CEDEX

TECHNICAL AND SCIENTIFIC ACTIVITIES

2022

CENTRO DE ESTUDIOS Y EXPERIMENTACIÓN DE OBRAS PÚBLICAS

Centro de Publicaciones
Secretaría General Técnica
Ministerio de Transportes, Movilidad y Agenda Urbana

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CEDEX HIGHLIGHTS **2022**

XVI World Winter Service and Road Resilience Congress

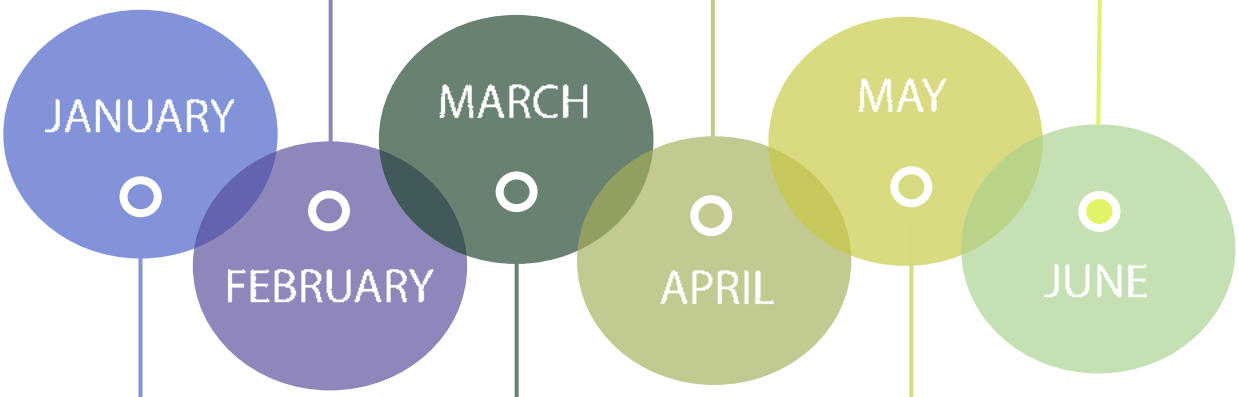
Successful participation and award for resilience (co-authored by CEDEX-MITMA). Special mention in the category of adaptation to a changing world

Model "Railway Territory"

Definitive installation of the model in the Railway Museum at the Delicias station in Madrid, as a result of the agreement signed between CEDEX and the Foundation of the Spanish Railways

Europe's Rail Joint Undertaking

ERJU's Executive Committee approves the award of four Flagship Projects in which CEDEX is involved



New CEDEX Website

CEDEX revamps its website with improvements in its design, contents and updating

CEDEX Youtube Channel

CEDEX creates its own Youtube channel that will serve as a repository for the audiovisual contents it generates

XVI Spanish Conference on Coastal and Port Engineering

Very notable participation with 17 papers presented at the XVI Conference on Coastal and Port Engineering (Vigo)

European Regulations on Wastewater Reuse

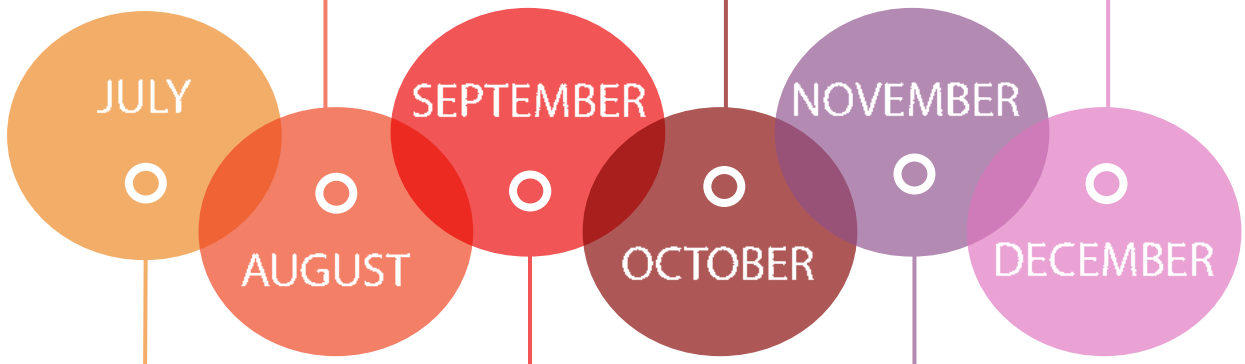
The European Commission publishes the guidelines for the implementation of the new European Regulations on Wastewater Reuse, in which CEDEX has participated

40th Edition of the Master in Soil Mechanics and Geotechnical Engineering

Commemorative day of this anniversary that included a presentation on the trajectory of the master, two special technical presentations, nine technical communications, and interventions by former students

Application of Environmental Isotopes to Water Management

CEDEX starts an experimental study of the development of a methodology based on the analysis of environmental isotopes to determine the evolution of nutrient pollution in the water environment



Biodiversity, Forests and Desertification

The Directorate-General for Biodiversity, Forests and Desertification commissions CEDEX with works on marine biodiversity and protected marine areas

Railway System and Edification

CEDEX begins work on the Adif contract for the provision of consultancy, research and technological development services in different techniques of the railway and edification systems

Technical Workshop at State Ports

Workshop, organized en collaboration with CEDEX, on the durability of reinforced concrete in dock embankments, and curing of floating caissons with seawater

FOREWORD

Áurea Perucho Martínez
Director of CEDEX

I'm pleased to present a new Annual Activity Report of CEDEX concerning the most significant actions carried out during 2022, a year in which we've finally been able to get back to normality after two years marked by the COVID-19 global pandemic.

Since our *Strategic Plan 2020-2022* ends in December 2022, we've delved deeply into where we should go in the next three years to remain a centre of excellence and reference in our fields of action, and a public service available to society to improve its living standards.

And from this reflection, together with intense teamwork and the participation and involvement of a very representative part of CEDEX workers, as well as with the involvement of the general directorates and public entities we work for, two documents have emerged that, once approved, will guide our steps in the next three years: *CEDEX Strategic Agenda 2023-2025* and *CEDEX Strategic Plan 2023-2025*. The former has focused on establishing the general priorities and thematic challenges, setting the lines of activity on which we will concentrate to provide the best service to our ministries based on the current context, centred on boosting innovation in mobility and in the natural environment with stress on resilience, sustainability, and digitalisation. The latter, for its part, is based on the former, adopting the priorities established in the former as Strategic Objectives, and developing them through specific objectives and concrete actions aimed at successfully achieving them.

In parallel to making a great effort to lay out our roadmap which, for the next three years, is to be fleshed out in the two aforementioned documents, we've also strived to facilitate the best service to the ministries we depend on, MITMA and MITERD, providing the technical assistance required.

To this end, we've relied on experimentation through our unique equipment and facilities for new developments and innovation, bolstering our national and international presence, participating in projects, committees and working groups, mainly in Spain and Europe, but also in other countries worldwide. Similarly, we've worked hard to resume intense activity in relation to knowledge transfer, increasing the number of conferences, courses, and exhibitions, which had been so

reduced in the previous two years due to the pandemic, and to intensify our cooperation with other institutions through the signature of new collaboration agreements. In this respect, the celebration in 2022 of the 40th edition of the *Master in Soil Mechanics and Geotechnical Engineering* -born 40 years ago as a course and subsequently converted into a master- has been a source of great pride for all of us.

Likewise, we pride ourselves on seeing how our work in research, development and innovation has been recognised this year by various organisations and institutions, which have awarded us several prizes and acknowledgements, for which we're deeply grateful, encouraging us to continue along this path with the aim of working towards continuous improvement.

In addition, throughout 2022, we have dedicated a great deal of effort to shoring up our communication tools, both externally and internally, by revamping our website and opening communication channels on social networks and, also, by maintaining the internal communication channel created in 2021 -'We Know What We Do'- and launching an internal newsletter and holding the first 'CEDEX Meeting'.

On the other hand, this has been a year when some events of great relevance for CEDEX have taken place, which we trust will help us reinforce our human resources soon and, thereby, reversing the downward trend we've been suffering since 2010 because of the severe global economic crisis which hasn't yet been overcome. Firstly, thanks to the support of MITMA, in June we pulled off the law creating the new Scale of Transports, Infrastructure and Safety Specialists of the Autonomous Bodies and State Agencies of the Ministry for Transports, Mobility and Urban Agenda, and the launching of the call for selective processes for the incorporation of highly qualified and vocational technical staff who, being needed, can find it fulfilling to join our technical scales.

Secondly, in September an amendment was approved to Law 14/2011, of 1 June, on Science, Technology, and Innovation, which now expressly declares CEDEX as an implementing agent of the Spanish Science, Technology, and Innovation System (SECTI), which will make it easier for us to formalise new staff contracts for scientific-technical activities linked to lines of research or scientific-technical services.

These two facts, together with the hope that a great deal of new personnel will soon be recruited through other calls intended to staff general services, such as IT, management or administration, so necessary for our Secretariat -the administrative engine of CEDEX-, give us hope that we will soon be able to grow again and return to the levels of provision prior to the economic crisis of the last decade.

It's our pride and desire to be able to contribute to the economic growth of our country and to the improvement of social welfare, supported by quality infrastructures and care for the environment, as well as by efficiency in public spending that will allow us to obtain the maximum overall benefit with the use of the minimum resources. Because this is, in short, the great value of CEDEX.

ABOUT US

ABOUT US

The Centre for Studies and Experimentation in Public Works, O.A and M.P., (CEDEX) is a public agency of the General State Administration, of those provided for in Article 98 of Law 40/2015, of 1 October, on the Legal Regime of the Public Sector.

It's also an implementation instrument for the Spanish Science, Technology and Innovation System (SECTI). As such, it is a public body of reference in R+D+i in the fields of civil engineering, building and the environment.

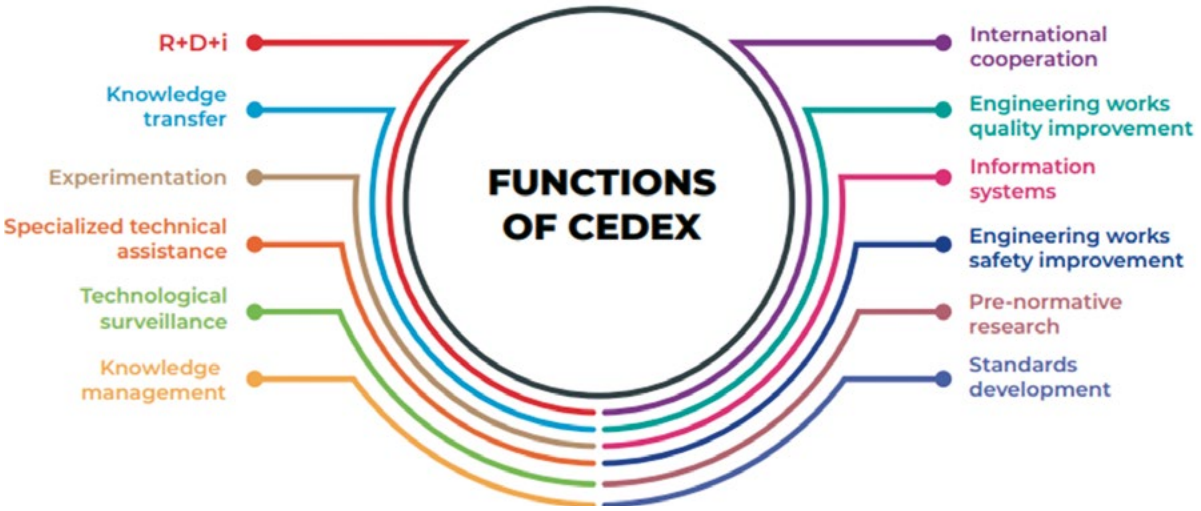
CEDEX is organically attached to the Ministry for Transports, Mobility and Urban Agenda (MITMA), through the State Secretariat for Transports, Mobility, and Urban Agenda, and it has functional dependence on the MITMA, and the Ministry for Ecological Transition and the Demographic Challenge (MITERD), within the scope of their respective competencies.

OUR MISSION

CEDEX's mission is to serve society by advancing knowledge and addressing traditional and emerging challenges in unique situations or projects within its areas of expertise. This is achieved through high-quality specialized services, research activities, and by serving as a channel for the introduction and dissemination of innovation both within and outside of Spain.

The purposes and functions of CEDEX defined in its Statute can be divided into three main categories of activities:

- Specialised technical assistance, often based on testing and experimentation with outstanding facilities
- R+D+i in the field of public works, sustainaible and connected mobility, environment, and climate change
- Training and knowledge transfer



The agency deals with other activity demands from both public and private sectors, maintains close collaboration with similar institutions in other countries in joint applied research programmes, and keeps a continuous presence in the international arena, especially within the framework of Spanish development aid cooperation plans.

CEDEX's organization and scope of work

These functions and activities are to be carried out through CEDEX's **centres and laboratories**, all along with the support of its **secretariat.**

Governing bodies

Board. This is the body that knows and guides the agency's activities. It's chaired by the secretary of State for Transports, Mobility and Urban Agenda of MITMA, and its vice-president is the secretary of State for the Environment of MITERD.

Steering Committee. This is the body that assists the director of CEDEX in the coordination and administration of the agency. It's chaired by the director of CEDEX, and is made up of the directors of the different centres and laboratories, plus the secretary of the agency.

CEDEX ORGANIZATIONAL STRUCTURE

CEDEX's Board.

CEDEX STRATEGIC AGENDA

The *Strategic Agenda* is a document that's created to identify the priorities that should guide CEDEX's activities for the period 2023-2025. It reflects the contributions that this agency can make to meet current challenges and needs, with the aim of continuing to contribute to the well-being of society.

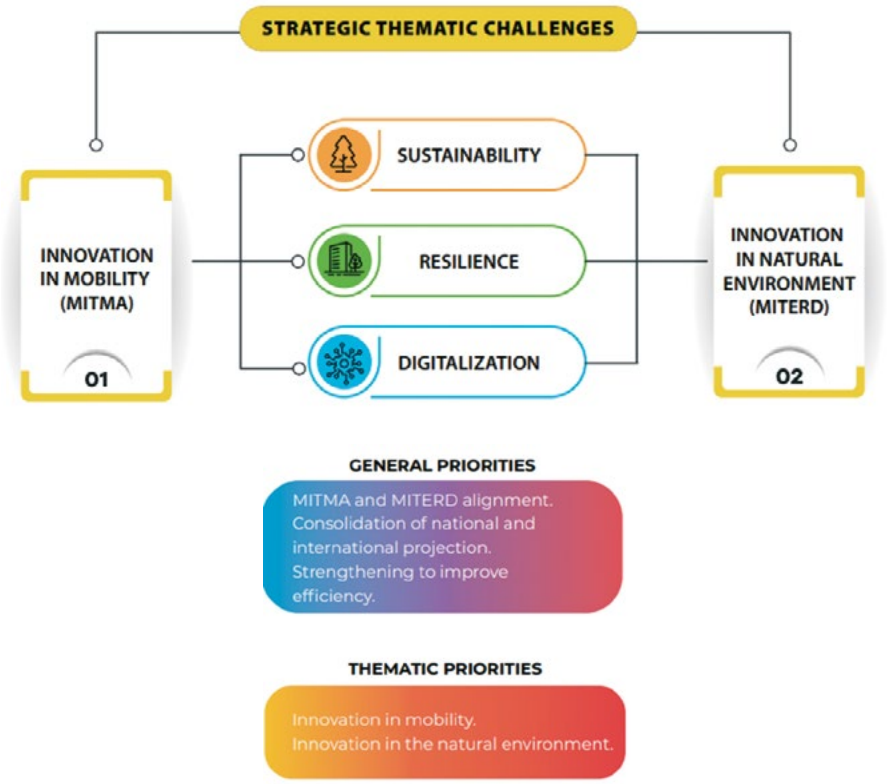
With regard to the general priorities of the Institution, CEDEX is committed to seek maximum alignment with the needs of MITMA and MITERD, to consolidate its national and international projection and to strengthen itself to improve efficiency in the provision of its services. These general priorities will be developed in the next *CEDEX Strategic Plan 2023-2025.*

Concerning its thematic priorities, the agency will promote all its lines of activity aimed at innovation in mobility and innovation, and in all the elements that make up and are present in the natural environment.

The promotion of innovation will be articulated around six strategic thematic challenges:

- Thematic challenge 1. Resilience in mobility
- Thematic challenge 2. Sustainable mobility
- Thematic challenge 3. Digitization in mobility
- Thematic challenge 4. Resilience in the natural environment
- Thematic challenge 5. Sustainability in the natural environment
- Thematic challenge 6. Digitalisation in the natural environment

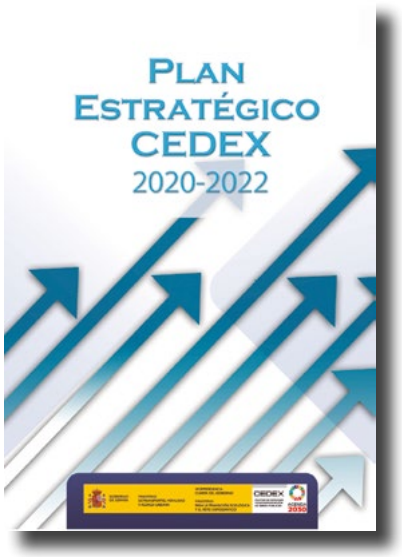
CEDEX is a cutting-edge agency dedicated to activities related to civil engineering, transportation and mobility, and to the integration of climate and environmental concerns

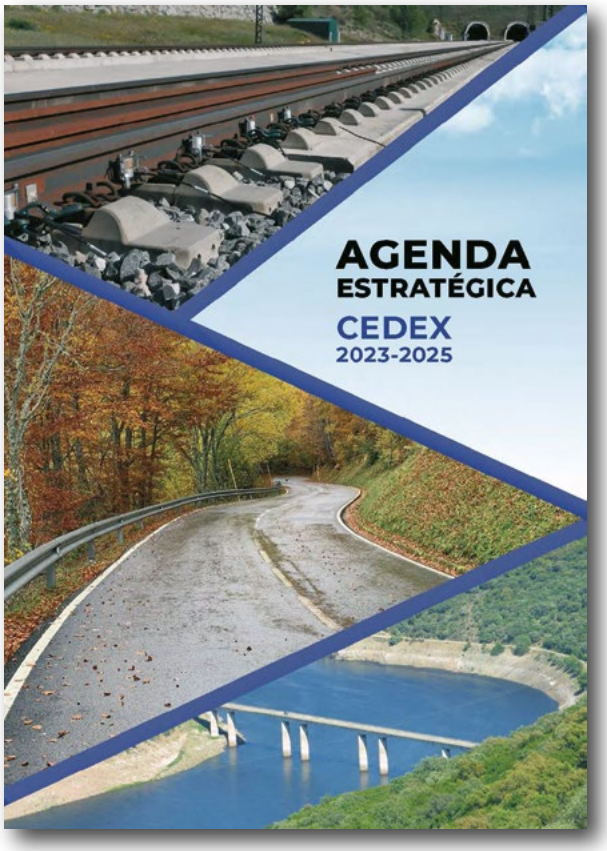


The innovation to be developed by the agency in the coming years will seek to meet the challenges at national level, internalizing the objectives of the *Recovery, Transformation and Resilience Plan* (PRTR), thereby making CEDEX activities contribute to a more resilient, sustainable and digital future.

