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I Introduction

The Stanford Linear Accelerator Center (SLAC) uses a maintenance management philosophy that is best described as opportunistic or event-driven. Opportunistic maintenance can be defined as a systematic method of collecting, investigating, pre-planning, and publishing a set of proposed maintenance tasks and acting on them when there is an unscheduled failure or repair "opportunity". Opportunistic maintenance can be thought of as a modification of the run-to-fail maintenance management philosophy. This maintenance plan was adopted and developed to improve the overall availability of SLAC's linear accelerator, beam delivery systems, and associated controls, power systems, and utilities. In the late 1980's, as the technical complexity of the accelerator facility increased, variations on a conventional maintenance plan were used with mixed results. These variations typically included some type of regular periodic interruption to operations. The periodic shutdowns and unscheduled failures were additive and resulted in unsatisfactory availability.

Maintenance issues are evaluated in a daily meeting by a group that includes the accelerator managers, maintenance supervisors and managers, safety office personnel, program managers, and accelerator operators. Lists of pending maintenance tasks are prepared and made available to the general SLAC population by a World Wide Web site on a local internet. A conventional information system which pre-dates the WWW site is still actively being used to provide paper copies to groups that are not yet integrated into the WWW system. As a communication system the local internet is unsurpassed. It provides real time maintenance information, allowing people throughout the facility to track progress on tasks with essentially real-time status updates. Some of the more powerful features are still in an evaluation and testing stage. With the introduction of opportunistic maintenance, the accelerator's availability has been measurably better. This paper will discuss processes, rolls and responsibilities of key maintenance groups, and management tools developed to support opportunistic maintenance.

II Background

The Stanford Linear Accelerator Center carries out experimental and theoretical research in elementary particle physics using high energy electron and positron beams, plus a broad program of other research using synchrotron radiation. The primary tool for particle physics research is a two-mile-long accelerator complex, which includes facilities

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for producing, accelerating and colliding electron and positron beams. Successful operation of the accelerator requires that 10's of thousands of active components meet stringent tolerances under the control of a database-driven control system.

The SLAC accelerator is a state-of-the-art physics research tool that employs a sophisticated control system, highly specialized beam monitoring equipment, and micron size beam positioning systems. However, most of the accelerator components and subsystems are based on well-understood conventional technology. The utilities, power supplies, modulator systems, and most of the control system are assembled from parts that are in common use throughout the country.

The SLAC accelerator facilities have been built with a sufficient level of redundancy that the accelerator can remain operational even with a number of minor problems and failures. Repairs to malfunctioning equipment typically require that the accelerator and many associated power supplies be shut down to allow safe access to the housing. Recovery from such a shutdown typically takes several hours. To minimize the need for such interruptions, operating techniques have been developed that allow beams to be accelerated, steered, and focused when a few segments of the accelerator are shut down or when some of the diagnostic instruments are inoperative. As a result, minor failures may go unresolved for several days with no affect on machine performance. After a few weeks of operation there may be more than 100 items in need of repair. With a maintenance backlog of this size, accurate database records are essential to take advantage of maintenance opportunities when they occur and to ensure that problems are not forgotten. Occasionally, a critical component fails, prompting a full shut-down of the accelerator. When this happens, a "Repair Opportunity Day" may be initiated on short notice. It is not uncommon to complete over 100 maintenance tasks on such a day.

III Maintenance Organization

The Accelerator Department and several maintenance departments share responsibility for the maintenance of the accelerator. The Accelerator Department is responsible for the overall efficient operation of the accelerator facility, which includes overseeing, coordinating and scheduling maintenance with in the primary operations program. The maintenance departments provide the hands-on support and engineering expertise. To be successful, opportunistic maintenance requires that Operations, the maintenance groups, and the engineering staff work closely with each other.

Accelerator Department

The management of maintenance in the Accelerator Department is the responsibility of two sections, each with it's own area of responsibility. The Maintenance Office and accelerator operators are part of the Operations Section. The Accelerator Section consists of system physicists, who are responsible for technical design and performance issues, and area managers, who oversee the readiness of all components within their geographical areas of responsibility.

The accelerator operators initiate and approve all immediate repairs, corrective maintenance, and deferred maintenance. In addition, the operators provide expert advice on the impact of maintenance on operations. They are the primary trouble reporting group for accelerator system malfunctions.

The Operations Section Maintenance Office consists of two individuals who coordinate most of the maintenance work. The Maintenance Office has, over the years, developed a number of different management tools. These include various databases and a WWW local internet site. The databases contain the deferred maintenance records and pending action items. The Maintenance Office also conducts a daily maintenance meeting to review the events of the past day.

