AEROSPACE STANDARD

AS1390™	REV. A
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(R) Level of Repair Analysis (LORA)

RATIONALE

Estimating life cycle support costs can be problematic due to a lack of a standard analytical methodology in both government and industry. This SAE Aerospace Standard (AS) provides a standardized approach for implementing and conducting the Level of Repair Analysis (LORA) activities required by the SAE standard TA-STD-0017A to determine an effective maintenance and support system for a product. This document provides general requirements and descriptions of activities which, when performed in a logical and iterative nature, constitute the LORA process. These requirements are structured for maximum flexibility in their application.

FOREWORD

Level of Repair Analysis (LORA) is usually included in the supportability analysis work completed during the design and modification of a product throughout its life cycle. It is important to have a process that can be applied consistently in all applications. This standard is intended to assist one in determining the completeness of a LORA process by identifying and describing minimum criteria that any LORA should include. It does not attempt to to define a specific LORA process nor does it provide an exhaustive set of equations to be used in a LORA model.

This standard establishes a process to implement the LORA activity identified in SAE TA-STD-0017A. The LORA process can also be applied to other similar supportability engineering processes. LORA is conducted commensurate with the level of design, operation, and support data available. The purpose of the LORA process is to determine the most effective maintenance and support system for a product through iterative evaluations of both economic and non-economic considerations. The LORA process is an analytical effort undertaken to influence decisions on the product's design, maintenance planning, cost, and integrated product support (IPS) element resources. As a consequence, the LORA process forms an integral part of the product support analysis (PSA) process by using results of, and feeding results to, various PSA activities and the logistics product data (LPD). The LORA process shall start early in the acquisition effort and then be reiterated as the product design and information about the product design becomes more refined throughout the product's life cycle to disposal.

This standard applies to all system acquisition programs, major modification programs, engineering changes, and applicable research and development projects through all phases of the product life cycle. This standard is for use by both industry and government activities performing LORA on products to which this standard applies.

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For more information on this standard, visit
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1. SCOPE

This SAE Aerospace Standard (AS) establishes general requirements and descriptions of specific activities for the performance of LORA during the life cycle of products or equipment. When these requirements and activities are performed in a logical and iterative nature, they constitute the LORA process.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP5580	Recommended Failure Modes and Effects Analysis (FMEA) Practices for Non-Automobile Applications
EIA-649C	Configuration Management Standard
EIA-836B	Configuration Management Data Exchange and Interoperability
GEIA-STD-0007C	Logistics Product Data
GEIA-STD-0009A	Reliability Program Standard for Systems Design, Development, and Manufacturing
TA-STD-0017A	Product Support Analysis

2.1.2 Associated SAE Engineering Standards

Appendix D of this document lists associated standards to the systems engineering, reliability analysis, configuration management, product data management, system safety, and product support analysis disciplines. These standards cover processes used to manage the development, production, and sustainment of systems, including products and services which will be useful to the LORA practitioner in understanding the characteristics of their system.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 U.S. Department of Defense Publications

Available from Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094, Tel: 215-697-6257, https://assist.dla.mil.

MIL-HDBK-502A	Product Support Analysis
MIL-HDBK-798	System Engineer's Design for Discard Handbook
MIL-STD-1388-2B	Logistics Support Analysis (Cancelled)
MIL-STD-1390D	Level of Repair Analysis (Cancelled)

2.3 Definitions

ACTIVITY: A unit of specific work behavior with a clear beginning and ending point. During the course of the product's life cycle, each activity may occur multiple times due to a variety of reasons, such as redesign, program schedule changes, life cycle extensions, etc. The activity should be directly observable or an otherwise measurable process, typically resulting in a product that can be evaluated for quantity, quality, or accuracy.

ADDITIVE MANUFACTURING (AM): Manufacturing or fabrication processes that involve the joining of materials to make objects from three-dimensional model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies. Examples of available additive manufacturing technologies are 3D printing, powder bed fusion, and cold spray.

AVAILABILITY: A measure of the degree to which a product is in an operable and committable state. Availability is typically expressed in terms of two components: (1) materiel availability, which is a fleet-wide measure, and (2) operational availability, which is an operational unit-level measure. Establishing an acceptable level of operational availability is an integral step in determining fleet-wide availability.

BREAKDOWN ELEMENT IDENTIFIER (BEI): A value that uniquely identifies a breakdown element or system/equipment. The value may be a generated identifier with no logical structure. The acquirer may specify additional rules and requirements for the structure of the identifier.

CONDITION BASED MAINTENANCE (CBM): A maintenance strategy based on equipment operational experience derived from analysis. CBM includes maintenance processes and capabilities derived from real-time or approximate real-time assessments obtained from embedded sensors or external tests and measurements using either portable equipment or actual inspection. The objective of CBM is to perform maintenance based on the evidence of need while ensuring safety, reliability, availability, and reduced total ownership cost.

COMPONENT: A subsystem, assembly, subassembly, or other major element of an end item.

CONSTRAINTS: Restrictions or key boundary conditions that impact overall capability, priority, and resources in system acquisition.

CONTRACTOR: The organization that provides goods or services as defined in a written agreement.

CORRECTIVE MAINTENANCE: All actions performed in order to restore a product to a specified condition after a failure has occurred.

CUSTOMER: An organization purchasing or requiring LORA activities.

DISCARD: A maintenance action in which no attempt is made to repair a failed item and that item is stored or thrown away (discarded). Before disposal, certain steps may be required such as destruction, reclamation of precious materials, or processing of hazardous materials.

ECONOMIC LORA EVALUATION: An analysis used to determine and identify the most cost effective maintenance concept for all products in the LORA candidates list.

END ITEM: A product that, when assembled or completed, will be considered ready for issue or deployment.

END USER: The organization or individual who actually uses a particular product.

ENVIRONMENT: The aggregate of all external and internal conditions (such as temperature, humidity, radiation, magnetic and electric fields, or shock vibration) either natural or manmade, or self-induced that influences the form, performance, reliability, or survival of a product.

FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS (FMECA): A quantitative reliability analysis by which each potential failure mode of a component, equipment or sub-system in a system is analyzed to determine the results or effects thereof on the overall system and to classify each potential failure mode according to its severity. FMECA leads to design improvement, mitigation of failure-caused hazards and identification of mission-critical functions.

GUIDANCE CONFERENCE: A conference used to ensure that the contractor and the customer have a firm understanding of the contractual requirements, establish funding and activity milestones, and formulate firm commitments for optional requirements in accordance with applicable data requirements. A vital aspect for any type of guidance conference is that the mutual agreements of all applicable contractual requirements are documented, dated and signed as agreed upon and accepted by both parties.

HUMAN FACTORS ENGINEERING (HFE): Is responsible for addressing the interplay of human interactions, abilities, limitations, behaviors, and processes with technology and environment.

HUMAN SYSTEMS INTEGRATION (HSI): A comprehensive management and technical approach applied to systems development and integration as part of a wider systems engineering process to ensure that human performance is optimized to increase total system performance and minimize the total system ownership cost. HSI efforts accomplish this by ensuring that the human is fully and continuously considered as part of the total system in the development and acquisition of all systems. HSI considerations comprise human factors engineering, safety and occupational health, habitability, force protection and survivability, manpower, personnel, and training. Refer to SAE6906 Best Practice Standard for Human Systems Integration for more information.

INTEGRATED PRODUCT SUPPORT (IPS) ELEMENTS: Those critical functions related to product readiness including, but not limited to, materiel management, distribution, technical data management, maintenance, training, cataloging, configuration management, engineering support, repair parts management, failure reporting and analysis, reliability growth tracking, and the logistics components (e.g., support equipment, spares) required to accomplish the functions. All of the IPS elements shall be considered during the development of the Product Support (PS) strategy. The IPS elements consist of the following: product support management; supply support; packaging, handling, storage and transportation; maintenance planning and management; design interface; sustaining engineering; technical data; IT systems continuous support; facilities and infrastructure; manpower and personnel; support equipment; and training and training support.

LEVEL OF REPAIR ANALYSIS (LORA): An analytical methodology used to assist in developing maintenance concepts, influencing design, and establishing the maintenance level at which components will be replaced, repaired, or discarded based on economic constraints, non-economic constraints, and operational readiness requirements.

LIFE CYCLE COST (LCC): Consists of research and development (R&D) costs, investment costs, operating and support (O&S) costs, and disposal costs over the entire life cycle.

LIFE CYCLE PHASE: One of a sequence of phases defining major stages in a product's life cycle.

LOGISTICS SUPPORT ANALYSIS CONTROL NUMBER (LCN): A code that represents a functional or physical hardware generation breakdown/disassembly sequence of system/equipment hardware including support equipment (SE), training equipment, and installation (connecting) hardware.

LOGISTICS PRODUCT DATA (LPD): That portion of product support analysis (PSA) documentation consisting of detailed data pertaining to the system and equipment design characteristics, including failure modes, reliability and maintainability, maintenance, supply support, human systems integration (HSI), packaging, handling, storage, and transportation (PHS&T), and environment, safety, and occupational health (ESOH) which contributes to the identification of the required Product Support resources and sustainment requirements of the products.

LORA CANDIDATES LIST: A list containing all of the selected items within the system architecture for which the LORA program is being established.

LORA INPUT DATA: LORA data elements and their corresponding values depicting the design, performance, cost, support characteristics, infrastructure, and features related to the product and its support alternatives.

LORA MODEL: A computer-based application designed to assist in conducting a LORA study. It accepts inputs, performs calculations, and provides reports toward completing an economic and non-economic LORA evaluation.

LORA PROGRAM PLAN: A description of how the LORA program will be conducted to meet the program requirements. These descriptions include a discussion of how LORA results are utilized as part of the PSA. The LORA plan may be included as a critical part of the PSA plan.

LORA REPORT: A report documenting the results of the LORA program which includes the LORA activities and evaluations performed, procedures used, and any subsequent recommendations made.

LORA PROGRAM STRATEGY: Identifies the proposed LORA activities to be performed and the organization responsible for each activity.

MAINTAINABILITY: The design characteristics that determine the ability to retain a product in, or restore a product to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources at each prescribed level of maintenance and repair.

MAINTENANCE CONCEPT: A brief description of maintenance considerations, constraints, and plans for operational support of the product under development.

MAINTENANCE LEVELS: The basic levels of maintenance into which all maintenance activity is divided. A “higher” level of maintenance typically implies the availability of more specialized personnel and equipment for the performance of more complex maintenance activities than “lower” maintenance levels.

MAINTENANCE PLANNING: The process conducted to evolve and establish maintenance/support concepts and requirements for the life cycle of a product.

MAINTENANCE TASK ANALYSIS (MTA): The identification of the steps, spares and materials, tools, support equipment, personnel skill levels as well as any facility issues that shall be considered for a given repair task. Also included in the MTA are elapsed times required for the performance of each task. MTAs cover both corrective and preventive maintenance tasks plus additional operational tasks (such as preparation for shipment) and, when complete, identify all physical resources required to support a product.

MANPOWER: A quantitative term referring to the number of people or amount of time required by a person or persons to perform an identified task, e.g., 20 personnel to operate and maintain a product, 100 man-hours to accomplish an inspection.

MANPOWER AND PERSONNEL: A term used to identify the amount of personnel resources and their specialized capability and experience required to operate, maintain, and support a product over its expected life cycle.

MATERIAL: Elements, constituents, or substances from which something is composed or can be made. Not to be confused with “materiel.”

MATERIEL: Equipment, apparatus, and supplies used by an organization or institution. Not to be confused with “material.”