CEDEX STRATEGIC PLAN

During 2022, the CEDEX executed the *2022 Action Plan,* which was the last of the three action plans through which the activities outlined in the *CEDEX Strategic Plan 2020-2022* were developed, thus concluding that planning cycle.





The *Strategic Plan 2023-2025* will be based on the Strategic Agenda document and will specify how to achieve the general and thematic priorities established therein and their deadlines so as to constitute CEDEX's roadmap for the next three years.

CEDEX: WORKING FOR MITMA AND MITERD

A fundamental part of CEDEX's activity is focused on specialized technical assistance to the ministries on which it depends functionally, being materialized in the formalization of contracts which also incorporates a R+D+i component.

Throughout 2022, within the scope of the MITMA management centres, 3 agreements were formalized with Adif (Spanish Railway Infrastructure Administrator), and work continued on the contracts in progress for the Directorate-General of the Merchant Marine, State Ports, the Directorate-General of Roads and the CIAIM.

Within the framework of the management centres of MITERD, contracts were formalized with the Directorate-General of the Coast and the Sea, the Directorate-General for Water, the Directorate-General for Biodiversity, Forests and Desertification, the Directorate-General of Quality and Environmental Evaluation, and ACUAMED. These contracts have shaped the activities of various CEDEX centres and laboratories in 2022. As well as these new contracts, there was the execution of actions related to the annual R+D+i program in water resources and hydraulic infrastructure for the Directorate-General for Water, as well as the completion of work for the Spanish Office for Climate Change.

CEDEX TO BOLSTER R+D+I

The Research, Development, and Innovation Unit (UIDI), has continued to promote and drive R+D+i in all areas of CEDEX's activities throughout 2022. This effort was supported by the R+D+i commission, which includes members of CEDEX's Management Committee, and the network of R+D+i coordinators, with one representative from each centre and laboratory. This coordinated approach ensures the effective communication and implementation of the initiatives being proposed.

Through the UIDI, CEDEX is reinforced as the technological mainstay of MITMA in R+D+i applied to mobility and transports, and of MITERD in relation to the natural environment and environmental quality. Its main objective is to promote collaboration between the different centres and laboratories of CEDEX toward the participation in R+D+i projects, both at national and international levels, and to increase its presence in networks and forums related to knowledge transfer and R+D+i results.

In 2022, CEDEX also had the support of 38 researchers hired to work on R+D+i initiatives in the field of knowledge and technologies with the aim of improving social cohesion through connected, modern, low-carbon infrastructures, guaranteeing the proper management of the natural environment and its sustainability.

CEDEX INTERNATIONAL ACTIVITY

The international activity of CEDEX is one of its main pillars. This activity has been increased in recent years through participation in the new EU's funding program for research and innovation, Horizon Europe (HE), for the period 2021-2027.

One of the main innovations within the new Horizon Europe program is the creation of partnerships, in which the European Commission and public and private representatives from member and associated states and third countries agree to address some of the most important global challenges through concerted research and innovation initiatives.

CEDEX, together with other MITMA group companies (Adif, Renfe-Operadora, Ineco and Adif-Alta Velocidad), has officially become a founding member of Europe's Rail Joint Undertaking (ERJU), the new European Union R+D+I partnership specifically dedicated to railroads, which replaced the former Shift2Rail program.

In 2022, 4 ERJU projects, in which CEDEX participates, were launched:

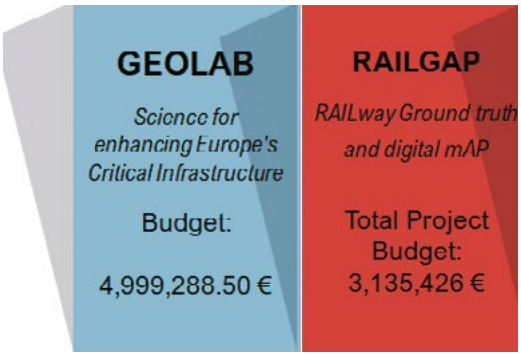
MOTIONAL
Mobility Management in a Multimodal Environment and Digital Enablers
89 participants
Budget: 37,875,973 €

R2DATO
Rail to Digital Automated up to Autonomous Train Operation
77 participants
Budget: 53,904,131 €

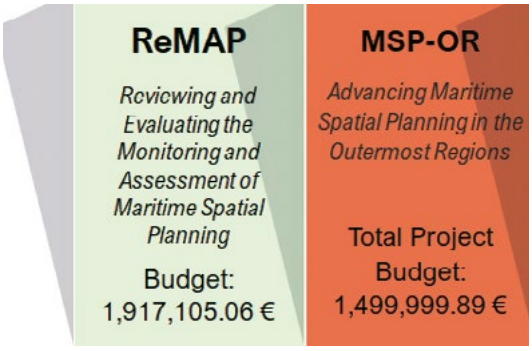
IAM4RAIL
Holistic and Integrated Asset Management for Europe's RAIL System
94 participants
Budget: 46,225,689 €

FUTURE
Delivering Innovative rail services to revitalise capillary lines and Regional rail services
50 participants
Budget: 15,484,001 €

Within the field of mobility, CEDEX is also a member of the European co-programmed partnership CCAM (Connected, Cooperative and Automated Mobility), which supports research and innovation activities focused on developing safe and sustainable road transport through automation.



As for other international programs, CEDEX has been participating in the European Maritime, Fisheries and Aquaculture Fund (EMFAF) program with two ongoing projects on marine spatial management.



And in INTERREG with a water monitoring project:

Besides, CEDEX's international activity is complemented by its cooperation activities through AECID's Water and Sanitation Fund (FCAS), providing assistance in the review of sanitation infrastructures through the preparation of guidelines and recommendations, and contributing to training and capacity building programs.

In the area of training, CEDEX participated in the AECID's Intercoonecta Plan by holding the course "Coastal Engineering and Marine Environment" for professionals from Latin America and the Caribbean belonging to various administrations, institutes and universities related to the topics of the course.

AWARDS AND RECOGNITIONS

CEDEX's work in research, development and innovation has been recognized through the granting of different awards and acknowledgments:

- **Research Award** at the XVI Potencia 2022 Awards
- TALGO Award for Technological Innovation in the **Railway Technology Category**
- **National Civil Engineering Award** to former CEDEX director Felipe Martínez
- World Road Association's **World Resilience Award 2022**
- **Carlos Oteo 2022 Award** to the best article published in Spanish in 2021

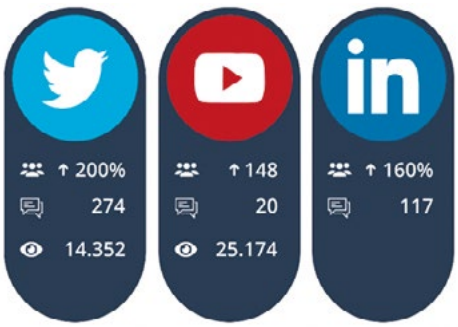
CEDEX is tasked with the managing of MITMA **National Civil Engineering Award**. This award is established, on an annual basis by Order of August 3, 2001, as a reward and recognition of the work accomplished by a professional related to civil engineering.

COMMUNICATION POLICY

In 2022, continuing with the communication strategy established for the 2020-2022 triennium, priority has been given to the dissemination of the agency's works and projects through new digital channels -Linkedin and YouTube, besides the Twitter account opened in 2021-, and the use of more visual, simple and accessible formats for the public.

Further, CEDEX has revamped its website, which has meant an important advance in the active presence of the agency in society, and the dissemination of activities, results and history of CEDEX has been promoted in social networks and through conferences and presentations.

Likewise, internal communication has continued to be strengthened by increasing the number of information channels, launching an internal news bulletin, holding internal information days, or promoting the first annual 'CEDEX Meeting', among other actions, as well as maintaining those already launched last year, such as 'We Know What We Do'.



THE SECRETARIAT AS THE ENGINE OF CEDEX

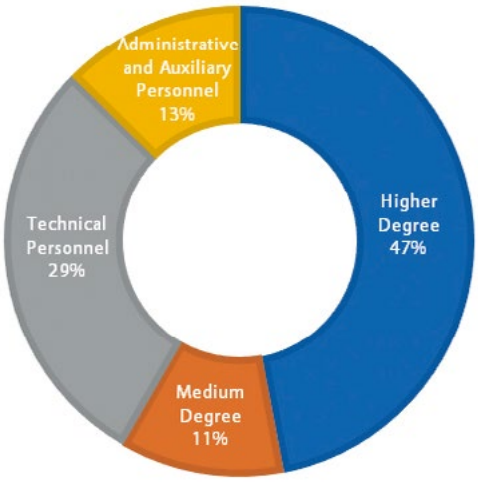
Human Resources

In order to undertake its functions, CEDEX requires specialized human capital supported by a set of top-level technological resources. The multidisciplinary nature of the CEDEX teams provides complementary visions in the study of increasingly complex issues. Continuity in knowledge management and the best use of CEDEX's capabilities require a sustained incorporation of personnel.

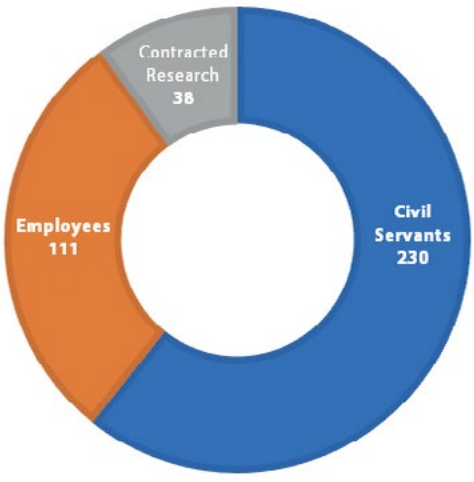
STAFF BY CATEGORY AND QUALIFICATION: 31 DECEMBER 2022

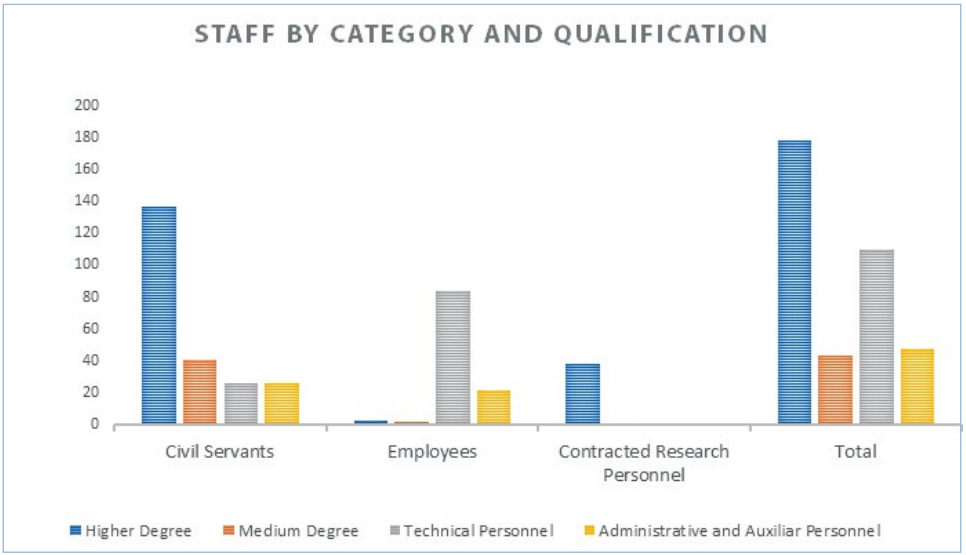
		Civil Servants	Employees	Contracted Research Personnel	Total	%
Degree	Higher Degree	137	3	38	178	47 %
	Medium Degree	41	2	0	43	11 %
Technical Personnel		26	84	0	110	29 %
Administrative and Auxiliary Personnel		26	22	0	48	13 %
TOTAL		230	111	38	379	100 %

STAFF BY QUALIFICATION



STAFF BY CATEGORY





Of the total number of CEDEX personnel, 22 were new hires in 2022, 14 were civil servants (3 of whom were through competitive examinations), and 8 were employees (7 of whom were through competitive examinations).

NEWLY INCORPORATED PERSONNEL TO CEDEX

	WOMEN	MEN	TOTAL
A1	3	5	8
Cuerpo Superior de Administradores Civiles del Estado	0	1	1
Cuerpo de Ingenieros Navales	0	1	1
Cuerpo de Arquitectos de la Hacienda Pública	1	0	1
Escala de Técnicos Facultativos OO.AA. Mº Medio Ambiente	2	3	5
A2	2	2	4
Cuerpo de Ingenieros Técnicos de Obras Públicas	0	1	1
Cuerpo de Gestión Postal y de Telecomunicaciones	0	1	1
Cuerpo de Gestión de la Administración Civil del Estado	2	0	2
C1	1	0	1
Cuerpo General Administrativo de la Administración del Estado	1	0	1
C2	1	0	1
Cuerpo General Auxiliar de la Administración del Estado	1	0	1
EMPLOYEES	2	6	8
M2	0	1	1
M1	1	4	5
E2	1	0	1
E1	0	1	1
TOTAL	9	13	22

LABOUR RIGHTS AND POLICIES

Social dialogue and collective bargaining

The agency participates in the various collective bargaining tables at MITMA through the Joint Subcommittee, the Technical Working Group on Occupational Risk Prevention, and the Joint Social Action Group, among others.

Social action

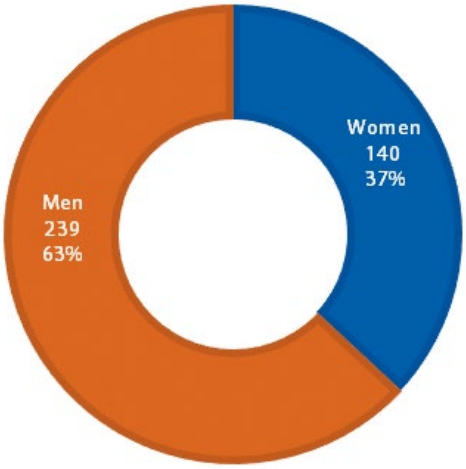
The granted credit for Social Assistance in 2022 amounted to 63,650 euros, not including Retirement Awards or the costs of extracurricular activities for employees' children. There were 195 applications submitted, which corresponded to 276 requests processed and 266 grants awarded.

Equality Policy

The CEDEX is fully involved in the plans that the General State Administration has approved to go deeper into the matter, among which the III Plan for Gender Equality in the General State Administration and in the Public Bodies linked to or dependent on it, approved on December 9, 2020, and the *III Strategic Plan for the Effective Equality of Women and Men (2022-2025)* stand out.

Likewise, CEDEX is included in the scope of application of the *MITMA's Gender Equality Strategy,* currently under preparation, which will combine the objectives of all the sectorial plans in common parameters for the different entities attached to it: Autonomous bodies, agencies, public entities, public business entities, state corporations and public foundations.

GENDER DISTRIBUTION



STAFF BY GENDER: 31 DECEMBER 2022

		Women		Men		Total
Degree	Higher Degree	71	40 %	107	60 %	178
	Medium Degree	15	35 %	28	65 %	43
Technical Personnel		28	25 %	83	75 %	111
Administration and Assistants		26	55 %	21	45 %	47
TOTAL		140	37 %	239	63 %	379

On the other hand, in terms of attention to the disabled, it should be noted that the CEDEX staff had 19 workers with some degree of disability, 11 of whom were employees, 7 civil servants, and 1 was hired for R+D+i.

Reconciliation of work and personal and family life

In 2022, CEDEX staff enjoyed a set of reconciliation measures aimed at favoring the organization of working time, the use of recognized leave and working online, first due to the coronavirus pandemic and, later, to save energy.

HEALTH, SAFETY AND HYGIENE AT WORK

Preventive activities

The main preventive activity for the protection of all the agency's personnel has been carried out through health surveillance by means of annual medical check-ups.

In terms of safety, hygiene and ergonomics, a job evaluation was done for each of CEDEX's employees, specifying the risks to which they're exposed, as well as preventive planning. These risk assessments also specify the individual or collective protection material that must be used depending on their job.

Health promotion

This has materialized, among others, through complementary health surveillance activities, such as the early detection of colorectal cancer, of breast cancer through hormone analysis, and of thyroid problems through the analysis of thyroid hormones. There's also a program for detecting urological problems in men and gynecological problems in women.

Safety at work

To guarantee the safety of workers and external companies, the necessary protocols for the coordination of business activities (CAE) were implemented through the application of the provisions of RD 171/2004 of January, 30.

With respect to prevention in emergency situations, the self-protection plans of the work centres were reviewed and implemented to guarantee the personal safety of all workers.

Prevention training

To ensure that in the event of an emergency workers knew what to do to safely leave their workplaces, emergency teams from each centre were trained and given instructions on how to evacuate their workplaces.

Quality and environmental management

In relation to Environmental Management System, the agency was certified by the EN ISO 14001:2004 Standard between 2009 and 2017 in all its centres for the following activities:

- High-level technical assistance to the administration.
- Applied research and technological development within the framework of civil engineering.
- Technical training courses.

In 2022 the certification of compliance with the requirements under the UNE-EN ISO 14001: 2015 Standard is maintained, renewed in April 2021 until April 2024 with certificate number ES09/6695. This is a multi-site certificate that includes all CEDEX centres.

