

OSIRIS

newsletter



Energy efficiency today is one of the main challenges urban rail operators and manufacturers are facing. An important part of their operating costs is related to energy and innovations are thus highly welcomed in this field.

In order to address this, OSIRIS – a FP7 three-year collaborative R&D project co-funded by the European Commission – worked during three years on the development and testing of technological and operational solutions and tools aimed at achieving an overall reduction of energy consumption in European urban rail systems by 10% compared to current levels by 2020.

In order to fulfill its objectives, OSIRIS put into place a number of important activities:

- The definition of overall needs and operational requirements allowing for the development of a global approach for the simulation, optimisation and benchmarking of the energy consumption of urban rail systems;
- The definition of standardised duty cycles and key performance indicators for urban rail systems in order to directly compare performance and the benchmarking of technologies;
- The use of optimisation methodologies in order to identify efficient strategies for realising low energy consuming urban rail systems, based on the use of the OSIRIS tool;
- The demonstration of energy savings feasibility through the OSIRIS tool and a number of defined demonstration scenarios based on simulations and real use cases.

Started in January 2012, OSIRIS has entered into its last month and all the results will be presented during the Final Conference on 31 March 2015 at the Solvay Library in Brussels.

For more info on OSIRIS and its partners, please visit our website www.osirisrail.eu!



OBJECTIVES AND RESULTS

Rather than focusing on specific technologies, OSIRIS partners worked to develop system-level solutions which offer significant opportunities for energy reduction in many different urban rail systems. We have adopted a global approach to benchmark, simulate, optimize and test a variety of energy-saving technologies, operational techniques and tools, in order to assess their individual benefits in real scenarios as well as the benefits of combining them.

OSIRIS achievements covers five main areas:

1. Cutting-edge technologies

An onboard energy storage system using lithium-ion batteries from SAFT was tested on a tram in Vitoria-Gasteiz. The aim was to capture and store energy during braking, in order to reduce overall energy consumption and cut the power losses from the catenary and substations.

A new type of auxiliary converter developed and installed on an ATM metro train in Milan. The purpose was to reduce the power consumption of onboard systems, including heating, air-conditioning, lighting and the battery charger.

A novel cooling and heating system for equipment rooms using underground water was deployed in Roma's Barberini metro station. The goal was to address the thermal behavior of fixed installations and the cost of maintaining correct temperatures to ensure the proper operation of signaling and communications equipment.

2. Innovative operational solutions

A variety of innovations covering escalators, tunnels and station ventilation, and station lighting were defined to potentially offer substantial energy savings in metro stations.

3. Energy Simulation & Optimisation

An ad-hoc holistic tool for electrical and thermal calculation of the whole railway system was developed in order to understand better the interactions between different energy consumers in the urban transport environment.

4. Energy and business KPIs

A number of energy and business-related Key Performance Indicators for urban rail systems were identified to allow direct performance comparisons and the benchmarking of technologies.

5. Duty cycles

Osiris defined a series of standardised duty cycles for benchmarking purposes. These will enable urban rail operators to compare the energy consumption of their various systems and support them in decision making as well as optimising their procurement processes.

CUTTING-EDGE TECHNOLOGIES

ESS in Vitoria

CAF tested an innovative type of On-board Energy Storage System developed by its affiliate company CAF Power & Automation, integrating a new Li-ion battery developed by SAFT, in a tram in Vitoria-Gasteiz (Spain). The objectives were, from one side, to reduce the energy waste during the braking phase thanks to the storage of energy on board while breaking and, from the other side, to decrease traction energy and losses into catenary and substations.

Lithium-ion on-board energy storage system offers a high power and energy density in a lightweight and compact system designed for railway applications.



ESS installation on Euskotren tram in Vitoria/Gasteiz

One of the most important features from the developed onboard energy storage is the energy supply optimization, an expected energy saving 25%, and allows that the tram could run in free catenary operation if needed. In this project by working on control strategies, CAF expects an increase of 5% in energy recovery by regenerative braking.

The local operator of Vitoria-Gasteiz, EUSKOTREN, has carried out the tests. During the trials the battery stability and its behavior during charging and discharging at high power have been checked and its safety verified.



