



2025 Edition

Research



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Research

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Editorial

Dear readers, partners, clients,
colleagues and friends,

AREP has become an ecosystem where worlds that are often separate come together: those of technology, uses, materials, science and territories. Research plays an essential role here, gathering, connecting, shaping and placing each issue in a broader context. At a time when urban environments require new synergies between architecture, socio-ecology and local knowledge, this ability to build bridges is essential. It allows AREP to transform itself in line with contemporary challenges, without losing touch with reality.

At AREP, we measure to reduce, we draw to clarify, we observe to report on reality, we analyse to explain and we model to anticipate. The living is just as important to us as the infrastructural legacies of the Anthropocene era. We transform cities for everyone, and research supports us in these ambitions, without censorship or taboos.

2025 was a memorable year. Two PhDs were successfully defended: those of Pierre Navaro-Auburtin and Alexandrina Striffling. They address crucial issues: the ecological impact of structures in buildings and lessons from the history of standardised railway station construction. This year also saw the publication of *The New Nature of Stations* (TU Delft Editions) and the conclusion of the research program *Frugacit *, with its research report, website and presentation at the 2025 Versailles Architecture and Landscape Biennale.

In 2025, new research projects have been launched, driven in particular by two emerging PhD studies: a geohistory of straw building and research on rain trees in constrained environments. Several research projects have been confirmed: bamboo construction, urban greening, inclusivity in stations, representation of the chronicity of GHG emissions, frugal modelling of stations for SERMs, and continuation of the CORIFER 'Mobil'quai' project. The growing number of schools and universities reaching out to AREP to co-develop projects confirms that our approach inspires others, both through its ecological commitment and its ability to combine professional practices with scientific requirements.

Engaging in critical research means recognising that the shift towards more sustainable infrastructure will not come about through increased technical sophistication, but rather through a transformation of our existing frameworks. This is the path that AREP is pursuing: producing context-specific, useful, shareable knowledge that can be used to drive concrete decisions. Our aim is to ensure that research is not merely a showcase, but a force for transformation.

Enjoy reading!

Rapha l M nard, Philippe Bihouix and Nils Le Bot,
December 2025



Rapha l M nard,
Chairman of the
Management Board at
AREP Group



Philippe Bihouix,
CEO of AREP Group.



Nils Le Bot,
Research Supervisor at
AREP Group.

  AREP - photographies
Maxime Huriez

Research at AREP

At AREP, we embrace the exploratory and uncertain nature of our project approaches. To invent a post-carbon future, we challenge our certainties, renew our knowledge and explore new practical and conceptual perspectives.

For us, research is an ethical requirement; an 'effort of sensitivity and refinement' in response to the world's needs. Independent and critical, our research engages in debates that shape the future of territories in transition.

Whether fundamental or applied, our research aims to define, develop and test practical and theoretical hypotheses. The benefits are not directly financial, but rather serve the excellence and values of our group.

We cultivate innovation transversally, combining expertise and creativity from all sources. Agile and responsive, our desire for innovation is one of the key conditions for our resilience and that of our projects.



We act to bring about the ecological transition. To achieve this goal, we have developed a unique approach, EMC2B, which guides through the design and analysis of our projects.

This approach allows us to set a series of ambitious objectives based on five pillars: Energy, Materials, Carbon, Climate and Biodiversity.

It then allows us to measure the results of projects and evaluate and compare their performance using about forty proven indicators.

Ultimately, it is an approach based on education and dialogue with all project partners (project owners, operators, users, etc.) and stakeholders (local authorities, associations, etc.).

“The EMC2B approach translates a commitment into indicators, actions and tools, and requires us to question their effectiveness.”

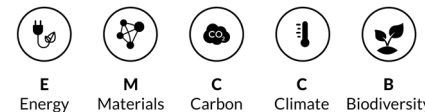
Energy
Seeking balance between reducing energy demand and producing renewable energy.

Materials
Save and improve the material cycle by using renewable, bio-based materials or the reuse of existing products. The aim is to reduce water consumption and waste, as well as the production of waste.

Carbon
Decision-making criteria throughout the design process to contribute to worldwide carbon neutrality.

Climate
Contribute to territorial resilience by creating cool islands and climate refuges to improve sensory comfort and air quality.

Biodiversity
Increase the services provided, raise user awareness, create ecological value and maintain as best as possible a place for all levels of life (plants, insects, animals, humans) within the projects.



Research Tax Credit

What is it ?

In France, the research tax credit (*crédit d'impôt recherche*, CIR) takes the form of a tax reduction calculated on the basis of research and development (R&D) expenditure incurred by companies. It is deductible from the income tax or corporation tax payable by companies for the year in which the expenditure was incurred.

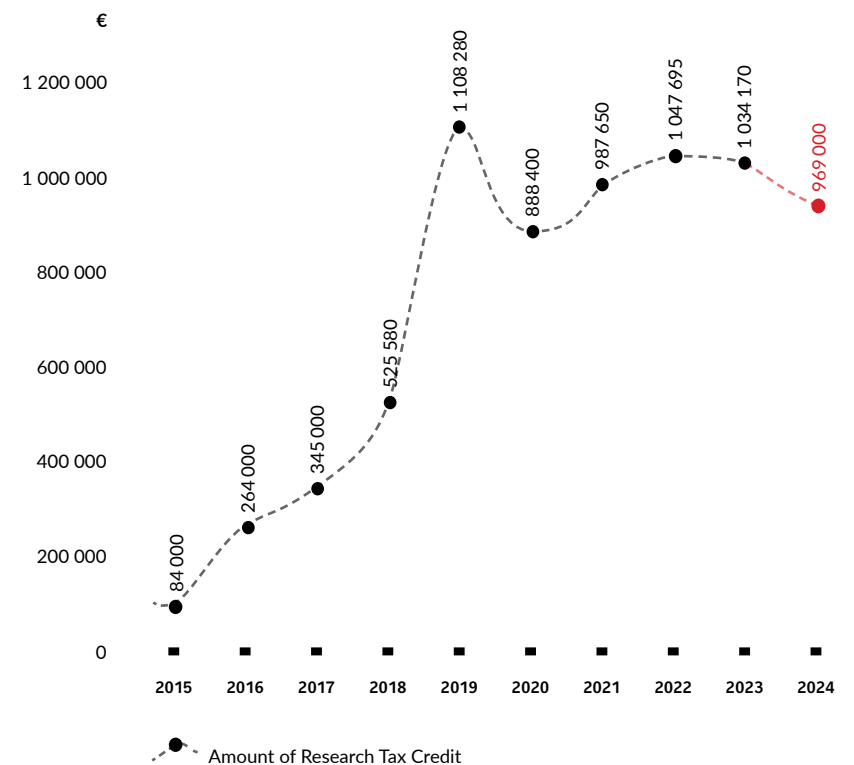
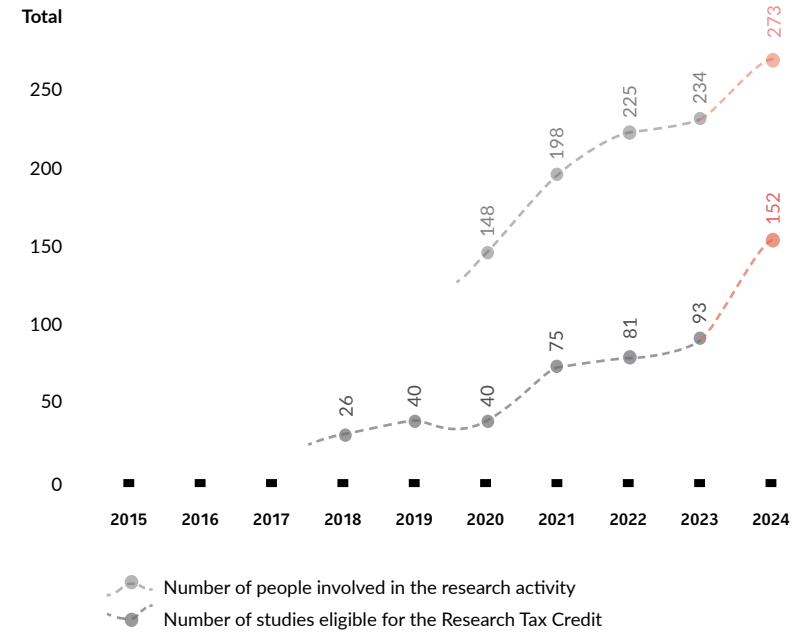
The CIR rate is 30% for research expenditure up to €100 million and 5% above that amount. Public subsidies received for research projects eligible for the CIR are deducted from the basis for calculating the credit.

Sustained investment

At AREP, our research is part of our commitment to a post-carbon world. We advance methods, tools and solutions by participating in the exploration of fundamental knowledge that fuels operational projects. Thanks to the involvement of a growing number of people and a high level of investment, the number of eligible studies continues to increase.

Despite changes in the methods used to calculate eligible investments for the CIR, 2024 demonstrates the quality and relevance of these investments with more than 150 eligible studies structured around 18 themes. 273 people were directly involved in the studies and are helping to build a dynamic research programme closely linked to operational challenges. Since 2019, AREP has consolidated a significant level of investment, exceeding the symbolic figure of one million euros in public subsidies granted under the research tax credit scheme since 2019. The year 2025 maintains the same momentum in the context of changing calculation methods for eligible investments that began in 2024.

Our commitment to research continues to pursue its goal of “inventing a post-carbon future”.



Research themes

In order to continue our efforts and structure our approach, we have built our programme around six unifying themes. These echo the five pillars of the EMC2B approach, but also reflect the importance of usage, the issue of obsolescence, architectural challenges, and all considerations relating to the project and new ways of approaching it.

6 main areas

The six themes outline the areas in which we wish to focus our efforts and be proactive. They affirm AREP's positioning and the importance of research in its practice, and embody the 'R' in AREP.

Together, these themes structure our collective work to achieve our shared mission: "inventing a post-carbon future".

1. Resources and materials
2. Land use and biodiversity
3. Energy and Sense of place
4. Representations and Collective imaginary
5. Design and adaptation
6. Architectures and mobility

Research ecosystem

Organisation and coordination

The research coordination aims to structure all research-related activities:

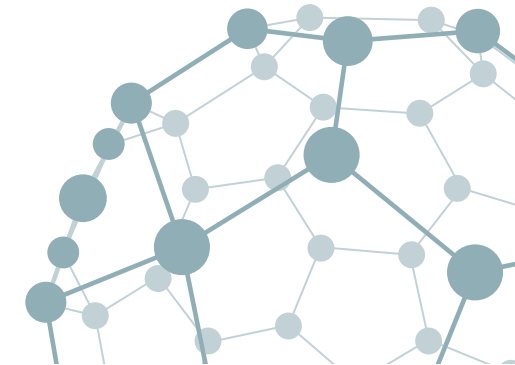
- The steering committee is responsible for directing and validating research dynamics and investments;
- Six research coordinators are appointed to bring teams together and develop research projects around each theme;
- The network of CIR advisors monitors ongoing research activities within its scope to ensure they are promoted;
- The PhD network brings together PhDs and PhD students to discuss research methods and topics and promote scientific ethics.

The organisation of research ensures the consistency, dynamism, cooperation and promotion of research and R&D activities at AREP.

