

# Comparative evaluation of terrain-generation tools for rail and road traffic simulation: Hermes, Carmen and Presagis Creator

## Analiza porównawcza narzędzi do generowania terenu na potrzeby symulacji ruchu kolejowego i drogowego: Hermes, Carmen i Presagis Creator

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This paper presents a comparative analysis of three terrain-generation tools used in simulation environments: Hermes, Carmen and Presagis Creator. The evaluation covers tasks from both railway and road simulator workflows and applies a unified assessment framework combining automation, precision, AI/GPS support, time efficiency, error reduction, and data integration. Scoring is based on a weighted model derived from industry standards and detailed performance measurements taken from real modelling steps. The results show that Hermes clearly outperforms the legacy tools in majority of criteria. Its high level of automation, multi-source data integration, and GPS/AI-assisted processing significantly reduce manual workload and improve geometric accuracy. Hermes also shortens project execution times, reduces critical errors, and delivers more repeatable outputs. Presagis Creator and Carmen remain limited by manual procedures, narrower format support, and lower precision. Overall, the study confirms Hermes as a more advanced and effective solution for large-scale, high-fidelity terrain and infrastructure generation in modern simulation pipelines.

**KEYWORDS:** terrain generation, virtual infrastructure, simulation tools, automation in virtual environment modeling, railway simulation

Niniejsza praca przedstawia analizę porównawczą trzech narzędzi do generowania terenu stosowanych w środowiskach symulacyjnych: Hermes i Presagis Creator. Ocena obejmuje zadania z symulatorów kolejowych i drogowych oraz wykorzystuje zunifikowany model obejmujący automatyzację, precyzję odwzorowania, wsparcie AI/GPS, efektywność czasową, redukcję błędów i integrację danych. Punktacja oparta jest na modelu wagowym zgodnym ze standardami branżowymi oraz pomiarach wykonanych podczas rzeczywistych etapów modelowania. Wyniki wskazują, że Hermes wyraźnie przewyższa narzędzia tradycyjne dla większości kryteriów. Wysoka automatyzacja, integracja danych z wielu źródeł oraz moduły GPS/AI znacząco zmniejszają zakres pracy manualnej i poprawiają dokładność geometryczną. Hermes skraca również czas realizacji, redukuje błędy krytyczne i zapewnia większą powtarzalność wyników. Presagis Creator i Carmen pozostają ograniczone przez manualne procedury, mniejsze wsparcie formatów oraz niższą precyzję. Analiza porównawcza potwierdza, że Hermes stanowi bardziej zaawansowane i efektywne rozwiązanie do generowania terenu i infrastruktury na potrzeby współczesnych środowisk symulacyjnych.

**SŁOWA KLUCZOWE:** generowanie terenu, wirtualna infrastruktura, narzędzia symulacyjne, automatyzacja modelowania środowisk wirtualnych, symulator kolejowy

### Introduction

Realistic 3D virtual environments are critical for modern transportation and autonomous-system simulators, as they enable safe, cost-effective training and experimentation under diverse scenarios. Vehicle and train operators can rehearse emergency or unusual situations in the simulator that would be dangerous or impractical on real roads, while researchers can test new designs and controls without real-world risks [1], [2]. In rail and bus training, high immersion requires accurate replication of large world fragments (e.g. entire routes or city districts). For example, future train drivers must learn the exact track geometry before operating real trains. However, creating extensive, high-detail 3D terrain and infrastructure models is complex and time-consuming. Although public sources like OpenStreetMap and GIS portals can provide base data, straightforward auto-generation from these sources often yields generic, simplified scenery unsuitable for high-fidelity simulators. Several tools exist for building virtual road and rail networks, but most require significant manual effort. Commercial platforms such as Presagis Creator provide powerful, polygon-based authoring for optimized 3D terrain and models, supporting applications from flight and ground vehicle simulation to architectural visualization. Creator is widely used in defense and transportation industries for generating real-time environments [3]. However, tools like Creator still rely on user-driven workflows and offer only partial automation of the data-import process. Similarly, road network tools (including editors in simulation suites like SUMO or proprietary systems) can import GIS sources but often need manual alignment and refinement. As noted in recent studies, many “automatic” 3D-generation solutions built on external data (e.g. OSM) cannot directly serve simulator requirements without further processing. In short, there is a clear need for better integration of heterogeneous geospatial data and streamlined pipelines to accelerate virtual terrain generation and infrastructure modeling. Recent research has begun to address this gap. For example, in [4] AI-driven method is proposed to automatically detect, classify and place railway-infrastructure elements (signals, trackside objects) from video and GPS data into a 3D simulation world, demonstrating one way to automate virtual railway construction. In paper [5], the

