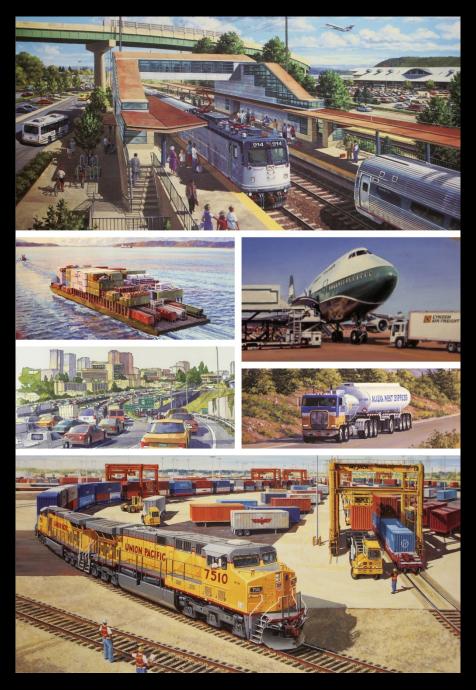
# **Fundamentals of**

# **Transportation Engineering**

**A Multimodal Systems Approach** 



Jon D. Fricker and Robert K. Whitford

Second Edition, 6th Printing

Fundamentals of Transportation Engineering, Second Edition, 6th Printing.

© July 2018, Jon D. Fricker and Robert K. Whitford.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without prior written permission from the authors. The first edition of this book was published by Pearson Education, Inc.

Credit for cover art: All images copyright J. Craig Thorpe; from original paintings commissioned by Amtrak, Lynden, Inc., All Aboard Washington and General Electric Transportation Systems.

For instructor materials and details about the changes made since the first edition, go to https://engineering.purdue.edu/~ce361/JFRICKER/FTE/.

### Preface to the Second Edition, 6th Printing

This is the sixth version of Edition 2. The first edition of *Fundamentals of Transportation Engineering* (FTE1) was published in 2004. Since 2004, new editions of several well-known manuals and other references have been published. Furthermore, much of the data that appeared in FTE1 has become outdated. For these reasons, the second edition of FTE was published in June 2014 and distributed by academic pub.com, followed by several subsequent versions (printings).

In the 6<sup>th</sup> Printing, the font size and line spacing of the text has been changes to make electronic versions of the book easier to read. Changes in content have been made to update data and topics, and to respond to suggestions by users of the book. See <a href="https://engineering.purdue.edu/~ce361/JFRICKER/FTE/">https://engineering.purdue.edu/~ce361/JFRICKER/FTE/</a> for details.

As with the previous versions, Fundamentals of Transportation Engineering continues to:

- (1) Cover topics beyond the highway mode. Chapters 10-12 cover the transit, air, and freight modes. Chapter 13 on Sustainable Transportation includes non-motorized transportation and new technologies.
- (2) Allow use of reading assignments to replace a traditional "lecture". This increases class time for taking student questions about the reading, working problems, and facilitating discussions.

(3) Begin each chapter with a realistic scenario, build toward analyzing and solving related example problems, and invite students to ponder the "Think About It" boxes.

We continue to think about the future of the textbook. Should we continue the current online distribution, with its softcover, spiral bound, and eBook options? Should we return to a hardbound format? What topics should be added? Which topics could be deleted? We invite comments and suggestions from those who are using the book.

Thank you to those of you who have adopted the book. Please continue to tell us how the book has met your needs and how it could be improved.