Researchers, PhD and experts

The research ecosystem relies on more than 200 people at AREP. Evolving over the years in line with the topics addressed, each professional can play a role in applied research, a multi-partner research programme or exploratory research in their field of expertise.

> See the list of key persons on the next page.



Organisation of research

Research coordination

Research Supervisor Nils Le Bot

Assistant Louise Jammet

Direct and validate

Unite and develop

Collect and promote

Share and transmit

Research steering committee

Permanent members

Raphaël Ménard
Philippe Bihouix

Rotating members

Technical Departments involved
Researchers and PhDs

Sponsors

Élise Dageons
Hiba Debouk
Donatien Frobert
Léonard Hamburger
Émilie Hergott
Céline David
Luc Néouze

Research coordinators

Resources & materials

Nils Le Bot (acting)

Land use & biodiversity

Maya Rivera

Energy & Sense of place

Nils Le Bot (acting)

Representations & Collective imaginary

Grégoire Robida

Design & adaptation

Romaric Quentin

Architectures & mobility

Matthieu Goudeau

CIR advisors

Building Design

Émilie Hergott

Heritage

Véronique Veston

Industrial Buildings

Léonard
Hamburger

Design

Rémi Guers

Urban Studies and Regional Planning

Hiba Debouk

Mobility and pedestrian flows

Matthieu Goudeau

Environment

Jean-Baptiste
Lefeuvre

Structure

Jean-Luc Martin

GIS

Thomas
Lannelongue

L'Hypercube

Anne Mesureur

BIM

Marie Chaumaz

DATA / Digital

Félix Pouchain

Project Management Assistance

Sabine Thomas

Programming

Mélanie Barey

Innovation

Alistair Lenczner

International

Fabien Clavier

PhD network

PhDs

Alexandre Auvray
Mateusz Bogdan
Julien Dallot
Arnaud Delamarre
Morgane Delarc
Capucine-Marin Dubroca-Voisin
Antoine Hubert
Louise Jammet
Nils Le Bot
Aya Mansouri
Raphaël Ménard
Alexis Sauvageon
Khaled Serrai
Alexandrina Striffling
Fatima Zreik

PhD Students

Paul Le Bot
Lukas Madl
Martin Paquot

Scientific network and partners

More than 50 academic and professional partners

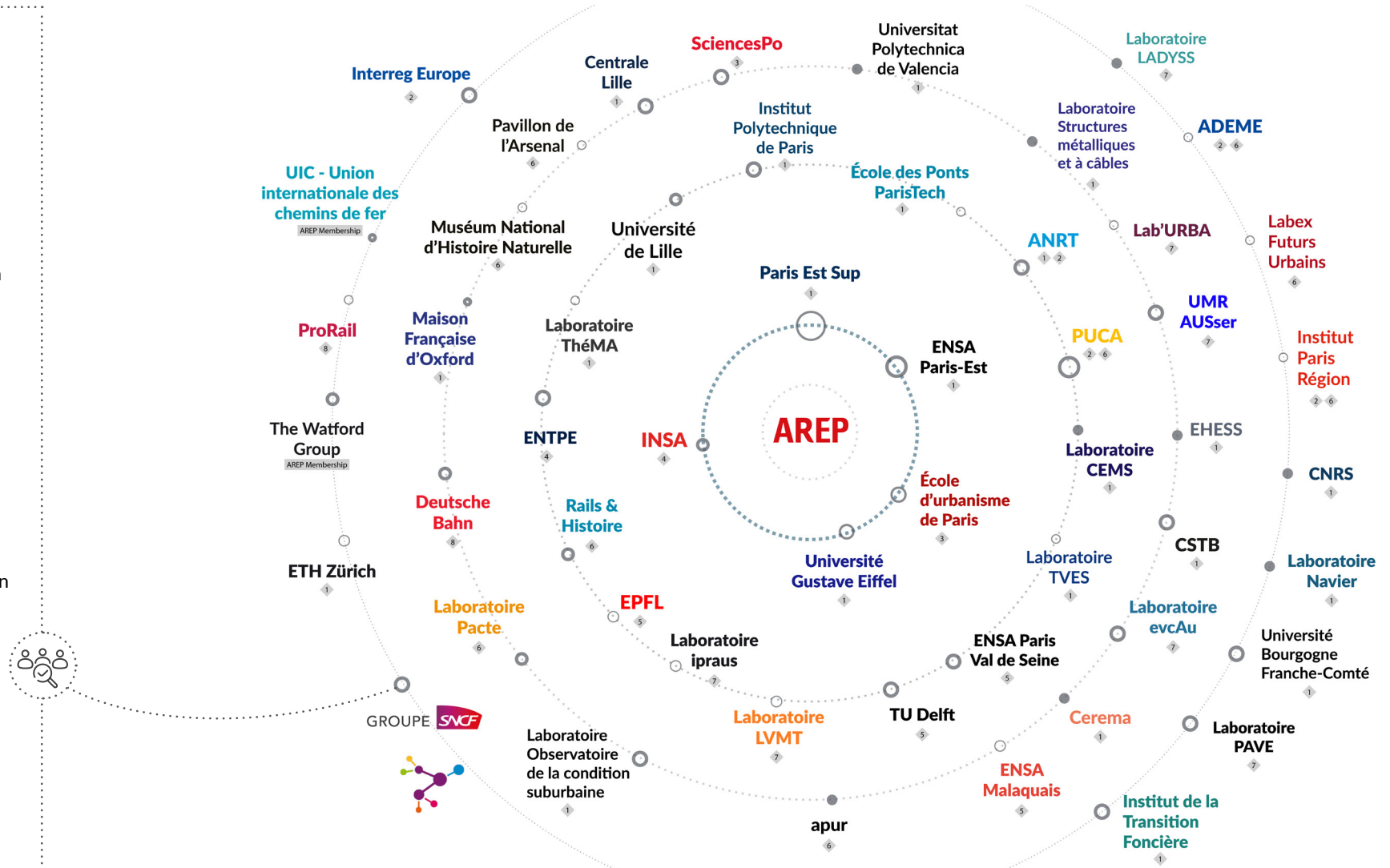
- Universities & research laboratories
- Higher education institutions & professional master's programmes
- National & international public research and funding institutions
- Railway industry associations & professionals

Focus on the Synapse network

Led by the SNCF Group's Innovation & Research department, the Synapse network is a group of experts committed to advancing innovation and research through collective and cross-functional actions, and ensuring the sustainability and development of key expertise for the Group's future.

In 2025, 14 experts from AREP are part of Synapse

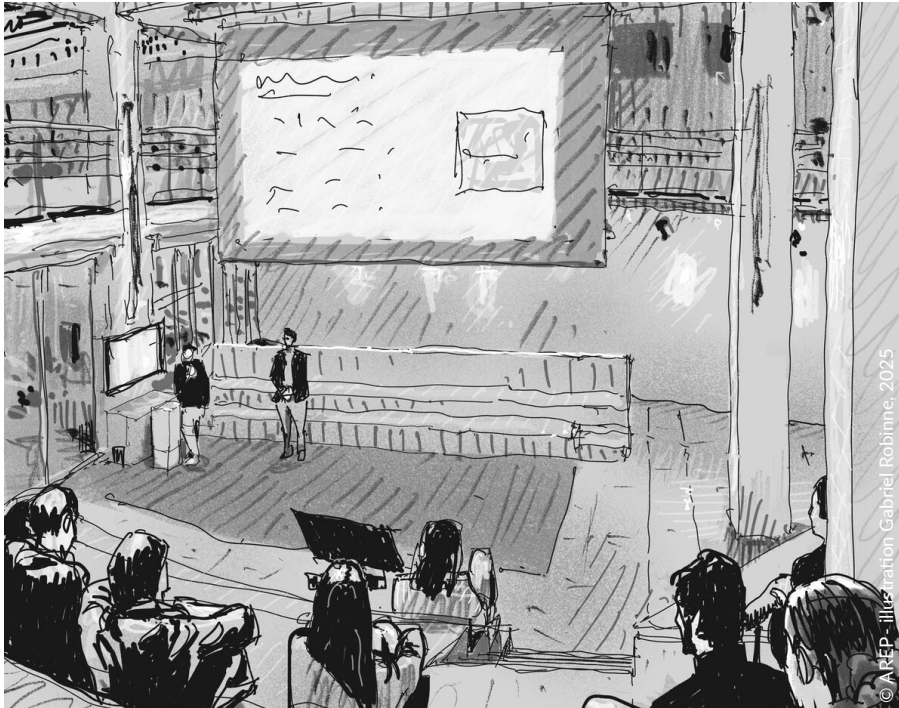
- Mateusz Bogdan
- Morgane Delarc
- Capucine-Marin Dubroca-Voisin
- Léonard Hamburger
- Antoine Hubert
- Nils Le Bot
- Jean-Baptiste Lefeuve
- Alistair Lenczner
- Mario Lorenzo
- Jean-Luc Martin
- Cédric Rivière
- Alexis Sauvageon
- Sophie Untersinger
- Véronique Veston



- 1 Academic partner for PhD Students
- 2 Financier and co-financier
- 3 Partner for professional masters' programmes
- 4 Skill-based sponsorship by AREP

- 5 Higher education institution where AREP employees teach
- 6 Research partner
- 7 AREP PhDs' research laboratories fellowship
- 8 Preliminary discussions initiated

Communication and promotion



Events



© AREP - picture Julien Lelièvre, illustration Gaëtan Amossé

Conference « Grenoble 2040 » - September 2025

What will life be like in Grenoble in 2040? Faced with climatic, social and urban challenges, what choices must we make today to build a more resilient, inclusive and desirable city tomorrow?

Presentation of the forward-looking approach led by Hiba Debouk, Director of Urban Studies and Regional Planning at AREP, and Nicolas Tixier, architect and professor at the Grenoble National School of Architecture, as well as Erwan Mahé, Head of Urban Studies and Heritage at the City of Grenoble, and a representative of the Grenoble Region Urban Planning Agency.



Forum Matières #2 - November 2025

Building and retrofitting with straw

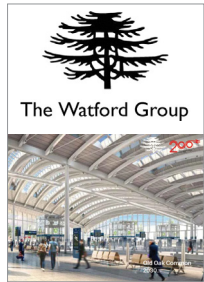
Organised by Loïc Tchernatinski and Sophie Untersinger (AREP, Project Management Assistance) with Cécile Michel and Cloé Chretiennot (AREP, Material Library) and Collect'IF Paille, the second Forum Matières provides designers and specifiers with a platform to share experiences, transform practices and build differently.

Symposium



Cerisy Symposium
“Railways in cities and in the countryside: popular attachment, contemporary ambivalence, ecological emergency”
 Véronique Veston, Alexandrina Striffling and Nils Le Bot spoke about “railway archaeology”, discussed railway stations and station districts, and debated the subject of staging urban rail in September 2025 in Cerisy-la-Salle.

> Recent scientific publications are listed at the end of this document.



Watford Conference
“Legacy: The Past – The Present – The Future”
 Raphaël Ménard and Nils Le Bot spoke at the Watford conference in London in September 2025. Raphaël Ménard presented the United Station of Europe project developed by the AREP teams, while Nils Le Bot shared his work on the future of railway stations, which will need to become significantly more energy-efficient in order to meet environmental challenges.