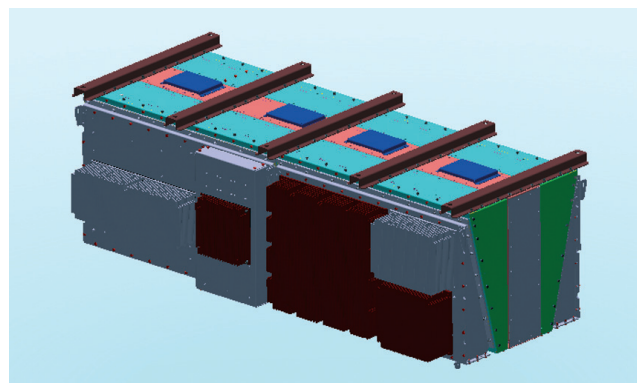
Tram with new ESS in Vitoria-Gasteiz

New type of auxiliary converter in Milan

On current auxiliary converters, the power components used are based on Silicon IGBT. On the two new auxiliary converter installed on a metro train of Line 3 in Milan, Alstom used new technologies power components base on Silicon Carbide MOSFET (Metal Oxide Semiconductor Field Effect Transistor) in order to:

- reduce losses compared to Silicon IGBT. These properties will allow us to reduce the losses and passive component mass
- hold less losses so natural convection could be used instead of forced convection.
- increase the efficiency of the converter by the fact of less losses in the semiconductor

Among the advantages of SiC, lower losses compared to Si (conduction and switching losses) can be observed. By comparing Si IGBT and SiC Mosfet of the same calibre (1200V/100A), the conduction losses of the SiC are 1.7 times lower than the Si IGBT one. This is due to the fact the IGBT is a bipolar semiconductor and the conduction losses are composed by a threshold voltage and a resistive characteristic, compared to the MOSFET only composed by a resistive characteristic.



3D representation of the auxiliary converter design

The disadvantage of the SiC is the difficulty (and impossibility) to implement it on existing power module design. The gatedriver and the power loop has to be so low that the proximity of the gate command and the power components can lead to EMC (ElectroMagnetic Compatibility) challenges. This proximity is also problematic for thermal aspects

Alstom has developed two auxiliary converter prototypes in order to organise a demonstration on a real environment as the Milan Metro L3 train. The two converters have equipped one of the two traction unit of the train. This demonstration has been done during the period from November 2014 to December 2014.

Heat-pump in Rome

The Rome Barberini Station Demonstrator is an innovative free-cooling system for metro technical room. It uses the cold underground water inside a bailing well near the station. The test was carried out by Ansaldo STS in collaboration with Rome public transport operator ATAC. The water is pumped inside a heat exchanger that is connected to the water pipes of the air conditioning fan coils plant installed inside the TLC room present in Barberini station. The aim is to verify the actual energy savings that this kind of plant can generate. The free-cooling is possible when the temperature of the water of the bailing well is less than the temperature of the air in the areas that will be cooled, in these conditions it is possible to use water to cool directly, without the need of chiller.

The well's characteristics, used for the sizing, are:

- Temperature: 10–15 °C ;
- Existing pumps capacity at 60% power rate: 3600 l / min;
- Minimum water level declared: 2 meters;
- Depth of the well: 12 meter.

The pilot plant includes the following subsystems:

• Hydronic Subsystem

- . Primary: which includes the items located in the area surrounding the extraction well (the pumps room);
- . Secondary: which includes the items installed in technical locals and the necessary lines for their feeding (the technical room).

• Electric Feeding's Subsystem: which includes the electrical panels for system's feeding;

• Control's Subsystem: which allows the monitoring and the control of the whole system.



TLC Technical Room Fan Coil

The two main technical challenges were:

- To study new HVAC systems with higher cooling efficiency;
- To find and integrate innovative technologies that are used in other fields ready and suitable to be used for railway application.

Among the main advantages respect to existing solutions, partners identified, from one side a reduction of the electrical consumption of the stations and depots HVAC system and related installation and operation costs, from the other side, that technology can be used for existing but also new stations or depots. It's can be used not only for technical rooms but also for other areas of the station such as platforms and atria.

