National University Rail Center - NURail
US DOT OST-R Tier 1 University Transportation Center

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Railway Operations Class

By

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DISCLAIMER

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TECHNICAL SUMMARY

Title

Railway Operations Class

Introduction

Increasing the number and diversity of rail focused courses is an important step in rebuilding America's railway education infrastructure. Currently, most college level rail courses are on railway civil engineering topics. The Universities of Tennessee and South Carolina jointly developed a college class on railway operations. Providing engineering students with a better understanding of operations can improve infrastructure design and maintenance practices. The course also attracted business students interested in a career in railway management.

Description of Activities

The course goal was to present basic operating principles of North American freight and passenger railroading, including shared access corridors handling both services. Identified course topics included railway vehicle and infrastructure fundamentals; freight and passenger services; traffic planning and management; terminal and line haul operations; labor relations and management; and railway administration.

The course content addressed operating differences based on railroad size or market (e.g., intercity passenger versus commuter rail, Class 1 freight railroad versus Class 3 short line). Students did not need prior railroad knowledge.

Outcomes

The team developed a syllabus for the semester long class. Based on this syllabus, the team created a series of PowerPoint slide presentations to serve as student lecture notes in each of the major course topic areas. In addition, the team created a set of representative documents (rulebooks, employee timetables, rosters, operating plans, tariffs, etc.) based around a hypothetical Class I railroad. Students use these documents in various exercises during the class.

The class was offered six times during the period 2014-2019, with a total of 94 students enrolled. The University of South Carolina hosted distance education delivery mechanism allowed students from multiple campus locations to participate.

Conclusions/Recommendations

The course has been well-received and will continue to be offered in upcoming years. Improvements to course materials continue with each class. A textbook in the subject area that reflects North American practice would be most beneficial.

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SECTION 1: OVERVIEW

Rebuilding America's college based railway education programs is an important step in addressing projected railroad workforce needs. A large percentage of the current professional workforce will retire in the next decade. College programs in railway transportation can play an important role is preparing their replacements.

The important fields of railway operations and management are underrepresented in American universities. Departments of business have moved away from railway specific courses in favor of a supply chain management approach that deals little with individual transport modes. Yet experienced railroad operating managers are retiring, and replacing this knowledge base is essential for the industry's health. Future railway managers will benefit from coursework in operations. In addition, exposure to operating principles provides insight for engineers involved in line, terminal, and facility design.

The authors began initial discussions relating to the development of a one semester rail operations class during the 2012 Railway Engineering Education Seminar (REES) held in Overland Park, KS. At the time, Dr. Rizos was planning a certificate program in railroading at the University of South Carolina (USC). He felt that railway operations class would be a useful addition to a largely engineering dominated curriculum. Dr. Clarke felt similarly that the course could draw both engineering and business students at the University of Tennessee, Knoxville (UTK).

The authors next conducted a search to locate other North American universities having a rail course related to operations. This search was generally unsuccessful. A number of universities (e.g., Penn State-Altoona, University of Illinois at Urbana-Champaign) have well developed academic programs oriented towards railway engineering. Some other universities offer one or two classes with railway content, typically engineering. However, none of the programs offered, at the time, a college class on railway operations. Michigan State University has a railway certificate program that includes an operations component, but the offerings are targeted to professionals rather than college students and do not have a classroom format.

SECTION 2: COURSE DEVELOPMENT

This section describes the development of the course.

2.1 Course Goals

The overall course objective was to present basic operating principles of North American freight and passenger railroading, including shared access corridors handling both services. Specifically, students would:

- Examine the railroad industry, governing organizations, and stakeholders
- Review the technical elements of a railway, including
  - Right-of-way and track infrastructure
  - Yards and terminals
  - Rolling stock
  - Signaling and traffic management systems

    - Information technology and communications
- Study railroad services
    - Freight
    - Passenger
- Learn the fundamentals governing
    - The movement and control of trains
    - The management of railway terminals
    - Network operations
    - Effective management of rail assets
    - Leadership, skill building and developing core competencies
    - The role and importance of safety and human factors in operating a railway and managing organizational performance
    - Emergency planning, management and investigation
- Identify the best practices for delivery of rail service at standards acceptable in the marketplace
- Identify train planning and performance management best practices

Content would address operating differences based on railroad size or market (e.g., intercity passenger versus commuter rail, Class 1 freight railroad versus Class 3 short line). Students would not need prior railroad knowledge. However, they should have upper class or graduate standing.

