
ikerlan
MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE
Where technology is an attitude.

About us

We are a **technology center.**

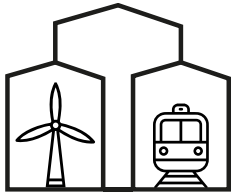
OVER

400

PEOPLE

28 M€

TOTAL INCOME FOR 2021



Sectors

We are a cooperative created in 1974 by the companies of the current Mondragon Corporation.

Member **of Basque Research & Technology Alliance** and **RVCTI.**

- 13,8 M€ **Transfers** to companies
- 12,9 M€ In research projects in 2022 **(DFG, GV, AGE and Horizon Europe)**
- 1,2 M€ Other income

43 %	Transport ando mobility	**7 %**	Automotive
19 %	Manufacturing	**2 %**	Health
14 %	Energy	**1 %**	Aeronautics
5%	Services and other industries		

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Key Capabilities

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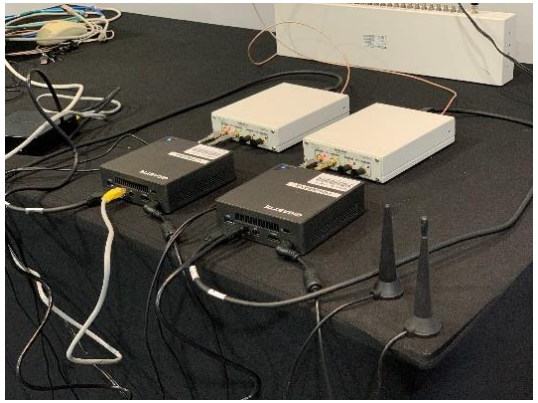
- **Communication** technologies:
  - Private 5G networks
  - Lightweight transport protocols (e.g QUIC)
  - NTN communications based on NB-IoT
- **Edge-cloud** monitoring framework
- Intelligent **task offloading** as a service
- AI-based host and network **security** anomaly detection and response
- Technologies **beyond 5G**:
  - Time Sensitive Networking (**TSN**)
  - Mobile Edge Computing (**MEC**)

Private 5G Networks



	Operator-based	Amarisoft	OpenAirInterface
Stack	Commercial	Configurable	Open-Source
Edge	Remote	Local	Local
Aim	Real deployments	Testing	Research platform

Simulation & Emulation

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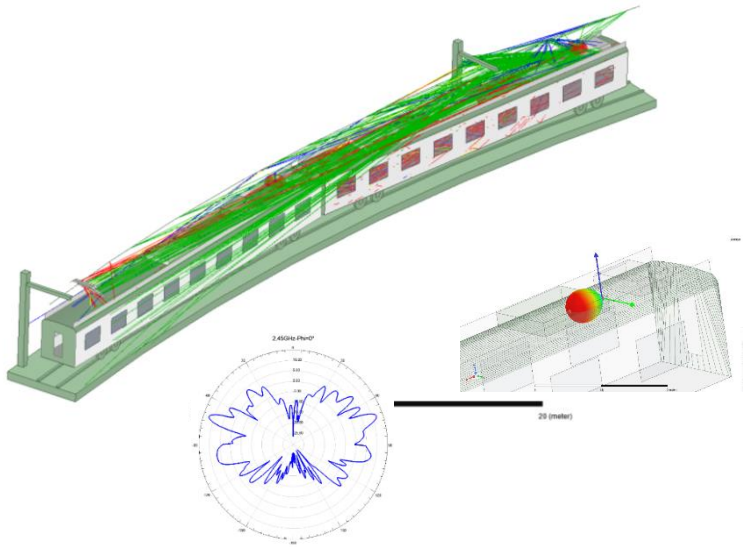

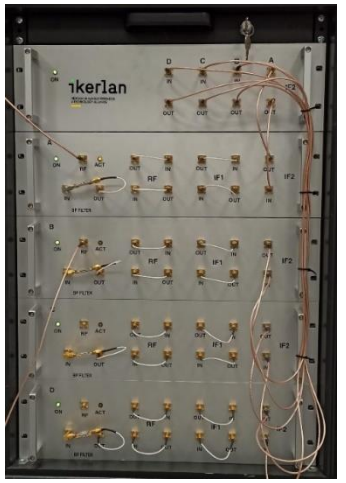

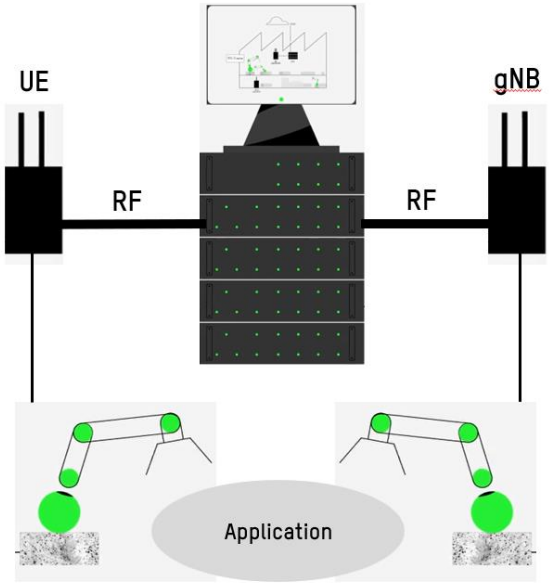

- **Ray-tracing simulation for antena installation and optimization (Ansys SBR+):**
  - Ray-tracing
  - Antenna installations
  - Channel models

- **Real-Time Emulation and Testing of Radio Propagation Channels:**
  - Up to MIMO 2x2 channel emulation
  - Direct RF connection
  - Emulation of propagation characteristics: multipath fading, Doppler spread, etc.

