TOWARD THE DEVELOPMENT OF A PERFORMANCE MODEL OF RAILROAD DISPATCHING

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Railroad dispatchers shoulder more responsibilities today than ever before due to changes in technology, operating practices and the economy. This paper reviews literature on the job of railroad dispatching and summarizes research conducted to identify and document railroad dispatcher tasks and activities. An initial set of dispatcher tasks was generated. Then two questionnaires were developed to expand the list, identify other factors that affect dispatcher taskload, and determine how challenging it is to collect data on these tasks. Questionnaires were sent to representatives from Federal Railroad Administration regional offices, railroad officers, and railroad dispatchers. Sixty-seven different dispatcher tasks were identified and organized into six top-level task categories. Questionnaire results suggest there is no single, efficient mechanism to collect dispatcher taskload data. The literature review and questionnaire data highlight the importance of the cognitive aspects of dispatching. Based on the results, a preliminary, but comprehensive, model of railroad dispatching performance is proposed.

INTRODUCTION

Railroad dispatchers (see Figure 1) shoulder more responsibilities today than ever before due to changes in technology, operating practices and the economy. In their capacity as rail traffic controllers, dispatchers play an integral role in rail safety. In the 1990s, the Federal Railroad Administration (FRA) raised concerns about the safety of the U.S. rail network in two separate audits (FRA, 1990; 1995). One area of concern was periodic work overloads. Due to their central role coordinating rail traffic, railroad dispatchers are the lynch pin of railroad operations. Thus, dispatchers must perform optimally under all circumstances to ensure safe operations. A breakdown in dispatcher performance can lead to delays, or worse, fatalities. For example, dispatcher performance was cited as a contributing factor in a fatal collision between two trains in 1997 (NTSB, 1998).

Figure 1. Railroad dispatcher's office

Subsequent to the audits, FRA Office of Research and Development initiated a broad research program to better understand dispatcher workload, stress, and fatigue (e.g., Popkin, Gertler, & Reinach, 2001) and the nature of railroad dispatching (e.g., Reinach, Gertler & Kuehn, 1998; Roth, Malsch & Multer, 2001; Gertler, 2003), in order to identify ways of improving dispatcher performance and railroad safety. These efforts have led to a number of tools to aid the railroad industry and have provided a greater understanding of the job demands of dispatching.

As far back as 1948, researchers observed the cognitive aspects of railroad dispatching. McCord (1948), a medical doctor who conducted naturalistic observations of railroad dispatchers, noted, "The train dispatcher carries a greater minute-by-minute mental load than that for any known occupation save a general in battle" (p. 377). More recently, Tom White (1992) in his monograph on the job of a railroad dispatcher, explains that "Train dispatching is a science of strategy and tactics" (p. 4). Gertler (2003), studying railroad dispatcher selection practices, identified a number of cognitive abilities associated with railroad dispatching. She concluded, "The relatively large number of cognitive abilities…is proof of the cognitive nature of this job" (p. 34). Roth et al. (2001) studied strategies railroad dispatchers use to safely and efficiently route track vehicles, and concluded that "dispatching is a cognitively demanding task" (p. 55).

Due to a critical safety concern, FRA Office of Safety conducted a system-wide safety audit of a large railroad in the late 1990's, including an assessment of dispatcher taskload. Taskload was defined as the average time demanded of a dispatcher in carrying out all job-related tasks at a dispatching desk over a shift. Though effective at identifying overburdened dispatching desks, the tasks that were examined and the method of calculating taskload were specific to the audited railroad. Further, the method was time-consuming and required a number of individuals to collect these data.

Because of the comprehensive nature of the FRA dispatcher taskload assessment, and its innovative characterization of dispatcher tasks, FRA's Human Factors R&D Program wanted to explore the possible use of this taskload calculation method for application to all railroads, regardless of the dispatching technologies used or the nature

or size of the operation. FRA was also interested in how taskload data could be collected, how usable this tool might be, and how to better characterize the job of railroad dispatching.

METHODS

Four specific questions were addressed in this study: Can a dispatcher taskload tool be developed for use across the industry; what methods can be used for collecting taskload data; what is the feasibility of collecting these data; and what do the data collected from dispatcher taskload tell us about the dispatcher's job?