There are other certifications of quality activities carried out in the different laboratories of the agency, the most important of which are shown in the following table:

Unit undergoing a Quality Certification or Accreditation Audit Process	Certification Standard: Quality System	Certification or Accreditation Issuing Body
Central Laboratory for Structures and Materials (LCEYM) Activity: Tests Accreditation nº: 82/LE688 - Metallic Materials	UNE-EN ISO/IEC 17025:2017 Entry into force: December 2021	National Accreditation Body (ENAC)
Centre for Applied Techniques Studies (CETA) Activity: Tests Accreditation nº: 82/LE1955 - Radiological Protection	UNE-EN ISO/IEC 17025:2017 Entry into force: April 2012	National Accreditation Body (ENAC)
Railway Interoperability Laboratory (LIF) Activity: Tests Accreditation nº: 465/LE1003 - Railway and its components	UNE-EN ISO/IEC 17025:2017 Entry into force: April 2005	National Accreditation Body (ENAC)
Centre for Hydrographic Studies (CEH) Water Environment Area of the Water Quality Laboratory	UNE-EN ISO 9001:2015 Vality period: March 2024	System Certifiers SGS

COMMITTED TO TRANSPARENCY AND GOOD GOVERNANCE

With a view to promote transparency and improve access to public information, we have continued with:

- The procedures associated with the entry into force of the Transparency Law 19/2013
- The publication of contracts once awarded in the Public Sector Procurement Platform
- MITMA is periodically informed, through patterned questionnaires, of the activity carried out
- 7 requests for access to public information received under the Transparency Law have been processed
- 5 parliamentary initiatives from the Congress of Deputies and the Senate have been processed through the Parliamentary Initiatives application

Electric vehicles

The installation of recharging points for electric vehicles has been completed in the CEDEX centres and laboratories that didn't have them.

In each centre, a charging post with a PLUS model featuring two charging outlets, has been installed. Moreover, at the Centre for Transportation Studies, an additional wall-mounted point with two outlets has been installed in the warehouse.

ETHICAL CODES

The specific ethical codes of of the organization, following MITMA protocols, are as follows:

- Declaration of Principles on Occupational Risk Prevention (PRL)
- Statement of Principles on Labour Harassment at CEDEX (AL)
- CEDEX Environmental Policy Statement (GMA)
- CEDEX Quality Policy Statement (Q)

ECONOMIC AND FINANCIAL RESOURCES

EXECUTION OF THE 2022 REVENUE BUDGET

SECTION	FINAL BUDGET	RECOGNIZED RIGHTS	EXECUTION %
3. Fees, public prices and other incomes	11,902,170	7,371,240	62 %
4. Current transfers	15,947,510	16,029,877	101 %
5. Equity incomes	1,550	13	1 %
7. Capital transfers	5,844,465	5,822,265	100 %
8. Financial assets	6,343,262	10,065	0 %
TOTAL INCOME BUDGET	40,038,957	29,233,460	73 %

EXECUTION OF THE 2022 EXPENSE BUDGET

SECTION	FINAL CREDIT	RECOGNIZED OBLIGATIONS	EXECUTION %
1. Personal expenses I	20,688,054	18,661,065	90 %
2. Goods and services	5,573,855	4,796,669	86 %
4. Current transfers	164,581	109,725	67 %
6. Investments	13,574,147	10,705,951	79 %
8. Financial assets	38,320	14,532	38 %
TOTAL EXPENSE BUDGET	40,038,957	34,287,942	86 %

SITUATION BALANCE SHEET

ASSETS	2022	2021
NON-CURRENT ASSETS	81,972,241	75,011,375
Intangible fixed assets	505,583	308,174
Industrial and intellectual property	1,430	1,625
Computer applications	504,153	306,549
Tangible fixed assets	81,457,214	74,699,033
Lands	28,515,852	28,515,852
Constructions	39,274,433	33,804,795
Other tangible fixed assets	11,508,598	12,378,386
Fixed assets in progress and prepayments	2,158,331	0
Long-term financial investments	9,444	4,168
Credit and Debt securities	9,444	4,168
Other financial investments	0	0
CURRENT ASSETS	9,373,439	14,472,857
Trade and other receivables	6,674,347	11,814,226
Receivables for management operations	3,084,682	8,327,235
Other receivables	143,835	47,264
Receivables from public authorities	3,445,830	3,439,727
Short-term financial investments	1,092	3,989
Credit and Debt securities	1,092	1,900
Other financial investments	0	2,089
Adjustments due to accrual	296	296
Cash and cash equivalents	2,697,705	2,654,346
Cash	2,697,705	2,654,346
TOTAL ASSETS	91,345,680	89,484,232

EQUITY AND LIABILITIES	2022	2021
EQUITY	89,535,662	88,154,529
Contributed equity	84,251,752	84,251,752
Generated equity	4,997,543	3,727,552
Profits or loss from previous years	-506,684	3,326,287
Profits or loss for the year	5,504,227	401,265
Other capital increases pending imputation to income	286,366	175,225
CURRENT LIABILITIES	1,810,018	1,329,703
Current payables	212	69,212
Other receivables	212	69,212
Trade and other payables	1,808,807	1,260,491
Payables from management operations	0	89,675
Other payables	1,300,678	745,146
Public Administrations	508,129	425,669
Adjustments due to accrual	1,000	
TOTAL EQUITY AND LIABILITIES	91,345,680	89,484,232

CENTRES AND LABORATORIES

CENTRE FOR TRANSPORT STUDIES

" We're working for roads that provide a safe service to users in the face of new environmental, climatic and operating conditions "

Throughout 2022, the activity of the **Centre for Transport Studies** (CET) has focused on the development of activities oriented towards the **characterization and experimentation of materials,** including their environmental aspects, the study of **pavement behaviour** through measurement vehicles, remote monitoring and modeling and, finally, the conduct of research and innovation in the field of **mobility.**

All these activities have been undertaken from the perspective of mitigating and adapting to **climate change** in order to achieve a more **resilient** road network, aiming to prioritize safety and contribute to the efficient maintenance of pavements. In doing so, it's also studied how new technologies and digitalization can be used to optimize road management.

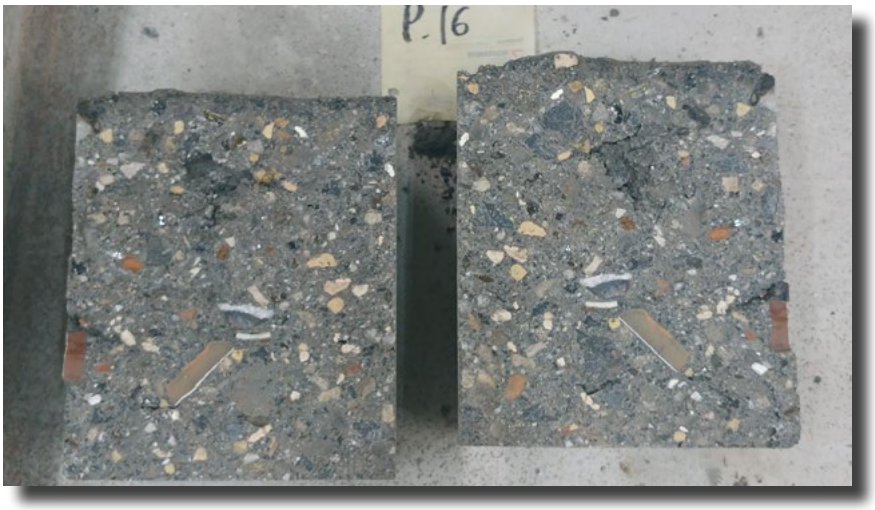
The research activities concerning **Characterisation of Basic, New and Recycled Materials** are geared towards promoting the circular economy and the adoption of more sustainable technologies. These activities have focused on:

- The use of secondary materials or by-products
- Methods for manufacturing and laying bituminous mixtures at lower temperatures
- Both objectives combined

These materials and technologies provide an environmental benefit, but there's insufficient information on how they are applied and how they perform. Therefore, further investigation through experimental studies on their behaviour is needed.

In this sense, the CET has been collaborating with the National Road Administration (DGC) by assessing the evolution of road sections in which the aforementioned techniques and materials were used. These include the

CDW aggregates and USW incineration slags for concrete production.



Indirect tensile strength test on a concrete specimen made with CDW and USW incineration slags.

so-called road sections declared to be of exceptional regulatory nature, built under the auspices of Circular Order 1/2022 issued by the Directorate-General of Roads (DGC), of the Ministry for Transports, Mobility and Urban Agenda (MITMA).

Regarding the use of aggregates obtained from waste, work has been done with the Department of the Environment and Sustainability of the autonomous city of Melilla. The application of construction and demolition waste (CDW) and slag from the incineration of urban solid waste (USW) in road and highway construction was studied. They were tested as aggregates in roller-compacted dry concrete for paving and mass concrete for prefabricated elements. Other less demanding applications are currently being studied, such as its use for granular or stabilised layers, as well as in the construction of forest tracks.

A study has also been conducted with waste polymeric materials and derivatives. It's part of the agreement signed in 2021 between CEDEX and ECOEMBES, an organisation that links companies that generate and manage plastic waste. The study consisted of testing with a mixed waste from the paper industry, with a particle size grading suitable for incorporation into SMA bituminous mixtures to replace commercial cellulose fibres. Tests have also been performed on a BBTM 11B mix.

Most of the works mentioned include the Fénix test to determine the cracking characteristics of the mixes. This test was recently standardised as NLT-383/2020 and has been included in the DGC technical note NT 01/2022. However, it still requires experimentation to specify reference values that are closer to reality than those currently included in the NT as a guideline. Also, with a view to a future and more complete validation of results, the degree of sensitivity of this test to different variables is being studied.

In the matter of **environmental characterization of materials,** the Leaching Laboratory has worked during the last year to develop the DSLT (Dynamic Surface Leaching Test), in accordance with the UNE-EN 15863 and prEN 16637-2 test standards. This test makes it possible to evaluate the leaching of dangerous substances from materials in bound uses (such as bituminous mixtures), or with very low permeability. These tests are essential to determine compliance with the condition of protection of human health and the environment, in accordance with Law 7/2022, which is necessary for certain waste flows to be considered as by-products, or that they

Mixed cellulose-polymeric waste used in an SMA mix.

are no longer considered as waste, provided that they meet the rest of the established requirements. Likewise, different studies have been carried out to determine the eluates of different materials.

Similarly, and in the line of activity of **Pavement Management,** CET has continued carrying out the assignment from the Directorate-General of Roads of MITMA for the verification and supervision of compliance with the values of the quality and condition indicators that appear in the concession contracts of the first-generation freeways of the National Road Network (RCE). Specifically, the CET collects data and assesses the indicators related to the pavement bearing capacity (deflections and cracking), as well as safety and comfort conditions (slip resistance is evaluated by means of the SFC and surface regularity by means of the IRI).

In regard to experimentation through the **Full-Scale Accelerated Pavement Test Track,** the test begun at the end of 2021 has been completed. To this end, and with the purpose of comparing the evolution of their performance, two sections with bituminous mixtures have been studied: one of them made with aggregates obtained from construction and demolition waste (CDW), and the other with conventional aggregates. This study, executed for the University of Extremadura, has been complemented by laboratory testing and the monitoring of the structural capacity through measuring deflections.

Continuing the work started in previous years, in the **Sustainability and Climate Change** line, during 2022 the maintenance of the five CET weather stations spread throughout Spain has carried on, having climatological data and temperature profiles of different types of pavements. These works are necessary to adjust the prediction models of its temperature and the humidity of the subgrade. The evaluation of the climatological information generated by these stations can also help to know the effects of climate change on pavements, taking into account that bitumens and bituminous mixtures are particularly sensitive to temperatures.

Besides, work has been carried out within the Asociación Técnica de Carreteras (ATC), and in collaboration with other entities and companies in the sector, on a methodology to assess the vulnerability to climate change of the different road assets, as well as the risks and adaptation measures that can help reduce these risks.

Within the ATC work has continued during 2022 on defining the elements of a Life Cycle Analysis study of the pavement sections most frequently used on our roads. Moreover, the database that will feed the corresponding calculation tool is being developed. Further, the work related to the monograph *State of the art on Green Public Procurement of Roads* has been completed and published.

With respect to the **promotion of road sustainability,** it's worth mentioning the participation of CET in the CEDR (Conference of European Road Directors) Working Group on Decarbonization.

In the field of **Pavement Modeling**, the collection of real-time data of the dynamic variables produced at the passage of traffic circulating in a section of the A-62 in Valladolid continues. The processing of this collected data and the indicators obtained through deterioration prediction models allow us to know the pavement condition.

As for **Pavement Monitoring,** a task commissioned by the Directorate-General of Roads of MITMA was initiated at the end of the year to place sensors in two sections of the road, as a way of obtaining real-time data and increasing understanding on the field of predictive maintenance of roads.

When it comes to **Innovation and Mobility,** work aimed at monitoring and promoting activities related to traffic management and various innovative developments in the field of mobility has been conducted.

These include activities related to the weigh-in-motion (WIM) of road vehicles. These techniques make it possible to collect, on a continuous and fully automated basis, detailed information on the loads due to traffic, mainly trucks and other heavy vehicles, which are the main input parameter for determining the stresses that road surfaces must withstand, and thus optimizing both their design and their maintenance. CET has got a piezoelectric dynamic weighing (WIM) system installed on the A-1 near El Molar (Madrid), as part of the Repara 2.0 R+D+i project, which provides data on heavy vehicles (weight of each axle and gross weight of each vehicle), as well as a series of complementary variables, of great practical application in road management.

Work is also being done to gather information on Electric Road Systems (ERS), which are based on providing an electrical installation to the road to transmit this type of energy to the vehicles on the road, which is fundamentally aimed at solving the problem of electrification of heavy vehicles, in which the technical problem of their autonomy has not been solved due to the large size that their

SCRIM device measuring the sideway force coefficient (SFC) of the pavement.

Dynamic weighing makes it possible to know the loads exerted by new types of vehicles, of increasing size.

batteries would require, which would reduce the payload of these vehicles. The various existing technologies present a different degree of technical development, and each one has its particular advantages and disadvantages, so it's of great interest to participate in international working groups in which, in addition to the technical aspects, possible business models are studied. All these aspects are dealt within PIARC Task Force 2.2 "Electric Road Systems", in which CET participates and is also the Spanish-speaking Secretariat.

It's also worth mentioning the work initiated by CET and focused on analyzing the infrastructure conditions for automated vehicle driving, which is one of the most important challenges in the road and traffic fields.

Since it's difficult to achieve fully automated driving based on vehicle capabilities alone, an in-depth study of the minimum characteristics and road equipment, including those related to connectivity that will enable such autonomous driving, is required. CET participates in the European platform CCAM (Cooperative, Connected and Automated Mobility), which seeks among other objectives, to test cooperative ITS systems and deploying these systems on roads open to traffic, and plans to participate in R+D+I projects related to this topic.

In the area of **Technical Assistance and Regulatory Support in Roads,** and within the framework of knowledge transfer activities, it can be highlighted the participation of CET in different national and international working groups concerned with standardization in all areas related to its activity, such as the standardization of road and traffic management equipment and materials for road construction, among others.

Finally, CET continues to collaborate with various working groups of the ATC and PIARC-AIPCR, as well as with the associations ALEAS (included in ASEFMA) and ATEB, belonging to the asphalt mix and emulsion manufacturing sector, respectively, with a focus on contributing to the progressive adoption of more sustainable techniques for the manufacture and laying of bituminous mixtures, including the incorporation of recovered asphalt at medium and high rates, as well as the manufacture of mixtures at reduced temperatures.

CENTRE FOR HYDROGRAPHIC STUDIES

" The Centre for Hydrographic Studies contributes to improving knowledge of natural resources and water availability "

During 2022, the **Centre for Hydrographic Studies (CEH)** has focused its activity on improving knowledge of the resources and the water environment and the acquisition and exploitation of data, on the development of regulations, standards and technical specifications, and on the research, technological development and innovation in the field of continental waters. Knowledge transfer has been accomplished through the organization of training activities and the participation in courses and conferences, publications and collaboration with different national and international institutions.

An important part of this activity has been dedicated to specialized technical assistance, mainly to the Ministry for Ecological Transition and the Demographic Challenge (MITERD), through the General Directorate for Water (DGA) and the hydrographic confederations, and to the Ministry of Foreign Affairs, European Union and Cooperation (MAEUEC), commissioned by the Secretary of State for Ibero-America and the Caribbean, to support the programs of the Cooperation Fund for Water and Sanitation (FCAS).

With regard to data relating to resources and natural phenomena, the hydrological database update of the control network of Spanish rivers, reservoirs and channels (HIDRO) has gone on, and work has been completed with the publication of the *2019-20 Gauging Yearbook*. The Yearbook, which can be viewed in its entirety on the CEDEX website, makes available to the public all the hydrological information captured by the official control network since its inception at the beginning of the 20th century.

Regarding the improvement of knowledge of natural resources, after concluding in March the updating of the inventory of water resources in natural regime with its extension until 2019-2020, progress has continued in the improvements in the treatment of the underground phase of the SIMPA hydrological model. These advances were presented in the 10th Spanish-Portuguese Assembly of Geodesy and Geophysics, held in Toledo in the months of November and December.

At the request of the DGA, a study has been carried out on the effect that the modification of ecological flows derived from the new river basin management plan of the Tajo River basin district may have on the volumes transferable through the Tajo-Segura aqueduct, considering the different temporal scenarios of ecological flows established in the plan. This is a modification that may have a significant impact on the areas receiving the transfer waters.

Work has proceeded on with updating the map of maximum daily rainfall in Spain, drawn up by CEDEX in 1999, including a new

characterization of the relationships between intensity, duration, and frequency of rainfall (IDF curves). This activity not only has an impact in the field of water management, but also in the transport sector, as it affects the drainage of communication routes.

The process of identifying the mouth points of the 280 rivers classified as bodies of water has been completed. This identification, which complies with the INSPIRE directive, allows the Navy Hydrographic Institute to update the closure of the coastline in the mouth areas and provides the DGA with the basis to trace the river drainage network and delimit the river basins to its application in Spanish hydrological planning.

Work has kept on with the identification and monitoring of priority exotic and invasive species of fauna and flora in continental waters, completing the study on zebra mussel, which is the species that most substantially alters ecosystems and causes the greatest economic damage, its eradication being almost impossible once it colonizes the environment.

In the field of **regulations and technical standards,** support for the DGA in the implementation of the new European Reuse Regulation and in the development of different methodologies for its implementation has carried on, referring specifically to health and environmental risk assessment systems and the validation of treatment facilities. At European level, we have participated in the review and debates for the drafting of the regulation application guides and for the technical specifications on risk management that the European Commission is preparing. This is a particularly important regulation for Spain, as it's the country in the European Union (EU) that reuses the largest volume of water.

Continuing with the technical specifications, during this year we have worked on the development of the *Guide for Calculating the Design and Extreme Floods of Dams,* referred to by the Technical Safety Standards for dams and their reservoirs approved in 2021. Work has been done on a first draft of the guide and various studies have been done to support the selection of the methodologies that will be included in it. Given that the purpose of this guide is to provide recommendations for undertaking the hydrological studies necessary for the analysis of the hydrological safety of dams, it's foreseeable that it will have a significant impact on the sector.

The regulatory chapter ends with participation in the revision of Directive 91/271 on urban wastewater treatment. The focus was on estimating the costs involved in amending the directive in relation to the extension of specific requirements for small towns, the situation of households with individual treatment systems, the increase in demands on nutrient removal, and new requirements for stormwater management and reduction of micropollutants.

