U.S. Department
Of Transportation

**Federal Railroad
Administration**

Research Results

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Passenger Rail Car Egress Time Prediction

SUMMARY

The FRA is investigating how to improve rule provisions addressing the safe, timely, and effective emergency evacuation of intercity and commuter rail passengers in various emergency scenarios. A variety of evacuation concepts, strategies, and techniques for applicability to U.S. rail passenger cars are being investigated and evaluated.

Under the sponsorship of the FRA, the Volpe Center conducted a series of twelve commuter rail car passenger egress tests involving 86 passenger subjects, in cooperation with the Massachusetts Bay Transportation Authority (MBTA), at North Station, Boston, MA, USA, on August 25, 2005. The egress experiment time data are intended to be used as an input to a computer egress model in order to predict emergency evacuation time for various car configurations. Additional egress experiments are planned.

Preliminary egress experiment results indicated consistent egress times by subjects for all trials with very small learning effects and no fatigue effect. In addition, subject flow rates were less than those at previous train egress trials since no incentives were given and subjects were instructed not to push. No significant difference was observed between normal and emergency lighting conditions. The egress times for 84 passengers averaged 58 seconds using 2 side doors to a high platform, and 1 minute and 40 seconds, using either a single side door to a high platform or an end door to the adjacent car.

Figure 1. Passengers Exiting from MBTA Commuter Rail Car during Egress Experiment

BACKGROUND

Passenger Car Egress Experiment

A series of 12 trials was conducted August 25, 2005 at North Station, Boston, MA, to obtain human factors data related to the length of time necessary for passengers to exit a single-level coach car to an adjacent car or to the station platform using one or two doors, under both normal and emergency lighting conditions (see Table). To FRA knowledge, this is the first time that passenger egress trials were conducted using U.S. rail cars with regular commuter rail passengers as subjects.

Train Egress Trials and Types

TRIAL #	DESTINATION	LIGHTS
1, 7	Platform – 1 door	Emergency
5, 11	Platform – 1door	Normal
3, 9	Platform – 2 doors	Emergency
4, 10	Platform – 2 doors	Normal
6, 12	Adjacent Car	Emergency
2, 8	Adjacent Car	Normal

The exit-time data are intended to be directly used to establish norms for egress times and to examine various aspects of car design that impede prompt egress. The data may also be used to provide input data for an egress computer model, in order to predict emergency evacuation time for other car configurations.

Passenger / Subject Distribution

86 subjects were recruited from the population of regular commuter rail passengers by means of posters placed in North Station, where the trials were conducted. To qualify, individuals must have possessed a commuter-rail pass for the month of August. Subjects were selected from those who applied according to the following guidelines:

- Equal numbers of male and female subjects
- Equal numbers of subjects in each of the following age groups:
  - 18 to 29
  - 30 to 50
  - over 50.

Except for 81 persons in Trial 1, 84 subjects participated during each of the 12 main trials.

This target distribution required a higher proportion of women than that used by the FAA for aircraft evacuations, but a slightly lower proportion of older subjects. However, the actual distribution used during the egress experiment was slightly different than the target with a few more female and middle-aged subjects than planned.

In addition to the 84 subjects who participated in the main 12 trials, two persons with mobility impairments participated in separate tests to measure their egress times.

A major issue with conducting human factors egress experiments is the safety of subjects and privacy concerns. Federal regulations generally require that all human experimental subjects be briefed on the purpose of the experiment and that they read and sign “Informed Consent “ documents explaining the experiment as well as authorizations to make information protected by the Privacy Act available to the researchers. All personal data (height, weight, etc.) is protected information. Although the experimental protocol, subject briefing, and consent forms must usually be reviewed and approved by a duly constituted Institutional Review Board prior to the conduct the tests, Volpe legal staff reviewed the experiment and determined that it met the Office of Management and Budget exception for “public behavior” since the subjects would not asked to perform actions that are different from those they normally do in the course of their daily routine.

Subjects were compensated with certificates from various local stores.

