

NURail Final Report

Submission Procedure

For Projects Completed After

September 1, 2015

Table of Contents

**OST-R Requirements**………………………………………………………………………………… 3

**Design Format**………………………………………………………………………………………… 6

**Front End** …………………………………………………………………………………………….. 9

**Final Report Completed Example**………..…………………………….…………………………... 14

**Frequently Asked Questions**………………………………………………………………………... 26

OST-R Requirements

# *(This information was taken from pages 4 – 5 of the US DOT Grant Deliverables and Requirements for 2013 University Transportation Centers document dated June 2014.)*

# Final Research Reports

The Center Director shall submit a final report for each research project conducted with UTC Program funding including matching funds. Final research reports shall give a **complete description of the problem, approach, methodology, findings, conclusions, and recommendations** developed as a result of the project and shall completely document all data gathered, analyses performed, and results achieved. The inside of the front cover shall show a disclaimer including the following:

*DISCLAIMER*

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Within two months after the completion of each project, the Center Director shall:

1. Publish on the Center’s website the full text of each report.
2. Notify the Transportation Research Board (TRB) of the URL of the full text report so that the report may be indexed and abstracted in TRB’s Transportation Research International Documentation Database (TRID). Notification should be made by e-mail to [TRIS-TRB@nas.edu](mailto:TRIS-TRB@nas.edu). For help with TRID, contact Lisa Loyo, TRB’s Manager of Information Services, [lloyo@nas.edu](mailto:lloyo@nas.edu).
3. Transmit each report electronically to the National Transportation Library at [NTLDigitalSubmissions@dot.gov](mailto:NTLDigitalSubmissions@dot.gov). E-mails to this address may include URLs or attached PDF documents.
4. Provide to the USDOT Research Hub the exact title of the project and the URL for the final report via the [Research.Hub@dot.gov](mailto:Research.Hub@dot.gov) e-mail.
5. Also distribute each report in the format noted to the following addresses:
   1. Transportation Library

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Evanston, IL 60208-2300

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Design Format

## Design Format

**Short Answer:** For projects completed AFTER September 1, 2015:

1. Complete the “Front End” pages.
2. Write your final report being sure to follow the formatting instructions detailed below.
3. Insert that report behind the front end.
4. Send the document to LB Frye (lbfrye@illinois.edu)

**Background:** In the US DOT Grant Deliverables and Requirements document, OST-R does NOT specify a general reporting format (font, spacing, etc.) However, they DO specify the necessary content for the reports. As described in the preceding section, that content is: problem, approach, methodology, findings, conclusions, and recommendations. Please see the next section, titled “Front End” to view cover pages and section titles for a final report.

**Formatting Instructions**: In an effort to provide a uniform, professional image, the NURail Center has developed a set of internal structural guidelines for final reports which are described below:

Font: Times New Roman, 12 point unless otherwise specified

Spacing: Single spaced paragraphs, double spaced between paragraphs and headings

Justification: Left hand justified unless otherwise noted

Margins: 1”

Section heading format**:** Each main heading should be all caps, centered and double spaced from the lines below. Example:

SECTION 1: CAPACITY ANALYSIS ON SHARED RAILROAD CORRIDORS

Subsection heading format: Should have the first letter in each word capitalized, be left justified and both italicized and underlined. Example:

*2.1 Analytical Approach*

Figures**:** All figures and tables must be numbered and should have a clear, brief caption.

Numbering system: Use a progressive decimal notation system. The main sections are given single Arabic numbers -1, 2, 3 and so on. Sub-sections are given a decimal number - 1.1, 1.2, 1.3 and so on. Sub-sections can be further divided into - 1.11, 1.12, 1.13 and so on.

**Grant Number**: At the bottom of each cover page please indicate which grant supported the funding for the project:

Grant Number: DTRT12-G-UTC18

NURail’s first grant (written in 2011 and awarded in 2012) through SAFETEA-LU.

Grant Number: DTRT13-G-UTC52

NURail’s second grant (written and awarded in 2013) through MAP-21 legislation.

**Acknowledgement**: In your articles, conference proceedings, thesis and dissertations, please use the following sentence for acknowledging NURail funding:

*“This research was supported by the National University Rail (NURail) Center a US DOT OST-R Tier 1 University Transportation Center."*

The word “research” might in some instances be substituted with “project” if it was an educational activity, or something else as appropriate.