In the field of **research, technological development, and innovation,** we have participated in the European research project MED-SCOPE on seasonal prediction, carrying out an analysis on the seasonal prediction of precipitation in the headwaters of the Tajo River.

During 2022, the latest activities of the Albufeira project, a joint program for the evaluation of water bodies of the Spanish-Portuguese river basins, included in the Spain-Portugal Cross-Border Cooperation Program (Interreg-POCTEP), were carried out. The objectives of this project focus on research and the establishment of common criteria for monitoring these bodies of water, improving the integration of the environmental objectives of the Water Framework Directive and the Habitats Directive, and raising awareness about cooperation in shared hydrographic basins. A joint methodology has been proposed to monitor the ecological sta-

tus or potential of shared water bodies, which includes the analysis of discrepancies identified between both countries and agreed solutions to resolve or minimize them. Two scientific-technical seminars were organized by CEDEX and DGA.

The centre has continued to support DGA by participating as a National Focal Centre in the ICP-Waters Program (*International Cooperative Program on Assessment and Monitoring Effects of Air Pollution on Rivers and Lakes*). In 2022, monthly data on the physicochemical and hydrological variables were obtained at the pilot monitoring network stations located in the Sierra de Guadarrama and Cabañeros national parks.

The centre organized the annual ICP-Waters meeting in May, in Miraflores de la Sierra, with the participation of 64 national representatives and researchers. Spain's participation in this network is of great relevance, since it's the only Mediterranean country with monitoring stations, which contributes to a better understanding of the effects of atmospheric pollution on the aquatic ecosystems of southern Europe.

Specialized technical assistance has been provided mainly to the DGA and some hydrographic confederations. In 2022, on behalf of the DGA, studies were conducted on the Yesa (Ebro), Rumblar, Jándula and Tranco de Beas (Guadalquivir), Amadorio and Arenós (Júcar) dams, and the interceptor project in the northern area of the city of Murcia. The purpose of this project is to collect the flows from the channels in this area of the city and divert them, through an underground

Scientific-technical seminar of the Albufeira project at the CEH (above), and closing session of the project in Lisbon (below).

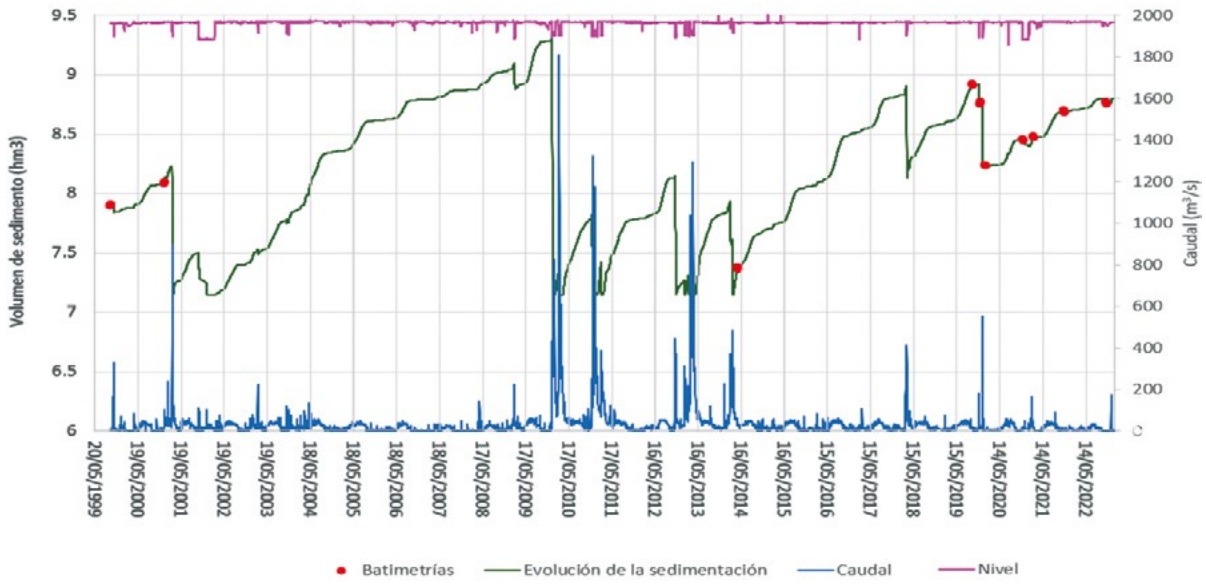
CEDEX sampling work in the Cabañeros National Park for the activities of the ICP-Waters Pilot Network.

National representatives at the *38th ICP-Waters Joint Meeting in Miraflores de la Sierra (Madrid),* 10-12 May 2022.

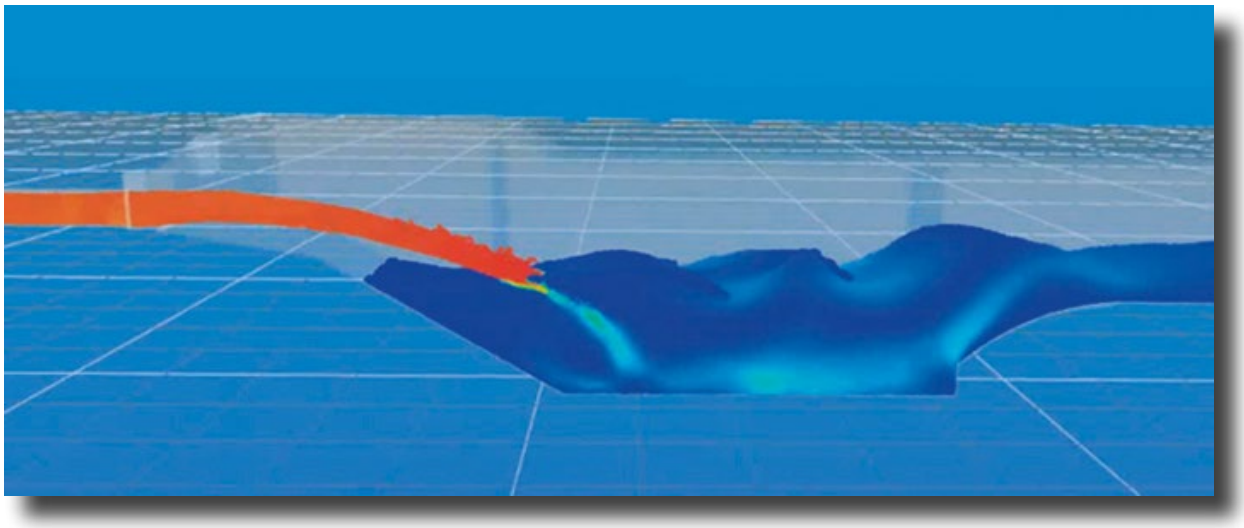
General view of the Yesa landfills with the variant solution.

conduit with free-flow operation, to the Segura River. Numerical modelling work were carried out in two and three dimensions and the main operational and capacity problems that could condition the viability of the initial design have been identified.

Work has also continued to study the influence of the exploitation of the Marmolejo dam on the sedimentation of the reservoir and the flooding of Andújar. This work, commissioned by the Guadalquivir Hydrographic Confederation, gives continuity to previous commissions from the same institution, and seeks to improve the safety of the population of Andújar against the floods that occur periodically. In 2022, an experimental numerical campaign was undertaken to reproduce the bathymetric evolution of the reservoir, and thus determine the best exploitation instructions to reduce flooding problems in Andújar.



Evolution of sedimentation of the Marmolejo reservoir.



Numerical model of the proposed solution for the bottom drainage of the La Loteta dam. Q= 25 m^3/s.

In 2022, work began on the hydraulic study of the bottom drainage of the La Loteta reservoir, commissioned by the Ebro River Basin Authority.

The other important activity of specialized technical assistance is that provided to FCAS programs. In 2022, the work has consisted mainly of reviewing and supervising the status of several treatment plants in Bolivia and Cuba, developing a training program in Paraguay, reviewing and developing sectoral regulations in El Salvador, and the development of a guide for the selection of treatment technologies in Panamá. Furthermore, on a transversal basis, the guide has been published *Selection of Treatment Technologies*, aimed at both designers and technicians of the administrations involved in this type of projects. Some initial recommendations have been prepared for sectoral planning in wastewater treatment, and the Latin American platform for discussion of sectoral regulations has been launched.

Supervision of the sanitation and purification project for the population of San Pedro (Bolivia).

The CEH, in collaboration with the CETA, participates in a project promoted by the Madrid City Council to improve the final section of the Manzanares River in the Villaverde district. This project is part of the call made in 2022 by the Biodiversity Foundation to promote actions aimed at restoring river ecosystems and reducing the risk of flooding in urban environments through nature-based solutions.

The work of the CEH consists, fundamentally, of the hydraulic study of the channel and the spillways of the treatment plants located in this section.

In the **training chapter,** the *XXXIX Course on Wastewater Treatment and Operation of Purification Stations* was held in November, and the *Course on the Impact of Climate Change on Water Resources* was given in October, organized jointly by CEDEX and the International Foundation and for Ibero-America for Administration and Public Policies (FIIAPP), within the framework of the Euroclima+ Program. The online training course for wastewater treatment plant operators, organized jointly by CEDEX and the Secretariat of Infrastructure and Water Policy and the Argentine National Water Institute, has also been managed, taking place between March and June.

In terms of **dissemination and technology transfer,** the *Methodological Guide for the Cost-Benefit Analysis of Structural Flood Defence Actions* was published in 2022, and the Conference on the Contribution of Experimental Studies to Dam Safety was held in November.

Within the framework of **institutional collaboration,** the centre has continued to participate in the Central Commission for the Operation of the Tajo-Segura Aqueduct, of which it has been a part since its creation in 1978 and has prepared monthly reports on the situation and application of the exploitation rule, from which decisions are made regarding the volumes to be transferred.

Participation has also continued in the Large Dam Standards Commission, which, after the approval in 2021 of the Technical Safety Standards for dams and their reservoirs, is now focusing on the preparation of the Technical Safety Standards for Water Ponds. As well as in the Hydrology Section of the Spanish Commission of Geodesy and Geophysics, which in 2022 held its *10th Spanish-Portuguese Assembly.*

Finally, as a tribute to Cristóbal Mateos, *A Tribute to Cristóbal Mateos Iguácel. 1938-2022* was published in collaboration with the ICCP College.

Inauguration of the *Technical Conference on the Contribution of Experimental Studies to the Safety of Dams.*

RAILWAY INTEROPERABILITY LABORATORY

" Towards an increasingly digital European railway "

2022 can be considered as a key year for the deployment of an increasingly digital European railway. This is a European railway that bases its operation on fully digital technologies and that eliminates the old analog systems that still survive in much of the European network. This digitization of the railway should be one of the premises for the construction of the Single European Railway Area (SERA), which the European Commission has been trying to deploy for so long and which still has a few decades to become a reality.

And we talk about 2022 because it's the year of the launch of the joint venture ERJU (*Europe's Rail Joint Undertaking*), which will be the R&D tool that will facilitate the transformation of the European railway into a digital and interoperable railway, being this the necessary basis for the development of the trans-European railway network. CEDEX is a founding member of ERJU in a membership led by Adif and shared with Renfe and Ineco, being the LIF the laboratory of CEDEX with a more relevant presence in ERJU.

The Railway Interoperability Laboratory (LIF), of CEDEX, has been one of the drivers of this railway digitalization for being the pioneering laboratory in tests of the European signalling system ERTMS, a system that will allow the digitalization of the railway and,

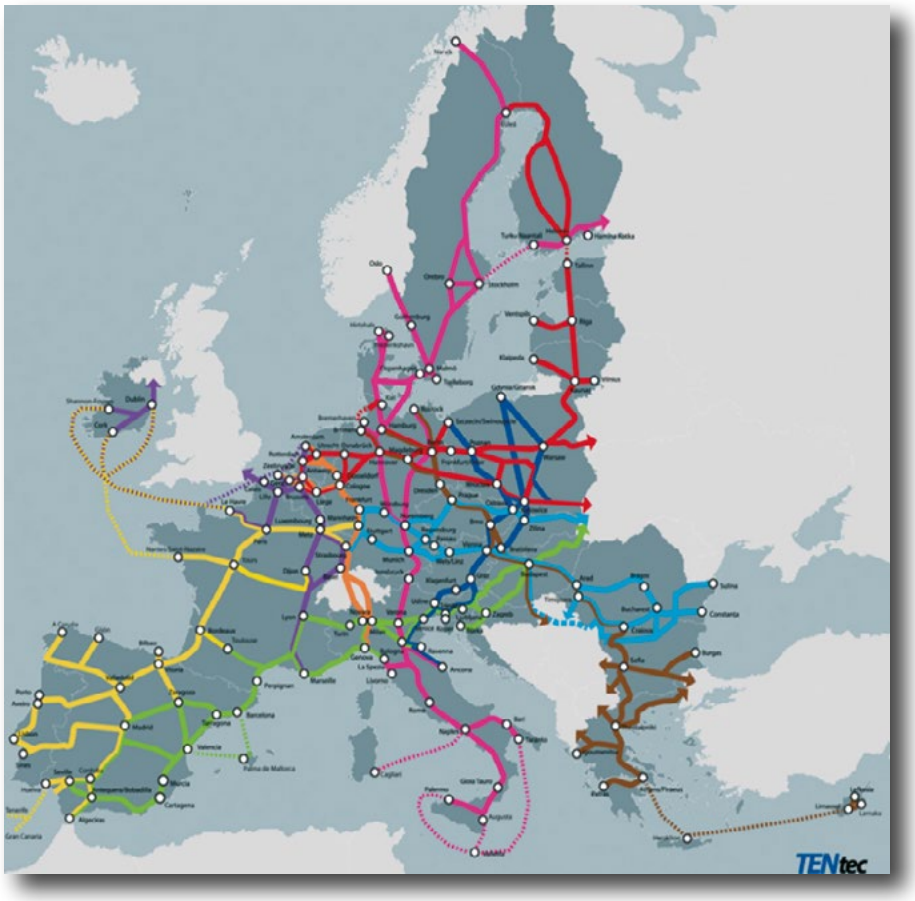


Figure 1. Trans-European Railway Network.

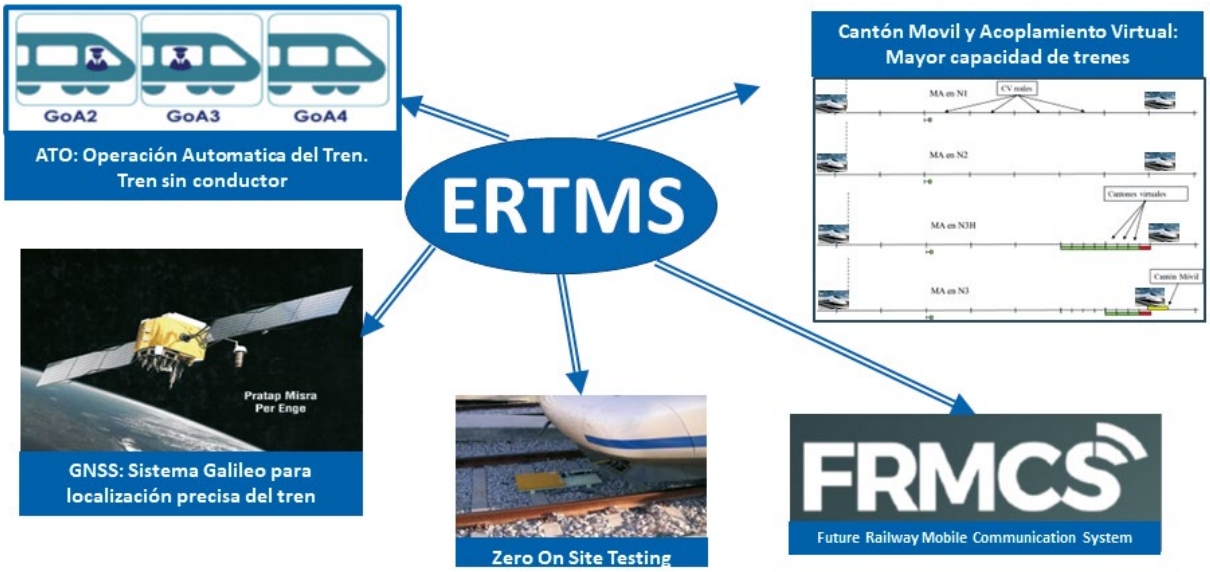


Figure 2. ERTMS as the backbone of railway digitalization.

additionally, for being one of the first laboratories in the world to have generated a digital twin in laboratory of this ERTMS system.

What does the digitalization of the railway consist of? It's talked about a lot, but sometimes it's a vague concept in which sometimes conflicting visions are mixed. Well, the digitalization of the railway, like the digitalization of other environments whether they are transport, financial, management etc., consists of nothing more than the application of digital technologies to all, or most, of the technical railway areas.

Apart from digital techniques of auscultation and/or maintenance of the infrastructure, where digitalization should be more accentuated will be in the application of new technologies for a safer, more centralized, more capacity and more automatic operation of the railway. And this can only be done by using ERTMS, which is presented in this way as the backbone of railway digitalization as shown in figure 2.

Therefore, taking into account the previous considerations, the participation of the LIF in the joint venture ERJU is presented as a unique opportunity to contribute to railway digitalization, thanks to LIF's capabilities as a leading laboratory in ERTMS, and the development throughout the duration of the ERJU, which will practically extend until 2032, of all these digital technologies that allow for a modernization of the current railway.

That's why the transition of the LIF, initiated in 2021 from a stage of testing the ERTMS of the Spanish lines in the laboratory to a much more relevant activity in European railway R&D, has found in the membership of ERJU the perfect channel for its realization: The LIF is going to be an important actor in ERJU, but it's also going to develop enormously its capabilities in all these new digital technologies to continue being a reference laboratory in Europe.

2022 began with a very intense work of the LIF within ERJU for the preparation of the

calls for projects in 3 of the 7 flagship areas (FAs), into which the ERJU Master Plan had been divided. The LIF participated very actively in FAs 1, 2 and 6. In June 2022 the acceptance of the proposals to these 3 FAs was confirmed, which resulted in the projects MOTIONAL (FA1, then FP1), R2DATO (FA2) and Future (FA6).

These projects, which are described in more detail in the section of outstanding projects of the LIF, cover the spectrum of digital applications of the railway in which the LIF can both contribute its experience as a testing laboratory and develop digital capabilities for the future.

The **MOTIONAL** project focuses on the generation of the upper layer of the ERTMS for the advanced management of the European railway traffic including the intermodality with other modes of transport. The LIF participates mainly in the standardization of the track data formats that are used in the ERTMS, as well as in the generation of digital twins, with its experience in laboratory simulation.