To answer these questions, an initial set of observable dispatcher tasks was produced based on past research (e.g., Devoe, 1974), naturalistic observation, and input from a subject matter expert. Next, a questionnaire was developed to expand the list and identify factors that can affect dispatcher taskload. The questionnaire was sent to one representative from each of the eight FRA regional offices, two different railroads, and the union that represents a majority of railroad dispatchers in the United States. Representatives were asked to distribute the questionnaire to as many individuals within their respective areas of responsibility as possible. An assumption was made that at least one individual from each of the eight FRA regions, two railroads, and the dispatcher's union, would complete a questionnaire, to provide broad representation across the three populations. Individuals from these three populations were selected because they are representative of most, if not all, of the dispatching operations across the United States; are among the most knowledgeable on current dispatching tasks, technologies and operations, as well as means of collecting task-related information; and will be among the end-users of a dispatcher taskload assessment tool.

Based on the results of the first questionnaire, a second questionnaire was developed to determine how data on these tasks can be collected from different railroad dispatching operations, and how easy, time-consuming, and obtrusive it is to collect these data. Respondents to the first questionnaire were sent the second one.

Eleven individuals completed the first questionnaire. Nine respondents were FRA regional safety inspectors or Operating Practice (OP) specialists, representing six of eight FRA regions. The two other respondents were active railroad dispatchers—one from a passenger operation and one from a freight railroad. Of the 11 individuals who completed the first questionnaire, all but one completed the second questionnaire.

RESULTS

In terms of the overall dispatcher's job, a total of 67 different dispatcher tasks (see Table 1) were identified and organized into six top-level task categories:

1. Actuation of signals, switches, blocking devices and bridge controls via centralized traffic control (CTC) or computer-aided dispatching (CAD) systems.
2. Issuance and cancellation of dispatcher-authorized mandatory directives.
3. Granting of other track-related permissions, protections and clearances (non-mandatory directives).
4. Carrying out non-movement authority or non-permission/protection/clearance communications. This generally involves advisories, coordinating activities, and the exchange of work-related information.
5. Performance of general record-keeping tasks.
6. Review of reference materials.

These 67 tasks represent the gamut of possible railroad dispatching activities across the United States.

Table 1. Railroad dispatcher tasks

General task category	Task
1. Actuate signals, switches, blocking devices and bridge controls via CAD system	1. Route passenger/commuter train 2. Route local freight trains 3. Route through freight trains 4. Route work trains 5. Route hi-rail vehicles 6. Route other moving track vehicles 7. Open/close railroad bridges
2. Issue/void dispatcher-authorized mandatory directives	8. Issue (or cancel) Form Ds 9. Issue track warrants 10. Issue Direct Traffic Control block authorities 11. Issue track bulletins (e.g., Form B) 12. Issue track permits 13. Issue track and times 14. Issue work and times 15. Issue joint track and times 16. Issue joint work and times

Table 1. Railroad dispatcher tasks (continued)

General task category	Task
3. Grant other track-related permissions, protections and clearances	17. Grant permission to pass a red signal 18. Grant permission to open up a switch onto main line 19. Grant permission to close a main track switch 20. Grant permission to make a reverse move 21. Grant permission to leave a passenger station/terminal 22. Grant other permissions, clearances, and protections 23. Protect for other-than-normal switch operations 24. Protect passengers crossing main tracks between platform and station 25. Provide blue flag protection 26. Provide roadway worker protection/foul time 27. Issue plate orders (catenary out of service) and other electrified territory maintenance protections 28. Issue yard protection 29. Issue "Stop and protect" orders (to protect highway users at grade crossings with reported activation failures) 30. Cab signal failure procedures 31. Issue heat orders for welded rail/catenary territories
4. Carry out non-authority or non-permission/protection/clearance communications	32. Issue traffic advisories 33. Issue weather advisories 34. Issue track condition advisories 35. Issue speed restrictions, slow orders, bulletins, etc. 36. Issue line-ups 37. Coordinate b/w parties 38. Communicate with train crews (e.g., time train crew goes on duty, outlaw-related information, initial terminal Form D check) 39. Communicate with dispatchers at other centers and with other departments: yardmasters, crew callers, police dept., etc. 40. Communicate with other railroads (e.g., dispatcher, chief dispatcher) 41. Call for taxis/crew transportation for outlawed/incoming crews 42. Communicate and coordinate incident-related matters 43. Conduct conference calls with freight agents and clerks 44. Field incoming wrong number calls 45. Field passenger complaints 46. Field requests from emergency responders to intrude into right-of-way to handle emergencies 47. Communicate with power manager (electric traction territory) 48. Communicate with those inside the dispatching center, such as another dispatcher, a chief dispatcher, or other supervisor in the same center
5. Perform general record-keeping tasks	49. Enter train sheet data (e.g., train times, crew duty times, unusual events, equipment defects such as signal failures, etc.) 50. Complete train delay reports 51. Enter train ID data 52. Prepare train consist reports 53. Complete incident logs 54. Set up train sheet 55. Prepare daily Bulletin Order 56. Keep payroll records 57. Check automatic equipment inspection (AEI) readers and record car numbers 58. Transfer on/off duty 59. Maintain block register territory record 60. Complete various other FRA and railroad-required reports (e.g., grade-crossing malfunction, signal failure)

