Conf-950512--36

LA-UR-95-1468

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Submitted to:
1995 Particle Accelerator Conf. and Intl. Conf. on
High-Energy Accelerators
May 1-5, 1994
Dallas, Texas

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Los Alamos
NATIONAL LABORATORY

Development of a RAMI Program for LANSCE Upgrade*

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Abstract

Improvement of beam availability is a prime objective of the present LANSCE (Los Alamos Neutron Scattering Center) Upgrade. A RAMI (reliability, availability, maintainability, and inspectability) program is being developed to identify the most cost-effective improvements to achieve the availability goal. The beam-delivery system is divided into subsystems appropriate for the modeling of availability. The availability of each subsystem is determined from operation data and assessment of individual component designs. These availability data are incorporated in an availability model to predict the benefit of improvement projects to achieve cost-benefit prioritization. Examination of the data also identifies a comprehensive list of factors affecting availability. A good understanding of these factors using root-cause analysis is essential for availability improvement. In this paper, we will describe the RAMI program and the development of the availability model.

Introduction

Presently, the Los Alamos Meson Physics Facility (LAMPF) is undergoing an availability upgrade [1] so that the accelerator can become a reliable driver for the Los Alamos Neutron Scattering Center (LANSCE). The availability goal is to operate LANSCE at 100 μA with better than 85% availability over an operation period of eight months per year. Because of the durations of neutron-scattering experiments, it is important to keep the downtimes longer than 8 hours to less than 10% and those longer than 24 hours to less than 1%. A RAMI (reliability, availability, maintainability, and inspectability) program is being developed to insure that the upgrade is done in a cost-effective fashion. It will be used to plan, monitor, predict, and improve availability of the LANSCE beam-delivery system.

The RAMI Program is also being used to plan the maintenance and upgrade of LAMPF in the next five years. The purpose is to systematically replace obsolete and unreliable equipment from the LAMPF beam-delivery system so that the Facility can extend its lifetime for another 20 years.

RAMI works have been carried out previously at LAMPF. In the late 70's, a RAMI program was instituted to bring the availability from 65% to 80% [2]. The system tracked the failures of equipment and the repair cost. The program was later terminated. A review of the recent RAMI works at LAMPF have been given by Macek in Ref. 3. In 1994, a pilot Project, Development of a Reliability, Availability, Maintainability, and Inspectability Model for High Power Accelerators, was funded for a year. A report is being prepared [4]. The work described in this paper is the continuation of the recent RAMI works.

RAMI Program

The RAMI Program has three parts: Availability Model, Root-Cause Analysis, and Maintenanc Policy. The beam-delivery system is divided into subsystems and the subsystems are collections of individual components. The Availability Model uses a database that contains the availability data of all the components to predict the availability of the beam-delivery system and the subsystems. The prediction is made using a set of assumptions, for example, the distribution of failures and repairs. These assumptions are part of the Availability Model. The commonly used assumptions can be found in Ref. [3] and [5]. The Availability Model should reproduce the observed availability and will be able to predict the gain in availability of improvements and the cost-effectiveness. The availability model will also be used to identify the low-availability subsystems so that a Root-Cause Analysis can be done on the subsystems. The Root-Cause Analysis is an indepth analysis of the performance of a subsystem and suggests improvements. Maintenance Policy helps us to maintain the performance of the accelerator.

Availability Model

The database used by the Availability Model is assembled by first listing all the components in the beam-delivery system. Examples of components are power supplies, klystrons, and beam-position monitors. These components are grouped into subsystems. Subsystems are usually groups of components with similar locations and purpose along the beam-delivery system. They are grouped with enough components to have sufficient availability statistics. Examples of subsystems are injector, PSR (Proton Storage Ring), and Neutron Production Target. Components are also assigned function designators according to their functions. Examples of function designators are magnet, water, and vacuum. Both subsystem and function designators are needed to facilitate sorting available information in the database so that the information is presented in a more digestible form. For example, one can easily find the availability of the water system in PSR by selecting all the components that have subsystem designator of PSR and function designator of water and summing their availabilities.

After listing all the components, availability data of these components were collected. These availability data are in the form of MTF (mean time between failures) and MTR (mean time of repairs). They are derived from experience and assessment of designs. At this point, the assembly of the database is complete and predictions of availability of subsystem can be made in conjunction with assumptions made in the Availability Model.

The present Availability-Model database for the beam-delivery system has a total of 385 components. These are actually component types because similar components are counted as one component. These components are separated into nine subsystems. Subsystem names are given in Table 1. There are 14 function designators (Table 2).