NON-ECONOMIC LORA EVALUATION: An analysis addressing preempting considerations which override cost factors, or existing LORA decisions on similar products, to determine the maintenance level(s) where repair or discard can be performed. This evaluation is performed without consideration of costs. However, any recommendations or conclusions based upon this evaluation should also include an economic LORA evaluation which will assign economic value to the non-economic decisions.

OPERATING AND SUPPORT (O&S) COSTS: The cost of operation, maintenance, manpower, infrastructure and follow-on product support of the product and its associated support systems.

OPERATIONAL CONCEPT: A general description of the way in which an entity is used or operates.

OPERATIONAL ENVIRONMENT: An environment that addresses all operational requirements and specifications required of the final product, to include its platform and packaging. May include factors such as physical environment, operational or nonoperating use, operational scenarios, electomagnetic interference (EMI)/electromagnetic compatibility (EMC), electrostatic discharge (ESD), compatibility issues, interoperability issues, and geographical location.

OVERHAUL: The disassembly of a product as required to permit inspection of every component part. Component parts that, upon inspection, will not meet requirements as set forth in applicable specifications are restored or replaced by new parts so that after reassembly and test the product will meet the requirements set forth in the applicable specifications.

PART: An item which cannot normally be disassembled or repaired, or is of such a design that disassembly or repair is impractical (e.g., bracket, gear, resistor, toggle switch).

PERSONNEL: Individuals, identified by specialty or classification; skill; skill level; and grade, rate, or position, required to satisfy the manpower demand associated with a product.

POLICY: Standards, handbooks, bulletins, specifications, regulations, and other documents written by accepted authorities which prevent/restrict and provide guidance as to the maintenance level(s) at which repair/discard actions can be performed.

PREVENTIVE MAINTENANCE: All actions performed in an attempt to retain a product in specified condition by providing systematic inspection, detection, and prevention of incipient failures.

PRODUCT: The result of research, development, test, and evaluation (RDT&E) in terms of hardware or software being produced or manufactured; also known as an end item. A product is the item stipulated in a contract to be delivered under the contract (i.e., service, study, or hardware).

PRODUCT READINESS: A measure or measures of the ability of a product to undertake and support its designed function over its lifetime operational environment.

PRODUCT SUPPORT (PS): A unified and iterative approach to the management and technical activities needed to influence operational and materiel requirements and design specifications, define the support requirements best related to product design and to each other, develop and acquire the required support, provide required operational support at lowest cost of ownership, improve readiness and life cycle cost (LCC) in the product and support systems during the operational life cycle, and repeatedly examine support requirements throughout the service life of the product.

PRODUCT SUPPORT ANALYSIS (PSA): The selective application of scientific, engineering and logistics assessment activities undertaken throughout the life cycle, as part of the systems engineering design and sustainment process.

PROVISIONING: The process of determining and acquiring the range and quantity (also called “depth”) of spares and repair parts, and support and test equipment required to operate and maintain a product or materiel for an initial period of service.

RELIABILITY: The ability/probability of failure free performance of the system/product, over the expected service use profile and environmental conditions over a given period of time. Reliability is expressed in terms of operational reliability and non-operating reliability.

RELIABILITY CRITICAL ITEM: Items that have a relatively high impact in determining product reliability. Critical items can include hardware and software.

REPAIR PARTS: Individual non-repairable parts or non-repairable subassemblies required for the repair of spares or major products.

RESEARCH AND DEVELOPMENT (R&D): Includes all scientific study and experimentation directed toward increasing knowledge and understanding in the fields of the physical, engineering, environmental, and life sciences.

RESEARCH and DEVELOPMENT (R&D) COSTS: Those costs primarily associated with R&D efforts including the development of a new or improved capability to the point where it is appropriate for operational use.

RESEARCH, DEVELOPMENT, TEST AND EVALUATION (RDT&E): Activities for the development of a new product or to expand the performance of established products.

SENSITIVITY ANALYSIS: An analysis concerned with determining the amount by which model parameter estimates can be in error before the generated decision alternative will no longer be superior to others.

SPARES: Items kept in case another item of the same type is lost, broken, or worn out.

SUPPORT CONCEPT: A complete system-level description of a support system that meets the functional support requirements and is in harmony with the design, maintenance, and operational concepts.

SUPPORT EQUIPMENT: All equipment and tools (mobile or fixed), not integral to a product, but required to support its operation and/or maintenance.

SUPPORT ITEMS: Items subordinate to, or associated with, a product (i.e., spares, repair parts, tools, support and test equipment, and sundry materials) and required to operate, service, repair, or overhaul a product.

SUPPORT RESOURCES: The materiel, infrastructure, and personnel elements required to operate and maintain a product to meet readiness and supportability requirements.

SUPPORT SOLUTION: The integrated design and coherent support provided throughout the life cycle of a system that is realized in its integrated support system and the associated technical data. The support solution comprises the sum of the services, resources, and information required to effectively support the equipment throughout its in-service life.

SUPPORT SYSTEM: A composite of all the services and resources that shall be acquired for operating and maintaining a product throughout its life cycle.

SUPPORTABILITY: A key component of availability and suitability. It includes design, technical support data, and maintenance procedures to facilitate detection, isolation, and timely repair and/or replacement of product anomalies.

SUPPORTABILITY FACTORS: Qualitative and quantitative indicators of supportability.

SUSTAINMENT: The provision of personnel, training, logistics, and other support required to maintain and prolong operations or combat until successful accomplishment or revision of the mission or of the national objective.

SYSTEMS ENGINEERING PROCESS: A logical sequence of activities and decisions transforming an operational need into a description of product performance parameters and a preferred product configuration.

TECHNICAL DATA: Recorded information regardless of form or character (e.g., manuals, drawings) of a scientific or technical nature.

TRADEOFF: The determination of the optimum balance between product characteristics. Cost, schedule, performance and supportability are the most relevant characteristics for product support considerations.

TRAINING: The structured process by which individuals are provided with the skills necessary for successful performance in their job, slot, billet, or specialty.

TRANSPORTABILITY: The design characteristics determining the inherent capability to move materiel to specified locations with available and projected transportation assets to meet planned delivery schedules and/or mobility plans. It includes consideration of the limitations and restrictions of the transportation assets and modes in conjunction with the required product equipment and support items required to enable the movement of the materiel.

2.4 Acronyms

AM	Additive Manufacturing
BEI	Breakdown Element Identifier
BIT	Built-in Test
BITE	Built-in Test Equipment
CBM	Condition Based Maintenance
DMSMS	Diminishing Manufacturing Sources and Material Shortages
EC	Engineering Change
ECP	Engineering Change Proposal
EMC	Electromagnetic Compatibility

EMI	Electromagnetic Interference
ESD	Electostatic Discharge
ESOH	Environment, Safety, and Occupational Health
FMECA	Failure Modes, Effects, and Criticality Analysis
HMS	Health Monitoring System
HSI	Human Systems Integration
HUMS	Health and Usage Monitoring System
IPS	Integrated Product Support
LCC	Life Cycle Cost
LCN	Logistics Support Analysis Control Number
LDT	Logistics Delay Time
LORA	Level of Repair Analysis
LPD	Logistics Product Data
MTA	Maintenance Task Analysis
NPV	Net Present Value
O&S	Operating and Support
PdM	Predictive Maintenance
PIP	Product Improvement Program
PPMx	Prognostics and Predictive Maintenance
PHS&T	Packaging, Handling, Shipping, and Transportation
PS	Product Support
PSA	Product Support Analysis
R&D	Research and Development
RDTandE	Research, Development, Test, and Evaluation
SE	Support Equipment
SMR	Source, Maintenance, and Recoverability
TOA	Tradeoff Analysis

3. GENERAL REQUIREMENTS

3.1 General

LORA is an integral part of PSA as defined in SAE TA-STD-0017A. LORA decisions, which are based on economic and non-economic considerations and readiness objectives, influence the logistic support cost, total life cycle cost of ownership, and operational readiness of the product. Furthermore, LORA recommendations for new materiel shall be made as soon as the product's preliminary design has been determined and then updated, as required, throughout the life cycle.

3.2 Purpose

The purpose of LORA is to establish a cost effective, feasible repair or discard solution for performing maintenance actions. These analyses are based on economic and non-economic considerations and readiness objectives.

3.3 LORA Program

The LORA program shall be planned, developed, integrated, and conducted in conjunction with other design, development, production, and deployment functions to permit the most cost effective achievement of the overall program objectives.

3.3.1 A Managed Program

The LORA program is a managed program to provide LORA activities and is established as part of the PSA and called out in the Product Support Analysis plan per Activity A.2.1 of SAE TA-STD-0017A. The LORA program shall be conducted commensurate with the design maturity and life cycle phase of the program. Procedures shall be established to ensure the LORA program is an integral part of the systems engineering process. Interfaces between the LORA program and other related systems engineering analyses and design programs shall also be identified. The LORA program shall include the management and technical resources, plans, procedures, schedules, and controls for performance of LORA.

3.3.2 LORA Program Objective

The objective of the LORA program shall be to analyze product support solution and product design alternatives; use the results to influence product design and maintenance planning; and achieve a maintenance concept which is the most effective compromise between economic and non-economic considerations or characteristics related to the product and its support.

3.3.3 LORA Program in the Life Cycle

The LORA program aligns with the PSA activities and shall be applied throughout the life cycle of a product (see Appendix E). The primary use of LORA is during design and acquisition; however, it shall be applied for operational in-service reviews of the support solution and for optimal reduction in operational support costs through the disposal phase. The LORA program shall be included in Engineering Changes, comensurate to the level of technical detail and ability to change the support solution.

3.4 LORA Program Interfaces

Maximum use shall be made of analyses and data resulting from other systems engineering programs to satisfy the LORA input data requirements.

3.4.1 Detailed Interfaces

LORA, as part of the PSA process, interfaces with maintenance planning; reliability; and MTA in the following ways:

a. Maintenance planning: LORA identifies the maintenance level and logistic support costs associated with an unscheduled maintenance task and influences product design and maintenance planning in producing an effective support solution. This information is provided by the LORA evaluations and is a key IPS element. These maintenance plans involve both engineering and supportability analyses to develop plans for product maintenance. Ultimately, maintenance planning identifies the support resources required to perform maintenance.

b. Reliability: LORA is used to analyze reliability critical items to determine whether they are maintenance significant. LORA may be used as a design tool for conducting tradeoff analyses to determine whether to design an item for repair or discard. Multiple LORA and sensitivity iterations may be performed to verify the validity of a repair/discard decision.

c. MTA: LORA uses MTA outputs, such as task time and resource requirements, to calculate the optimum maintenance solution for each item under analysis with consideration to cost and availability implication of the maintenance level and locations.

d. Performance assessment: LORA is used to evaluate the effectiveness of the maintenance plan and to recommend changes based on the analysis of feedback data from actual events.

3.4.2 Products Delivered to the End User

LORAs conducted on products that have been delivered to the end user are used to evaluate the existing maintenance policy, support costs, use rates, capabilities, and other factors that may affect the support of a product and require adjustment to the support system in order to maximize the product's operational readiness or cost effectiveness. Data obtained from the use of these products during a follow-on LORA is more accurate than the engineering estimates used in earlier LORAs and increases confidence in the product's maintenance policy.

3.5 LORA Program Coordination

Activities and data required by this standard, which are also required by other standards and specifications, shall be coordinated and combined to the maximum extent possible to avoid duplication of effort. LORA input data and the information used and provided shall be based upon, and traceable to, other systems engineering data and activities where applicable. Maximum use shall be made of LORA data and information resulting from applicable activities in the LORA program to satisfy the PSA requirements detailed in SAE TA-STD-0017A.