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authors evaluate traffic simulation engines such as SUMO combined with OpenStreetMap in the context of high-immersion requirements. These studies underscore the importance of automated virtual infrastructure generation for railway simulation and road traffic simulation. Building on this trend, a novel, automated terrain-generation system was recently introduced called Hermes [6]. Hermes integrates multiple data sources (national geoportals, OpenStreetMap, etc.) and processes them into intermediate “tiles” that are merged into a coherent terrain model. The Hermes workflow explicitly automates steps such as obtaining digital elevation models, 2D city maps, and imagery, generating 3D building and terrain models, and synthesizing them into a unified 3D environment. In fact, Hermes is described as a route-editor within a larger system whose goal is to generate a complete 3D virtual world for simulation. This end-to-end automation distinguishes Hermes from traditional editors by reducing manual modeling time and improving data consistency.

Despite advances in automated terrain modeling, a systematic comparison of leading tools under unified criteria remains missing. This paper fills that gap through a comparative evaluation of three terrain-generation systems – Hermes, Carmen and Presagis Creator. The analysis is focusing on data integration, automation, processing time, and output quality. The tools are assessed in a real-world context involving the Szczecin–Świnoujście rail corridor and the Łasztownia road area. The results offer insights into tradeoffs between automation and user control, and provide practical guidance for selecting simulation-asset generation tools in transport applications.

### Terrain generation tools

This chapter provides descriptions of the three tools selected for evaluation: Presagis Creator as a representative commercial modeling environment, Carmen as a classical tool for virtual railway database generation and Hermes as a modern, automation-focused approach.

#### *Presagis Creator*

Presagis Creator is widely used to build high-detail terrain NASA’s ACELeRATE project uses Presagis Creator Pro to import high-resolution and models for simulation. For instance, terrain insets into its visual database [7]. The authors report that these insets – often “hundreds of thousands or even millions of polygons with higher-resolution texture” – are created in Creator to “realistically simulate the outside world”. Similarly, in a USAF/NASA flight-vision simulator, teams extracted elevation data from Google Earth and automatically converted it to OpenFlight format using Presagis Creator Pro [8]. These published examples show Presagis Creator employed as a 3D modeling tool for generating custom, geo-specific databases in transportation/defense simulators.

#### *Carmen*

CARMEN (Computer Aided Railway Modelling ENvironment) is a route editor designed for creating and modifying databases for railway simulators. The tool supports a logical database in which track layouts, the location and type of signals, switches, magnets, and their relationships are defined, as well as a visual database based on OpenFlight files that are subsequently processed into the format of the visual system. Key functionalities include graphical design of track layouts, configuration of railway signaling and control systems, linking the logical and visual layers, and preparing complete input data for training and simulation systems.

#### *Hermes*

The Hermes editor, as described in [6], is a dedicated system for automated generation of spatial terrain models that integrates heterogeneous geospatial inputs, including digital elevation models, cartographic datasets, and imagery, into a unified processing workflow. Its architecture is based on the creation of intermediate terrain “tiles,” which are systematically processed and subsequently merged to form a coherent three-dimensional representation of the modeled area. By automating key stages of terrain construction, Hermes reduces manual workload and limits the potential for user-introduced inconsistencies, thereby improving reproducibility and data integrity. The authors emphasize that this workflow enables efficient generation of extensive virtual environments suitable for simulation tasks. As a result, Hermes offers a scalable, data-driven, and workflow-oriented approach that contrasts with traditional, predominantly manual terrain-modeling methods.

### Comparison methodology

This chapter outlines the methodology used to evaluate the three terrain-generation tools: Hermes Carmen and Presagis Creator. The assessment integrates modelling tasks from both railway and road-simulation workflows and converts them into category-level performance scores. Hermes is compared with CARMEN in terrain-modeling tasks for railway simulators and with Presagis in terrain-modeling tasks for road-vehicle simulators. The methodology consists of two main components:

- (1) definition of evaluation categories and their associated tasks,
- (2) a weighted assessment model used to compute the final scores reported in the Results chapter.