The Availability Model can be benchmarked by comparing its availability prediction with observed availability for subsystems. The observed availabilities of subsystems are provided through operation logs where operators record the times and causes of component failures and repairs. Presently, the operators are recording the failed subsystem and the failure mode in a specified format. The subsystem and function designators have been chosen to correlate with that format so that data can be easily derived from the operator log to compare with the Availability Model. Figure 1 shows the observed distribution of time-between-failures for subsystems injector and Sector A during the operation in 1994. These data were used to drive the availability, MTF, and MTR for the subsystems.

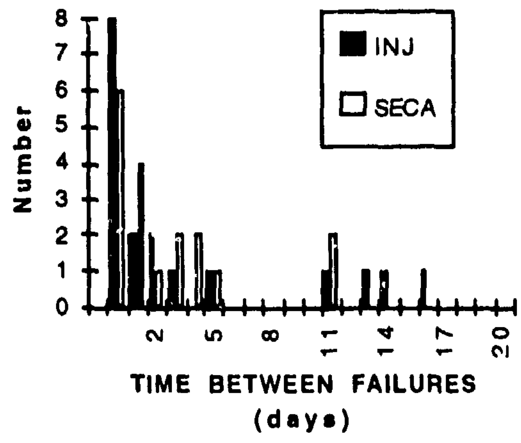

Fig. 1 Distribution of time-between failures

Table 1: List of subsystems

Injector	Sector A	Sector B-H
Switchyard	Area A	Line D
PSR	Target	WNR

Table 2: List of functions

Aperture	Beamline	Control/data
Diagnostic	Facility	Magnet
RF	Safety	Source
Structure	Timing	Vacuum
Water	Misc.	

The PSR Pulsed Power System has been studied before using an Availability Model and is described here as an example [6]. The complete system was divided into four subsystems: switchyard kicker magnets (LDKIs), PSR injection linekicker magnet (RIKI), the 2.8 MHz RF beam buncher (SRHM), and the electromagnetic extraction kickers (SRFK). Table 3 shows the part of the database used for RIKI. The availabilities predicted using the database for the subsystems and complete system were compared to observed availabilities from operator's logs (Table 4).

Root-Cause Analysis

The Availability Model and the observed data can identify the low-availability subsystem. A Root-Cause Analysis is needed to identify the failure modes so that improvements can be made. These improvements include a better design, preventive maintenance, and monitoring programs. Assuming these improvements, new MTF and MTR data can be generated and used in the Availability Model to predict the improved availability. Examples of Root-Cause Analysis can be found in Ref. [3].

Maintenance Policy

Maintainability and inspectability will be addressed with Maintenance Policy. Regular monitoring and maintenance are needed to reduce failure and downtime. In older facility like LAMPF, a sustained replacement program is also needed for equipment that has moving parts. Because of budgetary constraints, the replacement program is not in place yet. A conscious effort has been made, instead, to keep an inventory of spare parts of long-downtime components. A record of these spare parts will be incorporated in the Availability-Model database. In the future, component maintainability, monitoring, and inspectability will also be incorporated in the designs of components.

Summary

A RAMI Program is being developed to insure that the upgrade of LANSCE will be done in a cost-effective manner. The Availability Model is being assembled and complemented with Root-Cause Analysis and Maintenance Policy.

Acknowledgment

This work is supported by Los Alamos National Laboratory Institutional Supporting Research, under the auspices of the United States Department of Energy

References

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Table 3: Availability-Model Database for RIKI

Subsystem	Component	Function	MTF (days)	MTR (h)	Spares	Avail.
PSR	**Magnet:**					
PSR	Magnet current connections	magnet	20000	6	Parts	0.999988
PSR	Coils	magnet	10800	340	1	0.998690
PSR	**Charging system:**					
PSR	PS,Sorenson DCR 600-8T	magnet	3600	4	1	0.999954
PSR	PS, Christie 1C015-600EBBX4S	magnet	3600	8	some parts	0.999907
PSR	**Modulator:**					
PSR	Resonate Charge SCR	magnet	3600	8	3	0.999907
PSR	Zener Diode Assembly	magnet	1000	5	3	0.999792
PSR	Charge Recover SCR	magnet	3600	8	3	0.999907
PSR	Freewheel SCR	magnet	3600	8	3	0.999907
PSR	Transfer Chassis	magnet	1800	16	0	0.999630
PSR	**Controls and Interlocks:**					
PSR	RIKI01 Run Permit	safety	3600	1	Parts	0.999988
PSR	NIM Crate	safety	1800	8	Parts	0.999815
PSR	Short Nim Crate	safety	1800	8	Parts	0.999815
PSR	**Computer Interface:**					
PSR	CAMAC	control/data	7300	4	?	0.999977
					Sub. Avail	0.997280

Table 4: Comparison of observed availability and availability predicted with Availability Model. All availabilities are in percentages.

	LDKI	RIKI	SRHM	SRFK	Total
Observed	99.1	98.8	96.5	97.8	92.4
Predicted	97.7	99.7	98.6	98.4	94.6