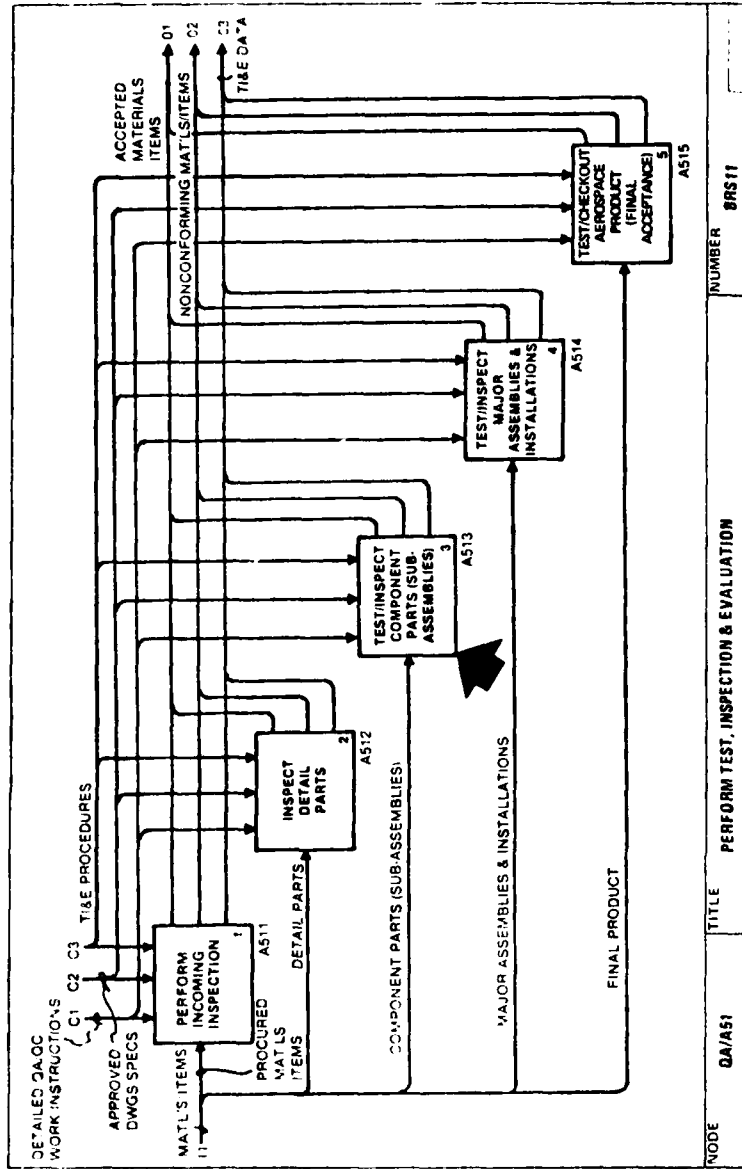


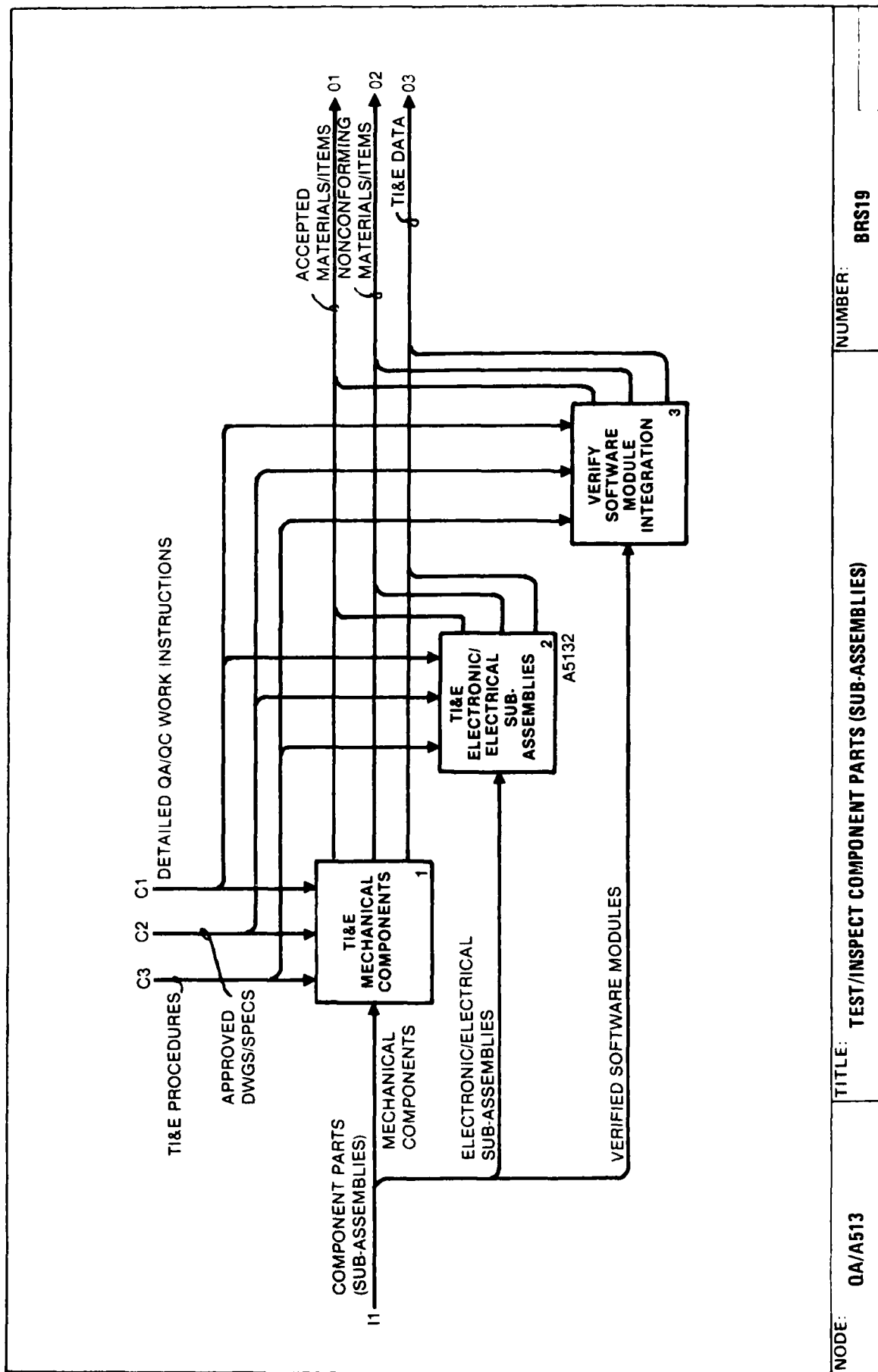


A513 and A513F Test/Inspect Component Parts (Sub-assemblies)

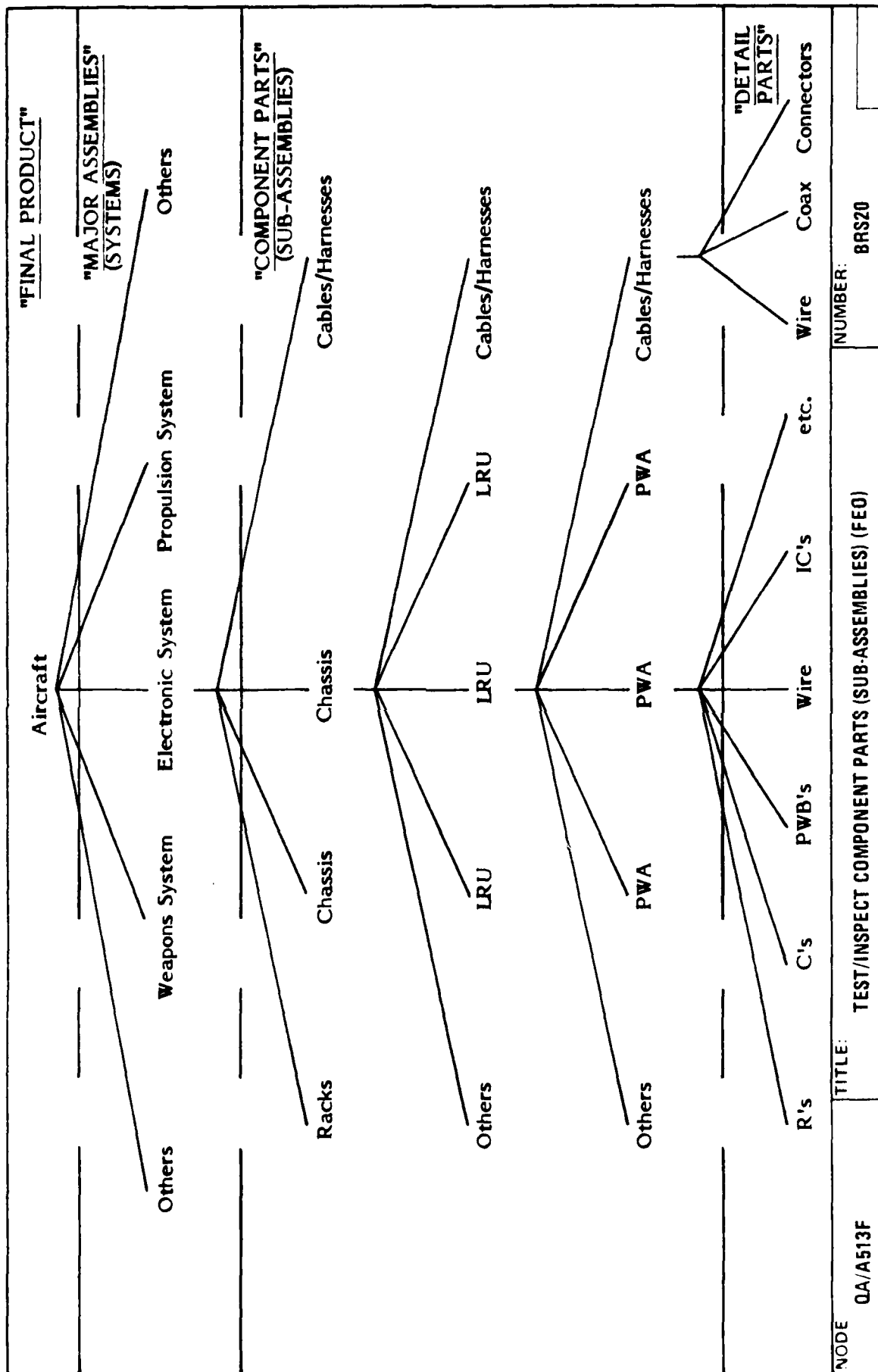
Component Parts (Sub-assemblies) are inspected to assure compliance with requirements. The parts are either accepted or declared nonconforming for subsequent MRB action. TO&E data is collected for analysis and potential corrective action.

FEO, A513F (attached), shows a structure tree for "Electronic Systems". For purposes of this model, "Systems" are analogous to "Major Assemblies" (MFGO A6333). "Component Parts (Sub-assemblies)" (MFGO/6332) include racks, chassis, LRU's, PWA's, etc. and "Detail Parts" (MFGO/A6331) include resistors, capacitors, IC's, etc.