2.2 Existing Content

The course developers began by searching for existing courses and texts on North American railroad operations.

With the modern focus on supply chain management, along with retirement of older faculty, U.S. universities seem to have dropped classes addressing carrier operations and management. Some courses did exist at least until the 1990s. In 1992, for example, the late Dr. E.P. Patton was still teaching the subject in his Logistics and Transportation 402/504 class at the University of Tennessee, Knoxville. A search of college course catalogs and the internet generally did not identify any current university courses addressing railway operations.

A search revealed no English language academic textbooks dedicated to railroad operations. The search did provide several relevant in-print non-academic books. These are:

- Joern Pachl, Railway Operation and Control, VTD Rail Publishing, ISBN 0-9719915-1-0
- Thomas White, Managing Rail Transportation, VTD Rail Publishing, ISBN 0-9719915-3-7
- Thomas White, Elements of Train Dispatching, Vol. 1, VTD Rail Publishing, ISBN 0-9719915-0-2
- Thomas White, Elements of Train Dispatching, Vol. 2, VTD Rail Publishing, ISBN 0-9719915-2-9
- John H. Armstrong, The Railroad What It Is, What It Does, 5th Edition, Simmons-Boardman Books, Inc., ISBN-13: 978-0-9112382-58-7

While these texts contain useful subject material, no single one addresses all topics previously listed. Requiring students to purchase the complete package was unreasonably expensive. However, the texts provided valuable references and are useful as supplemental reading. For the 2020 class offering, the syllabus required the Armstrong book as a required textbook. This permitted all students to have a reasonably priced foundation reference source. At the drafting of this report, the authors had not evaluated the effectiveness of this text.

Magazine articles on topics related to railway operation represented another potential source of content. TRAINS Magazine, a monthly periodical from Kalmbach Publishing, is one excellent source of well-regarded articles on the railroad industry. Kalmbach graciously provided permission to distribute copies of relevant TRAINS articles to students for educational purposes. Two industry trade magazines, including Railway Age and Progressive Railroading, provide on-line content that is freely accessible to students via web link.

2.3 Content Development

The instructional team elected to develop a series of PowerPoint slide presentations to serve as student lecture notes. Sets of slides address each of the major course modules. Students view the slides during the lecture, and may download them after class lectures.

To illustrate railroad operating concepts presented in the lectures, the instructional team created a hypothetical railroad called the Piedmont Western System (PWS). The PWS, shown in Figure 1, is a 920 mile freight railroad with a network of lines having the typical infrastructure elements of a modern North American freight railroad. Students receive detailed information on the company's infrastructure, terminals, rolling stock, employees, customer base, and traffic patterns. Resources available to the students include rulebooks, employee timetables, facilities

