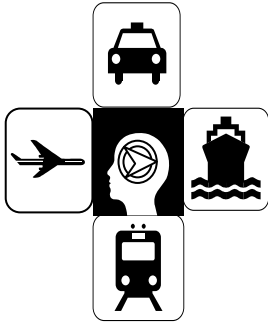


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Tech Brief

Fatigue Management, Rail Operations Personnel

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Summary

New Jersey Transit Corporation (NJ Transit) operates over 1900 buses and 600 trains and serves over 300,000 customers annually. By the end of 2004, the agency reached a record of rail ridership approaching 64 million passenger trips, bus ridership exceeding 150 million passenger trips, and light rail ridership reaching 11.3 million passenger trips. As an agency that depends upon the capabilities of both its equipment and operators, the ability to effectively manage operator fatigue is essential.

NJ Transit currently employs staff of over 1,500 rail operations personnel including: locomotive engineers, who operate the trains; conductors, who are responsible for collecting tickets and fares and ensuring passenger safety; and yard masters who are responsible for ensuring that the safety and operation of rail equipment is maintained. Effort to minimize fatigue associated with work schedules is not only essential to NJ Transit's business viability, but is also a key concern among the workers and their union representatives.

The goal of this study is to develop a set of practical recommendations for reducing fatigue while meeting applicable rules and regulations, addressing management and operations

personnel concerns, and meeting current and future demands of NJ Transit's rail passenger customers. This Tech Brief provides a summary of the research approach, findings, conclusions and recommendations of the study.

Background

Operator fatigue has serious consequences, not only in terms of impaired service, but can lead to serious injury. Operator fatigue has been identified as a probable factor in a number of major crashes and costly incidents, such as the crash of a BMT airport subway train, the Exxon Valdez tanker spill and the collision of New York City subway trains on the Williamsburg Bridge. Not surprisingly, rail operator fatigue is a topic that is receiving national attention.

"Fatigue Management Plans" provide scheduling strategies that consider the human body's natural sleep/wake cycles (circadian rhythm) to optimize service and/or production while minimizing costs. Under provisions of the Federal Railroad Safety Enhancement Act of 1999, Fatigue Management Plans amend the existing hours of service laws under the current United States Code. These changes are aimed at recognizing and reducing on-the-job fatigue and fatigue-caused accidents and injuries.

NJ Transit is New Jersey's principal bus, rail and light rail commuter transit provider with service extending throughout the entire state and into New York City and Philadelphia. NJ Transit currently operates 12 commuter rail lines and 2 light rail lines totaling nearly one thousand directional route miles with 163 rail and 27 light rail stations. Rail service alone accommodates approximately 225,000 passenger trips per day.

While fatigue management is an important safety issue for NJ Transit, there are no acceptable methods to quantitatively measure operator fatigue, and testing operators for fatigue is impractical. Therefore, efforts to develop and implement effective fatigue management strategies are essential.

NJ Transit maintains an "hours of service"(HOS) database for its rail operations personnel and crew assignments. Their intention is to use this database for comparison to HOS determinations using existing fatigue management modeling tools. In this project NJIT has partnered with Circadian Technologies Incorporated (CTI) to develop a model and procedures for evaluating

fatigue that can be used in conjunction with NJ Transit's HOS database. Results of the HOS database evaluation can then be used to develop strategies for minimizing fatigue of rail operations personnel.

Research Approach

Research approach includes a comprehensive literature review, development of a fatigue evaluation model, and recommendation of measures and strategies for fatigue mitigation based on results of the evaluation.

Literature review provides both, a general overview of information about social, physiological and psychological factors believed to cause fatigue, and an analysis of factors of fatigue specific to rail operations personnel.

Proper assessment of fatigue is one of the most important elements of an effective fatigue management model. For this purpose we used a computer model to estimate fatigue and assign a "fatigue score" to analyzed crew assignments. The model was developed by CTI and it can be interfaced with the NJ Transit's HOS database. CTI fatigue estimator can be used for testing "what if" scenarios, i.e. examining the impact of changing schedule parameters. For example, if the schedule is modified to adjust start and end times, the fatigue estimator is capable of evaluating those changes in terms of fatigue levels.

