NOT MEASUREMENT SENSITIVE

MIL-HDBK-115A(ARMY)
1 JUNE 2006
SUPERSEDING
MIL-HDBK-115(ME)
20 APRIL 1987

DEPARTMENT OF DEFENSE HANDBOOK

US ARMY
REVERSE ENGINEERING HANDBOOK
(GUIDELINES AND PROCEDURES)

This handbook is for guidance only.
Do not cite this document as a requirement.

AMSC N/A **AREA MISC**

FOREWORD

1. This handbook is approved for use by the Department of the Army and is available for use by all Departments and Agencies of the Department of Defense.

2. This handbook provides guidelines and procedures for reverse engineering, and can be employed by in-house personnel, engineering services contractors, and manufacturing contractors performing reverse engineering.

3. Comments, suggestions, or questions on this document should be addressed to Commander, US Army Aviation and Missile Command, ATTN: AMSRD-AMR-SE-TD-ST, Redstone Arsenal, AL 35898-5000 or emailed to Malinda.Allcorn@amrdec.army.mil. Since contact information may change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

CONTENTS

PARAGARAPH PAGE

PARAGARAPH PAGE

PARAGARAPH PAGE

PARAGARAPH PAGE

1. SCOPE

1.1 Scope. This HANDBOOK, which provides the guidelines and procedures for performing reverse engineering, was created using current applicable laws and knowledge gained during a trial program from July 1985 to April 1987, and is based on experiences obtained from military and industry participants. This handbook is for guidance only and cannot be cited as a requirement.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

INTERNATIONAL STANDARDIZATION AGREEMENTS (ISO)

ISO 10012-1	Equipment, Quality Assurance Requirements for Measuring – Part 1: Metrological Confirmation System for Measuring Equipment

MILITARY SPECIFICATIONS

MIL-E-2036	Enclosure for Electrical and Electronic Equipment, Naval Shipboard
MIL-DTL-31000	Technical Data Packages

FEDERAL STANDARDS

FED-STD-H28/18	Screw-thread Standards for Federal Services Section 19 Photographic Equipment Threads

MILITARY STANDARDS

MIL-STD-22	Welded Joint Design
MIL-STD-171	Finishing of Metal and Wood Surfaces

MIL-STD-1916	DoD Preferred Methods for Acceptance of Product

MILITARY HANDBOOKS

MIL-HDBK-1264	Radiographic Inspection for Soundness of Welds in Steel by Comparison to Graded ASTM E390 Reference Radiographs
MIL-HDBK-1265	Radiographic Inspection Classification and Soundness Requirements for Steel Castings

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein.

INDUSTRY STANDARDS

American National Standards Institute (ANSI)

ANSI B4.1	Preferred Limits and Fits for Cylindrical Parts
AWS A2.4	Standard Symbols for Welding, Brazing, and Non-destructive Examination
AWS A3.0	Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying

AWS C3.4	Torch Brazing
AWS C3.5	Brazing, Induction
AWS C3.6	Furnace Brazing
AWS C3.7	Aluminum Brazing, Specification for
NCSL-Z540.1	Laboratories, Calibration, and Measuring Test Equipment

(Copies of these documents are available online at http://www.ansi.org or by contacting the American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036-7417.)

American Society for Testing Materials (ASTM)

ASTM E125	Castings, Magnetic Particle Indication on Ferrous
ASTM E1444	Particle Testing, Magnetic
ASTM E1742	Radiographic Examination

(Copies of these documents are available online at http://www.ansi.org or by contacting the American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036-7417.)

Society of Automotive Engineers (SAE) Aerospace Material Specification (AMS)

SAE-AMS-H-6088	Heat Treatment of Aluminum Alloys
SAE-AMS-H-6875	Heat Treatment of Steel Raw Materials
SAE-AMS2175	Classification and Inspection of Casting

SAE-AMS2644	Inspection Material, Penetrant

(Copies of these documents are available online at http://www.sae.org or by contacting the Society of Automotive Engineers World Headquarters, 400 Commonwealth Drive, Warrendale, PA 16096-0001.)

American Society of Mechanical Engineers (ASME)

ASME Y14.5M	Dimensioning and Tolerancing
ASME Y14.24	Types and Applications of Engineering Drawings
ASME Y14.34M	Associated Lists
ASME Y14.100	Engineering Drawing Practices

(Copies of these documents are available online at http://www.asme.org or by contacting the American Society of Mechanical Engineers, P.O. Box 2300, Fairfield, NJ 07007-2300.)

National Aerospace Standards

NAS 410	NAS Certification and Qualification of Non-destructive Test Personnel

(Copies of these documents are available online at http://www.nist.org or by contacting the National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070.)

2.4 Order of precedence. In the event a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Applicable definitions. This section is not applicable to this handbook.

4. GENERAL GUIDANCE

4.1 Background. Defense contractors who supply systems, equipment and spare parts during the initial production phase of a weapon system acquisition in which they have performed in the development, frequently become the “sole-source” for follow-on procurements. The cost of items procured under these sole source conditions are sometimes inflated beyond their true value. Consequently, procurement costs for spare parts consume an increasingly larger share of the defense dollar. Recent emphasis on the prices paid for spare parts dictates the need for competition. Congress and the Department of Defense (DOD) directed the military services to increase competition in an effort to reduce the cost of spare parts. The Defense Acquisition Regulation Supplement No. 6 (DAR-S6), dated 1 June 1983, titled: DOD Replenishment Parts Breakout Program (see 4.3), was promulgated to encourage competition and reduce restrictive features which limit competitive procurement.

4.2 Rationale. One method of controlling the high costs of replenishment spares is by reverse engineering. Reverse engineering is the process of duplicating an item, functionally and dimensionally, by physically examining and measuring existing parts to develop the technical data (physical and material characteristics) required for competitive procurement. The reverse engineering process may be performed on specific items which are currently purchased sole-source. This may be due to limited data rights, in inadequate TDP, a diminished or non-existent source of supply, or as part of a Product Improvement Program (PIP). Normally, reverse engineering will not be cost effective unless the items under consideration are of a high dollar value or are procured in large quantities. Such items may be reverse engineered if an economical savings over their acquisition life cycle is demonstrated, and if other methods of acquiring the necessary technical data for competitive reprocurement are either more costly or not available.

TO BE A CANDIDATE FOR REVERSE ENGINEERING ALL OTHER EFFORTS TO OBTAIN DATA MUST BE EXHAUSTED.

4.3 DOD replenishment parts breakout program – DAR-S6. This paragraph is included in this handbook to emphasize the importance of exhausting all possible sources of data acquisition before considering reverse engineering. The objective of the breakout program is to reduce costs by breakout of parts for purchase from other than prime contractors, while maintaining the integrity of the systems and equipment in which the parts are to be used. The acquisition method code/acquisition method suffix code (AMC/AMSC) indicates the competitive status of the part and defines the various encumbrances to competitive procurement. Examples of encumbrances are inadequate, missing, or restricted data; source control; or

annual buy value (ABV) less than $10,000 or a dollar amount set by current requirements. Upon completion of the breakout screening and coding process, candidates for reverse engineering are identified as items which have been assigned a competition-restrictive AMC/AMSC code based on unavailable technical data. Spare parts with AMC/AMSC codes which are in a suspended status (pending further investigation, resolution, or recoding) should not be considered as candidates for reverse engineering until the breakout process has been completed. Candidates may also be recommended for breakout when the item demonstrates a 25% increase in unit price over the previous year. Regardless of AMC/AMSC codes and unit price, when a part cannot be procured but is mission critical, all efforts must be made to obtain the spare part. This may include reverse engineering even when it is uneconomical. Appendix A provides a listing of the AMC/AMSC codes and definitions, and is included for information purposes.

4.4 Data rights. Reverse engineering is a LEGAL and ETHICAL method of design replication

4.4.1 Proper use. Reverse engineering is deemed proper when:

a. The procurement contract does not contain any clauses prohibiting reverse engineering, either specifically or by implication;

b. The organization performing the reverse engineering effort is supplied with the candidate and only with data which is in the public domain;

c. The engineers and technicians involved in examination of the part or preparation of drawings do not have access to proprietary data;

d. The organization performing the reverse engineering efforts does not have any employees who were recently employed by the manufacturer of the part, and those examining the item must not have had access to proprietary data; and

e. Visits to the manufacturer’s plant are not made by any personnel involved in the actual performance of reverse engineering.

4.4.2 Data screening. All documentation delivered for reverse engineering purposes must be carefully screened by the Government/Tasking Agency prior to delivery, to ensure that no restricted or proprietary data is included. Any additional data subsequently requested by reverse engineering personnel from sole-source or prime vendors must be delivered via the Government/Tasking Agency to preclude inadvertent access to restricted or proprietary data. The technical data developed through reverse engineering should be delivered to the Government with “unlimited rights.” When a subassembly has been reverse engineered and one or more pieces within the

subassembly remain sole source for economic or other reasons, it/they remain as limited rights piece(s). Unauthorized disclosure or access to proprietary data for competitive procurement purposes disqualifies the candidate from reverse engineering. In the case where the reverse engineering effort is performed by contractor support, if the contractor gains access to restricted data concerning a specific candidate, the contractor is liable if he performs reverse engineering function for that candidate. However, the Government may select a different contractor who has not had access to the restricted data to perform the reverse engineering function for the candidate in question.

4.4.3 Formal authorization. Reverse engineering candidates with existing patents require formal Government authorization for the contractor to reverse engineer such items (including piece-parts or components). This formal authorization must include the official (dated) 'Authorization and Consent' clause (see Appendix B).

4.4.4 Patent restrictions. Reverse engineering candidates with "Patents Pending" or "Patents Applied For" also require formal Government authorization for the contractor to reverse engineer such items (See 'Authorization and Consent' clause – Appendix B). Patent restrictions are of no force and effect until a patent is actually issued, and many patents take years to be formally issued. Each case should be individually examined with respect to patent status. Appendix B provides detailed information concerning data rights and includes samples of valid restrictive or proprietary legends.

5. DETAILED GUIDANCE

5.1 The reverse engineering process.

5.1.1 Primary objective. The primary objective of reverse engineering is the development of unrestricted technical data, adequate for competitive procurement, through engineering evaluations of existing hardware. The nominal reverse engineering process is depicted in Figure 1. Detailed procedures are described in Subsections 5.2 through 5.43. In Process Reviews (IPRs) should be performed at the end of each principal phase of the reverse engineering process (see Figure 1) to assure compliance to the process and to evaluate the need for continuing reverse engineering on the item.

a Functional/economic analysis (see 5.2) should be completed to collect available documentation, determine missing data requirements, determine testing requirements, and develop the Reverse Engineering Cost-Estimates and Schedules;

b. A disassembly procedure (see 5.16) should be completed for each candidate to ensure functional integrity is maintained to allow for a viable analysis and documentation;

c. A reverse engineering management plan (see 5.19) should be completed for each candidate to ensure a logical sequence of events to prevent delays or misinterpretations in the overall program objectives;

d. A hardware analysis (see 5.20) should be performed to develop the missing data required for Level 3 drawings;

e. Level 3 drawings (see 5.25) are the result of the reverse engineering process and contain the documented parameters necessary to reproduce the selected candidate;

f. A quality control study (see 5.27) should be performed and documented on the Level 3 drawings and prototypes of candidates to certify their compliance with original candidate specifications;

g. A production review (see 5.31) should be performed to determine the economics of production of the reverse engineered item;

h. Prototype production (see 5.36) involves the manufacture and testing of prototypes to determine if they meet all required specifications; and

i. A finalized TDP (see 5.43) should be formulated and delivered to the Government/Tasking Agency requesting the reverse engineering of the candidate item.

5.1.2 Recommended changes. As a result of the reverse engineering effort, product improvements or value engineering changes may be recommended (see 5.46). These alternatives may be considered during the reverse engineering process and may be incorporated prior to completion of the process.

5.2 Functional/economic analysis. A Functional/Economic Analysis should be accomplished to collect available documentation, determine missing data requirements, determine testing requirements, and develop the reverse engineering cost-estimates and schedules.

5.3 Data collection.

5.3.1 Documentation. A competitive TDP should include all the documentation necessary to describe the design configuration, manufacturing, quality assurance, testing, and packaging requirements of the equipment. The TDP for a reverse engineering candidate may include restricted or inadequate end-item documentation and drawings which must be developed through engineering analyses of existing hardware.

5.3.2 Data collection phase. The purpose of the Data Collection phase is to secure all the unrestricted documentation available, to preclude unnecessary duplication and to facilitate the development of technical documentation through reverse engineering. The following data is desirable:

a. Next higher assembly, which provides information on input/output parameters, mating parts, end-use, etc;

b. Specifications, such as Test Specifications; Acceptance Test Procedures, Purchase Descriptions, etc;

c. Parts list/data list, which identifies all parts and indicates if they are standard National Stock Numbers (NSNs), Military Standard (MIL-STD) parts, etc. The Data List should indicate the applicable drawings and specifications necessary and provide valuable information on specifications that should be researched to remove restrictive requirements;

d. Schematics, which provide basic information for the Physical Configuration Audit (PCA), verify the parts list, and save time in tracing circuitry (i.e., Printed Circuit Board (PCB) wiring);

e. Master pattern drawings, which provide copies of the mylars, saving both time and the cost of re-drafting; and

f. Next lower assembly, which identifies interfaces, input/output parameters, mating parts, etc.

5.4 Alternate data sources

5.4.1 Typical documentation. Some of the technical documentation used for reverse engineering may be obtained from the Configuration Management System, Engineering/Readiness Commands, Item Managers, Procurement Officers, Data Repositories, or Vendors/Manufacturers. Some of the more typical documentation might be:

a. System technical manual

b. Operation/maintenance manual

c. Illustrated parts breakdown

d. Maintenance allocation chart

e. Next higher assembly drawing

f. Lower assembly drawing

g. Part drawings

h. Qualified parts list

i. System test requirements

j. Where-used data

k. Commercial catalogs/sales brochures

5.4.2 Verbal input. For reverse engineering candidates with unavailable or inadequate technical data, as much verbal input as possible should be obtained to define application and end-use. This will help to establish the specifications of input/output parameters; identify critical items which may call for additional test criteria over/beyond standard military or NSN specifications, and which may be called out on Selected Item Drawings; or help in performing analysis to define criteria.

5.4.3. Technical manuals. When technical manuals are necessary, they may be requested from: Commander, USAMC Logistics Support Activity, Attn: AMXLS-AP, Redstone Arsenal, AL 35898-7466.

5.4.4. Command sources of information. The cognizant command for the item should be determined, and if technical manuals are not available, the following major subordinate command may be contacted for information, as applicable:

Commander,
U.S. Army Edgewood Chemical Biological Center
Attn: AMSRD-ECB-ENA-S, E3331
5183 Blackhawk Road
Aberdeen Proving Ground, MD 21010-5424

Commander,
Aviation and Missile Research, Development, and Engineering Center,
Attn: AMSRD-AMR-SE-TD-ST
5400 Fowler Road
Redstone Arsenal, AL 35898-5000

Commander,
US Army Communications-Electronics Command
Attn: AMSEL-LC-LEO-E-EP
Fort Monmouth, New Jersey 07703-5023

Commander,
US Army TACOM-ARDEC
Attn: AMSRD-AAR-AIC-S
Picatinny, NJ 07806-5000

Commander
US Army TACOM-TARDEC
Attn: AMSRD-TAR-E/ESA, MS 268
6501 East 11 Mile Road
Warren, MI 48397-5000

5.5 Screening of requested documentation. All requested technical documentation must be delivered via the Government/Tasking Agency, for screening, to exclude any restricted or proprietary data. The unrestricted documentation may be reviewed for pertinent data such as design specifications and drawings; parts lists; form, fit and function; next higher and lower assemblies; pertinent military/DoD specifications and standards; etc. (See Appendix E.)

5.6 Candidate File. A candidate file should be established, to include all the technical documentation collected, as well as the records, findings, and results of the reverse engineering procedures performed throughout the process.

5.7 Data evaluation. The purpose of the data evaluation phase is to identify the missing data required, develop the Reverse Engineering Cost-Estimates and Schedules, and establish an economic point of diminishing returns for re-evaluation of the effort throughout the reverse engineering process. The objective of this phase is to review the documentation so that the tasks necessary to complete the TDP may be itemized and scheduled.