#### *Evaluation criteria*

The evaluation framework is based on six criteria capturing the essential dimensions of terrain and infrastructure generation. Each criteria covers groups of modelling tasks representing real operations performed during project preparation, geometric

construction, attribute assignment and data integration. To make the weighting structure easier to reference, the evaluation criteria are represented using symbols A–F:

- A. Automation includes all tasks involving automatic acquisition and preparation of input datasets such as OSM, NMT, GPS/RTK or 3D libraries, as well as steps where the tool reduces user interaction during early project stages.
- B. Precision covers tasks related to geometric and spatial accuracy, including visual documentation, RMS positional correctness, shaping of track and road geometry, topological consistency of alignments and correct terrain representation relative to source elevation models.
- C. AI/GPS applies to tasks where the tool supports automatic detection, classification or correction using AI and GPS. These tasks influence the accuracy of object placement and the reliability of the generated geometry.
- D. Time reduction reflects all tasks where execution time is measurable and where workflow automation directly shortens project duration relative to historical or manual baselines.
- E. Error reduction involves tasks in which the stability of a tool can be assessed—particularly the repeatability of results, sensitivity to user mistakes, and occurrence of critical modelling errors.
- F. Data integration corresponds to tasks that require merging heterogeneous inputs, handling multiple formats, ensuring interoperability and correctly integrating terrain with vector, sensor and 3D data.

Together, these criteria ensure that the evaluation captures both modelling quality and operational performance across different simulation domains.

### Weighted assessment model

The weighted assessment model converts the results of all modelling tasks into a unified performance score for each tool. Since terrain and infrastructure generation consists of tasks with different impact and complexity, each task receives a specific weight, and each weight is assigned to one of the evaluation criteria. These criteria represent the key dimensions of modelling quality and workflow performance.

These weights reflect the relative contribution of each process component to the overall quality of generated terrain and infrastructure. Automation and precision receive higher weighting due to their direct impact on simulation fidelity and production efficiency. The consolidated weighting is presented in the Table 1. The sum of the weights A-F weights is always 1.

The final score for each task is computed using following formula:

$$J = \sum w_i s_i, \text{ where:}$$

$$S_i - \text{score for criterion } i, S_i \in [0,1],$$

$$w_i - \text{weight of criterion } i,$$

$$i \in \{A, B, C, D, E, F\}$$

X – criterion not applicable for specific combination of task and evaluation criteria and therefore ignored

### Tasks description

The evaluation involved executing a defined set of modeling tasks designed to reflect realistic terrain generation workflows. These tasks were applied consistently across all tested tools to ensure comparability.

**Table 1. Task-level weight distribution.**

**Tabela 1. Dystrybucja wartości wag w zależności od zadania.**

Task	A	B	C	D	E	F
Rail – Project preparation + OSM import	0.30	0.30	X	0.10	0.10	0.20
Rail – Visual documentation	0.20	0.30	0.20	0.10	0.10	0.10
Rail – Main track shape modelling	0.30	0.30	X	0.10	0.10	0.20
Rail – Full track with switches	0.30	0.30	X	0.10	0.10	0.20
Rail – Terrain shaping	0.30	0.30	X	0.10	0.10	0.20
Rail – Railway infrastructure modelling	0.20	0.30	0.20	0.10	0.10	0.10
Rail – Modeling of characteristic objects and 3D buildings	0.30	0.30	X	0.10	0.10	0.20
Road – Project preparation	0.10	0.40	X	0.30	0.20	X
Road – Visual documentation	0.45	0.20	X	0.10	0.10	0.15
Road – Road-layout modelling	0.20	0.30	0.10	0.10	0.10	0.20
Road – Terrain shaping	X	0.40	X	0.20	0.20	0.20
Road – Horizontal road markings modeling	X	0.40	X	0.30	0.20	0.10
Road – Vertical traffic signs modeling	0.10	0.20	0.30	0.15	0.15	0.10
Road – Modeling of characteristic objects and 3D buildings	X	0.40	X	0.20	0.20	0.20

To assess overall productivity and practical applicability, a complete project was executed within each tool. This included the full end-to-end modeling of two scenarios: a 100 km railway segment between Szczecin and Świnoujście (for comparing Hermes and Carmen), and an urban road environment in the Łasztownia district of Szczecin covering approximately 170 hectares (for comparing Hermes and Presagis Creator). The total duration of project execution was measured in working days, and the relative reduction in time compared to estimated baselines was calculated to quantify the tools impact on modeling efficiency. Throughout the modeling workflow, errors and quality-related aspects were also analyzed. This involved tracking tool-induced errors, identifying critical modeling mistakes that could compromise simulation validity, and evaluating the repeatability of the modeling process. Consistency of output across repeated runs was used to derive a reproducibility score, while the number and severity of errors contributed to the robustness assessment of each tool.

