Functional Safety

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Qualitätskonstruktion GmbH

ISO 26262:2011
HARA – ranking cards

Overview of Classifications

Severity	
S0	No injuries
S1	Light and moderate injuries (arm hurted)
S2	Severe and life-threatening injuries (survival probable - arm detached)
S3	Life-threatening injuries (survival uncertain), fatal injuries (head detached)

Exposure (Duration + Frequency)	
E0	Incredible
E1	Very low probability
E2	Low probability
E3	Medium probability
E4	High probability

Controllability	
C0	Controllable in general
C1	Simply controllable
C2	Normally controllable
C3	Difficult to control or uncontrollable

		C1 (1Pt)	C2 (2Pt)	C3 (3Pt)
S0	E1-4	QM	QM	QM
S1 (1Pt)	E1 (1Pt)	QM	QM	QM
	E2 (2Pt)	QM	QM	QM
	E3 (3Pt)	QM	QM	ASIL A
	E4 (4Pt)	QM	ASIL A	ASIL B
S2 (2Pt)	E1 (1Pt)	QM	QM	QM
	E2 (2Pt)	QM	QM	ASIL A
	E3 (3Pt)	QM	ASIL A	ASIL B
	E4 (4Pt)	ASIL A	ASIL B	ASIL C
S3 (3Pt)	E1 (1Pt)	QM	QM	ASIL A
	E2 (2Pt)	QM	ASIL A	ASIL B
	E3 (3Pt)	ASIL A	ASIL B	ASIL C
	E4 (4Pt)	ASIL B	ASIL C	ASIL D

S0 or E0 or C0 ➔ always QM

Description of Severity

SO	S1	S2	S3
AIS 0 and less than 10% probability of AIS 1-6 Damage that cannot be classified safetyrelated	More than 10% probability of AIS 1-6 (and not S2 or S3)	More than 10% probability of AIS 3-6 (and not S3)	More than 10% probability of AIS 5-6
Bumps with roadside infrastructure Pushing over roadside post, fence, etc. Light collision Light grazing damage Damage entering/ exiting parking space Leaving the road without collision or rollover	Side impact with a narrow stationary object, e.g. crashing into a tree (impact to passenger cell) with very low speed Side collision with a passenger car (e.g. intrudes upon passenger compartment) with very low speed Rear/front collision with another passenger car with very low speed Collision with minimal vehicle overlap (10 % to 20 %) Front collision (e.g. rear-ending another vehicle, semi-truck, etc.) without passenger compartment deformation	Side impact with a narrow stationary object, e.g. crashing into a tree (impact to passenger cell) with low speed Side collision with a passenger car (e.g. intrudes upon passenger compartment) with low speed Rear/front collision with another passenger car with low speed Pedestrian/bicycle accident while turning (city intersection and streets)	Side impact with a narrow stationary object, e.g. crashing into a tree (impact to passenger cell) with medium speed Side collision with a passenger car (e.g. intrudes upon passenger compartment) with medium speed Rear/front collision with another passenger car with medium speed Pedestrian/bicycle accident (e.g. 2-lane road) Front collision (e.g. rear-ending another vehicle, semi-truck, etc.) with passenger compartment deformation

Source: ISO 26262-3:2011, Table B.1 — Examples of severity classification

Description of Controllability

CO	C1	C2	C3
Controllable in general	99% or more of all drivers or other traffic participants are usually able to avoid harm	90% or more of all drivers or other traffic participants are usually able to avoid harm	Less than 90% of all drivers or other traffic participants are usually able, or barely able, to avoid harm
Situations that are considered distracting Unexpected radio volume increase Warning message – gas low Unavailability of a driver assisting system	Faulty adjustment of seat position while driving Blocked steering column when starting the vehicle	Failure of ABS during emergency braking Headlights fail while night driving at medium/high speed on unlighted road Motor failure at high lateral acceleration (motorway exit)	Failure of ABS when braking on low friction road surface while executing a turn Failure of brakes Incorrect steering angle with high angular speed at medium or high vehicle speed (steering angle change not aligned to driver intent) Faulty driver airbag release when travelling at high speed