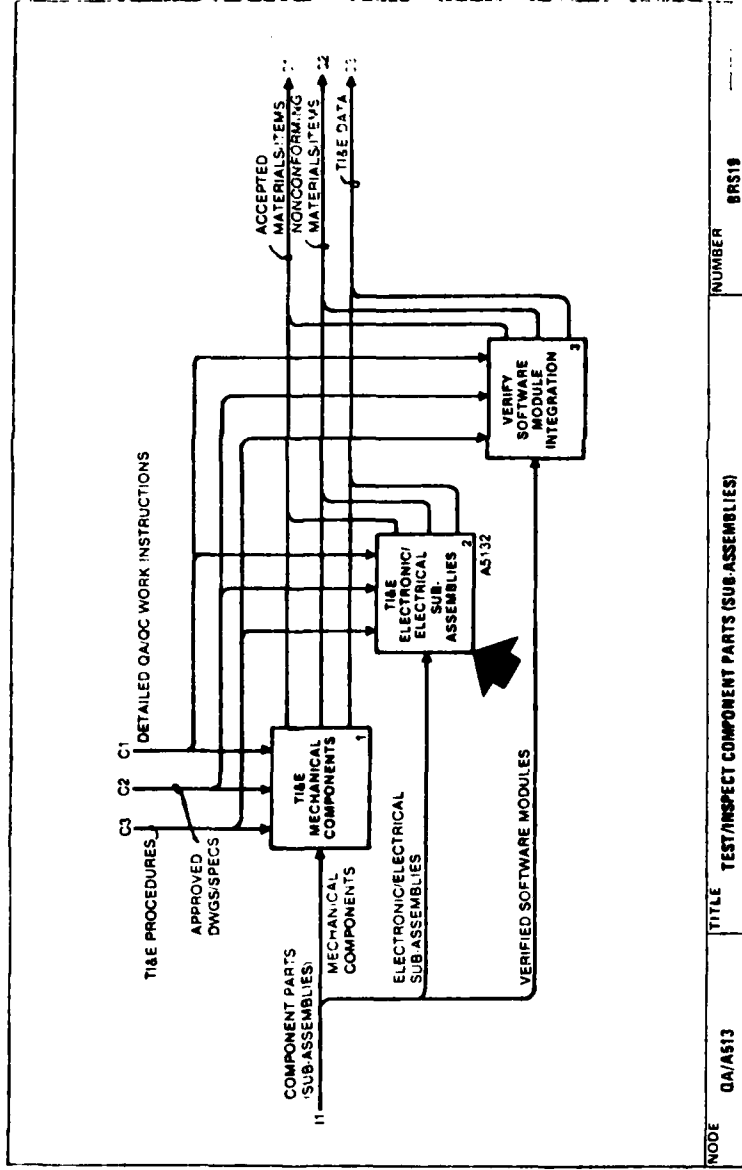


2-22031



A5132 TI&E Electronic/Electrical Sub-assemblies

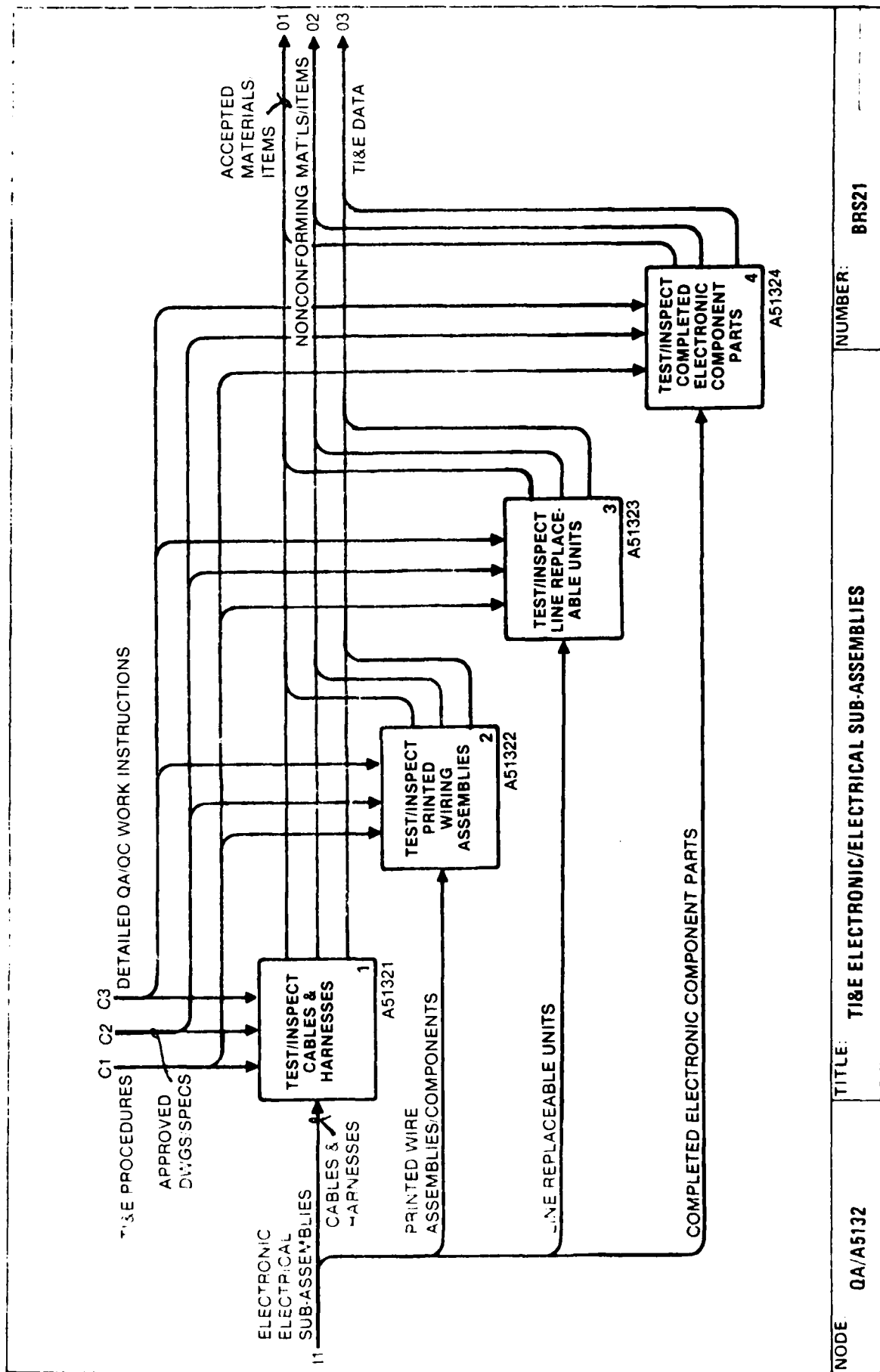
For purposes of this model, Electronic/Electrical Component Parts (Sub-assemblies), consist of: cables and harnesses, printed wire assemblies, Line Replaceable Units (LRU's) and finally, completed electronic component parts. These component parts, in turn, consist of chassis, interfaces and racks (see A513F). Each of these sub-assemblies is tested and inspected to assure conformance to requirements.



Glossary

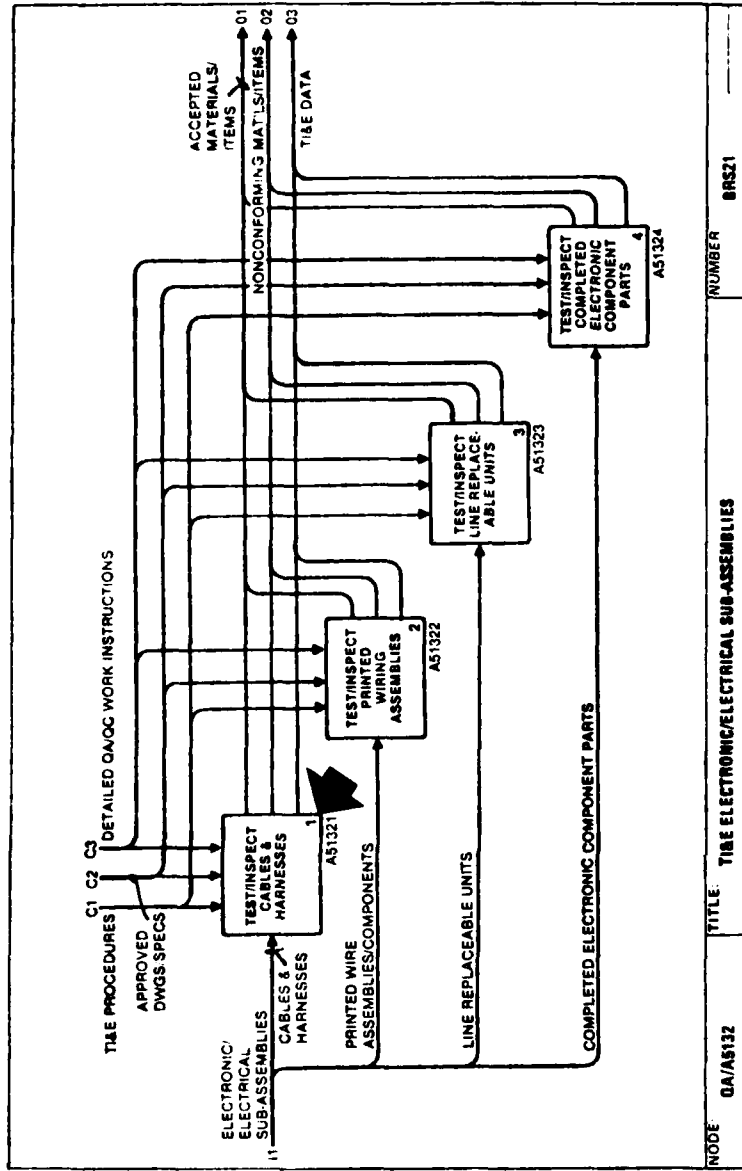
Line Replaceable Unit (LRU)

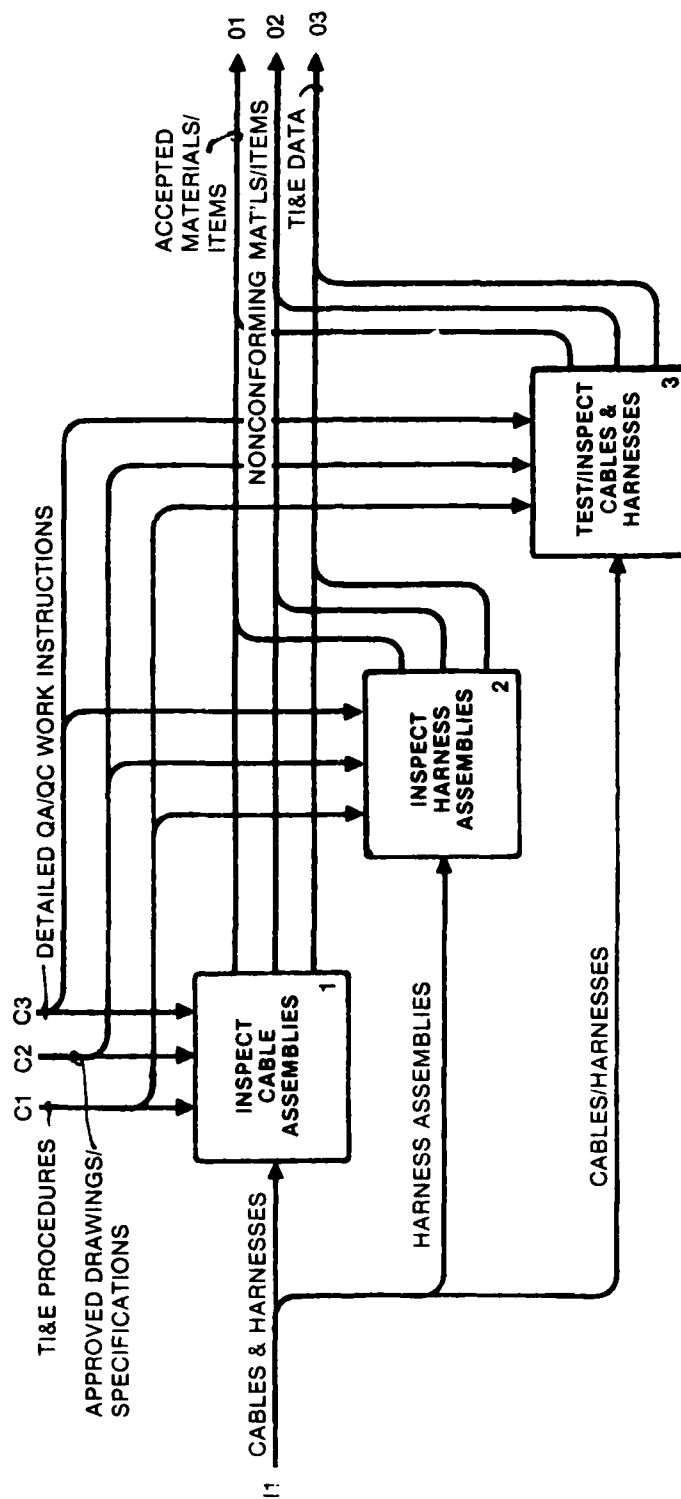
Equipment that can be removed and replaced with quick disconnection without disrupting the balance of the system.



A51321 Test/Inspect Cables & Harnesses

Cable assembly checks include visual inspections to assure: cable dimensions agree with drawing requirements, absence of physical defects, proper orientation of connector keying and backshell tightness. Harness assembly checks include visual inspections to assure proper harness breakouts and lengths, wire strip, crimp and solder. Cables and harness are functionally tested for continuity leakage, resistance and voltage. Test results are verified to assure all operations have been performed and that test data is acceptable.





NODE QA/A51321

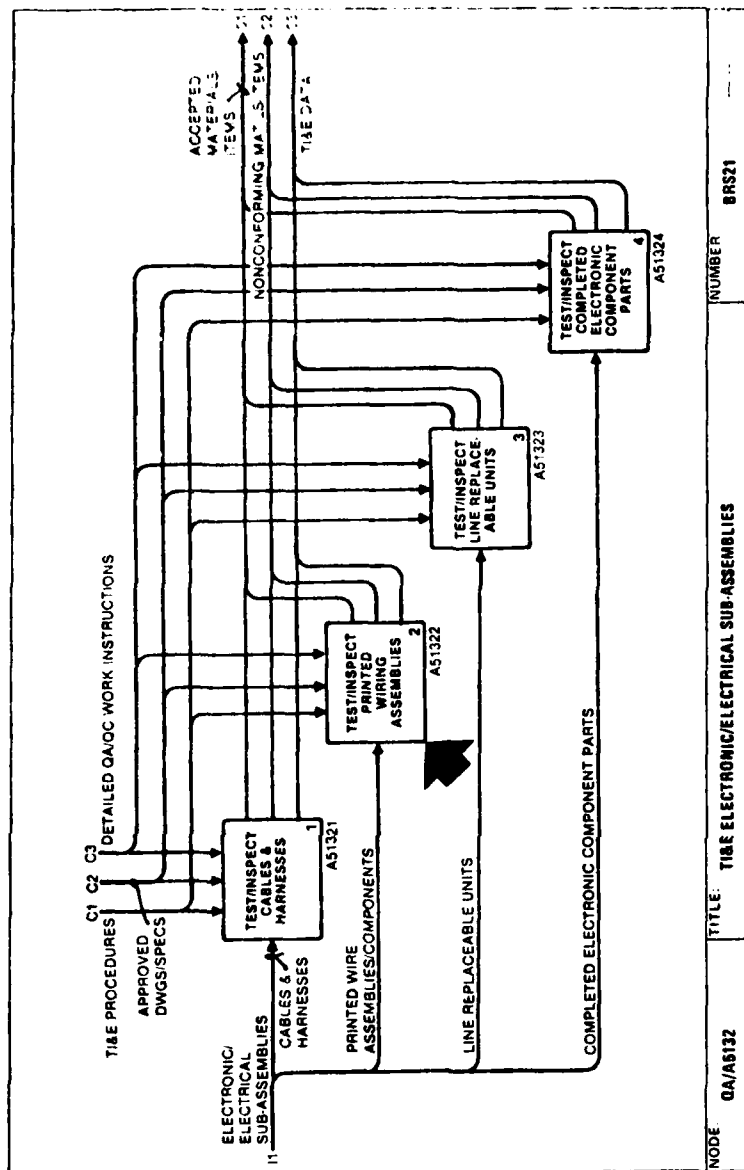
TITLE: TEST/INSPECT CABLES & HARNESSES

NUMBER: BRS22

2-22231

A51322 Test/Inspect Printed Wiring Assemblies

Part markings are inspected to assure identification agrees with Engineering drawings and work instructions. The "stuffed" printed wire board is inspected for completeness, conformal coating, wiring and solder. MIL-STD-454 (Workmanship Practices for Electronic Related Work) is used for guidance. Completed printed wire assemblies are functionally tested and the test results verified.

