

doc. Ing. Jozef Gašparík, PhD.
prof. Ing. Jozef Majerčák, PhD.
doc. Ing. Jaromír Široký, Ph.D.
doc. dr. sc. Borna Abramović
Ing. Pavol Meško, PhD.
Ing. Petr Nachtigall, Ph.D.
Ing. Vladislav Zitrický PhD.

RAILWAY TRAFFIC OPERATION

Žilina
2016

The text book is supported by the VEGA Agency by the Project 1/0095/16 "Assessment of the quality of connections on the transport network as a tool to enhance the competitiveness of public passenger transport system" as well by the project ITMS 26110230083 "The quality of education and human resources development as the pillars of a knowledge society", that are solved at Faculty of Operations and Economics of Transport and Communication, University of Žilina.

Scientific editor prof. Ing. Miloslav Seidl, Ph.D.

Reviewers prof. Ing. Václav Cempírek, Ph.D.
 Ing. Peter Šulko, PhD.

Published by University of Žilina/EDIS-vydavateľské centrum ŽU

Copyright©University of Žilina 2016

ISBN 978-80-554-1281-8

CONTENT

INTRODUCTION.....	7
1. RAILWAY MARKET	9
1.1. Production process in transportation.....	9
1.2. Relations in the transport market	11
1.3. European transport policy	13
1.4. Transformation Process of Unitary Railways in Slovakia	15
1.5. Basic Terms.....	16
2. RAILWAY NETWORK	21
2.1. Railway network definition.....	21
2.2. Railway line.....	27
2.3. Operating control points	28
2.3.1. Operating control points with the track lead.....	28
2.3.2. Operating control points without the track lead.....	29
2.4. Posts.....	30
2.4.1. Rail-yard and operating structures of a railway station	31
2.4.2. Indication of transport and operation facilities and means	32
3. TRACK LINE DESIGN	35
3.1. Railway substructure	35
3.2. Railway superstructure	38
3.3. Other facilities of the railyard.....	44
3.4. Line class and structure gauge.....	45
4. ROLLING STOCK	47
4.1. Major rolling stock constituent parts.....	47
4.1.1. Outline of the vehicle	49
4.1.2. Coupler and buffer gear	50
4.2. Braking system and train braking	51
4.2.1. Rolling stock braking.....	51
4.2.2. Pneumatic brake operating principle.....	52
4.3. Classification of rolling stock	55
4.3.1. Independent haulage traction vehicle.....	57
4.3.2. Dependent haulage traction vehicle	61
4.3.3. Railcars and multiple units.....	62
4.3.4. Pus-pull trains	63
4.4. Trailer vehicles.....	63

4.4.1. Freight wagons	63
4.4.2. Passenger coaches.....	71
4.4.3. Special vehicles	73
4.5. Marking of rolling stock	74
4.5.1. System of marking traction vehicle axle arrangement	76
4.5.2. Letter marking for wagons.....	78
4.5.3. Numerical marking for wagons.....	81
5. RAIL SIGNALLING SYSTEM	85
5.1. Signal aspects on rail signal devices.....	86
5.1.1. Mechanical signal devices	87
5.1.2. Light signal devices	87
5.2. Marking of fixed rail signal devices	93
5.2.1. Marking of non-portable rail signal devices by letters and numbers.....	93
5.2.2. Colour marking of fixed rail signal devices	95
5.3. Other Fixed signal devices and signals for rail vehicles movement	97
6. SAFETY DEVICES AND TELECOMMUNICATIONS	101
6.1. Station safety devices	101
6.1.1. Mechanical station-based safety communications.....	102
6.1.2. Electromechanical station-based interlocking.....	106
6.1.3. Relay station-based safety communication	113
6.1.4. Electronic safety devices	116
6.2. Line safety devices	119
6.3. Train safety devices.....	120
6.3.1. Components enabling communication between the device and the running rail vehicle.....	121
6.3.2. Continuous train control system applied by ŽSR	122
6.3.3. The European train control system ERTMS/ETCS	123
6.4. Level crossing safety devices.....	125
6.5. Information and communication railway devices.....	126
7. TRAFFIC MANAGEMENT IN RAILWAY TRANSPORT	133
7.1. Rail traffic operation.....	133
7.2. Train definition.....	135
7.2.1. Classification of trains.....	135
7.2.2. Numbering of trains	139
7.2.3. Composition of the train.....	139
7.3. Ensuring the train movement	141
7.3.1. Securing train movement in the area of station	141
7.3.2. Ensuring train movement in interstationary section.....	144
7.3.2.1. Telephone interaction.....	145