3.6 LORA Process

The LORA program shall be implemented through a process of systematic and comprehensive LORA evaluations conducted on an iterative basis throughout the life cycle to arrive at a maintenance concept that is effective, yet affordable. The process shall integrate design, operation, performance, cost, and supportability characteristics or constraints to identify and update the support solution for the product. The level of detail of the evaluations and the timing of the activity performance shall be tailored to each product and shall be responsive to the LORA program's schedules and milestones.

3.6.1 Product Development

The LORA program shall be initiated as early as possible in the design and acquisition phase of the product's life cycle and be updated in subsequent phases as the product configuration becomes better defined. In the product's developmental stages, the LORA program shall aid in the evaluation of the design alternatives from a supportability standpoint. Also, the LORA program shall provide a basis for identifying items which should clearly be designed for discard at failure, from those that should be designed for repair at failure.

3.6.2 Product Production and Deployment

During product production and deployment, the LORA program is conducted to evaluate significant changes in supportability factors and to recommend modifications in the established maintenance concept of the product. The objective of the LORA program during this time is to:

a. Review, refine, and revise the existing maintenance concept established for the product commensurate with changes in supportability factors (e.g., use rates, cost of repair parts, maintenance policy or capabilities).

b. Propose enhancements to the maintenance concept as it is affected by product improvements or engineering changes to the product.

c. Provide a basis of information on which to build a maintenance concept for a similar product.

3.7 LORA Input Data

The LORA input data and values shall be established through the use of data from other related systems engineering programs or from measured data and shall be traceable to their specific source (e.g., product specification, contract, regulations, reliability allocation report, maintainability predictions report, operational use plan, in-service support performance measurement). The quality and level of detail of the data evaluated shall be commensurate with the life cycle phase.

3.8 LORA Models

The LORA process should make use of computer based modelling to assist in defining supportability characteristics and in decision making for optimal repair levels of the product under analysis. The LORA model used must be approved for the LORA Program application. Guidance in the requirements for LORA models is provided in Section 10.

Any mathematical and statistical formula that are used in the application of LORA modeling shall be logically robust. The algorithms must be logical, well described, defensible, repeatable, and adaptable to various modeling scenarios. Analytical methods shall be available and approved by the owner or user of the asset and its support system. The LORA model used must comply with this standard.

4. ACTIVITY SECTIONS

4.1 General

The LORA activities are divided into five general sections: (1) program management, surveillance, and control; (2) data preparation and management; (3) evaluations; (4) use and implementation; and (5) operations and support reviews.

4.1.1 Program Management, Surveillance, and Control

The program management, surveillance, and control section contains the earliest planning activities in the development of an effective LORA program, in addition to providing an opportunity to review the progress of the LORA program and results. This section contains three activities: Activity 1 - Program Strategy; Activity 2 - Program planning; and Activity 3 - Program Reviews.

4.1.2 Data Preparation and Management

The purpose of the data preparation and management section is to identify the LORA input data which will be used in the LORA evaluations. This section contains one activity: Activity 4 - Input Data Compilation.

4.1.3 Evaluations

The evaluations section serves to optimize the benefits of the LORA while considering cost, schedule, performance, and supportability prior to the product design being finalized. This section contains one activity: Activity 5 - Evaluation Performance, Assessment, and Documentation.

4.1.4 Use and Implementation

The purpose of the use and implementation section is to provide a method for utilizing the results of the LORA to influence the product's design and support solution while deriving an optimal maintenance concept. This section contains one activity: Activity 6 - Using Results.

4.1.5 Operations and Support Reviews

The purpose of the operating and support reviews section is to establish a methodology and process including LORA for the assessment and improvement of the support solution performance during the in-service phase. This section contains one activity: Activity 7 - In-Service Support.

4.2 Activity Structure

4.2.1 Activity Description

Each LORA activity contains an objective statement in addition to detailed tasking statements (sub-activities) which constitute the overall activity.

4.2.2 Activity Input

The activity input tables identify the general information required to define the scope of, and perform, each activity. When an element of the activity input is only applicable to certain sub-activities, the applicable sub-activity numbers are identified. Where an element is applicable to all sub-activities listed under a specific activity input, the word “all” is used.

4.2.3 Activity Output

The activity output tables identify the expected results from performance of the activity. Each output is linked to the applicable sub-activity by identifying the sub-activity number.

4.3 Activity Selection

It is not intended that all LORA activities and sub-activities be accomplished in the sequence presented. The sequence of activities and sub-activity accomplishments shall be tailored to the individual acquisition program to exclude any unnecessary requirements. Consequently, for some activities, not all sub-activities may be required to be performed for a given contract period.

5. PROGRAM MANAGEMENT, SURVEILLANCE, AND CONTROL

5.1 Activity 1 - Program Strategy

Develop a LORA program strategy to identify the LORA activities to be accomplished as part of the LORA program. The LORA program strategy shall be incorporated into the PSA strategy established in SAE TA-STD-0017A, Activity A.1.

5.1.1 Activity 1.1 - LORA Program Strategy

Identify proposed LORA activities to be performed and the entity responsible for each activity. Propose any additional activities, modifications, or deletions to activities or requirements with supporting rationale for such additions, modifications, or deletions. The selection of LORA activities and the degree of their accomplishment shall be based on the following factors:

a. The probable design, supportability, and operational approaches for the product undergoing LORA.

b. The availability, accuracy, and relevance of LORA input data required to perform the proposed LORA activities.

c. The potential design impacts of implementing, or not implementing, the LORA recommendations.

d. LORA efforts conducted during previous phases of the product life cycle.

e. Related systems engineering analyses planned and completed which are still relevant.

5.1.2 Activity 1.2 - Schedule

Develop a schedule to accomplish the LORA activities identified in Activity 1.1 and the delivery of LORA products based on the relationship of the LORA program with other IPS program requirements and associated systems engineering activities and programs (e.g., PSA per SAE TA-STD-0017A, reliability per SAE GEIA-STD-0009A, FMEA per ARP5580). The schedule shall provide estimated start and completion milestones for each LORA program activity. The schedule depicts the relative timing of the LORA program activities in relation to the PSA program. Included in the schedule shall be any requirements for program and design reviews identified under Activity 3.

5.1.3 Activity 1.3 - Manpower Estimate

Estimate the man-hours required to perform each activity identified under Activity 1.1 based on the schedule developed in Activity 1.2.

5.1.4 Activity 1.4 - LORA Candidates List

Develop a list of items to be included in the LORA. The LORA candidate items shall be in an order that represents the hardware breakdown relationship of the items within the product. The LORA candidate items shall be identified by a product breakdown identifier (e.g., BEI or LCN if assigned).

Table 1 - Activity 1, program strategy inputs

Activity Inputs	Activity
Previously conducted analyses and LORA evaluations pertinent to the product for which the LORA program is being established. This data shall include no proprietary data of any contractor.	All
Expected mission and functional requirements for the product for which the LORA program is being established.	All
PSA strategy outlining the proposed supportability objectives and proposed PSA activities and sub-activities to be performed for each phase of the acquisition program from SAE TA-STD-0017A, Activity 1.	All
Overall system program event and milestone schedule.	All
LORA review procedures, LORA review team, and LORA guidance conference and Review schedules from Activity 3.	All

Table 2 - Activity 1, program strategy outputs

Activity Outputs	Activity
A LORA program strategy outlining the proposed LORA activities to be performed, the entity responsible for each activity, and the schedule for accomplishing the activities identified.	1.1, 1.2
Manpower estimate for conducting the LORA activities identified.	1.3
LORA candidates list.	1.4

5.2 Activity 2 - Program Planning

Develop a LORA program plan detailing the approach for accomplishing the LORA activities identified in the LORA program strategy. The LORA program plan shall be incorporated into the PSA plan established by SAE TA-STD-0017A, Activity A.2.

5.2.1 Activity 2.1 - LORA Program Plan

Prepare a LORA program plan which describes how the LORA process will be conducted to meet the program requirements. These descriptions shall include a discussion of how the LORA results will be used in the PSA. The LORA program plan shall include the following elements of information, with the range and depth of information for each element tailored to the life cycle phase.

NOTE: The following list is not all encompassing. It is meant to serve as a representative sample only.

a. Identification of each LORA activity to be accomplished under the LORA program and a detailed description of how each selected LORA activity shall be performed.

b. Identification of the organizational unit with the responsibility for executing each LORA activity to be performed. This includes the identification and responsibilities of all parties involved.

c. Description of how LORA activities and data will interface with the IPS elements and systems engineering program activities and data. The description will include analysis and data interfaces with the following programs, as applicable.

    1. Design program.
    2. Reliability program.
    3. Maintainability program.
    4. Human systems integration.
    5. Environmental, safety, and occupational health program.
    6. Parts management program.
    7. Test and evaluation program.
    8. Data management and configuration management programs.

d. The method by which the LORA program requirements and data are to be obtained from, and disseminated to, personnel in all other related program areas.

e. Description of the procedures which will be used for collecting, updating, and validating LORA input data and results. These descriptions shall include a discussion of how the LORA results shall be used in the PSA.

f. The LORA candidates list as defined by Activity 1.4.

g. Identification of the LORA model(s) to be used in conducting the LORA evaluations. See Section 10 for the requirements for a LORA model.

h. A list of the LORA input data elements required to execute the LORA model(s) identified and the sources to provide that data (i.e., customer, contractors, subcontractors, vendors, and test agencies). See Appendix B for relevant data elements.

i. Discussion of the sensitivity analysis requirements and proposed ranges of particular quantitative data elements so the uncertainty of design and program characteristics can be considered.

j. Identification of major supportability and design tradeoffs or constraints to be evaluated under the LORA program. In particular, describe the support and support equipment alternatives to be evaluated.

k. Identification of the required product data and any applicable rights that should be obtained.

l. Discussion of how the application of advanced manufacturing solutions is a design and support alternative that should be considered (e.g., using additive manufacturing to create repair parts or tools where and when needed).

m. A list of considerations (e.g., safety, environmental impacts, hazardous materials (HAZMAT), training requirements, facilities, security, policies) which will be examined in the non-economic evaluation. In particular, describe any considerations or characteristics related to the data elements identified which may impact, or shall be considered when conducting, the LORA evaluations.

n. Identification of data from similar products, which will be used to establish a baseline maintenance concept for the product under analysis. This shall include the identification of the similar products and quantification of any data to be used from the similar products.

5.2.2 Activity 2.2 - LORA Program Plan Updates

Update the LORA program plan as required, subject to customer approval, based upon analysis results, program schedule modifications, program decisions, and other events which will require the LORA program plan to be resubmitted for customer approval.

Table 3 - Activity 2, program planning inputs

Activity Inputs	Activity
PSA Plan outlining the scheduling of PSA activities and how each will be performed from SAE TA-STD-0017A, Activity 2.	All
Overall system program event and milestone schedule.	All
Identification of the contractual status of the LORA program plan and approval procedures for updates.	All
The requirements for the establishment of a LORA program and its accomplishment along with identification of deliverable data items.	All
Identification of any specific LORA process indoctrination or training to be provided.	All
LORA review procedures, LORA review team, and LORA guidance conference and Review schedules from Activity 3.	All
Program plans for related systems engineering analyses which have been accomplished in previous acquisition phases or are to be accomplished in the current acquisition phase.	All
Activity and sub-activity requirements specified in the LORA program strategy from Activity 1.	All

Table 4 - Activity 2, program planning outputs

Activity Outputs	Activity
LORA program plan outlining proposed activities to be accomplished; how each activity is proposed to be accomplished; and proposed supportability and design tradeoffs or constraints to be evaluated under the LORA program.	2.1
LORA program plan updates as applicable.	2.2

5.3 Activity 3 - Program Reviews

Establish a requirement to plan and provide timely reviews of the LORA program and provide the customer with appropriate surveillance and management control of the LORA program through reviews. In addition, this activity shall ensure the LORA program is proceeding in accordance with the contractual milestones so that the LORA requirements will be achieved.

