BERTHA

Deliverable 4.2: Runnable scenario scripts for simulation

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IMPORTANT

This document serves as a template for deliverables and follows a proposal structure. The mandatory sections include: Executive Summary, Introduction and Objectives, and Conclusions. The remaining sections are customizable.

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EXECUTIVE SUMMARY

BERTHA's details

Project name	BEhavioural ReplicaTion of Human drivers for CCAM
Project acronym	BERTHA
Grant Agreement number	101076360
Duration and dates	36 months (1 November 2023 – 31 October 2026)
Call and topic	HORIZON-CL5-2022-D6-01-03: Safe, Resilient Transport and Smart Mobility services for passengers and goods
Granting authority	European Climate, Infrastructure and Environment Executive Agency (CINEA), under the powers delegated by the European Commission
Official project website	berthaproject.eu

The BERTHA consortium

N°	NAME	ROLE	COUNTRY
1	INSTITUTO DE BIOMECANICA DE VALENCIA (IBV)	Coordinator	Spain
2	INSTITUT VEDECOM (VED)	Beneficiary	France
3	UNIVERSITE GUSTAVE EIFFEL (UGE)	Beneficiary	France
4	DEUTSCHES FORSCHUNGSZENTRUM FUR KUNSTLICHE INTELLIGENZ GMBH (DFKI)	Beneficiary	Germany
5	CENTRE DE VISIO PER COMPUTADOR (CVC-CERCA)	Beneficiary	Spain
6	CAPGEMINI ENGINEERING DEUTSCHLAND SAS & CO KG	Beneficiary	Germany
6.1	VORTEX - ASSOCIACAO PARA O LABORATORIO COLABORATIVO EM SISTEMAS CIBER-FISICOS E CIBERSEGURANCA (VOR)	Affiliated entity	Portugal
7	CONTINENTAL AUTOMOTIVE FRANCE SAS (CON)	Beneficiary	France
8	FUNDACION CIDAUT (CIDAUT)	Beneficiary	Spain
9	AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH (AIT)	Beneficiary	Austria
10	UNIVERSITAT DE VALENCIA (UVEG)	Beneficiary	Spain
11	EUROPCAR INTERNATIONAL	Beneficiary	France
12	F. INICIATIVAS, CONSULTADORIA E GESTAO, UNIPESSOAL, LDA (FI)	Beneficiary	Portugal
12.1	F. INICIATIVAS ESPANA I MAS D MAS I SLU (FI_ES)	Affiliated entity	Spain
15	SMART EYE AKTIEBOLAG	Beneficiary	Sweden

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Project's summary

The main objective of BERTHA is to develop a scalable and probabilistic Driver Behavioural Model based mostly on Bayesian Belief Networks (BBN). The DBM will be implemented on an open-source HUB (repository) to validate the technological and practical feasibility of the solution with industry, and provide a distinctive approach for the model worldwide scalability. The resulting DBM will be translated into a simulating platform, CARLA, using various demonstrations which will allow the construction of new driving models in the platform.

BERTHA will also include a methodology which, using the HUB, will allow to share the model with the scientific community, in order to facilitate its growth.

The project includes a set of interrelated demonstrators to show that the DBM can be used as a reference to design human-like, easily predictable and acceptable behaviours of automated driving functions in mixed traffic scenarios.

BERTHA is expected to go from TRL 2 to TRL 4. The requested EU contribution is €7,981,801. The consortium, formed by several entities from different countries, deems this Project as vitally relevant to the CCAM industry due to its impact for safer and more human-like CAVs and its market and societal adoption.

Document details

Deliverable type	Code (SCENIC scripts) & descriptive report.
Deliverable n°	D4.2
Deliverable title	Runnable scenario scripts for simulation
Lead beneficiary	CVC-CERCA
Work package and task	WP4 – T4.2
Document version	1.1
Contractual delivery date	April 2025
Actual delivery date	May 2nd , 2025
Dissemination Level	Public
Purpose	SCENIC scripts (.scene) instantiating different executions (scenarios) of the UCs of BERTHA project (D1.1) in CARLA simulator.