5.8 Missing data required.

5.8.1 Identify missing data. The available documentation should be reviewed to determine the technical data provided and to identify the missing data required. You may assume that, unless specific missing data is requested, it may not be included in the documentation provided to you.

5.8.2 Technical documentation. The following technical documentation may help to facilitate the process and lower the reverse engineering costs:

a. Engineering drawings

b. Engineering specifications

c. Schematics

d. Wiring diagrams

e. Parts lists

f. Applicable military standards and specifications

g. Illustrated parts breakdowns

h. Manufacturing instruction sheets

i. Purchase descriptions

j. Quality assurance provisions

k. Acceptance test procedures

l. Test specifications

m. Test equipment/fixtures

n. Pertinent engineering changes/revisions

o. Next higher assembly drawings

p. Lower assembly drawings

5.8.3 Data evaluation considerations. The data evaluation sub-phase should answer the following questions:

a. Are all required manufacturing materials specified in the bill of materials, notes, military or process specifications, or elsewhere within the applicable data? (Any deletions or omissions should be specified.)

b. Are all parts completely dimensioned or otherwise fully defined? (Any deletions or omissions should be specified.)

c. Are all processes, finishes, material specifications, and other necessary elements noted in the data? (Any deletions or omissions should be specified. Notes should be made of any conflicting information or potential errors in the data.)

d. Does the data indicate that the item or components thereof are “Source Controlled,” “Altered Item,” “Selected Item,” or otherwise source restricted? (If so, the applicable restriction and the source(s) should be

identified.) Are acceptance test requirements noted? (If so, such requirements should be identified.)

e. Are all inspection requirements which would be required by normal industry engineering practices noted in the available data; such as dye penetrant, hardness tests, etc? (If not, the type of missing information should be identified.)

f. Does the data indicate that the part is critical or has critical characteristics? If so, are the critical characteristics identified and defined? (The findings should be summarized.)

g. Does the manufacture of the item require a loft or contour drawing? If so, is the drawing identified or the required contour adequately described? (If contour or loft drawings are required for manufacture of the item, but are not contained within the data, this fact should be noted.)

h. Is the part made from a forging or casting? If so, are the forging or casting drawing numbers set forth in the data? (If the casting or forging drawings are available, they should be included in the package. The absence of necessary forging or casting drawings should be noted in the evaluation. Whether the available data restricts forging or casting sources to particular firms should also be noted.)

i. If the part is to mate with other parts, such as hole patterns, are the mating parts identified in the data? (If not, a note should be included concerning the absence of such information.)

j. Does the manufacture of the item require the use of master or coordinated tooling? If so, is the master or coordinated tooling identified in the data? (The use of jigs or fixtures to ease manufacture or assembly should not be considered master tooling.)

k. Can a military or Federal specification or standard, or more preferably an industry standard, be substituted for the prime contractor's specification or standard set forth in the data? (If so, the applicable potential substitution should be noted.)

l. Is proprietary data necessary to manufacture the part? (If so, the absence of the data should be noted and identification made of the proprietary data to the extent possible, based on the unrestricted data available.)

5.8.4 Data call sheet. A data call sheet should be generated (figure 2) and included in the candidate file.

5.9 Hardware required. It is important that adequate hardware be available as early as possible to develop the necessary data through reverse engineering. The number of parts required varies greatly with the complexity of the part and the testing requirements. The quantity of hardware required for reverse engineering should be determined depending upon complexity and risk assessment. Consideration should be given to the possible destruction of an item during disassembly and material analysis. Whenever possible, only new items from inventory should be used as it is difficult to establish performance criteria or tolerances on used parts. The use of new items from inventory precludes the reverse engineering process from resulting in an unsuitable part, due to existing defects. It may be necessary at times, to obtain the hardware from other sources such as field units or commercially available items direct from the vendor.

5.10 Test requirements.

5.10.1 Initial inspection. The test requirements to be determined include initial inspection and testing of the hardware provided for reversing engineering, and for inspection and acceptance of the prototype to be built and tested in accordance with the preliminary TDP. Special testing and test equipment/fixture requirements should be identified and a test plan developed.

5.10.2 Test plan objective. The objective of the test plan is to verify adherence to the requirements delineated in the applicable specifications and standards, including verification of performance, determination of reliability and endurance, and verification of structural integrity.

5.10.3 Worse-case analysis. If the available documentation lacks sufficient test data, a worse-case analysis should be performed to develop testing criteria and procedures, including critical failure modes and limitations. Experts in the field should be contacted to identify common failure areas. The tests for item failure limits, such as overload, fatigue, vibration, and temperature, are the most convincing means of ensuring equivalence of manufacture. The Acceptance Test Procedures should define these requirements and specify the test procedures in accordance with the applicable specifications and standards. A sample Test Plan Format is provided in figure 3.

5.11 Reverse engineering cost-estimate and schedule.

5.11.1 Review. Cost estimates and schedules previously generated should be reviewed. Most of these estimates were based on a best guess, at the time, without benefit of hardware availability.

5.11.2 Development. The Reverse Engineering Cost-Estimate and Schedule should be based on the complexity of the item and the number of

piece-parts/components involved. The total effort involved is dependent upon the technical data available versus the amount of data to be developed.

5.11.3 Sample cost-estimate guide. A sample Cost-Estimating Guide is provided in figure 4. These are only guidelines and most data was derived during the trial program; however, the estimates for drawing preparation, producibility studies and quality control reviews are based on years of experience.

5.11.4 Prototype values. The Reverse Engineering Cost-Estimate and Milestone Chart should be developed and included in the Candidate File. The values for prototype production and testing may be estimated at this time, and revised later in the process when actual bids are received from the manufacturers.

5.11.5 Dollar values. A dollar value for a point of diminishing returns should be established and the estimated cost to complete should be monitored throughout the process. The TDP preparation costs should not change significantly, however, as tolerances are developed and tooling requirements identified, they may affect the cost of reverse engineering.

5.12 Disassembly procedures. Disassembly procedures should be developed for each candidate to ensure functional integrity and to allow for a viable analysis for documentation. The pertinent data obtained as a result of the disassembly procedures should be included in the candidate file.

5.13 Initial inspection and testing.

5.13.1 Post-shipment inspection. To preclude the replication of defects, the hardware provided for reverse engineering should be inspected for possible damage in shipment. The necessary documentation for control of Government Furnished Equipment (GFE), i.e., Damage Reports or Failed Item Reports (Form DD-1149), should be generated as required. An initial operating test should be performed to ensure the item functions in accordance with established performance specifications.

5.13.2 Pre-disassembly photographs. The hardware should be photographed prior to and during disassembly since, in some cases, no other record of the item exists. In addition, since the piece-parts will be identified by bagging and tagging, their position in the assembly should be noted.

5.14 Physical configuration audit (PCA)

5.14.1 Formal examination. The PCA is the formal examination of the as-built version of a configuration item against its technical documentation in order to establish the configuration item’s product baseline. A Functional

Configuration Audit (FCA) should be conducted to ensure the item performs in accordance with established performance specifications.

5.14.2 Hardware/documentation comparison. The hardware provided for reverse engineering should be examined against the unrestricted technical documentation available, such as manuals, drawings, specifications, etc., to ensure the hardware is accurately reflected by the documentation. The hardware should be compared for uniformity of components, particularly fabricated parts. In the event that discrepancies or inconsistencies are discovered, the hardware should take precedence over the existing documentation for reverse engineering purposes, and all discrepancies should be reported to the cognizant command. Often electronic assemblies will use components of a higher reliability class and a decision will be required on which takes precedence, the hardware or the existing documentation. This should be done by the project engineer familiar with the initial testing of the item during the acquisition cycle.

5.15 Initial measurements. Prior to disassembly, all dimensions and electronic data should be recorded, such as input/output parameters, clearances, torque values, and assembly critical dimensions that would be unobtainable after disassembly. On PCBs in particular, “pads” or other information may be destroyed during disassembly. The measurements should be taken on all moving parts and their working envelope, including rotation angles, clearances between close tolerances, and non-critical dimensions.

5.16 Disassembly.

5.16.1 Record keeping. When disassembling the hardware, notes should be recorded for possible assembly procedures to be included in the TDP. As they are disassembled, a list of all piece-parts/components should be created, including quantities and special part markings which may indicate that the part is either commercially available or a military specifications part. A layout of the parts, marked with the assembly sequence, may be useful for creating the assembly drawing and for reassembly of the item.

5.16.2 Parts control. During disassembly, each piece-part/component (bagged and tagged) should be identified to facilitate control of parts. Each piece-part/component should be examined to determine any markings which could identify the actual manufacturer, i.e., trademark, FSCM (federal supply code for manufacturers) number, manufacturer’s name, part number, patent mark, mold mark, etc. Where lubricant is applied, look for markings on the grease fittings which may indicate the lube oil requirements. Samples of the grease or lubricant should be taken for future identification prior cleaning the disassembled parts.

5.16.3 Terminal/pin markings. When disassembling electrical assemblies, all terminal markings should be reviewed. If the terminal and pin location or FROM-TO data is not stamped on the wires, each end should be clearly marked and a wire-run list should be created. The photographs with all plug and terminal designations should also be clearly marked.

5.16.4 Inseparable assemblies. Items that are not bonded, welded, or otherwise permanently joined should be treated as an inseparable assembly. Destructive disassembly may not be required. If possible, all non-destructive testing of hardware should be performed prior to destructive testing.

5.17 Parts identification/screening.

5.17.1 Identification. After disassembly each piece-part/component should be researched to identify existing NSNs, commercially available hardware, MIL-STD parts, and non-standard parts.

5.17.2 Economic analysis. An economic analysis should be performed on all sole-source and non-standard piece-parts/components to determine the cost-effectiveness of reverse engineering the piece-part/component. A limited screening process to DAR-S6 should also be performed on these components. All data supplied by the component manufacturer should be properly screened for proprietary data prior to providing it to the agency/contractor performing the reverse engineering. This is discussed in depth in the Data Rights section of this handbook (see. 4.4).

5.17.3 Document research. Research concerning the existence of specifications or source control drawings should be conducted. A similar item drawing could exist and a simple tabulation drawing could be re-created to add the new part to the system. Most configuration control systems include a listing of parts and related drawings.

5.17.4 Master Cross Reference List (MCRL). A search may be made via a MCRL to screen the pertinent nomenclature and part number. The MCRL accesses the Technical Logistics Reference Network data bases which provide the exchange of technical information on parts and components, as follows:

a. Enables identification and location of components, sub-assemblies, and assemblies which are already used and supported in the Federal Supply System;

b. Identifies components and piece-parts having multiple uses across different systems and Services;

c. Allows searches by technical characteristics;

d. Identifies like-items used by all the Services; and

e. Identifies alternate manufacturers.

5.17. 5 Government-Industry Data Exchange Program (GIDEP).

5.17.5.1 Identify sources. The GIDEP may be researched for additional information to identify items which could be included in a list of diminishing manufacturing sources or supply. The GIDEP may also be used to determine which off-the-shelf items and parts are out of production, which items have low reliability, and which items can be successfully competed in lieu of sole-source procurement. The GIDEP provides additional data, such as:

a. Metrology data,

b. Engineering study reports,

c. Failure analysis data,

d. Dimension source data, and

e. Test data.

5.17.5.2. GIDEP representatives/membership. The GIDEP is an important tool in the reverse engineering process. Many commands have GIDEP representatives and membership may be obtained by contacting:

Officer in Charge
GIDEP Operation Center
Corona, California 91720

5.17.5.3 Additional sources of data.. Additional data may be obtained by searching:

a. Vendor catalogs,

b. Military/federal standards/specifications,

c. Military handbooks,

d. Data item descriptions,

e. MS drawings, and

f. Qualified parts lists.

5.18 Technical data package requirements. The number and size of drawings, specifications, and associated lists required to complete the TDP should be determined. A block of drawing numbers should then be requested from the cognizant Command, along with the format requirements, such as drawing media and special notes or procedures unique to that Command.

5.19 Reverse engineering management plan.

5.19.1 Reverse engineering management plan objective. A reverse engineering management plan should be completed for each candidate to ensure a logical sequence of events in order to prevent delays or misinterpretations in the overall program objectives.

5.19.2 Management plan development. A reverse engineering management plan may be developed at the beginning of the process. This plan may not be complete, however, until hardware and data are reviewed. This management plan may include in-process reviews and possible economical cut-off points. A tasking plan should be developed upon completion of the disassembly process, when a better knowledge of the parts has been obtained,

5.19.3 Tasking plan. The tasking plan should define the tasks necessary to complete the TDP, as well as the management control and monitoring procedures necessary to ensure the objectives are achieved in a timely manner. The tasking plan may include the:

a. Specific tasks to be accomplished,

b. Order in which the tasks must be performed,

c. Resources (personnel, materials, and costs) required to complete each task, and

d. Start and completion times for each task.

5.19.4 Program Evaluation and Review Technique (PERT) Chart. A PERT chart is useful for monitoring the activities and events that must be completed in a specified sequence to achieve the objectives, and to identify those activities which can be accomplished concurrently.

5.19.5 Identify lead times. Where necessary, the long lead time items should be identified and the procurement of these items recommended prior to completion of the complete process. These items may be provided as GFE during the prototype phase. Also, the possibility of furnishing items that may currently be in the federal supply system, should be investigated.

5.20 Hardware analysis.

5.20.1 Hardware analysis objective. A hardware analysis should be performed to develop the missing data required for a TDP. In those cases where the existing technical documentation is either incomplete or unavailable, hardware analyses (dimensional, material, electrical/electronic) should be performed to develop the technical data (product baseline) required for production. The data developed by physically examining, measuring and analyzing the existing hardware should be included in the end-item drawings and specifications.

5.20.2 Accuracy. All test equipment should be calibrated prior to use in order to detect and adjust any variation in the accuracy of the instrument being checked. ISO 10012-1 and NCSL-Z540.1 may be used as guidance for the calibration of all measuring and test equipment.

5.21 Dimensional analysis.

5.21.1 Dimensional analysis objective. The dimensions define the size and shape of the part and locate all part features. Tolerances describe the dimensional limits to facilitate manufacturing while ensuring proper fit and function of parts or assemblies. A dimensional analysis should be conducted on all hardware piece-parts/components. Parts that could not be disassembled previously may be cross-sectioned and cut away if necessary to establish the dimensional data.

5.21.2 Considerations. The following should be considered when performing the dimensional analysis:

a. Bearing housings and shaft fits should be noted. When they are not in accordance with standard recommended practices in the bearing manufacturer’s catalog, additional bearing seats and tolerances should be reviewed and investigated. The variation could be a manufacturing error or done deliberately for some engineering purpose.

b. Assumptions concerning screw threads should be avoided since manufacturers often produce unique threads to prevent others from copying them or substituting standard threaded parts. The pitch diameter should be measured and compared to the classes provided in Federal Standard H28/18.

c. All clearances should be measured and noted to assist in the tolerancing of individual parts. These should include, but are not limited to:

(1) Lateral movement,

(2) Backlash (gears and splines),

(3) Torque,

(4) Operating loads (i.e., handles), and

(5) Keyway clearances.

d. Welded joints should be cross-sectioned to determine the depth of penetration and the preparation treatment which may have to be performed and the length and size of fillets and bevels used.

e. When parts have features that appear to be of no useful function for the item's intended use, consideration should be given to the manufacturing processes involved. A hole or protrusion could have been designed to facilitate the manufacturer's requirements. Such features should be noted. When the final drawing is prepared, those features should be indicated as optional for manufacturing purposes.

f. In many cases, manufacturing methods, such as punched parts, injection molded, or investment cast parts, indicate dimensional requirements.

(1) Normally, items that are sheared or punched do not require a good surface finish on the sheared edge. However, in some cases, the manufacturer will intentionally punch a hole with a minimum clearance between the punch and the die. This is done to create a larger "straight land" in the hole, which may be required as a load bearing surface or to minimize wear on mating parts. When reverse engineering a punched hole, the "land-width" should be noted. If it is more than 25% of the length of the hole, it could be intentional.

