

Design for Maintainability

Definition

Maintainability is the degree to which a product can be maintained or repaired easily, economically, and efficiently. Design for maintainability (DFMaint) encompasses the measures taken to reduce the time and other resources spent in keeping a product performing well. It benefits the end user by reducing the total ownership costs through less downtime (lost productivity), lower maintenance costs, less inventory, fewer tools, and improved safety.

DFMaint can be a differentiating feature for otherwise commodity products. Although it may increase the costs to manufacture a product, DFMaint can also increase market share and extend the product lifecycle.

DFMaint is presented in this tutorial as an approach for durable goods. However, it can also be adapted appropriately for software, service, operations, and processes.

How to Apply Design for Maintainability

DFMaint Features

The following features are commonly found in easily maintained products and systems:

- Relatively few components in the final assembly
- Standard components and fasteners
- Conformance to national, international, and industry standards and codes
- Components that are easily replaced
- Components that can be easily removed with standard tools
- Components that are install only one way
- Space around or inside the product to perform maintenance activities
- Nondestructive disassembly
- Safety precautions protect maintenance workers from hazards
- Owner's manuals and other appropriate documentation (e.g., wiring diagrams, help facilities, or videos showing how to perform minor repairs)
- Consistent labels to identify parts
- Installed product required no or minimal adjustment
- Self-diagnostics, built in tests, or indicators that isolate problems quickly and automatically
- Streamlined testing, calibration, and troubleshooting procedures
- Simple after-sale processes that ensure service can be received promptly

DFMaint in the Product Development Process

The features of DFMaint products are obvious. Yet they can easily be overlooked unless DFMaint is a deliberate consideration in the product development process.

Furthermore, DFMaint should be considered early in the product design process when the product concept is flexible and change costs are low. The following closed-loop process outlines this approach:

1. Form a team that represents design, manufacturing, product maintenance, and customer support functions.
2. Gather and analyze data from service technicians, field personnel, customer surveys, and warranty records. (See related tutorial on such analysis tools as failure modes and effects analysis [FMEA], fault-tree analysis [FTA], Pareto analysis, and Ishikawa diagrams at this website.)
3. Identify and prioritize maintenance issues. Develop concepts to address the greatest concerns.
4. Incorporate the selected maintenance concepts into the product. (See related tutorials on design for manufacturing [DFM] and durability at this website.)
5. Analyze, test, and improve the product, allowing the design to evolve as maintenance concepts are reviewed and revised.
6. After product engineers finalize the design, release the product to manufacturing.
7. Evaluate the performance of the product in the field through customer feedback, warranty information, surveys, and service records. Use this information to inform the design of new products.
8. Modify the product as required by critical safety, economics, and performance demands.
9. Repeat the DFMaint process with the next generation product.

Measuring DFMaint Results

Maintenance cost benchmarks are collected by the Plant Maintenance Resource Center (<http://plant-maintenance.com/benchmarking.shtml>). These benchmarks can help a firm assess its competency in comparison with industry benchmark companies.

Maintenance metrics address three factors: product design attributes, after-sale costs, and product performance. Typical measures include

- conformance to specifications
- frequency of repairs
- repair costs
- total ownership costs
- training costs
- maintenance work orders per year

- downtime
- total maintenance hours
- number of maintenance personnel

Example

In the early 2000s, GE's Electro-Motive Division (EMD) was compelled to modify designs for its railway locomotives. New EPA requirements mandated a significant reduction in NOx emissions produced by locomotives. Since redesign was unavoidable, the division decided to take the opportunity to improve the maintainability of the equipment at the same time. Such improvements would improve the safety and reduce the required maintenance hours of the equipment.

Following an iterative design process, engineers not only surpassed the mandatory EPA standards, they incorporated several DFMA features into the new product:

- An easily removable hood
- Track-level access to the traction motor speed probe
- Solid-state components to replace more fragile fuses
- Simpler processes for insulation testing
- Reconfiguration and consolidation of electrical wiring and pneumatic piping onto separate sides of the underframe
- Advanced software to help technicians isolate defective components
- Clearer messaging on the crew's cab display screens to accurately convey important maintenance-related information
- A wireless remote monitoring and communications system that provides early alerts of predicted health and maintenance events
- An ergonomic cab to improve the engineer's comfort and reduce fatigue

Most importantly, the new design did not alter the basic engine dimensions, nor does it require additional workforce training or tooling.

Further Information about Design for Maintainability

Significant content for this article was found at the website for the Reliability Center (RAC), an information analysis center affiliated with the U.S. Department of Defense. A broad range of quality assurance information can be found at their website <http://rac.iitri.org>.

Additional Sources

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