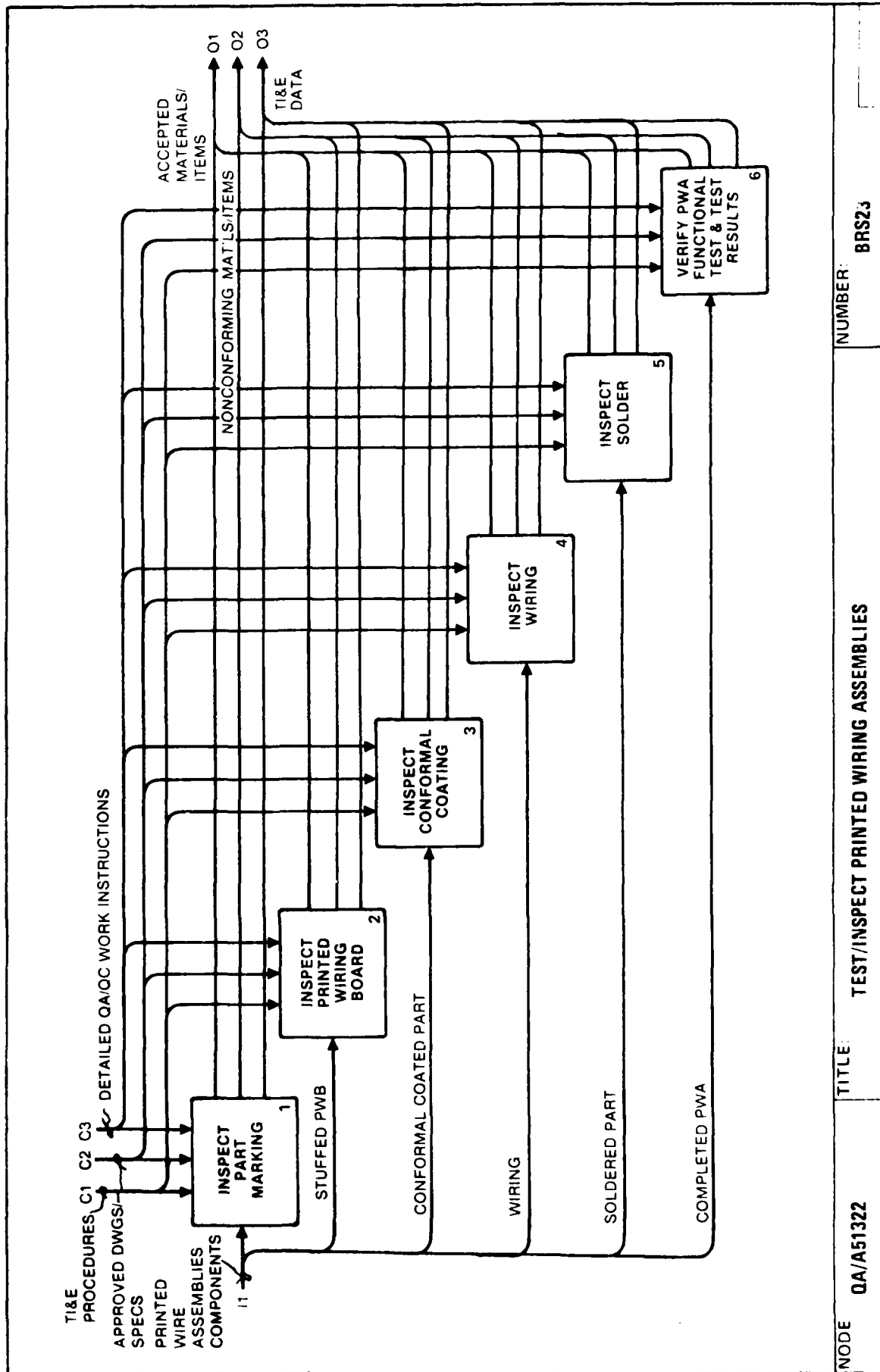


Glossary

Stuffed PWB

A printed wiring board (PWB) on which the electronic components have been mounted.

(Also called Printed Wire Assembly - PWA).

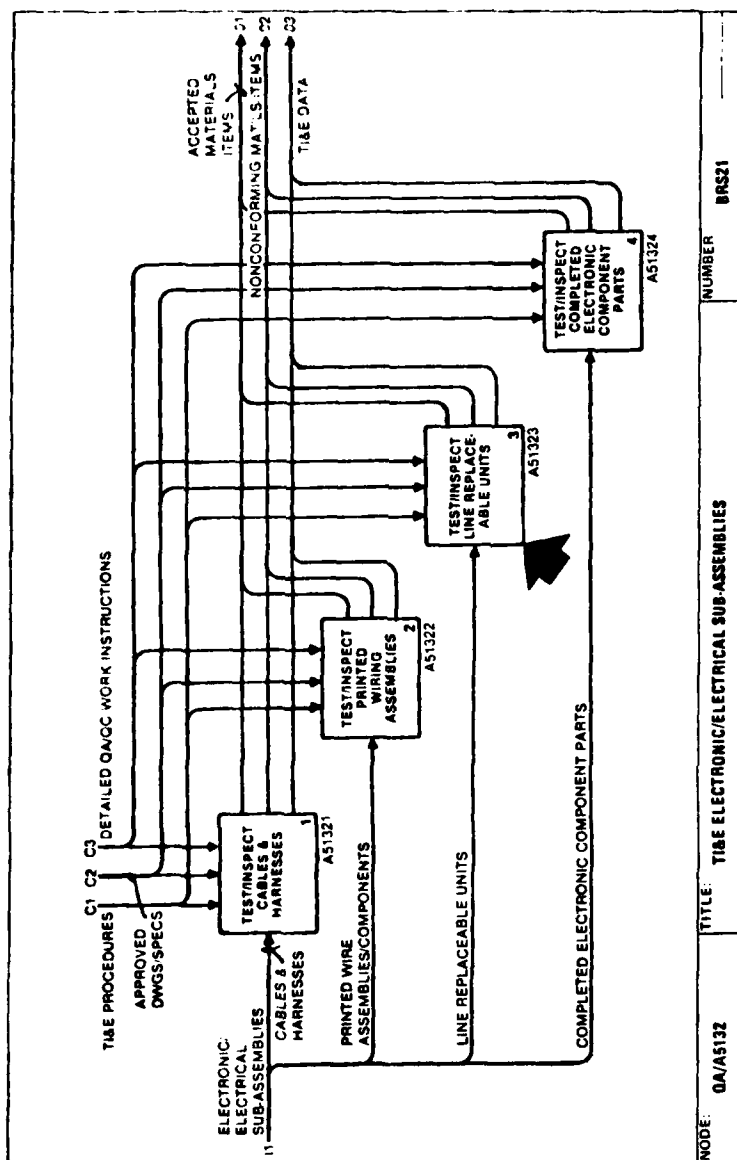


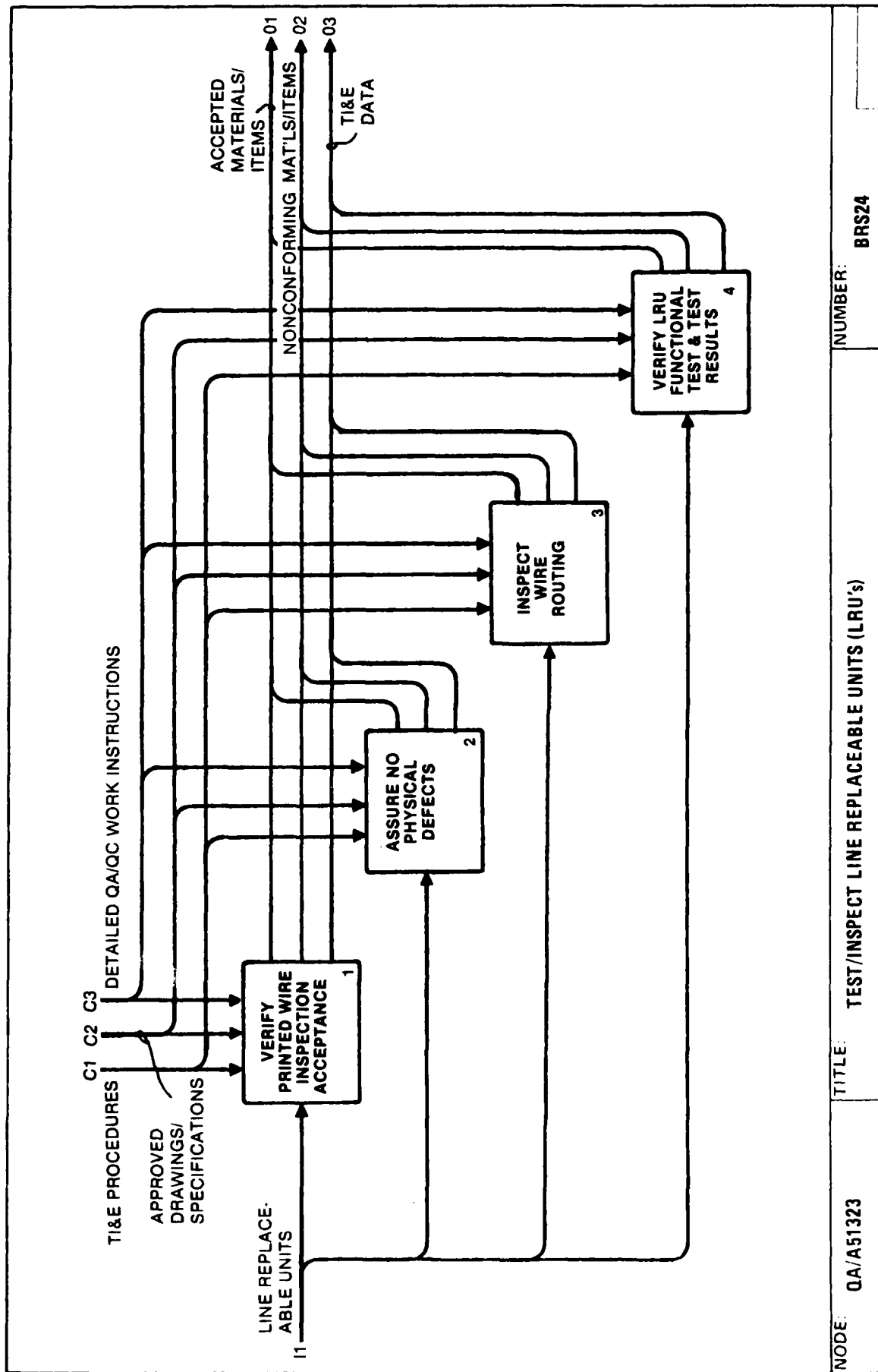
NODE	QA/A51322	TITLE	TEST/INSPECT PRINTED WIRING ASSEMBLIES	NUMBER	BRS23
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2-2223*

A51323 Test/Inspect Line Replaceable Units (LRU's)

An inspection verifies that the printed wire assembly was performed and accepted. Visual inspections assure proper wire routing and absence of physical defects. A functional test of the LRU is verified for proper performance and acceptable test results.





NODE: QA/A51323

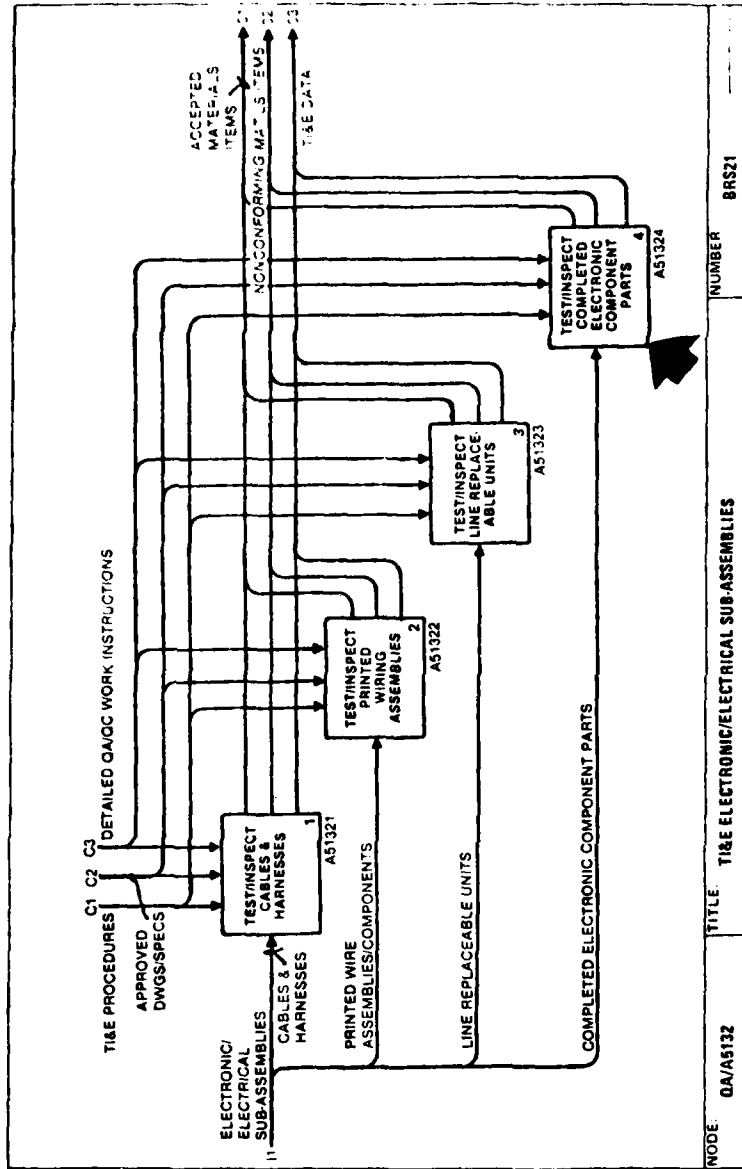
TITLE: TEST/INSPECT LINE REPLACEABLE UNITS (LRU's)

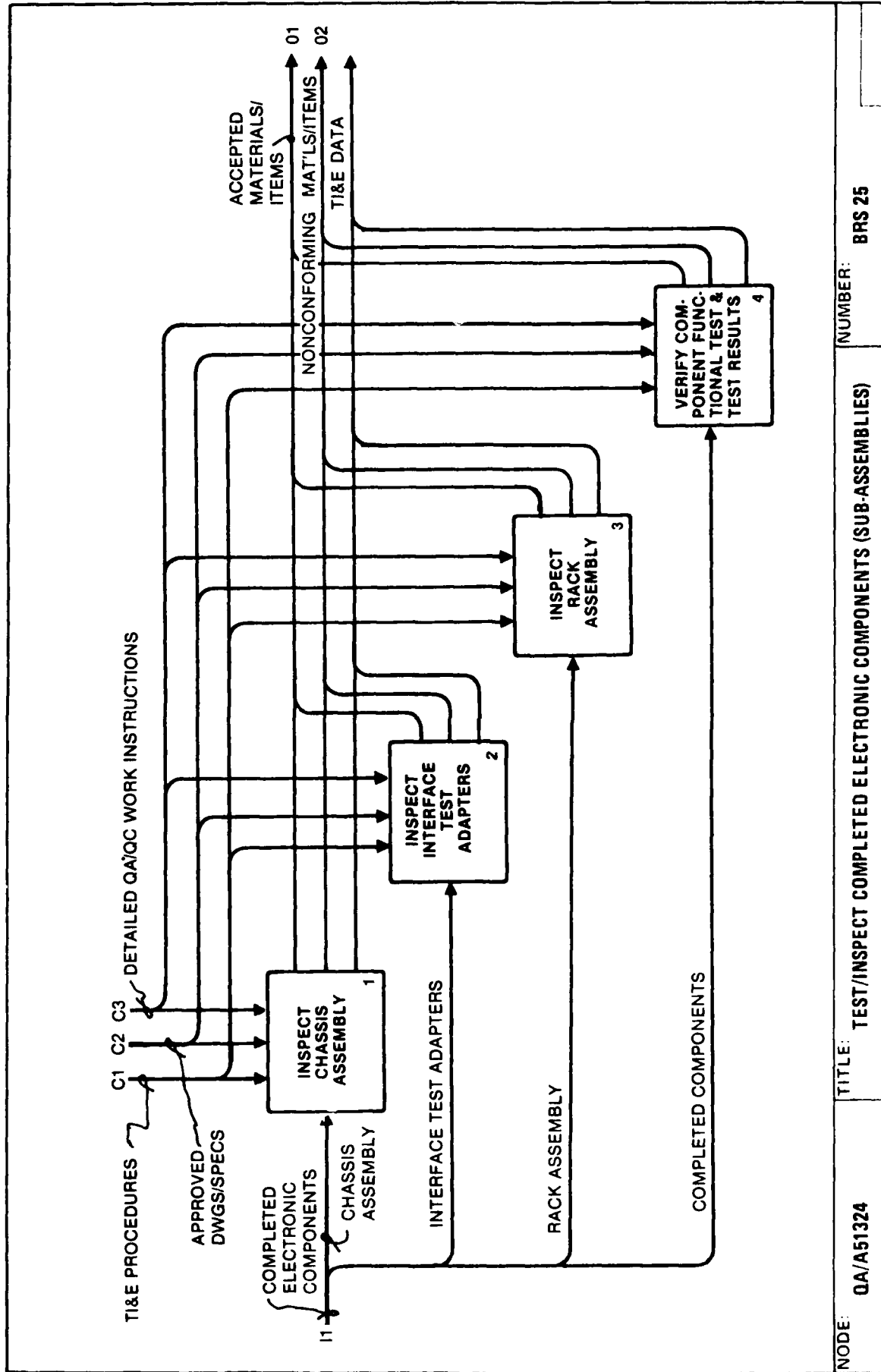
NUMBER: BRS24

2-22031

A51324 Test/Inspect Completed Electronic Components (Sub-assemblies)

The chassis assembly is inspected for component installation, connector orientation and installation, harness routing and debris. Interface Test Adapter inspection include visual patch panel checks and configuration cable keying. The Rack Area is inspected to assure proper operation of reactor arms, proper wire routing and coax cable undistorted by cable/harness clamps and ties.