(2) In addition to the draft and parting lines, ejection-pin locations should be included in the final drawing.

g. Joining methods such as riveting or spot-welding may require testing to determine the strength requirements. Many spot-welded items are controlled at the weld by pull-tests. If necessary, applicable specifications should be reviewed for inclusion in the final TDP.

h. Heat treatment should be evaluated, using cross sections as required to determine case depth, grain structure and other metallurgical requirements. Grain flow on forgings should be noted.

i. Whenever a pressed-in bushing exists, concentricity of that bushing to the diameter securing it should be ensured.

j. If dowel pins are used to align mating parts, the location of the pins at the projected distance should be ensured to assure the fit of those parts.

k. Surface finishes on all mating surfaces should be checked, whether or not a gasket is used.

l. Casting surfaces subject to wear for grain structure variances caused by special casting processes should be examined using chills to “harden” the casting in that particular area.

m. Electrical wire diameters should be measured and insulation type and thickness noted. The length of the wire should be duplicated even if it appears to be excessive. Shortening a wire length could change the electrical characteristics of the end item.

5.21.3 Process variation. A manufacturing process variation can produce some strange numbers for part or assembly dimensions. Unless the dimensions or specifications for the next higher assembly are known, “normalizing” of interface dimensions is not recommended.

5.21.4 Establish tolerances. If possible, dimensional analyses should be performed on not less than two items. The results of each may then be compared to determine the possible existence of manufacturing variances as an aid to establishing tolerances, and to ensure they are identical as the probability of randomly selected items with identical defects is negligible.

5.21.5 Lot determination. If possible, it should be determined whether items were manufactured in the same lot and this fact noted accordingly for the producibility study. Parts manufactured in the same lot may have very slight dimensional differences, may not accurately depict the allowable tolerances, and may have identical defects.

5.22 Material analysis.

5.22.1 Material analysis objective. The material analysis, including chemical and metallurgical analysis, should be performed to determine the composition, surface treatments, finishes, hardness, and heat treatments pertinent to each piece-part/component.

5.22.2 Sample size. Spectrographic samples should be submitted for composition analysis and identification of elements. The suggested sample size is: 1” X 1” X 1,” as smaller-sized samples are less cost efficient and may prohibit the use of instrumental analysis. The material analysis for plastic parts usually requires as much as one month additional time. Where possible, samples should be submitted in their entirety for metallurgical analysis.

Improper cutting of the sample could affect the hardness readings or the interpretation of the heat treating process.

5.23 Electrical/electronic analysis.

5.23.1 Electrical/electronic analysis objective. The electrical/electronic analysis defines the input/output parameters, component characteristics, circuit paths, materials, crating and bonding necessary to reproduce the candidate through reverse engineering. The documentation available on the candidate may range anywhere from complete to nonexistent.

5.23.2. Validate documentation. Documentation should be validated to verify:

a. Design parameters,

b. Prescribed test procedures,

c. Configuration and dimensional tolerance data,

d. Producibility or a like item at reduced cost not using unrestricted or proprietary information, and

e. QC/QA (quality assurance) information.

5.23.3 Complete documentation. Level 3 drawings may be formulated on like items when the documentation has been validated.

5.23.4 Incomplete documentation. If documentation on the candidate is incomplete or not available, the following approach may need to be taken:

a. Input/out parameters may need to be determined using data from the next higher assembly,

b. Circuit paths may need to be documented,

c. Circuit components may need to be identified and function characteristics ascertained,

d. A determination may need to be made that substitute items can be used without changing circuit parameters, and

e. An equivalent circuit design may need to be made for the candidate under consideration,

5.23.5 Design validation. Design validation of the reverse engineered circuitry may consist of one or both of the two major electronic circuit disciplines, analog and/or digital. Documentation should include the classical engineering tools and definitions.

a. Analog circuit designs should be checked for:

(1) Circuit stability,

(2) Step response,

(3) Frequency response,

(4) Gain and phase linearity,

(5) Slow rate,

(6) Non-linear characteristics,

(7) Thermal characteristics,

(8) Ripple and noise,

(9) Input/output parameter and impedances,

(10) Power consumption (max/min), and

(11) Specialized functional parameters,

b. Digital circuit designs should be checked for:

(1) Input/output level (with and without stimuli),

(2) Proper bias levels,

(3) Rise and fall time of signaling pulses,

(4) Clock frequency and duty cycle,

(5) Circuit interaction and component characteristics,

(6) Thermal characteristics,

(7) Input/output impedances,

(8) Functional parameters of circuitry/effects of fault simulation,

(9) Power consumption of circuitry (max/min), and

(10) Specialized functional parameters.

5.23.6 Environmental requirements. Environmental requirements should be thoroughly documented and tested for shock, vibration, temperature, humidity and any EMI/RFI (electro-magnetic interference/radio frequency interference) requirement.

5.23.7 Performance characteristics. In conjunction with the above circuit analysis and design validation, component performance characteristics should be examined to guarantee that input/output parameters can be realized to meet the specifications and reliability requirements of the candidate. All specifications and component characteristics should be included in the parts list and/or appropriate drawings.

5.24 Engineering sketches and specifications.

5.24.1 Engineering sketches and specifications objective. Engineering sketches and specifications developed at this time may be used to draft the Level 3 drawings, control drawings, and other technical documents required for the preliminary TDP.

5.24.2 Technical data requirements. The engineering sketches and specifications should provide the complete technical data requirements and circuit drawings, parts listings, component parameters, all input/output data, special requirements, special wave form drawings and timing information, and circuit layout required for end item production of all assemblies, subassemblies, piece-part/components, to produce a prototype of the item under consideration.

5.24.3 Test requirement specifications. Test requirement specifications may include:

a. The scope of the requirement, which should state the purpose of the specification to be established;

b. Applicable documents, which should include the end item specifications (applicable service, Army, Navy, Air Force, etc), military standards, drawings, publications and non-government documents;

c. Requirements containing the functional characteristics of the circuitry, with applicable drawings and functional data, which should represent the overall operational parameters;

d. Quality assurance provisions, which should contain the inspection criteria.

e. All military standards, end-item specifications and test findings; and

f. An acceptance test should be formulated and documentation of standards and specifications should be included.

5.25 Level 3 drawings.

5.25.1 Level 3 drawings objective. Level 3 drawings are the result of the reverse engineering process and should contain the documented parameters necessary to produce the selected candidate.

5.25.2 Preparation. One of the final results of a reverse engineering process should be the preparation of a drawing to be used for competitive procurement.

5.25.3 Content. A reverse engineered item may result in the use of several types of drawings. Level 3 drawings consist of engineering drawings and associated lists which provide sufficient definition for manufacturing and production without resorting to additional product design efforts, additional design data, or recourse to the original design activity. Level 3 drawings should:

a. Provide requirements which permit replication of the original item except for characteristics changed as a result of value engineering, product improvement and other formal design change actions;

b. Provide the engineering data for support of quantity production; and

c. Provide the necessary data to permit competitive procurement.

5.25.4 Considerations. Based on sound engineering judgment concerning the complexity and engineering sophistication of the design, the types and number of drawings required to satisfy the function should be prepared (see Appendix C). The engineering drawings should consider the following:

a. Details of unique processes,

b. Performance ratings,

c. Dimensional and tolerance data,

d. Critical manufacturing assembly sequences,

e. Input/output characteristics,

f. Diagrams,

g. Mechanical and electrical connections,

h. Physical characteristics including form and finish,

i. Details of material identification,

j. Inspection, test, and evaluation criteria,

k. Calibration information,

l. Quality Control data,

m. Interface characteristics,

n. Critical safety items,

o. Electrostatic discharge sensitive items, and

p. Part marking items.

NOTE: MIL-DTL-31000 may be used as guidance concerning engineering drawings and definitions.

5.25.5 Drawing media. Level 3 drawings should be prepared on the media and formatted specified by the cognizant command. Pre-printed format paper and designated blocks of drawing numbers may be requested from the cognizant command.

5.25.6 Completeness of drawings. Level 3 drawings should be developed using the engineering sketches and specifications described in 5.24. As many subassembly drawings as possible should be prepared so that the top assembly drawing will be easier to read and build. A drawing tree for each assembly should be prepared prior to drafting to facilitate completeness and accuracy of drawings.

5.25.7 Computer-generated drawings. The preparation of detail and assembly drawings using Computer-Aided Design/Drafting (CADD) equipment versus traditional drafting methods may facilitate rapid and accurate input/output, updates/revisions, and storage/transmission of pertinent technical data. However, unlike drawings produced by conventional methods where lines can be blended and approximations made, computer-generated

drawings require more accurate inputs. For example, inaccuracies will become visible on plotted drawings if tangent arcs, circles, etc., are not defined to 3-or-more decimal places.

5.25.8. Library files. The use of library files which include standard symbols; common parts such as bolts and washers; and standard notes, eliminates the task of re-drawing these items continuously. To aid in monitoring costs and compiling parts lists, input data may be extracted from drawing files.

5.25.9 Drawing references. The drawing references to specifications, military, federal, or commercial, should be backed up in a reference notebook or file. This list of references can be used to compile the data list when all drawings are complete.

5.25.10 Quality control review. A package submitted to Quality Control (QC) for review should be accompanied by a book or folder containing copies of all specifications used or referenced on the drawings. This could expedite the review by approximately 50%.

5.25.11. Candidate file inclusions. Copies of the drawings, associated lists, and technical data developed during this phase of the process should be included in the Candidate File (see 5.6).

5.26 Producibility study

5.26.1 Purpose. The purpose of a producibility study is to verify the adequacy of the preliminary TDP for competitive procurement. In order to ensure legibility, accuracy, and completeness of the drawings and specifications developed through reverse engineering, you should:

a. Review for other engineering considerations such as product improvement and value engineering (see 5.45 and 5.46),

b. Determine adequacy of the technical documentation for production competition (manufacturing),

c. Determine adequacy of drawings and specifications with respect to the manufacturability of parts or assemblies,

d. Verify the tolerances and ensure the interchangeability of parts at assembly (*),

e. Ensure that the drawings are completely dimensioned and toleranced in accordance with applicable standards, and

f. Ensure that the drawings meet the requirements of the specified level.

(*) The next higher assembly drawings and manuals may be used to verify tolerances. Actual measurements on next higher assemblies may be required.

5.26.2 Areas of consideration. The following areas should be considered when performing a producibility study:

5.26.2.1 Dimensions/tolerances. Tolerance analysis should be performed to ensure that the dimensional limits are sufficiently controlled so that the form, fit and functional requirements are met, and to minimize any potential manufacturing difficulties in the machining, forming, assembly, and inspection operations. The maximum tolerance allowances should be determined to permit manufacturers to use alternate fabrication techniques to minimize costs. American National Standards Institute (ANSI) Y14.5M may be used as a guide for dimensioning and tolerancing.

5.26.2.2 Materials. The materials specified should be reviewed for impact on availability, cost, producibility, and function of the part. A range of materials equivalent in strength to the material to be used in the prototype should be specified to permit bidders to estimate manufacturing costs based on their best in-house process.

5.26.2.3 Heat treatment. The capability of materials to respond to specified heat treatments should be verified and specified. SAE-AMS-H-6088 and SAE-AMS-H-6875 may be used as guides.

5.26.2.4 Finishes. The impact of finishes on function and cost should be evaluated. The most economical finishes that will satisfy the functional requirements should be specified. If machine finishes are required, the highest roughness acceptable should be specified for the designed function.

5.26.2.5 Clean and joining methods. The proper joining methods, such as mechanical fasteners, metallurgical welding, brazing, soldering, and chemical adhesives, should be specified and evaluated for applicability, ease of access during the joining process, and alternate method of joining for cost reduction. The following documents may be used as guidance:

a. Welding: MIL-STD-22
ANSI/AWS A2.4
ANSI/AWS A3.0

b. Brazing: AWS C3.4
AWS C3.5
AWS C3.6

5.26.2.6 Coatings. The proper coatings, surface treatments and finishes should be specified, including proper paint specifications and pre-treatments. MIL-STD-171 may be used as guidance.

5.26.2.7 Selection of standard parts/components. The parts defined by military standard (MS), Army-Navy (AN), National Aircraft Standards (NAS), or other Government standards, should be used wherever possible for compliance with the requirements of the applicable standards.

5.26.2.8 Quality assurance provisions. Where applicable, the drawings should list the appropriate data concerning acceptance of detail parts or assemblies, as follows:

a. Dynamic tests, defining pertinent cycling, torsional deflection capabilities, and gear backlash,

b. Electrical parameters and characteristics, continuity checks, dielectric data, and durability,

c. Circuit parameters and characteristics, circuit path checks, input/output parameters, special functions, wave form analysis, and layering and bonding requirements,

d. Enclosure requirements, such as pressure and leakage allowances, (MIL-E-2036 may be used as a guide.)

e. Liquid penetrant inspections and personnel certifications, (SAE AMS2644 and NAS 410 may be used as guides.)

f. Magnetic particle inspections and personnel certifications, (ASTM E1444 and NAS 410 may be used as guides.)

g. Radiographic inspections, (SAE AMS2175, MIL-HDBK-1264, MIL-HDBK-1265, and ASTM E1742 may be used as guidance.) and

h. A review of interchangeable, moving and mating parts to ensure proper dimensions of close fitted items. ANSI B4.1 may be used as a guide.

5.26.3 Drawing maintenance. All drawings and specifications should be revised as required to reflect any changes or corrections resulting from the producibility study. Upon completion of this update all documentation should be placed in the candidate file for use in the production of Level 3 drawings.

5.27 Quality control (QC).

5.27.1 QC study. A quality control study should be performed and documented on the Level 3 drawings and prototype of candidates to certify their compliance with original candidate specifications.
.

5.27.2 QC plan. A quality control plan should be developed to ensure the product conforms to drawings, specifications, inspections, tests, and task order requirements.

5.27.3. QC inspections. Quality control inspections should be applied to the procurement of supplies and services, as follows:

a. Engineering service contracts where software/documentation deliverables are necessary, and

b. Minor limited production or prototype hardware contracts where inspection is the major quality control factor.

5.27.4 QC program. A quality control program that applies to complex supplies, components, equipment, and systems should be implemented to provide the necessary quality assurance.

5.28 Quality assurance provisions (QAPs)

5.28.1 QAPs objective. The QAPs included on the Government drawings are the documented requirements, procedures and criteria necessary for demonstrating that designs conform to user requirements and, that material and associated services conform to approved designs. The QAPs should establish a quality baseline by providing the means to audit the product to assure contractor’s production capability to meet various requirements in the technical data package.

5.28.2 QAPs required. Normally, QAPs should be prepared for inclusion on component, subassembly, and assembly drawings.

5.28.3 QAPs not required. QAPs are not required for the following:

a. Components, subassemblies, or assemblies that are not required for installation in the maintenance or repair of an end-item, subassembly, or component (except those destined for use in modifications, reconditioning, or retrofit programs),

b. Commercial, proprietary, or off-the-shelf items, unless modified, or where specific performance requirements are necessary for the military application,

c. Simple items such as nuts, bolts, washers, locks, hinges, etc., except when these items are employed for critical usage or high accuracy is required,

d. Items not supported by detail drawings whose requirements are contained in a detail specification, and

e. Components, such as, springs, gears, etc., having like characteristics and that are applicable to a category of related items. In such cases, the QAP should be included in the specification for those items.

5.28.4 Characteristic classification. Each characteristic on the drawing should be classified as critical, major, or minor, as applicable. MIL-STD-1916 may be used as a guide for classifying the drawings. Classification of a characteristic should be determined by analyzing the effect on the end item, if only that characteristic was discrepant. This analytical procedure identifies those characteristics whose conformance will verify the design objectives. The classification of characteristics should be applied to drawings prior to approval for production. All pertinent QAP data should be entered on each specific drawing. The engineering notes should include all pertinent QAP data required.

5.29 Documentation of quality control.

5.29.1 QC review. A quality control review should be conducted for adequacy of all drawings, test data, and quality assurance provisions. A check-list should be prepared for each drawing to ensure that all elements pertaining to the item have been fully delineated.

5.29.2 Inspection of drawings. Drawings should be inspected for defects. MIL-STD-1916 may be used as a guide for inspecting the drawings. Drawing defects are defined as follows:

a. Major defect: An error in the drawing that, if not corrected, could cause a hardware defect that would affect form, fit, function, production contract cost, or scheduled delivery. Illegibility and non-reproducibility are classified as major defects.

b. Minor defect: An error in the drawing, other than a major error, which is in violation of the standard or specifications for the drawing requirements.

