

Contents

Danksagung	V
Abstract	VII
Zusammenfassung	IX
Contents	XI
List of Figures	XIII
List of Tables	XV
Introduction	1
I. Decomposition Algorithms for Multi-Period Network Design	7
1. Motivation	11
2. Strategic Infrastructure Planning in Railway Networks	15
2.1. Basic Terminology	15
2.2. Strategic Track Infrastructure Planning	18
2.3. The Problem in the Literature	28
3. Modelling the Expansion Problem	49
3.1. Modelling Assumptions	50
3.2. Input Parameters	53
3.3. Single-Period Approach	56
3.4. Multi-Period Approach	59
4. Model Analysis and Solution Approaches	67
4.1. Comparing Models (FMNEP) and (BMNEP)	67
4.2. A Compact Reformulation of Model (FMNEP)	70
4.3. Preprocessing of (NEP) and (CFMNEP)	72
4.4. Decomposition Algorithms	74
5. Case Study for the German Railway Network	85
5.1. Our Planning Software and the Computational Setup	85
5.2. Evaluating the Models and their Enhancements	88
5.3. The Germany Case Study	90

II. Iterative Aggregation Procedures for Network Design Problems	103
6. Motivation	107
7. An Iterative Aggregation Algorithm for Optimal Network Design	111
7.1. Graph Aggregation and the Definition of the Master Problem	112
7.2. Possible Enhancements of the Algorithm	119
8. Integration of Routing Costs into the Aggregation Scheme	123
8.1. A Special Case: Aggregating Minimum-Cost s - t -Flow Problems	124
8.2. An Aggregation Algorithm incorporating Routing Costs	129
9. The Computational Impact of Aggregation	135
9.1. Computational Setup and Benchmark Instances	135
9.2. Computational Results on Scale-Free Networks	136
9.3. Computational Results on Real-World Railway Networks	148
III. Approximate Second-Order Cone Robust Optimization	155
10. Motivation	159
11. Polyhedral Approximation of Second-Order Cone Robust Counterparts	163
11.1. Outer Approximation of the Second-Order Cone	163
11.2. Inner Approximation of the Second-Order Cone	166
11.3. Upper Bounds for Second-Order Cone Programs via Linear Approximation .	171
11.4. Approximating SOC Robust Counterparts	172
12. Computational Assessment of Approximate Robust Optimization	179
12.1. Implementation and Test Instances	179
12.2. Results on Portfolio Instances from the Literature	180
12.3. Results on Real-World Railway Instances	185
Conclusions and Outlook	189
Bibliography	193