RFTM 2025
 At the Franco-phone Transport and Mobility Conference in Dunkirk in June 2025, Capucine-Marin Dubroca-Voisin organised the Flow session and presented *“The wicked problem of flow management”*; Alexandre Auvray gave a presentation on *“The translation challenges posed by biodiversity in the development of urban mobility spaces: a study of station districts”*.



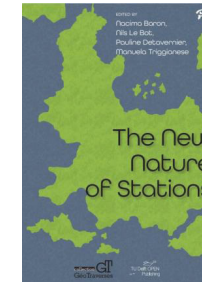
ICUC 12
 Mateusz Bogdan presented the results of a post-doctoral research project he was involved in on the ABRICOCODA project (“shelters like trees”) at the International Conference on Urban Climate in July 2025 in Rotterdam.

Publications



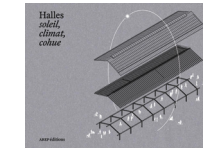
Frugacité
 The scientific report presents the results of Frugacité: an analysis of the interactions between urban forms and landscape connectivity around railway stations, aimed at better integrating ecological issues into the practices of the various actors involved in urban and railway development.

> Auvray Alexandre, Ficamos Fabienne, Gremion Karine, Le Bot Nils, Marty Pascal, Martin-Hackett Elodie, Rivera Maya, Sahraoui Yohan, Thomas Sabine. 2025. *Cahier Frugacité, formes urbaines des quartiers de gare ou à fortes contraintes et biodiversité*. éditions PUCA, 110 p.
 > frugacite.arep.fr/



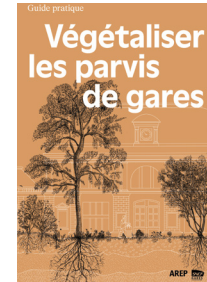
The New Nature of Stations
 Open source publication in English of the book *“La nouvelle nature des gares”*, which examines railway stations in relation to ecology and transitions, the new dimensions of the flows passing through them, and the new socio-environmental dynamics that challenge them.

> Le Bot, Nils, Nacima Baron, and Pauline Detavernier (eds). 2025. *The New Nature of Stations*. TU Delft OPEN Publishing.



Halles, soleil, climat, cohue
 Following the delivery of the solar bicycle hall at Gare du Nord rail station in Paris, this book invites readers to explore this seemingly ordinary family of architectural structures. Halls feature a multitude of construction methods and materials; they also offer a myriad of atmospheres and a unique multi-sensory experience; and this family of architecture houses an incredible range of uses, some of which have evolved over time.

> Ménard, Raphaël (dir.) 2025. *Halles, soleil, climat, cohue*. Paris: AREP Éditions, 131 p.



Végétaliser les parvis de gare
 Designed to help assess ambitions, define objectives and determine the possibilities for planting vegetation on station esplanades, this guide is intended as a practical tool for all those involved in transforming stations and their esplanades to make them more resilient.

> SNCF Gares & Connexions, AREP. 2025. *Guide Pratique: Végétaliser les parvis de gare*. AREP éditions, 200 p.

Ongoing PhD studies

Renaturing



Lukas Madl

Integrating knowledge of urban soils into renaturation practice - towards a support tool for decision-makers and practitioners.

Gustave Eiffel University, under the supervision of Youssef Diab (since January 2024).

Straw



Martin Paquot

Socio-environmental history of straw building.

EHESS, under the supervision of Geneviève Pruvost and Guillaume Habert (since December 2024).

Rainwater



Paul Le Bot

Integrated stormwater management: reconcile technical constraints, environmental requirements, and social expectations.

University of Lille, under the supervision of Olivier Blanpain, in collaboration with the CEREMA (TEAM unit) (since September 2025).

Defended PhD thesis in 2025

Alexandrina Striffling

Thinking the station through the serie: A systemic approach of its architecture. Comparative study of three railway lines in France, Spain, and Italy (1850-2025).

Paris-Est University, under the supervision of Virginie Picon-Lefèbvre and Arnaud Passalacqua (April 2025).



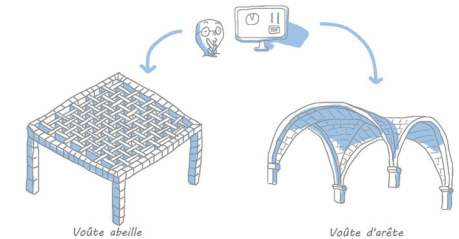
Photomontage de trois gares — A. Striffling

Alexandrina Striffling analysed the design of serially constructed railway stations based on an adaptable and modular standard plan that has been applied repeatedly across European networks. She thus highlights the territorial roots of railway stations, which serve as a catalyst for new projects tailored to current socio-environmental needs.

Pierre Navaro-Auburtin

Life Cycle Assessment for the design of low environmental impact building structures: from materials to the structural skeleton.

École nationale des ponts et chaussées Marne-la-Vallée, under the supervision of Olivier Bayerel (April 2025).



Croquis de deux voûtes en pierre — P. Navaro-Auburtin

Pierre Navaro-Auburtin conducted a study combining two approaches, structural design and life cycle analysis, in order to quantify the environmental impacts of building structures and identify ways to reduce these impacts, from materials to construction systems, through to a prospective analysis of environmental issues.

A multidisciplinary and diverse research

Research overview

Multi-partner research programmes, CIFRE doctoral programmes and internal research conducted at AREP form a highly diverse multidisciplinary set of topics and original scientific approaches. The topics explored and methods used cover both fundamental and applied research in fields ranging from the humanities and social sciences to the natural sciences and engineering.

Basic research

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

Applied research

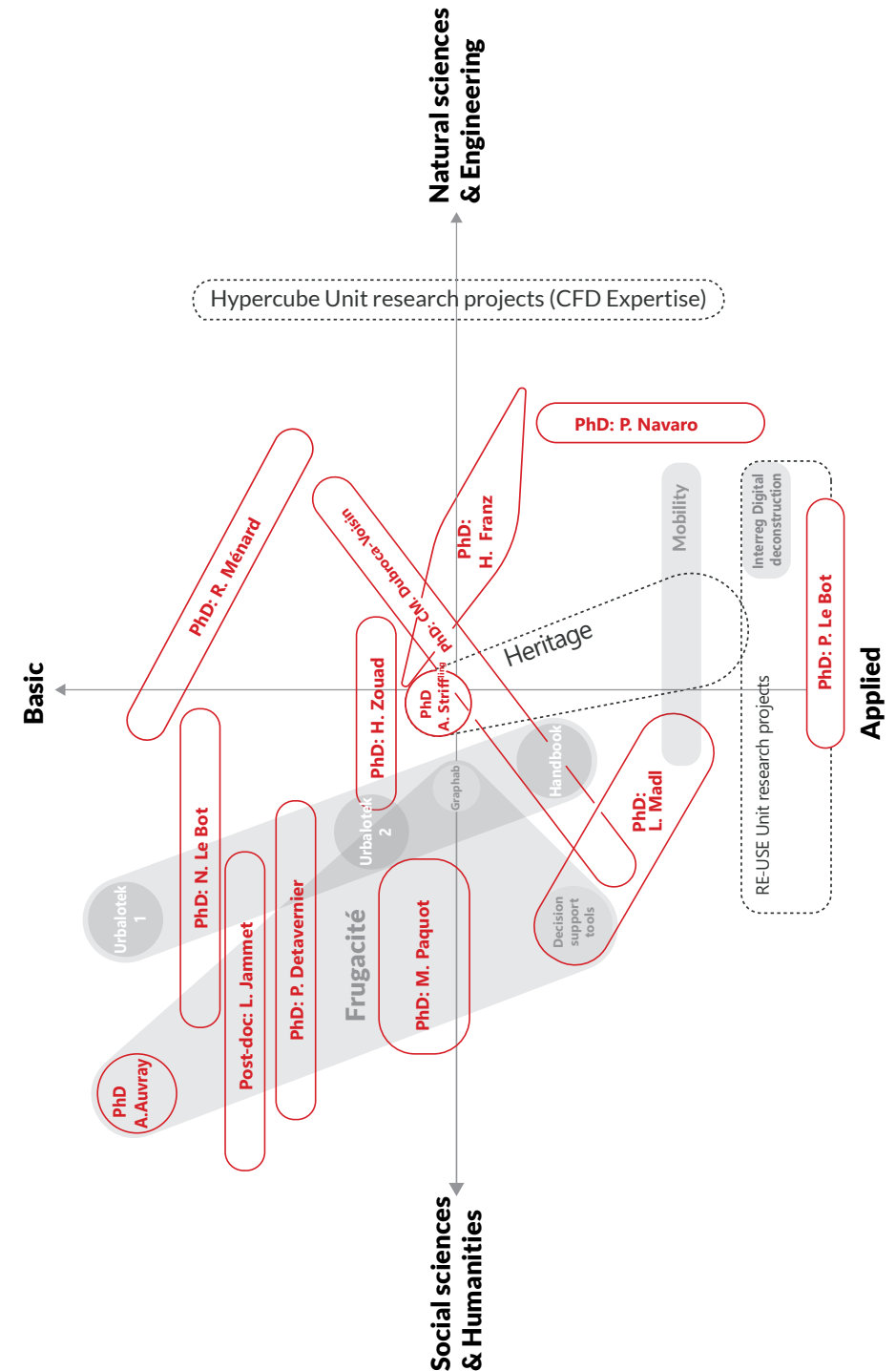
Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.

Social sciences and humanities

Field of knowledge that aims to understand humans, culture and society.

Natural sciences and engineering

Field of knowledge concerned with the study and understanding of physical, natural and technical phenomena, laws and principles.



Source : OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities*, OECD Publishing, Paris.

2025 Panorama

Resources & Materials

Bio-based materials

Case study on the use of French bamboo
Socio-environmental history of straw building

Weighing

Macro-weighing of buildings on a conversational basis

Design

Design of lightweight, modular and reversible rail platforms (Mobil'quai)
EMC2B catalogue

Representations & Collective imaginary

Atlases and maps

Map of European railway stations
Atlas of Greater Paris railway networks

EMC2B

Representation of the chronicity of greenhouse gas emissions

Land use & Biodiversity

Renaturing

Soil restoration in renaturation projects
Calculation tool for maximum vegetation coefficient

Biodiversity

Cross-conceptual analysis of the concept of heritage for building and biodiversity
Critical analysis of the concept and overview of French 'urban forests'

Energy & Sense of place

Inclusivity

Tools and methods for gender and inclusivity studies in railway stations

Solar energy

Integration of solar energy on linear land property

Design & Adaptation

Comfort

Cartographic approach to urban microclimates in summer and evaluation of a comfort indicator
Characterisation of heatwave mitigation measures in railway stations

Climate

Climate shelters

Architectures & Mobility

Railway stops

Atlas of low-density railway lines

Comfort

Studying the links between comfort, frugality and mobility in railway stations

SERM

Intermodality and car parks at SERM railway stations
Mobility modelling

2026 Outlook

Resources & Materials

Design

Comparative LCA of generic facades

Maintenance

Maintenance, materials and sustainability
Research on volatile pollutants

>> Design of lightweight, modular and reversible rail platforms (Mobil'quai)
>> *Socio-environmental history of straw building*

Representations & Collective imaginary

Knowledgeable representations

Project and work phasing representation methods
Representation of knowledgeable architectural and urban design

>> Depicting future climates
>> Atlas of low-carbon mobility

Land use & Biodiversity

Land transition

Cross-analysis "soils, values, uses"
Constrained urban environments
Study of rainwater management in constrained urban environments
Greening strategy in railway stations

Specialized tools

Automated tool for analysing biodiversity indicators in large-scale plans
Study on the value of land according to its natural state and uses

Energy & Sense of place

Micro-confort

Monitoring of local bioclimatic environments

>> Studies on gender and inclusivity in railway stations

Design & Adaptation

Comfort

Evaluation of the efficiency of heatwave mitigation equipment in railway stations

Carbon

Scope 3 analysis of AREP's activity

>> Climate shelters

Architectures & Mobility

Railway stations

Right sizing and anticipating usage at stations

Mobility

New stops and minimal stations
Qualitative research on peri-urban and rural mobility
Development of a LUTI (Land Use and Transport Interaction) module for Mobility

Research & Development

Research conducted in 2024



SOLVEIG prototype
(Reversible solarisation system on tracks).
© SNCF / AREP - picture Yann Audic,
January 2025

Biodiversity in railway environments

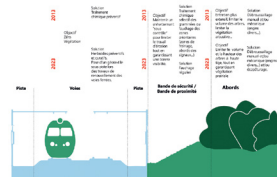
The research aims to deepen knowledge about the relationships between human activities and biodiversity, with a particular focus on neighbourhoods with high technical constraints.

