

# ISO/TR 16352:2005-12 (E)

## Road vehicles - Ergonomic aspects of in-vehicle presentation for transport information and control systems - Warning systems

---

<b>Contents</b>		<b>Page</b>
Foreword .....		v
Introduction .....		vi
<b>1</b>	<b>Scope .....</b>	<b>1</b>
<b>2</b>	<b>Warning signals .....</b>	<b>2</b>
2.1	Criteria of warning effects .....	2
2.2	Categorization of warning signal failure .....	4
2.3	Urgency mapping .....	6
2.4	Alarm theories .....	8
2.5	Design recommendations .....	10
<b>3</b>	<b>Psychological and physiological aspects .....</b>	<b>10</b>
3.1	Human processing of warnings .....	10
3.2	Workload .....	12
3.3	Expectancy .....	13
3.4	Further human factors, individual differences .....	13
3.5	Recommendations .....	14
<b>4</b>	<b>Sensorial modality .....</b>	<b>15</b>
<b>5</b>	<b>Visual warning signals .....</b>	<b>17</b>
5.1	Psychological/physiological bases .....	18
5.2	Types of visual displays .....	19
5.3	Design parameters .....	20
5.3.1	Sensorial-related parameters .....	20
5.3.2	Coding parameters .....	24
5.3.3	Organizational parameters .....	37
<b>6</b>	<b>Auditory warnings .....</b>	<b>39</b>
6.1	Psychological/physiological bases .....	40
6.2	Advantages of auditory presentation .....	41
6.3	Tonal signals, auditory icons .....	42
6.3.1	Advantages of tonal signals .....	42
6.3.2	Standards .....	42
6.3.3	Attributes .....	42
6.3.4	Sensorial parameters .....	44
6.3.5	Coding parameters .....	47
6.3.6	Organizational parameters .....	54
6.4	Speech output .....	55
6.4.1	Advantages of speech output .....	56
6.4.2	Sensorial-related parameters .....	56
6.4.3	Coding parameters .....	60
6.4.4	Organizational parameters .....	63
6.4.5	Warning applications of speech output .....	65
6.5	Comparison of tonal signals and speech output .....	66
<b>7</b>	<b>Tactile warnings .....</b>	<b>68</b>
7.1	Advantages of tactile presentation .....	68
7.2	Design parameters .....	70

7.2.1	Sensorial-related parameters .....	70
7.2.2	Coding parameters .....	71
8	Redundancy of message presentation .....	71
8.1	Visual/auditory combination .....	72
8.2	Visual/auditory qualities for in-vehicle displays .....	73
8.3	Visual/auditory indications for displays .....	74
8.4	Visual/auditory/tactile combination .....	74
8.5	Master alerting .....	75
8.6	Other concepts .....	75
9	Comparison of warning types, codes and modalities .....	77
9.1	Visual/auditory presentation of non-verbally-coded objects .....	77
9.2	Visual/auditory presentation of verbally-coded objects/abstract information .....	78
9.3	Visual/auditory presentation of verbally-/non-verbally-coded spatial information .....	79
9.4	Visual presentation of non-verbally-coded information/auditory presentation of verbally-coded information .....	81
9.5	Visual/tactile presentation of non-verbally-coded objects/spatial information .....	82
9.6	Auditory/tactile presentation of non-verbally-coded objects/spatial information .....	85
9.7	Visual/auditory/tactile presentation of verbally-coded objects/abstract information .....	86
9.8	Recommendations for warning systems .....	86
10	Warnings in assistance systems .....	88
10.1	Distance warning systems .....	91
10.2	Collision warning systems .....	92
10.3	Side-obstacle warning systems .....	98
10.4	Lane-departure warning systems .....	100
10.5	Manoeuvring aids for low speed operation .....	102
10.6	Usability of intelligent-transport-systems information for drivers .....	104
10.7	Other assistance systems .....	104
11	Warnings in other applications .....	105
11.1	Aircraft .....	105
11.2	Intensive care unit .....	106
11.3	Industrial plants .....	106
12	Discussion .....	108
13	Summary .....	110
13.1	Introduction .....	110
13.2	Warning signals .....	110
13.3	Psychological and physiological aspects, sensorial modality .....	111
13.4	Visual warning signals .....	111
13.5	Auditory warnings .....	113
13.6	Tactile warnings .....	115
13.7	Redundancy of message presentation .....	116
13.8	Comparison of warning types, codes and modalities .....	116
13.9	Warnings in assistance systems .....	117
13.10	Warning in other applications .....	118
	Bibliography .....	119