The area managers are the regional experts for the various accelerator subsystems. They investigate and collect all the details of a proposed task, including time constraints and safety permits. After the information is collected and receives their approval, the maintenance database is updated. Deferred maintenance repairs are previewed and approved by the area manager before they can be added to the list of pending tasks. Quality assurance and configuration control are also their responsibility.

Maintenance Departments

The maintenance groups are usually subgroups within larger departments that include engineering, maintenance and support responsibility. These departments are organized along functional lines, such as the Power Conversion Department (power supplies and modulators), Plant Engineering Department (utilities), Controls Department (accelerator controls), and Mechanical Facilities Department (mechanical & vacuum systems). These organizations provide the personnel and technical expertise for the maintenance tasks in their areas of responsibility. They also provide prompt engineering support and risk assessment for complex tasks.

IV Management Tools

The management of opportunistic maintenance centers around several important tools. These include a SLAC built computer-driven trouble reporting system, a daily meeting in which current problems and deferred problems are reviewed and undocumented problems are collected, and a new local internet WEB site to publish the maintenance lists.

CATER

Computer Aided Trouble Entry and Reporting, CATER, is a flat file database that runs on the accelerator control computer. This database is the primary method to document accelerator problems and is available to all maintenance personal as well as the operators and maintenance managers. A selected list of problems from the preceding 24 hours is created each morning from the CATER records and reviewed at the maintenance meeting. The system is versatile and is used by some maintenance groups to track spare parts as

well as problems. CATER is also the source of revealed failure data used to calculate operations statistics and accelerator availability for periodic reports.

Meetings

The morning maintenance meeting is the single most important management tool for planning maintenance. It is a forum where problems can be discussed, and action plans developed to solve pressing problems or coordinate large maintenance tasks.
The standard agenda for the meeting is:

- Review CATER reports
- Action Items from past meetings
- Review Deferred Maintenance Problems
- Open the meeting to collect unreported problems.
- Present Special Reports; not more than 15 min.

In the process of going through the agenda, problems are identified and discussed. Maintenance items usually fall into one of three categories: Benign, Immediate, or Standby Maintenance. Benign items are tasks that can be done without any interruption or adverse impact to the ongoing operations and usually are not reviewed in the meeting. Immediate maintenance items are problems that require immediate action to restore normal operations or to prevent a more severe failure from occurring, and are usually not reviewed until the following day. Immediate problems are reviewed with the following questions addressed:

- Have we learn anything from event ?
- Are there related issues that need further action?
- Are engineering studies required?

If an item is identified as a Standby Maintenance task or as a candidate for a deferred maintenance list, it is turned over to the area manager who reviews the work and enters the job in the database. When this has been done, operators may initiate action on the task when an opportunity arises, and without the need for further review. Other deferred maintenance lists include jobs that should be done during a prolonged downtime (more than a day or two) or during a short one- or two-day downtime. The meeting lasts for 20 to 30 minutes, and also provides the maintenance staff with up-to-date information on the current operating schedule.

Internet

The Accelerator Department's Operations Section local internet connection and World Wide Web server have several functions. A recent extension of the system now makes the updated maintenance lists available to everyone at their desks or at their workbenches; however, these lists can only be accessed from within SLAC. This system also makes the detailed agenda for the morning's meeting available to everyone. A partially developed feature, now undergoing tests, allows area managers, operators, and others to input data directly into the database. Operators can mark tasks as

complete, maintenance shops can add comments, and managers can add and modify new work requests. In addition, links to other SLAC local internet based communications systems and maintenance databases are available.

V Conclusion

Our operating experience over the past eight years has shown a steady improvement in availability. In this paper, availability is only calculated for revealed failures for accelerator hardware. In the late 1980's and the first few years of the 1990's the availability was typically between 60% and 70%. In 1992 the availability climbed into the low 80% range, depending on the operating and experimental configuration in use. For some configurations of the accelerator, the availability reaches into the low 90% range.

"Opportunistic maintenance" is a method of organizing and managing the response to maintenance problems to optimize overall productivity. The key idea behind opportunistic maintenance is simply to make all preparations for disruptive maintenance in advance and as thoroughly as possible, but to initiate the actual work only when an opportunity arises. In a research facility such as SLAC, the hardware is constantly being upgraded and pushed to more demanding performance standards. In this environment, opportunistic maintenance has proven to be an effective maintenance tool.

Acknowledgments

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