MAINTAINABILITY CONSIDERATIONS IN THE DESIGN OF TRAINING DEVICES

Mr. Don R. Taylor
Maintainability Engineer

Maintainability has been described as a characteristic of design and installation which is expressed as the probability that an item will be restored to a specified condition within a specified time using prescribed procedures and resources.

Lack of maintenance considerations have proven to be costly, time consuming and in some cases the total effectiveness of equipment has been destroyed. Some examples of these given by General Osmonski at a Maintainability-Engineering and Management Seminar conducted by George Washington University in January of this year: -

> A battle tank where the engine had to be pulled to change a sparkplug,
> A personnel carrier whose engine had to be removed to change the oil,
> A mechanized artillery piece where components of its power train had to be dropped to clear or replace an air filter.

Hitting closer to home, examples of the lack of maintainability considerations in Training Devices developed for the Center, - I won't mention the Device by name to prevent further embarrassment. Examples, such as: -

A drawer arrangement for a piece of equipment that must be extended completely in order to gain access to test point and connections for the external test equipment, blocking the aisle so completely that the technician was required to go out the back door of the trailer and return through the front door in order to reach the controls on either side of the equipment.

Adjustments that were so critical in a certain piece of equipment that the drawer in which the equipment was mounted could not be opened because of the drastic effect the open drawer had on the operational characteristic of the equipment, yet there were no provisions made for adjustments while the drawer was close. Many hours of hit and miss adjustments were required in order to calibrate the equipment.

Five or six hours were required to remove the entire stick force assembly to replace a defective limit resistor inside the stick column, that could have easily been replaced in five minutes had the resistors been placed in the external circuitry of the control loading system.

To repair the hydraulic accumulator in one of the cockpit motion systems, the only way to gain access is by means of a cutting torch through the bottom of the trailer. We are hoping it never fails.

In order to remove a 400 cycle generator in one device we need a technician 3 feet tall and capable of lifting 500 pounds or we could use a weight lifter with arms 8 feet long. However, these qualifications are considered critical field areas. Several technicians spend many hours with this one.

I am sure that many other examples could be mentioned and I am equally sure that many of us have thought of examples we had rather not mention.

Maintainability is not a prescribed method of performing maintenance. Maintainability is designed and built into the equipment. Maintenance is required to live with the inherent maintainability, it cannot change it.

Maintainability Design Factors may be grouped into three basic areas; Operational Factors, Human Factors and Logistical Factors.

Operational Factors to be considered are:

Interchangeability of parts and components

Accessibility of components, test points and adjustments

Identification of components, test points and adjustments

Environmental effects

Modularization and microminiaturization

Packaging, need for special tools

Connectors

Types of test equipment required

Fault isolation methods

Ground support requirements

Adequacy and accuracy of maintenance data

Safety features

Maintenance procedures required

Human factors to be considered are:

Degree of logical analysis required

Motor performance

Body restrictions and limitations

Effectiveness of layout and knobology

Motivational levels

Skill levels required

Logistical Factors to be considered:

Standardization of parts and circuits

Availability of spares and consumption rate of spares

Preventive maintenance versus repair procedures

Repair versus thro-aways

Maintenance manhours expended throughout equipment life

Level and types of maintenance support

Burden-operating cost

Inventory obsolescence versus modification or overhaul

The Department of Defense is placing increased emphasis on maintenance. Expanding requirements for maintenance is a result; of the increased complexity of Training Devices, the lack of skilled military technicians, (The Navy is finding it more and more difficult to retain technicians at the upper rate levels), increased utilization demands on training devices, and budgetary considerations of support cost. These factors have made it mandatory to raise the stature of maintainability, until it is now a key element in system effectiveness. As a result of the elevation of maintenance to a key element, increased weight has been placed on maintainability in the evaluation of all proposals. It is extremely important to the contractor to develop an active Maintenance Department for the purpose of meeting future defense contract requirements. The Department of Defense has directed that current Military Development Projects specify maintainability as a design requirement and that maintenance predicted in advance, measured during development, and validated during subsequent fleet operations.