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Document's abstract

WP4 involves training AIs to learn from or cooperate with a DBM in the context of autonomous driving and driving assistance. This allows us to evaluate the DBM's utility. The corresponding experimentation will be conducted in the open-source CARLA simulator. Regardless of the driving experiences considered in WP4 (including random driving), it is necessary to cover the use cases (UCs) defined in WP1. These consist of five UCs, with one more added from WP4. These UCs have been codified as six "*.scenic*" scripts using the SCENIC language.

For this deliverable, these "*.scenic*" files have been orchestrated to generate 1,000 executable "*.scene*" files, which, in WP4 terminology, are the pursued scenarios. Each scenario differs from the others in the parameter values, which involve location, weather, spawning points for traffic participants, speed of participant vehicles, distance between participant vehicles, etc. To determine these parameters and their range of feasible values, BERTHA's deliverables D1.1 and D1.2 have been considered. Moreover, the scenario generation accounts for a common development-validation split.

Document's revision history

The following table describes the main changes done in the document since it was created.

REVISION	DATE	DESCRIPTION	AUTHOR (PARTNER)
V1.0	April 30, 2025	1st complete version	Antonio M. López, Alex F. Levy, Rubén Abad
V1.1	May 2nd, 2025	Modified links to download scripts and videos Final version after revision	Andrés Soler, Helios de Rosario (IBV)

Terminology and acronyms

TERM/ACRONYM	EXPLANATION
DBM	Driver Behavioral Model

Disclaimer

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1. INTRODUCTION AND OBJECTIVES

This deliverable (D4.2) is a direct result of task T4.2 of WP4.

Within the context of WP4, proof-of-concept demonstrations are developed to showcase the potential uses of DBMs. These demonstrations are organized as tasks. Except for task T4.8, all other demonstrations are carried out using the CARLA simulator [1].

Essentially, in a demonstration, a system is subjected to a driving experience. This system can range from an AI for autonomous driving to an AI that supports human driving. The idea is to see how DBMs can help the system achieve better results in some aspects of interest.

In any case, this leads us to the need to design and implement the aforementioned driving experiences in the CARLA simulator. For this, there are two fundamental aspects:

- Maintain close collaboration with WP1, responsible for DBM development, with the aim of establishing relevant driving experiences.
- Determine the best way to implement these driving experiences in the CARLA simulator.

More specifically, each driving experience can be divided into two logical components: one static, the other dynamic. The static component defines a traffic event; for example, a simple case would be stating that “a vehicle has to make a left turn at a traffic-light-controlled intersection.” The dynamic component is established by the details; in the previous example, this would involve setting the speed at which the vehicle approaches the traffic light, the type of vehicle, the sensors on board, the state of the traffic light, etc. In the context of WP4, we term ***scene*** to an example of the static component, while we term ***scenario*** to an example of the dynamic component. In short, the scenarios can be seen as instances of the scenes.

Deliverable D4.2 focuses on scenarios, and it is complemented by deliverable D4.1 that focuses on scenes. These deliverables actually consist of executable code, but we complement the code with documents providing the necessary context for a good understanding. Accordingly, **this document focuses on scenarios**. It is recommended to read the document associated with D4.1 first [4].

2. METHODS

In document D4.1 we have already stated that we have used SCENIC [5] to codify driving experiences in CARLA simulator [1]. In particular, we cover the UCs defined in D1.1 [2] (WP1) and an additional one, these are:

- *UC1: “Collision risk avoidance”* on highway. File: *uc1_collision_risk_avoidance.scenic*
- *UC2: “Insertion on highway”*. File: *uc2_insertion_on_highway.scenic*
- *UC2b: “Insertion on new highway lane due to current lane termination”*. File: *uc2b_insertion_on_new_highway_lane.scenic*
- *UC3: “Pedestrian crossing”* in urban area. File: *uc3_pedestrian_crossing.scenic*
- *UC4: “Left turn at urban intersection”* with traffic lights. File: *uc4_left_turn_at_urban_intersection.scenic*
- *UC5: “Pull back in”* on urban highway. File: *uc5_pull_back_in.scenic*

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Each UC has associated parameters, each parameter with potential values on a range. By instantiating such parameters, we obtain a particular scenario in the WP4 terminology. Accordingly, we have proceeded as follows for each UC:

1. Identify the plausible range of values for each parameter.
2. Set specific values to have a deterministic split in terms of development and validation phases (please, refer to D4.1 [4] for the introduction of these concepts).

