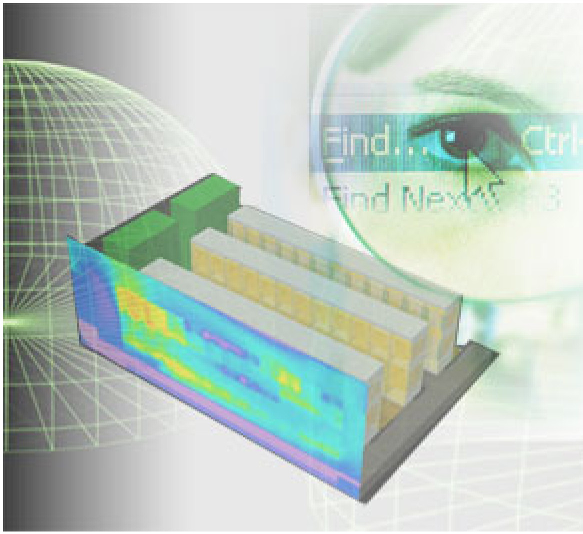
Welcome to Technical Activities

This lesson addresses various technical activities the Life Cycle Logistician (LCL) may need to use during the System Capability and Manufacturing Process Demonstration effort. During this effort, considerations like technology use for product support should be addressed. This will ensure that the most efficient processes are in place for support of the product once it is in use.



Popup Text

System Capability and Manufacturing Process Demonstration

This effort is intended to demonstrate the ability of the system to operate in a useful way consistent with the approved KPPs [Key Performance Parameters] and that system production can be supported by demonstrated manufacturing processes. The program shall enter System Capability and Manufacturing Process Demonstration upon completion of the Post-CDR [Critical Design Review] Assessment and establishment of an initial product baseline. This effort shall end when the system meets approved requirements and is demonstrated in its intended environment using the selected production-representative article; manufacturing processes have been effectively demonstrated in a pilot line environment; industrial capabilities are reasonably available; and the system meets or exceeds exit criteria and Milestone C entrance requirements. Successful developmental test and evaluation (DT&E) to assess technical progress against critical technical parameters, early operational assessments, and, where proven capabilities exist, the use of modeling and simulation to demonstrate system/system-of-systems integration are critical during this effort. T&E should be used to assess improvements to mission capability and operational support based on user needs and should be reported in terms of operational significance to the user. The completion of this phase is dependent on a decision by the MDA [Milestone Decision Authority] to commit to the program at Milestone C or a decision to end this effort. (Source: DoDI 5000.02, Encl 2, para 6.c.(6)(d).)

Objectives

Upon completion of this lesson, you will be able to:

- Identify Life Cycle Logistician (LCL) activities associated with collecting and analyzing system performance and maintenance data.
- Recognize the analyses that are used to evaluate system performance and maintenance data, to include: failure mode, effects and criticality analysis (FMECA), fault tree analysis (FTA), maintainability analysis and prediction (MAP), and level of repair analysis (LORA).
- Define reliability-centered maintenance (RCM).
- Recall the structures of RCM.
- Recognize the elements of interoperability and operational supportability.

Collecting and Analyzing System Performance and Maintenance Data

The LCL plays a critical role in collecting and analyzing system performance and maintenance data to ensure that program supportability requirements can be met. In those instances when analysis identifies deficiencies that cannot be resolved through product support refinements, system redesign and or improvements are pursued.