Department of Defense Directive 4100. 35 encourages close liaison and exchange of ideas between the Military Departments and Industry to:

Improve techniques used in Logistic Support

Improve or develop prediction and measurement techniques

Establish or improve measurable goals

An example of the typical maintenance cycle has been included in the material that you have received. See Figure 19.

You will note that there are eleven repair time elements or tasks listed. There is only one of the eleven that is not design controllable, and even this one could be taken care of in design if it were required. Three of the eleven are partially design controllable and seven are definitely design controllable. Ten out of eleven are directly affected by design.

Design Engineers must be made aware of their responsibility in reducing the Mean Time to Repair of each maintenance task. The maximum time an operation could be interrupted without seriously affecting the mission, could be used as a criterion for determining the maintenance features of the equipment design.

Effectiveness of a Training Device may be defined by two basic time elements, the time a device is capable of performing its complete function when required and the total time there is a requirement for the equipment's operation.

An analysis of over 200 Center Training Devices was made and it revealed the present rate of availability is slightly under 60%. Our present goals in Logistic Support is to bring this up to 98% by 1971. We are fully aware that this goal cannot be reached without the full cooperation and support of you in Industry.

We have an extensive challenge before us. The Navy has realized the importance of Maintainability for many years. Many studies and many volumes have been published outlining techniques to be used in the application of maintenance. These publications are available to you through the normal channels of Navy Publications.

Maintainability in the past has been like the weather, 'Many people talk about it but no one does anything about it." Well!, we are beginning to do something about it. I am sure that like the weather we will get wet, be left out in the cold, and have stormy days. However, we can enjoy the sunshine together if we weather the storms as a team.

Experience, to date, has indicated the usefulness of Maintainability design techniques. Yet these techniques and the efforts expended in their development become meaningless unless they are put to use by the design engineers and all levels of line management, in their program decisions.