5.3.1 Activity 3.1 - Review Procedures

Where procedures do not already exist, establish and document review procedures which provide for official review, and control of, released LORA information and results in a timely and controlled manner. The review procedures shall identify IPS and systems engineering program areas along with the contractors, subcontractors, and vendors which will conduct official review, control, and implementation of LORA information and results. These procedures shall define the interfaces and degree of authority that each of the reviewing activities has to accept/reject the LORA information and results.

5.3.2 Activity 3.2 - Establishing the LORA Review Team

The LORA program shall be monitored by a PSA review team if it is required by the contract. If a PSA review team is not required, establish a LORA review team to serve as the primary management vehicle for monitoring the status of the LORA program and implementation of customer approved LORA decisions. Members of the LORA review team shall include management and functional representatives from systems engineering and functional disciplines (e.g., design engineers; operations research specialists; reliability, availability, and maintainability engineers; maintenance engineers; human systems integration (HSI) specialists; environment, safety, and occupational health (ESOH) engineers; CBM engineers; test and evaluation engineers; and provisioning specialists). The members of the LORA review team serve as a staffing body for LORA input data and evaluation reports, and also serve as participants in LORA guidance conferences and reviews.

5.3.3 Activity 3.3 - LORA Guidance Conference

To ensure a mutual understanding of the required scope, a LORA guidance conference is recommended. The conference is normally an independent event, but can be included as a part of another conference, such as a post award or PSA guidance conference. If the LORA guidance conference is not contractually specified and the contractor desires a guidance conference, the contractor shall propose a date, place, and agenda to the customer to be agreed upon soon after contract award. The customer guidance provided to the contractor may include, but shall not be limited to, the following topics:

a. Inquiries relative to contractual LORA requirements and changes to the LORA program plan, which impact how the LORA effort will be conducted.

b. Clarification of review procedures to be employed.

c. Clarification of procedures for transfer of data between the customer and contractor.

d. Maintenance concepts, limitations, and expectations to be considered.

e. Baseline operational and logistics data to be used (e.g., deployment life, end item density, washout rate, operating time of end item).

f. Guidance relative to use and application of LORA data and results.

g. Technical features of customer supported LORA models to be employed.

h. Identification of the data rights and proprietary data that will have an effect on the LORA and subsequent repairs to the product.

5.3.4 Activity 3.4 - LORA Reviews

plan and schedule the LORA program to permit reviews at specific milestones of the life cycle. The status of the LORA program shall be assessed at LORA reviews scheduled and held, to the maximum extent possible, in conjunction with PSA reviews and major program reviews defined in SAE TA-STD-0017A and specified by the contract. LORA reviews shall identify and discuss all pertinent aspects of the LORA program. Reviews shall be scheduled with prime contractors, subcontractors, and suppliers, as appropriate, and inform the customer in advance of each review.

5.3.5 Activity 3.5 - Documentation of Reviews

The proceedings of each LORA guidance conferences and review shall be documented and provided to the customer for approval. The minutes of these conferences and reviews shall also include the status of any supportability-related design recommendations, description of design change, whether or not the design change was accepted, and, if accepted, the rationale (tangible and non-tangible) for acceptance. In addition to the minutes, agendas shall be developed and coordinated with the customer to address, at a minimum, the following topics as they apply to the LORA program activity and reviews being conducted.

a. Status of the LORA effort with respect to schedule.

b. Status of the LORA candidates list.

c. Assessment of LORA program effectiveness (i.e., design changes or maintenance concept changes that were made or planned as a result of the LORA effort).

d. Design, schedule, or analysis problems affecting the LORA program and corrective actions considered, proposed, or taken.

e. Supportability-related design recommendations based on LORA results.

f. Updated results from economic, non-economic, and sensitivity analyses.

g. LORA input data requirements and status.

Table 5 - Activity 3, program review inputs

Activity Inputs	Activity
Overall system program event and milestone schedule.	All
PSA plan, outlining the scheduling of, and procedures for, PSA guidance reviews, from SAE TA-STD-0017A, Activity 2.	All
Identification of any specific instruction or PSA training to be provided.	All
The specifications and requirements for the LORA program along with identification of deliverable data items.	All

Table 6 - Activity 3, program review outputs

Activity Outputs	Activity
LORA review procedures which provide for official review and control of released LORA information and results in a timely and controlled manner (between and among contractor IPS/systems engineering elements, prime contractors, subcontractors, and customer organizations).	3.1
Identification of LORA review team members.	3.2
LORA guidance conference proposal.	3.3
LORA reviews scheduled for input to the LORA program plan from Activity 1.	3.4
Agendas and documented results of each LORA guidance conference and review to include the status of any supportability-related design recommendations.	3.5

6. DATA PREPARATION AND MANAGEMENT

6.1 Activity 4 - Input Data Compilation

Identify pertinent LORA input data and assemble the data into a manageable form for use in LORA evaluations.

6.1.1 Activity 4.1 - Input Data for Economic LORA Evaluations

Identify values for the LORA input data elements corresponding to each item in the LORA candidates list and the item's associated support alternatives. Identify the specific source from which each data element value was obtained. When multiple values and sources exist for a data element, indicate the most current data value and the corresponding source. Perform this activity by reviewing data contained in requirements documents (contracts, specifications, regulations) and by examining data produced by other systems engineering programs (e.g., PSA program, reliability program, maintainability program). The values for the data elements shall be established, to the maximum extent possible, from existing sources. However, when no source is available for a data element, then a realistic range for the value shall be established through the engineering experience and knowledge of the contractor. All values, as well as changes to customer furnished values, are subject to approval of the customer. The LORA input data elements translate and quantify an item's design, operation, cost, and support characteristics and are used in conducting economic LORA and sensitivity analyses. All values related to cost shall be expressed in terms of a particular base year to ensure consistency and cohesiveness.

6.1.2 Activity 4.2 - Input Considerations for Non-Economic LORA Evaluations

Identify specific considerations (e.g., constraints, policies, special requirements, HSI, environmental impacts, HAZMAT, training requirements, facilities, deployment mobility, security, transportability, safety, repair feasibility) which affect items in the LORA candidates list and their associated support alternatives. Relate these considerations to the LORA input data elements. Perform this activity by reviewing program and requirements documents and examining other related systems engineering programs or analyses. Identify the specific source from which considerations were obtained. All considerations identified, as well as changes to any customer furnished considerations, are subject to approval of the customer. The identified considerations are used in conducting non-economic LORA evaluations and influence the results of economic LORA and sensitivity analyses.

6.1.3 Activity 4.3 - LORA Input Data Report

Prepare a LORA input data report which documents the data and sources identified under Activity 4.1 and Activity 4.2.

6.1.4 Activity 4.4 - Updates to the LORA Input Data

Perform updates on Activity 4.1, Activity 4.2, and Activity 4.3 as the product becomes better defined and as more reliable data becomes available. This activity shall include a re-examination of the LORA input data element values and non-economic considerations as the sources of information are updated or as new sources become available. Additional information shall be identified, as well as the applicability of existing information during the performance of this activity.

Table 7 - Activity 4, input data compilation inputs

Activity Inputs	Activity
LORA Program Plan from Activity 2.1 containing the LORA candidates list; LORA input data elements list; proposed sensitivity ranges for particular LORA data elements; factors which have already been identified; and support alternatives to be evaluated.	All
The specifications and requirements for the LORA program along with identification of deliverable data items.	All
Product specifications, requirements documents, and contracts in which LORA input data exists.	All
Studies, reports, and documentation available from all systems engineering and design programs.	All
Applicable LORA input data element definitions related to the LORA model identified in the LORA program plan.	All
Applicable factors identified in the LORA program plan.	All
Application assessment containing pertinent supportability factors and quantitative data related to the intended use of the product from SAE TA-STD-0017A, Activity B.1.	All
Supportability and supportability-related design constraints based upon support system standardization considerations identified from conducting SAE TA-STD-0017A, Activity B.2.	All
Projected supportability data for the baseline comparative system developed from SAE TA-STD-0017A, Activity B.3.	All
LPD and supportability and supportability-related design factors and alternatives for the product developed from SAE TA-STD-0017A, Activity B.5.	All
Functional requirements resulting from SAE TA-STD-0017A, Activity C.1.	All
Various support system alternatives developed for the various product design alternatives from SAE TA-STD-0017A, Activity C.2.	All

Table 8 - Activity 4, input data compilation outputs

Activity Outputs	Activity
Values and sources of economic LORA input data that depicts the design, operation, performance, cost, and support characteristics, factors, and features related to the product and its support alternatives which are used in conducting economic LORA and sensitivity analyses.	4.1
Pertinent considerations related to the product and its support which shall be addressed in non-economic LORA evaluations.	4.2
LORA input data report.	4.3
LORA input data report updates, as applicable.	4.4

7. EVALUATIONS

7.1 Activity 5 - Evaluation Performance, Assessment, and Documentation

Evaluate maintenance alternatives and determine the optimum level of repair or discard for each LORA candidate based on various economic and non-economic conditions.

7.1.1 Activity 5.1 - Economic LORA Evaluation

Conduct a LORA evaluation on all items under analysis using an approved LORA model as specified by the customer. Specifically, determine and identify the most cost effective maintenance concept for all items in the LORA candidates list.

7.1.2 Activity 5.2 - Non-Economic LORA Evaluation

When performing a non-economic LORA evaluation, the data identified in Activity 4.2 shall be used to eliminate support alternatives that are not practical or feasible. Identify the maintenance levels or support alternatives which are affected or restricted. Also, provide the considerations and rationale for the restriction or constraint imposed. In performing this activity, evaluate and interpret the results of other related systems engineering analyses that have been conducted on the product under analysis. Perform the evaluation without regard to cost. However, any LORA recommendations based upon this evaluation shall include an economic evaluation which will assign economic value to the non-economic recommendation.

7.1.3 Activity 5.3 - LORA Sensitivity Analysis

Conduct a sensitivity analysis on selected input parameters to assess the impacts on the baseline maintenance concept. A sensitivity analysis aids in determining the safest and most efficient support alternative to be implemented for a product. Specific parameters subject to sensitivity analysis shall include, but not be limited to: parameters for which engineering values are not available; parameters representing uncertainties in design characteristics; parameters critical to the logistic support and readiness of the product; parameters that have been estimated, calculated, or based on historical data; manpower and personnel skill parameters; parameters which are affected by the operational environment; resupply time; and spares budget.

7.1.4 Activity 5.4 - Documentation of Results

Prepare a LORA report which documents the results of the LORA program. The LORA activities and evaluations performed, the procedures used to perform the LORA evaluation, and the subsequent results of the LORA shall be included in the report. The LORA report shall support the conclusions, findings, and recommendations impacting the product's design, maintenance planning, life cycle costs, and IPS element resources.

7.1.5 Activity 5.5 - Updating the LORA Evaluations and Documented Results

Perform updates on Activity 5.1, Activity 5.2, Activity 5.3, and Activity 5.4 as the product becomes better defined and as more accurate and reliable data becomes available. At a minimum, updates shall be required when there are:

a. Significant changes in the data elements.

b. Significant changes in the support equipment requirements, capabilities, use, or costs.

c. Other requirements imposed by the contract.

d. Changes directed by the customer.