Testing in Real Environments

- Cooperative robots
- Autonomous Mobile Robots (AMRs)
- Rotating machines

Relevant Publications

- J. Elizalde, A. Arriola, M. Roset, J. Härri, I. López and M. Straub, **"Parametric Study of Radio Propagation in Railways Based on Ray-Tracing Simulations,"** 17th European Conference on Antennas and Propagation (EuCAP), Florence, Italy, 2023
- A. Larrañaga, M. C. Lucas-Estañ, I. Martinez and J. Gozalvez, **"5G Configured Grant Scheduling for 5G-TSN Integration for the Support of Industry 4.0,"** 18th Wireless On-Demand Network Systems and Services Conference (WONS), Madonna di Campiglio, Italy, 2023.
- J. Elizalde, A. Arriola, M. Alfageme, J. Härri and I. López, **"Characterization of a 5G Wireless Train Backbone via Ray-Tracing,"** 16th European Conference on Antennas and Propagation (EuCAP), Madrid, Spain, 2022
- M. Berbineau, R. Behaegel, J. Moreno García-Loygorri, R.Torrego, R. D'Errico, A. Sabra, Y. Yan, J. Soler, **"Channel Models for Performance Evaluation of Wireless Systems in Railway Environments,"** in IEEE Access, vol. 9, pp. 45903-45918, 2021
- A. Larrañaga, M. C. Lucas-Estañ, I. Martinez, I. Val and J. Gozalvez, **"Analysis of 5G-TSN Integration to Support Industry 4.0,"** 25th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), Vienna, Austria, 2020
- G. Nieto, I. de la Iglesia, U. López-Novoa and C. Perfecto, **"Deep Reinforcement Learning-based Task Offloading in MEC for energy and resource-constrained devices,"** 2023 IEEE International Mediterranean Conference on Communications and Networking (MeditCom), Dubrovnik, Croatia, 2023, pp. 127-132, doi: 10.1109/MeditCom58224.2023.10266609.
- Sáez-de-Cámara, X., Flores, J. L., Arellano, C., Urbieta, A., & Zurutuza, U., **"Clustered federated learning architecture for network anomaly detection in large scale heterogeneous IoT networks"**, Computers & Security,131, 103299, 2023.

Characterization of a 5G Wireless Train Backbone via Ray-Tracing

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***Abstract*—In this work the antenna propagation has been characterized for a 5G Wireless Train Backbone (WLTB). For this purpose, a train model has been generated and ray tracing simulations have been performed with antennas installed on the roof of the train. In order to obtain the most optimal antenna location, the position of the antennas has been modified in vertical and horizontal directions. Tunnels have also been simulated, changing their material properties to study their effect on the signal propagation. Obtained results have allowed to identify potential location for the antennas of the WLTB.**

***Index Terms*—antennas, propagation, simulation, 5G, railway**

I. INTRODUCTION

Shift2Rail initiative of Horizon 2020 aims at providing novel capabilities for railway industry through research and innovation [1]. One of these capabilities is the use of wireless communications in the Train Control and Monitoring System (TCMS), which has been one of the goals of CONNECTA-2 and Safe4RAIL-2 projects. In these projects, wireless devices based on LTE-V2X technology were developed for a Wireless Train Backbone (WLTB) at 5.9 GHz [2], and the applicability of 5G technology for the WLTB was also studied [3]. Regarding antenna installations for the WLTB, field tests done in CONNECTA-1 project indicated that the location of antennas and their close environment have a huge influence on the performance of the WLTB, as they can increase the multipath or even block the line-of-sight between antennas [4]. Therefore, antenna installation studies are considered of great importance for the correct deployment of the WLTB and are currently being carried out in Safe4RAIL-3 project via ray-tracing simulations [5].

Several works have been done related to ray tracing for either GSM-R Train-to-Ground (T2G) links [6, 7] or Train-to-Train links [8]. However, the wireless link between two antennas installed on the same train has not been simulated so far. The present paper presents these simulation results for antennas of the WLTB located on the roof of the train car. Usually, the roof of the train car has several metallic boxes accommodating multiple auxiliary items that generate a complex propagation environment.

The paper is structured as follows. The simulation model is detailed in Section II, which is a simplified version of a real train. In Section III the simulation results are presented for different antenna positions and tunnel environments with different material properties. Finally, conclusions and future work are presented in Section IV.

II. SIMULATION MODEL

To simulate the train, the SBR+ solver of ANSYS HFSS has been used. The model has been built based on the actual CAD file of a train. After importing the model, it has been simplified using surfaces to emulate the external contour of the real train. The model is shown in Fig. 1; it is composed of a train tractor unit with a pantograph, and a train car. On the roof of the train cars there are several metallic boxes to accommodate different items, as the power converters, or the air conditioning system. The model of the train is composed of metallic surfaces. A Perfect Electric Conductor (PEC) boundary has been established for these metallic surfaces.

An arched tunnel model [9] has also been included in the simulation in order to evaluate its effect in the signal transmission. The tunnel section is detailed also in Fig. 1. A Finite Conductivity boundary has been chosen for the tunnel, varying its permittivity and conductivity to study the effect of the material of the tunnel.

In large models, precise electromagnetic simulations can take a long time and lots of computer resources. To overcome this limitation, Shooting and Bouncing Ray tracing techniques (SBR) are used for such electrically large models (>10λ). This method is based on the optical properties of the

Fig. 1. Train model

Thank you very much!

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