The Energy Efficiency Ratio (EER) evaluated and validated with the measurement on field is about 12–14.



Heat pump in Rome Barberini station

Considering an acceptable temperature for the room of 22°C in summer and winter, all along the time and all time, we can choose on a catalogue an air-water chiller to extract the same heat Power measured during the experimentation. Choosing the chiller we can have the related EER that it will be a function of the external temperature. So we can do an estimation of ERR that will change with the seasons. While the demonstration system don't depend by external temperature but only by water temperature, so if we can guarantee a right replacement of water we have an EER that isn't affect by external temperature and seasons.

Comparing the OSIRIS solution with traditional one we have a 4x factor of improvement for the EER.

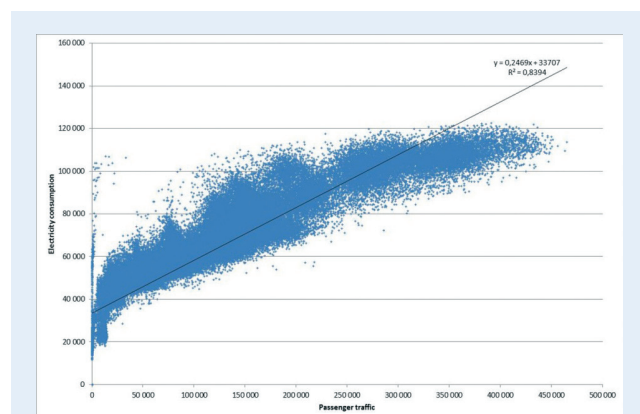
OPERATIONAL TECHNOLOGIES FOR REDUCED ENERGY CONSUMPTION

RATP thoroughly ventured into passenger traffic forecasting. The selected methodology was implemented through a general approach by studying statistically the evolution of passenger traffic over time.

RATP also investigated the correlation between passenger traffic records and energy consumption measurements over 5 years. It obtained a scatter plot exemplifying that:

- The intensity of the relation is close to being highly positive,
- The regression line closest to the data is in the form of $y=ax+b$. In this case, $y = 0.2469x + 33707$,
- The direction of the relation is linear and positive; when the number of passengers increases, so does the consumption and vice-versa.

In the aftermath of data correction, the regression line closest to the data was still in the form of $y=ax+b$ with $y = 0.2139x + 40315$ and r^2 is equal to 0.8269 (this means that 82.69% of the total variations in y can be explained by the linear relationship between x and y).



Scatter plot of the total passenger traffic and electricity consumption between 2007 and 2013

Given these results, RATP concluded that there was a strong correlation between passenger traffic and energy consumption on the condition that public transportation service was well matched to the needs of passenger transport.

In order to bring this study to a close, it remained to explore energy saving opportunities through optimized train scheduling. For this reason, RATP was going to identify periods when there might exist an oversupply of transport service.

ULASIM installed measurement system to analyze energy consumption profiles of major equipment in selected representative stations. To do this, Passenger Traffic and Energy Consumption of All Systems were measured during one week observing energy consumption in escalators and ventilators. The resulted average was equal of 20% and 21% respectively. The correlation between the number of the passenger incoming to passenger station and energy consumption amount of the systems was the highest for the escalators (0,61) and lowest the ventilators (0,03). However, ventilators have the biggest part of energy consumption meaning they were less sensitive against the passenger traffic. From that point usage of ventilators may have an important chance to reduce energy consumption regardless to passenger traffic.

ESCALATOR ENERGY CONSUMPTION

Energy saving potential was evaluated using the in-house energy consumption model. For dual mode operation frequency convertors have been mounted to 50 escalators. By dual mode operation 10% saving has been supplied from escalators.

VENTILATION ENERGY CONSUMPTION

Energy saving capacity was calculated using the thermal model of the station. The ventilation energy consumption values (Before and After) were measured by the analysers. Fans have been operated according to station temperature and with low capacity in 6 stations. 35% energy saving has been supplied from the ventilation system.