CTI's model is based on their research of rail operations personnel as well as a comprehensive body of medical research on circadian rhythm patterns. Schedule features, such as start and end times, days on and days off, are entered into the model, which is capable of producing "fatigue indices" for individual operators as well as crew assignments. Fatigue indices range from 1 to 100, with low numerical values representing little fatigue producing effects and higher scores correlating to high fatigue levels. In general, the majority of operator schedules produce scores ranging from 20 to 60. Fatigue indices above 60 may be considered problematic for rail operations personnel.

Since CTI's model was largely geared towards long haul freight rail clients, it was necessary to assess specific factors that pertain to developing fatigue for NJ Transit personnel. This was accomplished by conducting a survey of NJ Transit personnel and union officials who represent

NJ Transit's rail operations personnel. The survey questionnaire consisted of 136 multiple-choice questions and four general questions concerning fatigue, to which survey participants could provide written responses. The survey was distributed to 200 randomly selected participants, including 100 conductors and assistant conductors, and 100 locomotive engineers and assistant locomotive engineers. The results of the surveys were used to identify and document advantages, disadvantages, suggested schedules and guideline improvements from the point of view of the NJ Transit rail operations staff.

Findings and Conclusions

CTI fatigue indices were developed for NJ Transit rail operations personnel having regular assignments as well as "Extra Board" assignments. Regular assignments are generally schedules consisting of four to five consecutive days with two to three days off between work periods. Regular assignment shifts typically run ten consecutive hours during the day, with a set time-off period. Extra Board assignments are available and are used when an employee is unable to work and by their nature, are not set and may or may not be filled. Fatigue indices were then calculated for both assignment categories based on NJ Transit's October 27, 2002 crew assignment schedule. Some of the key findings are as follows:

- ❑ Fatigue indices both for conductors and engineers were consistently higher for Extra Board assignments as compared to Regular Assignments.
- ❑ The percentage of conductors and engineers with high fatigue indices (60 or higher) was nearly double for Extra Board Assignments as compared to Regular Assignments.
- ❑ Fatigue for the regular assignment group arises mostly from overnight/early morning schedules.
- ❑ High fatigue indices for Extra Board assignments arise from a combination of long working hours, variations in start time, lack of scheduled nights off (sometimes no nights off), and multiple days on.