Design and Development

Maintenance

Popup Text

Design and Development

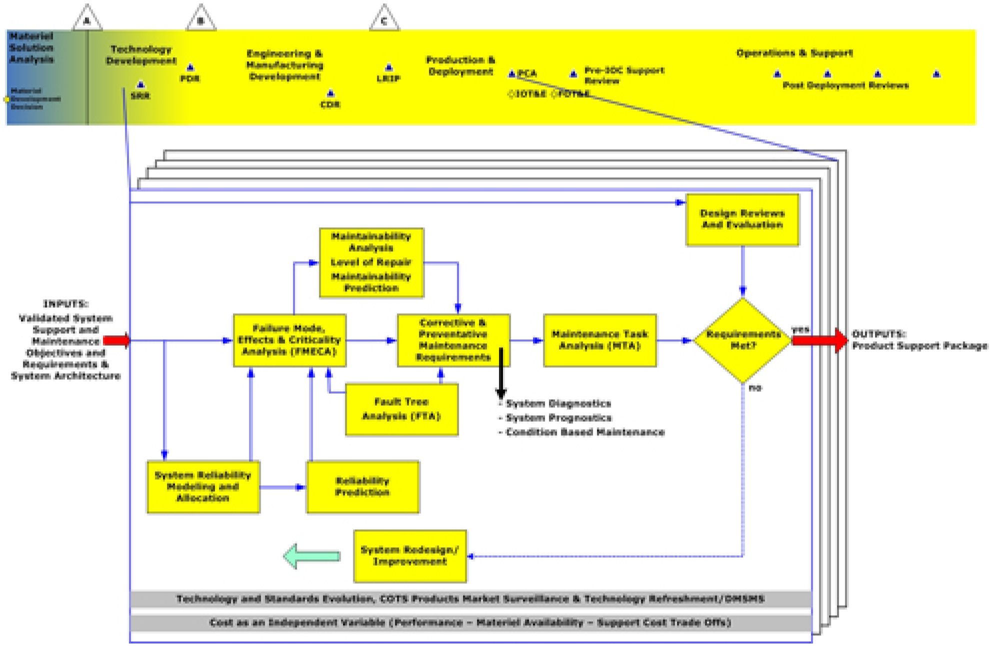
Design and development are system engineering processes that the LCL must participate in to ensure that the critical aspects of supportability are designed-in to the weapon system. Design synthesis that achieves high reliability involves a process that can be thought of as an iteration of design (design and redesign), where relevant failure modes are identified and removed. Reliability of a system arises from its resistance to failure, so during design and development, an effective design process eliminates the system failure modes that would be encountered in the field. The removal of failure modes requires a vigilant, informed, and sustained engineering effort.

Maintenance

Maintainability arises from ease of maintenance and involves a similar engineering effort to simplify and enable maintenance when it is required. To produce a maintainable design, designers, developers, and LCLs must actively pursue this end.

Collecting and Analyzing System Performance and Maintenance Data, Cont.

During the System Capability and Manufacturing Process Demonstration effort, a variety of analysis tools can be used to evaluate system performance and maintenance data. The illustration below shows key tools of the system reliability, maintainability, and supportability engineering processes. Select the image to enlarge it.



Select Image for Enlargement

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Long Description

The graphic includes a drill down of the Engineering and Manufacturing Development phase, which includes both Integrated System Design and System Capability & Manufacturing Process Demonstration.

Failure Mode, Effects and Criticality Analysis (FMECA)

A failure mode, effects and criticality analysis (FMECA) is a reliability evaluation and design review technique that examines the potential failure modes within a system, or lower indenture level component, to determine the effects of failures on equipment or system performance. Each hardware or software failure mode is classified according to its impact on system operating success and personnel safety. FMECA uses inductive logic (a process of finding explanations) on a "bottom up" system analysis. This approach begins at the lowest level of the system hierarchy and traces up through the system hierarchy to determine the end effect on system performance. Below are some design and function attributes of FMECA, select each for a description:

Design

Function

Popup Text

Design

- Facilitates investigation of design alternatives to consider high reliability at the conceptual stages of the design.
- Provides an effective method for evaluating the effect of proposed changes to the design on mission success.
- Provides the criteria for early planning of tests to characterize the weaknesses of the design.
- Provides a basis for the safety analysis that is done as part of evaluating the safety characteristics of the design.

Function

- Determines the effects of each failure mode on system performance.
- Provides a basis for identifying root failure causes and developing corrective actions.
- Aids in developing test methods and troubleshooting techniques.
- Provides a foundation for qualitative reliability, maintainability, safety and logistics analysis.
- Uses a documented, systematic, and uniform method.
- Can provide an early identification of single failure points and system interface problems.

Fault Tree Analysis (FTA)

A fault tree analysis (FTA) is a systematic, deductive methodology for defining a single, specific, undesirable event and determining all possible reasons (failures) that could cause that event to occur. The undesired event constitutes the top event in a fault tree diagram and generally represents a complete or catastrophic failure of the product. The FTA focuses on a select subset of all possible system failures, specifically those that can cause a catastrophic "top event."

When properly applied, an FTA is extremely useful during the initial product design phases as an evaluation tool for driving preliminary design modifications. Through an FTA, a product can be evaluated from both a reliability and fault probability perspective.

Fault Tree Analysis (FTA), Cont.

