

Toward a standard: RoadXML, the road network database format

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Abstract – *Driving simulator market and the diversity of its applications has been constantly growing for the past 20 years. The number of tools available to describe and produce database followed the same path and there is today a proliferation of applications and formats, usually proprietary, making interoperability difficult. Furthermore the numerous simulation tools and models used in a driving simulator (traffic model, vehicle dynamic model, visual rendering) require road network descriptions with different contents and level of details, depending on the scope of the simulation. Therefore the creation of road network database often require the use of several separate, non-harmonized proprietary tools and processes resulting in several representation of the same network in sometimes incongruous, incomplete and closed database format. Creation and modification of such databases is often a time-consuming labour and may be the source of inconsistencies between simulation modules. Today the actors of the driving simulation market are looking for a more cost-effective and time-saving way to produce and use road network databases. The simulation market is looking for interoperability: database and communication for training, test beds systems for industry. Most of the users want to have simulator contents independent of simulator technology vendors and need the same road environment definition for Software-in-the-loop, hardware-in-the-loop and Driver-in-the-loop systems for testing ADAS. At OKTAL we are involved in simulation and driving simulators since 1989 and had since worked with a number of road description formats. In this context, we propose through RoadXML a new road network description format for driving simulation applications within an open source cooperative approach to ease road database production, improve simulation models consistency, and achieve sharing and interoperability.*

Résumé – *Le marché des simulateurs de conduite et la diversité de ses applications a été constamment en croissance durant les 20 dernières années. Le nombre d'outils disponibles pour décrire et produire des bases de données a suivi le même chemin et il y a aujourd'hui une prolifération d'applications et de formats, généralement propriétaires, qui rendent l'interopérabilité difficile. De plus les nombreux outils de simulation et modèles utilisés dans un simulateur de conduite (modèle de trafic, modèle de dynamique véhicule, rendu visuel) requièrent*

des descriptions de réseaux routiers avec des contenus et niveaux de détails différents, suivant le champ d'application de la simulation. Pour cela, la création de base de données de réseau routier demande souvent l'utilisation de plusieurs outils propriétaires et processus séparés non-harmonisés résultant en de multiples représentations du même réseau dans des formats parfois incongrus, incomplets et fermés. La création et la modification de tels formats est souvent une tâche longue et peut être à l'origine d'incohérences entre les modules de la simulation. Aujourd'hui les acteurs du marché de la simulation de conduite sont à la recherche d'une méthode plus économe et rapide de produire et utiliser des bases de données de réseaux routiers. Le marché de la simulation est à la recherche d'une plus grande interopérabilité : communication des bases de données dans le domaine de la formation, banc de test pour l'industrie. La plupart des utilisateurs souhaite que le contenu des simulateurs soit indépendant des vendeurs de technologie de simulation et demande à avoir la même définition de l'environnement routier pour les systèmes Software-in-the-loop, hardware-in-the-loop et Driver-in-the-loop pour les tests ADAS. Chez Oktal nous sommes impliqués dans la simulation et les simulateurs de conduite depuis 1989 et avons travaillé depuis avec un certain nombre de formats de description routier. Dans ce contexte, nous proposons avec RoadXML un nouveau format de description de réseau routier pour les applications de simulation de conduite dans une approche Open Source et coopérative pour faciliter la production de base de données routières, améliorer la cohérence des modèles de simulation et rendre possible le partage et l'interopérabilité.

Background

A few works were made in the direction of a common road network description format for driving simulator in the past years:

- TRAIN-ALL project[3]
- OpenDRIVE™, release in 2007[4].

Other open road network formats like LandXML[5] and OpenStreetMap[6] are already commonly used for geographical needs, but are not dedicated to driving simulator.