2.1. Parameters defining each UC and their range of values

In addition to consider BERTHA's deliverable D1.1 [2], where the UCs are introduced, to define a plausible range of values for the parameters of interest we have relied on deliverable D1.2 [3], where UCs are described with an additional level of detail with the purpose of collecting driver surveys to categorize them. We have also relied on the CVC-CERCA experiences in the field of autonomous driving.

For UC1, we relied on D1.2 – page 23. As a result, we have established the parameters and range of values shown in Figure 2.1.1. Analogously, for UC2, we relied on D1.2 – page 24, giving rise to the parameters and ranges shown in Figure 2.1.2. Inspired by UC2, we worked on UC2b, obtaining the setting shown in Figure 2.1.3. For UC3, UC4, and UC5 we relied on D1.2, pages 24, 25, and 26, respectively; establishing the parameters and their ranges shown in Figures 2.1.4, 2.1.5, and 2.1.6, respectively.

Figure 2.1.1. Parameters to instantiate UC1 and their range of values.

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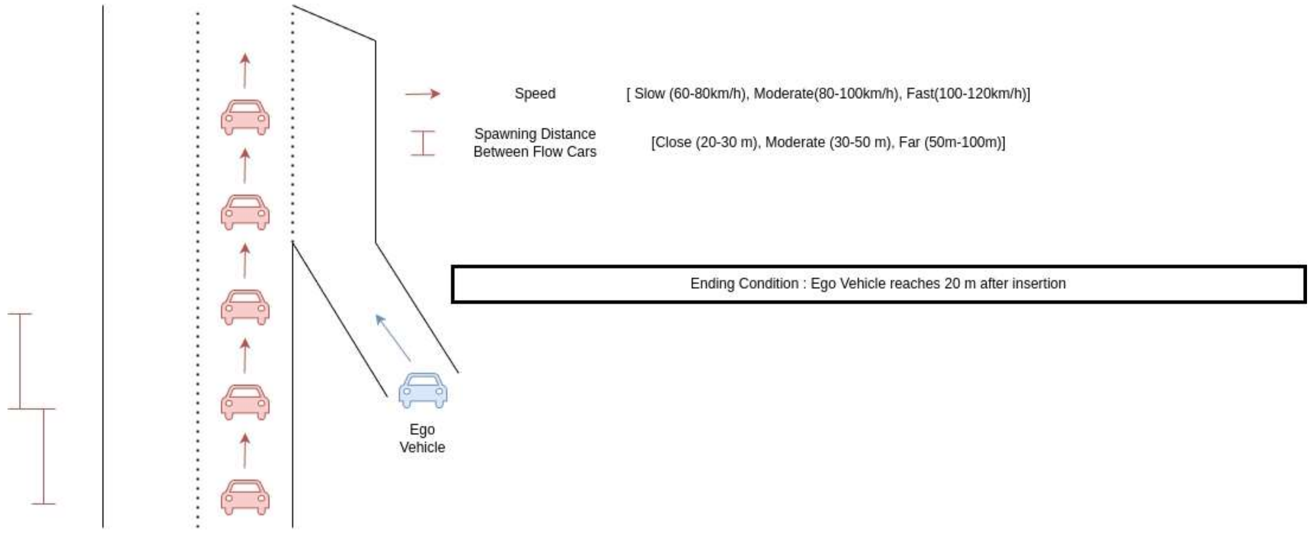

Figure 2.1.2. Parameters to instantiate UC2 and their range of values.