Jon D. Fricker Robert K. Whitford

West Lafayette IN Seattle WA

13 July 2018

### Table of Contents, Second Edition, 6th Printing

### **CHAPTER 1 TRANSPORTATION IN OUR DAILY LIVES**

- 1.1 The Role of Transportation
- 1.2 Fundamentals of Transportation Engineering
- 1.3 Multimodal and Intermodal Transportation
- 1.4 A Systems Approach to Transportation

### CHAPTER 2 TRAFFIC FLOW: THEORY AND ANALYSIS

- 2.1 Measuring Traffic Flow and Spacing
- 2.2 Measuring Traffic Speeds and Densities
- 2.3 Traffic Models for Continuous Flow
- 2.4 The Poisson Model for Continuous Flow
- 2.5 Measuring Roadway Performance

### CHAPTER 3 HIGHWAY DESIGN FOR PERFORMANCE

- 3.1 Capacity and Level of Service for Basic Freeway Segments
- 3.2 Queueing Systems
- 3.3 Systems with Stable Queues
- 3.4 Queueing Systems with Persistent Queues

### CHAPTER 4 MODELING TRANSPORTATION DEMAND AND SUPPLY

- 4.1 Basis for Transportation Planning
- 4.2 Trip Generation
- 4.3 Trip Distribution
- 4.4 Mode Choice
- 4.5 Trip Assignment

### CHAPTER 5 PLANNING AND EVALUATION FOR DECISION-MAKING

- 5.1 The Transportation Planning Process
- 5.2 Brief Review of Engineering Economics
- 5.3 Economic Evaluation of Transportation Alternatives
- 5.4 Ranking Transportation Alternatives

#### **CHAPTER 6 SAFETY ON THE HIGHWAY**

- 6.1 Highway Safety Data and Analysis
- 6.2 Human Factors and Transportation Engineering
- 6.3 Vehicle Attributes That Affect Safety
- 6.4 Traffic Control Devices

#### **CHAPTER 7 HIGHWAY DESIGN FOR SAFETY**

- 7.1 The Challenge of Roadway Alignment
- 7.2 Stopping Sight Distance and Alignment
- 7.3 Banking Curves (Horizontal Alignment)
- 7.4 Roundabouts

## CHAPTER 8 DESIGN OF INTERSECTIONS FOR SAFETY AND EFFICIENCY

8.1 Analysis of Non-Signalized Intersections

- 8.2 Signal Warrants and Stopping Distance at Signalized Intersections
- 8.3 Analysis of Signalized Intersections

### CHAPTER 9 HIGHWAY DESIGN FOR RIDEABILITY (PAVEMENT DESIGN)

- 9.1 Factors in Pavement Design
- 9.2 Determining Loads from Truck Traffic
- 9.3 Flexible Pavement Design
- 9.4 Rigid Pavement Design
- 9.5 Pavement Management Systems

#### **CHAPTER 10 PUBLIC MASS TRANSPORTATION**

- 10.1 Transit Modes
- 10.2 Designing a Rail Transit Line
- 10.3 Predicting Transit Ridership Changes
- 10.4 Performance Measures in Public

Transportation

10.5 Life-Cycle Costs in Public Transportation

### CHAPTER 11 AIR TRANSPORTATION AND AIRPORTS

- 11.1 Overview of the Air Transportation System
- 11.2 Airport Planning and Forecasting
- 11.3 Airport Capacity
- 11.4 Delay at Airports
- 11.5 Airport Site Determination and Runway Orientation
- 11.6 Runway Length Design

#### **CHAPTER 12 MOVING FREIGHT**

- 12.1 Freight -- The Movement Behind Economic Well-Being
- 12.2 Moving Freight by Truck
- 12.3 Moving Freight by Rail
- 12.4 Moving Freight by Barges on Inland Waterways
- 12.5 Oil Pipelines
- 12.6 Moving Freight by Air
- 12.7 Energy Analysis of Freight Modes

### CHAPTER 13 THE PATH TO A SUSTAINABLE TRANSPORTATION SYSTEM

- 13.1 Sustainability
- 13.2 Fueling Transportation Engineering for Sustainable Development
- 13.3 Infrastructure for Sustainable Transportation
- 13.4 Transportation Technology for Sustainable Development
- 13.5 Transportation Demand Management Policies
- 13.6 Urban Design for Sustainability