Table 1. Railroad dispatcher tasks (continued)

General task category	Task
6. Review reference materials	61. Rulebook(s)
Time spent reviewing…→	62. Special bulletins, speed restrictions, general orders, etc.
	63. Dispatcher notes
	64. Dispatcher manual of instructions
	65. Bridge maps, track charts
	66. Train consist reports
	67. Rule-of-the-day and other daily postings

A number of other factors that either affect a dispatcher's taskload, or can be used to describe the circumstances in which taskload is measured, were also identified. Some factors are internal to the dispatcher, while other factors are external to the dispatcher. Data were collected in the following four areas:

1. Track-related factors.
2. Railroad operation-related factors.
3. Dispatcher-related factors.
4. Other factors.

To determine methods for collecting taskload data, questions addressed how taskload data for a one week period can be collected for each of the six taskload categories. Respondents were presented with eight options for data collection—review of a CAD report, review of some other computer-generated report, review of a paper train sheet, review of some other paper record, review of an audio tape, direct observation of the dispatcher, some other method not previously listed, or cannot be collected—and were asked to identify all data collection methods that applied to each task category. Based on frequency of responses, results indicate that: computer-generated (CAD) reports are most advantageous in collecting (1) signal and switch actuation information, and (2) mandatory directive data; audio tapes of dispatcher conversations are most useful in collecting data on (3) other track-related permissions, protections and clearances; direct observation appears to be most advantageous in collecting information on (4) non-movement authorities and non-permission, -protection, or -clearance communications, and (6) amount of time dispatchers spend reviewing reference materials; and computer-based reports and direct observation appear to be equally advantageous in collecting (5) general record keeping tasks. Interestingly, paper-based records were not a frequently cited source of taskload data.

To assess the feasibility of collecting data using a taskload assessment tool, respondents were asked, using a seven-point Likert scale, to provide an indication of how much time, how much effort, and how obtrusive it would be to collect data over a one-week period on tasks carried out in each of the six task categories. Results indicate that while data on some observable dispatcher activities may be collected efficiently with the aid of automated computer-generated (e.g., CAD) reports, collection of data on many other dispatcher activities still requires a significant amount of time through direct observation and monitoring of dispatcher activity. There does not appear to be a single, efficient mechanism to collect all data. Overall, it appears that collecting taskload data for all six task categories would take slightly more than "some time," involve slightly more than "moderate effort," and would be "somewhat obtrusive."

Lastly, to gain a broader understanding of the dispatcher's job, and an appreciation for how much time a dispatcher spends performing activities within each of the six task categories, questionnaire respondents were asked to estimate how much of a dispatcher's time they felt a dispatcher typically spends on each task category in a typical eight hour shift. Over half of a dispatcher's work-related time was reported to be spent actuating signals and switches via CAD system and issuing and canceling mandatory directives to track occupants.

DISCUSSION

One goal of this research was to identify dispatcher tasks and data collection methods to support development of a dispatcher taskload assessment tool to reliably measure observable dispatcher activity at different dispatching desks. Sixty-seven dispatcher tasks were identified and organized into six different categories. A majority of dispatchers likely carry out one or more tasks in each of the six task categories. However, it is highly unlikely that any one dispatcher carries out all 67 activities.