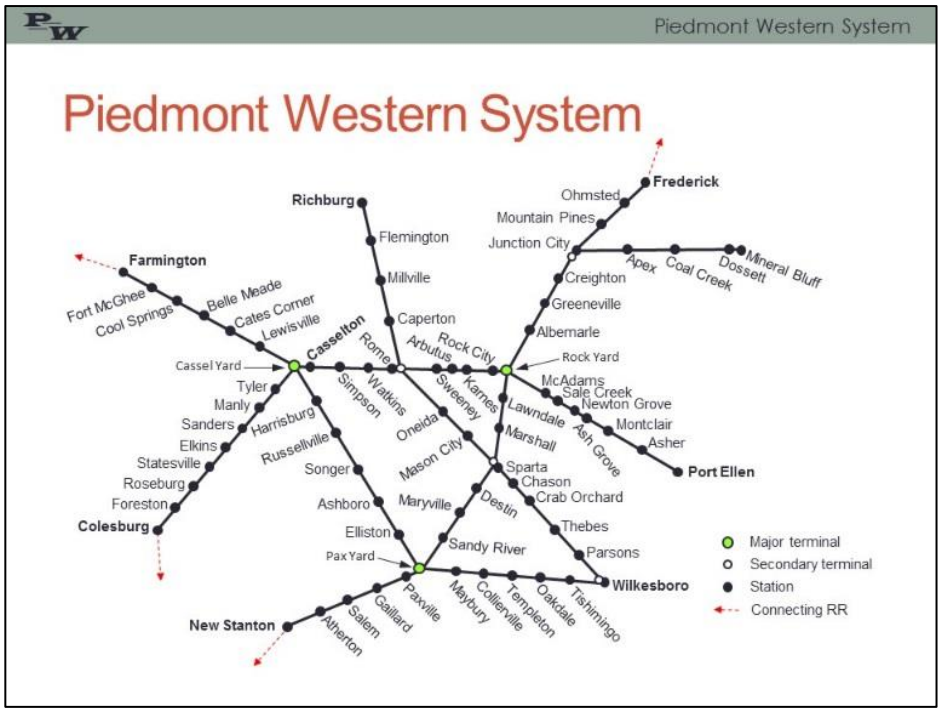

Figure 1. PWS System network

guides, yard diagrams, track charts, labor agreements, station/customer lists, network service plans, and traffic data sets. All of these items reflect counterparts used in the industry.