A PhD thesis associated with the Frugacit  programme specifically investigates building and neighbourhood scales. Led by Alexandre Auvray, it focuses on the landscape connectivity of natural habitats based on a study of multiple neighbourhoods located near train stations along a range of urban density. Through its involvement in the Frugacit  research programme launched in 2019 as part of a call for projects (BAUM) by the Urban Planning, Construction and Architecture Plan (PUCA), AREP is contributing to the development of a decision-making tool for architectural and urban planning and design aimed at improving landscape connectivity in neighbourhoods around railway stations.

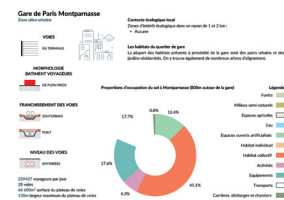
Research and its applications in multi-scale projects aim to drastically reduce carbon emissions and adapt territories to the climate change already underway in order to prepare for a carbon-free future. The rail network can play a lasting role in this approach and, more broadly, become a key player in the ecological transition. AREP's future work will focus on developing tools to improve ecological connectivity, drawing on graph theory and adapting it to the practices of each stakeholder. The aim is to create a strategy that respects the priorities of stakeholders while guiding their actions in favour of biodiversity.

Contact

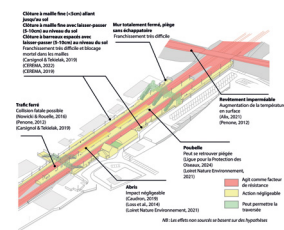
Dpt. Project Management Assistance / Environmental Strategy, Research and Innovation Unit: Alexandre Auvray
Research ongoing since 2019



Management practices applied according to railway infrastructure components.
 © AREP - A. Auvray, 2024



Analysis sheet for a railway station.
 © AREP - A. Auvray, 2024

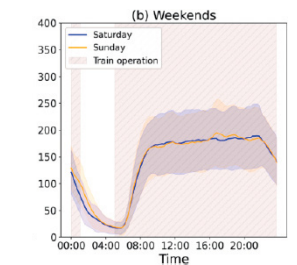
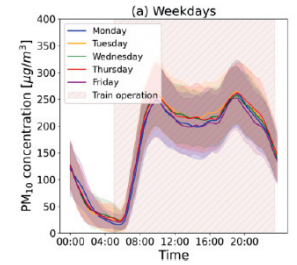


Details of architectural forms and their effects on the potential movement of wildlife at the station.
 © AREP, 2024

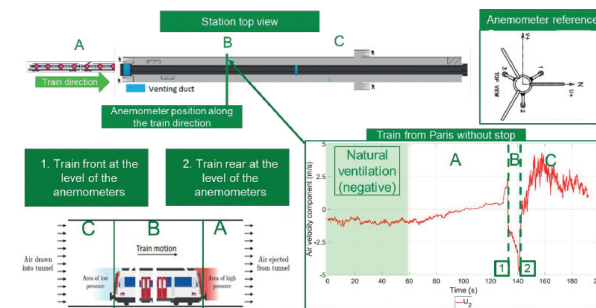
Predicting and improving Indoor Air Quality in underground stations (IAQ)

The research develops tools and models for continuously measuring air quality, providing a better understanding of its variations in railway contexts.

The work carried out has led to the development of a 1D modelling tool based on one-dimensional discretisation of underground stations along the track axis, enabling detailed modelling of the distribution of filtration sources on platforms. Its physical model accurately reproduces changes in fine particle concentrations (PM10-2.5 and PM2.5) in relation to railway activity. This tool can therefore be used to optimise filtration systems in underground stations according to different objectives: maximum reduction in concentrations, compromise with energy consumption, or maintenance management. It can also simulate the effect of filters with variable efficiency or flow rates modulated throughout the day. Designed to be adaptable to other particle size classes, it provides a robust basis for decision-making.



PM10 concentration profiles at the stations studied during the week and at weekends.
 © AREP, 2024



Schematic illustration of the piston effect measured at Sevran-Beaudoctes station showing the change in air speed during the passage of a train.
 © AREP, 2024

Contacts

Dpt. Engineering / L'Hypercube (CFD Expertise): Anne Mesureur, Mateusz Bogdan
Research ongoing since 2015

Sobriety and comfort

The research aims to further study design tools and passive solutions for adapting existing living spaces, integrating both technical and social dimensions. The objective is twofold: to understand the thermal efficiency of these solutions and to assess their suitability for users' needs, uses and perceptions.

AREP's objective is to develop and evaluate participatory support methods aimed at facilitating user engagement from the design stages onwards, in order to promote social acceptance and sustainable adoption of passive thermal adaptation solutions in existing buildings. The aim is to understand how these methods influence the redefinition of thermal comfort criteria and to identify the optimal technical and social integration conditions, combining architectural approaches and human sciences to remove the social barriers to the effective adoption of these systems.



Diagram showing the relationships between individual, participation and design.

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Contacts

Dpt. Project Management Assistance / Environmental Strategy, Research and Innovation Unit: Sabine Thomas
 Dpt. Engineering / Data and Modelling: Lucas Bohnenkamp
 Research ongoing since 2022

Mapping intermodality at railway stations

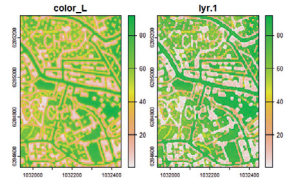
The research aims to address the lack of robust, systematic and reproducible methods for measuring actual intermodal accessibility at different spatial and temporal scales around a given rail hub, or for reconstructing land use based on old maps that are rarely suitable for automated processing.

The method combines the collection of territorial data (transport supply, roads, parking), field observations and interviews, which are translated into spatial and functional indicators. The tools presented include GIS templates for multi-layer visualisation, multi-criteria matrices for classifying stations by intermodal potential, and intervention scenarios (development of bicycle facilities, optimisation of station esplanades, creation of multimodal transport hubs).

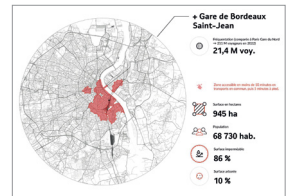
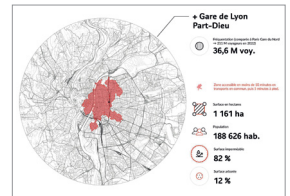
The research highlights the need for collaborative work with local authorities and operators to remove land and regulatory barriers and emphasises the importance of short-term operational indicators (actual access time, observed intermodality rate) and long-term indicators (modal share, user satisfaction). Examples of regional applications illustrate the rapid gains achieved through micro-developments and road reorganisation, as well as structural projects such as the creation of safe cycle paths connecting stations and neighbourhoods. It also enables several recommendations to be made: inclusive design (for people with reduced mobility), low-impact multimodality and timetable coordination, the use of continuous monitoring tools, and the integration of data into BIM/GIS.

Contacts

Dpt. Urban Studies & Regional Planning / Urbanisme : Grégoire Robida
 Dpt. Engineering / Data and Modelling: Félix Pouchain
 Dpt. Project Management Assistance / Environmental Strategy, Research and Innovation Unit: Louis Deloche



Pre-processing of a rasterised IGN map from the 1950s.
 © AREP, 2024



Maps showing accessibility by public transport from two SNCF railway stations.
 © AREP, 2024

Prospective studies on SERMs

The research aims to guide investment and optimisation decisions for stations as part of the deployment of SERMs (*service express régional métropolitain*). The challenge is to provide public and technical stakeholders with the tools they need to objectively determine priorities for action, taking into account local socio-economic profiles, accessibility constraints and station capacity at peak times.

The overall objective of this work is to develop a robust spatial analysis framework that will enable each station to be assessed according to a set of technical, territorial and functional criteria, and then to model the expected effects of the transformations based on several operating scenarios. This methodological framework is intended to be applied on a national scale (more than 250 stations analysed by 2024), with an initial field trial in the Rouen area.

The RADAR tool can be used to reproduce the multi-criteria assessments carried out on each site. This work provides a coherent territorial overview of station capacity in the event of a change in operating regime. It also paves the way for other uses, particularly in the context of intermodal planning, projects to revitalise underserved areas, or medium-term capacity growth scenarios.

Contacts

Dpt. Urban Studies & Regional Planning / Flows and Mobility Expertise: Guillaume Chauvet, Mina Roncière



Multi-stakeholder workshop on developing a strategic vision for the organisation of SERM car parks in Rouen.

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Example of results presentation – Summary for Sélestat station.

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Assessment of services offered at Sélestat station – RADAR tool.

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Railway gauges

The dimensions of gauges are governed by national and international standards that ensure interoperability between the railway networks of different countries and facilitate international transport. Controlling train gauges is therefore essential for the management and safety of railway infrastructure. The safety of passengers and railway staff depends directly on analyses that define and comply with gauges, ensuring that rolling stock and infrastructure are designed to allow trains to run freely and efficiently on the network. In practice, gauge analysis is used for planning new railway lines, adapting trains to new routes, and upgrading existing infrastructure. It plays a key role in the sustainable development of rail transport by optimising the use of resources and reducing operating costs.

The research involves automating gauge calculations to construct cross-sections and BIM objects in order to automate the detection of interference with structures to be built and ensure collision-free traffic with fixed elements of the railway network, such as platforms, tunnels, bridges and signalling.

The prototype gauge generator transforms geometric parameters (camber, vertical radius, speed, longitudinal slope) into numerical formulas to automatically generate railway gauges in a reproducible manner in different inter-software environments.

Contact

Dpt. Building Design & Production / Studio 1: Denis Malaquin
Research ongoing since 2023



Nom du champ de formulation	Commentaire	Illustration
Durées	Si c'est une voie temporaire ou dédiée, il n'y a pratiquement pas de durée. S'il n'y a pas de durée : metric + 0 ->. S'il y a du objet, renseigner la valeur en mètres.	
Vitesse maximale de circulation	Renseigner la vitesse maximale de circulation des trains sur cette voie, en km/h.	
Rayon vertical	Si c'est une voie temporaire ou dédiée, metric + 50 ->. Si c'est une voie normale d'axe plat, metric + 0 ->. Si c'est une voie normale d'axe plat, sélectionner « Non ».	
M = forfaitaire	Si c'est une voie normale d'axe plat, sélectionner « Non ».	