Having a reliable and valid taskload assessment tool could not only provide an objective measure of overall dispatcher taskload across different desks, but could also provide a more precise view of dispatcher taskload by type of task. The ability to specify this level of taskload could help identify potential technological solutions to offset those more onerous tasks. In addition, it could help clarify which desks might be more overloaded with tasks, and a potential safety risk.

Taskload assessment as a sole measure, though, has its limitations. In fact, the development of a taskload assessment tool based exclusively on observable task activity may not be the most appropriate approach to characterizing railroad dispatching due to the highly cognitive nature of the job. One can think of the job of railroad dispatching as analogous to an iceberg (see Figure 2). With an iceberg, one sees only its tip, while the rest remains under water. This is quite similar to a dispatcher's work, where one can observe only the physical activity of a dispatcher (the tip), not the cognitive activity that takes place inside the dispatcher's head. Just as an iceberg is not easily measured using only its tip, it is possible that a dispatcher's performance may not be easily measured using only the physical work (taskload). Further, the precise relationship between directly observable taskload and unobservable cognitive workload is unclear (Pawlak, Brinton,

Crouch, & Lancaster, 1996). In fact, Pawlak et al. suggest that taskload is often examined because of the ease and convenience with which these data can be collected.

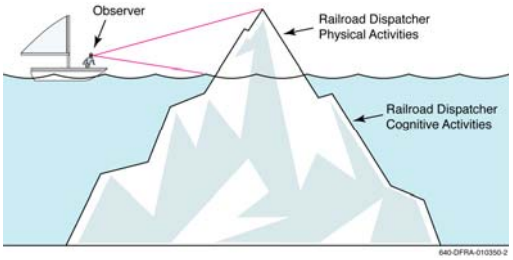

Figure 2. Railroad dispatcher-iceberg analogy

Data gathered as part of this research do provide a better understanding the job of a railroad dispatcher, though, by further documenting the physical activities involved in dispatching, and adding to the growing body of research on the job of a railroad dispatcher. Data provide information on the number and diversity of activities that are involved in railroad dispatching, and serve as the building blocks to a preliminary model of dispatcher performance and safety (Figure 3) that incorporates both the physical and cognitive aspects of a dispatcher's job. The model incorporates the four job functions of a railroad dispatcher (Reinach et al., 1998; shown in the four rectangular boxes in the middle), cognitive aspects (the innermost concentric circle), workload factors (the outermost concentric circle), and taskload components (shown at the top). The innermost concentric circle represents the cognitive elements of railroad dispatching, which are influenced by the functions of a railroad dispatcher. Two of the functions—controlling track use and performing required record-keeping—can be measured, at least in part, through their relationship to directly observable activities, i.e., taskload. The other two functions—planning and managing unplanned and emergency events—are not directly measured using taskload data.

Such a model, when fully developed and validated with the support of the industry, could provide a broader understanding of the dispatcher's job, show the relationship between physical taskload and cognitive workload, and produce a more comprehensive view of the function of dispatching in railroad operations. This model could be used to support a number of activities, including technological developments that might support safer, more efficient dispatching, identification and development of criteria for more effective dispatcher training programs, and monitoring the effects of changes in technology on the job of dispatching.

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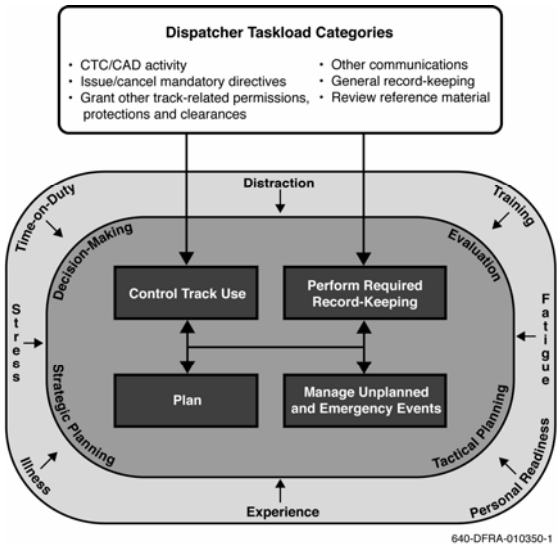

Figure 3. Preliminary model of railroad dispatching

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