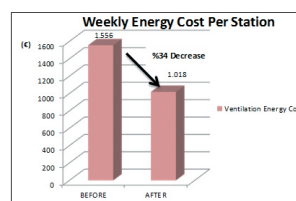
Measured Weekly Energy Saving

BEFORE

- 8 hour per day full capacity
- Weekly consumption: 16 408 kw.h
- Weekly cost: 1556 €

AFTER

- Fans run if temperature reaches to 26 C with %45 capacity.
- Weekly consumption: 10 736 kw.h
- Weekly cost: 1018 €



Energy Savings on Ventilation System

OSIRIS TOOL

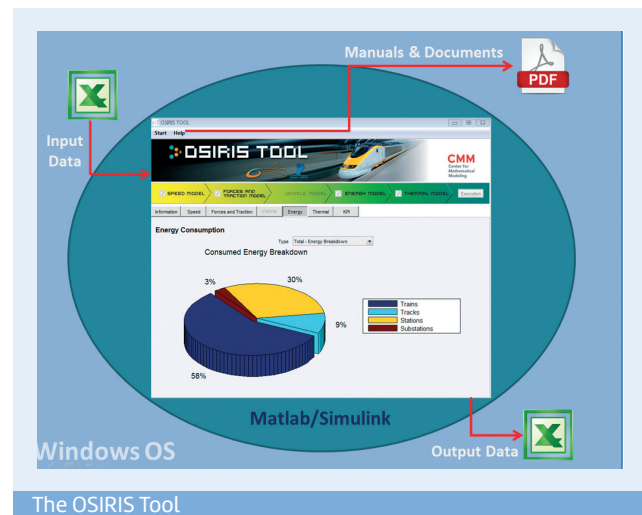


The purpose of OSIRIS Holistic Tool is to support the decisions of stakeholders in issues such as energy strategies, operational settings and determination of critical points when looking at energy efficiency improvements for metro and light rail networks. The system has been built by the Center for Mathematical Modeling (CMM), in the context of a joint work with ALSTOM, AREVA, ASTS, ATAC, CAF, RATP, SIEMENS, ULASIM and VUT.

OSIRIS Tool gathers mathematical and optimization models in order to perform simulations and test what-if scenarios, obtaining the total energy breakdown and thermal evolution for an urban rail system.

The holistic model is based on the interaction of four large scale systems. The first system corresponds to the Trains. Either light rail or subway systems, both have electrical energy input and produce kinetic and potential energy, plus thermal energy dissipation. This system is affected by technological aspects, passenger load, speed profiles and other variables. The second system is the Tunnels & Exterior Environment. In underground case, we consider both thermal inertia of the earth and ventilation in the tunnels, while in the case of above ground tracks, ambient conditions plus solar radiation determine train environment. The third system is the Stations Environment. These have significant energy usage and influence on the rest of the system, due to factors such as passenger load, HVAC systems, lighting, escalators and commercial premises. Finally, we included in the holistic model the Electrical Substations (both AC-AC substations and AC-DC substations).

The main Inputs to use the software can be classified in three categories: Topological information (data that describes the network such as number of lines, number of stations etc.), Systemic information (train's technical data such as Davis parameters, power and braking) and Operational information, including the settings for the different time frames during the day, such as travel time between stations, passenger's affluence, dwell times, and trains frequencies. Concerning the Outputs of the system, a menu of charts, graphics and tables are available for results visualization. Thus, the user can browse through a set of alternatives by changing the parameters and visualization displays.



The system is organised in five calculations modules, corresponding to the different models developed in the project. The Speed module, developed by CMM, generates the optimal speed curves at every segment of the network, by using topological, systemic and operational information provided by the user. The Forces and Traction module calculates the Traction power for every train along the time and segment of the line. This module has been provided by CAF, but a simple alternative developed by CMM is also available. In the Vehicle module, provided by VUT, the aim of the calculations is to determine the air conditions of the interior room, based on the environmental conditions and the conditions of the supply air. The Energy module, built by CMM, permits to know a general energy balance for the network for each simulation. This is the Energy Consumptions and Breakdown for trains/tunnels/stations/deposits per line/direction/hour/segment. The Thermal module, based on a thermal model proposed by CMM, determines for tunnels and stations the air temperature profile, the total heat absorbed by the ground, the heat transferred through ventilation, the heat gains due to traction and passenger losses, and the heat gains due to auxiliaries.

