Innovative Railroad Information Displays

Video Guide

## INTRODUCTION

From March 1996 through October 1998, the Volpe Center explored novel concepts of information displays for dispatchers along lines developed previously for aviation under sponsorship of the Federal Aviation Administration. The work was supported by the M.I.T. Media Laboratory, AMTRAK, and interested professionals in the railroad industry. It commenced with reviews and evaluations of existing and proposed railroad display systems and continued with the adaptation and development of pertinent elements of digital technology, information management systems and geographic information databases to generate advanced animated simulations and displays.

## OBJECTIVE

The objectives of this study were to explore the potential of advanced digital technology, novel concepts of information management, geographic information databases and display capabilities in order to enhance planning and decision-making processes of railroad dispatchers and traffic managers. The M.I.T Media Laboratory undertook to develop and demonstrate computer simulations of train movements on specific tracks. The Volpe Center's Geographic Information Systems (GIS) Research Group undertook to develop and demonstrate a simulation of train movements on major routes throughout the United States, termed "Digital AMTRAK Train Model" (DATM), with capability to "zoom" on specific localities. The results of these efforts were to be demonstrated in a video for presentation to railroad executives. Computer source codes and user instructions were to be documented.

## BACKGROUND*

Current dispatching technology ranges from radio directives and paper forms to almost "paperless" offices, where movement authorities and reports are completed using a computer-aided dispatching system (CADS). Typically, the larger the railroad, the more technology the dispatchers have available.

In computer-aided dispatching systems, train movement authorities, voice communications, and other information about trains are entered into computers situated at each dispatcher's desk. Specific desk configurations vary by operation, but dispatchers likely have one or more computer screens and a keyboard at their desks, as well as a voice communication system. Typically, one or more computer screens present a schematic of the interlocking and control points of a territory for which the dispatcher is responsible

*This section is based on material from the Report "Training Requirements for Railroad Dispatchers: Objectives, Syllabi and Text Designs," S. Reinach, J. Gertler and G. Kuehn, DOT/FRA/ORD-98-08, November 1998.

and over which the dispatcher has control, and shows track occupancy or other conditions of sections of track. Other screens may be used for data entry or information retrieval. In many instances, schematics of all of the railroad's territories are displayed on the walls of the dispatching control center so that dispatchers are able to view their own territory as well as adjacent territories. Using computers at their desks, dispatchers can change signals and switches, and enter and retrieve information about trains (e.g., train location, train identification, locomotive power, train size, and consist). Many computer-aided dispatching systems also record for future review and analysis every keystroke and entry made by the dispatcher.

There is also a wide spectrum of train control technologies that are currently being used, or are being explored for use in the future. At one extreme of the spectrum, there are "dark" territories that do not contain any signalized systems. Trains are moved using hand-written or verbal movement authorities issued by the dispatcher. Before the advent of signalized systems and computer-aided dispatching, all dispatching was conducted in this manner, hence the term "paper railroad" to describe this manner of railroad dispatching. At the other extreme of the spectrum, several railroads are using a demonstration system of positive train control (PTC). Under PTC train speeds are automatically adjusted (the speed of the following train is either reduced or the train is completely stopped) to ensure safety, and at the same time the distance between trains is reduced to increase traffic flow. PTC relies on a global positioning system (GPS), onboard computers, and other advanced technologies, and will likely change the way in which trains are dispatched. Among other changes, PTC will increase railroad dispatchers' reliance on computers to dispatch trains.

Concurrent with the increased reliance on computers, large centralized dispatching centers have evolved due to railroad mergers and consolidations. Dispatchers for the larger railroads work in shifts around the clock and may control territories that are located more than 1000 miles away. Changes in signal technology have led to a reduction in the use of tower operators, resulting in more direct dispatcher control over train movements and in an increase of responsibilities and of the number of individual tasks required in carrying out these responsibilities. Reduction in field operations personnel has eliminated the traditional career path from tower/block operator to dispatcher. As a consequence, the majority of recent dispatcher recruits have been without prior railroad operating experience and this circumstance will most likely continue in the future.

## APPROACH

The Volpe Center contracted the M.I.T. Media Laboratory to observe current railroad operations and information and display technology in order and to develop the software for animated elements representing track, sidings, switches, speed rules and train sets. These elements were to be manipulated interactively by the user to simulate specific operational scenarios. Concurrently, the Volpe Center undertook the development of DATM. Close contact was maintained with expert professional groups for review, comments and suggestions throughout.