Fault tree analysis can be used for:

- Functional analysis of highly complex systems;
- Observation of combined effects of simultaneous, non-critical events on the top event;
- Evaluation of safety requirements and specifications;
- Evaluation of system reliability;
- Evaluation of human interfaces;
- Evaluation of software interfaces;
- Identification of potential design defects and safety hazards;
- Evaluation of potential corrective actions;
- Simplifying maintenance and troubleshooting; and
- Logical elimination of causes for an observed failure.

The results of an FTA are expressed either qualitatively or quantitatively. Qualitative results include minimum cut-sets (combination of element failures capable of causing system failure), qualitative importance (qualitative rankings of various contributions to system failures) and common cause potentials (minimum cut-sets vulnerable to a single failure cause). Quantitative results consist of numeric probabilities associated with system failure.

In addition to driving preliminary design changes, FTA data provides the LCL with valuable information regarding potential maintenance, support equipment, and spare and repair parts necessary to support the design.

Maintainability Analysis and Prediction (MAP) and Level of Repair Analysis (LORA)

MAP and LORA are analyses that are used to evaluate system performance and maintenance data. Select each to read how the analyses are used by the LCL.

- Maintainability Analysis and Prediction (MAP)
- Level of Repair Analysis (LORA)

Popup Text

Maintainability Analysis and Prediction (MAP)

MAP assesses the maintenance aspects of the system's architecture, including maintenance times and required resources. This analysis identifies strategic opportunities for diagnostics, prognostics, performance monitoring, and fault isolation that can enable reduced maintenance times and support cost reductions.

Level of Repair Analysis (LORA)

A LORA optimally allocates maintenance functions for maximum affordability. The services all have various models that can be used to perform LORA to determine the level and degree of maintenance.

Knowledge Review

The reliability evaluation and design review technique that examines the potential failure modes within a system, or lower indenture level component, to determine the effects of failures on equipment or system performance is which of the following?

- [x] Failure mode, effects and criticality analysis (FMECA)
- [ ] Fault tree analysis (FTA)
- [ ] Maintainability analysis and prediction (MAP)

Check Answer

Failure mode, effects and criticality analysis (FMECA) examines the potential failure modes within a system, or lower indenture level component, to determine the effects of failures on equipment or system performance.

Reliability-Centered Maintenance

Reliability-centered maintenance (RCM) is a logical, structured process used to determine the optimal failure management strategies for any system, based upon system reliability characteristics and the intended operating context. RCM defines what must be done for a system to achieve the desired levels of safety, environmental soundness, and operational readiness, at best cost. RCM is to be applied continuously throughout the life cycle of any system.

RCM planning shall be based upon mission requirements, performance of the system or equipment, safety, environmental compliance, cost effectiveness, and operational and logistics impacts. Both tangible and intangible benefits apply to RCM.

- Tangible benefits could include return on investment, reduced work requirements, and improved readiness.
- Intangible benefits could include quality of life, morale, and warfighter confidence.

Reliability-Centered Maintenance, Cont.

RCM is based on the following precepts:

- The objective of maintenance is to preserve an item's functions. RCM seeks to preserve a desired level of system or equipment functionality.
- The RCM process is a valuable life cycle management tool and should be applied from design through disposal.
- RCM seeks to manage the consequences of failure - not to prevent all failures.
- RCM identifies the most technically appropriate and effective maintenance task and/or other logical actions
- RCM is driven first by safety. When safety (or a similarly critical consideration) is not an issue, maintenance must be justified on the ability to complete the mission and finally, on economic grounds.
- RCM acknowledges design limitations and the operational environment. At best, maintenance can sustain the inherent level of reliability within the operating context over the life of an item.
- RCM is a continuous process that requires sustainment throughout the life cycle. RCM uses design, operations, maintenance, logistics, and cost data, to improve operating capability, design and maintenance.

For the LCL, the RCM analysis process provides an opportunity to learn more about the various logistics resources that will be required to support a particular maintenance course of action. For example, the LCL would provide information/estimates on various training, support equipment, technical publications, and spares required to return an item to serviceable condition if the RCM analysis determines that the best maintenance course of action is to repair on failure vice some sort of preventive maintenance action.

Reliability-Centered Maintenance, Cont.

RCM determines proper balance of planned and unplanned maintenance, along with "other actions", to establish a "failure management strategy." The image below shows the two basic types of maintenance considered during RCM.