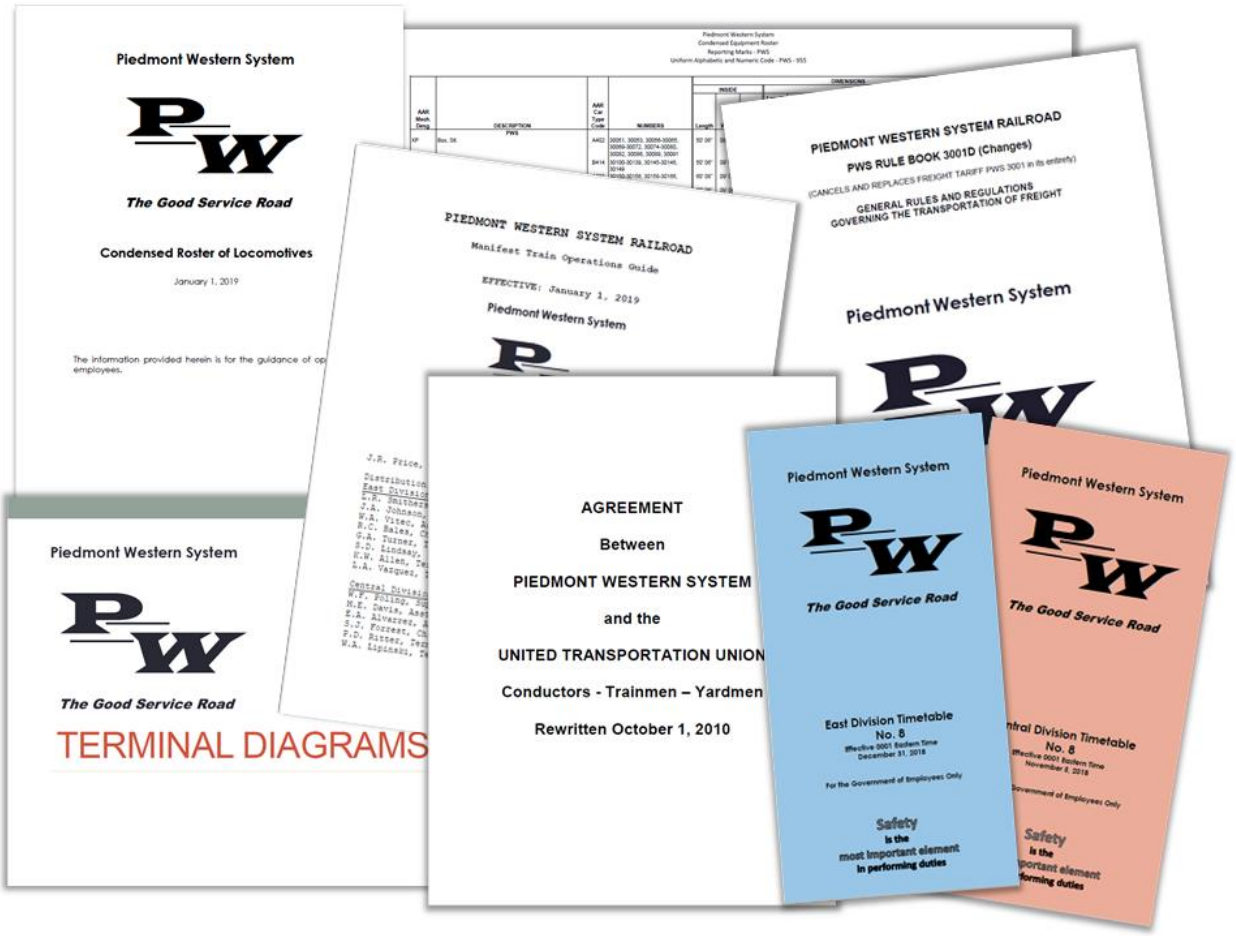

Figure 2. Representative PWS documents

The course content includes a series of traditional homework assignments. Some of these call for analysis of operating issues or problems with the hypothetical railroad. Others address material in the assigned readings. One assignment has students practice train dispatching. The open source Train Director 3.0 software (www.backerstreet.com) simulates the track and signal infrastructure of a PWS mainline route with trains directed using dispatcher controlled turnouts and signals. Unlike an actual dispatch screen, the simulation also includes non-controlled automatic signals. This helps students better understand signal behavior. Figure 3 shows a sample of the simulation interface.

The simulation includes a train lineup for each weekday. Trains operate at realistic speeds reflecting their type, line characteristics, and signal indications. Given an operating plan, students must plan train meets and passes in an efficient manner to minimize delays. The simulation permits the student to line turnouts and clear signals to authorize train movement according to their plan.

The class has three closed book exams, each intended to cover approximately one-third of the material. Exams, generally provided in written format, are changed each time the course is offered. The format consists of problems, short discussion questions, and short answer question.

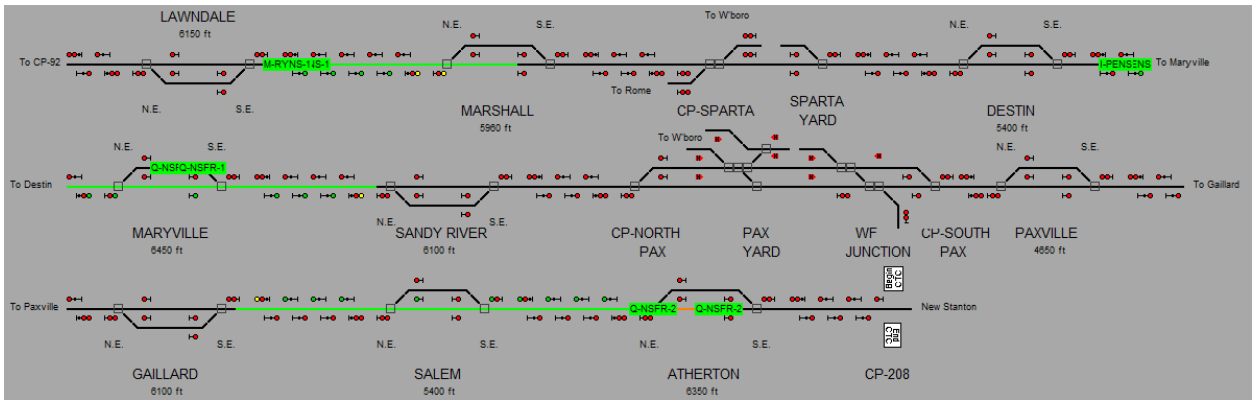

Figure 3. Portion of PWS simulation dispatch screen

SECTION 3: COURSE DELIVERY

The course is presented over one academic semester. Thus far, classes have been offered twice weekly, with a session being 75 minutes. The semester schedule typically provides for 28 class sessions and a dedicated final exam period. Based on this, the class time has been generally allocated as follows:

- Introduction, overview of North American railways
- Railroad rolling stock
- Railroad Infrastructure
- Train performance
- Freight operation fundamentals
- Introduction to the PWS Railroad
- Documents relevant to operations
- Equipment management
- <Exam 1>
- Communications and Signals (2 classes)
- Network service planning (2 classes)
- Crew management (2 classes)
- Yard and terminal operations (3 classes)
- <Exam 2>
- Train dispatching principles (2 classes)
- Marketing and customer service
- Passenger railroad operations (2 classes)
- Managing disruptions
- Future challenges and opportunities for railroads
- Wrapup

One class period is deducted to account for discussion, assignment review, exam review, etc. Students take the third exam during the final exam period.