Table 9 - Activity 5, evaluation performance, assessment, and documentation inputs

Activity Inputs	Activity
The LORA candidates list developed in Activity 1.4.	All
Any previous analyses performed on the product or on similar products.	All
The LORA input data compiled during performance of Activity 4.	All
The LORA input data report.	All
The LORA model specified by the customer which will be used to perform the economic LORA and sensitivity analyses.	All
LORA program plan.	All

Table 10 - Activity 5, evaluation performance, assessment, and documentation outputs

Activity Outputs	Activity
The results, conclusions, and recommendations established during performance of the economic LORA.	5.1
The results of the non-economic LORA evaluation including identification of the factors affecting the maintenance level.	5.2
The results, conclusions, and recommendations established during performance of the sensitivity analysis.	5.3
The LORA report.	5.4
The updates performed and the resulting changes, as the product becomes better defined and as more accurate and reliable data is obtained.	5.5

8. USE AND IMPLEMENTATION

8.1 Activity 6 - Using Results

Establish a methodology for using the LORA results to influence the design and support solution of the product and to ensure the LORA results are an integral part of the PSA.

8.1.1 Activity 6.1 - Design Influence

Prepare a list of recommendations and actions for the product designer to influence the design of the product under development. Establish a process that tracks these LORA design change candidates and identifies the disposition of each candidate. Identify any supportability risks that may occur if the recommended design changes are not implemented.

8.1.2 Activity 6.2 - Support Solution Influence

Identify the effect the LORA results will have on each IPS element. Particular attention shall be given to the maintenance plan, supply support, support equipment, technical data, manpower and personnel, and training along with their associated products.

8.1.3 Activity 6.3 - Related Analyses

Establish a methodology or process for using the LORA as part of the systems engineering and product support analyses. Prepare and identify a list of analysis results which shall be incorporated into the development or revision of other PSA-related systems engineering analyses.

8.1.4 Activity 6.4 - Updates

Identify the requirement for further analysis to be performed on the product and update the LORA program plan as necessary.

Table 11 - Activity 6, using results inputs

Activity Inputs	Activity
Results of the evaluations performed, and the recommendations established during the accomplishment of Activity 5.	All
The LORA report developed in Activity 5.4 and the LORA program plan generated in Activity 2.1.	All
The customer's determinations and approved results based on review of the LORA report.	All
The PSA-related products.	All
The results of other PSA-related systems engineering analyses conducted on the product.	All

Table 12 - Activity 6, using results outputs

Activity Outputs	Activity
A list of the proposed recommendations to be provided to the product designer to influence the design of the product under analysis.	6.1
A process to track and identify the deposition of each LORA design change candidate and identify any supportability risks that may occur if the recommended design changes are not implemented.	6.1
A list of each IPS element and the effect the LORA results will have on each.	6.2
Identification of the results which shall be incorporated into other related PSA systems engineering analyses.	6.3
Identification of the need to perform further analysis and the resulting updates to the LORA program plan.	6.4

9. OPERATIONS AND SUPPORT REVIEWS

9.1 Activity 7 - In-Service Support

Establish a methodology and process including LORA in the review of support solution performance during the in-service phase to ensure the product is subject to an optimal support plan and to determine when engineering change is required.

9.1.1 Activity 7.1 - Collecting Supportability Data

Identify the data to be tracked during the In-Service phase for the LORA input data elements corresponding to each item in the LORA candidates list and the item's associated support solution. Identify the specific source from which each data element value will be obtained. The LORA process should incorporate end user input by assessing field-generated maintenance data and materiel readiness monitoring systems. Field supportability data provides valuable insight to assess the achievement of supportability objectives and thresholds including problem areas associated with the maintenance support concepts. Standard reporting systems will be analyzed to determine the amount and accuracy of supportability information that can be obtained in the intended operational environment. Identify any shortfalls in the standard reporting and monitoring systems that affect the analyst's ability to use the data collected for the purposes of assessing the effectiveness of the maintenance concept. This supportability data will include both operations and maintenance data so that analysts can put the data into context for use in follow-on studies/research and recommendations. Describe data processing to be applied to recorded O&S data to establish LORA input data. Perform updates as the product is used and as more usage data becomes available. This activity shall include a re-examination of the LORA input data element values and factors identified as the sources of information are updated or as new sources become available. SAE TA-STD-0017A Activity E.2.1 applies.

9.1.2 Activity 7.2 - Support Solution Effectiveness Review

Using O&S measured data, conduct a LORA evaluation on all items in the LORA candidates list. Specifically, determine and identify the effectiveness of the current maintenance concept based on cost and performance parameters. Supportability and supportability-related field feedback data analysis will be used to verify that established supportability objectives and thresholds are achieved. Evaluate maintenance alternatives and determine the optimum level of repair or discard or each LORA candidate, based on as-reported data. Evaluating the adequacy of existing maintenance concepts and involving end users at critical decision points in the LORA process will assist in achieving an effective and efficient LORA program. Where operational results deviate from projections, analysts will determine causes and corrective actions, provide feedback, identify cost-effective improvements (design, support, or operational) and recommendations for implementation. A LORA model shall be used to assess the improvements available for the current support solution and identified alternatives. SAE TA-STD-0017A Activity E.2.2 applies.

9.1.3 Activity 7.3 - Engineering Change and Support Solution Updates

Engineering change (EC) shall require LORA assessments to be made for modifications and updates to supportability-related characteristics of the support solution. Equipment EC will apply a LORA program as described in previous activities proportional to the cost and support solution influence possible.

During the in-service phase, it may be necessary to conduct a LORA in order to update or adjust the support system because of significant changes that occur (e.g., materiel changes, engineering change proposals (ECPs), or changes in utilization rates, operating environment, costs, maintenance capabilities, or policy) or if a service-specific timeframe for re-examination has expired. If so, it may be cost beneficial to adopt the new maintenance concept determined by the LORA. Cost savings and improved support capability may result from changing an item from discard to repair or from repair to discard, or by changing repair levels when the item failure rate has increased and repairing it requires existing test equipment and stocked parts.

LORA updates conducted during the in-service phase should incorporate relevant information from previous LORAs. When conducting a LORA on fielded systems/equipment, the LORA results should be used to assess the current maintenance concept and to recommend how it may be improved. This LORA report is used to support the efforts of a fielded system review, post provisioning review, or sample data collection program.

9.1.4 Activity 7.4 - Managing the Approved Support Solution

A product's approved support solution is to be managed and applied to achieve desired supportability outcomes. The approved support solution is to be used to compare alternative repair options when new methods, technology or equipment is identified.

As noted in 9.1.3, LORAs may be conducted for update purposes to adjust LORA decisions based on field experience or design evaluations presented in ECPs and product improvement programs (PIPs). LORA updates and their recommendations should be processed and approved or disapproved through a specific approval process depending on the requesting and requiring authority. Should a maintenance concept change be approved on a fielded system, it is imperative that transitioning from the current maintenance concept to the new maintenance concept be implemented in an orderly manner. The introduction of the new support and maintenance concept and the retirement of the previous approved support and maintenance concept must be managed as any "baseline" should be. Maintenance concept changes have to be well defined, approved, planned and scheduled, budgeted, supported with acquired resources, implemented, and deployed. Depending on the controlling activity, the process associated with deploying a new maintenance concept may vary greatly (i.e., from processing source, maintenance, and recoverability (SMR) code change requests to a formal project associated with acquiring various support resources identified in the LORA in support of the new maintenance concept).

Table 13 - Activity 7, operations and support reviews inputs

Activity Inputs	Activity
LORA Results and Models used to select approved support solution	All
EC proposal and design changes	7.3
Current approved support solution	7.4

Table 14 - Activity 7, operations and support reviews outputs

Activity Outputs	Activity
Record of use and support events as a processed data set	7.1
Recommended changes to approved support solution	7.2
Maintenance plan for EC implementation	7.3
Managed approved support solution establishing current state of system	7.4

10. REQUIREMENTS FOR LEVEL OF REPAIR ANALYSIS MODELS

10.1 Purpose

This section describes the minimum criteria for a LORA model to be capable of providing optimal level of repair decisions. It does not define a specific model or equations.

Historically, equations were prescribed to provide direction for the acceptance of LORA deliverables[1]. These equations detailed how costs were to be calculated, and the results were then compared to determine the optimal repair level of failed items. This is no longer a reasonable method for the following reasons:

a. There are multiple equations that achieve the same outcome. It is overly complex and redundant to document them all.

b. Not all models make determinations using equations. For example, some models may use integer programming or genetic algorithms.

LORA has been a valuable engineering analysis to determine optimal maintenance plans for more than 50 years. It was initially defined by MIL-STD-1390 as a supporting process to logistics support analysis requirements of MIL-STD-1388-1.

With this level of maturity and more enhanced technical solutions, a method of evaluating applications of LORA modeling rather than providing the desired equations is necessary. Prescribing equations could limit the development of models and prevent the use of new mathematical methods. However, providing a method to evaluate LORA models through the definition of standard criteria gives confidence that the LORA model is acceptable. The criteria provided in this document are based on expert knowledge and extensive experience in the application of LORA modeling. Appendix A provides examples of calculations based on these criteria.

This section is intended for either:

a. Developers of LORA models who wish to provide a comprehensive and acceptable product; or,

b. Customers of optimized maintenance and support plans who wish to be assured the model in use will provide effective and reasonable solutions.

10.2 LORA Modeling in the Life Cycle

The LORA utilizes the level of design, operation, support data, and other documentation which is generated in the product support functions during the product's life cycle. Throughout the life cycle, the minimum data set changes to incorporate different modifications over the life of the product. As the amount of data accumulates and as the system matures, the quality of the data improves during the development process and optimizes support solutions for cost and availability. The improved data enables the LORA to be updated and more accurately depict maintenance activities. This iterative process indicates supportability analysis is being performed at different phases in the life cycle. This accounts for changes in the maintenance procedures, operating environment, performance feedback, and in-service operation (see Table 7).

10.2.1 Economic and Non-Economic

LORA is designed as a cost-based optimization method. By defining maintenance and support activities with respect to cost, a comparison can be made to determine that one option is better than another (e.g., less costly). The LORA model shall apply life cycle cost as the primary comparator in the analysis. The LORA model must also recognize that other considerations will override the use of cost as the decision method and shall permit non-economic overrides in the analysis. These two methods are usually referred to as "economic" and "non-economic" LORA.

[1] For example, see Mil-Std-1390D 19 January 1993 Appendices D to M

10.2.2 Economic LORA

Economic LORA is addressed using cost models that calculate the possible costs of all support options and then identify the least-cost solution. The cost elements that must be included and their relationships are defined in this section.

10.2.3 Non-Economic LORA

In non-economic LORA the decision criteria are based on a list of rules or guidelines that are used to determine if there is an overriding reason why the maintenance should be other than the economical solution. For example, any item costing less than a predetermined price level will be discarded and replaced rather than be repaired; or some repair activity needs a special facility to conduct the work; or some political reason requires a specified location to be used. Typical elements should include:

a. Safety.

b. Environmental impact.

c. Constraints on the support organization.

d. Special transportation factors.

e. Deployment mobility.

f. Technical feasibility of repair.

g. Mission success (criticality and effectiveness).

h. Security.

i. HSI.

j. Policy and regulations.

k. HAZMAT.

l. CBM and PdM/PPMx.

m. DMSMS management, obsolescence management, and counterfeit prevention.

See Appendix C for an example of a LORA non-economic evaluation worksheet that could be used for documentation of overriding preemptive considerations that resulted in a non-economic determination for the LORA recommendation.

10.3 LORA Model Requirements

Any LORA model shall include the following minimum requirements.

10.3.1 Demand Driven

A demand driven model ensures that support activities and the required support resources are determined for each support event. While predicted failures are an obvious trigger for the repair process, there are other ways that the repair process may be triggered, such as actual failures, induced failures, no fault found replacements, false removals, etc. Demands for repair and overhaul activity are a combination of failures and preventive removals that should be considered in the LORA decision. All support demands are influenced by the item's operating rate, which is a proportion of the equipment's usage (i.e., duty cycle).