The RoadXML format is the outcome of the study of these projects and of the compilation of several proprietary formats developed by different driving simulation actors:

- GRS file format of EVARISTE software product since 1995
 - Tracks version co-developed with PSA Peugeot Citroën
 - Network version co-developed with INRETS [1][2]
- RNS / RS file format (1997) coming from EU TRaCS project with Thales, Renault and Autosim. RNS / RS are the files formats of SCANeRII software [8].

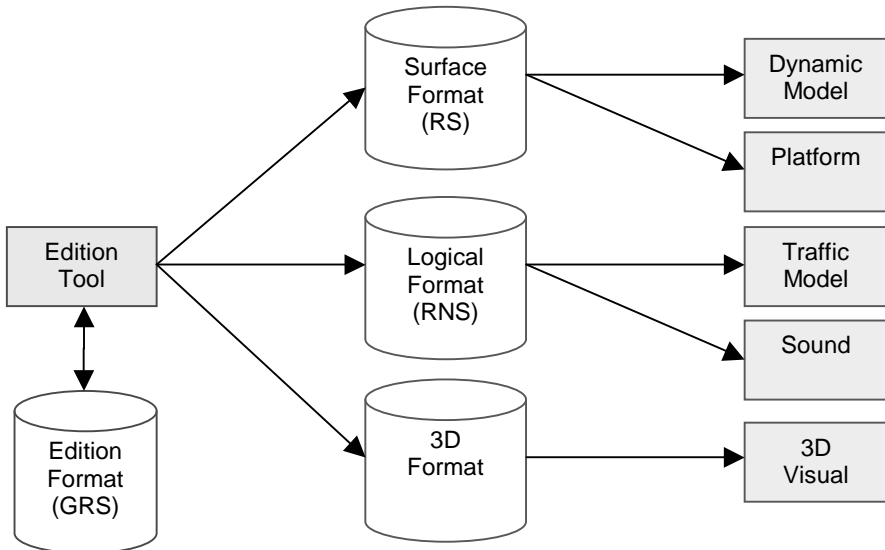
Former format analysis

RNS file format contains a logical description of the road network dedicated to traffic engine. The axes of the road are simple polylines. Road signs and circulation lanes are attached to them. The format is very simple and therefore accessing data is straight forward. But autonomous vehicle behavior accuracy was limited by the lack of information in the environment description.

RS file format is a road surface description format entirely dedicated to road surface picking tools. It contains an analytic description of the surface (as Bezier patches) but no information on the network.

GRS file format is an edition file format and is the most complete of the 3 formats described here. A 3D representation of the network can be generated from its content, as well as a topological representation. The road surface can also be described analytically from its data [9].

Each file format was specialized according to the needs of the driving simulator modules. The production chain of a database looked like this:

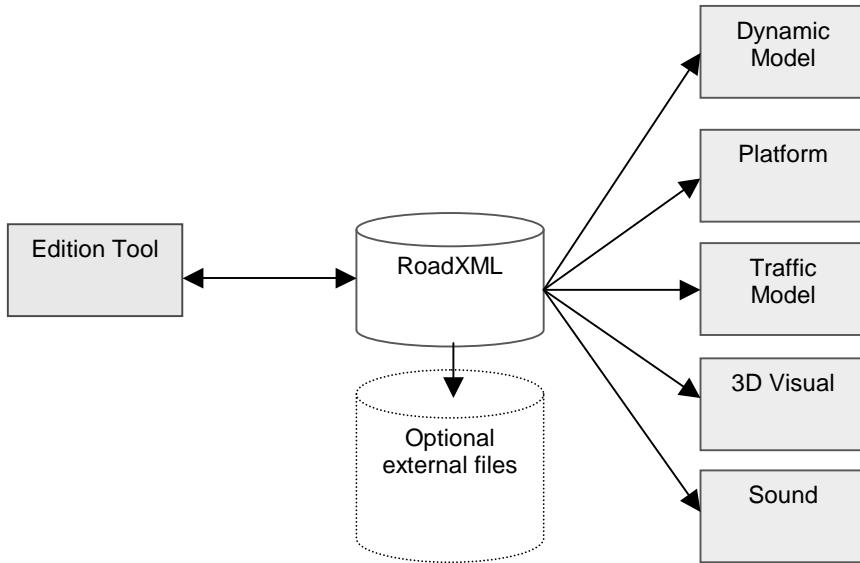


Former Production Chain

This multiplication of the file formats had several major issues:

- Each file format can be adjusted individually, the consistency between the formats is then broken.
- It's difficult to compare the results of several simulation modules since they don't use the same input data.
- Database handling is not eased: the user need to keep track of all this files.