As the course is implemented, students may attend the live lectures, view the live lectures via internet broadcast, or view recordings of the lectures. Students outside the studio have only a one-way link (instructor to student), so questions must be submitted via email or a telephone call following the class.

Students receive lecture material, assignments, instructor announcements, and grades via a course Blackboard site. Blackboard also provides links to assigned readings, lecture recordings, and other resources. Students submit homework using either Blackboard or email as directed in the assignment.

On-campus students take exams during a scheduled class period. Students taking the class via distance learning receive an assigned exam time compatible with their schedule. The exam is delivered in electronic form, printed and completed within the assigned time period, scanned, and returned to the instructor via email. The instructor has experimented with online exams, primarily due to ease of grading, but these generally seem more complicated to implement than written tests.

Appendix A provides the syllabus for the 2020 version of the course.

SECTION 4: OUTCOMES

The class was offered six times during the period 2014-2019, with a total of 94 total students enrolled. The average class enrollment was 16 students. Overall, enrollments ranged from 9 to 24 per class. These are within normal bounds. The class is open to undergraduates as an elective and to graduate students.

The students taking the class were predominantly undergraduate seniors in civil engineering. These students were taking the class as an elective. The remainder consisted of graduate students in civil engineering. Interestingly, while some of the graduate students were focused on transportation, others were in other disciplines like geotechnical or structural engineering.

The average class final grade was 87 out of 100. Class averages ranged between 85 and 91. No student failed to pass the class. Overall, these scores are quite satisfactory. Students seemed quite engaged in learning the material, and worked hard to earn their grades.

Student evaluations of the class have been positive. The most common criticism has been the inability of distance students to have direct interaction with the instructor during lectures. Frankly, this is a frustration felt by the instructors as well. Unfortunately, the distance delivery mechanism available is not robust enough to permit this type of interaction.

SECTION 5: FUTURE STEPS

The instruction team continues to consider ideas for improving the learning experience.

One intriguing idea is to incorporate client-server based railroad simulation software into the course. One such offering, Run 8 (www.run8studios.com), can accurately reflect three actual railroad territories—CSX Transportation lines in the southeastern U.S., Union Pacific and BNSF Railway lines in the southwestern U.S., and CSX Transportation lines in the northeastern U.S. The software provides a simulated 3-D environment reflecting rolling stock, infrastructure, and environment. More importantly, however, users may interact as clients to a server, permitting group interaction. Run 8 provides a diverse collection of passenger and freight rolling stock along with a dispatching system and a traffic management system. Routes include lines, yards, industrial sidings, intermodal terminals, and passenger stations that accurately reflect the prototype. Thus, it is a railroad simulator and not a train driving game. Using this software, students could work as a team to conduct operations in one of the territories. However, existing course content would need to be adjusted somewhat and each student would have to purchase a copy of the software and have an adequate computer to run it. Another consideration is that activities (train operation, switching, etc.) take the same amount of time in the simulation as they do in the real world.

The instruction team definitely plans to continue developing and improving the materials for the hypothetical PWS railroad. The PWS demonstrates well the concepts of large network oriented railway companies, yet at a scale that students can comprehend.

APPENDIX A. EXAMPLE SYLLABUS

ECIV 582 Operation and Logistics of Railway Systems

1. ABOUT THE COURSE

This course will provide students with an introduction to the complex subject of railway operations. A railway exists to provide transportation serving customer demands. Infrastructure, rolling stock, control systems, and personnel are critical components that, in conjunction, allow the railway to produce transportation. The coordination of these (and more) elements into a functioning and efficient system is a key challenge in railway operations. This course will explore the roles of the various railway system elements in shaping and governing operations. The course will also consider how external social, political, financial, and institutional influences affect railway business.