5.29.3 Limited physical configuration audit (PCA). A limited PCA should be performed to ensure that the documentation developed through reverse engineering conforms to the actual item.

5.29.4 Rejection criteria. The rejection criteria should be determined and all discrepancies should be resolved and corrected prior to final approval of the drawings and specifications.

5.30 Certificate of compliance. A certificate of compliance should be placed in the candidate file certifying that the enclosed documentation is correct and meets all applicable specifications and requirements and all corrections and/or changes have been completed.

5.31 Production review. A production review should be performed to determine the economics of production of the reverse engineered item. The objective of the production review is to determine pertinent prototype production data based on actual quotes from competent manufacturers, as described in paragraphs 5.32 through 5.35 below.

5.32 Estimates. Quotes from three or more sources should be obtained for prototypes, as well as one-, two-, and three-year quantity requirements based on average annual buy quantity.

5.33 Make-or-buy. Where necessary, depending upon contractual agreements, a make or buy decision may be required by the government or contractor based on prototypes. Validation of the TDP during prototyping is important.

5.34 Schedules. New schedules should be developed based upon delivery times quoted for both the prototypes and production quantities.

5.35 Should-cost.

5.35.1 Data development. Should-cost data may be developed using actual quotations from suggested sources of supply developed during the procurement process.

5.35.2 Actual costs and schedules. The reverse engineering cost estimate and schedule (see. 5.11) should be updated to reflect the actual costs and schedules resulting from the production review.

5.35.3 Results. The candidate file should be updated to include the results of the production review.

5.36 Prototype production.

5.36.1 Prototype production objective. Prototype production involves the manufacture and testing of the prototype to determine if it meets all required specifications.

5.36.2 Sub-contracting. All prototype manufacturing should be sub-contracted to prove the adequacy of the preliminary TDP. When assembly and testing procedures are part of the TDP, the entire assembly should be completed. Testing that is not a normal function of the manufacturing industry may be sub-contracted.

5.36.3 Record maintenance. A record should be maintained of all subcontractor requests for waiver or deviation, and the cognizant engineer should review all such requests. All discussions with the vendors should include participation by the cognizant contracts or procurement personnel.

5.37 Procurement. A decision to procure the individual prototypes for test, as opposed to a first article test in a production run, should be the result of an economic analysis considering delivery times and tooling costs.

5.38 Parts fabrication. When an item is a relatively simple assembly, consideration should be given to procuring the parts individually and assembling the items in-house.

5.39 Inspection and quality control.

5.39.1 Inspection. All prototype parts and assemblies should be inspected in accordance with the incoming inspection policy. The decision to accept, reject, or rework the item should be made by the cognizant engineer, and all appropriate documentation should be completed.

5.39.2 Quality control plan. The quality control plan should define procedures for controlling procurement, manufacturing, assembly, inspection, testing, rejection, rework, and approval of the prototype built in accordance with the developed drawings and specifications. Each item should be inspected in accordance with disciplines such as mechanical, electrical, welding, material, dimensioning and tolerancing, as applicable.

5.40 Assembly. During the assembly cycle, care should be taken to duplicate the requirements annotated on the assembly drawing and ensure that lubricants and fluids meet the applicable specification (this includes all clearance and torqueing requirements).

5.41 Test.

5.41.1 Validate concepts. Prototype testing may be used to validate concepts for function and producibility; prove out production concepts; and demonstrate adequacy to meet user requirements. Testing may not, depending upon a risk assessment, be required for simple items such as nuts and bolts.

5.41.2 Focus on conformance. Prototype testing may be conducted in accordance with the developed test plans, and should focus on conformance to reliability, availability, and maintainability requirements; supportability, survivability; human factors; and safety.

5.42 Certificate of compliance. A certificate of compliance should be placed in the candidate file certifying the product complies with workmanship standards and that all requirements and/or changes have been completed and the prototype is an acceptable replacement for the candidate.

5.43 Finalize TDP.

5.43.1 Formulate/deliver TDP. A finalized TDP should be formulated and delivered to the agency requesting the reverse engineering of the candidate item.

5.43.2 Include changes. After approval of the prototype, all data changes required as a result of the manufacturing phase should be included in the final TDP.

5.43.3 Procedures. Cognizant command procedures for finalizing the TDP, such as, mono-detail and multi-detail drawings, and associated lists, should be used.

5.44 Additional engineering logistics considerations.

5.44.1 Re-evaluate design. The reverse engineering process as described earlier in this handbook does not address additional engineering and logistics considerations. The newly acquired technical knowledge, gained by reverse engineering, allows us to re-evaluate the design for maintenance philosophy, reliability, cost, and other changes that may affect the logistics support requirements.

5.44.2 Follow-on considerations.

5.44.2.1 End-item TDP update. The new TDP, including drawings, parts lists, specifications, specification change notices, drawing change notices and notices of revision should be incorporated into all affected documentation using the configuration management procedures required by the individual commands.

5.44.2.2 Integrated logistics support (ILS). A review should be made of the level of repair analysis (LORA) based upon the new technical data available. Due to lack of repair, items that are currently throw-away may now be reclassified as repairable.

5.45 Engineering recommendations.

5.45.1 Product improvement.

5.45.1.1 Inadequate data. The items, as documented during the reverse engineering process, may not have been previously considered for product improvement because of inadequate data.

5.45.1.2 Engineering evaluation. Using the new data developed during the reverse engineering process, an engineering evaluation may be conducted and product improvements made.

5.45.1.3 Product reliability. Remember, it may not be in the best interest of the current supplier(s) to improve the reliability of their products, thus reducing the requirements. Examples of areas with product improvement potential are:

a. Bearings operating beyond manufacturers recommendations,

b. Electronic components operating at peak capacity,

c. Use of inadequate materials and protective coatings,

d. Use of older technology, and

e. Use of non-standard components.

5.46 Value engineering.

5.46.1 Value engineering objective. A value engineering (VE) review of reverse engineering candidates may reveal cost drivers over and beyond the sole source restrictions. Some probable high cost drivers are: excessive material requirements, design defects, over design, functional redundancy, tolerance restrictions, excessive performance requirements, etc. When these or similar conditions are noted, consideration should be given to performing value engineering studies prior to the completion of the reverse engineering process. A sample VE Study and VE Proposal form is provided in figure 5.

5.46.2 Documented results. The results of all studies conducted should be documented in a format suitable to support the inclusion of the dollars saving into the DOD Value Engineering accountability system. The documentation should include, as a minimum, the following:

a. Originating individuals name, title, signature, official symbol and phone number

b. Item, component or part studied,

c. National/Federal Stock Number,

d. Major end item/system/program,

e. Appropriate code & program element, and

f. Results from the five phases of the VE job plan:

(1) Information phase,

(2) Function phase,

(3) Speculation phase,

(4) Evaluation phase, and

(5) Development phase.

*o Estimated cost of change(s) recommended
*o Estimated net savings to the government
*o Unit savings
o A cost analysis summary to support the above asterisked items.

5.45.3 Logistics support analysis/record. The Logistics Support Analysis and the Logistics Support Analysis Record may be affected by these changes and appropriate action taken to update these documents.

5.46.4 Manual reviews. Manuals should be reviewed and changes resulting from the creation of the technical data package should be incorporated.

6.0 NOTES

6.1 Intended use. This handbook provides the guidelines and procedures for performing reverse engineering.

6.2 Subject Term (Key Words) Listing

Reverse Engineering Procedures
Reverse Engineering Guidelines

6.3 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX A

ACQUISITION METHOD CODE/ ACQUISITION METHOD SUFFIX CODE

(AMC/AMSC)

DEFINITIONS

A.1. SCOPE.

A1.1 Scope. This appendix provides a listing of the AMC/AMSC codes and definitions, and is included for information purposes only.

A.2 Codes and definitions.

A.2.1 AMC/AMSC codes/definitions. The following acquisition method code/acquisition method suffix code (AMC/AMSC), assigned in accordance with the DAR-S6, indicates the competitive status of the part and defines the various encumbrances to competitive procurement (see 4.3).

AMC CODE	ASSIGNMENT/CONDITION
1	Suitable for competitive acquisition.
2	Suitable for competitive acquisition for the first time.
3	Acquire directly for the actual manufacturer, whether or not the prime contractor is the actual manufacturer.
4	Acquire, for the first time, directly from the actual manufacturer rather than the prime contractor who is not the actual manufacturer.
5	Acquire only from the prime contractor although the engineering data identifies the Commercial and Government Entities (CAGE) and part number of a source other than the prime contractor.

AMSC CODE	ASSIGNMENT/CONDITION
A	The Government's rights to use data in its possession is questionable. (Note: This code is only applicable to parts under immediate buy requirements and only as long as rights to data are still under review for resolution and appropriate re-coding.) Valid AMCs: 1, 2, 3, 4, 5.
B	Acquisition of this part is restricted to source(s) specified on "Source Control," "Altered Item," or "Selected Item" drawings/documents. Valid AMCs: 1, 2, 3, 4.
C	This part requires engineering source approval by the design control activity in order to maintain the quality of the part. An alternate source must qualify in accordance with the design control activity's procedures, as approved by the cognizant Government engineering activity. Valid AMCs: 1, 2, 3, 4.
D	(Reserved)
E	(Reserved)
F	(Reserved)
G	The Government has unlimited rights to the technical data, and the data package is complete. Valid AMCs: 1, 2.
H	The Government physically does not have in its possession sufficient, accurate or legible data to purchase this part from other than current source(s). (NOTE: This code is applicable only to parts under immediate buy requirements and only as long as the deficiency is under review for resolution and appropriate re-coding.) Valid AMCs: 1, 2, 3, 4, 5.
J	(Reserved)
K	This part must be produced from Class IA castings (e.g., Class 1 of MIL-C-6021) and similar type forgings. The part must be procured only from sources

	which use castings or forgings obtained from approved (controlled) source(s). Valid AMCs: 1, 2.
L	The annual buy value of this part falls below the screening threshold of $10,000 but it has been screened for known source(s). (NOTE: This code should not be used when screening parts entering the inventory. It should not be assigned in preference to or supersede any other AMSC.) Valid AMCs: 1, 2, 3, 4, 5.
M	Master or coordinated tooling is required to produce this part. This tooling is not owned by the Government or, where owned, cannot be made available to other sources. Valid AMCs: 1, 2, 3, 4.
N	This part requires special test and/or inspection facilities to determine and maintain ultra-precision quality for its function or system integrity. Substantiation and inspection of the precision or quality cannot be accomplished without each specialized test or inspection facilities. Valid AMCs: 1, 2.
P	The rights to use the data needed to purchase this part from additional sources are not owned by the Government and cannot be purchased. Valid AMCs: 1, 2, 3, 4, 5.
Q	(Reserved)
R	The data or the rights to use the data needed to purchase this part from additional sources are not owned by the Government and it has been determined that it is uneconomical to purchase them. Valid AMCs: 1, 2, 3, 4, 5.
S	(Reserved)
T	Acquisition of this part is controlled by QPL (qualified product list) procedures. Valid AMCs: 1, 2.
U	The cost to the Government to breakout this part and acquire it competitively has been determined to exceed the projected savings over the life span of the part. Valid AMCs: 3, 4, 5.

V	This part has been designed a high reliability part under a reliability program. Probability of failure would be unacceptable from the standpoint of safety of personnel and/or equipment. The cognizant engineering activity has determined that data to define and control reliability limits cannot be obtained nor is it possible to draft adequate specifications for this purpose. Valid AMCs: 3, 4, 5.
W	(Reserved)
Y	The design of this part is unstable. Engineering, manufacturing, or performance characteristics indicate that the required design objectives have not been achieved. Major changes are contemplated because the part has a low process yield or has demonstrated marginal performance during tests or service use. These changes will render the present part obsolete and unusable in its present configuration. Limited acquisition from the present source is anticipated pending configuration changes. Valid AMCs: 3, 4, 5.
Z	(Reserved)

APPENDIX B

DATA RIGHTS

DEFINITIONS AND VALID LEGENDS

B.1 SCOPE

B.1.1 Scope. This appendix provides definitions and valid legends that should be included for formal authorization when reverse engineering candidates have existing patents(see 4.4.3).

B.1.2 Funding for development. If the item, component or process depicted by the technical data was developed by the contractor at Government expense, that results in "unlimited rights" to the Government for data involved.

a. The DOD regulations clearly indicate that 100% of R&D funding must be at private expense in order to resolve the data rights question in favor of the contractor.

b. In cases where there is an investment mix of private and Government funds, the data rights will not be allocated on a percentage basis. The data rights will be 100% "unlimited rights" to the Government.

c. If the Government funds modification of a portion of equipment with "limited" data rights, the Government will have "unlimited rights" to the technical data depicting only those enhancements, unless the modification is of such proportion that the original equipment is unrecognizable.

B.1.3 Challenges. There is no time limit on the Government's rights to challenge the contractor's use of a restrictive legend. The contractor must be notified in writing that he has 60 days in which to demonstrate that the markings are authorized. The contractor is obligated to prove that the limited rights legend is proper and in accordance with DAR/FAR regulations by providing records showing when the data was developed and that the contractor funded creation of the end-item for which the data was generated entirely at contractor expense.

B.1.4 Lack of restrictive legends. The lack of restrictive legends invalidates the proprietary claim and such unprotected data vests "unlimited rights" to the Government for the data involved.

B.2 DEFINITIONS

B.2.1 Definitions of data rights. The following definitions should be included to define the rights associated with technical data.

B.2.1.1 Unlimited rights. This means the Government has rights to use, duplicate or disclose technical data in whole or in part, in any manner and for any purpose whatsoever, including competitive procurement, and to have or permit others to do so. Where data is published without proprietary legends, any proprietary character is lost and the Government may use data with unlimited rights, which includes “breakout” of items. Where a contract stipulates an option for unlimited data rights or indicates substantial research and development (R&D) at Government expense, the Government may acquire unlimited rights in the item, component or system.

B.2.1.2 Limited rights. This is the basic DOD policy which requires a contractor to furnish all technical data which is designed for delivery under the contract terms, but permits the contractor to protect his legend. The burden falls upon the contractor to identify every piece or page of data to which he asserts a proprietary claim. The limited rights policy allows the Government to use data internally (i.e., for maintenance, repair, or operation of equipment) but does not give the Government the right to use or disclose data to anyone for purposes of manufacture, breakout, or reprocurement, if a proper legend is affixed to the drawing.

B.2.1.3 Proprietary data. This is technical data which embodies trade secrets developed at private expense, such as design procedures or techniques, chemical composition or materials, or manufacturing methods, processes, or treatments, including minor modifications thereof, provided that such data:

a. Is not generally known or available from other sources without obligation concerning their confidentiality;

b. Has not been made available by the owner to others without obligation concerning its confidentiality; and

c. Is not already available to the Government without obligation concerning their confidentiality.

B.2.1.4 “Form, fit, and function” data. This is technical data pertaining to end-items, components, or processes for the purposes of identifying sources, size, configuration, mating, and attachment characteristics, functional characteristics, and performance requirements (i.e., specification control drawings, envelope drawings, etc.). DAR/FAR policy states that form, fit, and function data should be furnished without any proprietary legends.

B.2.1.5 Patent. A patent is a right granted to an inventor by the Government to exclude others from making, using, or selling his/her invention to the public for a period of 17 years (extensions are permitted only in certain areas). Whoever invents any new process, item or composition of matter (includes micro-organisms), may obtain a patent. An issued patent contains the specifications and drawings submitted with the patent application. This patent right is not the positive right of the inventor to make, use, or sell

the invention, but a grant to exclude others from so doing. All the inventor obtains is the right to sue.

B.2.1.5.1 Example: Assume a patent “O” is granted to an inventor for a combination of steps or means for performing a specified function illustrated as means: 1 + 2 + 3. A second patent “P” is issued subsequently, which provides an improvement over “O.” The “P” patent claim contains the following means: 1 + 2 + 3 + 4. If the making, using, or selling of the items embodying patent “P” infringes patent “O,” the owner of patent “O” may enjoin the owner of patent “P” from making, using, or selling the “P” invention. While patentee “P” would own his invention, he could not use his invention without permission from patentee “O.” In these circumstances, if patentee “O” desired to license his invention to “P” it would not be logical to grant “P” the right to make, use, or sell the invention, e.g., the right “to practice” the invention. Rather, the license would more correctly contain an agreement by “O” not to sue if “P” made, used, or sold the “P” invention.