RoadXML first concept was to have one format for all the driving simulator modules and to give a unique access to the network description. Even when for some reasons another file format is needed, the access is done through the RoadXML file.



RoadXML production chain

The second main concept of the format is to be flexible enough to answer future or proprietary driving simulator needs.

RoadXML, previously named RND, has been developed for the past four years. The first version was released in 2006 for Evariste and the traffic model of the PSA Peugeot Citroën SHERPA simulator. In 2007 the version 1.3 is integrated in SCANer™ as an alternative file format for SCANer II traffic[7] and road surface. In 2009 the version 2.0 is the native format of SCANer™studio for road description and is freely available as RoadXML on www.road-xml.org.

The RoadXML format

Content

The RoadXML format is a modern XML base file format designed to answer all the needs of road simulators. It has been designed to be flexible and extendable to enable users to enhance the road network description with custom or proprietary data. Because it is XML based, user data can be added at any level of the file tree.

The RoadXML elements and attributes (in the XML sense) are fully readable and don't contain any mysterious tag or magic number. A file can therefore be opened and understood in a text editor.

```

< Track endNode = "Crossroad 1" name = "Main Street" startNode =
"Crossroad 2" >
< XYCurve direction = "0.60562" x = "10" y = "25.5" >
< Segment length = "10"/ >
< ClothoArc endCurvature = "0.02" length = "50 " startCurvature
= "0"/ >
< CircleArc curvature = "0.02" length = "30"/ >
< ClothoArc endCurvature = "0" length = "45" startCurvature =
"0.02"/ >
< PolyLine type = "spline" >
< Vector2d x = "23.0416" y = "0"/ >
< Vector2d x = "128.693" y = "33.9411"/ >
< Vector2d x = "159.265" y = "29.6569"/ >
< Vector2d x = "296.07" y = "-577.832"/ >
< /PolyLine >
< /XYCurve >
...
< /Track >

```

Extract from a RoadXML file

Structure

The structure of the format has been organized to ease the creation and the use of networks.

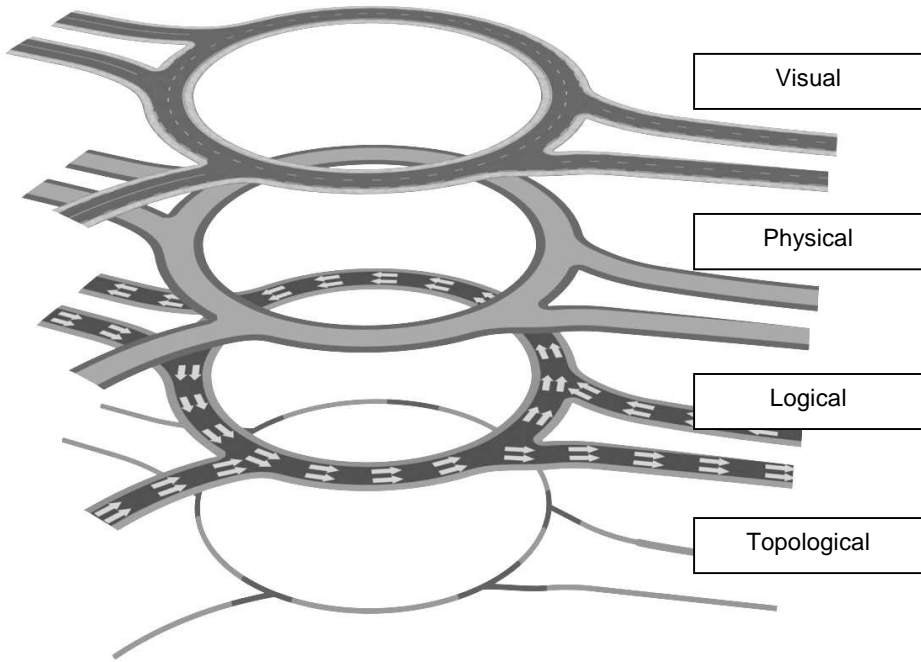
The road network is composed of adjacent tiles, each tile representing a piece of the whole network. Each tile contains a skeleton of the road network, made of axis and intersections, and is connected to its neighbor tiles through specific junction points. An axis is a planar description of the road axis and is made of segments, circle arc, spline and clothoid arcs (also called Cornu spirals or Euler spirals). An Intersection is a connection between axes.