NOTE 1: For C2, a feasible test scenario in accordance with RESPONSE 3 (see Reference [3]) is accepted as adequate: “Practical testing experience revealed that a number of 20 valid data sets per scenario can supply a basic indication of validity”. If each of the 20 data sets complies with the pass-criteria for the test, a level of controllability of 85% (with a level of confidence of 95% which is generally accepted for human factors tests) can be proven. This is appropriate evidence of the rationale for a C2-estimate.

NOTE 2: For C1 a test to provide a rationale that 99% of the drivers “pass” the test in a certain traffic scenario might not be feasible because a huge number of test subjects would be necessary as the appropriate evidence for such a rationale.

NOTE 3: As no controllability is assumed for category C3, it is not relevant to have appropriate evidence of the rationale for such a classification.

Source: ISO 26262-3:2011, Table B.4 — Examples of possibly controllable hazardous events by the driver or by the persons potentially at risk

Description of Exposure (Duration)

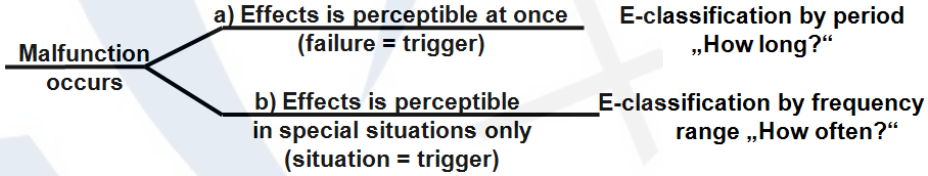
E1	E2	E3	E4
Not specified	<1% of average operating time	1% to 10% of average operating time	>10% of average operating time
Lost cargo or obstacle in lane of travel (highway) Vehicle during jump start In repair garage (on roller rig) Driving downhill with engine off (mountain pass)	Mountain pass with unsecured steep slope Country road intersection Highway entrance ramp Highway exit ramp Snow and ice on road Slippery leaves on road In car wash Nearing end of congestion Trailer attached Roof rack attached Vehicle being refuelled In repair garage (during diagnosis or repair) On hoist Driving in reverse (from parking spot) Driving in reverse (city street) Overtaking Parking (with sleeping person in vehicle) Parking (with trailer attached)	One-way street (city street) Wet road In tunnel Traffic congestion Vehicle on a hill (hill hold) Heavy traffic (stop and go) Unlighted roads at night	Highway Secondary road Country road Accelerating Decelerating Executing a turn (steering) Parking (parking lot) Lane change (city street) Stopping at traffic light (city street) Lane change (highway)

Source: ISO 26262-3:2011, Table B.2 — Classes of probability of exposure regarding duration in operational situations

Description of Exposure (Frequency)

E1	E2	E3	E4
Occurs less often than once a year for the great majority of drivers	Occurs a few times a year for the great majority of drivers	Occurs once a month or more often for an average driver	Occurs during almost every drive on average
Stopped, requiring engine restart (at railway crossing) Vehicle being towed Vehicle during jump start	Mountain pass with unsecured steep slope Snow and ice on road Trailer attached Roof rack attached Evasive manoeuvre, deviating from desired path	Wet road In tunnel In car wash Traffic congestion Vehicle being refuelled Vehicle on a hill (hill hold) Overtaking	Starting from standstill Shifting transmission gears Accelerating Braking Executing a turn (steering) Using indicators Manoeuvring vehicle into parking position Driving in reverse

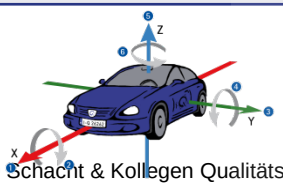
Source: ISO 26262-3:2011, Table B.3 — Classes of probability of exposure regarding frequency in operational situations