B.2.1.5.2 Patent vs technical data. What if data is stamped “Patented”? Patent legends and restrictive-use legends are treated differently. A patent excludes other parties from making an inventor’s items for 17 years. There is complete disclosure of the invention when the patent is filed with the US Patent/Trademark office. If a patented invention is used by the Government without the inventor’s authorization, the only remedy for the inventor is compensation for the use of the patented item (money damage). Title 28 of the U.S. Code, Section 1498 (a), allows the Government to infringe a patent. The patent owner cannot stop the Government from its use, nor can the patent owner stop a Government contractor from using the invention if the Government authorized it. By such authorization, the Government is responsible for whatever reasonable compensation has to be made.

B. 2.1.5.3 Example of authorization clause. The type of “Authorization and Consent” clause incorporated in a contract will depend on the type of contract. The following clause is incorporated in contracts calling for experimental, developmental, or research work or in supply or service contracts where research and development is the primary purpose of the contract:

AUTHORIZATION AND CONSENT (date)

(a) The Government authorizes and consents to all use and manufacture of any invention described in and covered by a United States patent in the performance of this contract or any subcontract at any tier.

(b) The Contractor agrees to include, and require inclusion of, this clause, suitably modified to indemnify the parties, in all subcontracts at any tier for supplies or services (including construction, architect-engineer services, and materials, supplies, models, samples, and design or testing services) expected to exceed $25,000; however, omission of this clause from any

subcontract, under or over $25,000, does not affect this authorization and consent.

B.2.1.5.4 Clause used for supplies. The following clause is included in all contracts for supplies except when complete contract performance and delivery is to be outside the United States, its possessions, and Puerto Rico, or where the research and development clause is required. This clause is more restrictive than that for R&D contracts.

AUTHORIZATION AND CONSENT (date)

(a) The Government authorizes and consents to all use and manufacture, in performing this contract or any subcontract at any tier, of any invention described in and covered by a United States patent (1) embodied in the structure or composition of any article the delivery of which is accepted by the Government under this contract or (2) used in machinery, tools, or methods whose use necessarily results from compliance by the Contractor or a subcontractor with (i) specifications or written provisions forming a part of this contract or (ii) specific written instructions given by the Contracting Officer directing the manner of performance. The entire liability to the Government for infringement of a patent of the United States should be determined solely by the provision of the indemnity clause, if any, included in this contract or any subcontract hereunder (including any lower-tier subcontract), and the Government assumes liability for all other infringement to the extent of the authorization and consent hereinabove granted.

(b) The Contractor agrees to include, and require inclusion of, this clause, suitably modified to identify the parties, in all subcontracts at any tier for supplies or services (including construction, architect-engineer services, and materials, supplies, models, samples, and design or testing services expected to exceed $25,000; however, omission of this clause from any subcontract, under or over $25,000, does not affect this authorization.

NOTE: In contrast with patent legends, a restrictive-use legend on technical data claims rights in a trade secret or item developed by a company at private expense, which is not disclosed to the public.

Bottom Line. The patent right excludes others from manufacturing an invention already disclosed to the public, but the Government may infringe the patent. Proprietary rights in technical data are asserted by a restrictive-use legend to prevent disclosure of data applicable to an item which is either a trade secret or developed by a company at private expense. The DAR/FAR regulations prohibit disclosure of such data outside the Government.

B.2.1.6 Copyright. This is an exclusive privilege granted to an author to print, publish, or copy his literary, artistic, or intellectual productions. It is a right given to

authors in an effort to advance the arts. The copyright term is the life of the author plus 50-years after the author's death.

B.2.1.7 Trade secret. This is any formula, pattern, device, or compilation of information, which is used in one's business, and which gives him an opportunity to obtain an advantage over competitors who do not know or use it. It may be a formula for a chemical compound, a process of manufacturing, treating or preserving materials, a pattern for a machine or other devices, or a list of customers. Trade secrets are protected property unless acquired by proper means. Proper means include:

a. Discovery by independent invention;

b. Discovery by "reverse engineering," that is, by starting with the known product and working backward to find the method by which it was developed. The acquisition of the known product must, of course, also be by fair and honest means, such as purchase of the item on the open market, for reverse engineering to be lawful;

c. Discovery under a license from the owner of the trade secret;

d. Observation of the item in public use or on public display; and

e. Obtaining the trade secret from published literature.

B.2.1.8 Predetermination/prenotification of rights.. This procedure allows for a predetermination of both limited and unlimited rights, to be used in cases where the parties can avoid later disputes by agreeing on their rights before contract performance. This should only be used when the rights in data can be "practically identified." The procedure may be initiated by the Contracting Officer or the contractor during the negotiation of a contract and is not mandatory.

B.2.1.9 Specific acquisition. This term applies when the Government purchases the rights from the developer of the item and uses the data as the basis for competitive procurement. These purchases are included as a separate line item in a contract with a separate price and require that such rights should not be acquired unless:

a. There is a clear need to reprocure the item;

b. There is no suitable alternative;

c. The item can be manufactured through the use of the technical data by the competent vendors; and

d. The anticipated net savings will exceed the acquisition cost of the technical data and rights therein.

B.3 LEGENDS

B.3.1 Valid legends.

B.3.1.1 Valid restrictive use legends. The following legends are valid for use on technical data that have restricted use.

B.3.1.1.1 Limited rights legend.: (*)

" CONTRACT NO.:_____
CONTRACTOR: _____
THOSE PORTIONS OF THIS TECHNICAL DATA INDICATED AS LIMITED RIGHTS SHALL NOT, WITHOUT THE WRITTEN PERMISSION OF THE ABOVE CONTRACTOR, BE EITHER (A) USED, RELEASED OR DISCLOSED IN WHOLE OR IN PART OUTSIDE THE GOVERNMENT, (B) USED IN WHOLE OR IN PART BY THE GOVERNMENT FOR MANUFACTURE, OR IN THE CASE OF COMPUTER SOFTWARE DOCUMENTATION, FOR PREPARING THE SAME OR SIMILAR SOFTWARE, OR (C) USED BY A PARTY OTHER THAN THE GOVERNMENT, EXCEPT FOR: (I) EMERGENCY REPAIR OR OVERHAUL WORK ONLY, BY OR FOR THE GOVERNMENT, WHERE THE ITEM OR PROCESS CONCERNED IS NOT OTHERWISE REASONABLY AVAILABLE TO ENABLE TIMELY PERFORMANCE OF THE WORK, PROVIDED THAT THE RELEASE OR DISCLOSURE THEREOF OUTSIDE THE GOVERNMENT SHALL BE MADE SUBJECT TO A PROHIBITION AGAINST FURTHER USE, RELEASE, OR DISCLOSURE; OR (II) RELEASE TO A FOREIGN GOVERNMENT, AS THE INTEREST OF THE UNITED STATES MAY REQUIRE, ONLY FOR INFORMATION OR EVALUATION WITHIN SUCH GOVERNMENT OR FOR EMERGENCY REPAIR OR OVERHAUL WORK BY OR FOR SUCH GOVERNMENT UNDER CONDITIONS OF (I) ABOVE. THIS LEGEND, TOGETHER WITH THE INDICATORS OF THE PORTIONS OF THIS DATA WHICH ARE SUBJECT TO SUCH LIMITATIONS SHALL BE INCLUDED ON ANY REPRODUCTION HEREOF WHICH INCLUDES ANY PART OF THE PORTIONS TO SUCH LIMITATIONS."

(*) A proper legend in accordance with DAR/FAR regulations.

B.3.1.1.2 Commercial proprietary legend. (**)

" (name of contractor)
PROPRIETARY INFORMATION
THIS PRINT OR DOCUMENT, AND THE INFORMATION AND KNOW-HOW IT CONTAINS ARE PROPRIETARY TO (name of contractor) AND MAY NOT BE USED OR REPRODUCED OR DISCLOSED TO OTHERS WITHOUT THE PRIOR WRITTEN PERMISSION OF (name of contractor). PERMITTED REPRODUCTIONS, IN WHOLE OR IN PART, INCLUDING BORROWER'S SHOP DRAWINGS, SHALL BEAR THIS NOTICE. RETURN OF THIS PRINT OR

DOCUMENT AND ALL COPIES THEREOF MUST BE MADE TO (name of contractor) UPON REQUEST."

(**) Variations/improperly worded legends do not necessarily invalidate a proprietary claim. The contractor may be offered the opportunity to properly comply, within 60 days, in order to protect his technical data due to inadvertent error.

APPENDIX C

ENGINEERING DRAWINGS

(Levels/Type/Content)

C.1 SCOPE

C.1.1 Scope. The types and number of drawings required to satisfy the function should be prepared based on sound engineering judgment concerning the complexity and engineering sophistication of the design (see 5.25.4).

C.2 LEVELS

C.2.1 Engineering drawing levels. Engineering drawings and associated data should be acquired at one or more of three levels -- Level 1, Conceptual and Development Design Data; Level 2, Production Prototype and Limited Production Data; and Level 3, Production Data.

C.2.1.1 Level 1 drawings. Level 1 engineering drawings and associated data will disclose, as a minimum, engineering design information sufficient to evaluate an engineering concept. They may also provide information sufficient to fabricate developmental hardware. Layout drawings and combinations of types of engineering drawings may be used to convey engineering concepts so that the information is understandable to cognizant Government engineers and scientists. This information should also enable fabrication by the design contractor of developmental hardware for test or experimentation.

C.2.1.2 Level 2 drawings. Level 2 engineering drawings and associated data should disclose a design approach suitable to support the manufacture of a production prototype and limited production models. Engineering drawings should include, as applicable, parts list, detail and assembly drawings, interface control data, diagrams, performance characteristics, critical manufacturing limits, and details of new materials and processes. Special inspection and test requirements necessary to determine compliance with requirements for the item should be defined on the engineering drawings or referenced to a document acceptable to the Government.

C.2.1.3 Level 3 drawings. Level 3 engineering drawings and associated data should provide engineering definition sufficiently complete to enable a competent manufacturer to produce and maintain quality control of item(s) to the degree that physical and performance characteristics are interchangeable with those of the original design. These characteristics should be obtained without resorting to additional product design effort or design data, and without recourse to the original design activity. Level 3 engineering drawings should:

a. Reflect the end-product;

b. Provide the engineering data for the support of quantity production; and

c. In conjunction with other related procurement data, provide the necessary data to permit competitive procurement of items substantially identical to the original item(s).

C.3 DRAWING PRACTICES

C.3.1 Engineering drawing practices – ASME Y14.100. ASME Y14.100 prescribes the general guidance for the preparation and revision of engineering drawings and associated data prepared by or for DOD departments and agencies. Reverse engineering personnel should become familiar with the various types of engineering drawings found in the drawing repositories, and with their impact when used for competitive acquisition. In developing adequate technical data packages (TDPs) for use in competitive acquisition, the data appearing on engineering drawings and their relationship to manufacturing should be clearly understood. AMSE Y14.100 may be used as a guide concerning the types of drawings and the information depicted on the drawings.

C.4 DEFINITION AND TYPES

C.4.1 Definition and types of engineering drawings.

C.4.1.1 Definition of engineering drawings. An engineering drawing is a document that discloses (directly or by reference) the physical and functional end-product requirements of an item through pictorial or written presentation, or combinations of both. Engineering drawings are normally procured from end-item contractors (manufacturers and designers) as part of the end-item acquisition. The Army receives, inspects and stores these drawings at designated data repositories. An original engineering drawing, and a Type I, Class I microfilm copy, are procured as deliverables under a production contract. Drawings and other technical data are acquired for two main purposes: for use in repair and installation of the system or equipment, and for use in procuring replenishment parts in support of system or equipment repair.

C.4.1.2 Types of engineering drawings. AMSE Y14.24 defines various types of engineering drawings, but only the major types of drawings will be discussed here, as follows:

C.4.1.2.1 Detail drawings. This drawing depicts the complete end-item requirements for the part(s) delineated on the drawing, except when additional end-product requirements are accomplished on inseparable assembly drawings.

C.4.1.2.2 Assembly drawing. This drawing depicts the assembled relationship of:

a. Two or more parts,

b. A combination of parts and subordinate assemblies, or

c. A group of assemblies required to form an assembly of higher order.

NOTE: An assembly drawing contains sufficient views to show the relationship between each subordinate assembly and part comprising the assembly depicted.

C.4.1.2.3 Detailed assembly drawing. This drawing depicts an assembly on which one or more parts are detailed in the assembly view or on detail views.

C.4.1.2.4 Matched parts drawing. This drawing depicts parts that are machine-matched or otherwise mated, and for which replacement as a matched set or pair is essential.

C.4.2. Schematic or electrical diagrams. These diagrams show, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. They facilitate tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.

C.4.3 Control drawing. This is an engineering drawing that discloses configuration and configuration limitations, performance and test requirements, weight and space limitations, access clearance, pipe and cable attachments, etc. The required level of detail is that necessary to allow the development or procurement of an item on the commercial market, or the installation and co-functioning of an item with related items. Control drawings are identified in four categories: Specification Control, Source Control, Altered Item, and Selected Item Drawings, as follows:

C.4.3.1 Specification control drawing.

a. A specification control drawing depicts an existing commercial item or vendor developed item which is advertised or cataloged as available on an unrestricted basis, on order as an off-the-shelf item, or as an item which, while not commercially available, is procurable on order from a specialized segment of an industry. The drawing, under the heading “Suggested Source(s) of Supply,” lists the name (address if known), manufacturer’s CAGE number, and item identification number of two or more known sources unless, after search of vendor data for similar products, it is determined that there is only one source. In addition, the notation “Specification Control Drawing” appears above the title block. The manufacturer’s (vender’s) part number is the item identification. The following appears in the body of the drawing:

> “IDENTIFICATION OF THE ‘SUGGESTED SOURCE(S) OF SUPPLY’ HERON IS NOT BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR THE ITEM(S).”

b. A specification control drawing discloses, as applicable, configuration, envelop dimensions, mounting and mating dimensions, interface dimensional characteristics, and limits to these dimensions. As necessary, it also discloses inspection and acceptance test requirements and performance, reliability, maintainability, environmental, and other functional requirements, to ensure identification and adequate reprocurement of an interchangeable item. If an electrical or electronics (or other engineering) circuit is involved, a schematic and connection or other appropriate diagrammatic disclosure is included or referenced on the drawing to provide sufficient information for making external connections.

c. In dealing with specification control drawings, you should be aware of the following:

1. The suggested sources listed on a specification control drawing are not intended to represent the only sources for the item;

2. Qualification testing of commercially or vendor developed items in advance of a procurement action is not a prerequisite for inclusion on a specification control drawing. If such testing or approval is essential, the item is normally a candidate for Source Control Drawing coverages;

3. Vendor developed items are those products of industries which normally provide customer application engineering services for a commercial product line; their products are commercially available from a specialized segment of an industry. Typical examples are special motors, synchros, transformers, potentiometers, hydraulic valves, carburetors, potted servo-amplifiers, keyboards, tape readers;

4. Altered items, selected items, and items depicted in Federal, military, and recognized industry association standards or specifications, are not delineated on Specification Control Drawings;

5. Specification control drawings are not used to depict commercially developed or vendor developed items upon which a design activity has placed requirements in addition to those normally provided by vendors. These kinds of items are depicted on either Selected Item Drawings or Altered Item Drawings, as appropriate;

6. This standard, by itself, should not cause preparation of specification control drawings for all applicable vendor items. Preparation criteria for engineering drawings are governed by the contract or order; and

7. Specification control drawings may be used for competitive acquisition. A specification control number is a control number and should not be used as a part identification number.