The costs determined and compared to make economical choices from alternative repair options must be generated from true demands for a repair action. True demands must include:

a. The engineering failure rate annualized by the operating rate.

b. Demand adjustments made for induced failures, damage, environmental factors, and no fault found rate.

c. Demand adjustments made for operating duty cycle of part with respect to its parent equipment.

d. Consideration for adjustments to demands due to scheduled replacements in an applied preventive maintenance program which add repair demands on the support system. This could include removals prior to the original estimated failure.

e. Consideration for reductions to demands from part failures associated with an applied preventive maintenance program due to preventing failures. This includes differences in expected failure rate due to following the preventive maintenance program.

10.3.2 Operational Profile.

The distribution of operating equipment and their operating rates are important drivers in the LORA. The data used in demand calculations must be based on the operating profile and quantity of operating equipment at all operating sites included within the scope of the LORA.

10.3.3 Support Chain

The support chain defines the path of providing support to the operational sites. The support chain must include:

a. Shipping costs between sites. Determine the cost for shipping items between sites, and whether the cost for shipping items will be calculated using a shipping rate or a fixed cost.

b. Shipping times between sites. Estimated times to move items between the maintenance facility locations and the supply warehouse locations is required to calculate logistics delay times (LDT) for each of the repair alternatives.

c. Maintenance and supply capabilities of all sites. Each support facility in the support organization will have maintenance and supply capabilities that are relevant to the repair decision. These must be clearly identified and applied in the LORA decision.

The following information can be useful in determining the above items.

a. Locations of all maintenance facilities. Maintenance facilities are the workshop locations that could possibly repair the item under analysis and are options within the LORA decision.

b. Locations of all supply warehouse sites. Supply warehouses are locations that could hold stock items to be supplied for repair or replacement tasks to return the item under analysis to a serviceable condition.

c. Distances between all sites. Estimated distances between the maintenance facility locations and the supply warehouse locations is required to calculate shipping and transportation costs for each of the repair alternatives.

10.3.4 Repair versus Discard

The LORA model must include the capability of making a recommendation between repairing or discarding a failed item.

10.3.5 Support Items and Resources

The LORA must include all support items and resources to a level commensurate with their influence on the repair solution. As a minimum, the following support items must be included:

a. Personnel and labor.

b. Training and training technologies.

c. Spares, repair parts, and supply chain.

d. Special tools and support equipment.

e. Documentation.

f. Transportation.

g. Special facilities.

h. BIT/BITE/HMS/HUMS (if separate from the end item).

10.3.5.1 Personnel and Labor

Personnel and labor costs must be calculated. The cost calculations may use:

a. Skill level.

b. Labor rates.

c. Labor hours.

10.3.5.2 Training and Training Technologies

Training costs must be calculated. The cost calculations may use:

a. Quantity of trainees.

b. Repair tasks training times.

c. Cost of training.

d. Annual regenerative training.

e. Training technologies could include simulators, emulators, training systems, computer-based training, virtual reality environments, etc. The cost of training technologies to train the technician required to conduct the repairs can be significant and it can influence the recommendation to repair or discard.

10.3.5.3 Spares, Repair Parts, and Supply Chain

Spares, repair parts and supply chain costs must be calculated. The cost calculations may use:

a. Quantity of spares required.

b. Shipping costs between warehouse locations and maintenance facilities.

c. Stock holding costs.

d. Discard and loss rates.

10.3.5.4 Special Tools and Support Equipment

Special tools and support equipment costs must be calculated. The cost calculations may use:

a. Quantity of special tools and support equipment.

b. Unit cost.

c. Locations held.

d. Replacement costs.

e. Maintenance costs.

f. Installation costs.

10.3.5.5 Documentation

Documentation costs must be calculated. The cost calculations may use:

a. Authoring costs.

b. Production costs.

c. Distribution costs.

d. Maintenance costs.

10.3.5.6 Transportation

Transportation costs must be calculated. The cost calculations may use:

a. Cost to ship spare and repair parts.

b. Transportation modes.

10.3.5.7 Special Facilities

Special facilities costs must be calculated. The cost calculations may use:

a. New construction costs.

b. Modification costs.

c. Operating costs.

10.3.6 Life Cycle Cost (LCC)

The LORA calculations must determine and compare costs based on their life cycle cost value.

10.3.7 Time Sequenced (Net Present Value [NPV] or Future Value)

Cost modelling uses different values for money. The LORA model must be clear which value of money is applied. The LORA model should identify the selection of base year, future value, or present value methods. These cost of money calculations must follow standard formulae.

10.3.8 Sensitivity and Tradeoff

The LORA model should provide the capability to run sensitivity analysis. A sensitivity analysis should be performed on significant cost parameters and data that has uncertainty. The result of this process indicates how stable the solution is with respect to life cycle cost and, if it does, the point at which the repair option changes.
The LORA model should facilitate trade-off analysis (TOA).

10.3.9 LORA and Individual Tasks

Often, a part will have different repair locations based on the mode of failure and the capability of the repairing organization. Whereas most LORA models propose the optimal repair location for the part itself, a more robust model would identify the portion of a part's repair assigned to a repair level, either by a repair fraction (RF%) or by assigning individual tasks.

It is not mandatory for the LORA model to have this level of detail to be an acceptable model; however, it should be considered when assessing proposed models.

10.4 LORA Model Output

The primary output of a LORA model is a recommended maintenance policy for all items in the LORA candidates list. This maintenance policy should represent the most cost-effective combination of repair method and repair level for the items within the LORA candidates list. It should be consistent with both the constraints on the potential support structure and the availability requirements for the end item.

Additional outputs can be useful to support the maintenance policy recommendations. For example, a cost estimate for the life cycle costs of following the recommended maintenance policy should be included. This allows for a cost comparison to other potential maintenance policies to support that the recommended maintenance policy is indeed the most cost effective. Similarly, since the result of the LORA is an optimal maintenance policy that meets an availability constraint, the operational availability when following the recommended maintenance policy should be provided.

The following items may be included in the LORA output. These items can vary due to the system or requiring authority and include, but are not limited to: source maintenance recoverability codes or reparability codes; line replaceable and shop replaceable units; weapon replaceable and shop replaceable assemblies; part identification information; item category codes; and task code information.

10.5 LORA Model Summaries

The LORA model shall have output summaries, usually in the form of formatted reports, to present the results of the analyses and provide repair level recommendations for all parts included in the analysis. The following typical summaries should be available:

10.5.1 Recommended Maintenance Plan

A summary output that presents the conclusion of the LORA and the optimal repair selections recommended. It contains repair levels for all the LORA items included in the analysis. As a minimum, the recommended maintenance plan summary will include the optimal maintenance facility for the initial diagnostics and repair of the item, the breakdown into repair fractions if appropriate, and the maintenance facility that will complete repair for each repair fraction.

10.5.2 Cost Breakdown of Recommended Maintenance Plans

A summary report should provide a detailed cost breakdown of the repair level recommendation to assist in the decision process to select a maintenance plan policy. The depth of detail on this report can vary, but should sufficiently identify and compare cost drivers generating the recommendation.

10.5.3 Alternatives to Optimal Maintenance Plan

An output method should provide the alternative maintenance plans that are not the most optimal but could be a recommended solution. The alternative maintenance plans output provides the analyst a method to compare all potential maintenance plans with cost breakdowns.

11. NOTES

11.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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APPENDIX A - LORA MODEL EXAMPLES

A.1 INTRODUCTION

This appendix provides example calculations that would usually be included in a LORA model. These are not mandatory requirements, but are provided to identify the basic concepts and equations that enable LORA.

A.2 CALCULATING PART REMOVALS

Repair decisions are based on supportability resource usage and costs that are generated every time a part removal is conducted. This removal is usually due to failure, but it can also be caused by a perceived failure (i.e., no defect), or it could be an induced failure. In some scenarios, it might be necessary to identify removals based on damage modes. Therefore, mean units between removal (MUBR) for a part is calculated as:

$$\mathrm{MUBR_p} = \frac{1}{\left(\frac{1}{\mathrm{MUBF}} + \frac{1}{\mathrm{MUBF_{no\ def}}} + \frac{1}{\mathrm{MUBF_{ind}}} + \frac{1}{\mathrm{MUBF_{damage}}}\right)} \quad \text{(Eq. A1)}$$

where:

MUBF = Mean units between failure (MUBF) of the part. This is also the inverse of the failure rate (1/λ). The operating units can be any measure of use, e.g., Time, Distance, Landings, Thermal Cycles, etc. It is often referred to as Mean Time Between Failure (MTBF) no matter what measurement base is used.

$\mathrm{MUBF_{(no\ def)}}$ = MUBF when a no defect situation was treated like a failure. This value decreases the MUBF, or increases the failure rate, to include phantom failure modes. Sometimes this value is provided as a no fault found rate (NFF%) indicating a ratio of the true MUBF.

$\mathrm{MUBF_{(ind)}}$ = MUBF when a failed item was induced by an external influence other than the random failure of the part. This value decreases the MUBF, or increases the failure rate, to include failure modes other than expected engineering failures.

$\mathrm{MUBF_{(damage)}}$ = MUBF when a failed item was caused by damage. This value is similar to induced, but may be used to distinguish external damage (e.g., military action) from maintenance or equipment induced failure.

A.3 MONTHLY AND ANNUAL DEMANDS, MD AND AD

The basic monthly demand (MD) of repair activity is calculated for each part (p) in a prime equipment under analysis (PE) at an operational site (*i*) by:

$$\mathrm{MD_{pi}} = \frac{1}{\mathrm{MUBR_p}} * (1 - \mathrm{PMSR}) * \mathrm{TOUM_{PEi}} * \mathrm{QinPE_p} * \mathrm{DC_p} * \mathrm{SRSF_{pi}} \quad \text{(Eq. A2)}$$

where:

$\mathrm{MUBR_p}$ = mean units between removal of part *p*

PMSR = PM survival rate based on a preventive maintenance strategy (note: 1-PMSR is the unprevented corrective maintenance rate)

$\mathrm{TOUM_{PEi}}$ = total operating units per month of PE at site *i* (note: the operating units can be other than hours—e.g., distance, cycles)

$\mathrm{QinPE_p}$ = quantity of part in prime equipment, adjusted by parent quantity in parent multipliers

$\mathrm{DC_p}$ = duty cycle of part in PE (adjusted by all DC between item and PE)

$\mathrm{SRSF_{pi}}$ = site reliability stress factor of part *p* at a site *i*; adjusts the part's reliability at that specific site

and:

$$\mathrm{TOUM_{PEi}} = \mathrm{QPE_i} * \mathrm{PEOUM} \quad \text{(Eq. A3)}$$

where:

QPE_i = quantity of PE at site *i* (note: if a PE distribution profile is in use, then the QPE at a site will vary by year and should be taken into account in demand calculations)

$PEOUM_i$ = PE operating hours per units at site *i*

Therefore, annual demands (AD) are calculated by:

$$\mathrm{AD_{pi}} = \mathrm{MD_{pi}} * \mathrm{MPY_i} \quad \text{(Eq. A4)}$$

where:

MD_{pi} = monthly demand of part *p* at site *i* as defined above

MPY_i = months per year operating at site *i* (this permits seasonal operations at different sites)

A.4 TIME VALUE OF MONEY

The LORA recommendations are based on the life cycle cost of optional support solutions. When estimating each option the cost can be considered with respect to time. The value of things, and especially money, changes over time. When an item increases in cost each year and more money is needed to make the purchase it is adjusted by inflation to determine the future value. When future costs can be valued in today's money but not spent until sometime in the future, it is said to be discounted to determine the present value. A LORA model should provide the capability to assess both types of value of money.