Preventative Maintenance (PM)

- Scheduled Maintenance
- Proactive Maintenance

Corrective Maintenance (CM)

- Unscheduled Maintenance
- Reactive Maintenance

D

Long Description

Preventative Maintenance (PM) consists of:

- Scheduled Maintenance
- Proactive Maintenance

Corrective Maintenance (CM) consists of:

- Unscheduled Maintenance
- Reactive Maintenance

Reliability-Centered Maintenance, Cont.

An RCM process includes the following items in sequence. Select each item for details.

- FUNCTIONS
- FUNCTIONAL FAILURES
- FAILURE MODES
- FAILURE EFFECTS
- FAILURE CONSEQUENCES
- MAINTENANCE TASKS AND INTERVALS
- OTHER LOGICAL ACTIONS

Popup Text

Functions

The desired capability of the system, how well it is to perform, and under what circumstances.

Functional Failures

The failed state of the system (i.e., the system falls outside the desired performance parameters).

Failure Modes

The specific condition causing a functional failure.

Failure Effects

The description of what happens when each failure mode occurs, detailed enough to correctly evaluate the consequences of the failure.

Failure Consequences

The description of how the loss of function matters (e.g., safety, environmental, mission, or economics).

Maintenance Tasks and Intervals

The description of the applicable and effective tasks, if any, performed to predict, prevent, or find failures.

Other Logical Actions

Includes but not limited to: run-to-failure, engineering redesigns, and changes/ additions to operating procedures or technical manuals.

Early Identification and Aggressive Pursuit of System Redesigns/Modifications to Ensure Affordable Support

The LCL must collect and evaluate system performance and maintenance data throughout the acquisition process but particularly when the system design is mature and the final product support plan is being worked. The LCL should be well-versed in the application of the various analysis tools that may be used. Once shortcomings are identified, the LCL has three options:

1. Refine the planned maintenance support structure,
2. Refine the maintenance resource requirements, or
3. Aggressively pursue system redesign/improvements as necessary.

While the latter option may be the most difficult, in some instances it will be the only option that will enable a support solution that will meet both the support performance and affordability requirements.

Demonstrating Acceptable Levels of Interoperability and Operational Supportability

During the System Capability and Manufacturing Process Demonstration effort, the LCL, as a key participant in the systems engineering process, ensures that acceptable levels of interoperability and operational supportability are demonstrated through developmental T&E and operational assessments. Interoperability is a key attribute that may need to be identified for a capability to ensure its effectiveness.

The Affordable System Operational Effectiveness (SOE) framework is a useful tool for framing the interoperability and operational supportability levels that must be demonstrated. The concept of SOE illustrates the dependency and interplay between technical performance, supportability, process efficiency, and life cycle cost. The definition of acceptable levels must support the Milestone C decision to enter low-rate production and reflect minimal or manageable risk.

Popup Text

Interoperability

Systems, units, and forces shall be able to provide and accept data, information, materiel, and services to and from other systems, units, and forces and shall effectively interoperate with other U.S. Forces and coalition partners. Information technology and National Security Systems interoperability includes both the technical exchange of information and the end-to-end operational effectiveness of that exchanged information as required for mission accomplishment. (Source: CJCSI 3170.01H, *Joint Capabilities Integration and Development System*)

Knowledge Review

The description of what happens when each failure mode occurs, detailed enough to correctly evaluate the consequences of the failure is which of the following?

- [ ] Functional failures
- [ ] Maintenance tasks and intervals
- [x] Failure effects

Check Answer

Failure effects is the name for what happens when each failure mode occurs, detailed enough to correctly evaluate the consequences of the failure.

Acceptable Levels of Interoperability

Demonstrating acceptable levels of interoperability covers various levels within the Affordable SOE framework. At the system level, there is the need to demonstrate open systems architecture and interoperability. Additionally, there are elements of interoperability that are specific to product support. These elements may be categorized into four areas where acceptable levels of interoperability must be demonstrated. The LCL can prioritize these areas and requirements based on time and resource constraints by focusing in on the high risk areas and cost drivers. The four areas of interoperability are below. Select each for a description.

1	2	3	4

Popup Text

Area 1

Requirements within the system including diagnostics, prognostics, weapon system information systems, etc. If diagnostics and prognostics elements cover more than one sub-system or component, interoperability must be demonstrated.

Area 2

Requirements within the support enterprise that must be demonstrated, such as the ability to exchange and share system information.

