Contents

Preface XV
List of Contributors XVII

Part One Introductory Section 1

1 Editorial Introduction 3
Luca Zamparini and Genserik Reniers
1.1 History, Importance, and Economic Aspects of Hazmat Transportation 5
1.2 Security of Hazmat Transportation: Unimodal Perspectives 6
1.3 Security of Hazmat Transportation: Multimodal Perspectives 7
1.4 Security of Hazmat Transportation: International Policies and Practices 8
Bibliography 8

2 History and Importance of Hazmat Transportation 9
Genserik Reniers
2.1 Introduction 9
2.2 History of Hazmat-Transportation Research 11
2.3 Importance of Research on Hazmat Transportation and Associated Risks 12
2.4 Conclusions 14
Bibliography 14

3 Economic Issues in Hazmat Transportation 17
Luca Zamparini
3.1 Introduction 17
3.2 Hazmat Transportation in the United States and in the European Union 17
3.3 Models of Hazmat Transport 22
3.3.1 Risk Assessment in Hazmat Transport 22
3.3.2 Routing/Scheduling and Hazmat Transport 23
3.3.3 Allocation Problem in Hazmat Transport 24
3.4 Concluding Remarks 24
Bibliography 24
# Part Two  Security of Hazmat Transports: Unimodal Perspectives  

## 4 Security of Hazmat Transports by Road  
*Mark Lepofsky*

4.1 Introduction  
4.2 Hazmat Truck Types  
4.3 Security-Sensitive Materials  
4.4 Carrier Responsibility  
4.4.1 General Security Issues  
4.4.1.1 Risk Assessment  
4.4.1.2 Attack Profiles  
4.4.1.3 Planning an Attack  
4.4.1.4 Training  
4.4.2 Personnel Security  
4.4.3 Unauthorized Access  
4.4.4 En Route Security  
4.4.4.1 Driver Responsibilities  
4.4.4.2 Technology Solutions  
4.4.4.3 Motor-Carrier Enforcement  
4.5 Shipper and Consignee Responsibility  
4.6 Motor-Carrier Enforcement  
4.7 Law Enforcement and Emergency Response  
4.8 Community Vigilance  
4.9 Security-Related Events  
4.10 Conclusions  