Speed-Definitions	Speed-Range
very low speed	maximum 15 km/h - Definition according to ISO 26262, part 10, page 11
low speed	16 km/h - 50 km/h [i-Q own definition, to fill up gap in standard]
medium speed	51 km/h - 90 km/h - Definition according to: ISO 26262, part 10, page 12
high speed	> 90 km/h [i-Q own definition, to complete standard]

Vehicle Situations – Examples for HARA

Common Situations	
Direction of Driving	turn
	straight ahead
	uphill
	downhill / pass
	standstill
	driving backwards
Acceleration	slightly accelerating
	strongly accelerating
	coasting with running engine
	coasting with engine OFF, ignition ON
	coasting with engine OFF, ignition OFF
	constant speed
Deceleration	partial braking
	full brake application
	automatic brake
	application of parking brake (emergency brake)
Traffic	platoon
	opposing traffic
	traffic jam
	urban traffic
Parking	Parking with strong tilt (transport on a ship, double carport, carpark, ...)
	Parking at a slope (downhill)
	Parking at a slope (uphill)
	getting into a parking lot



Common Situations	
Special Driving Situations	circular path
	steep turn
	bridge
	tunnel
	racing circuit
	crest [Berggipfel]
	wash tunnel, carwash
	lateral inclination
	jerky [ruckartig] steering (steering angle sensor step / staggered)
	elk test
	chassis dynamometer test bench
	automatic gearbox emergency program
	engine emergency program
	engine failure (coasting to standstill) ignition ON
	car / trailer combination
	driving with roof rack
	towing vehicle away, ignition and engine ON
	towing rope
	tow bar
	on a ferry / motor rail train
	on a rotary disc in car park
	common work in a garage
	diagnosis interface operation
	getting started with a battery jumper cable
	seasonal operation (e.g. for six month)
	u-turn using the hand brake

Common Situations	
Velocity	low velocity
	high velocity
	parking / switching
	highway
	country road
Environmental Conditions	
Temperature	heat
	coldness
	change of temperature
	room temperature
	heat emission
	Irradiation [Einstrahlung]
	refrigeration, cooling
Air	high mountains
	Dead See
Humi.	tropics
	desert
Dirtiness Condit.	desert sand
	dust
	salt spray
	agriculture
	droppings
Lane Characteristics	friction factor
	low µ
	high µ
	µ split
	chess board (alternating friction)
	rough / breakneck road
	Potholes [Schlaglöcher]
	bumpy road
	cobble stone pavement

Environmental Conditions	
Lane Characteristics	summit
	railroad crossing
	aquaplaning
	single damages
	off road
	mud
	wet grassland
	snow
	transversal slope
	interconnection
	passing a creek
	boulders, gravel, sand
	bedrock
	racing circuit
	take off due to curbs
Visibility & Weather Conditions	fog
	night
	day
	thunderbolt
	storm
	rain
	hail
	sun
	blinding
	ultraviolet radiation
	heating of passenger compartment
Crash Situation	rear collision
	frontal collision
	lateral collision
	rollover
	fire brigade at work

Driver`s Activities	
Pedal Activities	braking pedal slightly pressed
	braking pedal strongly pressed
	releasing brake pedal
	braking pedal not pressed
	braking pedal touched
	accelerator pedal slightly pressed
	accelerator pedal strongly pressed
	releasing accelerator pedal
	accelerator pedal not pressed
	accelerator pedal touched
	clutch pedal pressed completely
	clutch pedal slightly pressed
	clutch pedal slipped (no complete release)
	clutch pedal released
	clutch pedal not pressed
	clutch pedal touched
Hand	hand brake lever operated
	EPB control element operated
Miscellaneous Situations & Criteria	playing children in passenger compartment
	children seat on front passenger seat
	animals in passenger compartment
	driver enters vehicle without opening the door (convertible)
	driver leaves vehicle without opening the door (convertible)
	humidity in passenger compartment