### Railway tasks

The process began with data acquisition and preparation (Project preparation), which involved collecting and importing various datasets necessary for accurate terrain reconstruction. These included vector data from OpenStreetMap (OSM), numerical terrain models (NMT), high-precision GPS-RTK traces, 3D object libraries in multiple formats, and terrain data from national Geoportal services. This step also involves the acquisition of visual field data: video recordings and photographs together with geolocation information, followed by analysis of this material to identify infrastructure elements (Visual documentation). A set of references linking the imagery to spatial positions is created and subsequently used for model verification and for supplementing missing descriptive data. For each system under evaluation, the time required to obtain and prepare these datasets, the level of automation in the import process, and the number of user interactions—such as manual steps or confirmations—were systematically recorded. These metrics provided the basis for assessing the efficiency and automation of the data acquisition process.

Following the data preparation phase, the next set of tasks focused on railway network reconstruction. Based on geographic data and field documentation, the alignment of the railway centerline is defined as a sequence of straight segments, circular curves, and transition curves in both plan and profile. At this stage, chainage, elevations, and the basic track geometry are established, ensuring continuity and consistency with reference data (Main track shape modelling). The route axis is then expanded into a complete track layout by defining the number of tracks, their spacing, branches, turnouts, and inter-track connections (Full track with switches). The result is a topological track network with assigned attributes (directions, constraints, logical relationships) that can be directly used in traffic simulation. The degree of au-

tomation in these steps—such as whether alignments could be generated based on OSM or GPS data—was noted, along with key quantitative measures such as root mean square (RMS) positional error and topological correctness. Subsequently, a terrain model is introduced into the project and adjusted to the railway alignment so that the track follows a realistic elevation profile (Terrain shaping). At this stage, corrections of gradients, embankments, and cuttings are performed, and the basic landform features are represented, including slopes, valleys, and the beds of watercourses and water bodies. Evaluation criteria included the number of supported file formats and the quality of data integration achieved during this process, indicating the system's interoperability and flexibility in combining heterogeneous inputs. The next phase is focused on railway infrastructure – Signaling devices (e.g., signals, indicators, balises) are placed along the tracks, and their parameters and interdependencies are defined. This process includes assigning signals to specific track sections, specifying directions of operation, grouping them into signaling sequences, and establishing the relationships required for correct traffic-control logic. Based on the track layout and applicable standards, elements of the power supply network are designed, including masts, cantilevers, contact wires, and other traction components (Railway infrastructure modelling). This step involves defining their planimetric placement and vertical positioning to ensure that the catenary geometry is consistent with the track layout and enables realistic simulation of train operation under the overhead line system. The automation, precision and automatic object classification are the most critical aspects in the evaluation of this task, due to the large volumes of data involved even over short route sections. As the last step, objects of functional and visual significance are added to the scene, including bridges, tunnels, viaducts, technical buildings, and surrounding structures (Modeling of characteristic objects and 3D buildings). For each object, its position, orientation, scale, and basic parameters are defined to ensure consistency with spatial data and to fulfill its intended role within the simulation.

### Road tasks

The road workflow also starts with the Project preparation – the boundaries of the project area are defined by selecting the extent of the road network and its surroundings to be represented in the simulator. At this stage, the coordinate reference system is established, and cartographic data (maps, orthophotos, vector layers) are acquired and organized to form a coherent geographic base. It also follows with the Visual documentation task which is based on the same principles as the corresponding task in the railway workflow. Subsequently based on spatial data and field documentation, the road geometry is created, including carriageway alignment, number of lanes, curves, intersections, and connections between segments (Road-layout modelling). The result is a topo-