## Bibliography  

## 5 Security Aspects of Hazmat Transport Using Railroad  
*Manish Verma and Vedat Verter*

5.1 Introduction  
5.2 Railroad Transportation System  
5.3 Risk Assessment  
5.3.1 Probability of Attack  
5.3.2 Consequence  
5.3.2.1 Probability of Targeting Hazmat Railcars  
5.3.2.2 Hazmat Volume  
5.3.3 Route Risk  
5.4 Risk Management  
5.4.1 Steps Taken  
5.4.1.1 Information Sharing and Coordination  
5.4.1.2 Policing and Surveillance  
5.4.1.3 Routing of Hazmat  
5.4.2 Further Measures  
5.4.2.1 Interdiction Models  
5.4.2.2 Tank-Car Design  
5.4.2.3 Shipment Routing
<table>
<thead>
<tr>
<th>Part</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>Conclusion</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Acknowledgment</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
<td>67</td>
</tr>
<tr>
<td>6</td>
<td>Security of Hazmat Transports by Inland Waterways</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td><em>Pero Vidan and Josip Kasum</em></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Introduction</td>
<td>71</td>
</tr>
<tr>
<td>6.2</td>
<td>Transport of Hazardous Materials by Inland Waterways–Current Legislation</td>
<td>72</td>
</tr>
<tr>
<td>6.3</td>
<td>Incidents on Inland Waterways</td>
<td>73</td>
</tr>
<tr>
<td>6.4</td>
<td>Security of Inland Waterways and Ports–Current Practices</td>
<td>74</td>
</tr>
<tr>
<td>6.5</td>
<td>Proposals for Security Improvements on Inland Waterways</td>
<td>77</td>
</tr>
<tr>
<td>6.6</td>
<td>Proposals for Improvements of Inland Ports’ Security</td>
<td>85</td>
</tr>
<tr>
<td>6.7</td>
<td>Conclusion</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Consulted Web Sites</td>
<td>89</td>
</tr>
<tr>
<td>7</td>
<td>Security of Hazmat Transports by Pipeline</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td><em>Paul W. Parfomak</em></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Introduction</td>
<td>91</td>
</tr>
<tr>
<td>7.1.1</td>
<td>Hazmat Pipeline Infrastructure Around the World</td>
<td>91</td>
</tr>
<tr>
<td>7.2</td>
<td>Security Risks to Hazmat Pipelines</td>
<td>93</td>
</tr>
<tr>
<td>7.2.1</td>
<td>Commodity Theft from Pipelines</td>
<td>94</td>
</tr>
<tr>
<td>7.2.2</td>
<td>Global Terrorist Attacks on Pipelines</td>
<td>94</td>
</tr>
<tr>
<td>7.2.3</td>
<td>Costs and Impacts of Pipeline Security Incidents</td>
<td>97</td>
</tr>
<tr>
<td>7.2.4</td>
<td>Responding to Pipeline Security Threats</td>
<td>98</td>
</tr>
<tr>
<td>7.3</td>
<td>US Pipeline Security after September 11, 2001</td>
<td>99</td>
</tr>
<tr>
<td>7.3.1</td>
<td>Pipeline Operator Security Programs</td>
<td>99</td>
</tr>
<tr>
<td>7.3.2</td>
<td>Security Initiatives of the U.S. Department of Transportation</td>
<td>101</td>
</tr>
<tr>
<td>7.3.3</td>
<td>Transportation Security Administration and Pipeline Security</td>
<td>102</td>
</tr>
<tr>
<td>7.3.4</td>
<td>Federal Energy Regulatory Commission</td>
<td>106</td>
</tr>
<tr>
<td>7.4</td>
<td>Policy Issues in Hazmat Pipeline Security</td>
<td>107</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Security Threat Information</td>
<td>108</td>
</tr>
<tr>
<td>7.4.2</td>
<td>Identifying Critical Pipeline Facilities</td>
<td>108</td>
</tr>
<tr>
<td>7.4.3</td>
<td>International Cooperation in Pipeline Security</td>
<td>109</td>
</tr>
<tr>
<td>7.5</td>
<td>Conclusions</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Bibliography</td>
<td>110</td>
</tr>
<tr>
<td>8</td>
<td>Multimodal Transport: Historical Evolution and Logistics Framework</td>
<td>117</td>
</tr>
<tr>
<td></td>
<td><em>Wout Dullaert, Bert Vernimmen, and Luca Zamparini</em></td>
<td></td>
</tr>
<tr>
<td>8.1</td>
<td>Introduction</td>
<td>117</td>
</tr>
</tbody>
</table>
8.2 Evolution of Multimodal Transport in the European Union, in the United States and in Asia 118

8.2.1 Multimodal Transport in the European Union 118
8.2.2 Multimodal Transport in the United States 120
8.2.3 Multimodal Transport in the ASEAN Countries 122

8.3 Problem Statement 123
8.4 The Standard Framework 123
8.5 Reconsidering the Case 128
8.6 Conclusions 132

9 Multimodal Analysis Framework for Hazmat Transports and Security 135

Cathy Macharis, Koen Van Raemdonck, Juha Hintsa, and Olivier Mairesse

9.1 Introduction 135
9.2 Literature Review 136
9.2.1 Unintentional Incidents 136
9.2.2 Intentional Incidents 138
9.3 Refined Approach for the Calculation of Multimodal Hazmat-Transport Risk 139
9.3.1 Preliminary 139
9.3.2 Step 1: Determination of the Segmentation and Estimation of the Impact Distances 140
9.3.3 Step 2: Estimation of the General Probability of Occurrence of a Catastrophic Incident 142
9.3.4 Step 3: Estimation of the Local Probability of Occurrence 142
9.3.5 Practical Application and Visualization 144
9.3.6 Interpretation of the Results 145
9.4 Intended Incidents with Hazmat Transport 147
9.5 How to Include Security in the Modal Choice 149
9.5.1 Case Study 149
9.5.1.1 PROMETHEE 150
9.5.1.2 The Alternatives 151
9.5.1.3 The Weights: Valuation of the Critical Factors Influencing the Choice of Transportation 152
9.5.1.4 Multicriteria Analysis 156
9.6 Conclusion 158

Acknowledgments 159
Bibliography 159

10 Metaheuristics for the Multimodal Optimization of Hazmat Transports 163

Kenneth Sörensen, Pablo Maya Duque, Christine Vanovermeire, and Marco Castro

10.1 Introduction 163
10.2 Metaheuristics 165
10.3 Characteristics of Multimodal Hazmat Transportation Optimization Problems and the Case for Using Metaheuristics 167