THE VIDEO

The video, entitled "Innovative Displays for Dispatchers," combines animated software elements produced by the M.I.T. Media Laboratory and DATM simulations produced by the Volpe Center's GIS Research Group. The following narrative illustrates features of the video.

Observation of current railroad operations

The Boston AMTRAK Control Center was selected as a study site because of its proximity to M.I.T. and the Volpe Center. It provides day-to-day supervision, coordination, monitoring and dispatching for AMTRAK inter-city and Massachusetts Bay Transit Authority (MBTA) commuter trains, and for freight traffic.

During several sessions, typical dispatcher operations were observed and recorded. Figure 1 shows a typical dispatcher's desk. The dispatcher prepares documentation, performs preliminary planning, monitors and coordinates train movements, signals and switches, communicates with train crews and other track users, issues special instructions and responds to unscheduled events and emergencies. The efforts of M.I.T. and the Volpe Center were aimed at enhancing these capabilities, both for operational and training purposes, particularly in view of the expected growth of high-speed rail traffic.

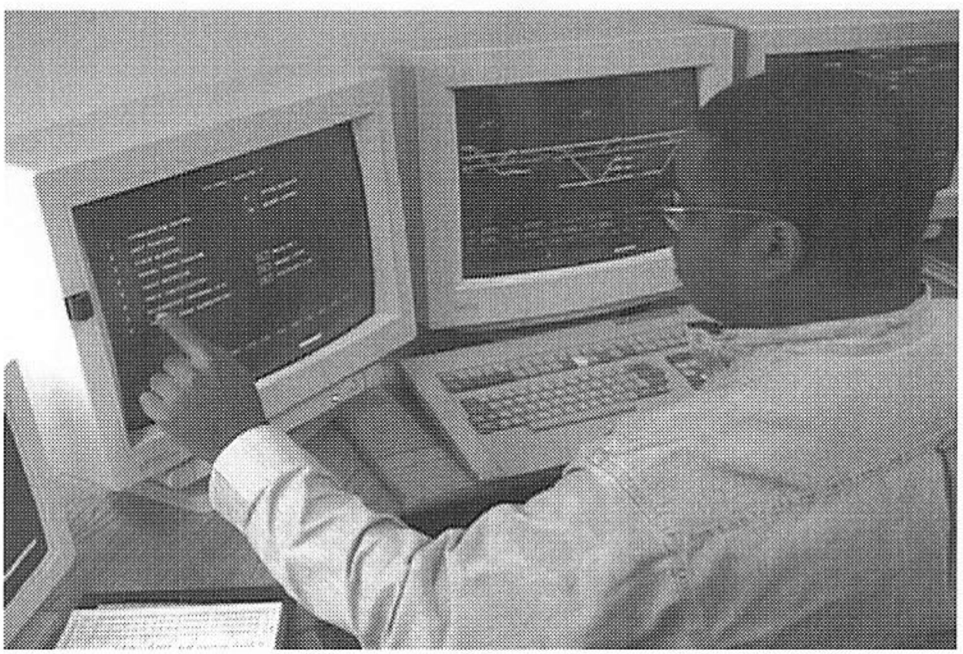

Figure 1. Boston AMTRAK Control Center

Selected animated software elements of train movements on specific tracks.

Track View

The Track View (Figure 2) is the basic animated simulation of a railroad. It includes such elements as track characteristics (lines), sidings, switches and trains (boxes). Through pop-up menus, information can be accessed, as for example, switch position, location, number and repair history. Clicking on a train can indicate destination, cargo, and any speed restrictions that might apply. Progress of the train can be followed relative to specific landmarks. If desired, the scheduled route can be highlighted in a specific color (not shown). An additional train can be added interactively with its selected route