logical road network with assigned attributes (traffic directions, lane widths, road classes) that can later be used in traffic simulation. Following the Road layout modeling a terrain model is introduced into the project, and the elevations of roads and intersections are adjusted to the actual terrain morphology (Terrain shaping). This includes correcting longitudinal and cross slopes, designing embankments and cuttings, and ensuring continuity of road connections after terrain fitting. In the next stage, the horizontal road markings are modeled, including lane markings, solid and dashed lines, pedestrian crossings, directional arrows, and other pavement markings (Horizontal road markings modeling). Their shapes, dimensions, and positions relative to the road geometry are defined in accordance with applicable traffic organization standards. Along the roads, vertical traffic signs, traffic lights, and other traffic safety devices are placed (Vertical traffic signs modeling). For each object, its type, precise location, orientation, and, where applicable, operational parameters (e.g., signal timing programs) are specified to ensure compliance with regulations and design documentation. As the last step, objects of particular importance for driver perception are added, such as bridges, tunnels, viaducts, and landmark buildings. These objects are modeled or imported as 3D solids and then integrated into the project (Modeling of characteristic objects and 3D buildings). Finally, the project is supplemented with vegetation and environmental elements, including trees, shrubs, lawns, parks, water bodies, and street furniture. The placement of these objects is aligned with the road layout and surrounding buildings to achieve a realistic and coherent environment for simulation scenarios.

## Results and discussion

Table 2 presents the complete evaluation results for the three analysed terrain-generation tools: Hermes, Carmen and Presagis Creator. The evaluation was carried out on modelling tasks originating from both railway and road simulator workflows, ensuring that the results reflect performance across two distinct application domains. Scores are based on the weighted as-

essment model (described in chapter 3.2) and reflect the performance of each system across automation, precision, AI/GPS capabilities, time reduction, error reduction, and data integration.

Hermes achieves the highest automation levels (0.89-0.90), reflecting full integration of OSM, NMT, GPS, and multi-format 3D data. Carmen and Presagis show significantly lower automation, 0.52 and 0.57 respectively, which is consistent with their manual workflows. As far as precision is concerned, Hermes provides higher precision by deriving all scene elements from a unified geospatial reference (OSM, DTMs, GPS-RTK), which constrains geometry and elevation consistently. On the other hand, for the Presagis Creator, comparable precision is achievable, but it largely depends on manual or semi-manual operations, introducing greater variability. Taking into consideration, the AI/GPS recognition Hermes is the only tool with automatic object classification and GPS consistency correction. Presagis Creator provides only partial GPS alignment whereas Carmen does not support this functionality at all. Thanks to special features added to Hermes like automatic railway and road geometry validation tool the time and error reduction score is the highest of all three tools. Furthermore, looking on integration criterion, Hermes reaches higher score than Carmen by offering superior integration capabilities, like treating the project as a single, coherent geospatial model in which all layers: transport networks, terrain, 3D objects, signaling, and vegetation share the same source data and coordinate reference system. For the road workflow, Presagis Creator obtains significantly higher score than Hermes providing the support for more input formats such as DAE files for 3D models and DXF files for vector/CAD data.

## Conclusions

The comparative analysis demonstrates that Hermes offers a substantially more efficient and accurate workflow than Carmen and Presagis Creator. Across majority of evaluation criteria – automation, precision, AI/GPS capabilities, time efficiency and error reduction, Hermes consistently achieves the high-

**Table 2. Evaluation of terrain-generation tools across all selected criteria – performance score J**  
**Tabela 2. Ocena narzędzi do generowania terenu dla wszystkich wybranych kryteriów – wskaźnik wydajności J.**

Criterion	Hermes (Rail)	Carmen (Rail)	Hermes (Road)	Presagis Creator (Road)
Automation	0.89	0.52	0.90	0.57
Precision	0.67	0.52	0.78	0.73
AI/GPS	0.80	0.00	0.60	0.00
Time reduction	0.71	0.56	0.70	0.66
Error reduction	0.69	0.42	0.62	0.52
Integration	0.71	0.36	0.64	0.73

est scores. It is worth to mention that Hermes was designed to address the flaws and limits of other terrain generation tools especially for railway and road simulators. Its automated data handling, multi-format support, and GPS/AI-assisted processing significantly reduce manual workload while improving spatial accuracy and model consistency. On the other hand, Presagis Creator has advantage over Hermes as far as data integration is concerned.

Moreover, legacy tools like Carmen provide functional modelling environments, but their reliance on manual editing leads to longer project durations, higher error rates, and limited scalability for large simulation areas.

Overall, the results confirm that Hermes represents a more advanced and effective approach to terrain and infrastructure generation. The findings support its adoption in both railway and road-simulation workflows, especially where high fidelity, automation, and integration with heterogeneous data sources are critical.

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