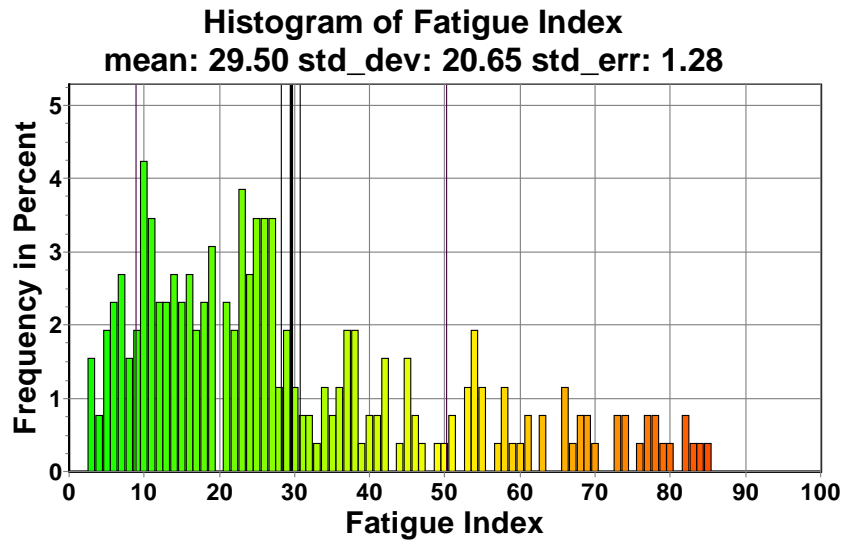


Figure 1. *Engineers with Regular Assignments*

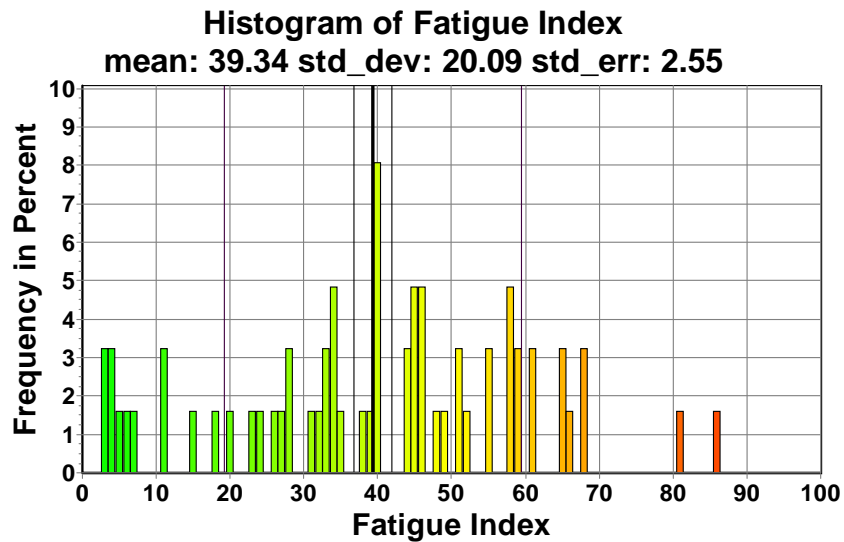


Figure 2. *Extra Board Assignments for Engineers*

Of the 200 survey questionnaires that were sent out to selected participants 33 were completed and returned to the research team, resulting in a response rate of 17 %. The survey findings were then summarized and analyzed in order to develop a better understanding of fatigue factors specific to NJ Transit personnel. Here are some of the key findings of the survey:

- The majority (61 %) of respondents indicated difficulty in obtaining an adequate amount of sleep.

- ❑ Over half of the respondents indicated at least some difficulty in maintaining alertness on the job, and fighting fatigue or drowsiness on the job.
- ❑ While 84 % of respondents indicated they required 7 to 8 hours of sleep to be alert and well rested, less than half reported they obtain 7 or more hours of rest.
- ❑ More than half (17 of 31) of the respondents indicate they do not use the napping/resting rooms and the majority (21 of 31) rated the quality of these facilities as “poor”. Written responses also suggest that more consistent work shifts, longer break time between trains, better rest facilities and improved working relationships between crew members and upper level management could help reduce operator fatigue. Lack of job security was also noted as a concern among rail operations personnel.

Recommendations

Based on the results of the literature review, CTI’s evaluation of the October 2002 schedule and survey questionnaire responses, several recommendations have been developed and are elaborated in more detail in the Recommendations section of the final report for this study. Here is the summary of the key recommendations:

- ❑ *Eliminate split shifts where a night shift is followed by a day shift assignment.* Schedule combinations that look at start time changes and number of consecutive hours worked should be examined further, both from a fatigue index point of view and from actual reports of operators, to gain the maximum benefit of fatigue reduction.
- ❑ *Reduce the number of hours worked at night.* To the extent possible, working long nighttime hours should be limited.
- ❑ *Engage in active discussions to comprehensively examine revamping the Extra Board concept.* Extra Board assignments result in the highest fatigue indices and are, according to the body of research, the most fatigue inducing. However, the economic benefits and need to maintain adequate staffing levels when normally scheduled crew members are not available must be balanced with potential safety risks associated with potential fatigue related problems associated with Extra Board assignments. There needs to be an ongoing dialogue among NJ Transit officials and union officials

so that an equitable balance between the economic benefits and potential safety risks due to fatigue can be achieved.

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A final report is available online at:

<http://www.state.nj.us/transportation/research/research.html>

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research Technology Transfer Group at (609) 530-3722, or send an e-mail to Research.Division@dot.state.nj.us and ask for:

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