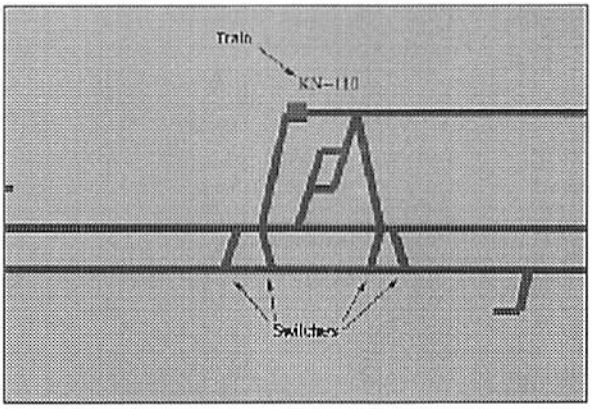


Figure 2. Track View

World View

The World View is a more complex simulation (Figure 3) which can display the entire track system. As above, tracks are shown as lines, trains as boxes, and icons represent movable mileposts. These permit sections of the system to be highlighted by changing the scale of the distance between them. The World View also contains a slider, which can be moved back and forth to change the covered track territory. The territory of the slider can be enlarged or reduced by moving its left or right edges.

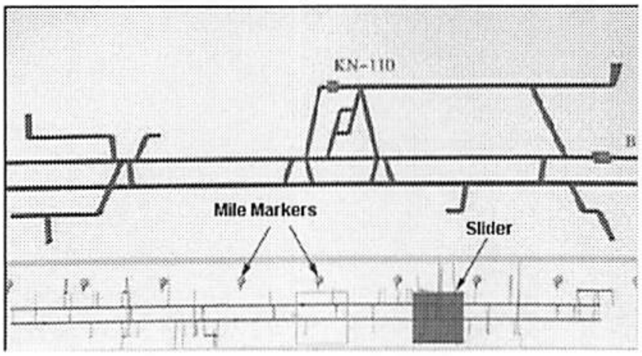


Figure 3. World View

Train Follower Windows

This simulation permits multiple displays of trains under the control of different dispatchers. This feature (not shown) can provide look-ahead information and can improve teamwork, particularly in cases of emergency.

String Graph

A String Graph can present spatial and temporal information of track occupancy. Consider first the simple spatial view of Figure 4 of trains BN-112 and AG-322 on two tracks, approaching an area of switches A, B, C and D from opposite directions. Train BN-122 (blue box) moves left to right on the upper track (yellow), and then moves through switches A and B to the lower track (green). Train AG-322 (red box) moves from right to left on the upper track (yellow), passes through switches D and C to the lower track (green), and returns through switches B and A back to the upper track (yellow). Train BN-122 precedes train AG-322 through the switches. The String Graph of these events, which includes the element of time, is shown in Figure 5. The horizontal axis represents distance, increasing from left to right, the vertical axis represents time. The slopes indicate the relative speed of the trains; speed decreases as slope increases.

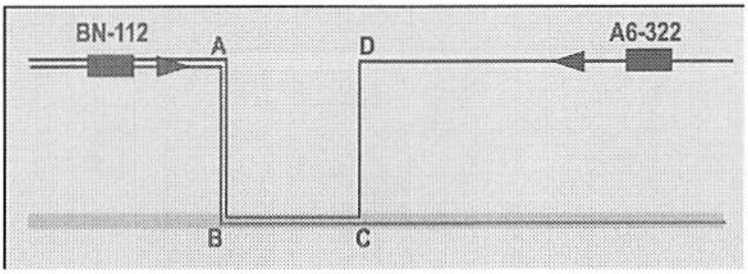


Figure 4. Spatial View of Track Occupancy
Switches A, B, C, and D

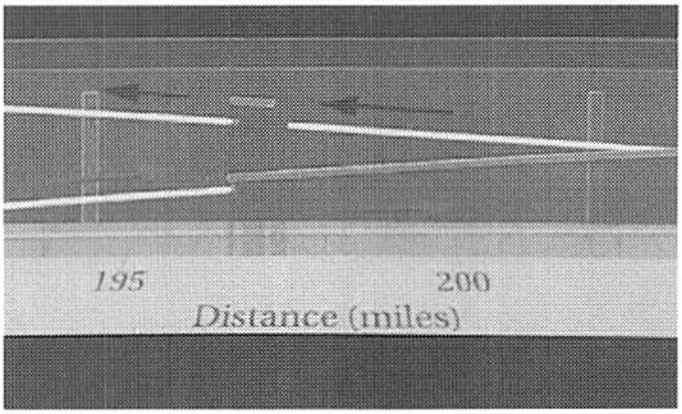


Figure 5. String Graph of Track Occupancy
Upper Track Yellow, Lower Track Green
Train BH-112, Blue Arrows, Train A6-322 Red Arrows

Digital AMTRAK Train Model (DATM)

The animated Digital AMTRAK Train Model is designed to indicate scheduled train locations over a wide area (similar to the Aircraft Situation Display at the Volpe Center ). For convenience, the AMTRAK passenger network was chosen, but the model can also be applied to a freight rail system.