Front End



NURail Project ID:

**Title of Research Report**

**(optional subtitle)**

By

Name

Title

Department

University

Email address

Name

Title

Department

University

Email address

Grant Number: DTRT12-G-UTC18 (Grant 1)

**or**

Grant Number: DTRT13-G-UTC52 (Grant 2)

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Funding for this research was provided by the NURail Center, University of Illinois at Urbana - Champaign under Grant No. DTRT12-G-UTC18 of the U.S. Department of Transportation, Office of the Assistant Secretary for Research & Technology (OST-R), University Transportation Centers Program. The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation’s University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

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**TECHNICAL SUMMARY**

**Title**

Please enter title here.

**Introduction**

Please provide a brief introduction to your report which should include a problem statement.

**Approach and Methodology**

Please describe your approach (overall style or general idea) and methodology (step by step procedure and researched plan) to tackle this research.

**Findings**

Please provide a brief summary of the major results of your project.

**Conclusions**

Please give a concise summary of your interpretations.

**Recommendations**

Please provide a brief summary of your suggestions.

**Publications**

Please provide a list of publications associated with this research, noting those that are attached to this report.

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*On the following page you would start the text of your final report. Be sure to follow the NURail formatting guidelines.*

Final Report

Completed Example

*(Please note: this is a dummy report.)*



NURail project ID: NURail2013-UIUC-R06

**Impact of High-Speed Passenger Trains on Freight Train Efficiency**

**in Shared Railway Corridors**

By

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**TECHNICAL SUMMARY**

**Title**

Impact of High-Speed Passenger Trains on Freight Train Efficiency in Shared Railway Corridors

**Introduction**

This project has developed a series of decision support tools that can help evaluate the impact of high-speed passenger trains on freight corridor capacity, e.g., by answering the following fundamental questions:

• How does the introduction of high-speed passenger trains affect the railroad freight carrying capacity?

• How is this impact dependent of various design factors (e.g., speeds, headways, and infrastructure design)?

• What policies will be suitable for public agencies and private sectors to support the development and deployment of the proposed high-speed passenger trains?

**Approach and Methodology**

There were two experiments conducted to examine the effects of train speed on freight traffic. The first experiment was designed to look at three factors: traffic composition, passenger train priority and maximum speed of passenger trains. The traffic level was held constant at 64 trains per day. The traffic composition starts with a homogenous freight line and then passenger trains replace a percentage of the freight trains to create a heterogeneous traffic composition. Eventually the line will transition to only homogeneous passenger traffic. There were 9 compositions studied. The traffic composition is measured by the heterogeneity level defined as the percentage of the total traffic that is freight trains.

The methodology included development of a new, hybrid analysis concept that takes advantage of the strengths of both timetable and non-timetable based software. The tools used in the study included RTC as the non-timetable based simulation tool and RailSys as the timetable-based tool.

**Findings**

This research project addresses congestion chokepoints by considering congestion effects in railroad transportation network caused due to the impact of high-speed passenger trains on freight train. Advanced network analysis models, as a result of this work, will yield short-term (ready-to-use computer tools for practitioners) and long-term (new mathematical modeling approaches and design paradigms) impacts.

The research lays the foundation to address issues regarding both short-term and long-term passenger and freight transportation chokepoints. This research project brings systems-level perspectives and advanced train control technologies into the railway transportation context, integrated within theoretical models, optimization and simulation approach, policy analysis, and implementation framework. It also addresses the urgent national needs for the development of HSR plan.

**Conclusions**

This paper has provided a brief introduction to the railway capacity, capacity analysis, and the use of commercial railway simulation software. The paper introduced a hybrid approach that attempts to improve level of service (LOS) criteria and capacity utilization through operational (scheduling) improvements. The method uses both timetable (RailSys) and non-timetable based software (Rail Traffic Controller (RTC)) for capacity analysis, by combining the strengths of each tool. The hybrid approach used for this research takes the output of RTC as input of RailSys and uses timetable compression technique offered by RailSys to improve the initial timetable. The improved results of RailSys are, again, considered as input in RTC, to validate the results of European capacity improvement technique in the U.S. rail environment. Ten minute maximum dwell time provided the best corridor capacity utilization, in addition to providing good level of service for the trains, in terms of delays, dwell times and number of stops. In that scenario, the unnecessary stops were reduced by 55%, delays reduced by 85%, and maximum dwell time was reduced from 60 minutes to 10, while the timetable duration was increased by only 18% compared to the initial schedule. This emphasizes the trade-off between LOS criteria and capacity utilization levels, as if LOS is improved, the capacity utilization of existing services may be increased (especially when capacity utilization is over 70%); and vice versa.