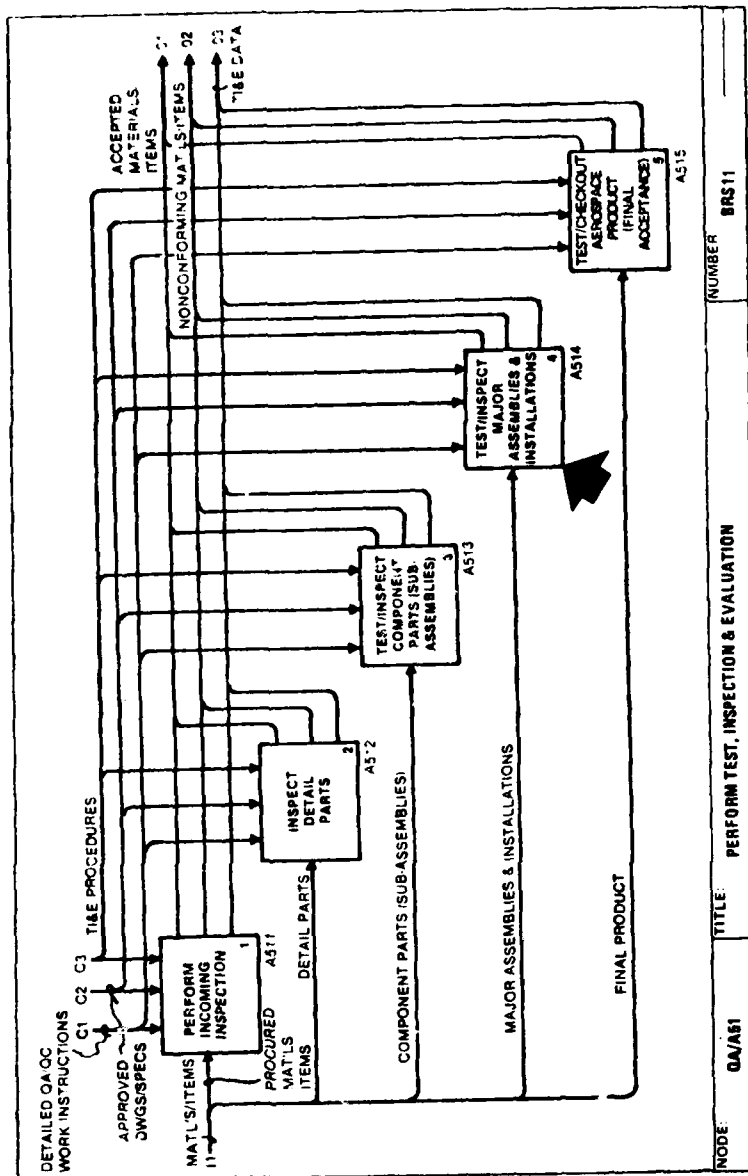


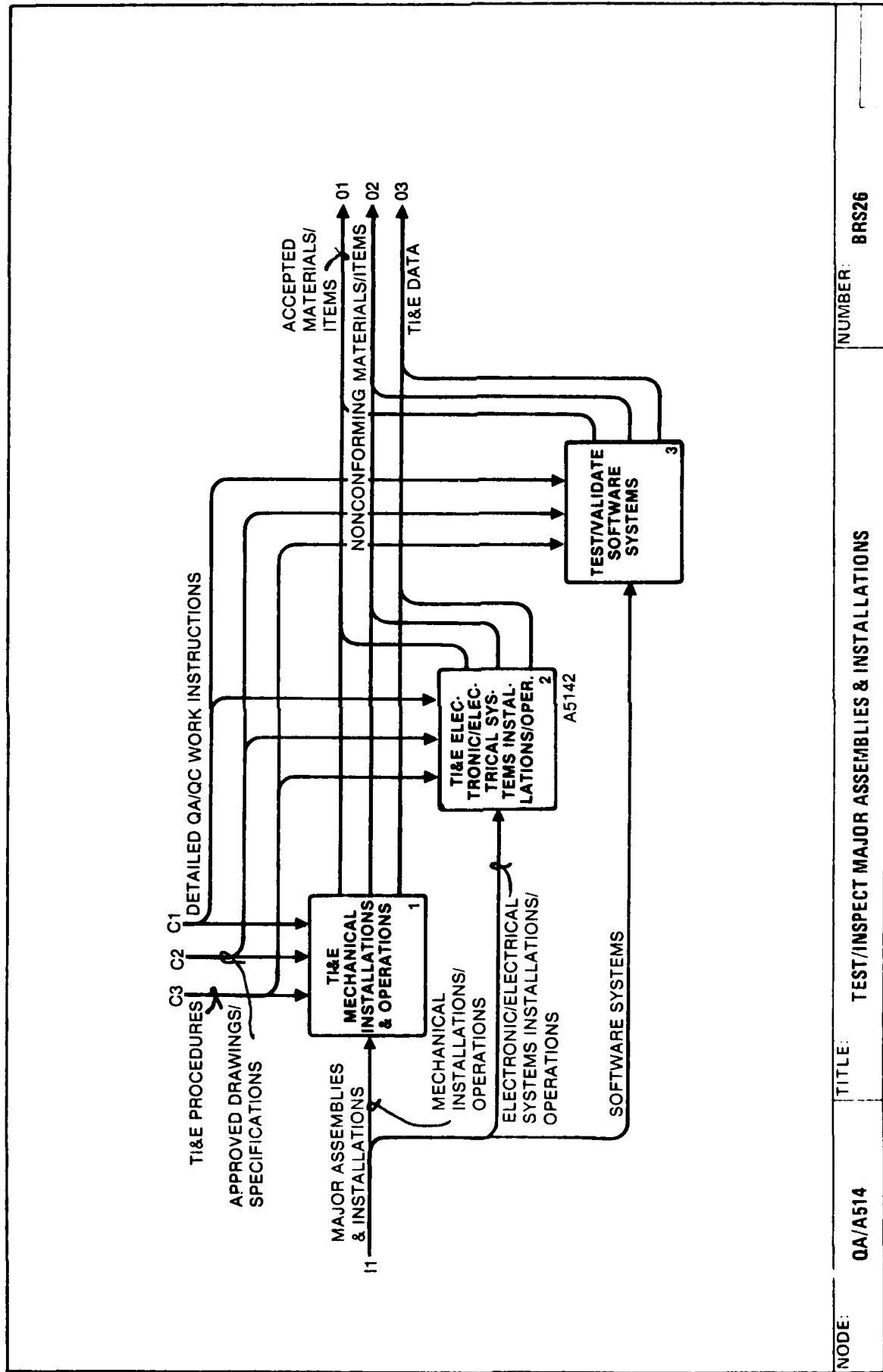


2-22031

A514 Test/Inspect Major Assemblies and Installations

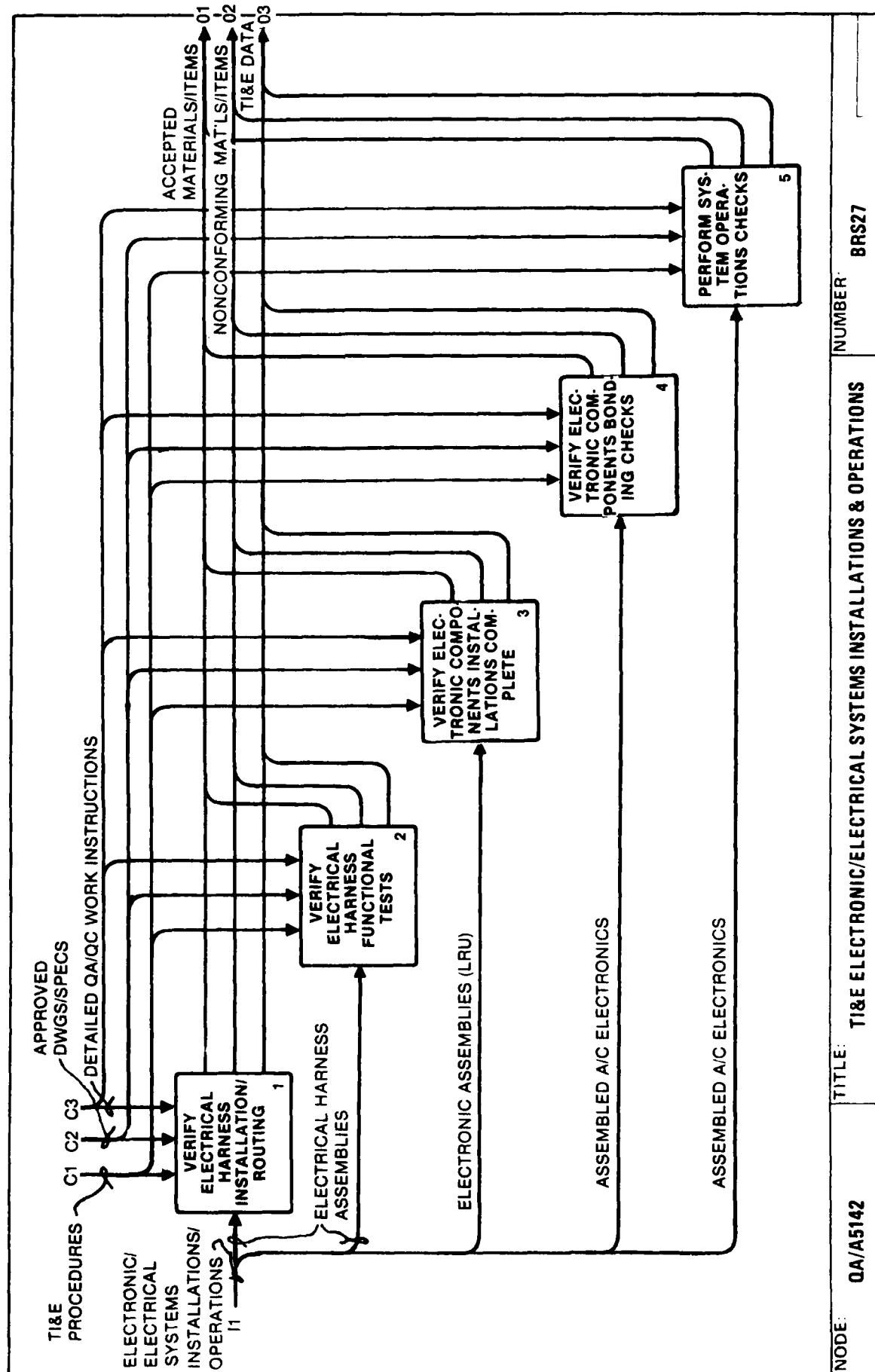
Major Assemblies and Installations are inspected to assure compliance with requirements. The parts are either accepted or declared nonconforming for subsequent MRB action. TI&E data is collected for analysis and potential corrective action.





Electrical harness installations are inspected for proper routing and functionally tested for proper operation. The installation of the Electronic components (e.g. LRU's, racks, chassis) is inspected/verified for completeness after which the components are checked for proper electrical bonding. Finally, the entire system is tested for proper operation.