The OSIRIS Tool is programmed in MATLAB™ and Simulink™, which are packaged in a friendly interface.

DUTY CYCLES AND SERVICE PROFILES

Generic duty cycles are the basis and also a major element of a self-contained and standardized energy consumption determination methodology for urban rail systems. This task elaborated and defined generic duty cycles and operational modes as well as the boundary conditions on the infrastructure side.

This included:

- Definition of required parameters to describe a specific operational profile (includes load status, operation of auxiliaries, etc.);
- Collection and evaluation of existing driving cycles;
- Proposal for definition of generic duty cycles for typical modes of operation.

The general purpose of this task was to provide the framework that enables to generate comparable energy performance values for urban rail systems rolling stock on a common basis and thereby support benchmarking and improvement of the energy efficiency of urban rail and to support decision making process to procure rolling stock with LCC approach..

In a first step existing duty cycles and operational modes of typical urban rail systems were analyzed and clustered.

Subsequent to this, a set of generic duty cycle modules for typical modes of operation were elaborated in a consensus oriented process and proposed for standardization. The intention was to have not one standard duty cycle but a set of cycles typical for various operating environments, similar to automotive duty cycles.

This task applies to the specification and verification of energy consumption of three specific urban rail system: Heavy metro, Light rail (light metro or exclusive right of way tram with at-grade crossings) and Mixed traffic (street running) tram

The development of the duty cycles was based on real-life measurements and a consequent simplification in order to be suitable as a generic duty cycle module.

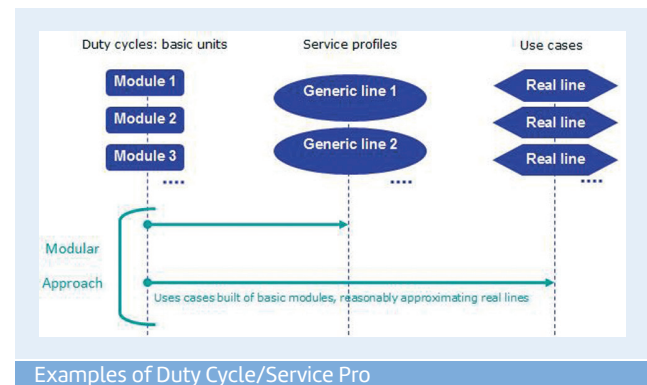
In the framework of OSIRIS, the chosen strategy for duty cycles was a modular approach, that is, to define the duty cycles as a combination of basic modules, each module representing a small portion of a line between two stations, and to build the service profiles from those modules.

Duty cycles and service profiles provided a reproducible comparison

of the energy consumption of different vehicles. It is important that cycles be easily repeatable (for sufficient confidence), simple (for easy and low-cost procedures), accurate (to avoid any disruption in interpreting results).

In close relation to duty cycles, the concept of “use cases” could be defined. Like the service profiles, use cases were built using the basic duty cycles modules, but take into account specific circumstances which characterize operational conditions on a specific network or line. Using basic modules allowed to reasonably approximate real lines. In this way, operators can adapt generic duty cycles to their own needs.

The relations of duty cycles, service profiles and use cases are shown on the figure below.



In the proposed methodology a module had two main characteristics:

- Length (representing an interstation)
- Speed (representing the average speed to run the interstation)

Partners used different axis strengthened representativeness:

- Geographic: the data analyzed to define the duty cycles should come from cities spread among Europe
- Generation: the data analyzed to define the duty cycles should come from lines and systems of different generations (new or older)
- Industry: the data analyzed to define the duty cycles should come from different vehicle suppliers

In order to be representative we analyzed the distribution of average speed regarding interstation length.

