

Tren Urbano Research Program at MIT

Year 7 Research Proposal and Initial Work

Tren Urbano Recovery Guidelines for Service Disruptions

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My research aim is to evaluate service disruption impacts from the operator and passenger's perspectives and provide Line Controllers with tools to quickly and uniformly evaluate and respond to lengthy or non-routine service disruptions.

I. Research Objectives

- Evaluate operations control strategies to minimize negative passenger impacts during service disruptions based on operating headways, system demand, location and duration of disruption, and total passenger inconvenience.
- Identify impacts of proposed recovery strategies on operator and contract.
- Develop a disruption recovery guideline notebook for Line Controllers, which includes disruption scenarios and a range of recovery strategies.
- Develop ATR vs. manual operations guidelines, which discuss under what conditions ATR and manual operations are most effective (with Dave Barker).

II. Motivation

Tren Urbano is a new grade-separated, heavy rail system scheduled to start revenue service in late 2002. Tren Urbano has a general operating plan, which includes headways and number of cars in each train, for normal operations. However, the service recovery plan, an essential part of the overall operating plan, has not been developed. The service recovery plan describes the procedures followed to return the system to normal operations after service disruptions. It serves as the primary guide during service recovery for the Line Controllers and other operations personnel. At this time, service recovery strategies have not yet been developed for use in a recovery plan.

In addition to comprising the service recovery plan to follow, the recovery guidelines should allow Line Controllers to quickly evaluate alternatives, respond uniformly to service disruptions, and focus on other responsibilities during the disruption. The Line Controllers have multiple responsibilities during the disruption. Before they can focus on

the ultimate goal of getting trains back on schedule, they must first define and understand the nature of the disruption problem and have a plan in place to resolve the disruption underway, coordinate Tren Urbano field personnel, and contact emergency services personnel.

Another OCC supervisor responsibility is notifying passengers of delays, since most passengers throughout the system will be unaware of the service disruption. This is important for passengers to trust the new Tren Urbano system and information allows them to adjust their travel plans accordingly. To accomplish this, Line Controllers compose and broadcast concise and accurate messages to the affected stations' changeable message boards and public address systems. All these responsibilities leave even less time for the Line Controllers to consider how to recover train operations in general, let alone how to do it while minimizing passenger inconvenience.

All these essential and time-intensive duties during a disruption necessitates that Line Controllers have as much as possible considered and addressed prior to the incident, so they can effectively deal with their remaining responsibilities. In addition, Line Controllers and operations personnel will all be operating the system for the first time when it begins operations in late 2002. The guidelines serve this need by providing Line Controllers with options for recovery and some direction concerning when it is more effective to use the ATR system or manual control to recover from the disruption.

III. Approach

- Review the Siemens Transit Team Operations Plan, recovery strategies research, and passenger sensitivities to different disruptions research.
- Identify primary inconveniences and quantify passenger sensitivity to them through research, additional studies, or assumptions.
- Select and model likely and critical recovery strategies.
- Identify the effects of each proposed recovery strategy on the passengers and the operator to better understand how each might respond, benefit, or lose from the proposals.
- Create recovery strategy and ATR vs. manual usage guidelines to provide options to the Line Controllers.

IV. Initial Progress

1. Literature Review and Advisory Resources (September – December 2000)

- Reviewed Siemens' existing operations manual and other Tren Urbano references involved in operations to understand and use the proposed operating framework for assumptions.
- Reviewed operating guidelines for existing North American New Starts and older grade-separated heavy rail systems, including MBTA and NYCTA to determine what operational areas are covered in their guidelines and what disruptions scenarios are considered.
- Reviewed previous research in employing control strategies, including their models, findings, and recommendations.

Identified Project Staff Advisors

- Charles Planck, Mike Francis and Ann Bickford, ACI in Boston
- Joe Ferretti, ACI in San Juan
- Bob McDonald, Siemens Transit Team in Boston

Initial Research Documents

Operations Guidelines

- Siemens Transit Team, Operations and Maintenance Plan, Version 3. October 1999.
- NYCTA,
Surface Transit Control Manual Final Draft, October 1991.
Rail Service Control Strategies, September 1992.

MIT Theses and Papers

- Xu Jun Eberlein, Real-Time Control Strategies in Transit Operations: Models and Analysis, June 1995.
- Susan O'Dell, Optimal Control Strategies for a Rail Transit Line, 1997.
- Iris N. Ortiz, Analysis of Real Time Operations Control Strategies for Tren Urbano, January 2000.
- Su Shen, Integrated Real-Time Disruption Recovery Strategies: A Model for Rail Transit Systems, January 2000.
- Wei Song, Real Time Dispatching Control in Transit Systems, June 1998.

Prior Research Findings

- Identified possible conflicts between passenger and operator interests in the contract.
- Assessed passenger impacts based on delay times and did not account for other inconveniences.
- Considered disruption times as fixed, known values.
- Identified recovery strategies and uses.

•Identified Recovery Strategies and Best Uses

- Holding can be used to lengthen and even out the headways for stations after the blockage.
- Short-turning may be used with Holding to even out the headways for stations after the blockage.
- Expressing may be considered for trains behind the blockage after the blockage has cleared.