Data Collection

Subjects wore vests with ID numbers on their front and back (see Figure 2) and were assigned to different seats during each of the 12 trials.

The following categories of data were collected:

- Characteristics of each subject – identifier, age, gender, weight, height.
- Physical dimensions of the car – measurements of seats, aisles and doors.

Figure 2. Subject with Vest Number

- Characteristics of each seat – identifier, location, proximity to various exits, and direction.
- Initial illumination data for the floor near the doors and at 25 inches above the floor along the aisle under both normal and emergency lighting conditions. (The trials were conducted with car windows covered with paper; the end side doors were clearly lighted and visible, and platform lights were on.)

To acquire the detailed video record of each subject's movements during each trial, 16 miniature surveillance cameras were installed on the interior ceiling and just outside at the door locations of the test car, and in the adjacent car (see Figures 3 and 4). Their signals were recorded directly to a single hard-drive with time stamping (see Figures 5 and 6).

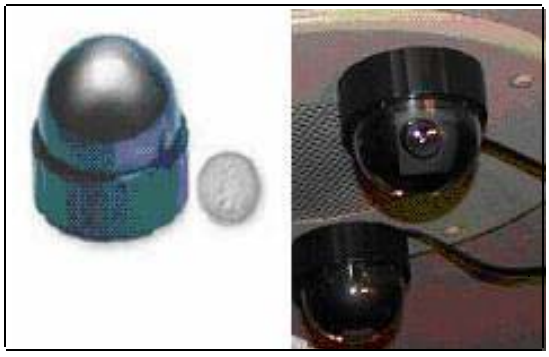

Figure 3. Miniature Ceiling Video Cameras

Each subject also completed a simple questionnaire after each trial. A team of four observers made written notes, again after each trial.

Figure 4. Platform Camera (at each car end)

Figure 5. Video Data Recording

Figure 6. Video Screen Data Recording

CONCLUSIONS

Preliminary results indicated consistent egress times by subjects for all trials with very small learning effects and no fatigue effect.

The egress times for 84 passengers averaged 58 seconds using 2 side doors to a high platform, and 1 minute and 40 seconds using either a single side door to a high platform or

using an end door to the adjacent car. (All doors were already open.)

In addition, subject average flow rates (0.88 per second) were less than those at previous passenger train egress trials since no incentives were given and subjects were instructed not to push. No significant difference was observed between normal and emergency lighting conditions.

FURTHER RESEARCH

A report is being prepared describing the egress experiment trials and the preliminary results in more detail.

Additional egress tests are planned. The first tests involve obtaining data for passenger egress from a single level commuter rail car using car door side steps to a low platform and to the right-of-way. Another planned major egress trial will involve a bi-level commuter rail passenger car.

In addition, future egress experiments are planned using an Egress Simulator apparatus constructed at the Carmen E. Turner Safety Training Academy of the Washington Area Metropolitan Area Transit Authority (WMATA), in Landover, MD. See also Research Brief RR 06-07.

ACKNOWLEDGMENTS

The success of this egress experiment was due to the individuals of the following organizations in addition to the FRA Office of Research and Development and the Volpe Center.

Logistical Support

The egress trials were conducted with the cooperation of the Massachusetts Bay Transportation Authority (MBTA). MBTA staff provided two single level cars, power to operate the lights and video equipment, platform track space at North Station, Boston, as well as extensive assistance and cooperation from operating and maintenance staff of the MBTA and the Massachusetts Bay Commuter Rail contractor.

Technical Support

Technical contributions were provided to Volpe Center staff during the development of the egress trial plan and during the actual trials by human factors experts. Professor Ed Galea, of the Fire Safety Engineering Group, University of Greenwich, and Professor Ann Mills, of the Railway Safety and Standards Board, both of the United Kingdom (UK), furnished important knowledgeable review and suggestions for the egress trial protocols, as well as serving as Observers during the actual 12 trials. In addition, Professors Galea and Mills, and Professor Helen Muir, Cranfield University, also of the UK, provided technical review of the trial data and recommendations for conducting future egress experiments.

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KEYWORDS

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