The **R2DATO** project is an ambitious attempt to develop a large number of digital technologies for automatic driving (ATO) up to the maximum degree of automation (GoA), which is 4. It will also address the deployment of level 3 of ERTMS with a first approach based on the hybrid level 3, as well as the technologies of mobile canton to increase the frequency of trains and the use of satellite technologies for the safe and precise definition of the absolute position of the train.

Finally, the **FUTURE** project will address the modernization of the railway for regional or low traffic density services by applying novel techniques of both train/track communications and satellite location of the train for the reduction of track components, being reduction of these components aimed at making

Figure 3. LIF Laboratory for the simulation of many of the technologies developed in the R2DATO project.

viable the maintenance cost of these weak traffic lines.

In 2022, the European project RAILGAP, funded by the EUSPA, has continued to develop the digitalization of the railway infrastructure by means of laser-based measurements (LiDAR), high-resolution cameras and satellite sensors, carrying out the first measurement campaign after having equipped an Adif dresina with this purpose.

Also, in 2022, the "Order for the technical advice of a new 'ATP ERTMS' system specifically intended for non-main railway lines throughout its development cycle: definition, engineering, installation and testing on a pilot line of the general interest railway network of Adif" was signed with Adif. The objective of this is to provide technical support to Adif in the development of an ERTMS with lower performance than that of the high-speed network that allows the deployment of this system in the Spanish conventional network, considerably increasing its level of safety. This project, which is also described among LIF's outstanding projects, will develop new engineering rules that will reduce the equipment on these weak traffic lines, as well as satellite technologies for location and use of public and/or satellite communications for levels 2 and 3 of the ERTMS.

Likewise, the collaboration with Adif continues through a second order entitled "Order for the provision of advisory services, research and technological development in the different techniques of the railway system and building", in which the Centre for Studies on Applied Techniques (CETA), the Geotechnical Laboratory (LG), the Central Laboratory for Structures and Materials (LCEYM) and the LIF participate. In this order, the LIF no longer provides support in the execution of ERTMS tests in the laboratory, due to Adif's decision to execute these tests on the track, but it does provide technical support on issues of electrical disturbances, digitalization of the infrastructure as a continuation of RAILGAP and training in ERTMS.

These two orders demonstrate that the collaboration with Adif in R&D issues works very fruitfully. In the case of the LIF, this collaboration is no longer concentrated on the execution in the laboratory of the ERTMS tests, but has been derived to R&D aimed at both railway digitalization and the development of new functionalities of the ERTMS.

Other activities carried out by the LIF throughout 2022 are those listed below:

- Execution in the LIF Traffic Simulation Laboratory of the ERTMS tests of Cercanías de Barcelona by the company Alstom
- Participation in the National Technical Standardization Committee on Hyperloop, holding the presidency of the CTN-326 of UNE
- Participation in the European Standardization Committee of Hyperloop JTC-20, of CEN/CENELEC, as head of the Spanish representation of UNE
- Participation at the request of MITMA as the Spanish representative in the meetings of the ERGO group, which, led by the EUSPA (European Agency for the Space Program), promotes the use of Galileo in the railway
- Participation in the Steering Committee of the European Association of Accredited ERTMS Laboratories (EAL: ERTMS Accredited Labs), together with five other accredited European laboratories (DLR in Germany, Multitel in Belgium, RINA and ItalCertifer in Italy, and LEF in France)
- Continuation of the preparatory work with Adif, the State Railway Safety Agency, Renfe Operadora and Ineco for the creation of the National ERTMS Laboratory at the LIF

Figure 4. ERTMS must be deployed on regional lines.

- Participation in the European Eulinx project for standardization and standardization of the interfaces of railway signaling systems

The conclusion is **that during 2022 the LIF has completed its transition, from a stage very focused on the execution of tests of the ERTMS lines in the laboratory for Adif to a new stage with two very defined axes: Railway R&D and internationalization.**

Railway R&D is specified, at the national level, with the two orders signed with Adif both for the development of low-cost regional ERTMS, in which new functionalities of ERTMS are incorporated, and for railway digitalization. The LIF Traffic Simulation Laboratory already constitutes in itself a digital twin of the complete ERTMS system, but the new developments will be able to provide it with more layers that complete said digital twin.

At international level, R&D is specified in the relevant participation of the LIF in the ERJU European program, with a remarkably high budget that will require very active participation in the next decade. This railway R&D is clearly aimed at railway digitalization and the development of new functionalities of ERTMS, which constitutes the cornerstone of such digitalization.

At international level, too, the LIF will continue to offer the execution of certification tests of ERTMS components, and will offer its services of simulation of ERTMS lines in the laboratory to collaborate actively in the deployment of ERTMS both in the European scope and in countries outside the European Union, developing the capacity to undertake remote tests that allow testing in the laboratory of lines and equipment located anywhere in the world.

CENTRE FOR PORT AND COASTAL STUDIES

" The completion of the works and the commissioning of the Maritime Experimentation Laboratory in 2023 will allow CEPYC to work with all its service capacities in ports and coasts, navigation, and sea "

In 2022, the **Centre for Port and Coastal Studies (CEPYC)** has developed its activity at the service of the executive units with competences in ports, coasts, navigation, and marine environment. This service is materialized in technical assistance, research, development, and innovation, responding to present needs and to the imperative of permanent improvement of capacities and competences to address current and emerging issues in our field of work.

After the catastrophe suffered during the exceptional snowstorm Filomena, since the beginning of 2022, except for the Maritime Experimentation Laboratory (LEM), all the dependencies and facilities of the centre have been available, including the Environmental Quality Laboratory and the Ship Maneuvering Unit. The dismantling and replacement work of the LEM roof, started in August 2021, have continued throughout 2022, marking the milestone of pulling down the collapsed roof in May 2022 and, then, starting the replacement works of the roof and affected facilities.

In these still limited circumstances, the activity focused on the best use of the available capacities has been developed: the centre's excellent human resources and the usable facilities, plus the support of computer equipment, thus continuing the process of renewal and updating of equipment and knowledge.

A remarkable feature in the activity of the centre is the **wide range of executive units to which it offers study capabilities** in both ministries of dependence, MITMA and MITERD. In 2022, we must highlight the incorporation of a contract assignment from

Experimental Hall during roof reconstruction (2022).

the recently created Directorate-General of Biodiversity, Forests and Desertification, DGBBD, of MITERD, for the study of various aspects of marine biodiversity and, with a very specific objective, the contract with the conservation directorate of Adif, MITMA group, of cabinet studies, field and experimentation through reduced scale models for the **maritime protection of the section of the Maresme railroad.** This railway section is part of the suburban trains of Barcelona, and includes the Barcelona–Mataró route, the oldest in Spain, currently at risk due to its low elevation above sea level.

In addition, and within MITERD, work has been done in 2022 for the Directorate-General of the Coast and the Sea, DGCM, the Spanish Office of Climate Change, OECC, the DGBBD, and for the public company ACUAMED. Both in the case of the DGCM and ACUAMED, new orders have been formalized in 2022 that give continuity to the services provided.

In the case of MITMA, work has been done for Puertos del Estado (general contract with CEDEX) and different State Port Authorities through agreements co-financed with the participation of Puertos del Estado; as well as for the Directorate-General of the Merchant Marine, DGMM, and the Commission for the Investigation of Maritime Accidents and Incidents, CIAIM.

The contract for "Applied research, technological development and innovation in matters within the competence of the Directorate-General of the Coast and the Sea" came into force in June 2022, and includes nine main tasks. Along with the main participation of the Centre for Port and Coastal Studies, the order includes subtasks to be developed by the Centre for Studies on Applied Techniques, the Central Laboratory for Structures and Materials, and the Geotechnical Laboratory, each collaborating within their areas of knowledge.

Within the framework of this assignment, a great deal of activity has been conducted by the CEPYC, issuing a total of twenty-one reports during the year corresponding to the development of the different tasks. As for **international activities,** work has been carried out corresponding to the national report to the Barcelona Convention on indicators 16 (length of coastline subject to disturbance due to the influence of artificial structures) and 21 (measures of concentration of enterococci), as well as the report as a member state on contributions from rivers and direct discharges to the sea.

The studies of dynamics and analysis of beaches with problems have had a lot of activity, working in El Portil (Punta Umbría, Huelva), beach of Preguntoiro (Villagarcía de Arosa, Pontevedra), Morro de Gos and Les

Activities and participation in programs for the protection of beaches.

Fieldwork in Albuñol beach (Granada).

Amplaries (Oropesa de Mar, Castellón), beach of Muiño (A Guarda, Pontevedra), urban beaches of Almería (San Miguel, Zapillo and Ciudad Luminosa), beach of San Sebastián (Sitges, Barcelona), and deltas of Albuñol and beaches of La Rábita and Pozuelo (Albuñol, Granada), also including two seasonal bathymetric and topographic surveys using conventional techniques and drones.

The environmental monitoring activities have been dedicated to the problem of marine litter (BM-6 program for monitoring microplastics on beaches), and the environmental recovery of the O Burgo estuary (A Coruña), with studies on the evaluation of flocculants for combined use with geotextiles and pre-operational studies for the Environmental Monitoring Program: characterization of sediments and bathymetric survey on the beach of Santa Cristina and campaign at the point of discharge. Partial reports have also been issued for the design of a database of actions on the coast, remote monitoring of the coastal area of Valencia from shorelines derived from satellite images, basic guide for topo-bathymetric monitoring of actions on the coast and state of the art, regulations, and identification of effects according to coastal diversity for the guide for the integration of climate change in coastal studies and projects.

The DGBBD Agreement was signed in June 2022, and aims to develop "Technical assistance, applied research and innovation in

Monitoring of microplastics on beaches.

Oceanographic campaign around discharges area into the sea of the environmental dredging work of the ría de O Burgo.

biodiversity and marine protected areas". Its 5 activities include technical support for the designation by the IMO (International Maritime Organization) of a **Particularly Sensitive Sea Area (PSSA)** in the western Mediterranean at the joint proposal of Italy, Monaco, France, and Spain; the main objective of this PSSA, which covers the existing Mediterranean Cetacean Migration Corridor, already declared by RD 699/2018, is to reduce the risk of collisions between ships and cetaceans in this area. This project has also had the contribution of fundamental importance of the DGMM in dialogue with the DGBBD, and in international talks and before the IMO for its successful conclusion.

For the OECC, CEDEX has completed in 2022 the work in relation to the Plan to Promote the Environment for Adaptation to Climate Change in Spain (Plan PIMA Adapta Costas), whose objective has been to support the activity of the coastal autonomous communities in the harmonized development of coastal adaptation plans to climate change through the compilation of information, risk reporting and viewer development. This activity for the OECC converges with others developed by the centre related to adaptation and mitigation of climate change in the sensitive marine and coastal territory and in relation to activities such as maritime transport.

Regarding ACUAMED, in May 2022 a multi-year assignment ended, and a new one was agreed upon in October, a new order for "Technical assistance, applied research and innovation in the field of **monitoring and environmental improvement of discharges into the sea from the facilities managed by ACUAMED",** which continues and reorients the activity. In the first semester, the studies of the behavior of the discharge of the desalination plant of Mutxamel, Alicante, the review of the Environmental Monitoring Program (PVA) of the discharge of the desalination plant of Águilas, Murcia, and the study of the flow parameters of the effluents discharged in the desalination plants of ACUAMED, as well as a final summary report, were delivered. These studies combine measurements in nature, numerical experimentation and application of empirical formulations developed by CEDEX, providing tools for the environmentally sound management of discharges.

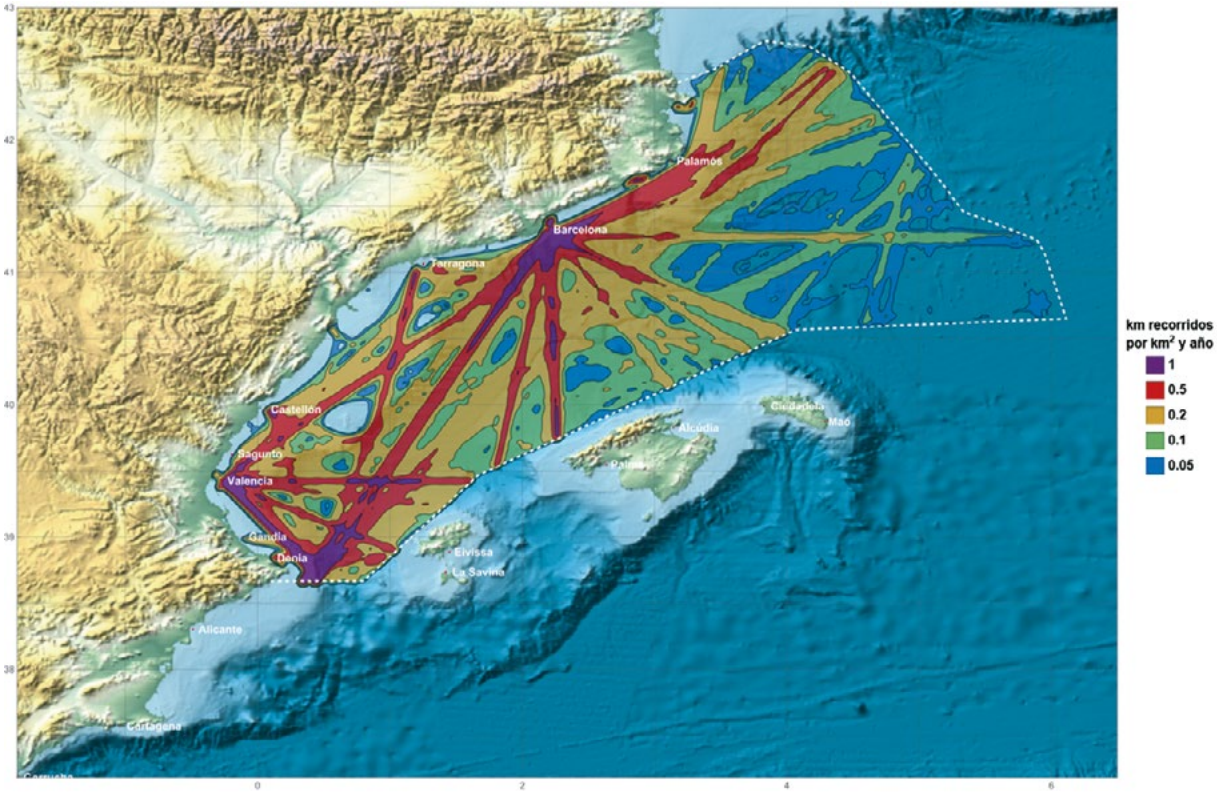
For the Directorate-General of the Merchant Marine, action has been taken within the framework of the current order, advancing in the development of the work entrusted. The study of the external anchorage of the port of Seville has been completed, with characterization of its climatic conditions and those of permanence of ships, also issuing reports regarding recommendations for the approval of specific products to tackle marine pollution and evaluation of the documentation of

certain solid bulk cargoes. With respect to the mitigation of climate change, progress has been made in the **study for the estimation of greenhouse gas (GHG) emissions and other pollutants from ships sailing** in Spanish territorial waters, developing the methodology for the evaluation, on a semi-annual basis, of these emissions. This implies the evaluation of emissions by aggregation of those corresponding to each of the merchant ships present at any given time, considering their power, instantaneous navigation situation and type of fuel used.

Keeping the existing collaboration since the creation of the CIAIM, the commission for the provision of technical assistance in the **investigation of the accident of the fishing vessel "Villa de Pitanxo"** has been received and completed in 2022, and specifically the study of the maritime climate conditions during the very serious accident that occurred in the waters of the great banks of Newfoundland in which 21 people died.

An important part of CEPYC's activity is dedicated to the **service of the state-owned port system.** In 2022 the activity of the CEDEX at its service, including the collaboration of other CEDEX centres and laboratories, has been regulated through the commission of Puertos del Estado to CEDEX for the period 2020–2022, "Realization of technical assistance, applied research and technological development works in matters of interest to the state-owned port system", and other orders from Port Authorities with support from Puertos del Estado to meet specific needs.

Among the completed works are the development of a methodology for the real-time estimation of emissions from ships in ports that can be integrated into the ShipLocus system of Puertos del Estado and, in relation to port dredging, the annual inventory of actions and the study of geochemical anomalies that could affect the characterization of sediments to be dredged in different locations, as well as the proposal of discharge



Traffic density in the Spanish area of the PSSA of the northwest Mediterranean.

Campamento floating dock (Algeciras).

areas close to the Galician estuaries as an alternative to point E/8. Other studies completed in the year are the general conditions of anchoring of ships and the investigation related to the risk associated with the traffic and maneuvers of ships in ports based on AIS data and results of simulated maneuvers, with proposal for revision of ROM 3.1-99. Among the studies commissioned by AAPP, the study of climate and agitation in the port of Ibiza, AP of the Balearic Islands has been completed, and a study in physical model on the new beacon of the port of Pasaia has been complemented with a numerical model of Computational Fluid Dynamics, being other studies in execution and preparation.

In the field of **international cooperation,** and within the INTERCOONECTA program of AECID, CEPYC staff, with the support of the R+D+i Unit of CEDEX run the course "Coastal Engineering and Marine Environment", with the participation of 44 professionals from 14 countries of Latin America and the Caribbean, belonging to various administrations, institutes, and universities. The course has allowed to expose the development and Spanish experience in these matters, and it's expected that it can be complemented with other training activities in the future. It's also worth mentioning the participation in the *XXXIX International Congress of the International Association of Hydro-Environmental Research, IAHR,* developing a meeting of Hydraulic Research Institutes moderated by CEDEX with the participation of representatives of 14 centres in Europe, America and Asia that discussed lines of research and new developments, recovering face-to-face contact after the COVID period. Likewise, it participated in the *XXX Latin American Congress of Hydraulics,*

Ship maneuvering simulator.

Presentation of paper at the *XVI JECYP.*

Felipe Martínez, National Civil Engineering Award 2022.

coordinating together with representatives of Peru and Argentina the Meeting of the Network of Ibero-American National Institutes of Engineering and Hydraulic Research, RINIIH. The MSP-OR and REMAP projects on Marine Spatial Planning are also noteworthy at the international level.

At the national level, the centre has been present in a large number of courses, conferences, and meetings, being especially noteworthy the participation in the **XVI Spanish Conference on Coastal and Port Engineering (JECYP, Vigo, May 2022),** which are held biannually, presenting 17 papers orally by CEPYC staff showing a wide overview of the centre's activities.

A noteworthy activity has been the visit to the port of Valencia by a large group of CEPYC staff led by the director of CEDEX, and at the invitation of the Port Authority. The visit included a presentation by its president of the activity of the institution, and a guided tour throughout commercial traffic terminals. The day also served to raise awareness of the port world for those of the centre's staff who, due to their professional profiles, don't usually visit this type of facilities.