The use of time value cost estimating requires assumptions to be made. The rates used in calculations are usually just best estimates based on history. Therefore, including the time value of money in LORA decisions should be applied with caution.

A.4.1 Future Value

The increasing cost of a repair activity or resource over time due to inflation is known as future value. It is calculated to estimate the real cost of the repair option choice. Future value is calculated using an inflation rate. An inflation rate is the percentage change (usually increase) in costs during a specified period, usually a year. The percentage identifies the rate at which costs change year over year. Usually an inflation rate is applied to a cost in LORA through standard future value equations. Inflation rates can be fixed or vary year by year over the life cycle.

A.4.2 Present Value

The stream of costs to repair an item over the life cycle can be estimated as a present value, or how much would those costs be if paid today. Present value is calculated using a discount rate. A discount rate denotes the change in money value in a specified time period, usually a year. The percentage identifies the rate at which the value of money changes year over year. Usually a discount rate is applied to a cost in LORA through standard present value equations.

A.5 ITEM REPAIR COSTS

The LORA decision is based on the cost of each of the options to repair a failed item. An item's repair, depending on how it fails and the policy for repairing, including discarding and replacing the item, will generate costs based on the repair activity and resources used. These costs in a LORA model should be identified as:

a. Manpower.

b. Repair materials.

c. Contractor repair.

d. Maintenance documentation.

A.5.1 Manpower Cost for Maintenance

A faulty line replaceable unit (LRU) removed from the operational equipment is sent to a repair facility and is diagnosed for the fault. It is then repaired by either disassembling to replace a faulty shop replaceable unit (SRU), or repairing a LRU fault. Similarly, a faulty SRU is diagnosed for the fault and then can be repaired by either replacing a faulty unit or repairing a SRU fault. Any, or all, of the maintenance procedures can be performed at any of the maintenance facilities, provided that facility has that repair capability. Sometimes diagnosis will determine a no fault found (NFF) situation when no additional repair or replace will take place.

The cost of maintenance manpower for a part at a site is calculated by the labor rate multiplied by each of the time: to diagnose the fault, to repair parts, and to replace parts for each repair task.

A.5.1.1 Cost for Diagnosing Failed Part

$$\mathrm{DIAGNOSE_p} = \sum_{\mathrm{Site\ i}} \mathrm{AD_{dpi}} * \mathrm{DT_p} * \mathrm{LR} \qquad \text{(Eq. A5)}$$

where:

AD_{dpi} = annual demand for diagnosis of part *p* at site *i*

DT_p = diagnostic time for part *p*

LR = labor rate of technician for this task

A.5.1.2 Cost for Repairs

$$\mathrm{REPAIR_p} = \sum_{\mathrm{Site\ i}} \partial_{\mathrm{pi}} * \mathrm{RT_p} * \mathrm{LR} \qquad \text{(Eq. A6)}$$

where:

∂_{pi} = demand for repair of part *p* at site *i* based on the ratio of repair tasks to all tasks

RT_p = repair time for part *p*

LR = labor rate of technician for this task

A.5.1.3 Cost for Replacement

$$\text{REPLACE}_p = \sum_{\text{Site i}} \partial R_{pi} * \text{ADT}_p * \text{LR} \quad \text{(Eq. A7)}$$

where:

∂R_{pi} = demand for replacement of part *p* at site *i*

ADT_p = average disassembly time of part *p* (based on removing children sub replaceable units)

LR = labor rate of technician for this task

then:

$$\text{Labor Costs for Part p} = \text{DIAGNOSEp} + \text{REPAIRp} + \text{REPLACEp} \quad \text{(Eq. A8)}$$

A.5.2 Corrective Maintenance Material Cost

The LORA model should include the capability to estimate costs for repair materials used in tasks to repair the part itself. This cost category does not include the cost to replace a condemned part that is not repaired. Cost of repair materials is based on a demand rate and a repair material cost for the item's repair.

$$\text{CMMC} = \sum_{\text{all sites}} \sum_{\text{andall andParts}} \partial_{pi} * \text{RMC}_{pi} \quad \text{(Eq. A9)}$$

where:

∂_{pi} = demand for repair of part *p* at site *i* (AD_{pi} * RF_{pi})

AD_{pi} = annual demand of part *p* at site *i*

RF_{pi} = repair fraction of part *p* at site *i*

RMC_{pi} = repair material cost of part *p* (typically calculated as FlatRate * $PartCost_p$)

FlatRate = percentage of purchase cost

$PartCost_p$ = purchase cost of part *p*

A.5.3 Contractor Repair Cost

The LORA model should include the capability to estimate costs for contractor repair of the part. It is based on a demand rate for contractor repairs and repair cost.

$$\text{CRC} = \sum_{\text{parts}} (\partial_{pc} * \text{Cost}_p) \quad \text{(Eq. A10)}$$

where:

∂_{pc} = demand for repairing part *p* at contractor, excluding discards

$Cost_p$ = cost of task at contractor (typically calculated as CR% x $PartCost_p$)

CR% = contractor repair cost as a percentage of purchase cost of part *p*

$PartCost_p$ = purchase cost of part *p*

A.5.4 Maintenance Documentation Update Cost

The LORA model should include the capability to estimate costs for repair documentation used in repair tasks. It should have the flexibility to calculate cost for different approaches to documentation, e.g., developing pages of a document, providing a commercial document, developing electronic documents (IETP).

A.6 PERSONNEL TRAINING COSTS

The LORA decision is based on the cost of each of the options to repair a failed item. An item's repair, depending on how it fails and the policy for repairing, including discarding and replacing the item, will generate costs based on the repair activity and resources used. These costs in a LORA model should include training costs for personnel required to conduct the repair tasks.

A.6.1 Maintenance Training Cost

The LORA model should include costs incurred for training technicians to complete maintenance, including diagnoses, removals, and repair of failed parts. It includes the initial training for each trade skill at each support site and the ongoing annual cost to replace trained technicians based on personnel turnover.

The course cost is the cost for each person being trained. It is based on a labor rate of the techs at each skill level and the length of training in hours. It may include some proportional amount for an overhead course cost.

$$\mathrm{IMTC} = \mathrm{DevCost} + \sum_{\mathrm{Site}} \sum_{\mathrm{Skill\ Set}} \mathrm{QTT}_{\mathrm{i}} * \mathrm{CourseCost} \quad \text{(Eq. A11)}$$

$$\mathrm{RMTC} = \sum_{\mathrm{Site}} \sum_{\mathrm{Skill\ Set}} \mathrm{QTT}_{\mathrm{i}} * \mathrm{TOR}_{\mathrm{i}} * \mathrm{CourseCost} \quad \text{(Eq. A12)}$$

where:

QTT_i = quantity of techs trained at that skill level at site *i*

TOR_i = turnover rate, the portion of techs to be trained each year due to personnel turnover at site *i*

CourseCost = training cost per tech + (set up cost for the course/number of techs per course)

DevCost = development cost for the course

IMTC = initial maintenance training costs

RMTC = recurring maintenance training costs per year

A.6.2 Maintenance Training System Cost

$$\text{IMTSC} = \sum_{\text{Site}} \sum_{\text{Trng Sys}} \text{Quantity}_i * (\text{UnitCost} + \text{SetupCost}) \quad \text{(Eq. A13)}$$

$$\text{RMTSC} = \sum_{\text{Site}} \sum_{\text{Trng sys}} \text{Quantity}_i * \text{AnnualMaintenanceCost} \quad \text{(Eq. A14)}$$

where:

Quantity_i = quantity of training system at site *i*

UnitCost = unit cost per training system

SetupCost = setup cost per training system

AnnualMaintenanceCost = annual maintenance cost per training system

IMTSC = initial maintenance training system costs

RMTSC = recurring maintenance training system costs per year

A.7 TRANSPORTATION COSTS

The LORA decision is based on the cost of each of the options to repair a failed item. An item's repair, depending on how it fails and the policy for repairing, including discarding and replacing the item, will generate costs based on the repair activity and resources used. These costs in a LORA model should consider the cost to transport annual demands (AD) of defective parts between the maintenance facility (MF) site where the failure is diagnosed to the MF where it is repaired.

$$\text{TC} = \sum_{\text{Sites}} \sum_{\text{Parts}} (\text{AD}_{\text{pi}} * \text{RF\%}_{\text{pi}}) * \text{ShippingCost}_{\text{pij}} \quad \text{(Eq. A15)}$$

where:

AD_{pi} = annual demands of part *p* at site *i*

$\text{RF\%}_{pi}$ = fraction of AD_{pi} that are not repaired at site *i* and transported to a higher site *j*

$\text{ShippingCost}_{pij}$ = the shipping cost of part *p* between site *i* and site *j*

Examples of shipping cost include:

1. $\text{ShippingCost}_{pij}$ = fixed price for the shipping cost of part *p* between site *i* and site *j*.
2. $\text{ShippingCost}_{pij}$ = weight_p * shipping cost per unit weight between site *i* and site *j*.
3. $\text{ShippingCost}_{pij}$ = weight_p * (distance between site *i* and site *j)** shipping cost per unit weight per unit distance.

A.8 SUPPORT AND TEST EQUIPMENT COSTS

The LORA decision is based on the cost of each of the options to repair a failed item. An item's repair, depending on how it fails and its repair policy, including discarding and replacing the item, will generate costs based on the repair activity and resources used. These costs in a LORA model should include the acquisition, distribution, and maintenance of special support equipment and test equipment.

$$\text{ISTEC} = \sum_{\text{Sites}} \sum_{\text{STE Item}} \text{Quantity}_{\text{ei}} * (\text{UnitCost}_{\text{e}} + \text{SUC}_{\text{ei}}) \quad \text{(Eq. A16)}$$

where:

ISTEC = initial support and test equipment costs

Quantity_{ei} = quantity of support and test equipment *e* at site *i*

UnitCost_{e} = unit cost of support and test equipment *e*

SUC_{ei} = setup cost of support and test equipment *e* at site *i*

$$\text{RSTEC} = \sum_{\text{Sites}} \sum_{\text{STE Item}} \text{Quantity}_{\text{ei}} * \text{AnnualMaintenanceCost}_{\text{e}} \quad \text{(Eq. A17)}$$

where:

RSTEC = recurring support and test equipment costs per year

$\text{AnnualMaintenanceCost}_{e}$ = annual maintenance cost of support and test equipment *e*

A.9 SUPPLY SUPPORT COSTS

The LORA decision is based on the cost of each of the options to repair a failed item. An item's repair, depending on how it fails and its repair policy, including discarding and replacing the item, will generate costs based on the repair activity and resources used. These costs in a LORA model should include supply management costs generated by the acquisition, replacement, and management of item spares.