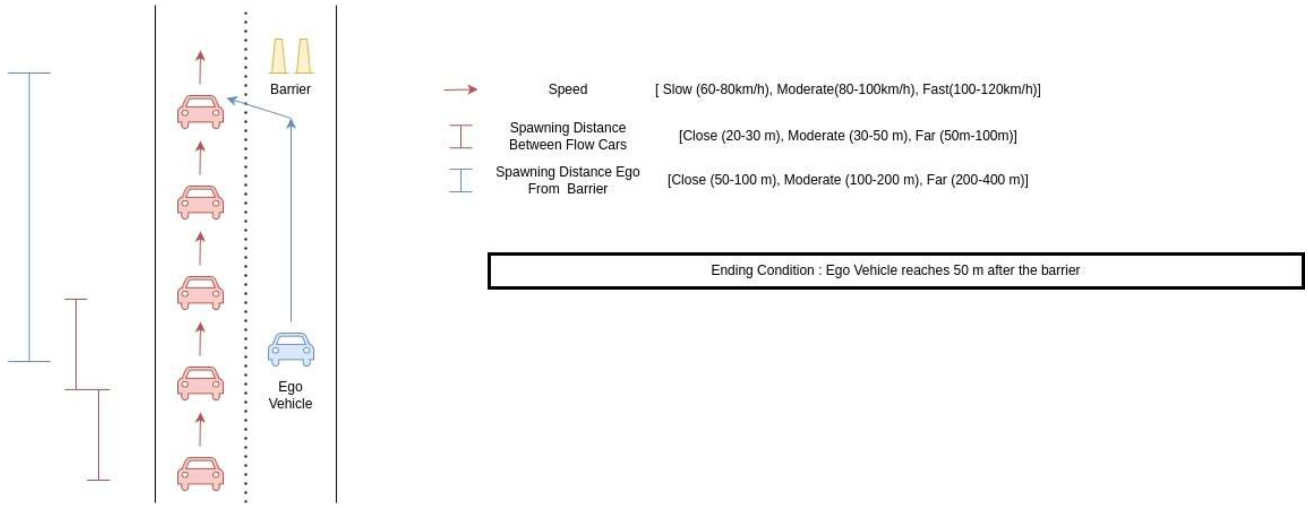

Figure 2.1.3. Parameters to instantiate UC2b and their range of values.

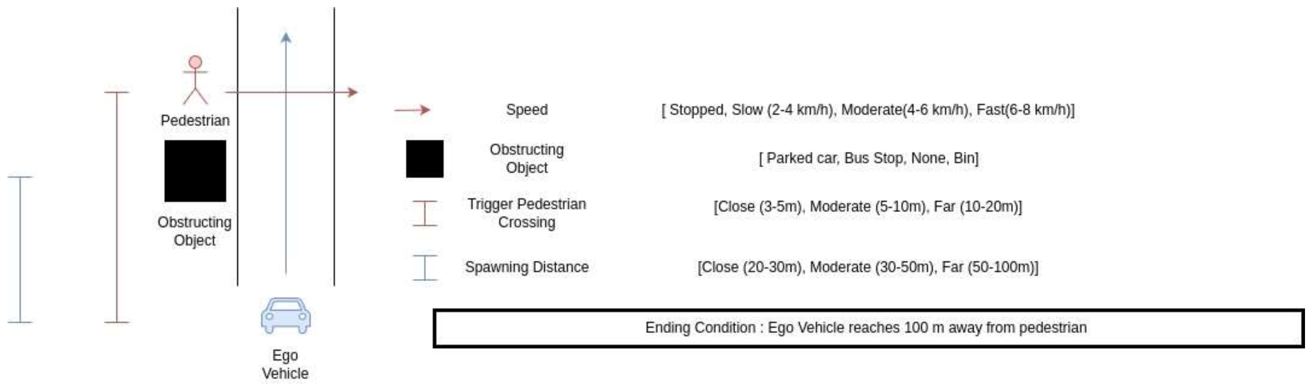

Figure 2.1.4. Parameters to instantiate UC3 and their range of values.