Description of several geometric parameters of the gauge generator.

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Building and biodiversity heritage

The research aims to develop an integrated approach to heritage preservation, considering both built (architectural) heritage and living heritage (flora and fauna). In this context, the goal is to develop a new unified vision of heritage, integrating and combining its built and biological components.

This work seeks to answer the following question: how can the preservation of built heritage be reconciled with the protection of living heritage, taking into account the sometimes contradictory requirements of architectural and ecological conservation? It explores the convergence between heritage and biodiversity, showing how their rapprochement redefines conservation and project practices. The research develops a methodology based on a renewed and regenerative approach in which heritage is not static, but becomes a living ecosystem, a player in ecological transition and cultural transmission. The answers provided cover both the study of epistemological issues and the operational side shared through international exchanges.



International exchanges: Seminar on Sino-French Contemporary Architecture Education.

© AREP, 2024



Research report on epistemological issues.

© AREP - Érica Champeau, 2024

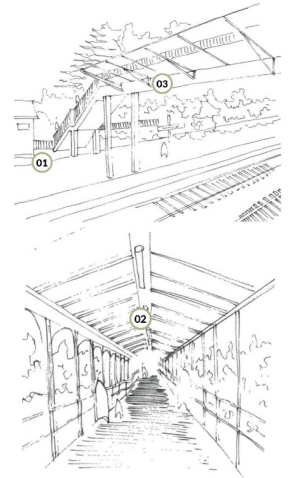
Contact

Dpt. Building Design & Production / Heritage Building Expertise / Elevating Systems Studio: Véronique Veston

Principles of railway eco-maintenance

Infrastructure projects today face two major challenges: the need to maintain existing structures quickly and efficiently, and the imperative to incorporate environmentally friendly practices. Corrective maintenance, often triggered by safety requirements, high demands or wear and tear, requires ad hoc interventions that are constrained by time. In this context, taking sustainability issues into account becomes a major challenge, as these operations must combine responsiveness, technical efficiency and environmental responsibility.

Eco-maintenance proposes integrating environmental criteria into railway maintenance practices in order to reduce the ecological footprint while preserving operational reliability. Targeted actions include optimising interventions (predictive planning), using low-impact lubricants and consumables, circular management of parts (repair, reconditioning) and waste control. Performance indicators (energy consumption related to construction sites, pollutant emissions) and diagnostic methods are used to monitor the application of these principles and prioritise interventions with the greatest environmental impact.



- 01 • Gestion des eaux pluviales
Récupération des eaux de pluie pour le nettoyage ou l'arrosage ; Gestion paysagère pour éviter le rejet dans le réseau.
- 02 • Éclairage • Biomatériaux
Approvisionnement par la filière de réemploi
• Efficacité et Sécurité Énergétique
Éclairage LED • Détection de présence
- 03 • Éviter les déchets
Privilégier la conservation et la rénovation pour limiter la production de déchets (pollués ou non pollués)
• Réemployer
Caractériser les ressources (volume de béton, linéaire de garde-corps et main courantes, revêtement de sol, etc.)
Dialoguer avec les acteurs locaux de l'ESS pour évaluer le potentiel de réemploi de ces « petits » éléments
• Valoriser les déchets
Caractériser les déchets générés par son chantier et cibler des taux de valorisation. Par exemple si la structure est en acier, le taux de valorisation du chantier pourra atteindre 100%
- 05 • Biodiversité
Respecter les périodes de nidification dans la planification des travaux. Prendre en compte le contexte écologique du site dans la réalisation du chantier.

Diagnostic criteria and methods for eco-maintenance –

Footbridges case study.

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Contacts

Dpt. Project Management Assistance / Paris Region Unit: Sophie Untersinger, Vanessa Nègre

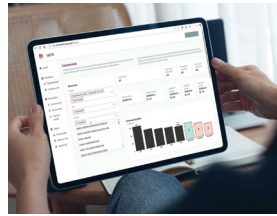
Strategies for reducing building energy consumption

The aim of the research is to support the implementation of the Tertiary Eco-Energy Decree (DEET) in the specific case of railway stations and to extend it in line with the group's ambitions (EMC2B criteria).

This research has two complementary objectives:

- Supporting SNCF Gares & Connexions in its energy transition and ensuring its assets comply with the DEET;
- Developing, deploying and continuously improving the 'energy calculator' specific to railway stations.

AREP offers an integrated methodology for reducing energy consumption in 277 stations by designing customised, phased action plans through to 2050. Within this framework, research is developing a methodology that incorporates on-site inventories, simplified energy models and data analysis capitalising on work already carried out in other similar heritage buildings. The research makes it possible to target the most relevant tools to ensure a simple user interface and complex, accurate calculations. A tool (ODETTE) and a collaborative platform facilitate the generation, verification and transfer of multi-site packages to other heritage sites, ensuring the reliability, feasibility and traceability of decisions.



Outil ODETTE.
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Contacts

Dpt. Engineering / Data and Modelling: Félix Pouchain / HVAC: William Teyssier
Research ongoing since 2021

Facades and building envelopes

Despite technological and regulatory progress, the facade systems currently in use still have certain limitations when it comes to meeting increasingly demanding performance standards.

These shortcomings relate in particular to reducing heat loss and improving energy efficiency throughout the building's life cycle, two key factors in meeting environmental requirements.

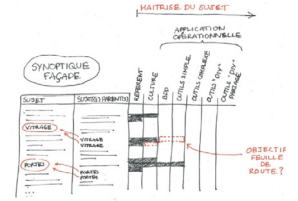
The objective of this research is to develop a new comprehensive approach to facades, by theorising a design framework between architecture and engineering in order to significantly increase their performance, particularly their energy efficiency, and to meet new performance requirements while complying with normative, regulatory, aesthetic, safety and comfort constraints, in line with the EMC2B approach.

The project consists of the following components:

- Mapping architectural, safety and comfort issues in relation to the environmental impact of facades;
- Assessing the level of expertise in various areas related to facades;
- Developing and deploying tools for studying facades at different scales in line with existing project design processes.

Contact

Dpt. Engineering / Building Structure & Enveloppe: Laura Poinloup



Roadmap diagram.
© AREP - L. Poinloup, 2024



Mind map of issues related to facades and building envelopes.
© AREP, 2024

RE-USE: reuse of wood

This approach responds to several converging motivations. From an environmental perspective, it reduces the carbon footprint and costs associated with extracting and processing virgin resources, while making use of already available deposits such as discarded railway sleepers or parquet flooring from renovation projects. From a scientific and technical standpoint, it aims to remove uncertainties related to the heterogeneity of these materials, their dimensional stability, their chemical safety and their compatibility with safety standards (particularly fire safety). Finally, from an operational standpoint, the aim is to verify that these materials can be processed and assembled in a reproducible process that is compatible with construction site constraints and architectural requirements.

To address these challenges, the approach was structured in three parts:

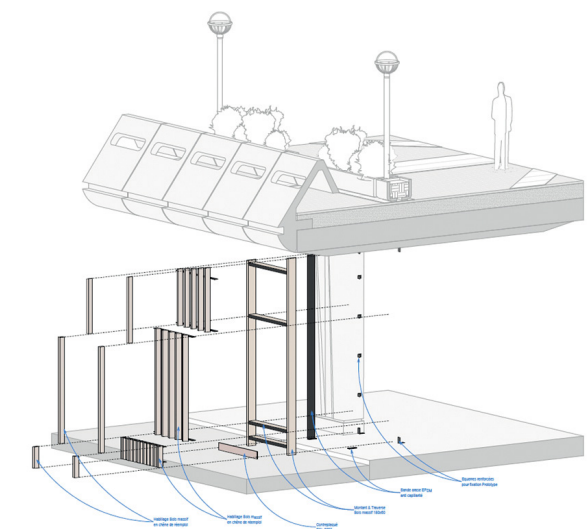
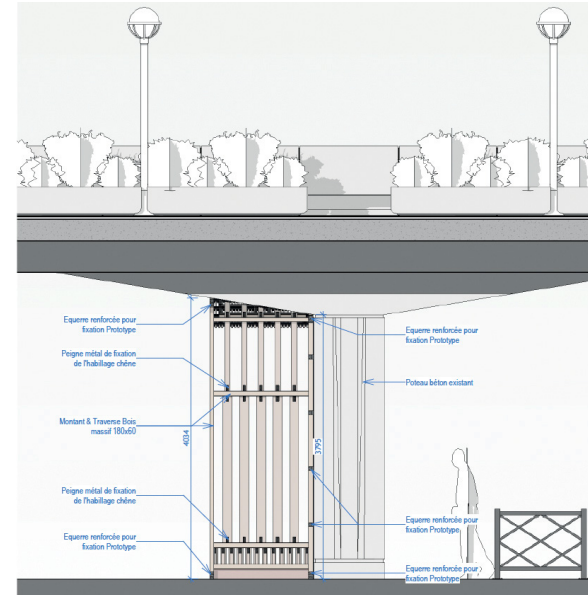
- The development of a facade prototype designed to test the methods for removing, preserving and reusing materials in real conditions;
- A study of the feasibility of construction, aimed at analysing the effective integration of available resources and addressing the technical and regulatory constraints of the project;
- A study of facade treatment, focusing on protection, finishing and dismantling solutions applicable to reused wood.



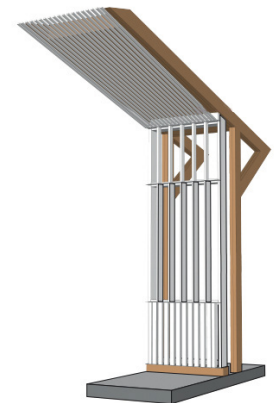
Parquet flooring deposits.
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Railway sleeper deposit.
© AREP - Alix Estique, 2015



Two full-scale prototypes have been built, one for a section of railway sleeper facade, the other for an oak slatted ceiling. These demonstrators are used not only to test architectural configurations and technical processes, but also to gather scientific and industrial feedback on the conditions necessary for the widespread reuse of materials in a complex urban project subject to strict safety and image constraints.
© AREP, 2024



Modelling and schematic drawings of the prototype at Gare de Lyon station.
© AREP, 2024

Contacts

Dpt. Building Design & Production / Studio 7 : Beatriz Castro, Gabriel Robinne, Honoré Albaret

Dpt. Project Management Assistance / Paris Region Unit: Thaïs Guimaraes

Research ongoing since 2019

RE-USE: reuse in the railway sector

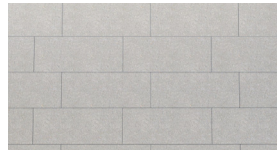
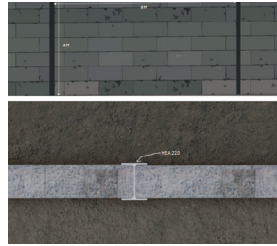
The research aims to organise, test and evaluate the potential for reusing concrete and sound equipment in a railway context.

The first phase identified 20 materials with high reuse potential using a multi-criteria pre-selection method based on field experiments and a targeted analysis of SNCF projects.

