

DIN SPEC 91516:2025-07 (E)

Human performance regarding the dynamic driving task for the specification of AI in ATO; Text in English

Inhalt	Seite
Foreword	5
Introduction.....	8
1 Scope.....	9
2 Normative references	9
3 Terms and definitions.....	9
4 Summary of regulations.....	15
4.1 Reference system comparison according to regulation	15
4.2 Regulations hinting driver performance.....	16
5 Similarity of human and technical senses as input interfaces.....	17
5.1 General.....	17
5.2 Basic similarity of visual perception capabilities	17
5.2.1 General.....	17
5.2.2 Purview.....	17
5.2.3 Dynamic range and discretization	18
5.2.4 Colour distinction.....	19
5.2.5 Angular perception, visual acuity and human eye resolution	19
5.2.6 Temporal resolution	20
5.2.7 Overall consideration and summary.....	20
6 Categorization of functions	21
6.1 General.....	21
6.2 Object recognition and collision prediction	24
6.3 Recognition of railway signals	25
6.3.1 General.....	25
6.3.2 Stationary optical trackside signals	25
6.3.3 Non-stationary optical signals	25
6.3.4 Acoustic signals.....	26
6.4 Recognition of points of turnouts.....	26
6.5 Recognition of damages and anomalies.....	26
6.6 Vehicle localisation.....	26
6.7 Velocity control.....	27
7 Performance metrics.....	27
7.1 General.....	27
7.2 Comparison by PFD and PFH	28
7.3 Comparison by reaction time, time to collision and distance to obstacle.....	28
7.4 Comparison by rate of avoided accidents.....	29
7.5 Submetrics for indirect measurement of mental processing and execution time	29
8 Measurement methods.....	30
8.1 General.....	30
8.2 Human reliability analysis	30
8.3 Driving simulators	31
8.4 In-field experiments.....	31
8.5 Accident and incident statistics	32
8.5.1 Accident and incident statistics for European mainline railways	32

8.5.2	List of accidents and incidents for German mainline railways	32
9	Performance shaping factors	32
9.1	General	32
9.2	PSFs in safety records	33
10	Sample measurements	33
10.1	General	33
10.2	Human performance at collision prediction	34
10.2.1	Human reliability analysis	34
10.2.2	Semi-estimated measurements	34
10.2.3	In-field experiments.....	35
10.2.4	Accident statistics	36
10.3	Human performance at signal detection	37
10.3.1	Human reliability analysis	37
10.3.2	Semi-estimated rates of SPADs	37
10.3.3	In-field measurements of signal detection	38
10.3.4	Statistics of SPADs.....	38
10.4	Human performance at recognition of damages and anomalies	41
10.5	Human performance at in- and outbound communication with the train traffic controller... ..	41
11	Abbreviated Terms.....	42
	Bibliography	44

Figures

Figure 1	— Reaction time, time to collision and distance to obstacle.....	28
Figure 2	— Points of CSM-RA placed into PSF taxonomy according to DIN EN 62508 (VDE 0050-2):2011-05.....	33

Tables

Table 1	— Operational assumptions for probability of failure [SUBSET-091]	16
Table 2	— Summary of similarity between human vision and camera system	21
Table 3	— Subtasks and functions of the driver	22
Table 4	— Submetrics for the performance of the human driver	29
Table 5	— Human reliability analysis procedure from DIN VDE V 0831-103:2020-09	30
Table 6	— Human reliability analysis of collision prediction [15]	34
Table 7	— Distance to obstacle semi-estimated measurements [38][14].....	35
Table 8	— Distance to obstacle semi-estimated measurements for fluorescent cubic objects at night [38][13].....	35
Table 9	— Distance to obstacle in-field measurements [12]	35
Table 10	— Distance to obstacle measurements for collision prediction [8]	36
Table 11	— Distances to obstacles recorded for collision prediction [6].....	36

Table 12 — Human reliability analysis at signal detection [15].....	37
Table 13 — Rates of signals passed per signal indicating stop from different origins [23]	37
Table 14 — Distance to obstacle measurements for signal detection [8].....	38
Table 15 — CSI data of SPADs per million train kilometres [16]	39
Table 16 — Human reliability analysis at recognition of damages and anomalies [15].....	41
Table 17 — Human reliability analysis at in- and outbound communication with the train traffic controller [15]	42