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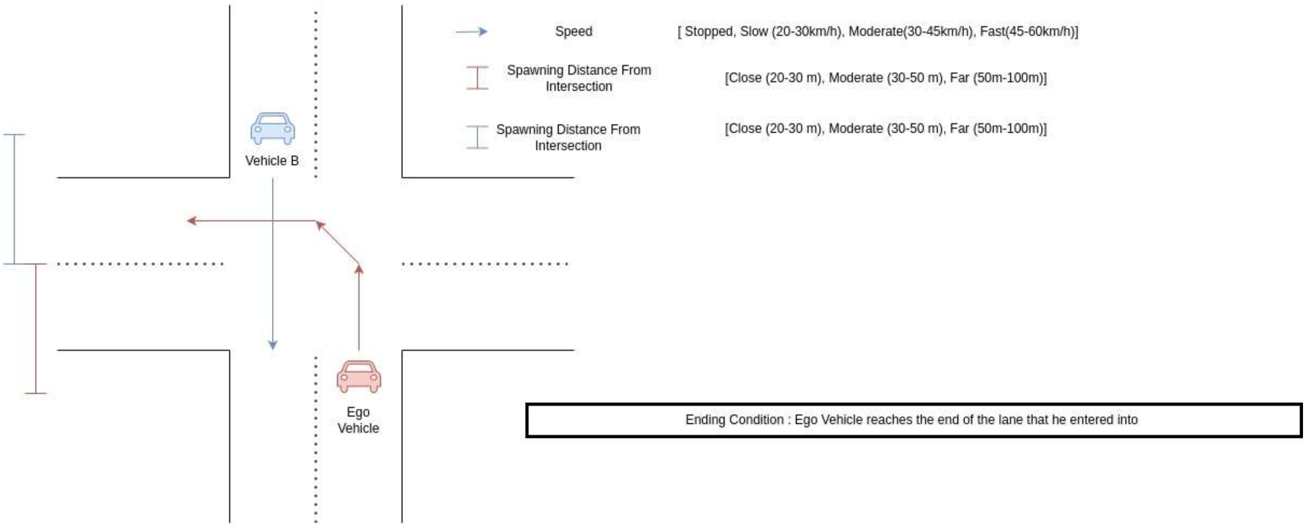

Figure 2.1.5. Parameters to instantiate UC4 and their range of values.