Area 3

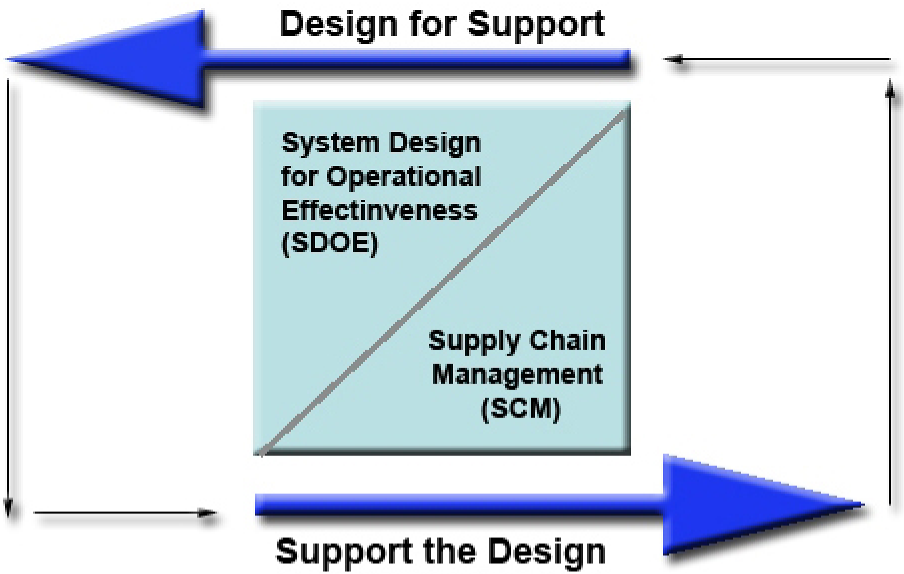
Requirements between the support enterprise and the warfighting customer organizations and commands. Information from a weapon specific information system must be interoperable with service specific systems in terms of information exchange requirements. If common support and handling equipment is to be used, the new system must be able to operate with that equipment.

Area 4

Requirement in joint service and coalition warfare. The support approach must be able to leverage commonality in support, especially if items are common across platforms. There is also the requirement to be able to provide weapon specific logistics command and control information (such as information on how long a system can be used before maintenance actions would be required) to battlefield commanders.

Acceptable Levels of Operational Supportability

Demonstrating acceptable levels of operational supportability covers the spectrum of elements in the SOE framework. In order to ensure that this is a manageable task, the LCL may choose to prioritize the significant support elements that are essential to meeting the mandatory sustainment KPP, the mandatory supporting KSAs, or major support performance requirements of the warfighting community.



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Long Description

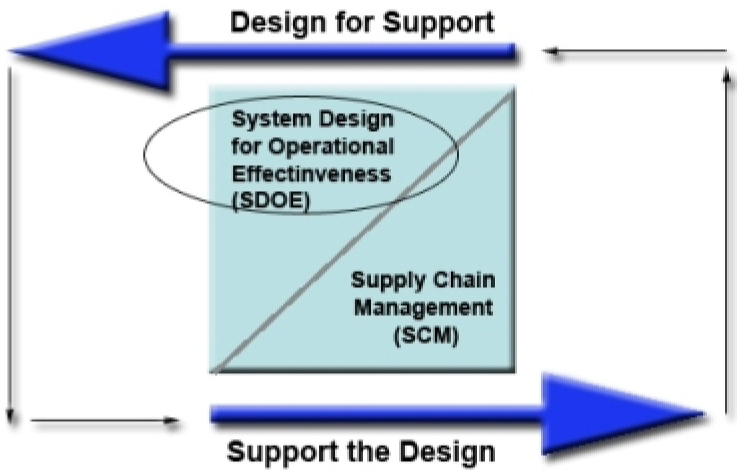
The graphic illustrates how System Design for Operational Effectiveness (SDOE) and Supply Chain Management (SCM) support the concepts of Design for Support (via SDOE) and Support the Design (via SCM). These are continuous, linked processes. There is a box in the middle divided by a line connecting the lower left to the upper right. The upper left represents SDOE; the lower right represents SCM. A large arrow indicating “Design for Support” sits above SDOE; a large arrow indicating “Support the Design” sits below SCM. The head of the Design for Support arrow is linked to the tail of the Support the Design arrow by a thin dotted arrow. The head of the Support the Design arrow is linked to the tail of the Design for Support arrow by a thin dotted arrow. These four arrows form a continuous loop.