Determined that Response strategies depend on the following key factors:

- Passenger Demand
- Direction and Location of Blockage
- Expected Duration of Blockage
- Headways

Recommended Recovery Strategies Depend on Values Assigned to Passenger Inconveniences

- Onboard and in-station delays
- Crowding
- "Dumping"
- Passengers at stations being passed by crowded, out of service, or expressed trains.
- Quality of Passenger Information

2. San Juan Encuentro (January 2001)

- Meet with San Juan operations staff, including Joe Ferretti.
- Speak with outreach staff about community concerns to assist with identifying likely San Juan passenger sensitivities to different inconveniences.
- Get feedback from students and faculty about their perceived impact of various passenger inconveniences.

V. Continuing Workplan

3. Determine passenger sensitivity to disruptions (February 2001)

- Determine passenger sensitivity to operator-induced disruptions during service recovery, including
 - Passenger "dumping" at stations where passengers then wait for the next train – Possible research or at least previous researchers have made assumptions or may have ideas of how to account for this
 - Differing impacts during peak and non-peak operations – Possible research
 - Crowding (V/C ratio or loads) in trains and on platforms – Possible research
 - Being passed by an out-of-service or expressed train – Possible research
 - In-vehicle at station, in-vehicle in between stations, and platform wait times – Existing research
 - Expressing trains – Existing research

- Increasing headways to smooth the loadings – Existing research
- Determine effects of these impacts with and without accurate real-time information (changeable message boards and announcements in affected stations).
- Quantify or otherwise account for these impacts in the simulation model.
 - Possible mechanisms to ascertain this include passenger surveys, customer service feedback, and the likelihood of packing the next train vs. waiting for the next one when there are problems.

4. Model Scenarios (March 2001)

- Determine likely and critical scenarios to evaluate as recovery strategies.
- Use Dave Barker's system simulation model to analyze alternative control strategies for the determined set of scenarios. The model simulates the Tren Urbano rail system and tracks trains through the system, recording the amount of passenger delay and inconvenience accumulated.
- System simulation model will allow for multiple outputs and is flexible enough to include additional output information as identified.
- Model both service blockage and degradation scenarios.

5. Analyze Model Scenarios and Strategies (April 2001)

- Compare and evaluate passenger delay and inconvenience in the model output for each scenario.
- Based on the output, develop maximum inconvenience levels allowed for individual trains, if necessary.
- Identify impacts of recovery strategies on operator and passengers.
- Analyze the influence of the contract on operator behavior.
- Develop recovery recommendations based on passenger delay and inconveniences.

6. Determine Disruption Time Frames (April 2001)

- From the model output, determine disruption time frames to consider.
 - ATR, no intervention: $0-X_1$
Determined on the performance and limitations of the ATR, since in this case the ATR parameters have to be able to deal with the disruption without any special intervention.

- ATR, with intervention: X_1 - X_2
Depends on the ATR's ability to deal with manual interventions. Determine allowable limits.
 - Manual: X_2 - X_3
Determined by the success of the available manual interventions when compared with staying on ATR operations.
 - Bus bridge or emergency plans: $> X_3$
Rather than finding a distinct point where a bus bridge or other emergency recovery strategy would need to be implemented, manual operations performance may taper into this operation type.
- Determine the effects of the accrued delay from when the incident occurs and the Line Controllers implement a recovery strategy. In addition, there will also be more delay time for incidents during the first year of operations, since the operations staff will all be new to operating Tren Urbano.

7. Guideline Development (April – May 2001)

Considerations when Developing the Guidelines

Isolate key determinants of how the service comparatively degrades for making incorrect assumptions. There has been some research in this area, but results of the model output will also highlight areas that induce fast service degradation if they make incorrect assumptions or if the delay is overestimated. In addition, accounting for passenger delay and inconvenience, as well as limiting the amount of penalty imposed on any one train are primary considerations. This process will serve as the backbone of recovery strategy selection process in the guidelines.

While developing recommendations and options, considering disruption time uncertainty and other uncertainties as identified through the research is important. In addition, when developing the guidelines, I will group appropriately similar scenarios to be addressed together. Another important aspect of the guidelines is that rather than suggesting one approach to each situation, the guidelines will provide options with their respective simulated outcomes. This allows Line Controllers to choose a solution that satisfies the desired results. I will also discuss the effects of recovery strategies on the contracted operator.

Developing the Guidelines Notebook

In order to create guidelines that are readily accessible to Line Controllers, I will review existing guidelines' or other publications' layouts. I will be looking for examples where the information and choices presented are well-understood by Line Controllers and they

minimize the amount of time needed to find the particular disruption scenario that best describes the situation they are looking for.

The recovery strategy guidelines notebook is currently envisioned as a binder containing the modeled scenarios and several suggested recovery procedures with notes on the effects of each recovery strategy. I will work closely with Dave Barker to develop the manual vs. ATR usage guidelines, since he will have a much better understanding of the strengths and limitations of the ATR system.

One consideration is creating an electronic copy with hyper-text pointers to other sections of the guidelines. This layout would likely reduce the amount of time to access the information, and possibly reduce the time and cost of updating the guidelines. It would also provide one master copy and instantly update all copies in the agency. My greatest concern with developing the electronic manual is future maintenance of the electronic copy, so I would propose project staff be involved with this, so they can find permanent staff to implement and maintain it.