NODE: QA/A5142

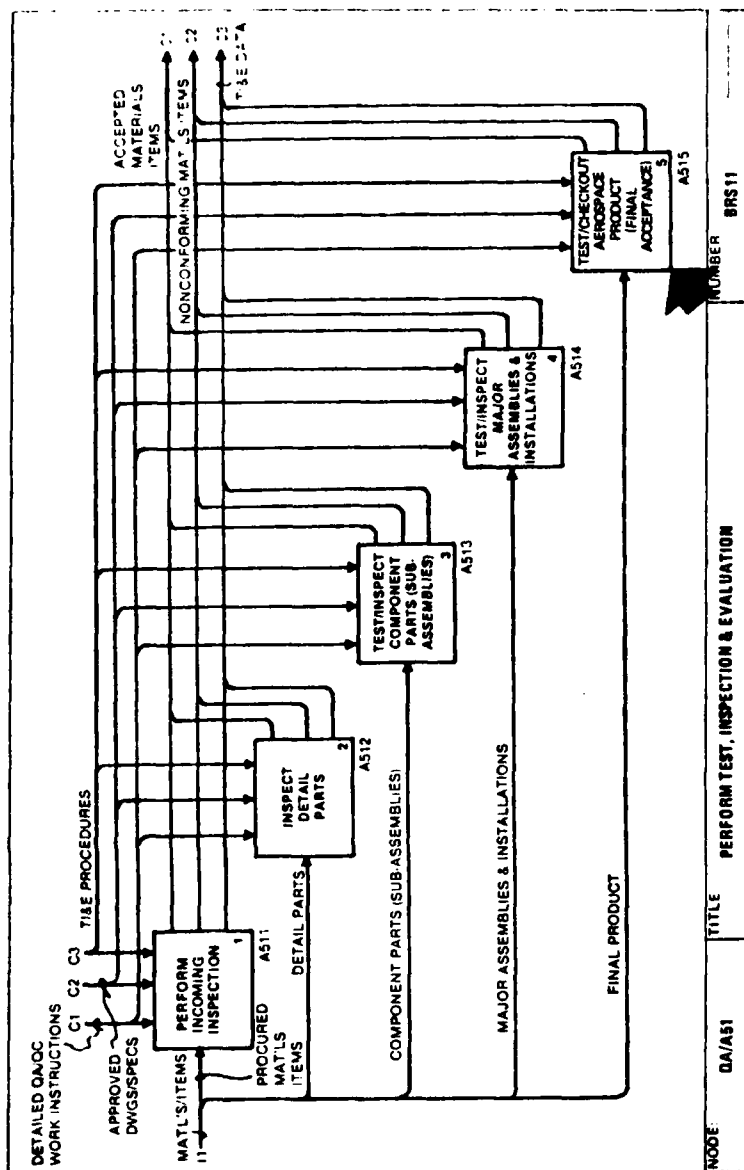
TITLE: TI&E ELECTRONIC/ELECTRICAL SYSTEMS INSTALLATIONS & OPERATIONS

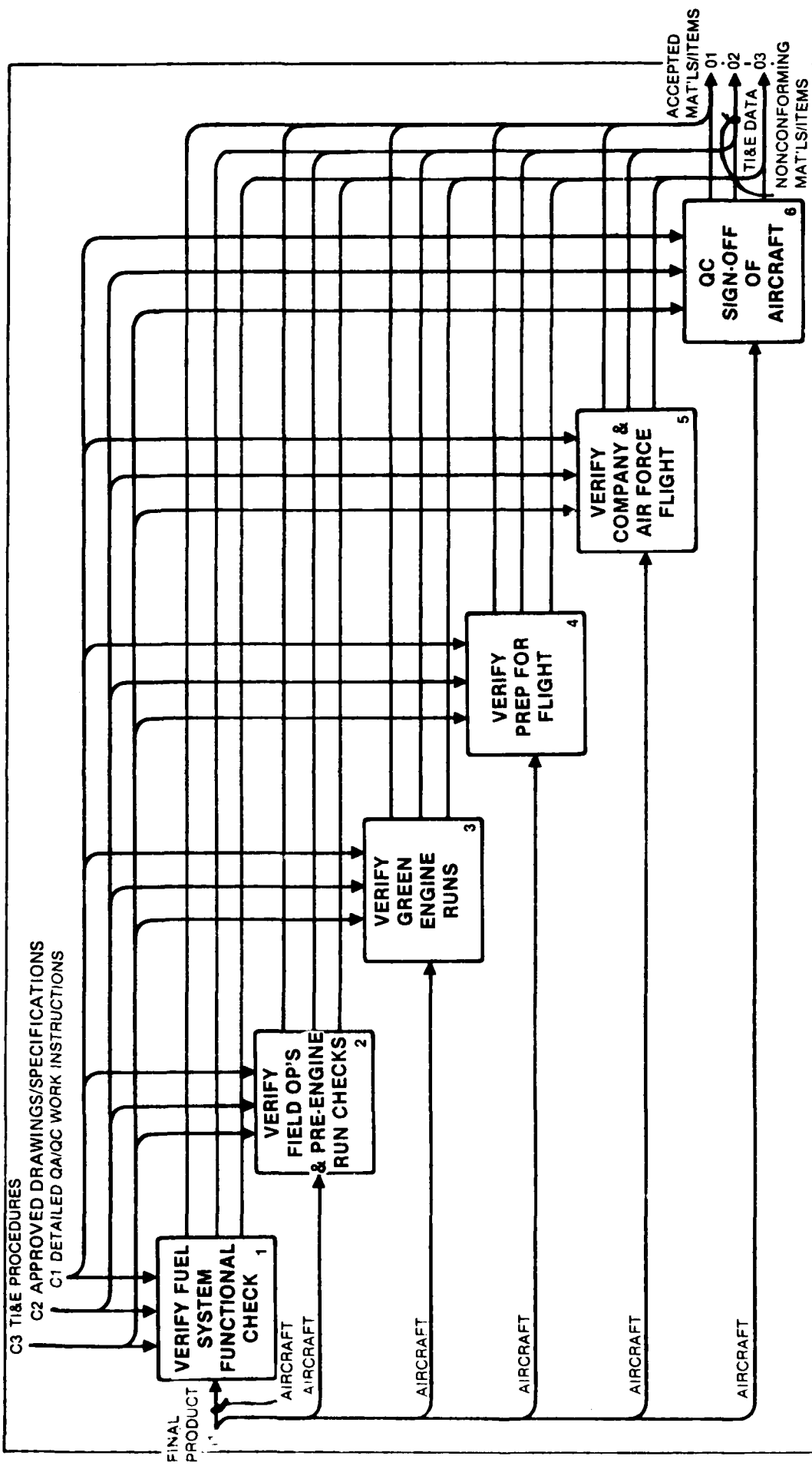
NUMBER: BRS27

2-22031

A515 Test/Checkout Aerospace Product (Final Acceptance)

Final Acceptance of the completed aircraft is subject to the following tests, inspections and verifications: 1) foreign object inspections; 2) completion of all required tests and inspections' verification; 3) preflight functional run of electronic systems; 4) hands-on physical inspections prior to every flight; 5) post-flight physical and electronic functional inspection; 6) post-flight physical inspection after company and USAF flights; 7) assurance that all discrepancies and malfunctions have been corrected and 8) assurance that non-conformance reports have been closed-out and all inspection procedures completed.





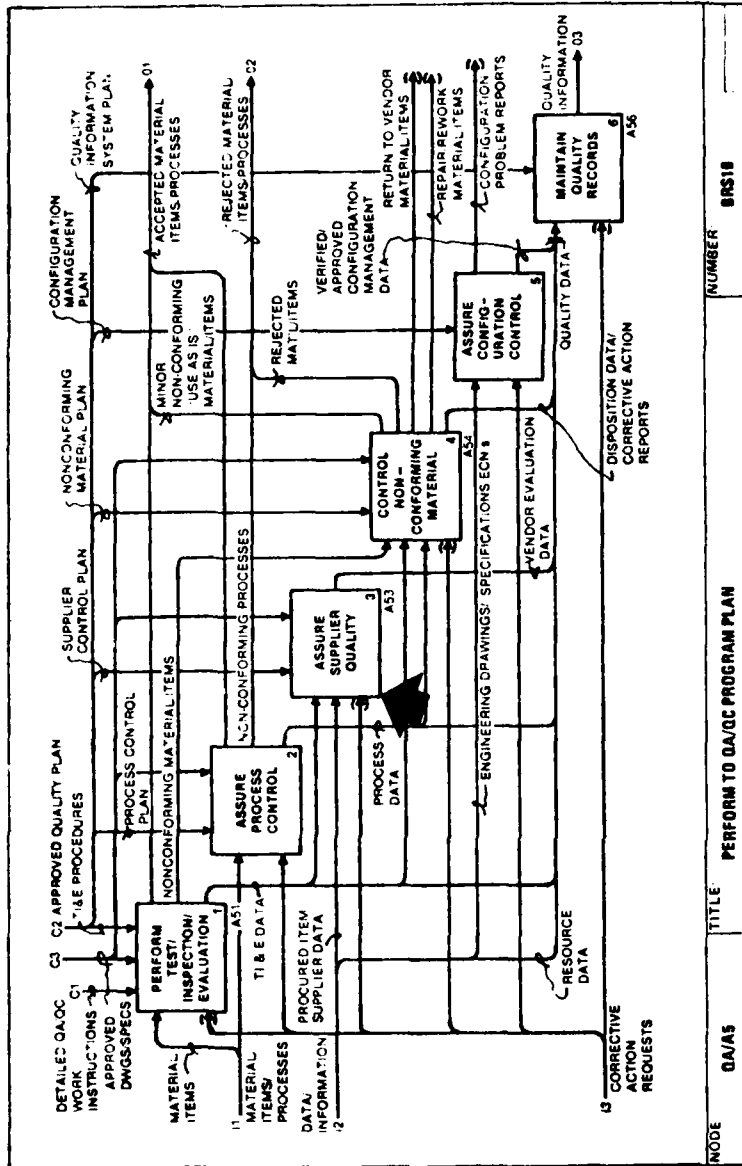
C3 T&E PROCEDURES C2 APPROVED DRAWINGS/SPECIFICATIONS C1 DETAILED QA/QC WORK INSTRUCTIONS	FINAL PRODUCT AIRCRAFT AIRCRAFT AIRCRAFT AIRCRAFT AIRCRAFT AIRCRAFT	VERIFY FUEL SYSTEM FUNCTIONAL CHECK 1 VERIFY FIELD OP'S & PRE-ENGINE RUN CHECKS 2 VERIFY GREEN ENGINE RUNS 3 VERIFY PREP FOR FLIGHT 4 VERIFY COMPANY & AIR FORCE FLIGHT 5 QC SIGN-OFF OF AIRCRAFT 6	ACCEPTED MAT'L S/ITEMS 01 TI&E DATA 02 NONCONFORMING MAT'L S/ITEMS 03
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NODE: QA/A515
 TITLE: TEST/CHECKOUT AEROSPACE PRODUCT (FINAL ACCEPTANCE)
 NUMBER: BRS28

2-22231

A53 Assure Supplier Quality

The Supplier Control Plan (guided by MIL-Q-9858A) provides the control required to Assure Supplier Quality. Special supplier QC requirements are tailored to the specific procured part requirements and supplier RFP's are issued. Responses to these RFP's are evaluated and appropriate assurance programs and systems are surveyed and approved suppliers listed. Vendor ratings result from evaluations of quality trends in TI&E data and vendor corrective action when appropriate. Source control functions include periodic product and process control evaluations to assure continued conformance to requirements.



Glossary

Approved Supplier Lists

These lists contain the names of suppliers who have been approved by the contractor to provide a specific product or service.

Audited Supplier Data

Supplier inspection and test data that has been audited by the contractor.

Rated Responses

The process of rating the responses from vendors to requests for proposal.

Supplier Capability Data

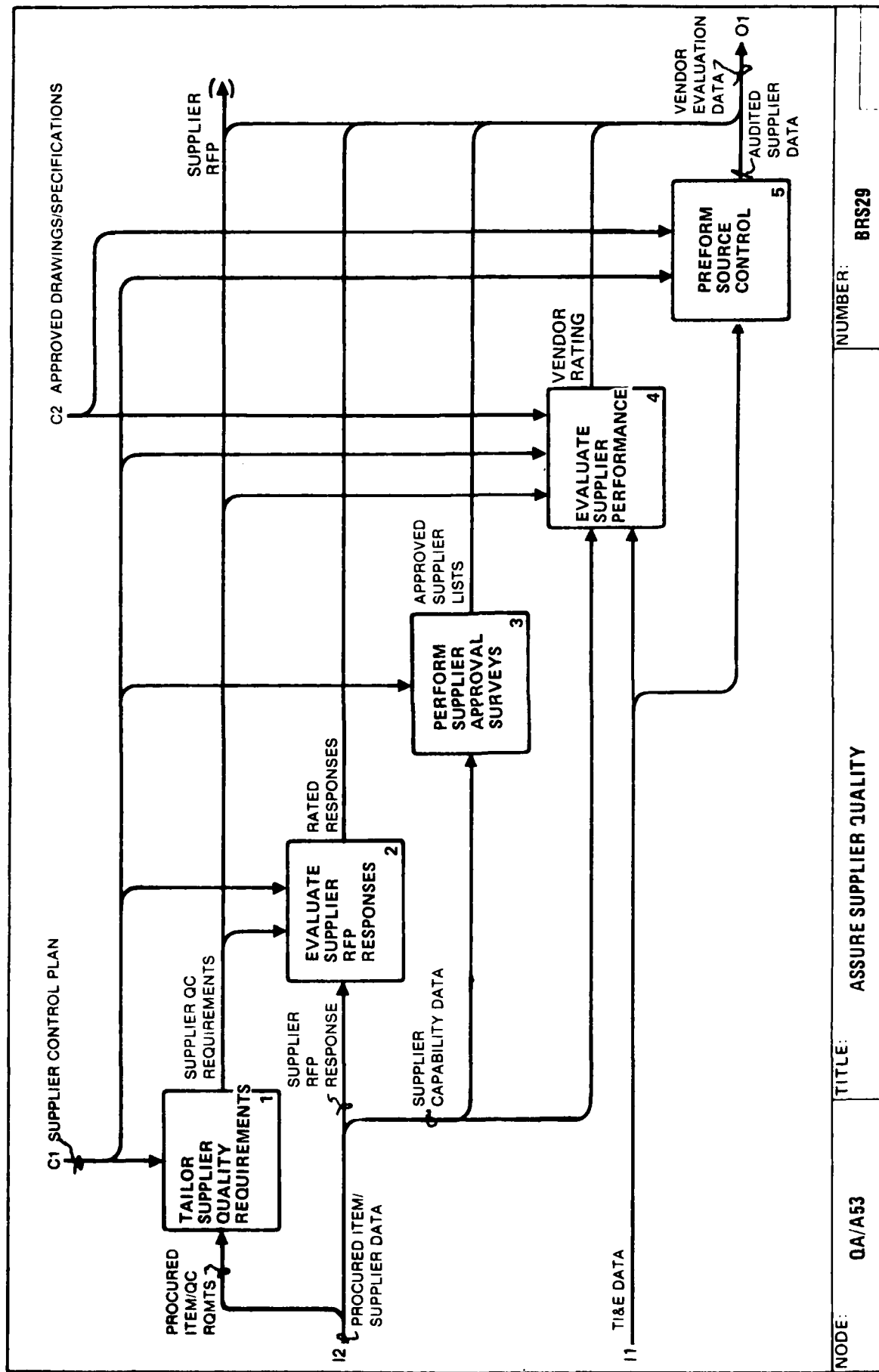
Data which documents a supplier's capability to supply material of the proper quality and quantity.

Supplier RFP

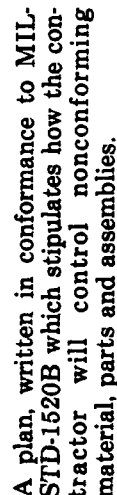
A request for proposal from a supplier.