A.9.1 Spares Initial Procurement Cost

$$\text{SIPC} = \sum_{\text{Sites}} \sum_{\text{Parts}} \text{QIS}_{\text{pi}} * \text{SpareUnitCost}_{\text{p}} \quad \text{(Eq. A18)}$$

where:

QIS_{pi} = quantity of initial spares for part *p* at site *i*

SpareUnitCost_{p} = unit price of a spare of part *p*

A.9.2 Spares Replacement Cost

The spares replacement cost includes procuring replacement spares for condemned spares. This cost does not include repair materials captured in A.5.2.

$$\text{SRC} = \sum_{\text{Sites}} \sum_{\text{Parts}} (\partial \text{R}_{\text{pi}} * \text{DF\%}_{\text{pi}}) * \text{SpareUnitCost}_{\text{p}} \quad \text{(Eq. A19)}$$

where:

∂R_{pi} = demand for replacement of part *p* at site *i*

$\text{DF\%}_{pi}$ = percentage of part *p* replaced at site *i* which is discarded upon failure

SpareUnitCost_{p} = unit price of a spare of part *p*

A.9.3 Spares Transportation Cost

The spares transportation costs include shipping of spare parts from a higher (more rearward) supporting site to a more forward supported site.

$$\mathrm{STC} = \sum_{\mathrm{Sites}} \sum_{\mathrm{Parts}} \mathrm{DS}_{\mathrm{pi}} * \mathrm{ShippingCost}_{\mathrm{pij}} \quad \text{(Eq. A20)}$$

where:

DS_{pi} = demand for spares of part *p* at supported site *i*

$ShippingCost_{pij}$ = the shipping cost of part *p* between site *i* and site *j*

A.9.4 Spares Holding Costs

The spare holding costs should reflect the costs of holding inventory. These costs should consider items such as physical storage space and replacement of loss of inventory over time. Examples of types of loss include pilferage, misplacement, damage, and obsolescence. This cost is typically estimated as a percentage of the value of the inventory.

A.9.5 Inventory Management Costs

Inventory management costs should capture the costs associated with requisitioning orders for replacement parts and monitoring stock levels of parts at each site. Requisitioning costs are usually estimated as a cost per event. Cost for monitoring stock levels is typically estimated as an annual cost per part spared.

APPENDIX B - RELEVANT DATA SET

This section includes a non-exhaustive list of data elements from SAE GEIA-STD-0007C that are related to the data associated with LORA. Not every data element will be relevant to every LORA model, and there will be data elements in the LORA model that are not present in SAE GEIA-STD-0007C. The data elements in this table should be evaluated for suitability as common data elements between the LORA model in use and the LPD. This reuse of data allows for better consistency between the LPD and the LORA model.

Entity	DTN	Data Attribute/Element Name	Short Name	Table Key
XA	**DTN**	**End Item Acronym Code Data**		
XA	2040	End Item Acronym Code	eiac	Primary
XA	1100	Administrative Lead Time	adminldt	
XA	1590	Contact Team Delay Time	contmdt	
XA	1630	Contract Number	contrno	
XA	1680	Cost Per Reorder Action	cpreoact	
XA	1690	Cost Per Requisition	cpreq	
XA	1830	Demilitarization Cost	demilcst	
XA	1900	Discount Rate	discrt	
XA	2090	Estimated Salvage Value	estsalvl	
XA	2490	Holding Cost Percentage	hldctper	
XA	2580	Initial Bin Cost	initbnct	
XA	2590	Initial Cataloging Cost	initcact	
XA	2680	Interest Rate	intrt	
XA	2720	Inventory Storage Space Cost	invssct	
XA	2900	Loading Factor	loadfact	
XA	2960	Logistics Support Analysis Control Number Structure	lcnstr	
XA	3680	Operating Level	operlvl	
XA	3690	Operation Life	operlife	
XA	3900	Personnel Turnover Rate Civilian	pertrciv	
XA	3900	Personnel Turnover Rate Military	pertrmil	
XA	4030	Productivity Factor	prodfact	
XA	4350	Recurring Bin Cost	recbncst	
XA	4360	Recurring Cataloging Cost	reccatct	
XA	4560	Retail Stockage Criteria	retstkcr	
XA	4610	Safety Level	safelvl	
XA	5070	Support of Support Equipment Cost Factor	soseqctf	
XA	5540	Transportation Cost	trancost	
XA	5580	Type Acquisition	typeacqt	
XA	5650	Type of Supply System Code	typosscd	
XB	**DTN**	**Logistics Support Analysis Control Number Indentured Item Data**		
XB	1200	Alternate Logistics Support Analysis Control Number Code	alc	Primary
XB	2970	Logistics Support Analysis Control Number	lcn	Primary
XB	2980	Logistics Support Analysis Control Number Type	lcntype	Primary
XB	2940	Logistics Support Analysis Control Number Indenture Code	lcnidcd	
XB	2950	Logistics Support Analysis Control Number Nomenclature	lcnnomen	
AG	**DTN**	**Reliability Requirement Data**		
AG	1240	Annual Operating Requirement	annopreq	
AG	3380	Annual Operating Requirement Measurement Base	anoprqmb	Primary
BA	**DTN**	**Reliability Availability and Maintainability Characteristics Data**		
BA	1670	Conversion Factor	convfact	
BD	**DTN**	**Reliability Availability and Maintainability Indicator Characteristics Data**		
BD	4420	Reliability Availability and Maintainability Indicator Code	ramincd	Primary
BD	1010	Achieved Availability	achvavlb	
BD	2240	Failure Rate	failrate	
BD	3380	Failure Rate Measurement Base	failrtmb	
BD	2560	Inherent Availability	inhavlb	
BD	2570	Inherent Maintenance Factor	inhmtfct	
BD	3170	Maximum Time To Repair	maxttr	
BD	3380	Mean Time Between Failure Operational Measurement Base	mtbfomb	
BD	3270	Mean Time Between Failures Operational	mtbfop	
BD	3290	Mean Time Between Maintenance Induced	mtbmind	
BD	3300	Mean Time Between Maintenance Inherent	mtbminh	
BD	3310	Mean Time Between Maintenance No Defect	mtbmnodf	

Entity	DTN	Data Attribute/Element Name	Short Name	Table Key
BD	3360	Mean Time To Repair Operational	mttroper	
BD	3360	Mean Time To Repair Technical	mttrtech	
BD	3880	Percentile	percentl	
CA	**DTN**	**Task Requirement Data**		
CA	5110	Task Code	taskcode	Primary
CA	5150	Task Identification	taskid	
CA	5140	Task Frequency	tskfreq	
CA	3210	Measured Mean Elapsed Time	msdmnelt	
CA	3210	Predicted Mean Elapsed Time	prdmnelt	
CA	3220	Measured Mean Man Hours	msdmnmhr	
CA	3220	Predicted Mean Man Hours	prdmnmhr	
CG	**DTN**	**Task Support Equipment Data**		
CG	4230	Support Item Quantity Per Task	siqpta	
CG	5720	Support Item Quantity Per Task Unit of Measure	seqptaum	
GA	**DTN**	**Skill Specialty Data**		
GA	4810	Skill Specialty Code	skspc	Primary
GA	2500	Hour Labor Rate	hrlbrate	
GA	4800	Skill Level Code	sklvlc	
GA	5470	Training Cost	trngcost	
EA	**DTN**	**Support Equipment Data**		
EA	3990	Design Data Price	dsgdatpr	
EA	3990	Extended Unit Price	extuntpr	
EA	3990	Hardware Development Price	hwdevprc	
EA	3990	Integrated Logistics Support Price	ilsprice	
EA	1700	Operating and Support Cost	opsupcst	
EA	3990	Pass Thru Price	pasthrpr	
EA	1700	Recurring Cost	recrcost	
EA	5010	Support Equipment Full Item Name	seqfitnm	
EA	2730	Support Equipment Item Category Code	seqicc	
EA	4830	Support Equipment Source Maintenance Recoverability Code	seqsmrc	
HA	**DTN**	**Item Identification Data**		
HA	4400	Reference Number	refno	Primary
HA	2790	Item Name	itemname	
HA	3520	National Stock Number National Item Identification Number	nsnniin	
HA	5770	Unit Weight	unitwt	
HD	**DTN**	**Item Unit of Measure Issue Price Data**		
HD	3990	Unit Price	unitprc	Primary
HD	3980	Price Concurrent Production Code	prcconpc	
HD	2300	Price Fiscal Year	prcfscyr	
HD	3000	Price Lot Quantity From	prcltqfr	
HD	3000	Price Lot Quantity To	prcltqto	
HD	4140	Price Provisioning	prcprovs	
HD	5640	Price Type of Price Code	prctyppc	
HG	**DTN**	**Part Application Provisioning Data**		
HG	4190	Quantity Per Assembly	qpa	
HG	4210	Quantity Per End Item	qpei	
HG	3060	Maintenance Replacement Rate I	mrri	
HG	3070	Maintenance Replacement Rate II	mrrii	
HG	3090	Condemned At Depot Maintenance Task Distribution	cndadmtd	
HG	3090	Condemned Below Depot Maintenance Task Distribution	cndbdmtd	
HG	3090	Depot Shipyard Maintenance Task Distribution	dshpymtd	
HG	3090	Intermediate Direct Support Maintenance Task Distribution	intdsmtd	
HG	3090	Intermediate General Support Maintenance Task Distribution	intgsmtd	
HG	3090	Organizational Maintenance Task Distribution	orgmtdst	
HG	3090	Special Repair Activity Maintenance Task Distribution	spamtd	
HG	4480	Contractor Repair Cycle Time	cntrrpct	
HG	4480	Depot Shipyard Repair Cycle Time	dshpyrct	
HG	4480	Intermediate Direct Support Repair Cycle Time	intdsrct	
HG	4480	Intermediate General Support Repair Cycle Time	intdgrct	
HG	4480	Organizational Repair Cycle Time	orgrepct	
HG	4480	Special Repair Activity Repair Cycle Time	sprarct	
HG	4530	Depot Shipyard Replacement Task Distribution	dshpyrtd	

Entity	DTN	Data Attribute/Element Name	Short Name	Table Key
HG	4530	Intermediate Direct Support Replacement Task Distribution	intdsrtd	
HG	4530	Intermediate General Support Replacement Task Distribution	intdgrtd	
HG	4530	Organizational Replacement Task Distribution	orgrtdst	
HG	4530	Special Repair Activity Replacement Task Distribution	sprartd	
HG	2730	Item Category Code	icc	
HG	4830	Source Maintenance and Recoverability Code	srcmtrcc	

APPENDIX C - LORA NON-ECONOMIC EVALUATION WORKSHEET

Subsystem:	P/N:	Nomenclature:

Non-Economic Considerations	Yes	No	Maintenance Level Restricted	Reason for Restriction
1. SAFETY:				
Do hazardous conditions exist that preclude the item from being repaired at a specified maintenance level?				
Conditions to be considered include, but are not limited to: — High voltage — Temperature extremes — Chemicals or toxic gases — Excessive noise — Explosives — Excessive weight — HAZMAT — Other				
2. SECURITY and CYBER SECURITY:				
Do security conditions exist that preclude the item from being repaired at a specified maintenance level?				
Are there cyber security considerations that override the economic decision?				
3. POLICY/EXISTING MAINTENANCE CONCEPTS:				
Are there specifications, standards, or regulations pertaining to the level of maintenance at which a particular item can or cannot be repaired? This includes existing maintenance concepts or policies on similar systems to be used as a baseline for comparison.				
4. WARRANTIES/PROPRIETARY DATA:				
Do proprietary data rights held by the manufacturer preclude repair analysis of the item?				
Are there warranties for the item that restrict the maintenance level for repair or discard?				
Does the warranty eliminate organic support of the item?				
5. READINESS/MISSION SUCCESS:				
Will mission readiness be compromised if the item is repaired or discarded at a specified maintenance level?				
6. TRANSPORTATION/TRANSPORTABILITY:				
Are there any transportation factors which might preclude the transfer of systems from the user to the maintenance activity for repair?				
The factors include, but are not limited to: — Weight — Size — Volume — Special handling requirements — Susceptibility to damage — Other				
7. SUPPORT EQUIPMENT AND TEST MEASUREMENT AND DIAGNOSTIC EQUIPMENT (TMDE)				
Are special tools/equipment required which force repair to be performed at a specific level of maintenance (e.g., test program set)?				
Does the item require calibration that forces performance of maintenance at a certain level due to system sensitivity or inability to place calibration equipment at a specified maintenance level?				
Does availability, mobility, size, or weight of SE and TMDE restrict the maintenance level?				