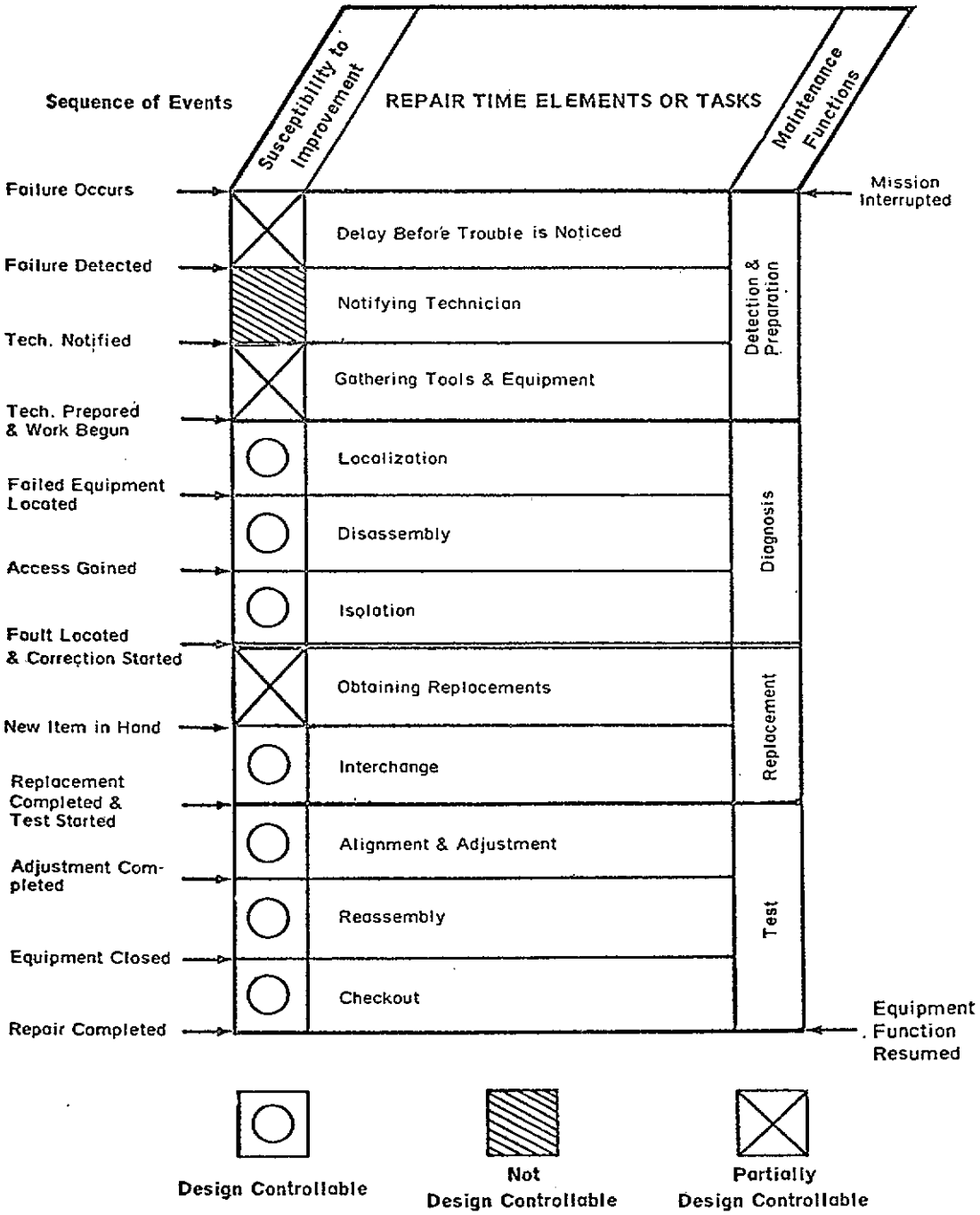

Figure 19. A Typical Maintenance Cycle

It is the responsibility of management to see that all program levels are educated in the usefulness of maintainability design techniques and to assure that this education is undertaken by a maintainability specialist.

Like any management technique, its communication system can make it work or cause it to fail. We must specify the type and amount of communication that is required for the Maintainability Manager to effectively perform his job.

I have mentioned a few examples of the lack of maintainability, shown the relationship of the maintenance cycle to the design control, pointed to the responsibilities of management to the maintainability program, shown the precentage rate of availability as it stands today with respect to where it should be, revealed the Department of Defense's request for corollary action, and made an appeal for your concern and assistance in attaining our mutual goals.

We do not claim to have all the answers nor do we profess to be the authority on Maintainability, however we do intend to reach our goal.

AUTOMATIC BUILT-IN TEST EQUIPMENT FOR TRAINING DEVICES

Mr. Lyman A. Whalen
Aerospace Engineer

Automation of electronic test, checkout and support equipment has grown over the past few years until it now represents a substantial nationwide effort.

Very often in the past, little thought and time were devoted to the design of support and checkout equipment. It is now evident that the same consideration should be given to the design of a test equipment system as we give to the design of a weapon system. This requires a thorough analysis of the mission of the test system and its environment. It also means making trade-offs between the constraints of cost, time, operator skill levels, accuracy, repeatibility, and user confidence to arrive at an optimum test system.

The alternative to the test system approach would be to solve each of the test equipment design problems independently, considering only the immediate requirements of the equipment under test.

One solution to the test system problem would be the utilization of Automatic Built-In Test Equipment. Such equipment can be used for fault detection, fault isolation, and continuous performance monitoring. Automatic Built-In Test Equipment has been used for aircraft and aerospace applications for quite some time, giving us extensive background information to draw upon.

Our primary goal is to achieve the maximum availability for our training devices. Availability may be expressed simply as:

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

It can be seen from this expression that availability can be increased by increasing the Mean Time Between Failures (MTBF) or by decreasing the Mean-Time-To-Repair (MTTR). Mil Standard 778 defines MTTR as: "A mathematical mean of the summation of active repair times during a given period of time divided by the total number of malfunctions during the same time interval." Experience at NTDC shows that fault isolation comprises approximately 75% of the active repair time for a given malfunction. Because of this, our efforts are directed to reducing MTTR by minimizing the fault isolation time. This may be done by effective utilization of more advance test systems.