10.3.1 Multilevelness 168

10.3.2 Multiobjectivity 169

10.4 Metaheuristics for Multimodal Hazmat Transportation 172

10.4.1 Metaheuristics for Multimodal Transportation 172

10.4.2 Metaheuristics for Hazmat Transportation 174

10.5 A Metaheuristic for Multimodal Hazmat Transportation 176

10.6 Conclusions and Research Opportunities 178

Bibliography 178

11 Freight Security and Livability: US Toxic and Hazardous Events from 2000 to 2010 183

Lisa Schweitzer, Pamela Murray-Tuite, Daniel Inloes, Jr., Mohja Rhoads, and Fynnwin Prager

11.1 Introduction 183

11.2 Background 184

11.3 Data on Consequences 187

11.3.1 National Transportation Atlas Database 2010 187

11.3.2 Hazardous Materials Information Reporting System (HMIRS) 187

11.3.3 Hazardous Substances Emergency Events Surveillance (HSEES) 188

11.3.4 Lexis-Nexis and Newspaper Reporting on Serious Spill Incidents 188

11.4 Consequences and Geography 188

11.5 Event Consequences 190

11.6 Conclusions 195

Bibliography 198


12 Security of Hazmat Transports in Italy 203

Paola Papa and Luca Zamparini

12.1 Introduction 203

12.2 Economic Significance of Hazmat Transport in Italy 204

12.2.1 Hazmat Transport by Road 204

12.2.2 Hazmat Transport by Rail 206

12.2.3 Hazmat Transport by Sea 208

12.3 The Italian Legal Framework on Hazmat Transport Security 210

12.4 Recent Italian Case Studies Related to Hazmat Transport Security 213

12.4.1 Detailed Description of the Most Recent Hazmat Transport Security-Related Events 214

12.5 Concluding Remarks 216

Bibliography 217
## Contents

### 13 Security of Hazmat Transports in The Netherlands from a Security Practitioner's Point of View  
*Henk Neddermeijer*  
219

13.1 Introduction 219  
13.2 Safety and Security 220  
13.3 The Netherlands: a Risk-Prone Country with a Risk-Prone Infrastructure 222  
13.4 The Dutch Transport Infrastructure as Risk Factor 223  
13.5 Transport and Logistics in The Netherlands 225  
13.6 Security Issues in Transport and Logistics 228  
13.7 Terrorism 229  
13.8 Transport and Logistics Crime 229  
13.9 Safety First 230  
13.10 Partners in Security 232  
13.11 Conclusion 234  
Bibliography 235  
Internet Sources 235

### 14 Safeguarding Hazmat Shipments in the US: Policies and Challenges  
*Joseph S. Szyliowicz*  
237

14.1 Introduction 237  
14.2 Intermodalism 237  
14.3 The Pre-9/11 Situation 238  
14.4 The Magnitude of the Problem 239  
14.5 The Impact of 9/11 240  
14.6 The Rail Sector 246  
14.6.1 Vulnerabilities 246  
14.6.2 Solutions and Their Effectiveness 248  
14.6.3 Emergency Planning and Response 250  
14.6.4 The Federal Government and the Private Sector 251  
14.7 Highways 252  
14.7.1 Vulnerabilities and Policies 252  
14.7.2 Administration and Coordination 253  
14.7.3 Local Governments and the Private Sector 255  
14.7.4 Minimizing Trucking Vulnerabilities 257  
14.8 Conclusions 258  
Bibliography 259  
Web Sites 261

### 15 Security of Hazmat Transports in Iran  
*Amir Saman Kheirkhah*  
263

15.1 Introduction 263  
15.2 Overview of the Current Status 264  
15.3 Strengths and Weaknesses of Iran’s Transportation System 267  
15.4 Safety and Security Strategies 268
15.5 Discussion 270
15.6 Conclusions 272
Bibliography 272

16 Conclusions and Recommendations 273
Genserik Reniers and Luca Zamparini
16.1 Unimodal and Multimodal Transportation Put into Perspective 274
16.2 A Country-Wise Comparative Study 275
16.3 A Look into the Future: Sustainable Multimodality 275

Index 277