TRAIN AND RAILWAY OPERATIONS CONTROL

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Contents

Summary

The main subject of train and railway operations control is to ensure the safe transport of people and goods, to their respective destinations. This goal requires control of trains and tracks in a way that will ensure protection against forbidden states. This task can be described in three hierarchical control layers:

- the control of a given train on a given track
- the control of multiple trains on a given track
- the network control of multiple trains on multiple tracks.

1. Introduction

Transportation by means of rail-guided trains on extensive track networks is one of the oldest technologies for carrying people and goods. Several kinds of operations have been established

- carrying people and goods over long distances at relatively high speed

- urban commuter links for rapid transit in densely populated areas
- suburban shuttle transportation for express trains (e.g., to link airport-city centre)

All over the world, transportation by means of guided trains offers a more or less efficient and economical mode of mass transportation. Its quantity can be characterized by several criteria, e.g., capacity, average travel speed, maximum operating speed, average individual passenger departure delay, average departure frequency, scheduled travel time, minimum operational headway time, etc. Table 1 comprises some characteristic values of train transportation for different geographical regions.
Besides these operational measures, some others can be considered

- as measures of safety - i.e., absolute or related number of fatalities and injured persons in railway accidents,
- as measures of modal split or market share, i.e., the percentage of passenger or freight
- transportation volume by railways in comparison to other modes such as vehicles, planes or ships, and in addition
- environmental measures like energy consumption, noise emission and pollution.
- Another important measure determines the spatial distribution of network infrastructure for railway service, such as length of tracks, number of track nodes or switches and number of scheduled stops at stations.

Nowadays, economic and business aspects of railway operations have become more and more important, since railways have to operate as a provider of logistic services, and the financial support of governments keeps decreasing. Hence, for operating railways, one has to identify several interacting roles: the customer, for passenger or goods transportation services; the train service provider; the track network and maintenance provider; and the suppliers for the technical equipment of rolling stock, stations and infrastructure, operations control and maintenance.

In a similar review of the equipment that carries out the transportation process, one can distinguish between:

- rolling stock, i.e., the locomotives, the wagons or train compartments
- the track network with its single tracks, switches, passenger stations and shunting yards operation which, in general, serve the efficient and safe movement of trains for passenger and goods transfer.
- the operation (control, command and communication) that will be performed by humans and technical equipment according to more or less complex operational rules. Both fulfil the different functions of the railway operation control system, consisting of planning and scheduling, dispatching, supervision and optimisation, control and protection. To ensure wide spatial distribution of rolling stock over the track network, all necessary data must be acquired and distributed quickly and precisely. Hence the implementation of communication tasks plays an important role in railway operation control and essentially determines the performance quality of railway operation.

	Area of country km²	Popu-lation	Population density	Length of roads km	Length of lines worked at end of the year			
					Rail gauge			of which electrified lines
					broad	standard	narrow	
	thousands	millions	Inhab./km²	thousands	in kilometres			
European Union	3.238,0	374,54	115,7	3.538,6	22.657	129.684	3.052	68.925
Western Europe	3.666,3	386,07	105,3	3.700,6	22.657	136.771	3.126	74.528
Eastern and Central Europe	1.167,4	122,51	104,9	599,3	822	67.176	2.087	29.263
Baltic States	1.020,2	71,95	70,5	367,9	33.809	116	712	10.328
Total Europe	6.633,4	643,98	97,1	4.728,7	57.288	212.670	5.925	115.825
Middle East	4.536,6	129,64	522,0	435,5	94	12.057	293	149
Africa	18.886,8	579,12	937,6	1.480,0		11.301	51.527	12.702
South East Asia	14.855,1	2.621,71	2.253,4	6.518,5	43.088	62.379	39.603	39.455
America South	2.042,1	39,62	38,9	152,6	-	1.506	133	-
America North	19.348,7	300,86	19.649,6	7.209,5	-	246.341	-	-
GUS	23.003,4	231,38	495,8	910,5	111.859	128	1.677	47.704
Australia and New Zealand	8.011,8	22,51	16,3	1.005,2	-	132	13.277	2.390
TOTAL WORLD					212.329	546.514	112.435	218.225