C.4.3.2 Source control drawings. Source control drawings depict an existing commercial or vendor item which exclusively provides the performance, installation, and interchangeable characteristics required for one or more specific critical applications.

a. A quality conformance inspection and approval procedure is stated on the drawing or in a document referenced on the drawing. The drawing includes the following statement:

> "ONLY THE ITEM DESCRIBED ON THIS DRAWING WHEN PROCURED FROM THE VENDOR(S) LISTED HEREON IS APPROVED BY (name and address of cognizant design activity) FOR USE IN THE APPLICATION(S) SPECIFIED HERON. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR APPROVAL BY (name of cognizant design activity) OR BY (name of Government procuring activity).
>
> IDENTIFICATION OF THE APPROVED SOURCE(S) OF SUPPLY HERON IS NOT TO BE CONSTRUED AS A GUARANTEE OF PRESENT OR CONTINUED AVAILABILITY AS A SOURCE OF SUPPLY FOR THE ITEM DESCRIBED ON THE DRAWING."

b. Source control drawing numbers are part identification numbers. When more than one vendor is listed on a Source Control Drawing for items that are repairable and the repair parts are not interchangeable, each vendor's item is assigned a dash-number of the Source Control Drawing.

c. The source control drawing includes, under the heading "Approved Source(s) of Supply," the name and address or manufacturer's CAGE number, and item identification number of each item that has been tested and approved for use in the specific applications stated on the drawing. In addition, "SOURCE CONTROL DRAWING" is shown adjacent to the title block. The item(s) thus disclosed will be identified in all subsequent actions (including procurement) by the Source Control Drawing number. When another vendor's item is qualified for stated applications, or when a new critical application is found, and all vendor items cited on the drawing are approved for use in the new critical application, the drawing may be revised, rather than a new drawing issued to show the vendor or application. Each new vendor added must be approved for all stated applications.

d. Altered items, selected items, and items depicted in Federal, military, and recognized industry association standards or specifications are not delineated on source control drawings.

e. A source control drawing discloses, as applicable, configuration, dimensions of envelope, mounting and mating dimensions, interface dimensional characteristics, and limits to these dimensions. As necessary, it also discloses inspection and acceptance test requirements, performance, reliability, maintainability, environmental, and other functional requirements, to ensure identification and adequate reprocurement of an interchangeable item. If an electrical or electronics (or other engineering) circuit is involved, a schematic

and connection or other appropriate diagrammatic disclosure is included on the drawing (or referenced thereon), thereby providing sufficient information for making external connections.

C.4.3.3 Altered item drawing. The design activity responsible for an alteration to a completed item prepares an Altered Item Drawing. (When a vendor activity document is referenced, the vendor data is submitted along with the Altered Item Drawing. If vendor or original design activity data is unobtainable, the Altered Item Drawing should contain the necessary information required to define the requirements for that item before its alteration.) An Altered Item Drawing delineates complete details on the alteration. The drawing should include the necessary information for identifying the item before its alternation, including the original identifying part number and, if it is a commercially or vendor developed item, the name (address if known), and manufacturer's CAGE number of the source of the original part. The name and address of the source do not need to be furnished if the original part is a Government or industry standard item. The notation "ALTERED ITEM DRAWING" should appear adjacent to the title block.

NOTE: Alterations may be shown on detail assembly drawings in lieu of a separate drawing, providing the above requirements are met and the altered item is noted as an "ALTERED ITEM."

C.4.3.4 Selected item drawing. A selected item drawing defines an existing standard or design or vendor activity item with further required selection or restriction of the item for fit, tolerance, performance, or reliability within the range or limits prescribed for that item. (When a vendor activity document is referenced, the vendor data is submitted along with the selected item drawings. If vendor or original design activity data is unobtainable, the Selected Item Drawing contains the necessary information required to define the requirements for that item prior to selection.) Although physical modification is not performed on the item, by virtue of the selection technique employed, it is demonstratively different than those identified on the document from which selection was made. In addition, the drawing should include all necessary information to identify the item prior to its delimited selection including the original identifying part number and, if it is a commercially or vendor developed item, the name (address if known), and manufacturer's CAGE number of the original source. The notation "SELECTED ITEM DRAWING" should appear adjacent to the title block.

C.4.3.5 Associated parts list. A parts list is a tabulation of all parts and bulk material (except those materials which support a manufacturing process) used in the item to which the list applies. The parts list may be integral or separate from the drawing. Generally, engineering drawings for electronic components such as transmitters, receivers, and power supplies are prepared with a separate parts list. When separate parts lists are required, a note "SEE SEPARATE PARTS LIST" should be located above the title block of the parent engineering drawing. ASME Y14.34M may be used as a guide preparing a parts list.

APPENDIX D

REFERENCE DOCUMENTS

D.1 SCOPE.

D.1.1 Scope. This appendix contains documents that may provide helpful information in addition to those documents listed in Section 2, Applicable Documents.

D.2 REFERENCE DOCUMENTS.

D.2.1 Reference documents. The following documents may be used as guidance for accomplishing the reverse engineering process.

D.2.1.1 International Organization for Standardization

ISO 10012-1	Quality Assurance Requirements for Measuring Equipment

D.2.1.2 Federal Specifications

GG-P-455	Plate and Foils, Photographic (Photosensitive Anodized Aluminum)

D.2.1.3 Federal Standards

FED-STD-H28/18	Screw-thread Standards for Federal Services Section 19 Photographic Equipment Threads

D.2.1.4 Commercial Item Descriptions

A-A-208	Ink, Marking, Stencil, Opaque (Porous and Non-Porous Surfaces)
A-A-50271	Plate, Identification
A-A-55822	Chests, Plywood
A-A-59544	Cable and Wire, Electrical (Power, Fixed Installation)

D.2.6 Military Specifications

MIL-PRF-27	Transformers and Inductors (Audio, Power, and High Power Pulse), General Specification for
MIL-DTL-3432	Cables (Power and Special Purpose) and Wire, Electrical (300 and 600 Volts)
MIL-PRF-5480	Data, Engineering and Technical, Reproduction, Performance Specification
MIL-G-10944	Gage, Dimensional Control
MIL-W-12332	Welding, Resistance, Spot, Seam, and Projection; for Fabricating Assemblies of Low Carbon Steel
MIL-PRF-19500	Semiconductor Device, General Specification for
MIL-P-19834	Plate, Identification, Metal Foil, Adhesive Backed

MIL-W-21157	Weldment, Steel, Carbon and Low Alloy (Yield Strength, 30,000 – 60,000 PSI)
MIL-W-22248	Weldments, Aluminum and Aluminum Alloy
MIL-DTL-45210	Welding, Resistance, Spot: Weldable Aluminum Alloys

D.2.1.5 Military Standards

MIL-STD-130	Identification Markings of U.S. Military Property
MIL-STD-209	Lifting and Tiedown Provisions
MIL-STD-419	Cleaning and Protecting Piping Tubing and Fittings for Hydraulic Power Transmission Equipment
MIL-STD-681	Identification Coding and Application of Hookup and Lead Wire
MIL-STD-690	Failure Rate Sampling Plans and Procedures
MIL-STD-882	System Safety
MIL-STD-889	Dissimilar Metals
MIL-STD-961	Defense and Program-Unique Specifications Format and Content
MIL-STD-1285	Marking of Electrical and Electronic Items
MIL-STD-1472	Human Engineering
MIL-STD-1474	Noise Limits
MIL-STD-2219	Fusion Welding for Aerospace Applications
MIL-STD-13231	Marking of Electronic Items

D.2.1.6 Military Handbooks

MIL-HDBK-198	Capacitors, Selection and Use of
MIL-HDBK-199	Resistors, Selection and Use of
MIL-HDBK-204	Design of Inspection Equipment for Dimensional Characteristics
MIL-HDBK-217	Reliability Prediction of Electronic Equipment
MIL-HDBK-223	Coded List of Materials
MIL-HDBK-310	Global Climatic Data for Developing Military Products
MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-HDBK-470	Designing and Developing Maintainable Products and Systems, Volume I and Volume II
MIL-HDBK-472	Maintainability Prediction
MIL-HDBK-691	Adhesive Bonding
MIL-HDBK-781	Reliability Test Methods, Plans, and Environments for Engineering Development, Qualification, and Production

D.2.1.7 Industry Standards

NCSL-Z540.1	Laboratories, Calibration, and Measuring Test Equipment
UL62	Flexible Cord and Fixture Wire

D.2.1.8 American National Standards Institute (ANSI)

ASME Y14.1	Drawing Sheet Size and Format, Decimal Inch
ASME Y14.1M	Drawing Sheet Size and Format, Metric

ASME Y14.5M	Dimensioning and Tolerancing
ASME Y14.13M	Mechanical Spring Representation
ASME Y14.24	Types and Applications of Engineering Drawings
ASME Y14.35M	Revision of Engineering Drawings and Associated Lists
ASME Y14.34M	Associated Lists
ASME Y14.38M	Abbreviations and Acronyms
AMSE Y14.100	Engineering Drawing Practices
ANSI B29.1	Roller Chains, Transmission, Attachments and Sprockets, Precision Power
AMSE B46.1	Surface Texture (Surface Roughness, Waviness and Lay)
ANSI Y32.10	Diagrams, Fluid Power, Graphic Symbols for

D.2.1.9 American Society for Testing and Materials (ASTM)

ASTM-G47	Aluminum Alloy Products, Determining Susceptibility to Stress Corrosion Cracking of 2XXX and 7XXX
ASTM B108	Aluminum Alloy Permanent Mold Castings
ASTM-B117	Salt Spray (Fog) Apparatus, Operating
ASTM B211	Aluminum and Aluminum-Alloy Bar, Rod and Wire ASTM-A309 Weight and Composition of Coating on Terne Sheet By the Triple-Spot Test
ASTM A400	Bars, Steel, Selection Guide, Composition and Mechanical Properties
ASTM A576	Steel Bars, Carbon, Hot-Wrought, Special Quality, Standard Specification for
ASTM-A630	Tin Coating Weights for Electrolytic Tin Plate Standard
ASTM-E1417	Liquid Penetrant Examination, Standard Practice for

D.2.1.10 Society for Automotive Engineers (SAE)

SAE-AMS-STD-66	Steel: Chemical Composition and Hardenability
SAE-AMS-W-6858	Welding, Resistance: Spot and Seam
SAE-AMS-H-7199	Heat Treatment of Wrought Copper-Beryllium Alloys, Process for (Copper Alloys: Numbers C17000, C17200, C17300, C17500, and C17510)

D.2.1.11 Miscellaneous Publications

TACOM	
Drawing 12479550	Arc Welding Procedures for Constructional Steel

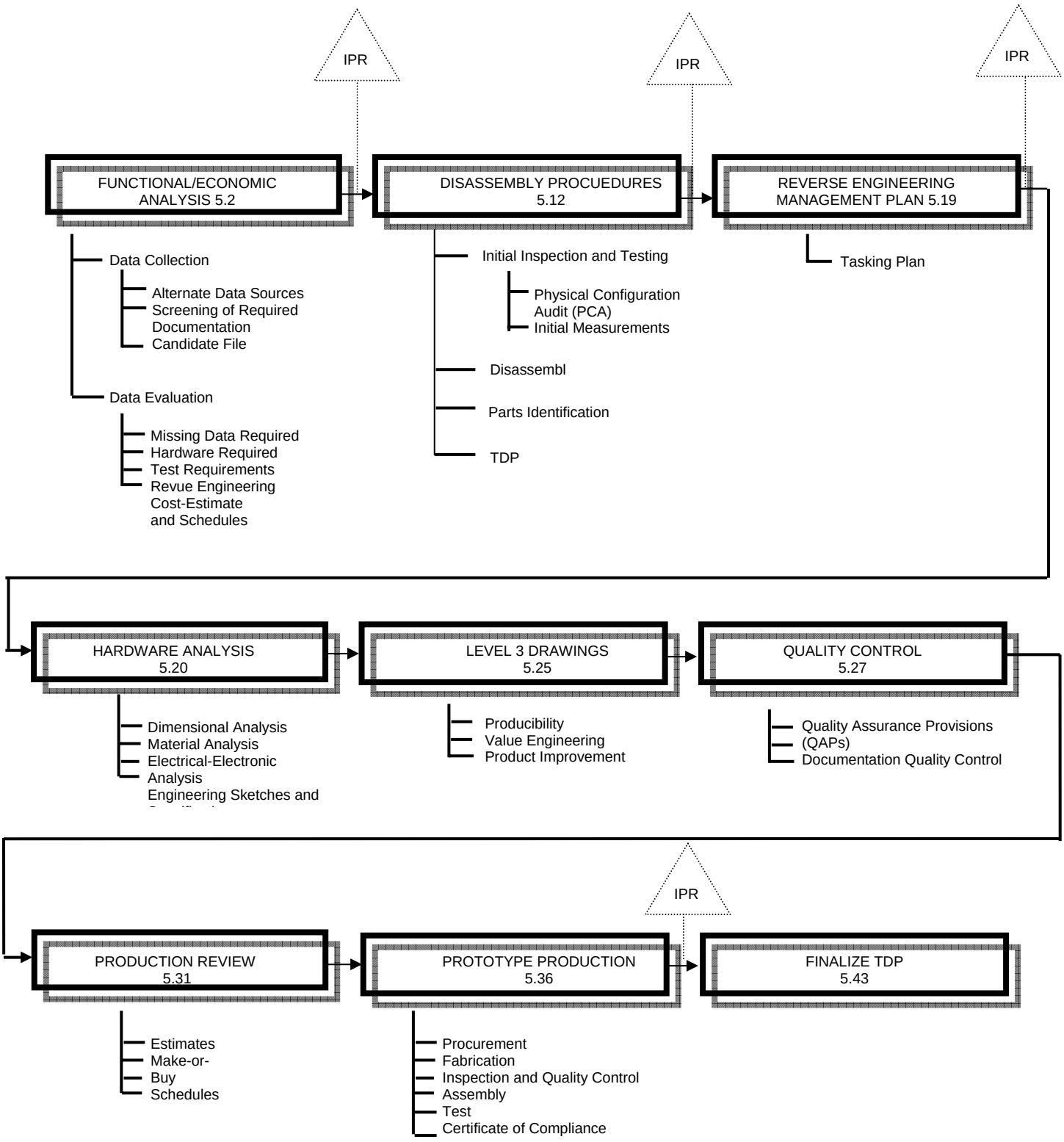


FIGURE 1: The reverse engineering process (see 5.1).

DATA CALL SHEET

NSN: _____

NOMENCLATURE: _____

PART NUMBER: _____

UNIT PRICE: _____

REPAIR CODE: _____

AVERAGE YEARLY DEMAND: _____

ANNUAL BUY VALUE: _____

QUANTITY IN STOCK: _____

QUANTITY DUE IN: _____

NUMBER ITEMS IN FIELD: _____

PRIORITY: _____

REASON: _____

NEXT HIGHER ASSEMBLY: _____

LOWER ASSEMBLY: _____

CURRENT AMC/AMSC: _____

CURRENT SOURCE: _____

ITEM MANAGER: _____

OTHER PERTINENT FACTORS:

FIGURE 2: Sample data call sheet (see 5.8.4).

TEST PLAN

NOMENCLATURE:
NSN:
DATE:

1.0 PURPOSE

The purpose of this Test Plan is to ensure that the (nomenclature) conforms to the contractual requirements, applicable Government Standards and Specifications, and the Technical Data Package (TDP) developed for competitive procurement.

2.0 REFERENCE DOCUMENTS

(number and title)

No. , Acceptance Test Procedure for (nomenclature)
ISO 10012-1 and NCSL-Z540.1, Calibration System Requirements

3.0 DEFINITION OF TEST PLAN

3.1 Introduction

The (nomenclature) will be tested as an (assembled unit – or – subassemblies - or component parts) in accordance with the Acceptance Test Procedure (ATP), No. , developed as part of this Test Plan.

3.2 Definition of Terms

TDP – Technical Data Package
ATP – Acceptance Test Procedure

3.3 Test Schedule

Each (nomenclature) manufactured to the Technical Data Package (TDP) will be tested upon receipt from the supplier.

FIGURE 3: Sample test plan format (see 5.10).
(Page 1 of 3)

TEST PLAN
(Continued)

3.4 Test Procedure

An ATP will be prepared for the (nomenclature) .
The ATP will include: Table of Tests, Test Equipment and Test Fixtures required; specific Test Methods to accomplish the tests; and Test Data Sheets. The test methods will be a step-by-step process to be utilized to accomplish the tests required. The test data sheets will define the acceptance/rejection criteria for all test parameters as well as provisions for recording actual measurements and pass/fail notations.