The outcomes (validated in RTC) suggest that UIC 406 compression techniques have the potential to be successfully applied for the U.S. rail environment. However, it was also recognized that while the conversion of infrastructure and operation rules database between software was simple, the fact that RailSys is originally developed in Europe makes the procedure of developing North American rolling stock and signaling features relatively challenging in RailSys, as the default database and information use European characteristics rather than North American ones. The deviations between signaling and rolling stock characteristics of European and U.S. rail systems may also cause some minor differences between the results of simulation packages.

**Recommendations**

The tasks under this project are the initial key step toward the creation of an advanced, integrated analytical and simulation framework for improving heterogeneous train traffic capacity in shared rail service corridors. This research provides a theoretical basis to address strategic, tactical, and operation level issues such as infrastructure investment, train timetabling plans, and train dispatching policies in such shared corridors. This project advances the state of the art in train delay estimation, train timetabling and dispatching, and complex system modeling.

The research efforts are the first few that considering the integration of different approaches in various analysis levels to estimate capacity impact and help to evaluate and determine train management policies and operational strategies (including speeds, headways, timetabling, dispatching, and control technologies) for HSR systems in shared railway corridors. Implementing this framework will provide important insights on policy analysis, corridor management strategy, railroad operational planning, and train control technology, for the on-going American National HSR Plan (including the Chicago-St. Louis HSR Project).

**Publications**

Lin, C-Y., M.R. Saat and C.P.L Barkan. Causal Analysis of Passenger Train Accidents on Freight Rail Corridors. In: *2013 World Congress on Railway Research*, Sydney, Australia, November 2013.

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TABLE OF CONTENTS

Page

LIST OF FIGURES .........................................................................................................iv

SECTION 1. INTRODUCTION .......................................................................................1

1.1 Background and Motivation .....................................................................................1

1.2 Study Objectives .......................................................................................................2

1.3 Organization of the Report ........................................................................................2

SECTION 2. REVIEW OF CAPACITY ANALYSIS ON SHARED RAILROAD

CORRIDORS ……………………………………………………………………………..4

2.1 Analytical Approach .................................................................................................4

2.2 Simulation Approach ................................................................................................5

2.3 Hybrid Approach ......................................................................................................7

SECTION 3. ANALYTICAL CAPACITY ANALYSIS OF IDEAL SHARED DOUBLE TRACK CORRIDORS .....................................................................................................11

3.1 Capacity Analysis of Freight Trains ........................................................................11

3.2 Delay Function of Freight Trains ............................................................................13

3.3 Total Cost Function of for the Freight Sector ..........................................................14

3.4 Conclusion ...............................................................................................................14

..

SECTION 4. CONCLUSIONS ........................................................................................34

4.1 Summary .................................................................................................................34

4.2 Future Research Directions .....................................................................................34

REFERENCES .................................................................................................................36

LIST OF FIGURES

Figure Page

Figure 3.1. Time-Space Diagram for One Direction of an Ideal Double-Track

Railway Corridor. ......................................................................................................................12

Figure 3.2. Cumulative Arrival and Departure Curves of One Direction of an

Ideal Double-Track Railway Corridor. ..................................................................................... 13

Figure 4.1. Induced freight train delays caused by speed differentials in train types ............... 20

Figure 4.2. Induced passenger train delays caused by speed differentials in train types .…..... 21

Figure 4.3. Distribution of freight delays when 79 mph passenger trains are added

to a base of 24 freight trains.......................................................................................................22

SECTION 1 INTRODUCTION

* 1. *Background and Motivation*

United States (U.S.), freight rail demand has doubled from 0.9 trillion ton-miles in 1980, to 1.8 trillion ton-miles in 2007, and railroad carriers reached a 39.5% market penetration in 2007 (BTS, 2011). Meanwhile, intercity passenger rail is increasingly being recognized as an energy-efficient, environmentally-friendly, and safe mode of transport. Development of high-speed passenger rail can improve mobility, reduce highway congestion, contribute to sustainable development, and reduce foreign oil dependency. The U.S. has begun development of high-speed rail (HSR) service (White House, 2011). In many places the new systems use shared corridors in which freight and passenger trains with heterogeneous configurations and operating characteristics will use the same tracks. However, the introduction of higher speed, high priority, passenger trains causes both primary delays (due to uncertainties in running and dwell times) and secondary or “knock-on” delays (due to meet, pass, and overtake for train conflicts, and primary delay propagations) to freight trains (typically with lower speed) (Mattsson 2007). Resolution of the conflicts between passenger and freight trains is essential to successful development of HSR on shared corridors. This highlights the need for an integrated, systems-level framework that incorporates new train control technologies and advanced analytical and simulation based modeling techniques for decision-making and policy analysis.