	Stock at end of the year				**Average staff strength thousands**	**% 98 97**
	Locomotives		**Carriages**			
	(including Light Rail Motortractors)	**Railcars**	**railcars and railcar trailers**	**Railway's own wagons**		
European Union	18.759	8.380	65.218	354.541	757,9	-4,0
Western Europe	20.443	8.762	70.234	371.186	800,9	-3,9
Eastern and Central Europe	14.710	3.329	31.181	394.625	610,2	12,6
Baltic States	6.005	2.352	2.278	222.027	510,8	-0,8
Total Europe	41.862	14.593	105.117	1.004.827	1.963,7	-6,1
Middle East	1.071	26	2.244	36.132	53,0	
Africa	2.623	120	9.799	73.823	207,7	
South East Asia	29.962	543	103.198	724.158	3.497,4	
America South	56	-	143	2.183	2,0	-10,9
America North	20.700	-	1.675	575.604	202,7	4,2
GUS	4.475	8.136	50.249	765.243	1.584,9	
Australia and New Zealand	539	126	942	18.234	19,4	-5,4
TOTAL WORLD	101.288	23.544	273.367	3.200.204	7.530,8	

	Train performance		**Revenue rail traffic**							
			Passenger				**Freight**			
	Train-kilometers	**Gross train ton-kilometers**	**Passengers carried**	**% 98/97**	**Passenger kilometers**	**% 98/97**	**Tons carried**	**% 98/97**	**Ton-kilometers**	**% 98/97**
	millions		**millions**		**millions**		**millions**		**millions**	
European Union	2.569,8	925.909	5.151,9	1,1	278.866	1,1	910,9	1,1	235.466	1,5
Western Europe	2.738,9	995.224	5.483,3	1,1	294.359	1,1	989,2	1,2	247.570	1,7
Eastern and Central Europe	788,4	406.630	962,9	-8,8	59.101	-5,5	541,8	-8,6	130.595	-9,7
Baltic States	345,9	505.205	761,6	-1,4	65.872	-6,5	534,8	-1,6	218.761	-1,1
Total Europe	3.917,5	1.930.767	7.317,5	-0,6	425.492	-1,0	2.081,4	-2,3	605.211	-2,2
Middle East	9,6	38.256	16,0		7.031		42,8		17.392	
Africa	128,8	34.935	1.899,2		84.629		84,1		127.017	
South East Asia	2.744,4	3.479.864	14.914,6		1.050.647		2.054,3		1.553.986	
America South	-10,9	3.479.864	0,9	-21,9	127	-20,2	2,0	9,3	599	13,5
America North	817,3	3.830.010	24,9	2,0	9.938	-0,1	1.495,6	4,0	2.010.027	2,1
GUS	1.195,8	2.407.215	808,7		113.082		1.065,4		1.037.111	
Australia and New Zealand	17,7	69.123	53,4	0,5	1.114	1,8	121,9	32,9	33.624	27,2
TOTAL WORLD	8.836,1	11.791.130	25.035,2		1.692.059		6.947,5		5.384.967	

Table 1. Characteristic values of train transportation (Source: UIC, 1998)

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Biographical Sketch

Eckehard Schnieder has a strong engineering background merging control theory computer science and transportation application resulting from 30 years of academic and industrial education and career. Eckehard Schnieder was born in 1949 in the seaport Wilhelmshaven, Germany. He received his diploma (comparable to an M.Sc. degree) in electrical engineering with a specialisation in control and computer engineering in 1972 from the Technical University Braunschweig. Until 1979, he worked as a research scientist at the same university concerning advanced electrical drive control systems simulation resulting in the world's first fully micro computer controlled four quadrant dc drive. He received his Dr.-Ing. (PhD in engineering) in 1978. From 1979 until 1989, Dr. Schnieder worked at Siemens Eisenbahnsignaltechnik (Transportation Systems), where he was responsible for the German maglev TRANSRAPID operation control system's design and development as well as for the automatic control of Siemens people mover. Since 1989, Dr. Schnieder is a full professor and head of the Institute of Traffic Safety and Automation Engineering, formerly Institute of Control and Automation Engineering, and board member of the Center of Transportation of the Technical University Baunschweig.

Professor Schnieder was offered several professorships; in 1998 he received the Carl-Adam-Petri-Award of the Society of Design and Process Science. He directed the first formal modelling of the European Railway Control System (ETCS), the basic research on satellite assisted railway location systems, and other German and European projects for advanced railway operation control systems in cooperation with operators, suppliers, and safety authorities. Professor Schreider is a member of the VDI, VDE, GI, IFAC, and the SDPS.