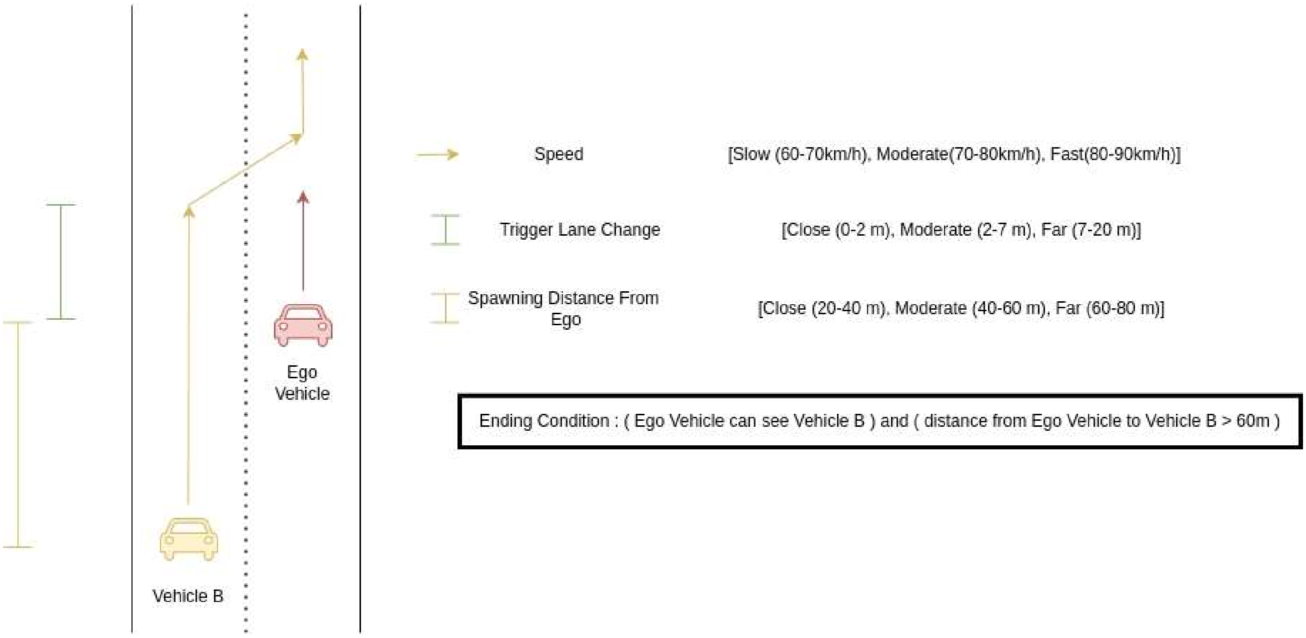

Figure 2.1.6. Parameters to instantiate UC5 and their range of values.

2.2. Development – Validation Split

Technically speaking, at execution time we can set each UC parameter with a random value from its range. By doing so for all the parameters of the UC, we obtain a specific instance of the UC, i.e., a scenario in WP4 terminology. In SCENIC terms, we are generating multiples "*.scene*" files from a single "*.scenic*", which can be done via an orchestrator Python script. Note that the "*.scene*" files are those executed to produce the desired driving experiences in CARLA simulator.

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Hence, if we need to use different scenarios to develop and validate an AI, we can do it, for instance, by using different development and validation random seeds to set parameter values. However, it is common practice to have a fixed split in terms of development and validation scenarios. In this way we can assess AI development progress with less computation, since changing random seeds would lead to K-fold validation procedures. Note that when developing some AI modes (as those for autonomous driving), the number of hours employed to collect data, train the models, and validate them, can become prohibitive unless considerable computational resources are available. This is why, in the context of WP4, we propose a particular development – validation split. However, this is not incompatible with generating more scenarios if the task at hand requires it during the rest of the BERTHA project.

3. RESULTS

3.1. Generated scenarios: development-validation split

Table 1 summarizes the number of scenarios that we have generated for the development-validation split. Note that there is a total of 1,000 ".*scene*" files, 508 for development and 492 for validation. These variations include selecting four out of nine weathers for development, and four out of seven for validation.

Table 1. In what town (Tnn) run the scenarios corresponding to the UCs, and how many are considered. Yellow means that the scenarios are planned to be used for validation purposes, blue for development purposes, green for both, and white means no used. Total number of ".scene" files: 508 + 492.

	T03	T04	T05	T06	T10	T15	Total Develop.	Total Validation
UC1		52	48 / 48	52			100	100
UC2		36 / 36					36	36
UC2b		64		64			64	64
UC3						100 / 100	100	100
UC4		100 / 100					100	100
UC5	36	32	40	40 / 32	20		108	92
						TOTAL	508	492

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3.2. Generated scenarios: organization and distribution

The “*.scene*” and “*.scenic*” files are organized under the same directory structure, where a README.md explains the relevant installation and usage details. Figures 3.2.1 and 3.2.2 depict snapshots of this structure.