Any other data is then attached to this light skeleton:

- Vertical and horizontal signalization.
- Road surface geometry and properties.
- Large scale data, such as routes and itineraries.
- Small scale data, such as obstacles or local surface properties.
- 3D features.
- Any user defined data.

RoadXML offers a multi layer description of the environment for fast data access for real time applications. Here are the 4 main layers of information:

- **Topological:** element's location and connections with the rest of the network.
- **Logical:** element's signification in a road environment.
- **Physical:** element's properties (road surface or obstacles).
- **Visual:** element's 3D representation.



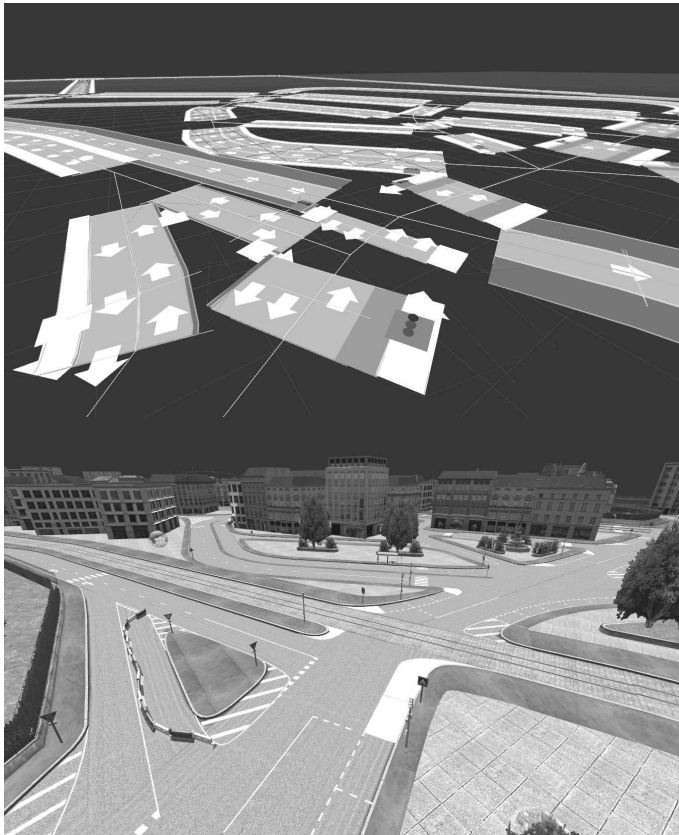
Four layers representation of a network

Therefore each element of the RoadXML format is described with 1 to 4 layers of information. Here are a few elements of the format that illustrate this 4 layers representation:

	Topological Layer	Logical Layer	Physical Layer	Visual Layer
Road Marking	Position between 2 lanes	Authorization for the vehicles to cross	Surface properties of the material	Road marking width, dot's length, texture
Road Sign	Position relative to a road axis	Road sign meaning for the traffic	NA	3D object used for its representation.
Cross Profile Lane	Distance to the road axis, width of the lane	Vehicles authorized on the lane, direction way	Road surface properties	Elevation profile, texture

Data Access

A driving simulator's component doesn't necessarily need to access all the RoadXML layers of data. But it should always be able to find the information it needs to understand its environment.



