SAFEXPLAIN

Safe and Explainable
Critical Embedded Systems based on AI

Ph01T0002 DL Operational Scenarios

Version **1.0**

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1 Review / Modification History

Version	Date	Description Change
V1.0	01/12/2023	First version after complete internal review
V0.2	25/10/2023	Modifications and improvements based on internal review
V0.1	05/10/2023	First draft

*Note: The paragraphs/name of the project/Rev./Ref./history table in **blue** must be replaced with the information for the specific project. The paragraphs written in **red** are instructions that can be used as a guide, so they must be deleted.*

2 Objective

The purpose of this document is to specify operations, scenarios, and environmental conditions for the system, in which the system has to function according to the specification. This specification must be under the Operational Design Domain (ODD). These operational scenarios include standard situations, but also challenging environments and cornerstone situations.

3 Scope

This document focuses on defining the operational scenarios in which the Deep Learning (DL) constituent will operate.

4 Description of the Operational Scenarios

This document defines the operational scenarios, understanding the operational scenario as follows: *"An operational scenario is described in part by a set of ODD characteristics that describe the environment in which the feature is designed to perform"* [1]. The following tables gather all the information to specify the operational scenarios categorized into:

- Operational Scenario Title: Title that summarizes the operational activities in the context of an operational capability.
- Scenario Description: a description of the behaviour of entities or possible actions or events that constitute the scenario, and any additional information.
- Scenario Conditions: Specifies the condition under which the feature is going to operate with respect to roadway types, speed range, lighting conditions, weather conditions, and other operational constraints.

This document proposes to generate the table represented below with the corresponding information of the operational scenario within the ODD defined. There is a table template to describe the scenario and conditions.

Table 1: Operational Scenario Specification

Operational Scenario title	
Scenario Description	
Scenario Conditions:	
Scenery	
Environmental Conditions	
Dynamic Elements	

NOTE: For the definition of the scenery, environmental conditions, and dynamic elements, this document refers the reader to the template *Ph1T0001_DL_Operational_Design_Domain_template.docx*.

In the Annex A: Operational Scenarios Examples of this document, it is provided an example of how to fill this template in a railway domain application.

5 Acronyms and Abbreviations

Below is a list of acronyms and abbreviations employed in this document:

- AI-FSM – Artificial Intelligence -Functional Safety Management
- DL – Deep Learning
- ODD – Operational Design Domain

6 Bibliography

[1] E. Thorn, S. C. Kimmel y M. Chaka, «A Framework for Automated Driving System Testable Cases and Scenarios».

Annex A: Operational Scenarios Examples

The current version of this document provides an example in the railway domain, while future versions will include examples in the automotive and aerospace domains.

A1: Railway domain

The following tables define a couple of operational scenarios for a railway use case, considering the ODD outlined in Annex A of the *Ph1T0001_DL_Operational_Design_Domain_Template.docx* template.

Operational Scenario 1	
With the conditions specified, the following operational scenario is described: A stopped object is parked, which is situated on the side of the track. The train is moving at a 50 km/h speed and accelerating 1m/s^2. The detected object must be analyzed if it is placed on the tracks or not, if it is a critical object or not, and the estimated distance where the object is located from the train. Depending on the results of these questions, the actions taken by the train will be different.	
Scenario Conditions:	
Scenery	
Maximum Speed Limit	90 km/h
Countryside	Yes
Multiple tracks	Yes
Distance threshold (warning)	[1001,1500] m
Distance threshold (warning & reduce)	[701, 1000] m
Distance threshold (breaking activation)	700 m
Environmental Conditions	
Sunny day	Yes
Daylight	[1200,15000] lm
Dynamic elements	
Vehicle	Car stopped

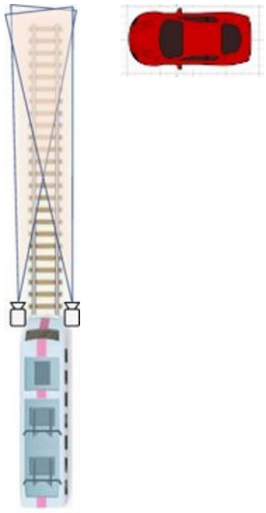

Figure 8: Train accelerating while a car is near the train tracks.

Operational Scenario 2	
With the conditions specified, the following operational scenario is described: A stopped car is situated on the side of the track. Another object is also positioned on the tracks in front of the train, a pedestrian. Train is moving at constant 30 km/h speed. If the detected objects are not positioned on the tracks, won't activate any warning or braking while they are on one side. If the objects are positioned on the tracks, it will be analyzed if they are classified as critical or not. In case they are critical and are detected in the warning zone distance, that is to say, the distance the pedestrian is positioned is less than the warning distance threshold, a warning to the DMI will be displayed (in our case, an activation of an output signal). If the distance is higher, no action will be taken. If the estimated distance is between warning and breaking thresholds, the corresponding digital output signals will be activated. In case the estimated distance is less than the breaking threshold, the corresponding digital output will be activated.	
Scenario Conditions:	
Scenery	
Maximum Speed Limit	60 km/h
Countryside	Yes
Multiple tracks	Yes
Distance threshold (warning)	[1001,1500] m
Distance threshold (warning & reduce)	[701, 1000] m
Distance threshold (breaking activation)	700 m
Environmental Conditions	
Cloudy day	Yes
Daylight	[400,1400] lm
Dynamic elements	
Person	Pedestrian at 5 km/h
Vehicle	Car at 60 km/h

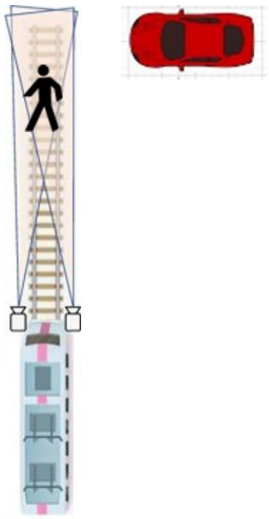

Figure 9: Train with constant speed while a pedestrian on the train tracks

A2: Automotive domain

The following tables define a couple of operational scenarios for an Automotive use case, considering the ODD outlined in Annex A of the *Ph1T0001_DL_Operational_Design_Domain_Template.docx* template.

Operational Scenario 1	
The Ego-vehicle drives at a constant speed towards a target vehicle coming from the opposite direction. When the distance with the target vehicle (from opposite direction) decreases but the driver is not in dangerous zone (no possible collision) the intended functionality shall neither warn the driver nor decelerate the vehicle.	
Scenario Conditions:	
Scenery	
Minimum Speed Limit – Ego vehicle	50 km/h
Maximum Speed Limit – Ego vehicle	130 km/h
Minimum Speed Limit – Target vehicle	10 km/h
Maximum Speed Limit – Target vehicle	30 km/h
Country road	Yes
Multiple tracks	Yes
Distance threshold (warning)	TTC == 3 s
Distance threshold (breaking activation)	TTC == 2 s
Lateral offset	Yes, greater than 1.5 m
Drivable area surface	
Uniform (asphalt)	Yes
Environmental Conditions	
Sunny	Yes
Daylight	[1200,15000] lm
Dynamic elements	
Vehicle	target vehicle from opposite direction, and ego vehicle.