For CEPYC, of which he was director (1986–1989) and with which he maintained an intense relationship later from the DGMM and the DGCM, the granting of the National Civil Engineering Award 2022 to Felipe Martínez has had a special resonance.

The completion of the works and the commissioning of the Maritime Experimentation Laboratory in 2023 will allow CEPYC to work with all its service capacities in ports and coasts, navigation, and sea.

Visit of CEPYC staff to the port of Valencia.

CENTRE FOR STUDIES ON APPLIED TECHNIQUES

" We reinforce our commitment to the environment "

The activities carried out by the **Centre for Studies on Applied Techniques (CETA)** in 2022, aimed at providing services to institutions and management centres with executive powers, in addition to those related to knowledge transfer, have covered several studies and projects. These have been linked to the protection and improvement of the environment and the care of human health, giving special consideration to the effects of infrastructures on different types of environments: atmospheric, terrestrial, and aquatic, either from their urban location or in the natural environment.

These activities include those associated with the development of climate change mitigation and adaptation measures and support for industrial pollution prevention measures.

In relation to the effects on the urban environment, the Area of Environmental Noise has continued to provide high-level technical assistance and innovative development services to the Ministry for Ecological Transition and the Demographic Challenge (MITERD). In this line, **the Noise Pollution Information System (SICA)** has been strengthened, providing information on noise pollution, and the Strategic Noise Maps (MER) and Noise Action Plans (PAR) prepared by more than 140 Spanish competent authorities, and informing the Spanish population affected by noise, all in line with the European Zero Pollution Plan, one of whose objectives is to reduce by 30 % the percentage of people chronically affected by transport noise. The SICA website is frequently consulted, receiving an average of 110 visits per day, with close to 40,000 visits in 2022, which shows its usefulness for the general and specialized public, complying with the basic principles of the legislation on access to environmental information.

During 2022, this Area has also developed an important extension of SICA to adapt the strategic noise maps to the requirements of the legislation on spatial data infrastructures, which will allow a more agile and efficient system of MER and PAR delivery by the competent authorities (with automatic checking of the information received), and its association with all the national thematic cartography, in addition to allowing the downloading of information on noise.

All the same, research work has been conducted, the results of which have been presented in communications at specialized acoustics and environmental noise congresses, with university internships and final degree projects being directed.

Among **the effects of infrastructures on the natural environment**, the Area of Environmental Engineering has continued its work on the impact of road traffic on insects in general and pollinators in particular. With this work, we have gained knowledge about the serious problem of insect decline, offering references to MITERD to meet the objectives laid out in the *National Strategy for the Conservation of Pollinators*.

For its part, Area of the Climate Change and Atmospheric Pollution has analyzed the fulfillment of the objectives of the strategy for **the adaptation of transport infrastructures to climate change**. Thus, coordinated by the Technical Road Association (ATC), the development of an adaptation strategy necessary to provide society with safe infrastructures is being finalized. In this line of work, the Area has developed, for Puertos del Estado, new tools to optimize the management of port infrastructures. Of particular note here is the SAMOA-2 application and real-time monitoring of ship emissions. In parallel to these projects, and also for Puertos del Estado, progress is being made, on the one hand, in a project for the calculation and management of the carbon footprint, gathering and relating public procurement criteria with the concept of carbon footprint in ports; and on the other, by developing the carbon footprint of the port of Seville.

These tools have an impact on a better service to society by decisively contributing to the reduction of GHG emissions and atmospheric pollutants generated in ports, thus contributing to the improvement of air quality in nearby urban areas.

As for **the aquatic environment**, the Area of Environmental Restoration is proposing specific measures and actions to recover the functions and services of this type of ecosystems that have been altered by human activity. Within this line of activity, we have continued to provide high-level technical advice to the MITERD´s Directorate-General for Water (DGA) for the implementation of a network to monitor the effects of climate change on the River Nature Reserves (RNFs). This activity is part of the Environment Promotion Plan for Climate Change Adaptation in Spain (*Plan de Impulso al Medio Ambiente para la Adaptación al Cambio Climático en España*-Plan PIMA Adapta AGUA), which in turn is part of the MITERD´s *National Climate Change Adaptation Plan* (Plan Nacional de Adaptación al Cambio Climático -PNACC) to adopt management and adaptation measures in River Natural Reserves against the possible effects of Climate Change.

Insect trapping on the A-40 motorway between Tarancón (Cuenca) and Santa Cruz de la Zarza (Toledo).

River Natural Reserve of the Barbaón river (Cáceres). The headwaters of the Barbaón river is a representative example of the Tajo siliceous plains river typology.

Likewise, work has continued on the development of **ecological flow regimes** for the DGA. Specifically, the evaluation of compliance with the environmental flow regimes defined during the second planning cycle has begun, and a proposal has been prepared to classify the different types of non-compliance with the defined environmental flow regimes. In addition, and within the framework of the POCTEP-Albufeira project that's coordinated by the DGA and the Centre for Hydrographic Studies (CEH), CETA has provided support for the comparison of the methodologies used by Portugal and Spain in the evaluation of the hydromorphological quality elements of the Water Framework Directive.

Furthermore, CETA is participating in the project "Recovery of the fluvial ecosystem Manzanares-Gavia-Bulera. Green and Blue Infrastructure of the Metropolitan Forest of Madrid", led by Madrid City Council, and with the participation of CEDEX -through CEH and CETA- and CONAMA Foundation. The three institutions were beneficiaries of a grant awarded by the Biodiversity Foundation, by means of the EU Next Generation funds, within the call **for the promotion of actions aimed at the restoration of river ecosystems and the reduction of flood risk in Spanish urban environments through nature-based solutions**. CETA's Areas of Environmental Restoration and Environmental

Spillways of the La Gavia WWTP and La Gavia stream, on the left bank of the Manzanares river.

Engineering participate leading the actions *A2: Initial ecological characterization of the study area, and C3: Environmental monitoring plan*.

The expansion of new work horizons has allowed the Area of Environmental Restoration to develop work with the Community of Madrid for the proposal of alternatives for the renaturalization of the Soto de las Cuevas lagoon using sedimentary material from the Soto de Legamarejo. Besides, a contract has been initiated with Adif, for the next four years, in which high-level technical consultancy will be carried out on the conservation and restoration of riverbeds and riverbanks, as well as revegetation of slopes on the General Interest Railroad Network.

Environmental radiological monitoring of the aquatic environment is conducted by the Area of Isotopic Applications and is part of two orders from the Nuclear Safety Council for the National Network of Continental Waters and Transitional, Coastal and Marine Waters in compliance with the EURATOM international treaty.

In the field of the application of environmental isotopes to water management, the "Experimental study for the development of a methodology based on the analysis of environmental isotopes to determine the evolution of nutrient pollution in the water environment", commissioned by the DGA, MITERD, has been initiated. This study supports the DGA in the development and evaluation of strategies to address water pollution by nitrates through the identification of potential markers of nutrient sources. In this line, a study has been completed to evaluate the watertightness of the Bellús reservoir and its possible effect on the water quality of downstream supplies.

In 2022, dating techniques were applied to evaluate the residence time of water in **aquifers** in the research project "IVRIPARC: methodology to estimate the impact of global change on the geological heritage of the national parks of the Canary Islands", in the Garajonay National Park (island of La Gomera, Canary Islands), commissioned by the IGME-CSIC, and in spring waters intended for human consumption for the company DANONE.

In the coastal sector, the Area of Environmental Restoration has begun work with the Directorate-General for the Coast and the Sea (DGCM), of MITERD, to evaluate **restoration actions on the coast**, which will continue over the next two years. Likewise, in collaboration with CEPYC, the Strategic Environmental Document of the Ebro Delta Protection Plan was prepared within the framework of the simplified strategic environmental assessment procedure promoted by the Directorate-General for the Coast and the Sea.

The Area of Environmental Engineering is also collaborating with the General-Directorate of the Coast and the Sea to implement the requirements of the *National Strategy for Green Infrastructure and Ecological Connectivity and Restoration (ENIVCRE) in the Maritime Terrestrial Public Domain*.

Regarding the **development of industrial pollution prevention measures**, the Area of Industrial Environment provides high-level technical assistance to MITERD's Directorate-General for Environmental Quality and

Measurement of unstable parameters in a water sampling campaign for isotopic study of water tightness of the Bellús reservoir.

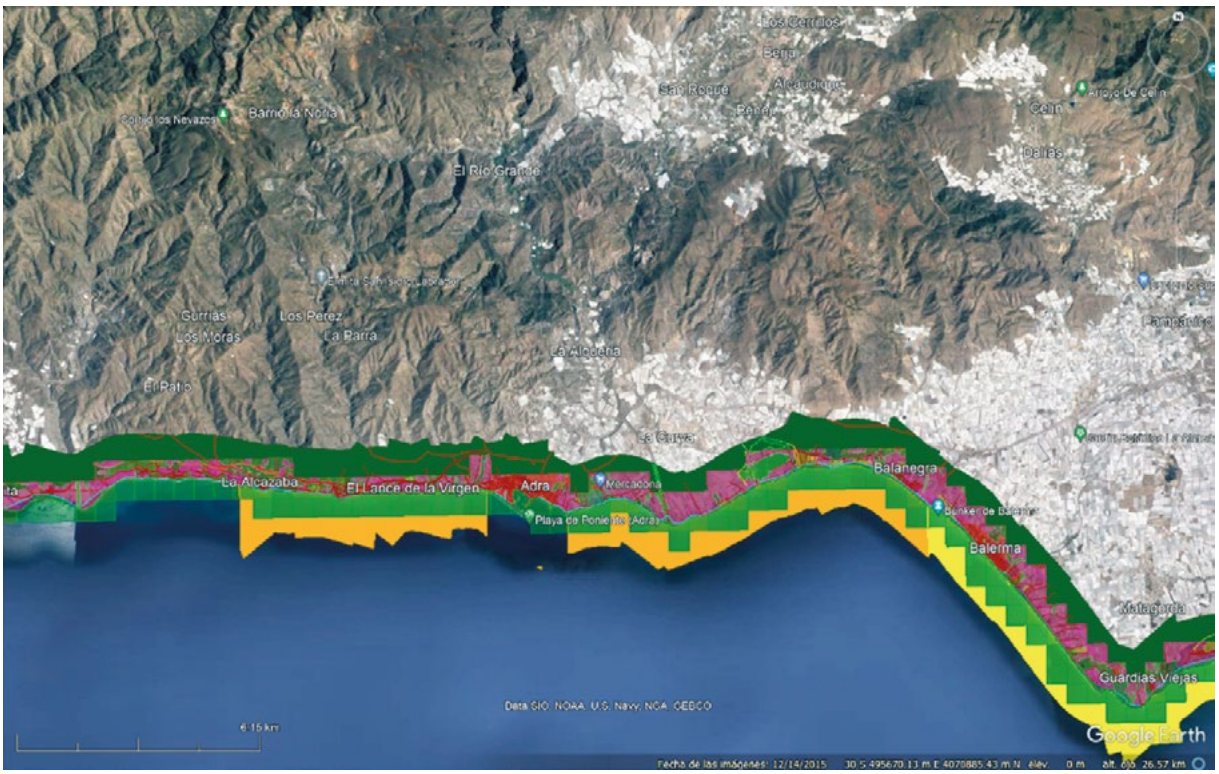
Digital Terrain Model (DTM) image of the Ebro delta.

Assessment (DGCEA) in the preparation of Best Available Techniques Reference Documents (BREFs) in the metal surface treatment (STM BREF) and large volume inorganic chemical industry (LVIC BREF) sectors.

One of the distinctive characteristics of studies on the industrial environment is that, in addition to emissions into the atmosphere, discharges into water, and waste generation, all technological aspects developed in every phase of industrial production must be considered, with the aim of reducing the adverse aspects for the environment. Knowledge of these technological features makes it possible to apply a pollution prevention policy using BATs in the different industrial processes. BATs provide a tool for the industrial sector to ensure that its activity produces the least possible negative impact on the environment.

In turn, we're working with the DGCEA to establish indicators that can quantify the measure of circularity, so that the implementation of the different measures and their results can be monitored to prevent the transition to the new economic model from being blocked by inefficient routes.

Finally, it should be noted that these activities are aligned with the achievement of the corresponding Sustainable Development Goals.



Google Earth image showing a stretch of the Andalusian coastline where the capacity of the Public Maritime Land Domain to support the *National Strategy for Green Infrastructure and Ecological Connectivity and Restoration* is being identified.

CENTRAL LABORATORY FOR STRUCTURES AND MATERIALS

" The LCEYM contributes with its studies to the sustainability and improvement of the durability of infrastructures "

During 2022, the **Central Laboratory for Structures and Materials (LCEYM)** has carried out an intense activity in the field of the study of dykes, dams and bridges. The purpose of this work is to contribute to the sustainability and resilience of infrastructures, increasing their useful life.

A significant part of the actions has been focused on the needs of MITMA and MITERD, thus accomplishing one of the main functions of CEDEX and of its *Strategic Plan 2020-2022.*

Technical assistance work has been done for the Directorate-General of Roads (DGC), studying the anomalies detected in the construction of the viaduct of the Mudéjar motorway (A-23) over the Gállego and Aurín rivers, in Sabiñánigo (Huesca). Through a multidisciplinary approach and transversal collaboration, the work has been carried out by a specialized technical team from the LCEYM and the LG, coordinated from the Area of Studies and Auscultation of Structures. The work has consisted of establishing a hypothesis about the origin and significance of those anomalies, as well as the technical assessment of the planned repairs and the proposal of action measures.

The Area of Materials Science has worked in the field of dam concrete pathologies for the Directorate-General for Water (DGA). Thus, the study of the El Atance dam has been completed, with an in-depth assessment of the condition of the dam's concrete, and a study of similar characteristics has been started on the Villameca dam, in the province of León.

In addition, the study of the concrete of the Tentudía dam in Badajoz has been carried out in the Area of Materials.

Likewise, the study of concrete corrosion processes in port structures has continued, at the request of Puertos del Estado. In this

Studies on the Mudéjar highway viaduct.

Study of the Villameca dam.

way, the study of corrosion in the reinforced concrete of Phase II of the Reina Sofía dock, in the port of Las Palmas, has been completed. The assessment of the causes that have reduced the service life of the seawall of this dock, together with the results obtained in four other seawalls studied previously, have enabled a global assessment to be made of the reasons why many reinforced concrete seawalls are showing evident durability problems in a short period of time.

Moreover, research has been successfully completed on the influence of caisson manufacture using floating platform technology, which is widely used in Spain, on the durability of port structures. The study, conducted in the laboratory for over 3 years, combined with samples taken from real structures in the ports of Barcelona and Tenerife, led to the conclusion that the curing of the concrete of the caissons with seawater doesn't have a significant influence on the service life of these structures due to corrosion.

The work on floating caissons and durability of dock breakwaters, which has been successfully completed, has led to actions focused on spreading the advances achieved, such as various communications at congresses and a conference for engineers from Puertos del Estado and Port Authorities. Work is underway to ensure that in the near future this work will also be published by CEDEX.

Similarly, two works are being undertaken for Puertos del Estado focused on preventing corrosion problems in port structures: The design of a field test to control the placement of concrete from the durability point of view, and a state of the art on very high durability concretes. The study of a new field test to control the durability of port concrete has been carried out in the laboratory and

during the construction of a new closure dock in the port of Las Palmas: Phase III of the Reina Sofía dock.

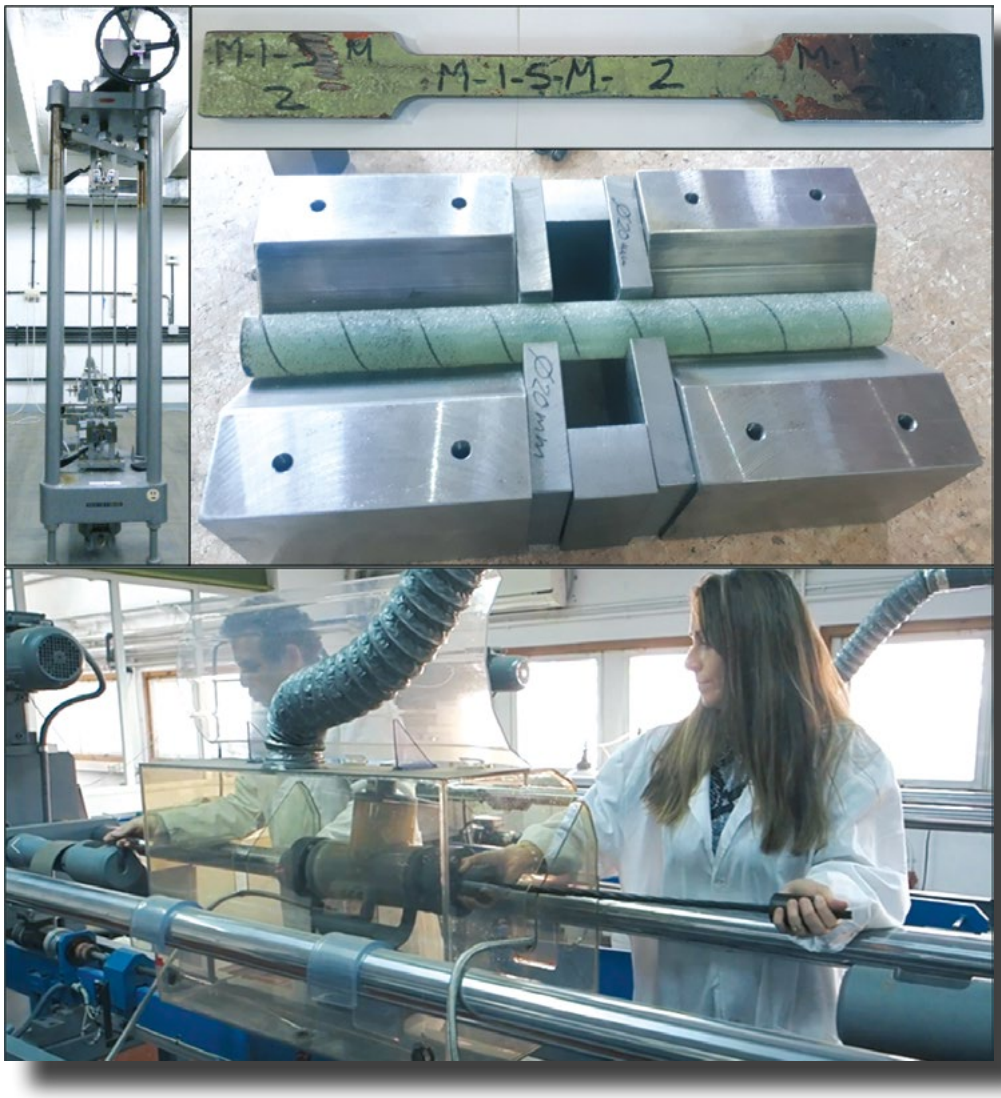
The conclusions of the work carried out for the DGA y Puertos del Estado have enabled improvements to be made to the current regulations (*Structural Code*) to avoid the appearance of problems like those found in this work in future structures. In this way, the objective of Cedex in its strategy of providing service to both the sector and society is covered, while improving the resilience and sustainability of hydraulic and port structures.

