

# Table of Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	IT systems in PT are complicated!	2
1.2	Standardisation	3
1.3	Challenges for system providers	6
1.4	The significance of a domain model	7
1.5	What awaits you in this book ...	8
1.6	What you will not find ...	8
<b>Part I</b>	<b>Overview</b>	<b>9</b>
<b>2</b>	<b>IT System Landscape of a Transport Company</b>	<b>11</b>
2.1	Systems and business processes at a glance	11
2.2	Actors and roles	16
2.3	Special requirements for systems in PT	20
2.3.1	Multitenancy	20
2.3.2	Versions and variants	21
2.3.3	Special notation for rules	22
2.3.4	Cross-process optimisation	23
<b>3</b>	<b>The ITTC Core Model</b>	<b>25</b>
3.1	Tips on notation	26
3.2	Defining the contents	27
3.3	The structure of the ITTC class model	28
3.4	The most important relations in the core model	34
3.4.1	The network: locations and links	34
3.4.2	Travel paths and routes	36
3.4.3	Calendar and time of day	39
3.4.4	Transport services: trip and connection	44
3.4.5	Vehicles and vehicle workings	47
3.4.6	Driver and duty	51
3.4.7	The link between trips and duties	56
3.5	Outlook	59

<b>Part II</b>	<b>Business Processes and IT Systems</b>	<b>61</b>
<b>4</b>	<b>Vehicles, Vehicle Types and Vehicle Formations</b>	<b>63</b>
4.1	Identifying objects – using the example of vehicles	63
4.2	How vehicles are equipped: Groups of attributes	68
4.3	Configurable attributes	75
4.4	Extract from the class model	79
4.5	Creating formations	80
4.6	Vehicle types	83
4.7	Maintenance	87
4.8	Vehicle equipment	88
4.9	Communication architecture in the vehicle	94
4.10	The software architecture of an on-board computer	97
4.11	Hardware for the on-board computer	102
<b>5</b>	<b>The Traffic Network and Routes</b>	<b>105</b>
5.1	Modelling the network in IT systems	111
5.2	Representation of the network in the user dialog	117
<b>6</b>	<b>Planning/Scheduling</b>	<b>121</b>
6.1	Taking irregularities into account (aspects)	124
6.2	IT architecture of planning systems	133
6.3	Timetable planning	134
6.3.1	Trips	136
6.3.2	The timetable planner’s working process	140
6.3.3	Connections	141
6.3.4	Timetable display and information	143
6.4	Vehicle working scheduling	154
6.4.1	Vehicle workings in the ITTC class model	156
6.4.2	Building vehicle workings from trips	159
6.4.3	Planning deadhead trips	164
6.4.4	Linking vehicle workings	167
6.5	Optimisation of trips and vehicle workings	170
6.6	Duty scheduling	172
6.6.1	Overview	173
6.6.2	Duties in the ITTC class model	179
6.6.3	The duty scheduler’s working process	183
6.6.4	Duty sequences	186
6.6.5	Optimising duties and duty sequences	188
6.7	Integrated vehicle working and duty scheduling	190

<b>7</b>	<b>Dispatch</b>	<b>193</b>
7.1	Personnel dispatch	194
7.1.1	Work processes	195
7.1.2	Personnel dispatch in the ITTC class model	199
7.1.3	IT systems for personnel dispatch	202
7.1.4	Automatic dispatch and optimisation	206
7.2	Vehicle dispatch	208
7.2.1	Work processes	208
7.2.2	Vehicle dispatch in the ITTC class model	216
7.2.3	IT systems for vehicle dispatch	219
<b>8</b>	<b>Transport Control</b>	<b>223</b>
8.1	Base data in the control system	225
8.2	Geolocating	227
8.3	Fleet control through control circuits	230
8.4	The model: events and actions	236
8.5	Operating an operation control system	240
8.6	System monitoring	248
8.7	Communication system	248
<b>9</b>	<b>Dynamic Passenger Information</b>	<b>257</b>
9.1	Dynamic information	257
9.2	Situations and types of passenger information	259
9.3	ITTC sub-model: DPI	
9.4	Scope	263
9.5	Preparing and displaying information	264
9.6	Forecast	268
9.7	DPI installations/stop computer	269
9.8	Transferring data between the control centre and DPI displays	270
9.9	Automated processing of actions	273
9.10	Deleting the display when the vehicle departs	274
9.11	Operating a DPI system	276
9.12	Joint DPI for multiple transport companies	277
<b>10</b>	<b>Sales and Distribution</b>	<b>279</b>
10.1	Ticketing class model: Overview	282
10.2	Ticketing role model	286
10.3	Access control	288
10.4	Products and fares	290
10.5	Sales	294
10.6	Payment flows and background systems	295