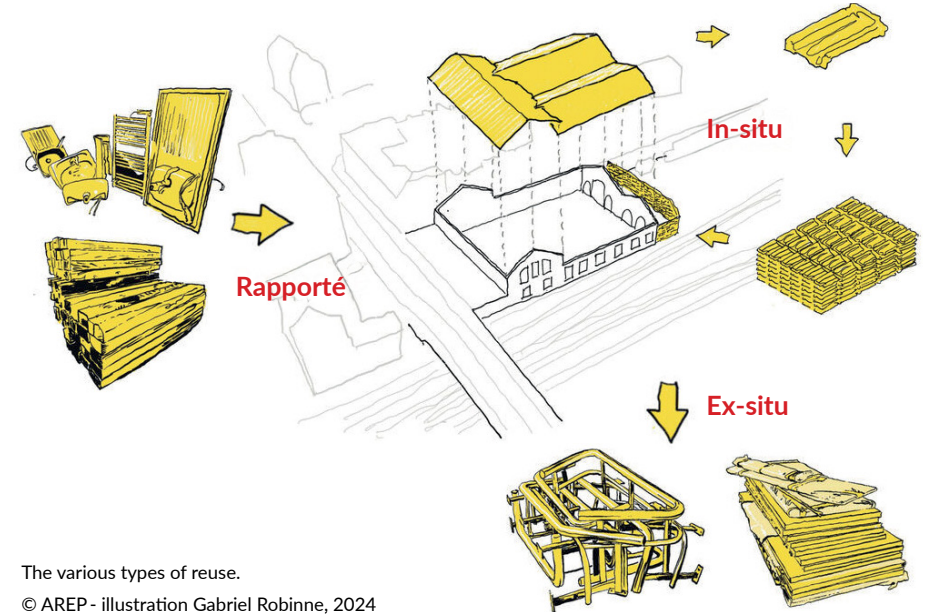
In a second phase, the focus was on deconstructed concrete: a diagnostic methodology was established (non-destructive and destructive), followed by the development of a prototype masonry wall using blocks cut from concrete walls.

This prototype, modelled from standardised blocks (1.5 m x 0.6 m), explores several types of assembly (weight, mechanical, stitching) and is the subject of an environmental analysis demonstrating carbon savings above certain dimensions.

Finally, a concrete strategy for reusing sound equipment (loudspeakers, end-of-line components) was implemented, based on a detailed PEMD diagnosis to identify, test and reimplement existing equipment in several areas of the project.



Prototype design for the reuse of sawn concrete slabs.
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The various types of reuse.
© AREP - illustration Gabriel Robinne, 2024



Construction site resources.
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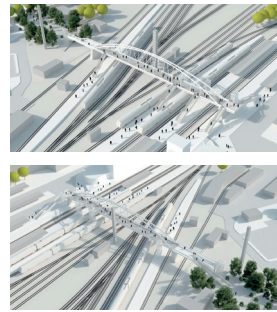
Contacts

Dpt. Engineering / Environnement : Valérie Cousturier, Olivier James
Research ongoing since 2019

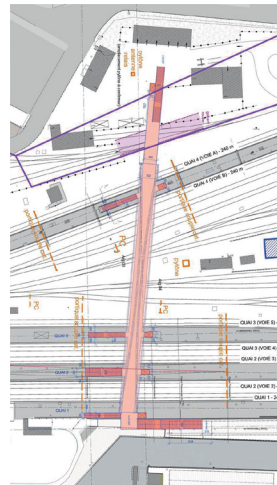
Development of a long-span railway footbridge

This project is part of the programme to make the platforms at Dunkirk station accessible, and aims to design and build a long-span footbridge (85 m) capable of spanning the entire railway network without intermediate supports, using a bow-string structure. The aim is to use models and environmental simulations to determine whether a long-span design can effectively achieve structural and environmental optimisation compared to a more conventional solution with several spans.

Over the course of these iterations, the long-span solution has been consolidated, not as a theoretical alternative, but as a technically credible and potentially more environmentally sound option. Residual uncertainties, particularly those related to fine catenary constraints, the implementation of protective measures, the impact of deflection during service, and the exact dimensions of the anchor blocks, have been documented and will be the subject of further investigation during the detailed design phase. The work carried out in 2024 has thus demonstrated that the challenge of a support-free footbridge in this context can be met without sacrificing technical performance or increasing the carbon footprint. The structured, reproducible approach, based on accurate simulations and a proportionate environmental assessment, has thus made it possible to objectify an initial decision based on the intuition of geometric simplification, turning it into a concrete leveraging point for optimisation across the entire life cycle.



Evolution of the structural principles of the footbridge.
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Implantation of the footbridge.
© AREP, 2024

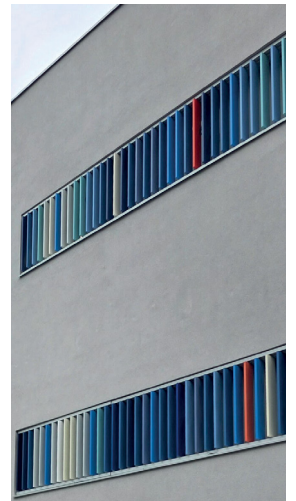
Contacts

Dpt. Project Management Assistance: Julien Dallot / Studio 12: Sébastien Geffroy

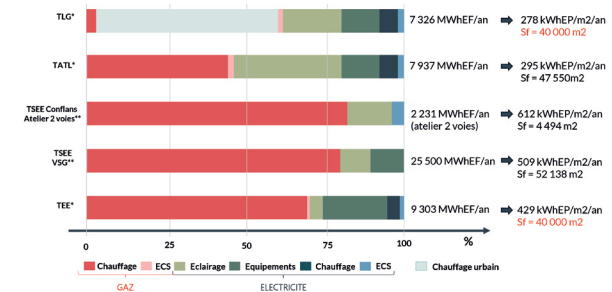
Sobriety and sustainability of maintenance facilities

As part of its energy transition commitments, SNCF Voyageurs has launched an ambitious project to transform energy management at its TGV maintenance facilities. These industrial sites, which have high energy consumption, represent the company's second largest energy expense after traction power. The overall objective is to achieve 45% energy savings by 2025 compared to the 2019 reference year, with a longer-term ambition to have a positive energy, fully decarbonised technical facility by 2030.

All the work carried out in 2024 made it possible to test, adapt and document two complementary applied research approaches. On the one hand, energy optimisation in partially instrumented technical centres led to a reproducible method for regulating and prioritising actions, which can be applied to all facilities. On the other hand, the experiment conducted at the Brétigny Technical Facility on a construction solution using reinforced solid stone opened up a new field of investigation, combining structural innovation and low-carbon performance, and resulting in initial models and protocols awaiting full experimental validation.



South-East European Technical Centre 4.0 – Multi-service building – Facade.
© AREP, 2025



Breakdown of annual energy consumption by technical facility (heating, hot water, lighting, equipment).
© AREP, 2024

Contacts

Dpt. Project Management Assistance / Paris Region Unit: Thaÿs Guimaraes / Regional Unit: Adrien Beretti / Environmental Strategy, Research and Innovation Unit: Laura Pointu

Multi-criteria modelling of people flows

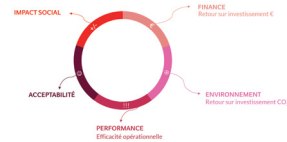
In a context of growing multimodal mobility and increased traffic flows in transport areas, understanding and anticipating user travel behaviour in and around stations is now a major scientific challenge. However, planning for low-carbon mobility involves striking a balance between environmental requirements and quality of use. If the measures put in place (longer pedestrian routes, increased connection times, reduced accessibility) make the passenger experience less comfortable, there is a real risk that people will turn away from rail travel, particularly in favour of cars.

These observations point to the same problem: the difficulty of simultaneously integrating behavioural, technical, environmental and psychosocial dimensions into robust predictive models that are adapted to the complexity of intermodal rail systems. This calls for a shift in methods towards more integrated, multi-criteria tools that are sensitive to the local context and capable of supporting the sustainable transformation of mobility.

Modelling passenger flows aims to provide an operational framework combining data collection, multi-scale modelling and decision support tools to optimise station design and operation. The methodology is based on the integration of static data (plans, capacities) and dynamic data (counts, sensors, validation data) to calibrate microsimulation models and macroscopic flow models.

Contacts

Dpt. Urban Studies & Regional Planning / Flows and Mobility Expertise: Matthieu Goudeau, Capucine-Marin Dubroca-Voisin



Criteria for evaluating flow management.
© AREP, 2024



Analysis of the configuration of an intermodal transport hub
– Lyon Part-Dieu station.
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Low-carbon structures

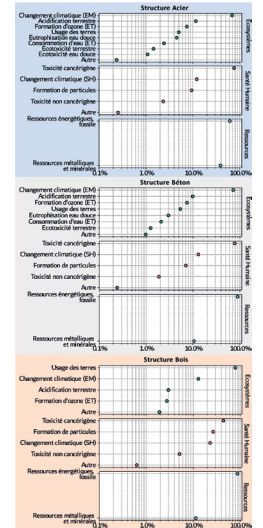
The aim of the research is to identify levers for reducing the environmental footprint of structural elements in buildings using a multi-criteria approach. As the subject of a PhD thesis, it identified the most significant areas in building structures based on various indicators: global warming, impacts on biodiversity, human health, resource consumption and waste production.

Pierre Navaro-Auburtin's work has led to the development of an in-depth Life Cycle Assessment (LCA) method coupled with structural calculations. By targeting various significant parameters such as materials, span, structural grid and number of levels, the analysis revealed how they influence overall environmental impact. The study also looked at ways to reduce these impacts, particularly through the use of cut stone structures, and analysed decarbonisation strategies in industry.

This research highlighted that floors have the greatest impact in terms of emissions, making them the priority area for reducing the carbon footprint of structures. Sensitivity analyses confirmed the decisive role of parameters such as transport, workshop losses and energy consumption during cutting, while the development of a structural carbon budget made it possible to position the solutions studied in relation to the trajectories set by the National Low Carbon Strategy (SNBC) and RE2020.

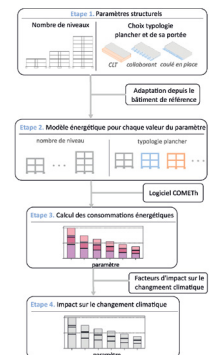
Methodology used to calculate the impact of energy consumption based on structural parameters.

© AREP - Pierre Navaro-Auburtin, 2024



Contribution of intermediate impacts to damage for concrete, steel and timber structures; logarithmic scale.

Pierre Navaro-Auburtin, 2024



Contact

Dpt. Engineering / Building Structure & Enveloppe: Jean-Luc Martin
Research ongoing since 2022



Paris Nord railway station – The solar bicycle hall.

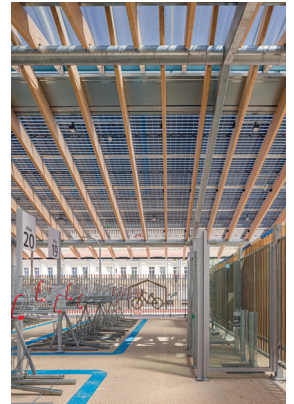
© AREP - picture Guillaume Satre, August 2024

Bicycle shelters designed by and for users

In a context of urban mobility transformation, the development of infrastructure adapted to cycling is an essential lever for encouraging active travel. This research aims to identify specific priority usage criteria, gain a better understanding of perceived shortcomings that are often overlooked in technical standards, and develop bicycle shelters that are tailored to the diverse needs of users, thereby optimising the safety, accessibility and practicality of these structures.