7.3.2.2. Anticipated departure	146
7.3.2.3. Automatic block.....	147
7.3.2.4. Automatic signal block.....	148
7.3.2.5. Safety device remote control	148
7.4. Transport services operation and service documentation.....	149
7.4.1. Transport services operation and service documentation	149
7.4.2. Aids for train traffic diagram.....	150
8. LOCAL PROCESSES AND TRAIN FORMATION.....	153
8.1. Model of wagon flow organization and components of train forming plan	154
8.1.1. Inputs for train forming plan	154
8.1.2. Assessment criteria in train formation	158
8.1.3. Definition of train formation issue.....	168
8.1.3.1. Combinations of wagon flows	169
8.1.3.2. Number of options in train formation	171
8.1.4. Approaches to train formation.....	174
8.2. Technological process in railway stations	177
8.2.1. Intermediate and section stations	178
8.2.2. Marshalling yards.....	179
8.2.3. Next type of the stations	182
9. TRAIN TRAFFIC DIAGRAM.....	183
9.1. Graphic presentation of train traffic diagrams.....	183
9.2. Classification of train traffic diagrams by their types.....	184
9.2.1. Mutual relationship between the speed of trains in train traffic diagrams	185
9.2.2. Number of line tracks	186
9.2.3. Relation between number of trains in one direction and in opposite direction.....	188
9.2.4. Organization of subsequent trains.....	188
9.2.5. Occupation time of open line sections	190
9.2.6. Duration of validity	191
9.2.7. Degree of occupancy and capacity utilisation	191
9.2.8. Systematic approach.....	192
9.3. Data for compiling train traffic diagrams.....	194
9.3.1. Train traffic extent.....	194
9.3.2. Quantitative indicators.....	195
9.3.3. Qualitative indicators of train traffic diagrams	195
9.3.3.1. Speed types in train traffic	195
9.3.3.2. Other qualitative indicators	198
9.3.4. Time normatives of the traffic diagram.....	199
9.3.4.1. Running times.....	200
9.3.4.2. Dwell times of trains.....	202
9.3.4.3. Operating intervals.....	204
9.3.4.4. Station intervals	208

9.3.4.5. <i>Line intervals</i>	220
9.3.4.6. <i>Interval of opposite direction running</i>	228
9.3.4.7. <i>Platform intervals</i>	229
9.3.5. Headway (sequential meantime)	230
9.3.5.1. <i>Headway for train paths secured by phone communication or semiautomatic block</i>	231
9.3.5.2. <i>Headway for trains paths with their running secured by automatic block</i>	234
9.3.6. Entrance headway and resulting value of sequential mean time	237
9.3.7. Electrical mean time (electrical headway)	238
10. ESTIMATION OF RAILWAY INFRASTRUCTURE CAPACITY	239
10.1. Essential terms and types of throughput efficiency	240
10.2. Essential principles and methodologies for measurement of throughput and capacity	242
10.3. estimation infrastructure capacity by using the simulation tools	253
10.3.1. Requirements for software tools	253
10.3.2. Scheme for techniques of estimation infrastructure capacity	254
10.3.3. Required outputs of measurement and evaluation of capacity analysis	256
10.3.4. Facilitation of timetable compilation and capacity analysis by means of software applications	258
10.3.5. Customer requirements for rail infrastructure capacity	261
10.4. International cooperation in timetabling	265
10.4.1. Forum Train Europe	265
10.4.2. Organisation for Co-operation between Railways	265
10.4.3. Rail Net Europe	265
LIST OF ABBREVIATIONS	271
BIBLIOGRAPHY	272
LIST OF APPENDICES	275