The network view of the traffic model and the equivalent 3D representation

Traffic model

The traffic model access the Topological and Logical layers of the format. The description contains information such as:

- Interconnection between the roads
- Signalization
- Road lanes, with their direction, speed limit and authorized vehicles
- Road marking.

Scenario control

Like the traffic model, the scenario control needs a topological representation of the network.

Vehicle dynamic models

Dynamic models have access to an analytic description of the road surface, as well as the ground material. Because a ground material is often specific to the model, the RoadXML ground material contains just a few simple parameters: everything else is defined in a user data element.

Platform control model

Like the dynamic model, the platform control model needs a smooth description of the road surface. It therefore asks an analytic description of the surface.

Sound restitution

Sound engine needs to know a few parameters about the physical properties of the ground surface.

3D Viewers

Viewers need a 3D representation of the network. The RoadXML format contains enough information to build a full 3D representation of the road network and its environment. The format can also reference external files for its representation.

Towards an open standard

Open Format

Since the 6th of October 2009, RoadXML is officially an open file format:

- The community and resources are gathered on a dedicated website: www.road-xml.org
- Its schema and specification are available
- Schema and specification are free of use for any commercial or non-commercial projects.
- Help and support is available from the website.
- Sample files will be added from time to time on the website.

A lively standard

With time, new needs are emerging from user's applications. RoadXML is therefore in constant evolution and regular updates are released through the website www.road-xml.org.

Cooperative approach

To respond to market needs, not only must a format match technical requirements, but its development and evolutions must also have to be managed in a cooperative approach.

Therefore, the RoadXML format will be managed through an international steering committee constituted by members from the industry and research. The board members will be elected among and by the RoadXML adherent. To become a RoadXML adherent, interested parties may register on the RoadXML website.

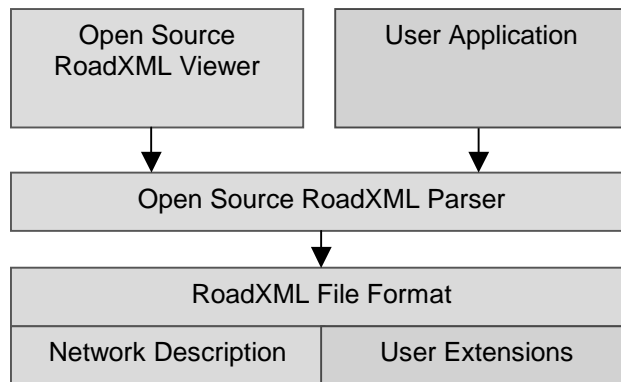
Open Source Projects

The expansion of a format is often restrained by the lack of free tools to manipulate it. To prevent this, Oktal will soon offer an open source project based on RoadXML to illustrate:

- How to read, write and access data in the XML file.
- How to draw a 3D representation of the road network.
- How to add custom user extensions into the file.

This application will be distributed through sourceforge under the terms of the LGPL license, allowing its use and modification in commercial and non-commercial applications, without restrictions.

Oktal will also offer RoadXML sample databases for download. The objective is to offer all the necessary tools for a newcomer to quickly decide if RoadXML is suited to its project.



RoadXML Open Format and Source

Conclusion

The driving simulation world is seeking an Open Standard on the road network database format. RoadXML is already used in a broad variety of training and research driving simulators. Databases creation and modification was simplified by its use in recent projects. The various modules in these simulators were able to find and use the data they needed within this format.

Opening its specification, making it available for all and constituting a management board is a new step toward the creation of a real international open standard for road network description in simulation.

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