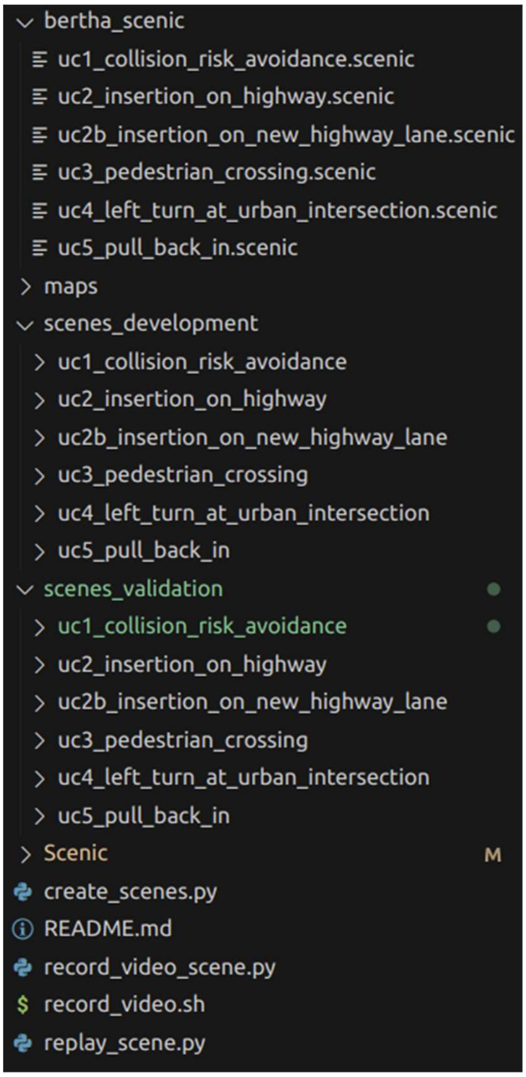

Figure 3.2.1. Structure of the directory containing the “.scenic” and “.scene” files. We can see how the executable scenarios (“.scene” files) are split into development and validation. Inside each “uc” directory, the scenarios are also distributed in different subdirectories corresponding to CARLA’s towns (see Figure 3.2.2). A README.md explains the relevant installation and usage details.

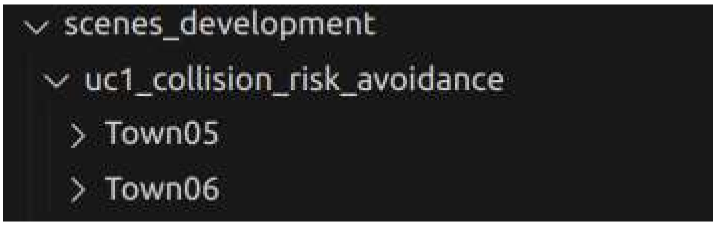

Figure 3.2.2. The scenarios are also separated per town.

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We can find this content in THIS LINK. This can be considered the core content of both D4.1 and D4.2. In any case, as the BERTHA tasks in WP4 evolve, now it will be relatively easy to modify this content to accommodate to arising needs.

In order to check visually how the scenarios translate into CARLA's driving experiences, we have generated a video for each of them from a camera following the ego-vehicle. However, to keep a low hard disk consumption, we have applied video compression. Note that these videos will be only used for visual checks, they are not going to be processed by any automatic procedure. Please, note also that at the moment, the vehicle behaviours are just "placeholders" based on a rule-based approach, since at this point of BERTHA project DBMs have not been released to control these vehicles. **The videos can be found in THIS LINK.** As a quick visual feedback, Figure 3.2.3 shows some frames corresponding to the *"instance_town_Town06_adv_speed_1_adv_switching_1_adv_spawning_0_weather_WetCloudyNoon.scene"* scenario based on *"uc5_pull_back.scenic"*.