In the field of innovation, a state of the art has been completed on highly durable concrete for application in port works, including a study of alternative reinforcements to traditional carbon steel reinforcements with high resistance to corrosion, considering galvanised, stainless steel, and fiber reinforced polymer (FRP) reinforcements as possible options. According to the conclusions reached, **the Construction Products Area has initiated a line of work on FRP reinforcement.** The studies underway are aimed at increasing the durability of reinforced concrete structures and their resilience to attack by aggressive chemical agents.

The focus of the works is aligned with the increase in the sustainability of materials, not only covering their production, but also considering their complete life cycle and the extension of the useful life of the structures. Likewise, this line of action is part of possible strategies to reduce the carbon footprint and the emission of greenhouse gases.

In the field of waterproofing, the work corresponding to the study of the performance of geomembranes used in water storage reservoirs has continued with the

Study of corrosion in the reinforced concrete of the Reina Sofía dock, in the port of Las Palmas.



Laboratory of Productos de Construcción.

Mancomunidad de los Canales del Taibilla as well as within the Collaboration Agreement with Balsas de Tenerife and the Consejo Insular de Aguas de La Palma, signing the extension of the latter in the month of August, for a duration of four years. These studies will contribute to the improvement of our water resources, one of our most precious and scarce assets, optimizing its management by the public sector.

For the DGA, this year the drafting of the *Practical Guide for the Inspection and Monitoring of Polymeric Geosynthetic Barriers Used in the Waterproofing of Reservoirs* has been completed. Among the objectives of the Guide are the determination of the significant characteristics that provide information on the degradation of polymeric geomembranes as well as their limit values, which will indicate the end of their useful life, along with a series of recommendations for re-waterproofing the reservoirs. Another primary objective of the Guide is to provide the owners of the reservoirs, the personnel related to their exploitation, and those working for the public sector, the analysis and evaluation of the natural aging of this type of products to enable the necessary actions such as repairs, replacements and even the re-waterproofing of the geosynthetic barrier to guarantee the safety of the reservoirs.

A pilot study using remote sensing techniques and geographic information systems has also been started, together with the Centre for Hydrographic Studies (CEH), with the aim of collecting information on existing reservoirs in Spain to prepare a white paper on reservoirs for water storage.

The LCEYM has kept on with its activity as a steel testing laboratory for construction: structural, and reinforcing and prestressing steel for reinforced concrete, in the field of product approval for the Ministry of Industry, Trade and Tourism and for the certification of products within the framework of various Technical Committees of the AENOR Certification Commission. Also, in the field of construction steels, but in this case in railway infrastructures, a new line of activity has been initiated relating to the quantification of the degradation of rails, and their wear due to the passage of trains. This work verifies compliance with the specifications and requirements for steel materials and products to guarantee their technical competence and durability in a sector of great economic importance for the country, such as steelmaking, manufacture, and marketing of steel products for construction.

In the field of technological development, work has gone on with the implementation of the BIM methodology on existing structures, with a proposal for practical application in dam works for the DGA. In this way, through BIM modeling, a digital model of the El Atance dam in Guadalajara has been generated, fed with the results of monitoring different parameters and structural evaluation studies and their materials. Thereby a Digital Twin of the dam has been generated that will serve as the basis for its

Activities of LCEYM's Area of Materials: Study of the concrete of the Tentudía dam (Badajoz) (above left), inspection of La Cruz Santa reservoir (Tenerife) (above right), and measurement of the retroreflection of vertical signage (below).

management. The Area of Studies and Auscultation of Structures has also continued to coordinate the CEDEX drone operator, adapted to new regulations and increasing service provision capabilities.

On the other hand, specific technological prospecting has continued to identify equipment that allows the evaluation of bridge post-tensioning stay cables and tendons, given the existing uncertainties about the real durability of this type of critical elements.

In the field of road signage, work has carried on monitoring more than 450 km of highways and numerous reports have been issued corresponding to the verification of the indicators related to the retroreflection of road markings and vertical signage, commissioned by the DGC. This work will have a clear impact on improving road safety, minimizing traffic accidents, and increasing the perception of well-being by making driving easier.

In the Photometry Laboratory, a singular facility of the LCEYM, studies have been carried out on the performance of retroreflective materials used in signage, commissioned by the company 3M Spain.

Prototype test for vibration test.

In the Structural Dynamics Area, work has been undertaken in two different areas. On the one hand, regarding the work carried out on the Seismic Simulator, it's important to highlight the frequency, vibration and shock sweep tests performed for the companies SEPSAMEDHA S.L.U., and Abengoa Innovación S.A. to verify the response of their prototypes to the stresses imposed by the applicable regulations in each case.

On the other, participation in the European program FP3-IAM4RAIL (Holistic and Integrated Asset Management for Europe's RAIL System) has begun, which will be developed over the next four years. The project consists of monitoring certain elements of a viaduct located in the province of Cuenca on the Madrid-Alicante High-Speed Line.

At international level, the Horizon Europe project LIAISON (Lowering Transport Environmental Impact Along the Whole Life Cycle of the Future Transport Infrastructure) has been accepted, in which the LCEYM Materials Area will participate, together with public and private entities from six European countries. Its objective is to develop a methodology, supporting tools and technological solutions to transform the EU's transport infrastructure into a more sustainable and low-carbon activity. The work consists of three phases. The first will entail the development of a methodology to evaluate the environmental performance of transport infrastructures in the project phase, defining objective and rigorous indicators within the context of sustainability and the circular economy. In the second, this methodology will be validated through practical demonstrations that will be executed using circular solutions. In the third, the LCEYM will lead the normalization activities that arise because of the project results.

The activity of the LCEYM linked to experimentation, involves the performance of numerous laboratory tests to evaluate physical, chemical, and mechanical properties, as well as the maintenance of the ENAC accreditation and a Quality Management System (QMS), according to UNE-EN ISO/IEC17025:2017 for certain steel products.

Finally, and to complete ENAC-accredited chemical tests on steels, the Area of Materials has acquired a new spark excitation optical emission spectrometer, facilitating start-up operations, personnel training, method validation and participation in international intercomparison tests, necessary actions to incorporate the equipment into the quality management system.

GEOTECHNICAL LABORATORY

" The Geotechnical Laboratory in 2022: with its feet on the ground, solving present and future problems "

The activity of the **Geotechnical Laboratory (LG)** in 2022 has been aligned with the challenges of the agency's *Strategic Agenda*. In particular, with those of resilience in mobility and the natural environment, sustainable mobility and sustainability in the natural environment.

Thematic areas have been addressed relating to the different phases of geotechnical studies of infrastructures under the responsibility of the Ministry for Transports, Mobility and Urban Agenda (MITMA), specifically, roads, railways and ports; as well as the Ministry for Ecological Transition and the Demographic Challenge (MITERD), in particular, hydraulic works (safety of dams and reservoirs), coasts (actions for the protection of the coast) and environmental quality and assessment.

The activity of the LG results in the correct maintenance and development of the country's infrastructures, through the technical analysis of projects for new works or pathologies detected in existing ones, and the pro-

MONITORING OF PATHOLOGIES ON THE STATE ROAD NETWORK

Road Demarcation	Road	Province/City/K.M.	Pathology Studied
Andalucía Oriental	A-7	Granada/Carchuna/ Cutting Slope 2	Slope
		Granada/Polopos-Albuñol/ Cutting Slope 32 and Ramoncillos Tunnel	Slope and Tunnel
	A-32	Jaén/Canena Diversion/K.M. 138+850	Embankment
Andalucía Occidental	SE-30	Sevilla/Sevilla/K.M. 2+500	Embankment
	N-432	Córdoba/Córdoba/	Embankment
Aragón	N-420	Teruel/Escucha/K.M. 648-649 Teruel/Utrillas/K.M. 654+400	Embankment
Castilla-La Mancha	N-420	Ciudad Real/ Fuencaliente/K.M. 99,6 y 102,5	Slope and Embankment
Castilla y León Oriental	BU-30	Burgos/Burgos/K.M. 12+625 to 13+000	Reinforced Earth Wall
Cataluña	N-420	Tarragona/Coll de Teixeta/K.M. 851	False Tunnel
Comunidad Valenciana	A-7	Alicante/Alcoy Bypass/K.M. 445 to 448	Embankment
	A-33	Valencia/Fuente de la Higuera7 UP-8.8 and at K.M. 85	Embankment

posal of technically and economically reasonable solutions.

In the area of **road geotechnics,** the LG has accomplished geotechnical consultancy work and, fundamentally, instrumentation, monitoring and analysis of the behaviour of road sections that have presented different ground-related problems. The studies have been carried out within the framework of the assignment of the Directorate-General of Roads to CEDEX for technical assistance in geotechnical issues in the period 2021-2024.

Within this area, new methodologies have been implemented for monitoring the evolution of geotechnical pathologies studied, based on laser-scanning techniques, photogrammetry, interferometry based on satellite images with high-resolution radar, etc., as illustrated in figures 1 and 2.

In **railway infrastructure geotechnics,** activities concerned with the European GEOLAB project were particularly noteworthy, including the preparation of the tests committed to with external entities and the management of activities related to the "Early Stay Research" program. Work also commenced on four actions under the new Adif commission: theoretical developments, laboratory tests on ballast, track instrumentation, and tests on the CEDEX Track Box, where maintenance and calibration work was carried out on the facility's instrumentation. Studies have proceeded on with critical speed, which led to the **Talgo Award for Technological Innovation.**

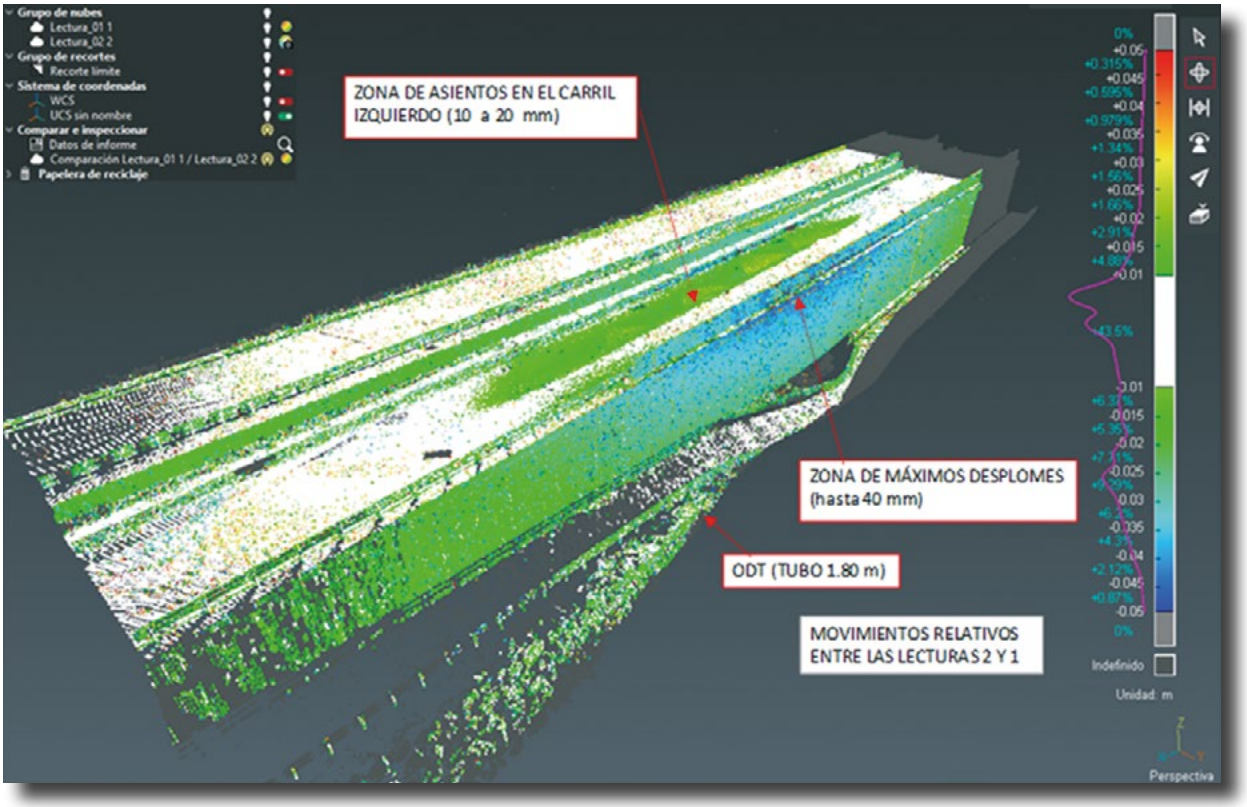


Figure 1. Terrestrial laser scanner (TLS) model on a gabion wall of the BU-30 motorway.

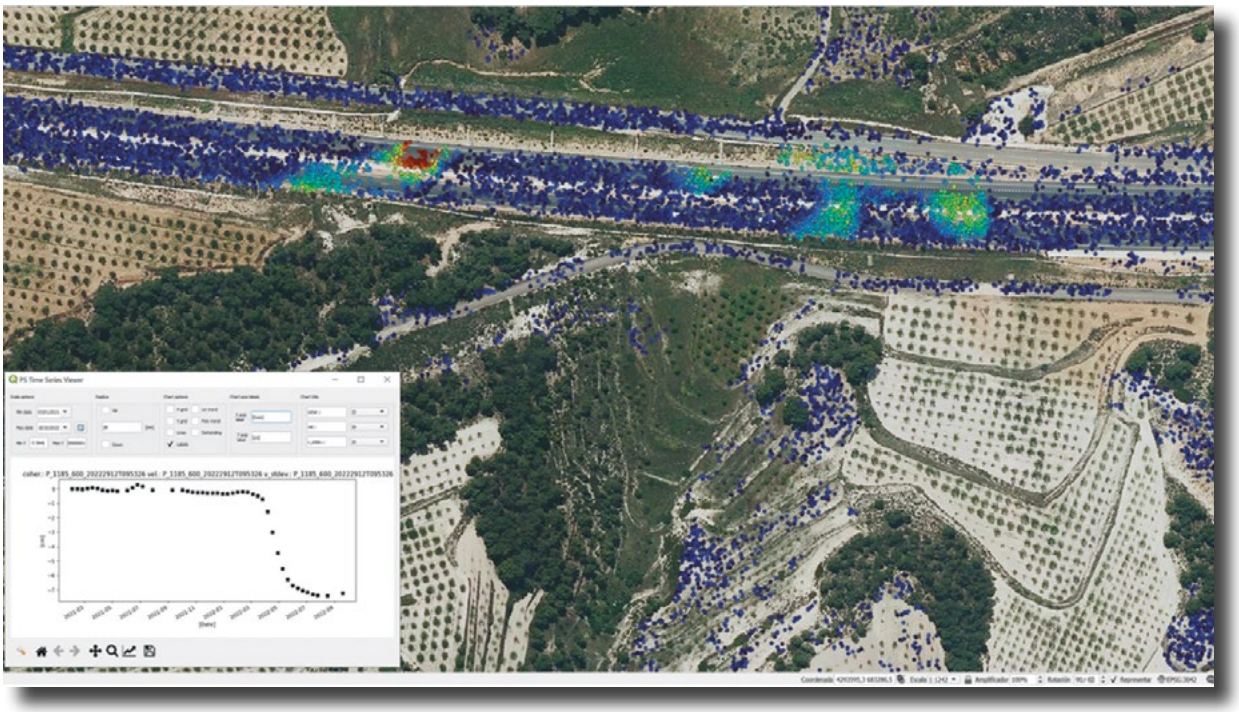


Figure 2. Interferometric processing of high-resolution radar images (PAZ satellite) for ground motion interpretation.

As regards the geotechnical engineering of port and coastal works, work has been carried out under the mandate of Puertos del Estado, both for technical assistance and R+D+i.

In port R+D+i, studies have been conducted on automatic learning techniques for terrain characterisation and profiling in the ports of Barcelona and Cádiz (in the latter using the kriging technique).

For the Directorate-General for the Coast and the Sea, two studies were undertaken on the stability of coastal slopes: one next to a housing development in Fuenterrabía (Guipúzcoa), and the other next to the beach of Alojera (La Gomera, Canary Islands).

In **geotechnical engineering of hydraulic works,** under the annual program of the Directorate-General for Water, studies have

Figure 3. LG-CEDEX Micro Deval equipment used for ballast degradation studies.

Figure 4. View of the instrumentation mounted on a section of the Madrid-Barcelona high-speed line.

GEOTECHNICAL STUDIES CARRIED OUT FOR STATE PORTS

Port Authority	Port	Type of Study
Las Palmas	Arrecife	Assessment of geotechnical campaign and proposal for a complementary campaign
Barcelona	Barcelona	Advice on the design and numerical modelling of draught increase in a caisson quay
Bahía de Cádiz	Cádiz	Advice on the commercial dock adaptation project; geotechnical campaign, interpretation, design of the reinforcement of the quays and support in the repair of the false access tunnel to the container terminal
Cartagena	Cartagena	Advice on the intended preload on the multi-purpose spring and its instrumentation
Gijón	Gijón	Assessment of the North Quay rail access project; ground treatments, proposal of alternatives, and specific geotechnical campaign
Málaga	Málaga	Quay and junctions of Quay 8 extension
Melilla	Melilla	Economic appraisal of a geotechnical campaign with pontoon and its technical implications
Tarragona	Tarragona	Geotechnical campaign in the Els Prats contradiction site

been conducted on several dams in service: El Atance (CH Tajo), on pathology in its foundations; Arenós (CH Júcar), on the stability of the slopes of the reservoir and spillway area, and proposal for an instrumentation plan; Castrovido (CH Duero), on a potential sinkhole. Support was provided in the drafting of the Santoña-Laredo sub-fluvial tunnel project, which is being managed by the Confederación Hidrográfica del Cantábrico (Cantabrian Hydrographic Confederation).

For the Guadalquivir Hydrographic Confederation, work has been done on a study of seepage in a hill of the Breña II dam (Almodóvar del Río, Córdoba).