3.5 Test Equipment

All test equipment used for measurements during acceptance testing will have evidence of current calibration in compliance with the requirements of MIL-C-45662. The specific equipment and test fixtures will be listed in the ATP, Number .

3.6 Equipment to be Tested

Each of the prototype units will be subjected to 100% test for all of the characteristics listed in the test data sheets of the ATP.

3.7 Classification of Defects

Departure from the limits specified in the ATP and the test data sheets are considered to be major defects. Any defect discovered during the performance of the acceptance test will result in rejection of the unit under test.

4.0 DISPOSITION OF REJECTED MATERIAL

Units which fail the requirements of the Technical Data Package (TDP) or the ATP will be evaluated and returned to the source for repair/replacement. Dependent on the nature of the failure/rejection, failure analysis and/or corrective action may be required for both the hardware and the TDP.

FIGURE 3: Sample test plan format (see 5.10).
(Page 2 of 3)

TEST PLAN
(Continued)

5.0 RECORDS

Test data sheets will be completed for each unit fabricated. All records generated for this task will be retained for not less than nine (9) months after completion of the task.

6.0 CORRECTIONS TO THE TECHNICAL DATA PACKAGE (TDP)

When the test failure is attributed to an error or deficiency in the TDP, the discrepancy will be recorded and submitted to the Quality Control Department for approval, prior to updating the TDP.

FIGURE 3: Sample test plan format (see 5.10).
(Page 3 of 3)

REVERSE ENGINEERING ECONOMIC ANALYSIS

ITEM NO.	FUNCTION	MECH HOURS PER ITEM	ELEX HOURS PER ITEM	EST. NO. OF ITEMS	TOTAL EST. HRS
1	RECEIVE ITEM AND ENTER IN REVERSE ENGINEERING MANAGEMENT SYSTEM (REMS)	2	2	1	
2	REVIEW GFE & RETRIEVE ADDITIONAL DATA	8	8	1	
3	IDENTIFY/REVIEW TEST DATA. VALIDATE OR DEVELOP TEST PROCEDURES	40	120	1	
4	IDENTIFY PARTS AND DRAWINGS REQUIRED	8	24	1	
5	DISASSEMBLE-CONDUCT PCA	24	24	1	
6	DEVELOP SCHEDULE AND REVERSE ENGINEERING PLAN	8	3	1	
7	CONDUCT DIMENSION ANALYSIS	2	4		
8	DEVELOP LEVEL THREE DRAWINGS	16	16		
9	CONDUCT PRODUCIBILITY AND Q/A ANALYSIS	12	24		
10	REVIEW DRAWINGS AND PROTOTYPE COST W/CUSTOMER	.5	1.0		
11	INITIATE PROCUREMENT ACTION FOR PROTOTYPE AND/ OR PARTS	3	3		
12	RECEIVE PROTOTYPES, INSPECT, ASSEMBLE, TEST	8	24		
13	PREPARE REPORTS (TECH) PER REPORT	2	2		

TOTAL HOURS FOR REVERSE ENGINEERING FUNCTIONS _____

FIGURE 4: Sample cost-estimating guide (see 5.11.3).
(Page 1 of 5)

A. REVERSE ENGINEERING COSTS

1. REVERSE ENGINEERING PROCESS _____ TOTAL HOURS X _____ COMPOSITE RATE = _____
2. COST OF RENTAL EQUIPMENT FOR ANALYSIS & TEST _____
3. LABORATORY COST (MATERIAL ANALYSIS) _____
4. DELAMINATION OF COMPLEX ELEX BOARDS _____
5. PROTOTYPE COST (AT LEAST ITEM UNIT COST) X UNIT QUANTITY _____
6. SPECIAL TOOLING COST (BEST ESTIMATE) _____
7. TOTAL ESTIMATED COST TO REVERSE ENGINEER _____

B. ESTIMATED PROCUREMENT COST

1. ESTIMATED PROCUREMENT COST PER UNIT _____
2. ANNUAL BUY QUANTITY _____
3. PRE-REVERSE ENGINEERING ANNUAL BUY VALUE (B.1 X B.2) _____

C. ESTIMATED ANNUAL SAVINGS AFTER ENGINEERING (25% X B.3) _____

D. ESTIMATED ANNUAL BUY VALUE AFTER REVERSE ENGINEERING (B.3 – C) _____

E. FIRST YEAR COST AFTER REVERSE ENGINEERING (A.7 + D) _____

F. MINIMUM ESTIMATED COST (SAVINGS OR LOSS) OVER ESTIMATED REMAINING SERVICE LIFE OF ____ YEARS _____

(B.3) Pre-Reverse Engineering Annual Buy Value	X	_____ Years	MINUS

(A.7) Reverse Engineering Cost	+	(D) Est. Annual Buy Value After Reverse Engineering	X	_____ Years

FIGURE 4: Sample cost-estimating guide (see 5.11.3).
(Page 2 of 5)

G. SAVINGS CONSIDERING COST OF MONEY OVER SERVICE LIFE OF _____ YEARS. _____

(Using Interest Rate of 10%)

Monthly Payback of Amount of (F) from Interest Table X
12 Mo. X _____ Years.

FIGURE 4: Sample cost-estimating guide (see 5.11.3).

10.00% MONTHLY

PAYMENT REQUIRED TO AMORTIZE A LOAN

TERM	1 YEAR	2 YEARS	3 YEARS	4 YEARS	5 YEARS	6 YEARS	7 YEARS	8 YEARS	9 YEARS	10 YEARS	11 YEARS	12 YEARS
AMOUNT												
50	4.40	2.31	1.62	1.27	1.07	.93	.84	.76	.71	.67	.63	.60
100	8.80	4.62	3.23	2.54	2.13	1.86	1.67	1.52	1.41	1.33	1.26	1.20
200	17.59	9.23	6.46	5.08	4.25	3.71	3.33	3.04	2.82	2.65	2.51	2.40
300	26.38	13.85	9.69	7.61	6.38	5.56	4.99	4.56	4.23	3.97	3.76	3.59
400	35.17	18.46	12.91	10.15	8.50	7.42	6.65	6.07	5.64	5.29	5.01	4.79
500	43.96	23.08	16.14	12.69	10.63	9.27	8.31	7.59	7.04	6.61	6.26	5.98
600	52.75	27.69	19.37	15.22	12.75	11.12	9.97	9.11	8.45	7.93	7.52	7.18
700	61.55	32.31	22.59	17.76	14.88	12.97	11.63	10.63	9.86	9.26	8.77	8.37
800	70.34	36.92	25.82	20.30	17.00	14.83	13.29	12.14	11.27	10.58	10.02	9.57
900	79.13	41.54	29.05	22.83	19.13	16.68	14.95	13.66	12.68	11.90	11.27	10.76
1000	87.92	46.15	32.27	25.37	21.25	18.53	16.61	15.18	14.08	13.22	12.52	11.96
2000	175.84	92.29	64.54	50.73	42.50	37.06	33.21	30.35	28.16	26.44	25.04	23.91
3000	263.75	138.44	96.81	76.09	63.75	55.58	49.81	45.53	42.24	39.65	37.56	35.86
4000	351.67	184.58	129.07	101.46	84.99	74.11	66.41	60.70	56.32	52.87	50.08	47.81
5000	439.58	230.73	161.34	126.82	106.24	92.63	83.01	75.88	70.40	66.08	62.60	59.76
6000	527.50	276.87	193.61	152.18	127.49	111.16	99.61	91.05	84.48	79.30	75.12	71.71
7000	615.42	323.02	225.88	177.54	148.73	129.69	116.21	106.22	98.56	92.51	87.64	83.66
8000	703.33	369.16	258.14	202.91	169.98	148.21	132.81	121.40	112.63	105.73	100.16	95.61
9000	791.25	415.31	290.41	228.27	191.23	166.74	149.42	136.57	126.71	118.94	112.68	107.56
10000	879.16	461.45	322.68	253.63	212.48	185.26	166.02	151.75	140.79	132.16	125.20	119.51
11000	967.08	507.60	354.94	278.99	233.72	203.79	182.62	166.92	154.87	145.37	137.72	131.46
12000	1055.00	553.74	387.21	304.36	254.97	222.32	199.22	182.09	168.95	158.59	150.24	143.41
13000	1142.91	599.89	419.48	329.72	276.22	240.84	215.82	197.27	183.03	171.80	162.76	155.37
14000	1230.83	646.03	451.75	355.08	297.46	259.37	232.42	212.44	197.11	185.02	175.28	167.32
15000	1318.74	692.18	484.01	380.44	318.71	277.89	249.02	227.62	211.19	198.23	187.80	179.27
16000	1406.66	738.32	516.28	405.81	339.96	296.42	265.62	242.79	225.26	211.45	200.32	191.22
17000	1494.58	784.47	548.55	431.17	361.20	314.94	282.23	257.97	239.34	224.66	212.84	203.17
18000	1582.49	830.61	580.81	456.53	382.45	333.47	298.83	273.14	253.42	237.88	225.36	215.12
19000	1670.41	876.76	613.08	481.89	403.70	352.00	315.43	288.31	267.50	251.09	237.88	227.07
20000	1758.32	922.90	645.35	507.26	424.95	370.52	332.03	303.49	281.58	264.31	250.40	239.02
21000	1846.24	969.05	677.62	532.62	446.19	389.05	348.63	318.66	295.66	277.52	262.92	250.97
22000	1934.15	1015.19	709.88	557.98	467.44	407.57	365.23	333.84	309.74	290.74	275.44	262.92
23000	2022.07	1061.34	742.15	583.34	488.69	426.10	381.83	349.01	323.81	303.95	287.96	274.87
24000	2109.99	1107.48	774.42	608.71	509.93	444.63	398.43	364.18	337.89	317.17	300.48	286.82
25000	2197.90	1153.63	806.68	634.07	531.18	463.15	415.03	379.36	351.97	330.38	313.00	298.77
26000	2285.82	1199.77	838.95	659.43	552.43	481.68	431.64	394.53	366.05	343.60	325.52	310.73
27000	2373.73	1245.92	871.22	684.79	573.68	500.20	448.24	409.71	380.13	356.81	338.04	322.68
28000	2461.65	1292.06	903.49	710.16	594.92	518.73	464.84	424.88	394.21	370.03	350.56	334.63
29000	2549.57	1338.21	935.75	735.52	616.17	537.25	481.44	440.06	408.29	383.24	363.08	346.58
30000	2637.48	1384.35	968.02	760.88	637.42	555.78	498.04	455.23	422.37	396.46	375.60	358.53
31000	2725.40	1430.50	1000.29	786.25	658.66	574.31	514.64	470.40	436.44	409.67	388.12	370.48
32000	2813.31	1476.64	1032.56	811.61	679.91	592.83	531.24	485.58	450.52	422.89	400.64	382.43
33000	2901.23	1522.79	1064.82	836.97	701.16	611.36	547.84	500.75	464.60	436.10	413.16	394.38
34000	2989.15	1568.93	1097.09	862.33	722.40	629.88	564.45	515.93	478.68	449.32	425.68	406.33
35000	3077.06	1615.08	1129.36	887.70	743.65	648.41	581.05	531.10	492.76	462.53	438.20	418.28
36000	3164.98	1661.22	1161.62	913.06	764.90	666.94	597.65	546.27	506.84	475.75	450.72	430.23
37000	3252.89	1707.37	1193.89	938.42	786.15	685.46	614.25	561.45	520.92	488.96	463.24	442.18
38000	3340.81	1753.51	1226.16	963.78	807.39	703.99	630.85	576.62	535.00	502.18	475.76	454.13
39000	3428.72	1799.66	1258.43	989.15	828.64	722.51	647.45	591.80	549.07	515.39	488.28	466.09
40000	3516.64	1845.80	1290.69	1014.51	849.89	741.04	664.05	606.97	563.15	528.61	500.80	478.04
41000	3604.56	1891.95	1322.96	1039.87	871.13	759.56	680.65	622.15	577.23	541.82	513.32	489.99
42000	3692.47	1938.09	1355.23	1065.23	892.38	778.09	697.25	637.32	591.31	555.04	525.84	501.94
43000	3780.39	1984.24	1387.49	1090.60	913.63	796.62	713.86	652.49	605.39	568.25	538.36	513.89
44000	3868.30	2030.38	1419.76	1115.96	934.87	815.14	730.46	667.67	619.47	581.47	550.88	525.84
45000	3956.22	2076.53	1452.03	1141.32	956.12	833.67	747.06	682.84	633.55	594.68	563.40	537.79
46000	4044.14	2122.67	1484.30	1166.68	977.37	852.19	763.66	698.02	647.62	607.90	575.92	549.74
47000	4132.05	2168.82	1516.56	1192.05	998.62	870.72	780.26	713.19	661.70	621.11	588.44	561.69
48000	4219.97	2214.96	1548.83	1217.41	1019.86	889.25	796.86	728.36	675.78	634.33	600.96	573.64
49000	4307.88	2261.11	1581.10	1242.77	1041.11	907.77	813.46	743.54	689.86	647.54	613.48	585.59
50000	4395.80	2307.25	1613.36	1268.13	1062.36	926.30	830.06	758.71	703.94	660.76	626.00	597.54
55000	4835.38	2537.98	1774.70	1394.95	1168.59	1018.93	913.07	834.58	774.33	726.83	688.60	657.30
60000	5274.96	2768.70	1936.04	1521.76	1274.83	1111.56	996.08	910.45	844.73	792.91	751.20	717.05
65000	5714.54	2999.43	2097.37	1648.57	1381.06	1204.18	1079.08	986.33	915.12	858.98	813.80	776.81
70000	6154.12	3230.15	2258.71	1775.39	1487.30	1296.81	1162.09	1062.20	985.51	925.06	876.40	836.56
75000	6593.70	3460.87	2420.04	1902.20	1593.53	1389.44	1245.09	1138.07	1055.91	991.14	939.00	896.31
80000	7033.28	3691.60	2581.38	2029.01	1699.77	1482.07	1328.10	1213.94	1126.30	1057.21	1001.60	956.07
85000	7472.86	3922.32	2742.72	2155.82	1806.00	1574.70	1411.11	1289.81	1196.69	1123.29	1064.19	1015.82
90000	7912.43	4153.05	2904.05	2282.64	1912.24	1667.33	1494.11	1365.68	1267.09	1189.36	1126.79	1075.58
95000	8352.01	4383.77	3065.39	2409.45	2018.47	1759.96	1577.12	1441.55	1337.48	1255.44	1189.39	1135.33
100000	8791.59	4614.50	3226.72	2536.26	2124.71	1852.59	1660.12	1517.42	1407.87	1321.51	1251.99	1195.08

FIGURE 4: Sample cost-estimating guide (see 5.11.3).