TECHNICAL AND BUSINESS KPIs



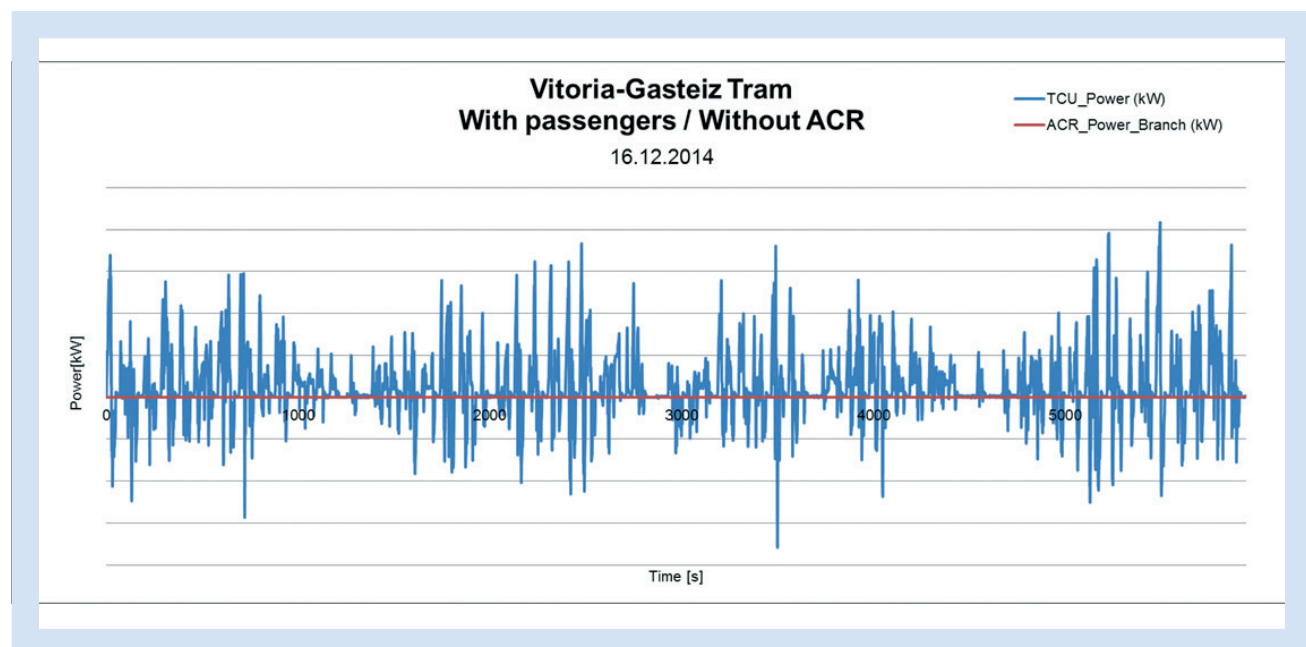
A key element of OSIRIS was the identification and definition of clear and measurable energy-related Key Performance Indicators. This would not only allow measuring the energy consumption of overall operations, but also to analyse key factors contributing to energy consumption, such as traction or on board and in stations mandatory utilities (light, tunnel and station ventilation). Indeed, for example stations and tunnels contain a number of energy consuming equipment which can often reach close 40% of total system energy usage. Hence, the OSIRIS partners worked on KPIs related to rolling stock, as well as to stations and tunnels. The thermal behavior of the overall system was also looked into. As of today, OSIRIS has in total listed twelve KPIs for an urban rail operation.

To calculate both Duty Cycles and KPIs, a large amount of data was needed. Project partners contributed to this, like for example ATM (Azienda Trasporti Milanese). In addition to this, organizations who

are not partners to the project did too. These organizations are part of the so-called OSIRIS "Support and User Group" (SUG) who meet up every six months to have access, contribute to and validate the results of the project. This SUG is managed by UITP.

Business KPIs

In addition to the above mentioned KPIs, economical indicators and ways to appreciate return on investment – both for operators and industrial actors – have been developed as part of the project. This is of particular importance in order to support the decision to invest or not in energy saving technologies and operational changes. At the end, whatever the other benefits may be, energy saving actions and means are evaluated on the basis of costs compared to results obtained. This is true for operators as well as for manufacturers, who will only invest in new technologies if a return on their investment is possible.



Preliminary results of the energy storage on-board a tram

OSIRIS User Group

The activities related to the OSIRIS Support and User Group (SUG) continued during the second half of the project.