Various missions were carried out:

- A study of the implementation of User Experience Assistance in the design and conversion of public buildings, enabling users and staff to be involved in all phases of the project, from diagnosis to operation, in order to better meet their needs and ensure sustainable appropriation of spaces;
- A comparative and participatory analysis to secure bicycle shelters, particularly at the Rosa Parks station, combining a review of technical and usage measures with user surveys to inform recommendations;
- Field surveys, particularly at the Champ de Mars station, to document the practices and expectations of different audiences, identify specific issues at the site, and develop appropriate development guidelines.



Paris Nord railway station – The solar bicycle hall, interior.

© AREP - picture Guillaume Satre, juin 2024



Colmar railway station – Bicycle shelter.

© AREP, juillet 2024

Contact

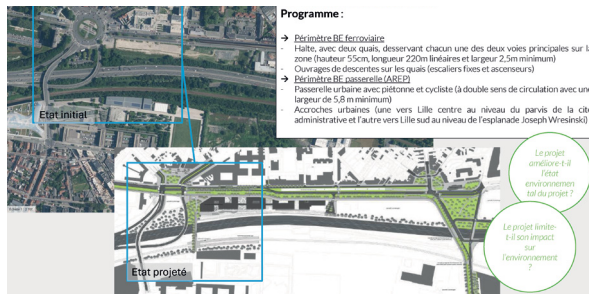
Dpt. Project Management Assistance / Paris Region Unit: Quentin Guyonnaud

Environmental indicators

The aim of this research area is to develop a tool for calculating environmental performance based on a multi-stage assessment analysing projects from the design phase to completion and operation:

- Design phase: indicators are developed based on public and documentary data;
- Implementation and operation phases: these are based on additional data from project-specific studies (ecological inventories, phytosanitary studies, acoustic studies, urban heat island studies, etc.);
- Administrative phase: these indicators are translated into concrete elements to inform regulatory files and support environmental procedures, particularly those covered by the Environment Code.

This tool aims to enable the environmental performance of a project to be assessed and the project choices to be justified (particularly with regard to Environment Code procedures), taking into account the diverse and complex impacts on natural environments, biodiversity, air quality, noise and other environmental components.



Example of the study and use of environmental indicators – Creation of a stop at Lille porte des postes.

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Contacts

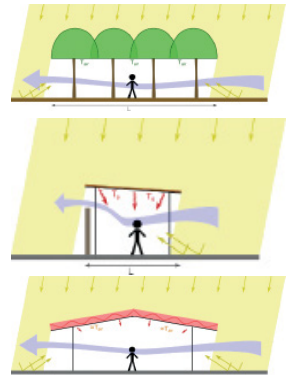
Dpt. Project Management Assistance / Environmental Strategy, Research and Innovation Unit: Sabine Thomas, Chloé Nguyen

Comfort in semi-open spaces (CSOS)

AREP is studying the perception of comfort in semi-open spaces. The research is developing simulation chains, analysis models and approaches for representing physical phenomena within stations and semi-open spaces, taking into account all the parameters that contribute to feelings of discomfort. The research refines the classic hypothesis of homogeneous room temperature by developing models with spatialised information. Today, it is being deployed through studies of thermal comfort, wind comfort and exposure to driving rain in numerous stations.

The approach combines:

- Empirical diagnostics and state of the art on hygrothermics and comfort;
- Hygrothermal and wind simulations to quantify exposure to WDR (wetting by rain) and thermal conditions;
- Development of AREP tools (Visumétéo, EMC2B indicator for thermal discomfort, characterisation of weather shelters);
- Integration of a framework of environmental indicators (carbon, materials, space) to assess life cycle impacts.



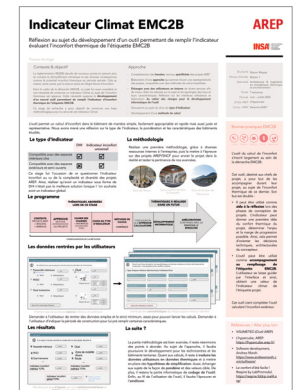
ABRICOCODA research: Thermal performance of continuous tree-covered areas; Design flaws in current covered shelters; Covered shelters that provide thermal refuge.

© AREP, 2024

The project highlights the need to combine physical simulations and user perception, as well as to incorporate participatory approaches to ensure the acceptability and robustness of the solutions deployed.

Poster presenting the EMC2B Climate indicator.

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Contacts

Dpt. Engineering / L'Hypercube (CFD Expertise): Mateusz Bogdan, Alexis Sauvageon
Research ongoing since 2015

Intermodality and informality

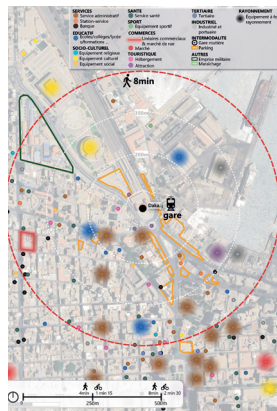
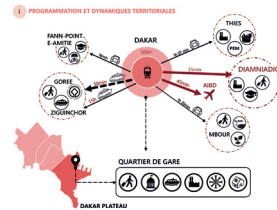
Through two studies conducted in Senegal, AREP is developing specific methods and results on the issue of urban planning in the context of informal occupation. One project focuses on the establishment and development of future Bus Rapid Transit (BRT) stations across 13 municipalities in Dakar. At the national level, a Regional Express Train project aims to relieve congestion in the capital by providing connections between major cities.

The research involves sociological surveys and site studies to characterise the informal occupation of land identified for the new stations. This work helps to inform urban development strategies that contribute to economic revitalisation in specific contexts. These studies are coupled with low-carbon ecological ambitions. The projects benefit from in-depth studies that enable the implementation of a low-carbon urban development demonstrator, adapted to the specific context of a Senegalese neighbourhood marked by informality, with the aim of becoming the pilot for a generation of future changes.

The work carried out has led to the development of an integrated approach to urban planning applied to the BRT corridor, combining multi-scale territorial analysis, tailored development strategies and improvements to digital modelling environments. The approach has resulted in the definition of robust spatial organisation principles, which have been translated into detailed development plans for each section and integrated into a scalable GIS platform.

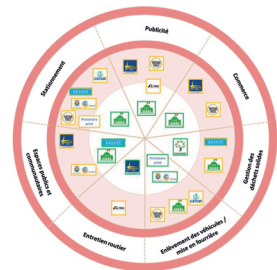
Contact

Dpt. Urban Studies & Regional Planning / Urban Studies: Cécile Lelasseux
 Research ongoing since 2017



Diagnosis of the Dakar railway station neighbourhood.

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Mapping of BRT stakeholders.

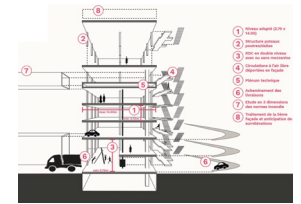
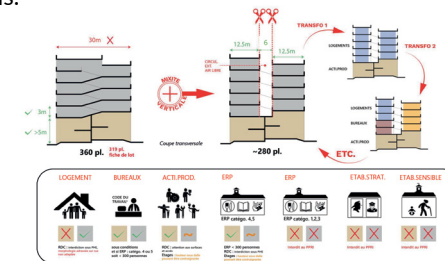
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Vertical mixed-use

The research aims to develop a reproducible method for designing buildings that are “capable” of vertical mixed-use:

- Establishing a reference framework for activity/housing compatibility (thresholds: surface areas, ceiling heights, loads, grids, acoustics/airflow);
- Define fire safety strategies that promote reversibility (external circulation, management based on the most restrictive volume, compartmentalisation/fire safety);
- Characterise the architectural framework (thickness, slab height, spans, externalised cores, reversible parking);
- Validate on real cases up to the point of obtaining a building permit without a specific use, i.e. a permit allowing the envelope and structural characteristics of the building to be constructed without immediately determining the final function of the spaces.

In 2024, the research provided a new technical standard for reversible vertical mixed-use buildings, which still needs to be supplemented by acoustic measurements under load, evacuation/compartmentalisation tests based on actual assemblies, and logistics tests. The objective of this area of research is to verify the reference framework from the previous phase in real-life situations.



Architectural and technical principles of a mixed-use building.
 © AREP, 2024

Adaptation of the initial project to anticipate the possibility of mixed use.

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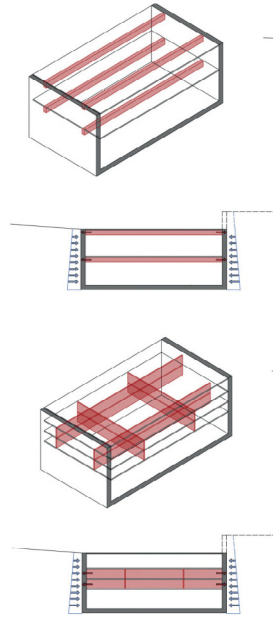
Dpt. Consulting & Programming: Simon De La Saussay

Architectural optimisation in highly constrained environments

The aim of this research is to develop underground plans that optimise space utilisation in a highly constrained environment and in line with significant safety issues.

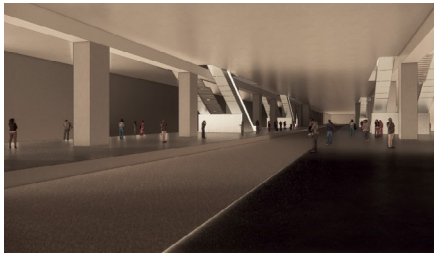
For the underground extension of Marseille Saint-Charles railway station, the aim is to ensure that evacuation routes from a depth of 25 metres comply with standards in both normal and degraded conditions, that the walls and structures remain stable over time, and that the tracks are functionally connected to the existing tunnels. These challenges are part of a complex context and complicate the architectural design: heterogeneous soils, numerous neighbouring structures, the requirement to evacuate passengers from the platforms in less than ten minutes, and the connection of the tracks to the existing tunnels without loss of gauge.

Various technical choices, such as moving the main ducts below platform level, combined with fine-tuning the altimetry by zone and taking into account the tramway/ tunnel interfaces, have made it possible to achieve a coherent set of usable surfaces and gauges without compromising the useful widths of the platforms.



Explored retaining solutions and variants.

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Impact of structural variations at platform level.

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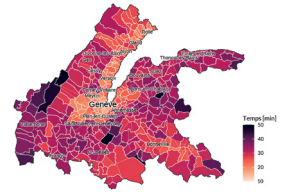
Dpt. Building Design & Production / Studio 8: Tim Kennaugh, Pierre Amic

Modelling of travel patterns at regional level (Mobility)

Development of the Mobility platform is continuing in order to perfect a tool combining multi-scale travel modelling and carbon footprint assessment. This solution makes it possible to analyse current mobility practices, test the impact of decarbonisation levers and provide a forward-looking framework to support public decision-making. It thus provides operational support to guide the region towards more sustainable, multimodal and low-carbon mobility.