Figure 6 represents scheduled (timetable) train locations on a map of the United States, with AMTRAK routes and major stations indicated. Future developments can extend the model to include both scheduled and actual locations, provided real-time tracking links are integrated into the model. To exercise the model, a specific period is selected for which train movements are desired (e.g., 5:30 p.m. Monday through 10:00 a.m. Tuesday). Then all train movements can be viewed nation-wide; alternatively, a "zoom" feature permits viewing of a localized section, such as the Northeast corridor.

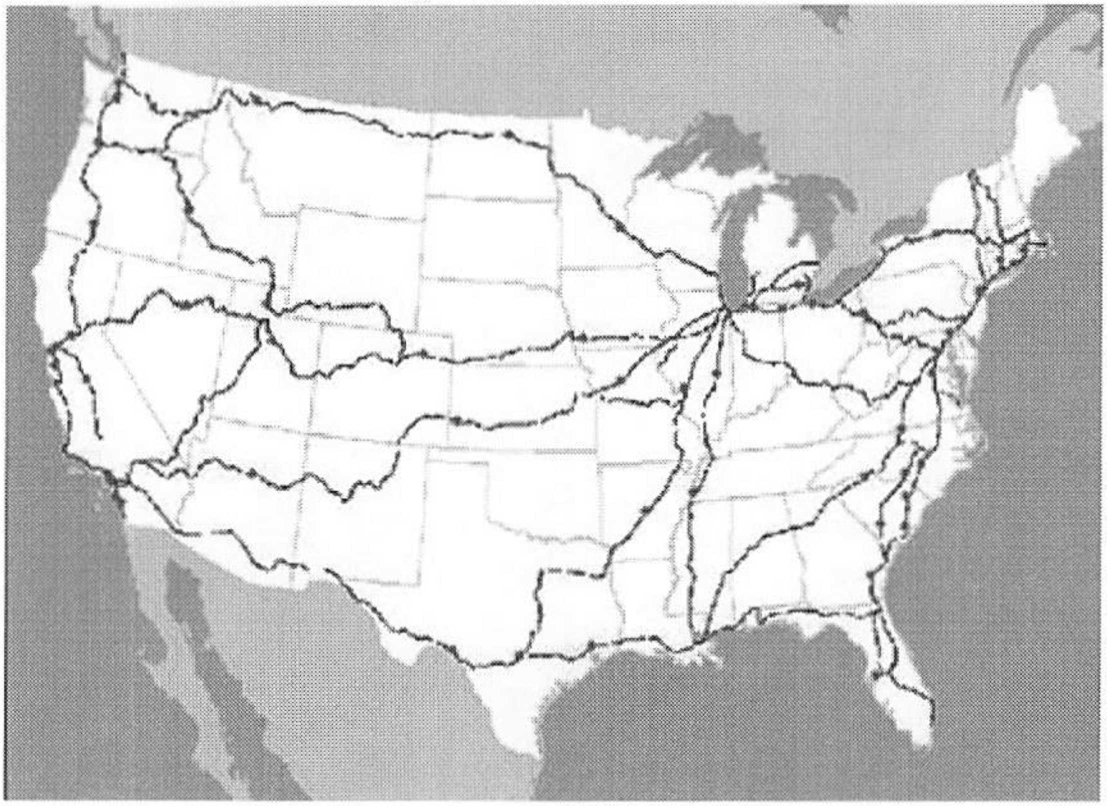

Figure 6. DATM Train Locations

Zoom Feature

Figure 7, shows a spatial view of two trains. Train #1 (Sunset Limited), from Florida to California, approaches New Orleans from the east. Train #59 (City of New Orleans) is heading south from Chicago. When train #1 reaches New Orleans, it stops until the arrival of train #59, before continuing to the west. Train #59 terminates in New Orleans.