Do you want to have access to the project results and contribute to them? That is what is proposed to UITP members, the end goal being to reach a global consensus on the results and thereby to validate them. Hence, the following UITP members took part in the SUG activities from the start: STIB, Metropolitano de Lisboa, Oradea, Keolis, Light Mobility, Rheinbahn AG, TMB, SWM.

During this second half of the project, in addition to regular contacts by email, two meetings were organized by UITP with the support of a local host.

The first took place on 23–24 April 2014 in Barcelona. As per usual, an update was given on the project activities. Then, the project partners went in more depth in the following topics: the Database of Network characteristics, the Duty Cycles, the Business KPIs. As meeting hosts, TMB (Transports Metropolitans de Barcelona) gave an oversight on how energy efficiency in urban rail is a strategic priority for them. Many energy-related cost reductions initiatives are taken by TMB (reduce traction related energy but also lighting in stations, inverters in sub-stations, etc.). They also presented the concrete results of their participation in the EU project SEAM4US and took the participants on a visit to a pilot station.

Visit of the Barcelona pilot station



The second meeting was held on 17 December 2014 in Bilbao. This time hosted by a project partner, CAF, this enabled the consortium and SUG members to visit one of the OSIRIS demonstration sites. Thanks to Euskotren's support, the group went to Vitoria-Gasteiz, to see (and take a ride on) the tram which has a modified on-board battery. In addition to this, the group was given a detailed update on the project's developments regarding Duty Cycles, Service profiles, technical and business KPIs and operational solutions to reduce

energy consumption. The two other OSIRIS demonstration sites also gave an update on their testing activities.

Thanks to a voluntary contribution from the SUG members, the consortium also obtained a lot of energy consumption related data. This fruitful collaboration nourished the partners work on the Database of Network characteristics, the Duty Cycles and the Key Performance Indicators.

The OSIRIS SUG members accompanied by partners during a site visit in Vitoria-Gasteiz



Major OSIRIS participated events



OSIRIS at the 60th UITP World Congress

- ➔ **60th UITP World Congress.** The event was held from 26 to 29 May 2013 in Geneva. The OSIRIS project was presented during the World Congress on the afternoon of 28 May 2013 by UITP (at the UITP stand), and the morning of 29 May by Unife (at the ATM stand, where part of a series of events supported by ATM).

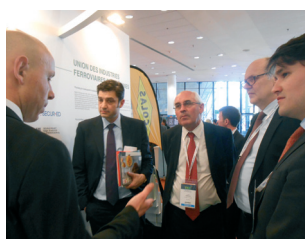


- ➔ **Workshop 'TecRec 100_001: a powerful tool for procuring energy efficient rolling stock'.** The event was jointly organised by UNIFE and UIC and took place on October 28th in Paris. OSIRIS was presented by the Technical coordinator AREVA, which highlighted benefits and limits of integrating the TecRec 100_001 for the Urban Rail sector.



Presentation of OSIRIS during UITP seminar on Energy savings

- ➔ **UITP seminar on Energy savings.** Some 50 experts from 11 countries including Malaysia, attended this Seminar organized by UITP Light Rail Committee on December 2013. OSIRIS, and more specifically the activities of on duty cycles, was presented by AREVA on behalf of OSIRIS consortium. It was followed by a discussion about ways of addressing energy consumption over life cycle in the light rail vehicle procurement process.



Presentation of OSIRIS during TRA2014 in Paris

- ➔ **OSIRIS AT TRA2014.** TRA is the major conference on transport in Europe, supported by the European Commission, the Conference of European Road Directors, and the three European Technology Platforms: ERRAC, ERTRAC and the WATERBORNE TP. The OSIRIS project was presented by Mr. Andrea Demadonna, UNIFE Project Coordinator, to Mr. Shane Sutherland, Member of the Cabinet of Commissioner Geoghegan-Quinn (Research, Innovation and Science), Mr. Liam Breslin from DG Research and Mr. Josef Doppelbauer, ERRAC Chairman at the UNIFE stand during the first day.

Notes

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March 2015

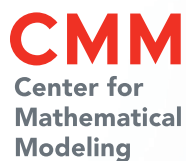


Partners

Project Coordinator



Technical Leader



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