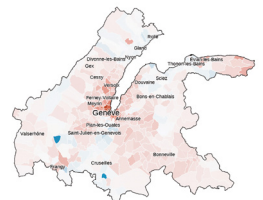
The 2025 project focused on measures to decarbonise transport across Greater Geneva. Previous research and development efforts had led to the creation of an integrated platform, Mobility Grand Genève, which provides an operational framework for analysing and simulating travel patterns.

The work carried out has made it possible to implement a dual macro and micro approach, develop modal choice and distribution models, and gradually integrate complementary modules such as intermodality, carpooling, congestion and increased spatial resolution. New methods were tested to resolve convergence issues and improve the accuracy of simulations, while exploring different decarbonisation scenarios. These developments have led to an operational platform capable of simulating mobility practices more realistically, assessing their territorial and environmental impacts, and providing a solid scientific basis for the next phases of the project.

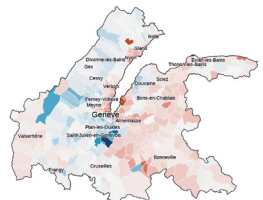


Temps moyen de trajet pour le motif domicile-travail – Genève.

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-2.514% 0.21% 5.16% 0.67 5.9%



-320% -51% 0% 51% 320%

Example of modelling a lever (bicycle subsidy) and its effects (change in overall cost [top], carbon footprint [bottom]).

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Contacts

Dpt. Engineering / Data and Modelling: Félix Pouchain

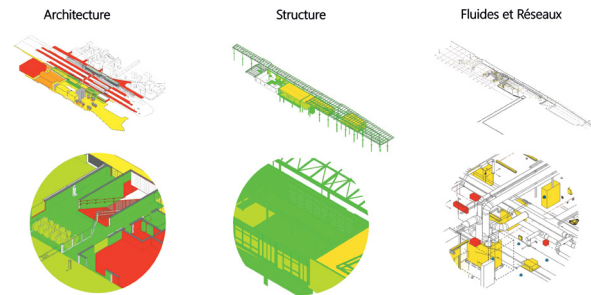
Dpt. Urban Studies & Regional Planning / Flows and Mobility Expertise: Capucine-Marine Dubroca-Voisin

Research ongoing since 2021

Development of BIM tools

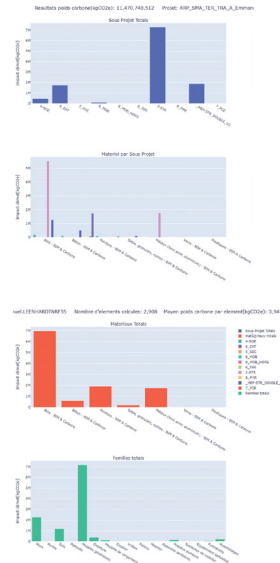
This research covers the design and development of BIM tools and a comprehensive BIM strategy. In 2024, the work led to the development of a module integrated into REVIT for calculating the carbon footprint of modelled buildings. All of these developments make it possible to perform these calculations throughout the design process, monitor construction sites, and identify malfunctions. The reports generated provide key indicators such as total carbon footprint, the number of elements analysed and their distribution by sub-project and by material. The BIM&Carbon module, combined with the BIM&Material developments, is thus establishing itself as an operational tool that not only identifies the main sources of emissions, but also proposes appropriate areas for improvement.

Additional studies have made it possible to examine the use of BIM through the prism of sustainability issues (organisational, digital, carbon, materials), to model a socio-ecological system in multi-level networks, and to develop effective data extraction tools.



Contacts

Dpt. Engineering / BIM and Methods: Marie Chaumaz, Joaquin Giner Calzada
 Research ongoing since 2019



Example of a report generated by the module (climate impact by element class).
 © AREP, 2024

Overview of results on digital models..
 © AREP, 2024

Play-based formats

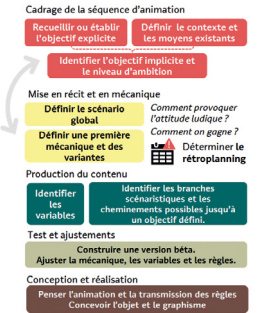
This research aims to understand the contribution of play-based approaches to the professional practices of programming designers and to determine the optimal conditions for their use in order to make them a reliable tool. The ambition is to move beyond the occasional and intuitive use of play-based approaches and propose a structured methodology that is adapted to the professional context and geared towards ecological and societal transition. Three pilot experiments were conducted to assess the impact of different gaming mechanisms (time constraints, simulation, cooperation, competition, manipulation) on creativity, cohesion and the effectiveness of collective productions: Workshop Passerelles, Taverny Archiclasse and Frugal Pursuit. The objectives pursued were:

- long-term training and learning, through the implementation of educational and accessible games that enable users to understand and memorise complex content;
- co-creation, by using collaborative formats that facilitate expression and take into account the participation of all stakeholders involved;
- communication and awareness-raising, using concise tools that make technical or conceptual ideas accessible in a limited amount of time;
- cohesion, through the introduction of personalised, fun formats that encourage informal sharing and strengthen bonds between participants.

Ultimately, the aim is to stimulate the collective ideation and production of new narratives and shared references that can inform urban and architectural design from a post-carbon perspective.

Contacts

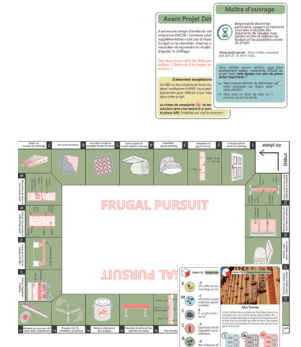
Dpt. Consulting & Programming: Mélanie Barey, Lisa Favaretto



Design methodology.
 © AREP, 2024



Taverny Archiclasse display unit.
 © AREP, 2024



Overview of the "Frugal Pursuit" game. © AREP, 2024

Prototypes

Testing innovative solutions for a post-carbon future

Innovative facades prototypes



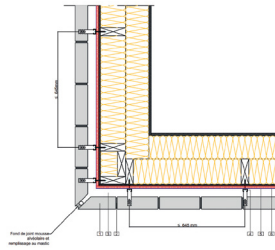
Pantin Grandes Serres Construction Site – Facade prototype.
© AREP, September 2025



South-East European Technical Centre 4.0
– Multi-service building
– Facade prototype.
© AREP, October 2025

ATEx COB

Development of a double-wall brick system on a wooden structure called “COBrique”. ATEx developed for the “Infrapôle” offices in Versailles-Chantiers.



Bevel cut with mitre joint.
© AREP, 2025



Relocation building for the SNCF “Infrapôle” offices in Versailles-Chantiers.
© AREP, 2025

SOLVEIG (Reversible solarisation system on tracks)

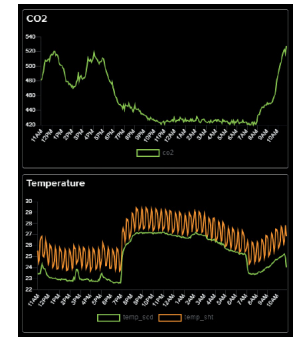
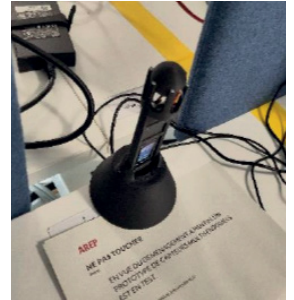
Production of a mobile and articulated prototype device for deploying photovoltaic solar panels on railway tracks.



Installation of the prototype on site.
© SNCF/AREP - picture Yann Audic, January 2025

Ambiant sensor

Prototype of an ambient sensor to assist in the use of passive thermal comfort systems.



Overview of the device and data collection.
© AREP, 2025

Outlook of scientific publications in 2025

Auvray, Alexandre. “Retour sur la journée d'étude ‘Qualifier l'interdisciplinarité : vocabulaires, réseaux, outils et indicateurs’”. *Natures Sciences Sociétés*, 2025. <https://doi.org/10.1051/nss/2025014>.

Auvray, Alexandre, Fabienne Ficamos, Karine Gremion, Nils Le Bot, Pascal Marty, Elodie Martin-Hackett, Maya Rivera, Yohan Sahraoui, and Sabine Thomas. *Frugacités : Formes urbaines des quartiers de gare ou à fortes contraintes et biodiversité*. La Défense: Plan Urbanisme Construction Architecture (PUCA), Ministère de la Transition écologique, 2025.

Auvray, Alexandre, Pascal Marty, Yohan Sahraoui, and Nils Le Bot. “Intégrer les formes du bâti dans la modélisation des continuités écologiques”. In *Morphologie urbaine et biodiversité : Apports de terrains de recherches pluridisciplinaires*, edited by Sophie Carré and Philippe Clergeau, 1st ed. *Écologies urbaines*. Paris: Éditions Quæ, 2025.

Baron, Nacima, **Nils Le Bot**, Pauline Detavernier, and Manuela Triggianese, eds. *The New Nature of Stations*. TU Delft OPEN Publishing, 2025. <https://doi.org/10.59490/mg.137>.

Gresse, Teddy, Damien David, Frédéric Lefevre, Mathieu Galtier, **Mateusz Bogdan**, Marjorie Salles, Marta Picazo Guerrero, Yiqi Sun, Estelle Morlé, and Karine Lapray. “AbriCoCoDA: A Novel Approach to Urban Heat Mitigation Through Bio-Analogous Climate Shelters”. Rotterdam, Netherlands, 2025. <https://hal.science/hal-05172092/document>.

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Jammet, Louise, and Nils Le Bot. “Alternative Futures: Between Conformity and Radicality”, in press 2025.

Madl, Lukas. “Renaturation ou restauration des sols? Définitions et enjeux sémantiques”, 1:23 - 28. Ecole d'architecture de la ville et des territoires Paris Est: Chaire Transition foncière, 2024.

Navaro-Auburtin, Pierre, Myriam Saadé, Manuel Manthey, Mathilde Louërat, Jérémy Bleyer, Jean-Luc Martin, and Olivier Baverel. “Stone Masonry Floor Systems for Low Environmental Impact Structures”. *Journal of Building Engineering* 113 (September 2025): 114017. <https://doi.org/10.1016/j.job.2025.114017>.

Navaro-Auburtin, Pierre. “Analyse du Cycle de Vie pour la conception des structures de bâtiments : des matériaux à l'ossature”. Phd thesis, École des Ponts ParisTech, 2025. <https://theses.hal.science/tel-05296346>.

P.-E. Prétot, C. Schulz, D. Chalet, J. Migaud, and **Mateusz Bogdan.** “Rapid 1D Design Method for Energy-Efficient Air Filtration Systems in Railway Stations”. *Environments*, November 2025.

Striffling-Marcu, Alexandrina. “Penser la gare par la série : une approche systémique de son architecture : étude comparative de trois lignes ferroviaires française, italienne et espagnole (1850-2025)”. Phd thesis, Paris Est, 2025. <https://theses.fr/2025PESC2004>.

V. Rakotonirinanahary, S. Crumeyrolle, **Mateusz Bogdan**, and B. Hanoune. “Comparison of Two Methods for Evaluating the Performance of Particle Filtration Systems in Underground Railway Stations”. *Indoor Environments*, December 2025, 100144. <https://doi.org/10.1016/j.indenv.2025.100144>.

AREP Group

16 avenue d'Ivry. 75013 Paris

www.arep.fr

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Contact recherche@arep.fr

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