Finally, the principal contractors were very cooperative in helping to plan and conduct certain critical experiments, in making available key personnel and project records on short notice, and in contributing to the content of this report.

## CONCLUSIONS AND RECOMMENDATIONS

The task force has completed its review and considers that, while there are problems remaining, a reliable demonstration, as defined in the Department of Transportation contract with Penn Central, could be initiated in 7 months subject to the prompt implementation of certain task force recommendations. It is our estimate that, with extremely vigorous and carefully coordinated management in all phases of this project—Government, railroad, equipment suppliers—it may be possible to improve on this schedule. The corollary possibility also exists. Limited nonrevenue operations that would not meet the frequency requirements of the demonstration project, but that could serve a useful purpose in training operational and maintenance personnel could be started within the next 3 months. Such preliminary operations had been planned as an integral part of the demonstration project for some time.

The task force found that many of the individual problems delaying the demonstration had been identified by the various contractors and that substantial resources are now dedicated to the prompt resolution of these problems.

However, the task force finds that managements in the project—Government, railroad, carbuilder, equipment suppliers—were overly optimistic with respect to the planning and scheduling requirements of a project of this magnitude and complexity. The Metroliners are the most sophisticated railroad equipment yet attempted anywhere, and properly so. We are dealing with a train consisting of six or eight locomotives that can draw more current than any other railroad load; that contains approximately 70 miles of wire and 25,000 electronic components.

The major remaining technical problems are:

(1) Electronic maintainability;

(2) Wheel thermal stress under specified deceleration when using air-brakes alone;

(3) Pantograph-catenary current collection stability at high speed during winter months, particularly under the remaining light wire; and

(4) Acceptability of ride quality.

To achieve a full demonstration within 7 months, we feel it necessary to implement right now certain maintainability and reliability programs, to proceed rapidly with specified pantograph-catenary experiments so that an early decision can be reached on modifications such as additional car busing and to continue the current ride improvement experiments with high priority.

*Electronic maintainability*

During the course of the study, electronic reliability calculations indicated that the mean time between failures (MTBF) of an electronic component in an eight-car train was 10 hours.[1] This is a preliminary number based on the failure rate data available to the task force. Attempts are being made to verify the failure rate data. MTBF numbers must be used with caution until the failure modes of equipment are thoroughly analyzed. These could not be completely developed in time for this task force report.

Nevertheless, a preliminary failure mode analysis indicates that the probability of meeting the present demonstration schedule is greater than 99 percent with a good lead car since both an eight-car and six-car train can pull two dead (freewheeling) cars at 100 miles per hour. Furthermore, in case of a failure in lead car electronics or train line control, there is still a probability of at least 99 percent of meeting the demonstration schedule by utilizing the backup power system.

Thus, the redudancy of multiple powered cars and the emergency power system lead to a high probability of reasonable schedule accomplishment if cars are properly maintained. Nonequipment factors, however, may limit schedule performance.

The major implication of the MTBF for the Metroliner is in maintenance. It is aggravated by scant fault indication equipment. One should add to the train

[1] There are approximately 3,000 electronic components per car with an average failure rate of $4 \times 10^{-6}$ hours.