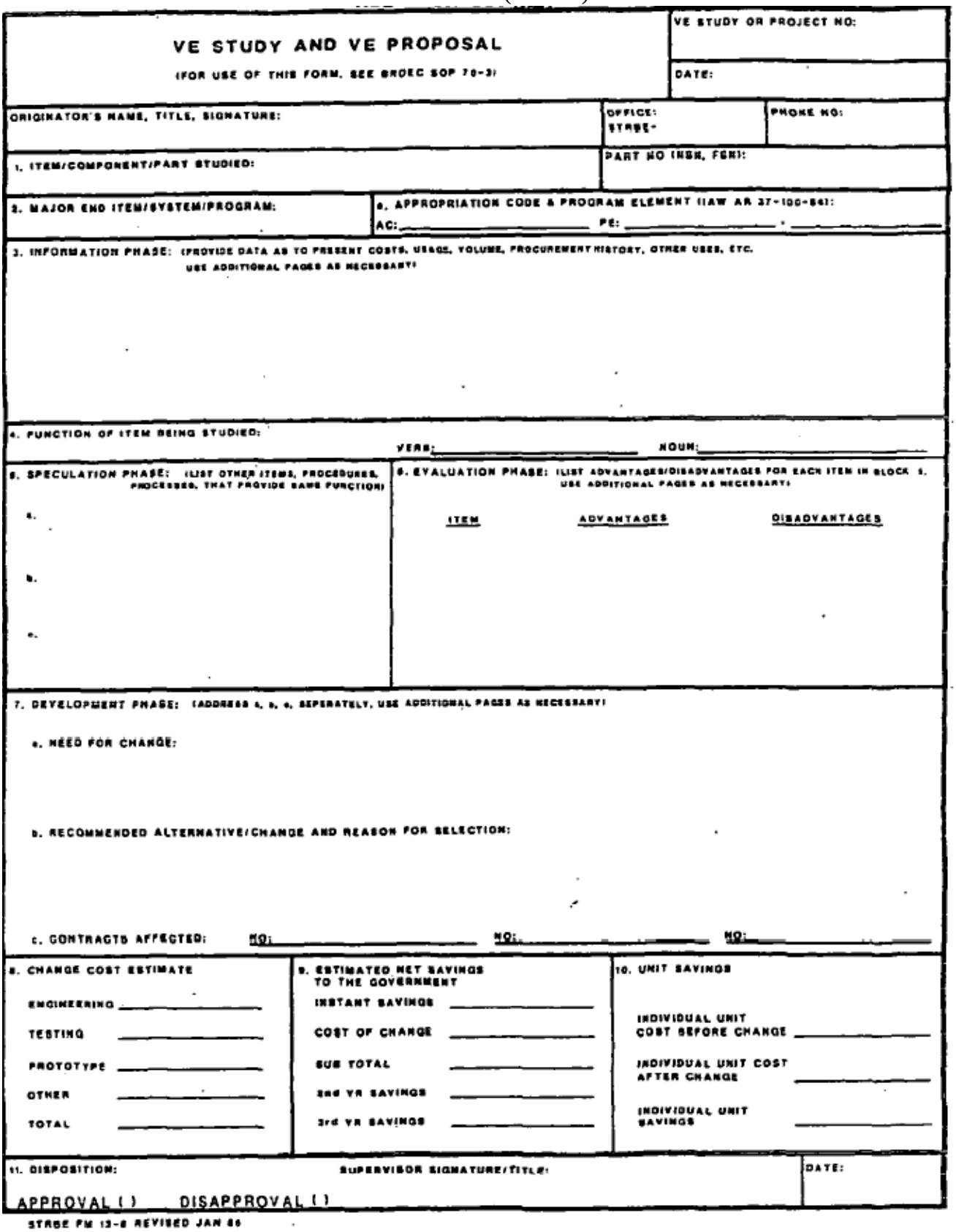
(Page 4 of 5)

MONTHLY 10.00%

PAYMENT REQUIRED TO AMORTIZE A LOAN

TERM	13 YEARS	14 YEARS	15 YEARS	16 YEARS	17 YEARS	18 YEARS	19 YEARS	20 YEARS	25 YEARS	30 YEARS	35 YEARS	40 YEARS
AMOUNT												
50	.56	.56	.54	.53	.52	.50	.50	.49	.46	.44	.43	.43
100	1.15	1.11	1.08	1.05	1.03	1.00	.99	.97	.91	.88	.86	.85
200	2.30	2.22	2.15	2.10	2.05	2.00	1.97	1.94	1.82	1.76	1.72	1.70
300	3.45	3.33	3.23	3.14	3.07	3.00	2.95	2.90	2.73	2.64	2.58	2.55
400	4.60	4.44	4.30	4.19	4.09	4.00	3.93	3.87	3.64	3.52	3.44	3.40
500	5.74	5.55	5.38	5.23	5.11	5.00	4.91	4.83	4.55	4.39	4.30	4.25
600	6.89	6.65	6.45	6.28	6.13	6.00	5.89	5.80	5.46	5.27	5.16	5.10
700	8.04	7.76	7.53	7.33	7.15	7.00	6.87	6.76	6.37	6.15	6.02	5.95
800	9.19	8.87	8.60	8.37	8.17	8.00	7.86	7.73	7.27	7.03	6.88	6.80
900	10.34	9.98	9.68	9.42	9.20	9.00	8.84	8.69	8.18	7.90	7.74	7.65
1000	11.48	11.09	10.75	10.46	10.22	10.00	9.82	9.66	9.09	8.78	8.60	8.50
2000	22.96	22.17	21.50	20.92	20.43	20.00	19.63	19.31	18.18	17.56	17.20	16.99
3000	34.44	33.25	32.24	31.38	30.64	30.00	29.44	28.96	27.27	26.33	25.80	25.48
4000	45.92	44.33	42.99	41.84	40.85	40.00	39.26	38.61	36.35	35.11	34.39	33.97
5000	57.40	55.42	53.74	52.30	51.07	50.00	49.07	48.26	45.44	43.88	42.99	42.46
6000	68.88	66.50	64.48	62.76	61.28	60.00	58.88	57.91	54.53	52.66	51.59	50.95
7000	80.35	77.58	75.23	73.22	71.49	69.99	68.69	67.56	63.61	61.44	60.18	59.45
8000	91.83	88.66	85.97	83.68	81.70	79.99	78.51	77.21	72.70	70.21	68.78	67.94
9000	103.31	99.74	96.72	94.14	91.91	89.99	88.32	86.86	81.79	78.99	77.38	76.43
10000	114.79	110.83	107.47	104.60	102.13	99.99	98.13	96.51	90.88	87.76	85.97	84.92
11000	126.27	121.91	118.21	115.05	112.34	109.99	107.94	106.16	99.96	96.54	94.57	93.41
12000	137.75	132.99	128.96	125.51	122.55	119.99	117.76	115.81	109.05	105.31	103.17	101.90
13000	149.23	144.07	139.70	135.97	132.76	129.98	127.57	125.46	118.14	114.09	111.76	110.39
14000	160.70	155.15	150.45	146.43	142.97	139.98	137.38	135.11	127.22	122.87	120.36	118.89
15000	172.18	166.24	161.20	156.89	153.19	149.98	147.19	144.76	136.31	131.66	128.96	127.38
16000	183.66	177.32	171.94	167.35	163.40	159.98	157.01	154.41	145.40	140.42	137.55	135.87
17000	195.14	188.40	182.69	177.81	173.61	169.98	166.82	164.06	154.48	149.19	146.15	144.36
18000	206.62	199.48	193.43	188.27	183.82	179.98	176.63	173.71	163.57	157.97	154.75	152.85
19000	218.10	210.56	204.18	198.73	194.03	189.98	186.44	183.36	172.66	166.74	163.34	161.34
20000	229.57	221.65	214.93	209.19	204.25	199.97	196.26	193.01	181.75	175.52	171.94	169.83
21000	241.05	232.73	225.67	219.64	214.46	209.97	206.07	202.66	190.83	184.30	180.54	178.33
22000	252.53	243.81	236.42	230.10	224.67	219.97	215.88	212.31	199.92	193.07	189.13	186.82
23000	264.01	254.89	247.16	240.56	234.88	229.97	225.69	221.96	209.01	201.85	197.73	195.31
24000	275.49	265.97	257.91	251.02	245.10	239.97	235.51	231.61	218.09	210.62	206.33	203.80
25000	286.97	277.06	268.66	261.48	255.31	249.97	245.32	241.26	227.18	219.40	214.92	212.29
26000	298.45	288.14	279.40	271.94	265.52	259.96	255.13	250.91	236.27	228.17	223.52	220.78
27000	309.92	299.22	290.15	282.40	275.73	269.96	264.94	260.56	245.35	236.95	232.12	229.27
28000	321.40	310.30	300.89	292.86	285.94	279.96	274.76	270.21	254.44	245.73	240.71	237.77
29000	332.88	321.38	311.64	303.32	296.16	289.96	284.57	279.86	263.53	254.50	249.32	246.26
30000	344.36	332.47	322.39	313.78	306.37	299.96	294.38	289.51	272.62	263.28	257.91	254.75
31000	355.84	343.55	333.13	324.23	316.58	309.96	304.20	299.16	281.70	272.05	266.50	263.24
32000	367.32	354.63	343.88	334.69	326.79	319.95	314.01	308.81	290.79	280.83	275.10	271.73
33000	378.79	365.71	354.62	345.15	337.00	329.95	323.82	318.46	299.88	289.60	283.70	280.22
34000	390.27	376.79	365.37	355.61	347.22	339.95	333.63	328.11	308.96	298.38	292.29	288.71
35000	401.75	387.88	376.12	366.07	357.43	349.95	343.45	337.76	318.05	307.16	300.89	297.21
36000	413.23	398.96	386.86	376.53	367.64	359.95	353.26	347.41	327.14	315.93	309.49	305.70
37000	424.71	410.04	397.61	386.99	377.85	369.95	363.07	357.06	336.22	324.71	318.08	314.19
38000	436.19	421.12	408.35	397.45	388.06	379.95	372.88	366.71	345.31	333.48	326.68	322.68
39000	447.67	432.20	419.10	407.91	398.28	389.94	382.70	376.36	354.40	342.26	335.28	331.17
40000	459.14	443.29	429.85	418.37	408.49	399.94	392.51	386.01	363.49	351.03	343.87	339.66
41000	470.62	454.37	440.59	428.82	418.70	409.94	402.32	395.66	372.57	359.81	352.47	348.15
42000	482.10	465.45	451.34	439.28	428.91	419.94	412.13	405.31	381.66	368.59	361.07	356.65
43000	493.58	476.53	462.09	449.74	439.13	429.94	421.95	414.98	390.75	377.36	369.66	365.14
44000	505.06	487.61	472.83	460.20	449.34	439.94	431.76	424.61	399.83	386.14	378.26	373.63
45000	516.54	498.70	483.58	470.66	459.55	449.93	441.57	434.26	408.92	394.91	386.86	382.12
46000	528.02	509.78	494.32	481.12	469.76	459.93	451.38	443.91	418.01	403.69	395.45	390.61
47000	539.49	520.86	505.07	491.58	479.97	469.93	461.20	453.57	427.09	412.46	404.05	399.10
48000	550.97	531.94	515.82	502.04	490.19	479.93	471.01	463.22	436.18	421.24	412.65	407.60
49000	562.45	543.02	526.56	512.50	500.40	489.93	480.82	472.87	445.27	430.02	421.24	416.09
50000	573.93	554.11	537.31	522.96	510.61	499.93	490.63	482.52	454.36	438.79	429.84	424.58
55000	631.32	609.52	591.04	575.25	561.67	549.92	539.70	530.77	499.79	482.67	472.82	467.04
60000	688.71	664.93	644.77	627.55	612.73	599.91	588.76	579.02	545.23	526.55	515.81	509.49
65000	746.11	720.34	698.50	679.84	663.79	649.90	637.82	627.27	590.66	570.43	558.79	551.95
70000	803.50	775.75	752.23	732.14	714.85	699.90	686.89	675.52	636.10	614.31	601.78	594.41
75000	860.89	831.16	805.96	784.43	765.91	749.89	735.95	723.77	681.53	658.18	644.76	636.86
80000	918.28	886.57	859.69	836.73	816.97	799.88	785.01	772.02	726.97	702.06	687.74	679.32
85000	975.68	941.98	913.42	889.02	868.03	849.87	834.08	820.27	772.40	745.94	730.73	721.78
90000	1033.07	997.39	967.15	941.32	919.09	899.86	883.14	868.52	817.84	789.82	773.71	764.24
95000	1090.46	1052.80	1020.88	993.61	970.15	949.86	932.20	916.78	863.27	833.70	816.69	806.69
100000	1147.85	1108.21	1074.61	1045.91	1021.22	999.85	981.26	965.03	908.71	877.58	859.68	849.15

FIGURE 4: Sample cost-estimating guide (see 5.11.3).
(Page 5 of 5)



VE STUDY AND VE PROPOSAL

(FOR USE OF THIS FORM, SEE SRDEC SOP 70-3)

VE STUDY OR PROJECT NO:

DATE:

ORIGINATOR'S NAME, TITLE, SIGNATURE:

OFFICE: STRBE-

PHONE NO:

1. ITEM/COMPONENT/PART STUDIED:

PART NO (NSN, FSN):

2. MAJOR END ITEM/SYSTEM/PROGRAM:

3. APPROPRIATION CODE & PROGRAM ELEMENT (IAW AR 37-100-84):

AC: _____ PE: _____ . _____

3. INFORMATION PHASE: (PROVIDE DATA AS TO PRESENT COSTS, USAGE, VOLUME, PROCUREMENT HISTORY, OTHER USES, ETC. USE ADDITIONAL PAGES AS NECESSARY)

4. FUNCTION OF ITEM BEING STUDIED:

VERB: _____ NOUN: _____

5. SPECULATION PHASE: (LIST OTHER ITEMS, PROCEDURES, PROCESSES, THAT PROVIDE SAME FUNCTION)

a.

b.

c.

6. EVALUATION PHASE: (LIST ADVANTAGES/DISADVANTAGES FOR EACH ITEM IN BLOCK 5. USE ADDITIONAL PAGES AS NECESSARY)

ITEM	ADVANTAGES	DISADVANTAGES

7. DEVELOPMENT PHASE: (ADDRESS a, b, c, SEPERATELY, USE ADDITIONAL PAGES AS NECESSARY)

a. NEED FOR CHANGE:

b. RECOMMENDED ALTERNATIVE/CHANGE AND REASON FOR SELECTION:

c. CONTRACTS AFFECTED: NO: _____ NO: _____ NO: _____

8. CHANGE COST ESTIMATE

ENGINEERING _____

TESTING _____

PROTOTYPE _____

OTHER _____

TOTAL _____

9. ESTIMATED NET SAVINGS TO THE GOVERNMENT

INSTANT SAVINGS _____

COST OF CHANGE _____

SUB TOTAL _____

2nd YR SAVINGS _____

3rd YR SAVINGS _____

10. UNIT SAVINGS

INDIVIDUAL UNIT COST BEFORE CHANGE _____

INDIVIDUAL UNIT COST AFTER CHANGE _____

INDIVIDUAL UNIT SAVINGS _____

11. DISPOSITION: SUPERVISOR SIGNATURE/TITLE: DATE:

APPROVAL ( ) DISAPPROVAL ( )

STRBE FM 13-8 REVISED JAN 86

FIGURE 5: Value engineering study and value engineering proposal (see 5.46.1).
(Page 1 of 2)

INSTRUCTIONS FOR PREPARATION OF VE STUDY
SUMMARY AND VE PROPOSAL

1. General. In accordance with AR 5-4, all in-house VE proposals must be the results of a Value Engineering Study. This form was designed to combine the two functions of documenting the study effort and presentation of the VE proposal.

2. Proposal Preparation. Instructions for preparation of STRBE-FM 13-8.

Block: VE STUDY OR PROJECT NO – Obtain from the BRDEC VEPM.

Block: ORIGNIATOR'S NAME, TITLE, SIGNATURE – Name of person(s) responsible for the proposal.

Block: DATE, OFFICE, PHONE NO – Self explanatory

Block (1) – Provide the name of the item or part being studied, plus part no. if available.

Block (2) – Provide the name of the major end item, process or system for item being studied.

Ex. Engine–Driven Generator.

Block (2a) – List appropriation code, program element number IAW AR 37-100-84.

Ex. AC: OMA, PE: 644714.19400.

Block (3) – INFORMATION PHASE. Record all pertinent information and data you have gathered; anything that has an influence on the item being studied.

Block (4) – FUNCTION. Describe the primary function of the item being studied in the verb-noun format; e.g., "The primary function of a file cabinet may be to organize files."

Block (5) – SPECULATION PHASE. List (at least two) alternative solutions being considered, one of which will be selected for the VE proposal.

Block (6) – EVALUATION PHASE. In brief terms, describe advantages and disadvantages of each alternative listed in Block 5, above.

Block (7) – DEVELOPMENT PHASE.

a. Need for Change. Enter either the problem the VEP intends to correct, or the new capability the VEP intends to provide.

b. Indicate selected alternative and why it was selected.

c. List known contracts which will be affected by this change.

Block (8) * - List all costs required to implement the alternative/change.

Block (9) * - Estimated savings.

Block (10) * - Unit savings.

* Cost estimates should be supportable and documentation furnished.

Block (11) – DISPOSITION. Approval/disapproval must be indicated. Signature of immediate supervisor.

FIGURE 5: Value engineering study and value engineering proposal (see 5.46.1).
(Page 2 of 2)

Custodian:
Army – AV

Preparing Activity:
Army – AV

Review Activities:
Army – AM, AR, AT, CR, MI

Project Number:
MISC-2006-004

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at http://assist.daps.dla.mil.