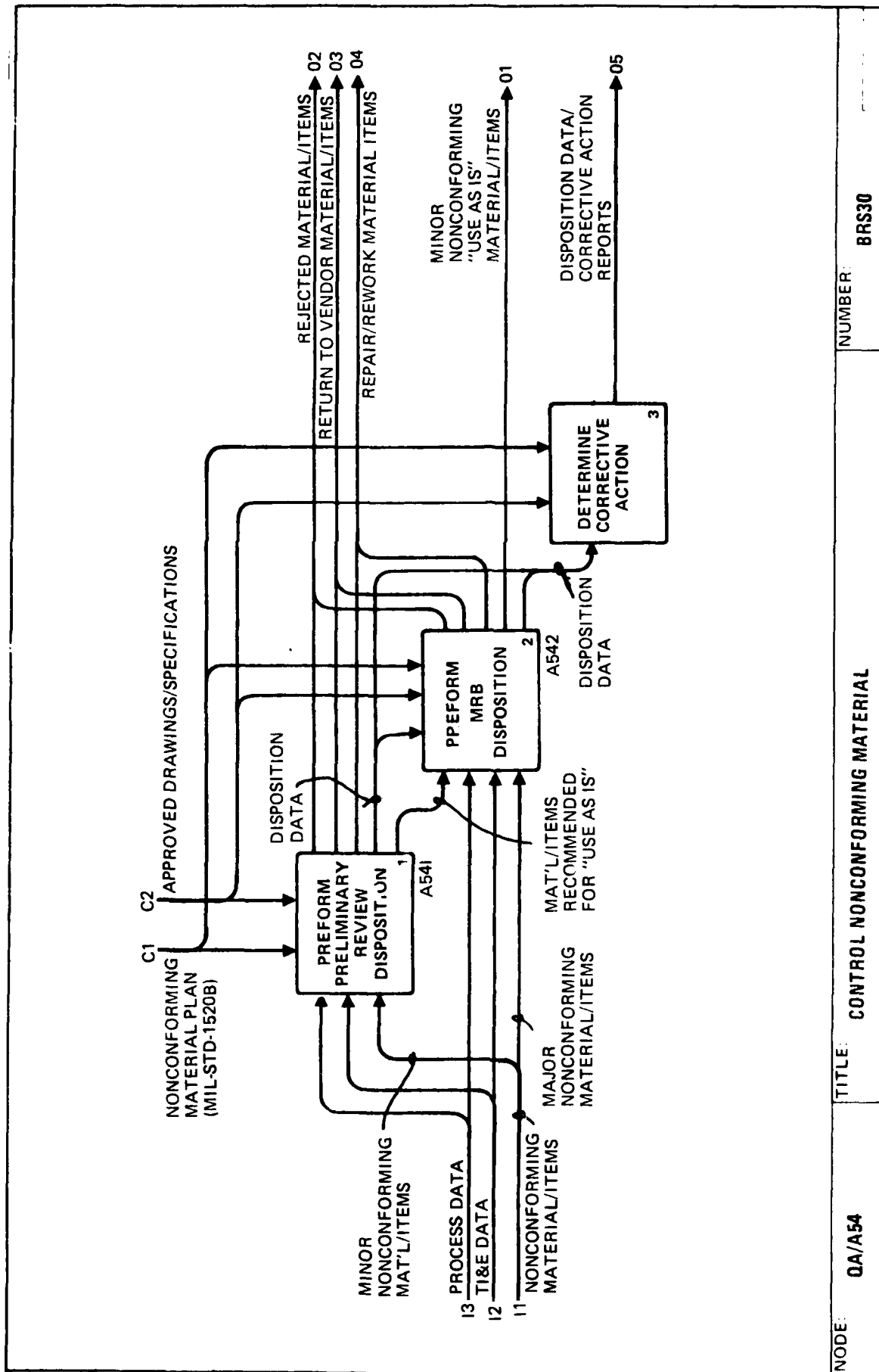
Vendor Ratings

The result of the compilation of test and inspection data into a single number which reflects the vendor's overall quality performance.



The control of nonconforming material begins when material is inspected or tested and found to be discrepant. Material (including components and assemblies) identified as nonconforming is marked and transferred to a controlled area or maintained in a controlled manner. At the same time, data is generated concerning the nonconformance. Minor discrepant material is re-dispositioned at Preliminary Review, except that a "use as is" disposition requires MMRB approval. Otherwise the material and data go to the Material Review Board for disposition. Corrective Action becomes part of the disposition and frequently requires changes in design specifications, manufacturing processes, manufacturing plans and/or quality assurance plans.

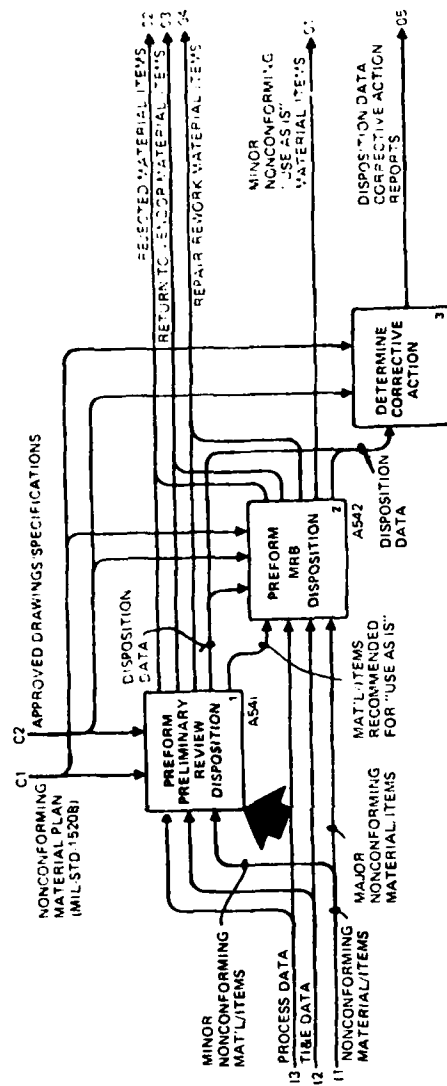




A Preliminary Review is made of minor nonconforming material. Dispositions authorized at Preliminary Review are:

- Rework to print
- Return to vendor
- Repair to approved standard procedure
- Scrap (reject)
- Refer to MRRB

When a disposition of repair or rework is made at Preliminary Review, rework instructions are provided and the material is released for rework or repair.

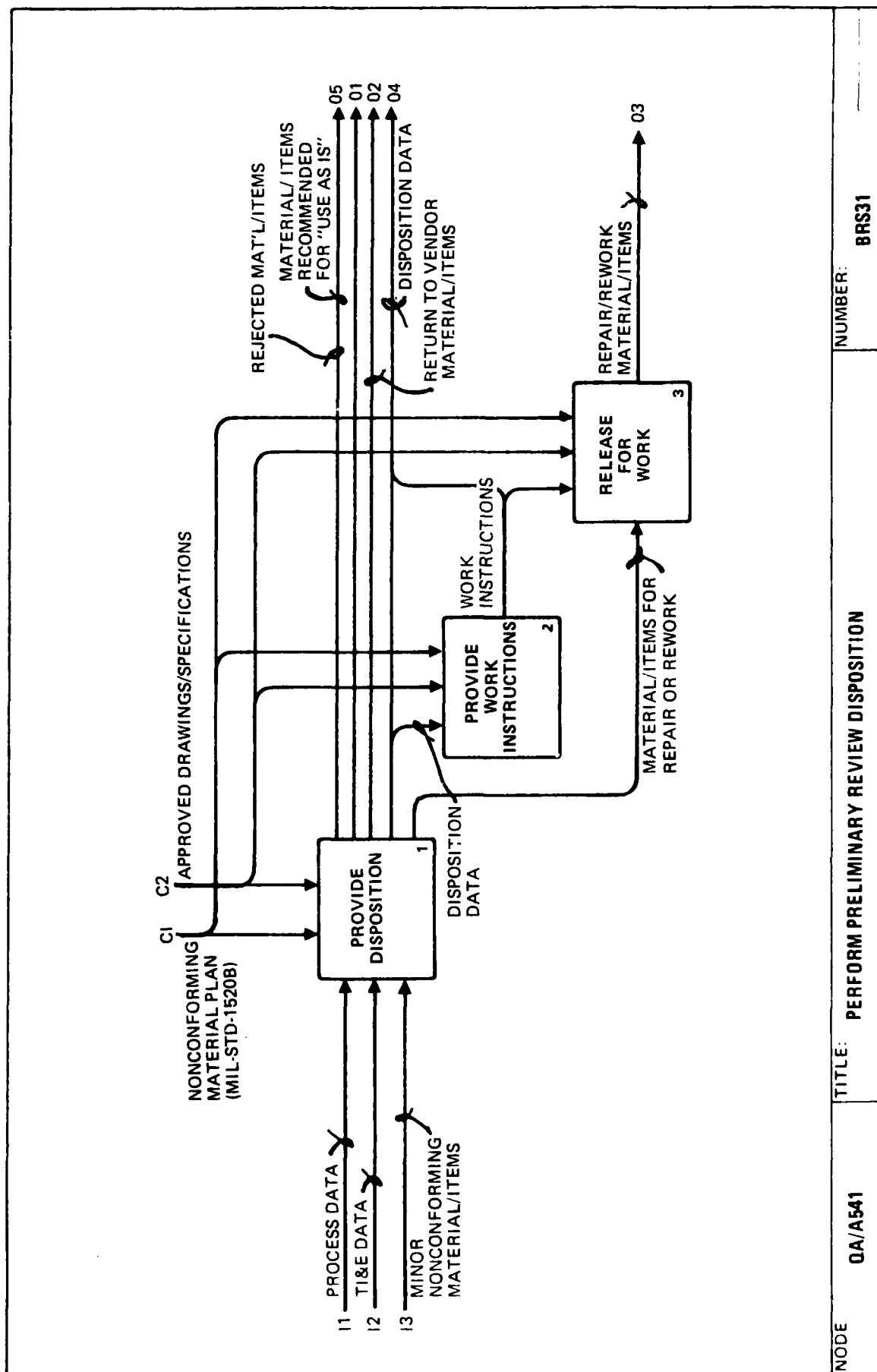


NODE	TITLE	NUMBER
QA/AS4	CONTROL NONCONFORMING MATERIAL	BRSS0

Minor Nonconformance

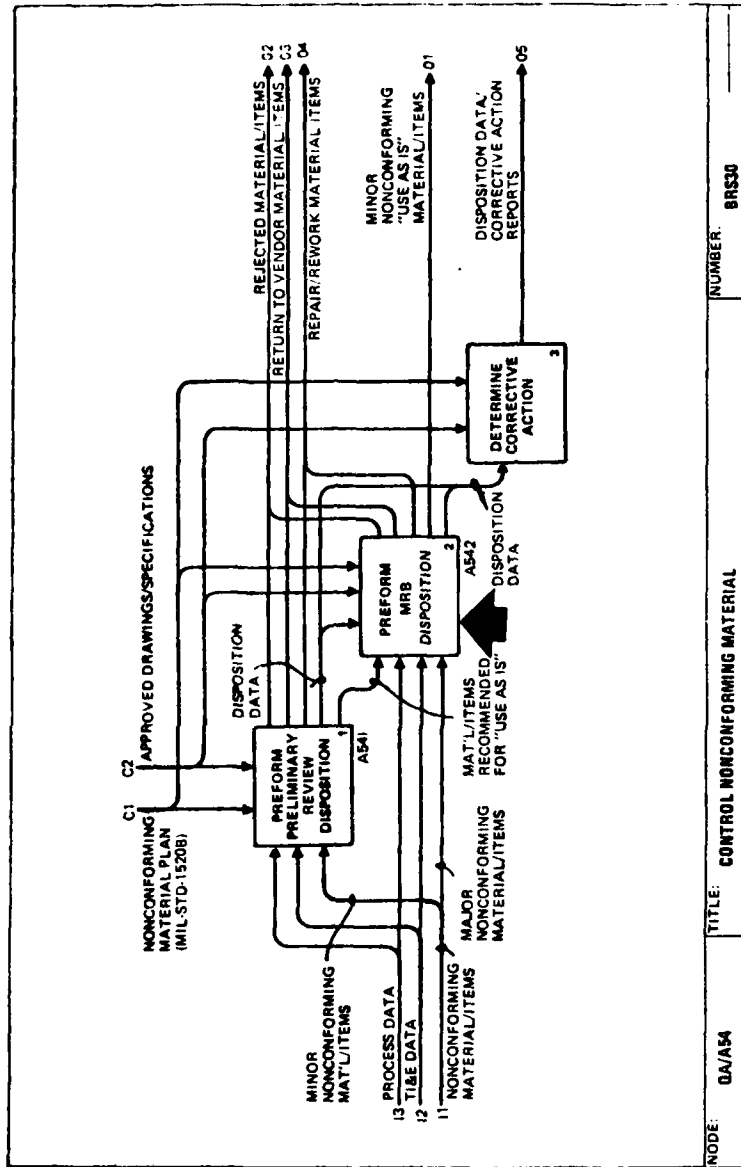
A nonconformance not adversely affecting:

- performance
- durability
- reliability
- interchangeability
- effective use or operation
- weight or appearance (where a factor)
- health or safety



A542 Perform MRB Disposition

Major nonconforming materials (parts or assemblies) are submitted to the Material Review Board (MRB) for disposition. Manufacturing Engineering and Quality (contractor representatives assigned to MRB) make an initial disposition. Repair/rework costs are then determined before obtaining final disposition approval from the customer (Air Force). Repair/rework instructions are provided with the material as it is sent out for repair/rework.



Glossary

Nonconforming Material Plan

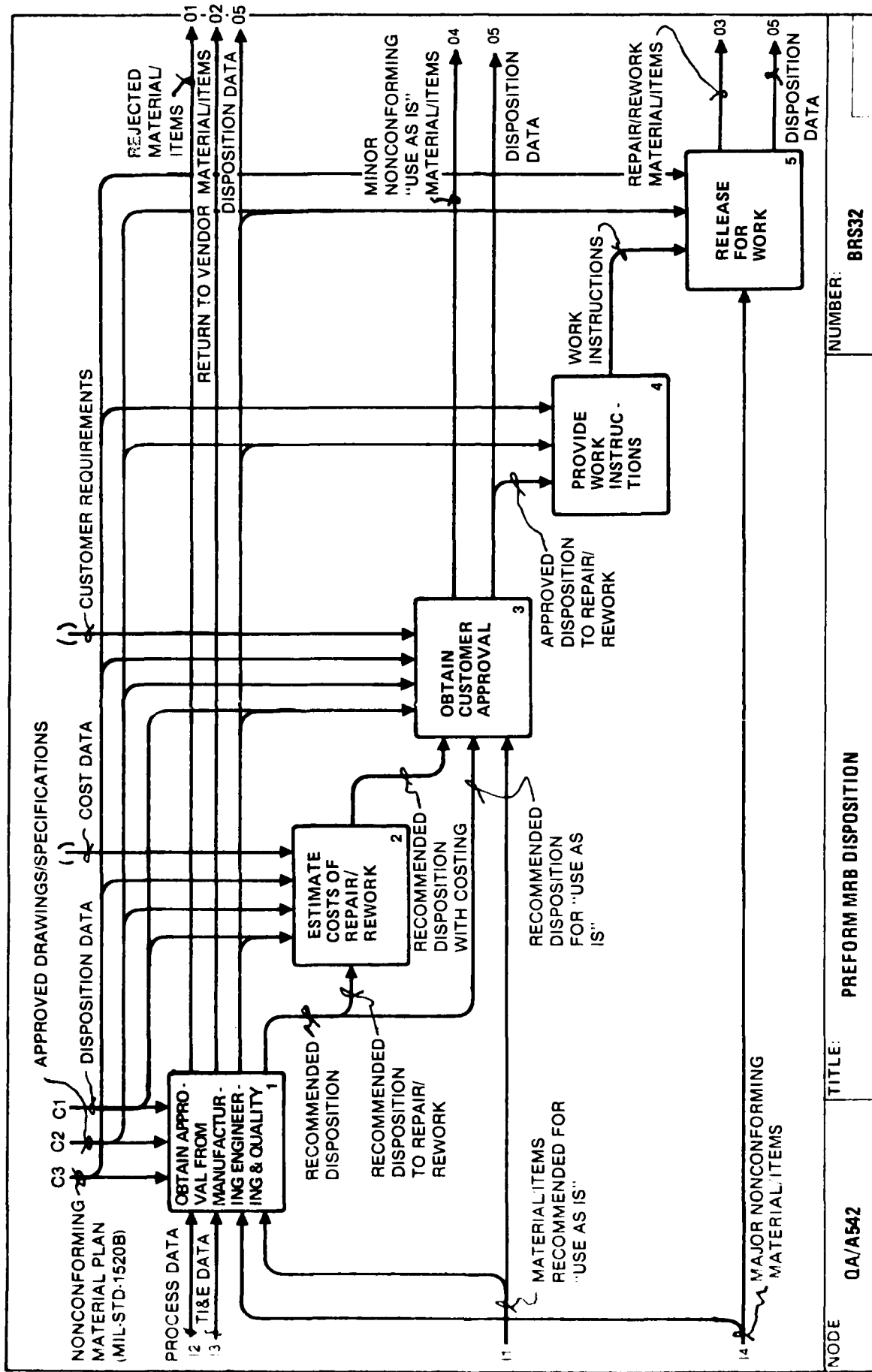
A plan, written in conformance to MIL-STD-1520B, which stipulates how the contractor will control nonconforming material, parts and assemblies.