* 1. *Study Objectives*

This project is to understand the complex interactions between high-speed passenger trains and freight trains in on shared railway corridors. The objective of this project is to develop a decision support modeling framework that can help evaluate the impact of high-speed trains on railroad freight corridor capacity and draw technical and policy insights that will address key issues of the proposed US HSR plan. This decision support modeling framework includes three types of approaches: (1) analytical approach, (2) simulation approach, and (3) hybrid analytical-simulation approach. We conduct numerical analysis using the simulation and hybrid approaches to demonstrate the proposed decision support modeling framework for real-world applications.

SECTION 2 REVIEW OF CAPACITY ANALYSIS ON SHARED RAILROAD CORRIDORS

This chapter reviews existing shared railroad corridor capacity analysis studies using analytical, simulation, and hybrid approaches in the U.S. and Europe.

2.1 *Analytical Approach*

One of the first analytical models on shared railroad corridor capacity was developed by Frank (1966) by studying the delay levels along a single track corridor considering both directional and bidirectional scenarios. The Frank’s model used one train running between two consecutive sidings (using manual blocking system) and a single average speed for each train to calculate the number of possible trains (theoretical capacity) on the given segment. Petersen (1974) expanded Frank’s model by considering two different speeds, independent departure times, equal spacing between sidings, and constant delays between two trains. Higgins et al (1998) developed a model for urban rail networks to evaluate the delays of trains by considering different factors such as trains’ schedule, track links, sidings, crossings, and the directional/bidirectional operation patterns throughout the network.



**Figure 2.1 FRA Definition of Shared-Use Corridor**

*2.2 Simulation Approach*

Simulation is an imitation of a system's operation which should be as close as possible to its real-world equivalent (Abril et al., 2007). In this approach, the process of simulation is repeated several times until an acceptable result is achieved by the software. The data needed for the simulation are similar to the analytical methods, but typically at a higher level of detail.

SECTION 4 CONCLUSIONS

This chapter summarizes the research, highlights its contributions, and proposes directions for future research.

*4.1 Summary*

This study has addressed two primary objectives:

1. Propose a series of decision support modeling frameworks by developing three new capacity analysis approaches: analytical, simulation, and hybrid. These three capacity analysis approaches can be used in separately or in combination for various applications such as strategic policy design and operational plan evaluation.
2. 2. Demonstrate real-world case studies using simulation and hybrid approaches. These case studies show that the proposed decision support modeling frameworks can be used to analyze the impact of high-speed passenger trains to freight trains on shared corridors. This helps address some of the most pressing needs faced by the current U.S. railroad industry.

*4.2 Future Research Directions*

The present research addressed the problem of impact of high-speed passenger trains to freight trains on shared corridors using three new proposed capacity analysis approaches for decision support. Future research can be conducted in a number of directions; some examples are listed as follows.

1. Develop a method to compare different approaches for shared corridor capacity analysis.
2. Develop analytical approach to analyze single track shared corridor capacity.
3. Develop approach to optimize infrastructure planning and operations, building upon the corridor capacity modules developed from this study.

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"Workshop On Railroad Capacity and Corridor Planning," in Transportation Research Board (TRB), Washington, 2002.

Frequently Asked Questions

1. **QUESTION: I have heard that OST-R wanted to have final reports submitted within 6 months of the completion of a research project. Is that true?**

**ANSWER:** According to OST-R guidelines, the Center Director shall publish on the Center’s website the full text of each report within **two** months after the completion of each project.

**2. QUESTION: If a single research program supported more than one professor working on different projects and/or more than one PhD student working on different dissertation topics, can more than one close-out final report be written for that research program?**

**ANSWER**: Yes. If you prefer, a final report can be written for each project within a single research program. For the NURail Project ID number, please use "NURail2013-UIUC-R05A, B, C, etc." However, it is also acceptable to include the work of more than one student in a single report with a single NURail project title.

**3. QUESTION: Does the title of the report need to be exactly the same as that of the internal NURail proposals that we first had approved by UIUC?**

**ANSWER:** Yes, your report title must be the same. However in cases where you are submitting more than one final report within a single research program, you may use subtitles corresponding to different volumes, theses, papers etc.

**4. QUESTION: I do not understand why we would want to split our external reports into 2011 and 2012 funding, even though our internal proposals are separately numbered that way. Has there been any decision on this?**

**ANSWER:** If a project is given more than one amount of funding within a single grant, only one final report needs to be written even though internally the project may have more than one NURail Project ID number. However, if a project is continued into a different grant an interim final report must be submitted.