10.7	Paper tickets	296
10.7.1	Carrier material and security precautions	296
10.7.2	Usage	297
10.8	Online tickets	298
10.8.1	Carrier material	298
10.8.2	Security precautions	298
10.8.3	Example: HandyTicket from the VDV	299
10.9	eTickets	300
10.9.1	Carrier material	301
10.9.2	Security precautions	302
10.9.3	Digression: the basics of security in eTicketing	303
10.9.4	Usage	310
10.9.5	The VDV core application	315
10.9.6	Example: Touch&Travel	316
10.10	Hardware for ticketing	318
<b>11</b>	<b>Settlement, Performance Analysis and Quality Management</b>	<b>321</b>
11.1	Transport contracts	323
11.2	The class model as the basis of all reports	324
11.3	Typical evaluations	330
11.3.1	Analysing passenger demand	330
11.3.2	Evaluating the transport service	330
11.3.3	Evaluating the quality of service	332
11.3.4	Evaluating ticket revenue	334
11.4	Platforms for evaluations	334
11.4.1	A conceptual model of a data warehouse	335
11.4.2	Technology for data warehouses	337
11.4.3	How it is displayed	339
	<b>Part III Background Knowledge</b>	<b>341</b>
<b>12</b>	<b>Passenger Transport</b>	<b>343</b>
12.1	Why does public transport exist?	343
12.2	Public transport and the market economy	344
12.3	Profitability	345
12.4	Public transport organisation	346
12.5	Subsidies and competition	348
12.6	Public transport vs. private transport	348
12.7	Success factors for public transport	350
12.8	Safety	351

	12.9 A look at the world	352
<b>13</b>	<b>Informatics</b>	<b>355</b>
	13.1 Description methods – a look back	356
	13.2 Designing IT architecture	357
	13.3 Tools for modelling	360
<b>14</b>	<b>Modelling Methods</b>	<b>361</b>
	14.1 Creating sub-models	361
	14.2 Displaying classes	362
	14.3 General naming rules	363
	14.4 Packages, classes, attributes, functions	363
	14.5 Temporal patterns and events	365
	14.6 Functionally unique key terms	367
	14.7 Class instance attributes	368
	14.8 Consistency conditions	369
	14.9 Navigating along relations	370
	14.10 Conditions for relations: Invariants	372
	14.11 Recursive relations	374
	14.12 Ambiguous relations	374
	14.13 Aggregations	375
	14.14 Inheritance and typing	377
	14.15 Corresponding class hierarchies	381
	14.16 Composite pattern	382
	14.17 Interfaces	383
	<b>Appendix</b>	<b>385</b>
<b>A</b>	<b>System Landscape</b>	<b>387</b>
	A.1 Business processes and systems at a glance	387
	A.2 Systems and data flows in detail	392
	A.2.1 Planning	393
	A.2.2 Dispatch	399
	A.2.3 Transport control	402
	A.2.4 Dynamic passenger information	410
	A.2.5 Ticketing	413
	A.2.6 Evaluation, quality management	416
<b>B</b>	<b>Packages and Classes</b>	<b>419</b>
	B.1 Connections	419
	B.2 Aspects	420
	B.3 BasicTypes	421
	B.4 Company	421
	B.5 DutyExecution	423

	B.6	DutyScheduling	425
	B.7	PassengerInformation	427
	B.8	TimetablePlanning	428
	B.9	TripExecution	429
	B.10	Vehicles	432
	B.11	VehiclePeripheralEquipment	434
	B.12	Calendar	435
	B.13	Communication	436
	B.14	ConfigurableAttributes	439
	B.15	Customer	440
	B.16	CustomerSpecificTypes	441
	B.17	Routes	442
	B.18	Network	443
	B.19	Location	445
	B.20	Personnel	446
	B.21	DisruptionManagement	448
	B.22	Fare	451
	B.23	Ticket	453
	B.24	VehicleWorkingScheduling	455
	B.25	Validation	457
	B.26	Sales	458
	B.27	TransportPlanning	460
	B.28	Payment	460
C		<b>Glossary</b>	<b>461</b>
D		<b>Literature</b>	<b>477</b>
	D.1	Public transport in general	477
	D.2	Vehicles	477
	D.3	Transport service, demand analysis	478
	D.4	Timetable planning	478
	D.5	Connection planning	478
	D.6	Timetable information	478
	D.7	Vehicle working scheduling	479
	D.8	Duty scheduling	479
	D.9	Integrated planning	479
	D.10	Dispatch	480
	D.11	Control	480
	D.12	Dynamic passenger information	480
	D.13	Fares, ticketing	481
	D.14	Quality management, accounting	481
	D.15	Transport policy, transport companies, associations	481
	D.16	Software modelling	482
		<b>Index</b>	<b>483</b>