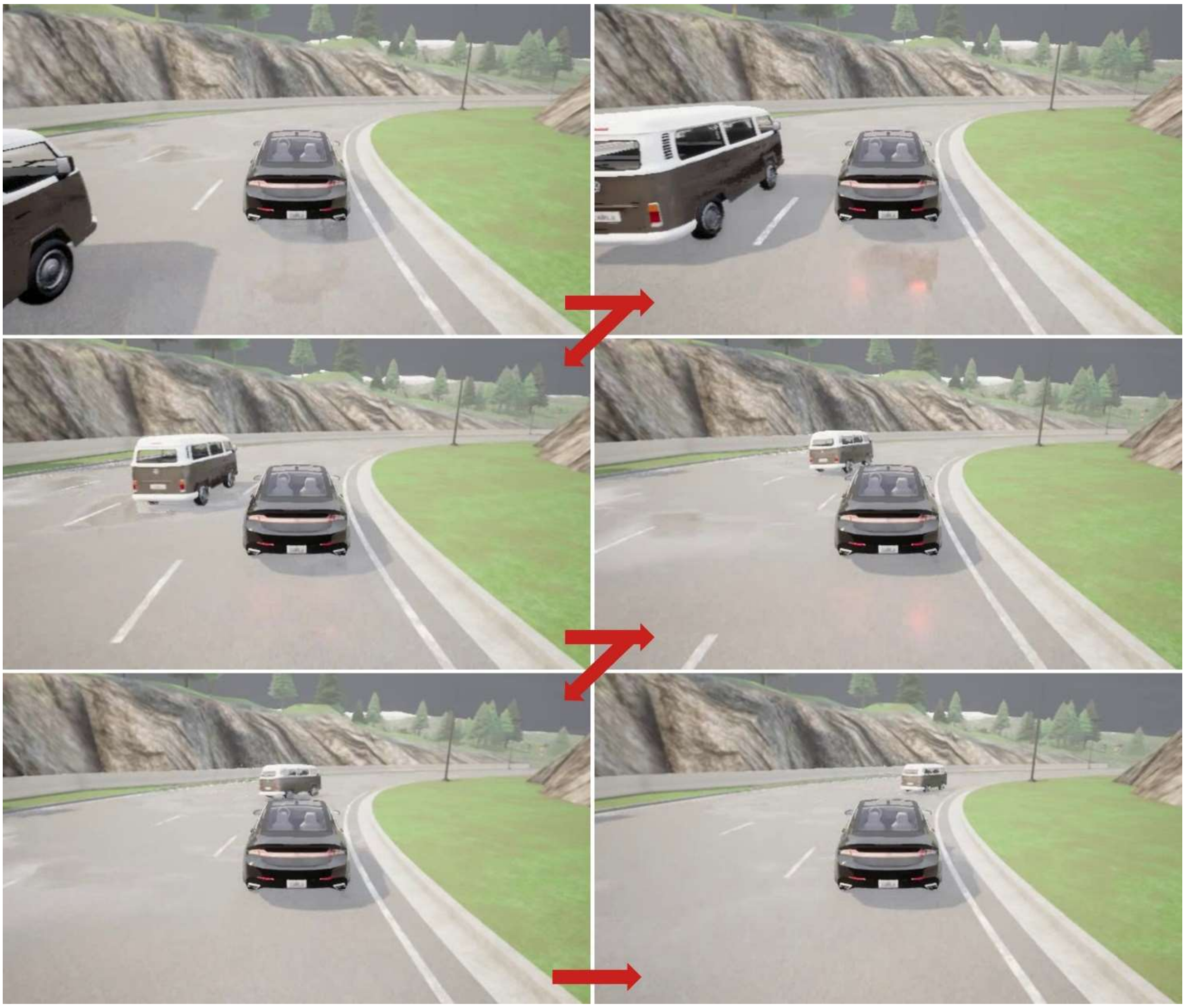

Figure 3.2.3. Shots from an scenario generated for the UC5 ("pull back in" on highway). See the conceptual scheme in Figure 2.1.6.

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4. CONCLUSIONS

In order to generate different scenarios for BERTHA's UCs [2], UC descriptions in [3] have been considered. Accordingly, for each UC, relevant parameters have been defined together with their feasible range of values. Scenario stopping conditions have been set too. Using SCENIC [5], this content has been stablished in the six "*.scenic*" files covering the UCs. Then, for all "*.scenic*" files an orchestrator script has generated 1000 scenarios, i.e., "*.scene*" files in the SCENIC terminology. Each scenario differs from the others in the parameter values, which involve location, weather, spawning points for traffic participants, speed of participant vehicles, distance between participant vehicles, etc. Moreover, the scenario generation accounts for a common development-validation split.

In conclusion, in WP4 terminology, the devised scenarios have been successfully generated.

5. REFERENCES

[1] CARLA. https://carla.org

[2] BERTHA project: "*Deliverable 1.1. Use cases for the identification of the model*".

[3] BERTHA project: "*Deliverable 1.2. Stratification of population according to driving styles*".

[4] BERTHA project: "*Deliverable 4.1. Drivable scenes for simulation*"

[5] SCENIC. https://github.com/BerkeleyLearnVerify/Scenic

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