Recommended Disposition with Costing

An action recommended by the Material Review Board with an estimate of the cost involved in completing the recommended action.

Major Nonconformance

A nonconformance which cannot be completely eliminated by rework or reduced to a minor nonconformance by repair.

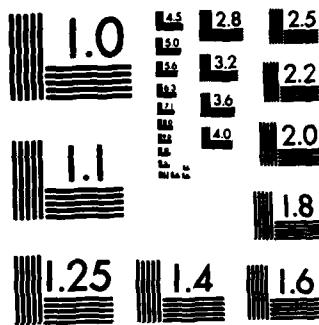


AD-A144 691 ICAM (INTEGRATED COMPUTER AIDED MANUFACTURING)
CONCEPTUAL DESIGN FOR COMP. (U) LTV AEROSPACE AND
DEFENSE CO DALLAS TX VUGHT AERO PRODUCTS D.
UNCLASSIFIED D L NORWOOD ET AL. JUN 84 2-20150/4R-2V014-5 F/G 13/8

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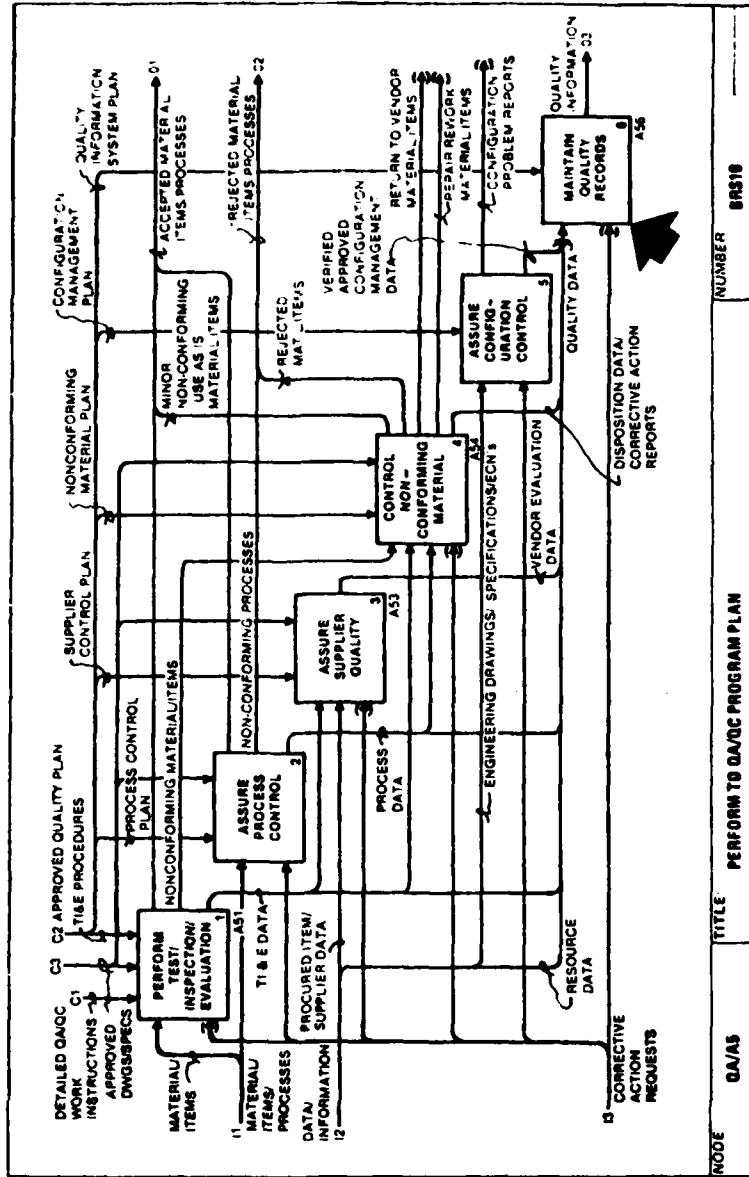
END



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

A56 Maintain Quality Records

Data required to assure product and process quality during manufacture as well as during use is collected, analyzed, displayed and preserved. This includes maintenance of the data required to assure compliance to military standards and specifications as well as additional data deemed necessary by the contractor to assure conformance to requirements.



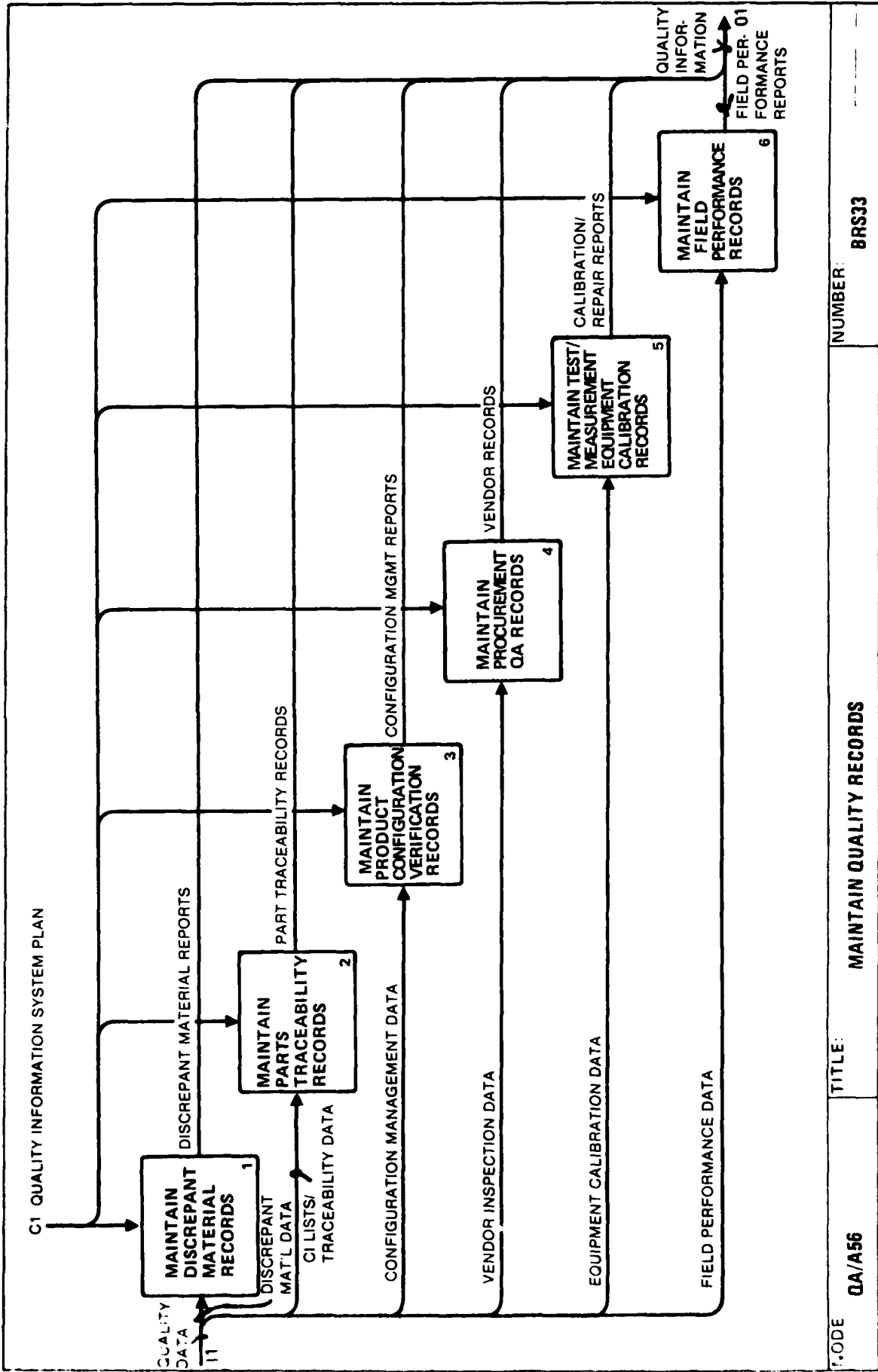
Glossary

CI Lists/Traceability Data

Data which tracks the source and processing of material/items by lot or part number.

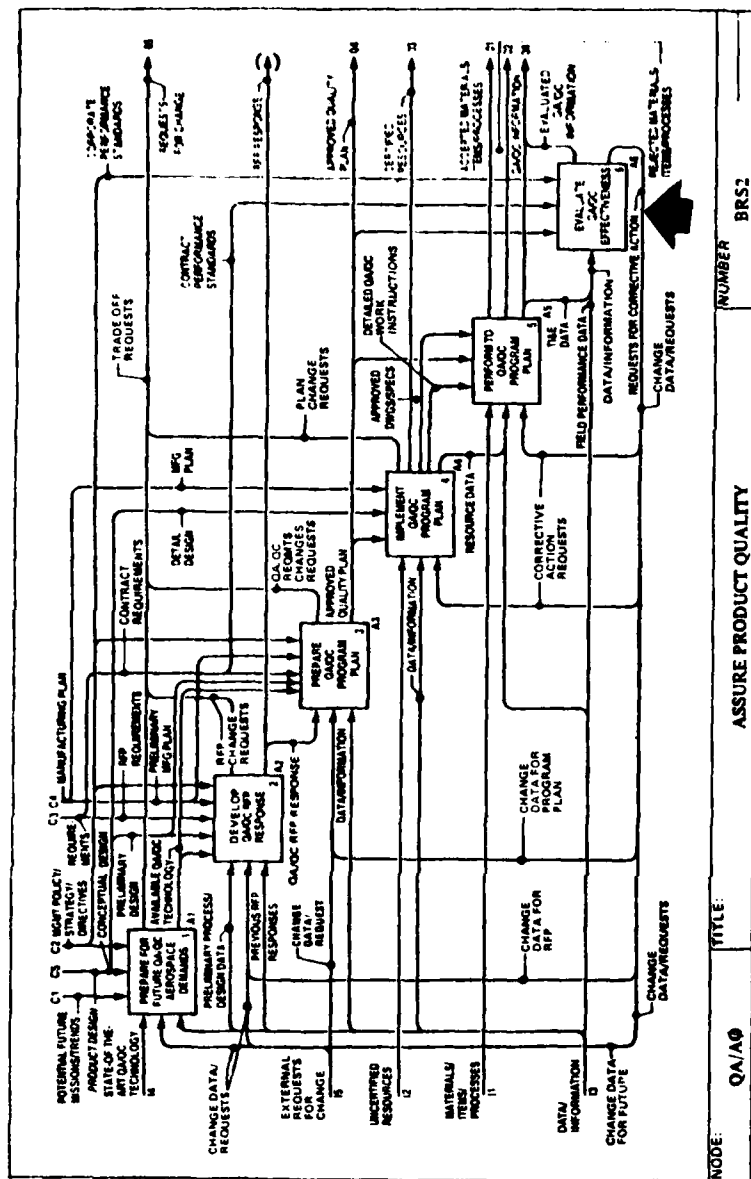
Equipment Calibration Data

Test/measurement equipment data such as calibration intervals, procedures and results including repair history.



A6 Evaluate QA/QC Effectiveness

A total assessment of the effectiveness of the QA/QC Plan is accomplished by reviewing contract requirements to establish a criteria for a test and inspection baseline against which all QA/QC audits are measured during the life of the contract. TI&E data is evaluated to determine necessary changes in manufacturing processes, inspection procedures or product configuration. Product performance reports from the customer and the contractor's field personnel provide data which is used to appraise the product performance against its design specification. This reliability and maintainability data is fed back to the contractor's Engineering and Manufacturing organizations for analysis and subsequent corrective action. An audit of QA/QC activities is provided so that Quality Assurance can assess its own performance in maintaining product quality requirements. The evaluation process takes inputs from both internal data (in terms of TI&E and audit data) and external, field performance data (reliability, maintainability, serviceability, etc.) and compares these results against Contract Performance Standards. Deviations can result in requests for corrective action.