Course Objectives

Understand the over-arching principles of rail operations

- Review the technical elements of a railway from an operations perspective, including
    - Right-of-way and track infrastructure
    - Yards and terminals
    - Rolling stock
    - Signaling and traffic management systems
    - Information technology and communications
- Examine the railroad industry, governing organizations, and stakeholders
- Gain insights into
    - The movement and control of trains
    - The management of terminals
    - Network management – passenger and freight
    - The proper and optimal use of rail assets
    - The business and operating environment of a railway
    - Leadership, skill building and developing core competencies
    - The role and importance of safety and human factors in operating a railway and managing organizational performance
    - Emergency planning, management and investigation
- Identify the best practices for delivery of service at standards acceptable in the marketplace
- Identify train planning and performance management best practices

Topics Covered

- **Introduction**
- **Vehicle technologies:** General characteristics, Propulsion, Braking, Coupling
- **Infrastructure:** Track alignment characteristics, Basic track arrangements, Junctions, Terminals
- **Dynamics of train movement:** Tractive effort, Resistances, Acceleration and deceleration, Running time calculation

- **Signaling and control:** Train separation, Non-controlled operation, Time based control systems, Radio based occupancy control systems, Signal based fixed block control systems, Interlockings, Communications based train control systems
- **Freight services:** Carload, Bulk, Intermodal
- **Passenger services:** Long distance intercity, Regional intercity, Suburban commuter, Urban rail transit
- **Service design:** Intermodal freight services, Bulk freight services, Single (loose) car freight services, Passenger timetabling
- **Capacity:** Factors, Impacts on operations, Analytical methods, Mitigation
- **Rolling stock management:** Fleet sizing, Servicing, Storage and layover, Monitoring asset location and utilization
- **Labor requirements/management:** Crew scheduling, Regulatory requirements, Labor relations
- **Terminal operations:** Passenger, Intermodal freight, Bulk freight, Maintenance/servicing/storage
- **Safety and security:** System safety planning, Safety assessment, Security considerations, Emergency response
- **Management and administration:** Organization structure, Performance metrics, External interfaces

2. COURSE REQUIREMENTS

Prerequisites

Instructor's approval for students not majoring in business or engineering.

3. TEXTBOOK

The Railroad, What It Is, What It Does – 5th Edition, John H. Armstrong, ISBN 9780911382587
Pages relevant to each lecture will be provided in advance. The text will be supplemented by other assigned articles that will be made available on the web or via BLACKBOARD. Complete all readings in advance of the lecture.

4. USEFUL REFERENCE MATERIALS

The following references are useful, should students seek additional information on class topics.
Railway maps (online):

OpenRailwayMap	http://www.openrailwaymap.org/
CN Interactive map of North America	http://cnebusiness.geomapguide.ca/

The following texts are very useful to augment understanding of the subjects discussed:
Managing Railroad Transportation, Thomas White and Al Krug, ISBN 9780971991538
Elements of Train Dispatching, Vol. 1, Thomas White, ISBN 0971991502
Elements of Train Dispatching, Vol. 2, Thomas White, ISBN 0971991529
TRAINS Magazine, published monthly by Kalmbach Publishing Co.

5. 2020 LECTURE TOPIC SCHEDULE (PLANNED)

Tuesday and Thursday, 2:50pm-4:05pm EST

1/14/2020	(No class—TRB Annual Meeting)
1/16/2020	Introduction to course
1/21/2020	Overview of North American Railway System
1/23/2020	Relevant railroad organizations, rolling stock
1/24/2020	Rolling stock (cont.), train performance
1/28/2020	Train performance (cont.), infrastructure
1/30/2020	Infrastructure (cont.), Freight operations
2/4/2020	Introduction to PWSRR
2/6/2020	Operating rules and documents
2/11/2020	Motive power management
2/13/2020	Traffic control
2/18/2020	Exam 1
2/20/2020	Traffic control
2/25/2020	Network service planning
2/27/2020	Network service planning
3/3/2020	Crew management
3/5/2020	Crew management
3/10/2020	<Spring Break, no class>
3/12/2020	<Spring Break, no class>
3/17/2020	Yard and terminal operations
3/19/2020	Yard and terminal operations (cont.)
3/24/2020	Yard and terminal operations (cont.)
3/26/2020	Exam 2
3/31/2020	Train dispatching principles
4/2/2020	Train dispatching principles
4/7/2020	Marketing and customer service
4/9/2020	Passenger railroad operations
4/14/2020	Passenger railroad operations
4/16/2020	Managing disruptions
4/21/2020	Future challenges and opportunities for railroads
4/23/2020	Wrapup

Final Exam: Thursday, 4/30/2020 - 4:00 p.m.