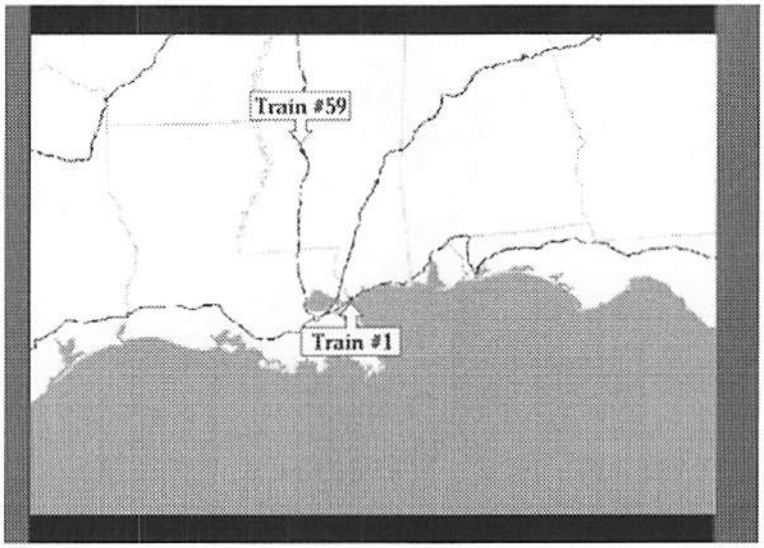


Figure 7. DATM Spatial View of Trains #1 and #59

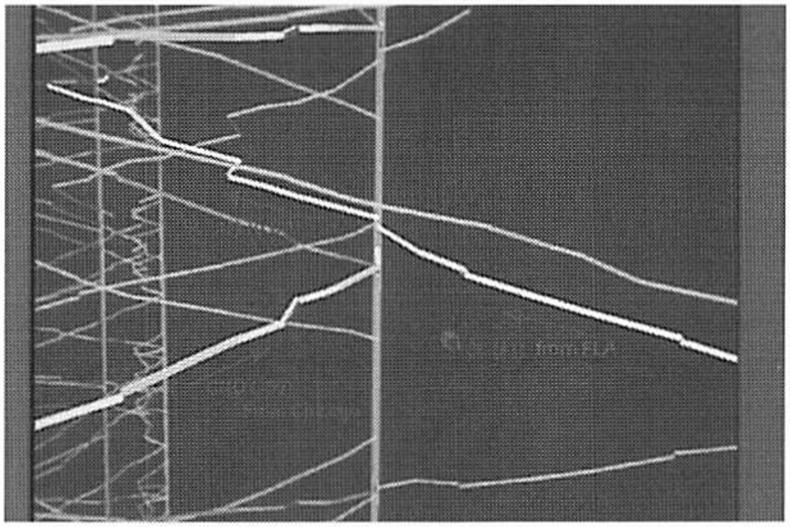

Figure 8. String Graph of Trains #1 and #59

With display devices such as this, a dispatcher could readily assess potential problems and communicate with selected stations.

Integration of DATM and String Graph

If the DATM display is integrated with the String Graph, a more complex display is created for potential use as a planning tool. It presents a simultaneous view of many trains on multiple routes; locations and speeds are displayed for any instant of time. Figure 8 is the display of these events. Other trains not specified are also shown. Notice: the vertical time-line (colored orange) indicates that both train #1 and train #59 have stopped.

SOFTWARE

The code for the simulations illustrated in the video is contained in the following volumes:

- Four volumes of code (I – IV) and one volume (V) of user instructions from M.I.T:

  I. Interface Code
  II. Simulation, Object and Database Systems
  III. Integrated Interface Code
  IV. Integrated Trackbuilder Code
  V. User Instructions for Integrated Trackbuilder and KDI Interface.

- One volume of code for DATM from Volpe Center GIS Research Group

SUMMARY

The displays developed by the study have the potential to enhance the performance and the decision-making process of the dispatching function. Their usefulness now needs to be explored and demonstrated jointly with the railroad industry. The adoption of innovative information systems and advanced operational systems, such as positive train control, can contribute to improvements in safety and productivity and can permit, for example, higher passenger- train speeds and more precise freight scheduling.

These improvements are contingent on suitable delivery of the required information to the dispatching staff. The display concepts developed in this study can lead the way.

Distribution of the video, shown publicly in Chicago, and requests for comments on its content from industry, are first steps to determine future directions. Subsequent to the receipt and review of these comments, government/industry partnerships may be sought for further development of these display concepts.

REFERENCES

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