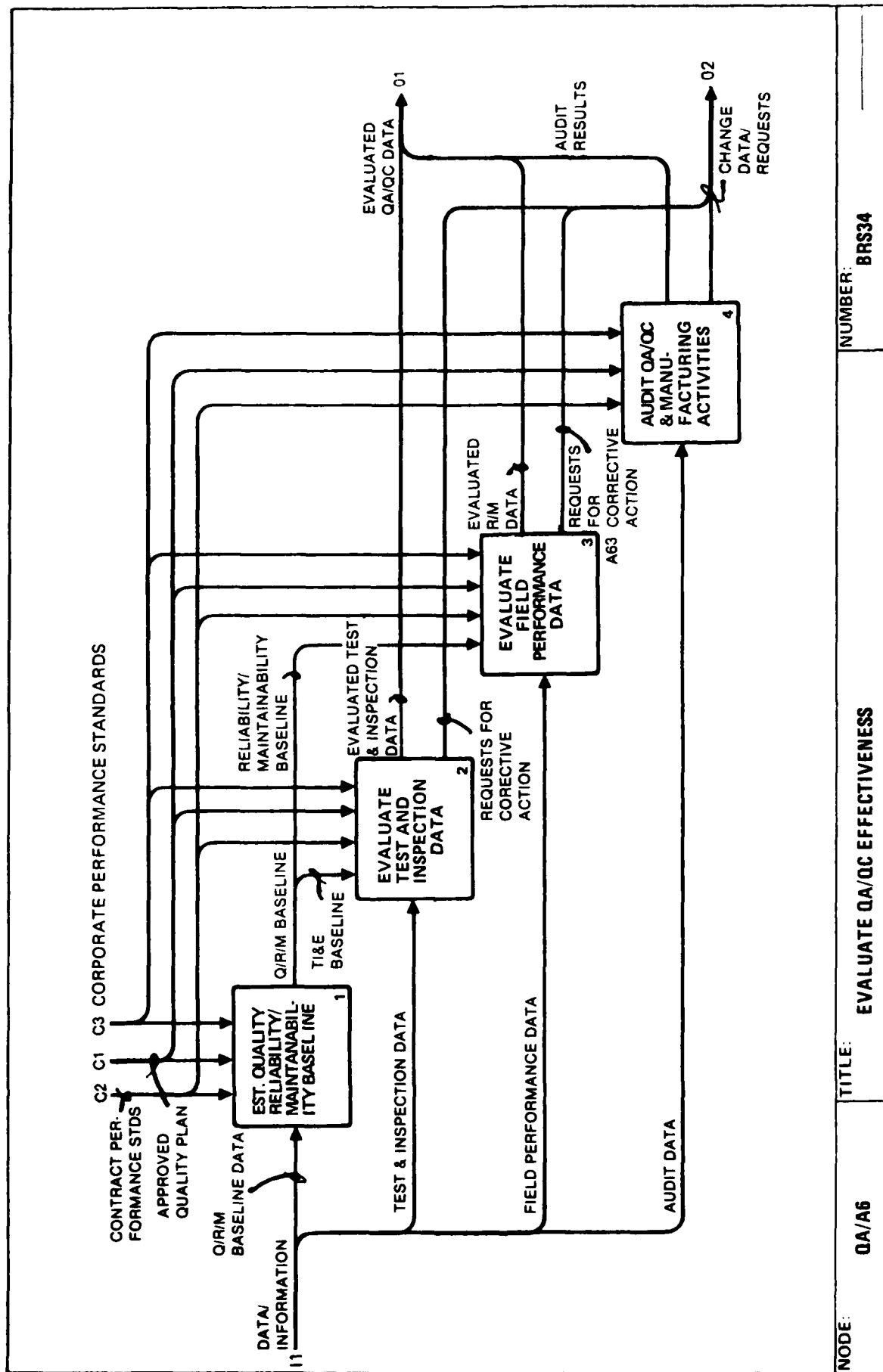
Glossary

Q/R/M Baseline

Established standards of acceptability for Quality, Reliability and Maintainability.

TI&E Baseline

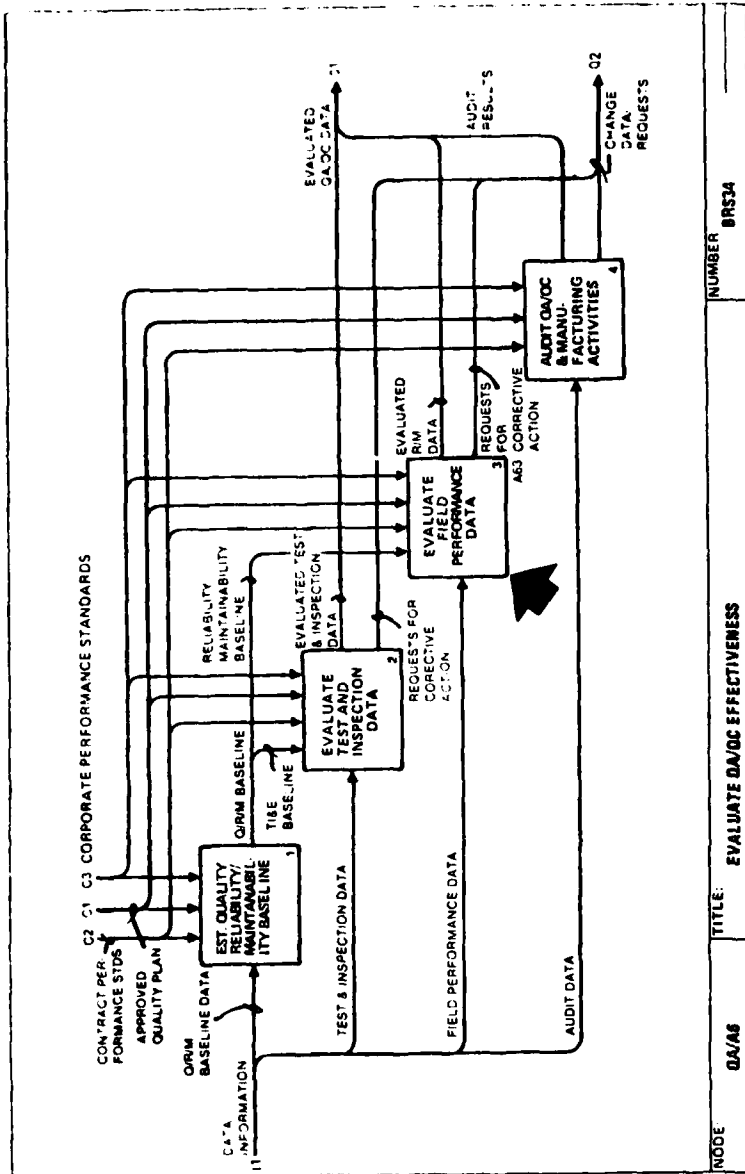
That portion of the Q/R/M baseline that pertains to the established standards for the Test, Inspection and Evaluation functions.



2-22031

A63 Evaluate Field Performance Data

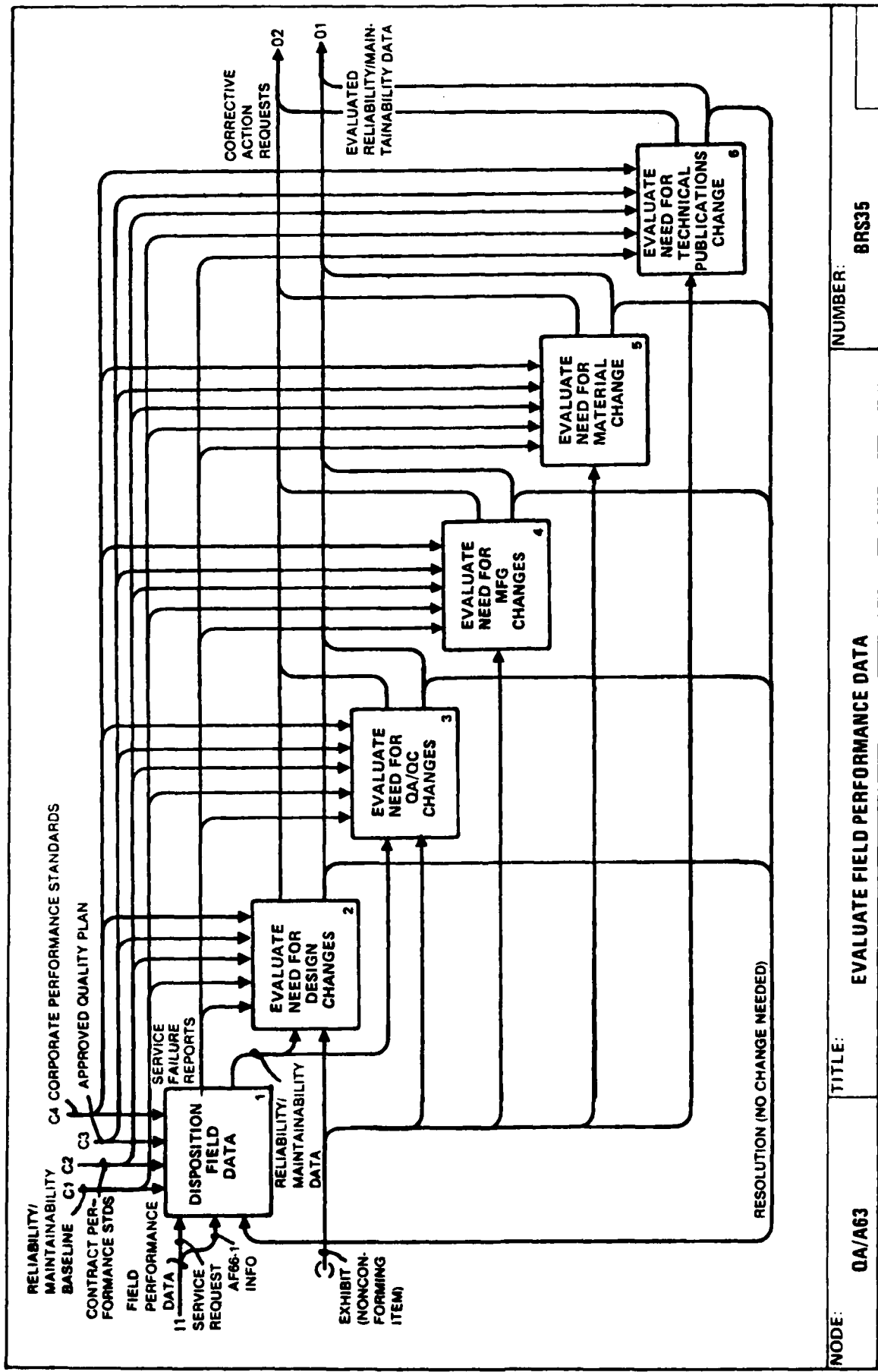
Field-generated quality failure data is collected and analyzed for probable cause. Evaluation of need for change by either Engineering, QA/QC, Manufacturing, materials or documentation result in requests for corrective action if appropriate. Resolution of the problem is reported in a Service Report.



Glossary

Service Failure Report

A report from the field describing a failure or a deficiency which requires the contractor to establish a corrective action plan to assure elimination of the problem.



NODE: QA/A63	TITLE: EVALUATE FIELD PERFORMANCE DATA	NUMBER: 8RS35
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2-22031

Section III

Information Model

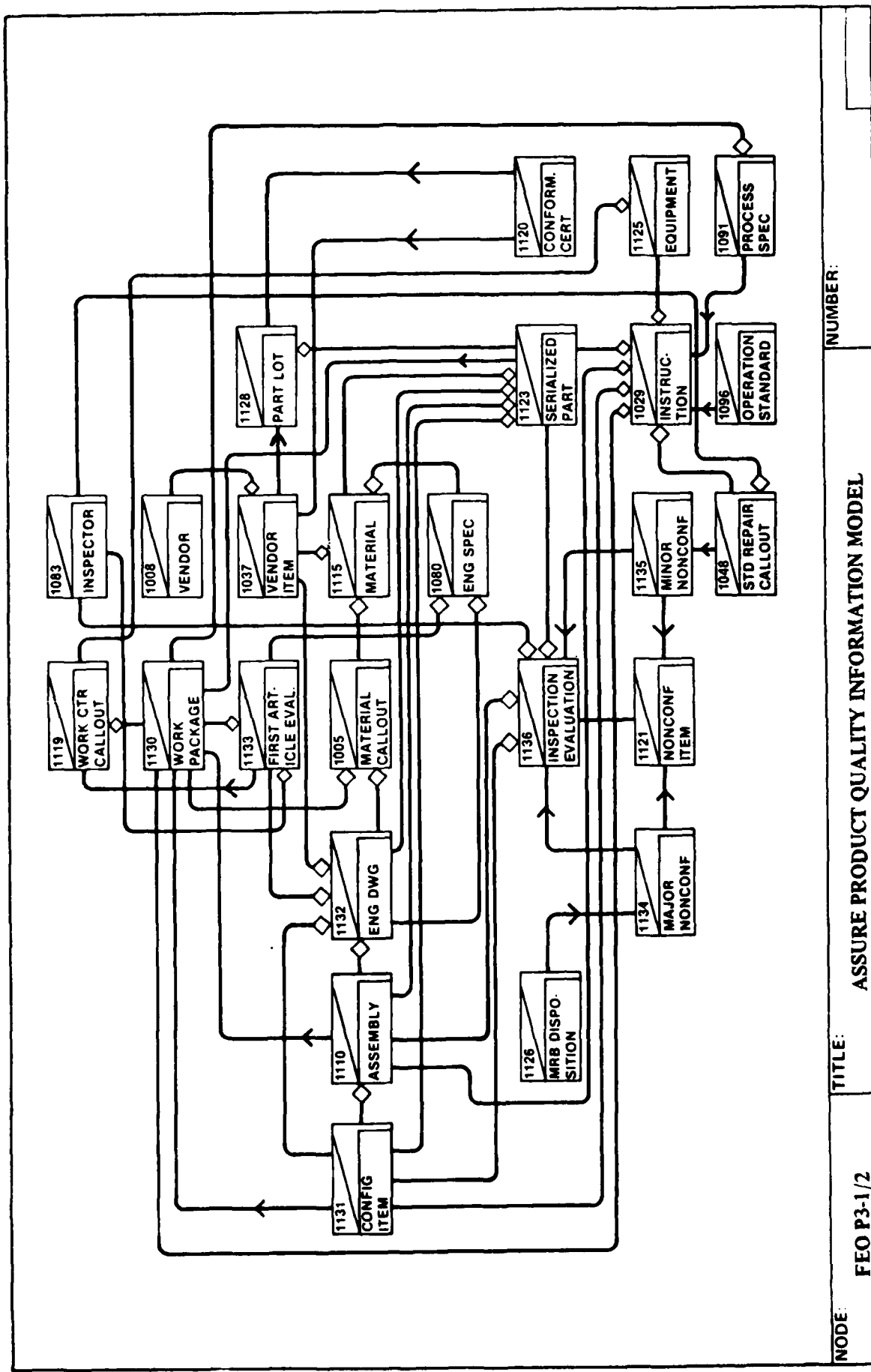
IDEF1

This last section contains an overview diagram of the Information Model (IDEF1) for *Assure Product Quality*. The purpose of the information model is to group information into classes and then show the relationship between classes of information.

This model includes six major activities directly associated with the manufacturing environment. They are:

- 1) Inspection Planning,
- 2) Process Control,
- 3) Inspection, Test and Evaluation,
- 4) Vendor Contact,
- 5) Material Control and
- 6) Material Review Board.

This information model is limited and does not include all the classes of information associated with QA/QC work activities. Despite its limitation, the model should prove useful as a start for developing a Quality Information data base.



NUMBER:

TITLE: ASSURE PRODUCT QUALITY INFORMATION MODEL

NODE:

FEO P3-1/2

END

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