Acceptable Levels of Operational Supportability – Design for Support

The earlier the LCL addresses issues associated with the inherent reliability and maintainability of the system, the easier it will be to affect any necessary design changes for improved supportability. In order to support the transition to Milestone C, the LCL should ensure that acceptable levels of operational supportability - based on the inherent reliability and maintainability as well as availability of all required logistics elements - are demonstrated.

In the event that acceptable levels of inherent reliability and maintainability are not demonstrated, the item should be identified as a critical issue that must be addressed before a Milestone C decision is made.

If reliability and maintainability cannot be demonstrated to acceptable levels, and budget and or time constraints preclude a redesign, then additional tasks and costs associated with increased logistics support need to be determined and flagged as necessary for achieving the supportability goals.



Acceptable Levels of Operational Supportability – Design for Support, Cont.

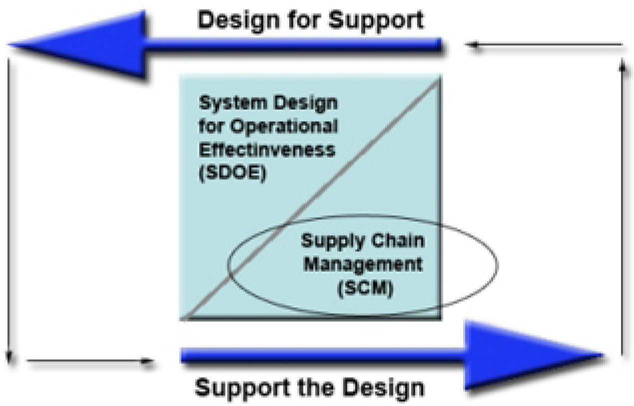
Demonstrating acceptable levels of operational supportability based on the refined product support strategy and approach begins in the System Capability and Manufacturing Process Demonstration effort but continues as an iterative process for the entire life cycle of the system.

The importance of system information to a knowledge based sustainment approach cannot be over-emphasized. A demonstration of acceptable levels of operational supportability should include successful developmental testing and evaluation of key support enablers, such as the technology for prognostics and diagnostics and unique item identification technologies.

Operational assessments of planned maintenance tasks may also be conducted to demonstrate the effectiveness of the approach based on the system as designed, the skill level of the maintenance personnel, and the requisite support resources.

M&S may be used to demonstrate acceptable levels of performance of the planned support enterprise along with some of the key processes—configuration management, supply chain management, transportation, information systems, and the establishment of the integrated digital environment.

Key elements associated with training of both operators and maintenance personnel may also be demonstrated through operational assessments.



Meeting Operational Support Requirements

The LCL must be confident that the operational support requirements will be met. The failure to demonstrate acceptable levels of interoperability and operational supportability during System Capability and Manufacturing Process Demonstration will only serve to exacerbate the logistics tail. It is imperative that all, to the degree feasible, high-risk or costly support elements be assessed through developmental testing and evaluation and operational assessments. The failure to do so will make the task of implementing effective and affordable product support very difficult, if not impossible.

The LCL must actively manage change throughout the life cycle. The ability to demonstrate supportability levels during System Capability and Manufacturing Process Demonstration will enable the identification and resolution of potential support deficiencies early enough in the process so that the warfighting community also can share the LCL's confidence in the product support strategy and its effective and affordable implementation.

Knowledge Review

Requirements within the system include, but are not limited to, diagnostics, prognostics, and weapon system information systems. If diagnostics and prognostics elements cover more than one sub-system or component, this characteristic must be demonstrated. This is part of which of the following?

- [x] Interoperability
- [ ] Maintainability
- [ ] Reliability

Check Answer

If diagnostics and prognostics elements cover more than one sub-system or component, **Interoperability** must be demonstrated.

Technical Activities Summary

You have completed Technical Activities and should now be able to:

- Identify Life Cycle Logistician (LCL) activities associated with collecting and analyzing system performance and maintenance data.
- Recognize the analyses that are used to evaluate system performance and maintenance data, to include: failure mode, effects and criticality analysis (FMECA), fault tree analysis (FTA), maintainability analysis and prediction (MAP), and level of repair analysis (LORA).
- Define reliability-centered maintenance (RCM).
- Recall the structures of RCM.
- Recognize the elements of interoperability and operational supportability.

Lesson Completion

You have completed the content for this lesson.

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