In **environmental geotechnics,** work was done with the Centre for Studies on Applied Techniques (CETA) on a study for the Confederación Hidrográfica del Ebro on the analysis of the impact of lindane contamination at the Sardas landfill (Sabiñánigo, Huesca). A study has been completed on the analysis of the stability of an industrial waste landfill in Vizcaya, and another has been started on the use of construction and demolition waste (CDW), and iron and steel aggregates in port facilities.

Concerning **geotechnical laboratory tests,** 21 works have been completed: 3 under an agreement, 6 for external clients and 12 for the permanent technical service. For the IFMIF-Dones project, Bender element, resonant column, torsional shear, cyclic simple shear and dynamic triaxial tests were performed on soil samples taken from the site where a particle accelerator will be built in the municipality of Escúzar (Granada). For DEME Group, a coarse granular material from Norway has been characterised using

Figure 5. Project for railway access to the north quay (port of Gijón). Aerial view of the quay.

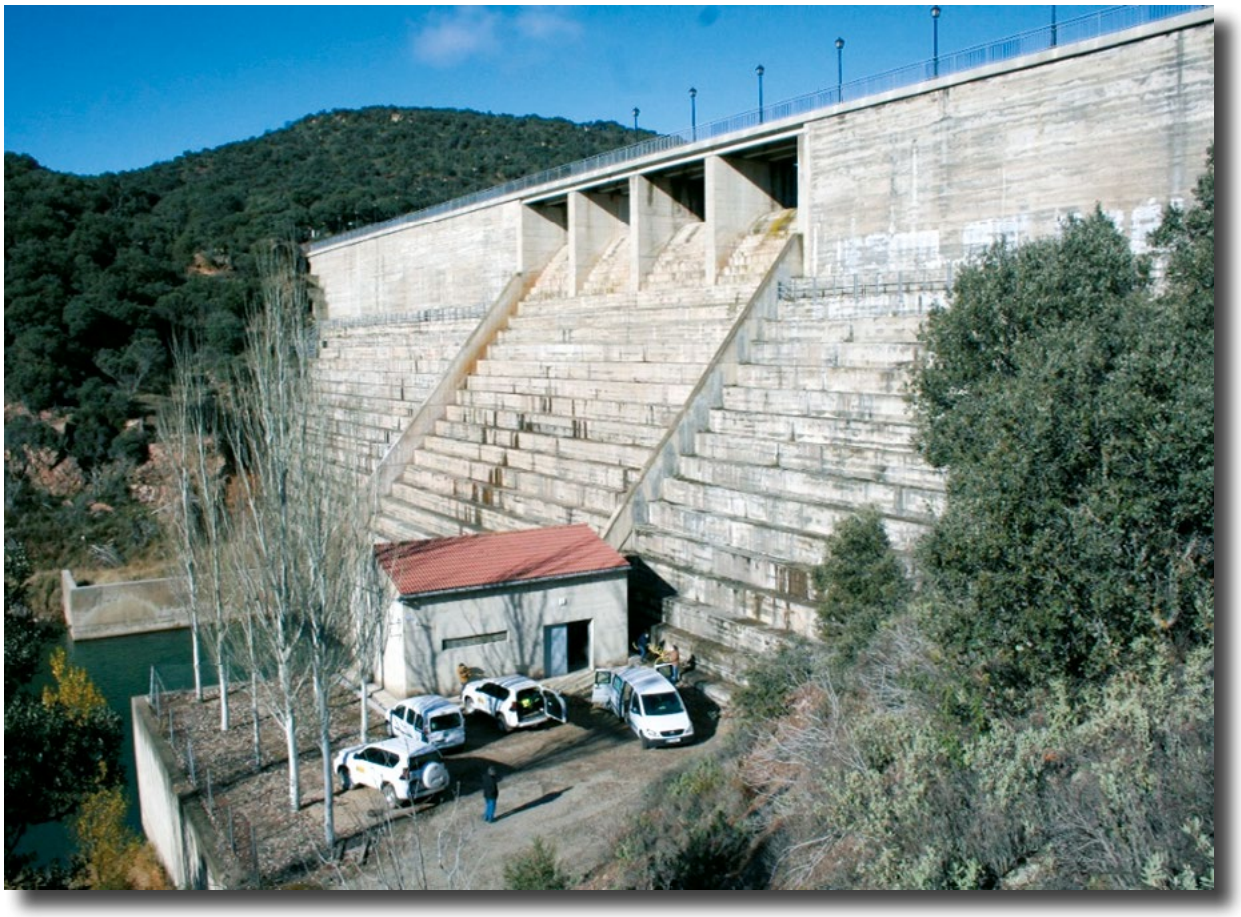


Figure 6. Characterisation of the foundation on the left abutment of the El Atance dam.

a 1 x 1 m shear test for its possible use as a support bench for a platform in the port of Le Havre (France). Ten chemical tests have been executed for different purposes, and the environmental management system of the LG has been implemented. In addition, the laboratory has participated in experimental work for the development of two doctoral theses: *Geotechnical Characterisation of Expanded Clay as a Light Aggregate,* and *Geotechnics of Reservoirs in Geological Storage of* CO_2.

On the other hand, the development of the direct shear test on rock and the updating of the corresponding ISRM Suggested Method continues, leading an intercomparison project of laboratories with the participation of several national and foreign universities.

As for **geophysical techniques applied to geotechnics,** several test campaigns have been performed in port, road and environmental fields.

In the area of **in situ geotechnical testing and instrumentation,** the work for the Júcar Hydrographic Confederation in preparing a large in situ shear test, a type of test that's uncommon in Spain and in which CEDEX has some experience, is of great interest to reliably determine the shear strength of certain surfaces or contacts in the ground. In 2022, the design of the test has been finalised and the jacks with which to carry out the test have been acquired.

In the area of **standardisation,** work continued on UNE's CTN 103-Geotechnics committee, of which it's the chair, as well as on

the UNE and CEN committees relating to *Eurocode 7.* Work has begun on updating the *Guide to Anchorages,* for the Directorate-General of Roads; work has been completed on the UIC document on Railway Infrastructure Maintenance; and we have collaborated in the revision of the *Practical Guide for the Inspection and Monitoring of Polymeric Geosynthetic Barriers Used in the Waterproofing of Ponds,* for the Directorate-General for Water.

An important effort has been made to maintain the presence of CEDEX in national geotechnical forums (Spanish geotechnical societies, UNE standardisation committees); as well as in international forums, generally adopting the form of telematic participation: international geotechnical standardisation committees and working groups (CEN, ELGIP platform).

On-site technical conferences have been organised, such as the SEMSIG-AETESS Technical Conferences and the Conference on Critical Speed of Railway Sections, which subsequently gave rise to the presentation of these works for the **Talgo Prize for Technological Innovation,** with the proposal presented winning first prize.

The *11th National Symposium on Geotechnical Engineering,* held in Mieres, Asturias, in May, and the *10th National Symposium on Slopes and Unstable Slopes,* in Granada, in September, were particularly noteworthy.

CENTRE FOR HISTORICAL STUDIES OF PUBLIC WORKS AND URBAN PLANNING

" CEHOPU keeps on, thanks to its traveling exhibitions, with its work of disseminating the culture and historical heritage of Spanish public works "

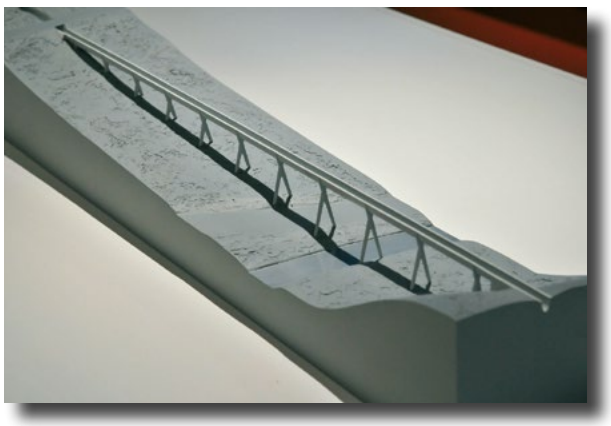
The recovery, conservation and enrichment of the historical heritage of civil engineering in Spain are the main task of the **Centre for Historical Studies of Public Works and Urban Planning (CEHOPU),** which focuses its activities on the revaluation of its historical heritage through the study and dissemination of the techniques and achievements of the most relevant figures of engineering throughout history, and by means of **exhibitions and publications.**

The dissemination and transfer of knowledge resulting from these activities highlight the magnitude and characteristics of this important cultural legacy, allowing society, aware of its existence and importance, to demand its **protection and care.**

The lines of activity maintained by the centre since its origins have been developed with the aim of:

- **Promoting the study and research** of the history of public works and urban planning.
- **Publishing works and, above all, managing the documentary collection** of the history of public works and urban planning included in its specialized technical library, in addition to the archives of illustrious engineers deposited in the centre and its graphic archive.
- **Elaborating, designing and producing new exhibitions,** to which should be added the program of traveling exhibitions, publications, and the participation in discussion forums, seminars and congresses, and the managing of programs for dissemination through Internet.

Thus, in 2022 the centre has maintained its usual activity with a notable effort to make up for its staff shortages.



Alloz Aqueduct.

Azud de Villareal.

Projects developed during 2022

Project proposal for the creation of the CEHOPU Museum of Public Works
Cuadernos Dieciochistas journal, monographic issue *Civil Engineering in the 18th Century*. Daniel Crespo Delgado and Alfonso Luján Díaz, "Public works in the Spanish press of the Enlightenment"
Revista *Anales de Historia del Arte*, monographic Art and the Archive. Joaquín Álvarez Barrientos, "The Astrologer and his Cabinet. Authorship, science and representation in 18th century almanacs"
Revista de Obras Públicas del Colegio de ICCP, recension of the facsimile "Main reinforced concrete works designed and supervised by Eduardo Torroja de1926 a 1936", published and presented by CEHOPU, in December 2021, at the Professional Association of Civil Engineers in Madrid
III International Congress of the Iberoamerican Association of Urban History "Rethinking the Iberoamerican City. Building the past and designing the future"
First Seminar on Collective Housing organized by the School of Architecture, Art and Design of the Monterrey Institute of Tecnology and Higher Education, México

HISTORICAL RESEARCH ON PUBLIC WORKS AND URBAN PLANNING

The study and research of engineering of the past contributes to understanding the significance of public works in the economic and social development of Spain.

Historical research studies on public works, civil engineering and urban planning, one of the main functions of CEHOPU, is at the base of practically all the other activities it carries out. In this, as in other tasks, the centre undertakes its own work, while promoting outside proposals in which it participates to varying degrees.

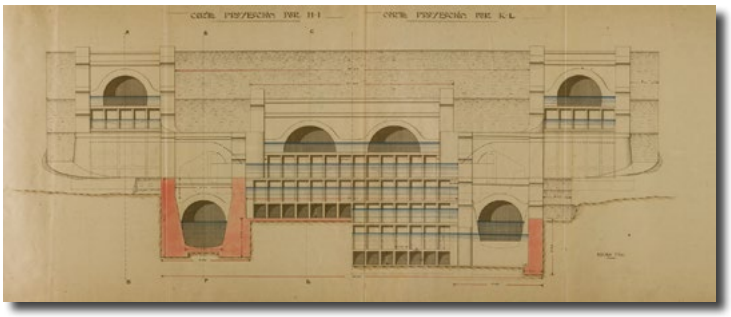
In order to strengthen the exhibition catalog, the necessary research work on the figure of **Manuel Lorenzo Pardo** (1881-1953) was begun beforehand, which feeds the proposed exhibition project with the aim of presenting it in 2023.

Manuel Lorenzo Pardo is, no doubt, a figure of special relevance in the field of civil engineering in Spain. His activity transcended the scope of his profession, imprinting a scientific character in all his achievements. He was part of the so-called *generation of wise men*, characterized by the take-off of Spanish science towards its own production and internationalization.

He was also the founder of the Centre for Hydrographic Studies, which, for a period, shared space in what was known as the *Colina de las Ciencias*, a project for the enlightened Madrid, with the Astronomical Observatory, the Royal Botanical Garden, the Hospital de San Carlos, and today's Prado Museum, formerly the Museum of Natural Sciences.

In parallel to the realization of a project for the inaugural presentation of the exhibition, we're working on the conception of an **itinerant model** of the exhibition that could begin a tour of inaugurations throughout Spain.

The second research activity deals with urban planning, in continuity with another major exhibition held by CEHOPU, *The Hispano-American City. The Dream of an Order*. This new project deals with the founding of



MLP_Proy. Ebro reservoir. Discharge spillway.

new cities created in the 18th century and linked to the history of Spain.

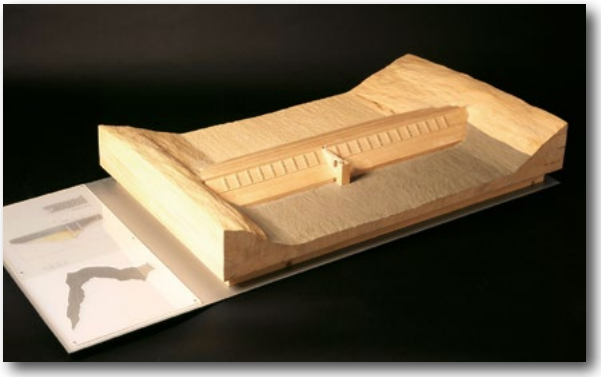
On the other hand, within the R+D+i projects related to the historical study within the framework of the heritage of public works in collaboration with leading agents of the sector, the following can be highlighted:

- "Analysis and definition of strategies for the characterization, recovery and enhancement of public works heritage. an approach from the territorial scale". Principal Investigator: Rita Ruiz Fernández. The Higher Engineering School of Civil Engineers, Department of Civil and Building Engineering, University of Castilla-La Mancha.
- "Water and Lights. Spanish treatises on hydraulic architecture in the Enlightenment". Resolution of the Presidency of the State Research Agency "R+D+i Projects", within the framework of the State Program for the Generation of Knowledge and Scientific and Technological Strengthening of the R+D+i System and the State R+D+i Program, Complutense University of Madrid.

As for grants and R+D+i projects, the "Study and research of public works funds in the General Administration Archive" continues, which, having started in 2020, is scheduled for completion and delivery in 2024.

DISSEMINATION OF THE HISTORY OF PUBLIC WORKS AND URBAN PLANNING

CEHOPU's **traveling exhibitions** bring its contents to the general public through the various openings held throughout Spain and abroad. At present, there are **eighteen** exhibitions that make up this fund of itinerant exhibitions, some of which are in the process of maintenance and improvement.



Cornalvo Dam.

Featured exhibitions in 2022

Exhibition *Artifex. Roman Engineering in Spain*, in the Convent of San Francisco de Santo Domingo de la Calzada (April-November 2022)

Exhibition *Ars Mechanicae. Medieval Engineering in Spain*, at the Social Hall of the Irrigation Community of Vila-Real in Castellón (December 2022-February 2023)

Model Railway Territory, at the Railway Museum of the Delicias station in Madrid. Permanent exhibition presented on April 22, 2022

At present, CEHOPU is making an effort to reach all geographical areas, with special dedication to the so-called unpopulated or low-density Spain, maintaining close cooperation with various local institutions.

The "CEHOPU COLLABORATES" program includes activities related to the organization's participation as a collaborator in exhibitions and events organized by other entities.

'CEHOPU collaborates'

Informative exhibition on the monument to the Virgen de la Antigua, in collaboration with the Alhóndiga Civic Centre of the City Council of Orduña, in Vizcaya (September-December 2022)

Exhibition *Atempora Sigüenza 2022. Segontia Between Power and Glory,* on the occasion of the 9th centenary of the reconquest of Sigüenza, in the cathedral of the ancient Segontia (July-December 2022), in collaboration with the Impulsa Castilla-La Mancha Foundation, of the Regional Government of Castilla-La Mancha

Exhibition *Models and Replicas. Engineering and Construction*, at the palace of Tarín in Zaragoza (September-October 2022), in collaboration with the Aragón Division of the Professional Association of Civil Engineers

Exhibition *The Legacy of Rome: The Alcántara Bridge in the Third Millennium*, at the Museo de Cáceres and at the Palacio Barrantes-Cervantes, headquarters of the Fundación Obra Pía de los Pizarro in Trujillo (November 2021-January 2022), in collaboration with the Royal Academy of Extremadura for Letters and Arts, and the Regional Council of Culture Cultura, Tourism and Sports of the Regional Government of Extremadura

Exhibition *Fortification, City and Construction*, at the Conde Duque Cultural Centre in Madrid (September 2021-January 2022), in collaboration with the Juanelo Turriano Foundation

Exhibition *We Are Water*, at the Canal de Madrid Foundation (December 2022-June 2023), in collaboration with the Canal de Isabel II Foundation

Exhibition of models from the Collection of the History of Publics Works

Collection of Historical Lighthouse Models, at the Lighthouse Museum of the Port Authority of Tarragona. Permanent exhibition at the Punta de la Baña lighthouse, restored for this purpose

In the Torroja Museum, permanently located in the basement of the grandstand of the Zarzuela Racecourse, to present various models and elements related to the works by the engineer Eduardo Torroja Miret

Monument to Our Lady Virgin of Orduña.

Lighthouse of Cádiz.

PUBLICATIONS AND DOCUMENTATION OF THE HISTORY OF PUBLIC WORKS AND URBAN PLANNING

CEHOPU published in 2022 the book *The Roman Road from Numancia to Osma and its Embrace with the A-11 Motorway,* by Isaac Moreno Gallo, coordinator and one of its authors, and director of the research project "Identification, Diagnosis and Technical Constructive Analysis of Roman Roads in Castilla and León", carried out between 2006 and 2010 and framed in the Historical Heritage Plan (PAHIS) of Castilla and León, which has allowed to undertake an extensive work of identification of Roman roads throughout the Castilian-Leonese region.

This has made it possible to bring together in one publication the work accomplished to save an important stretch of road.

As part of the activities dedicated to preserving, studying and disseminating the documentary heritage of public works, CEDEX, through CEHOPU, houses the project archives of engineers **Eduardo Torroja Miret and Carlos Fernández Casado.**

The web page of the respective archives Eduardo Torroja Miret and Carlos Fernández Casado, including the collections donated by the families of both engineers, is also managed, simultaneously attending to the public.

In both archives, digitalization of the documents is underway, with our own means, to increase the contents of the website with the electronic material obtained. Throughout 2022 there have been 17 visits by researchers and professionals to the Eduardo Torroja Miret (8) and Carlos Fernández Casado (9) archives.

The registration information of each item was checked to complete the cataloging, adding more fields to allow greater control of the documentation and guarantee its conservation, work that was completed in June 2022.

In 2021, **the family of J. J. Polívka donated unpublished documentation on the correspondence between the Czech-born engineer and Eduardo Torroja** related to the preparation of the book *Philosophy of Structures,* as well as the correspondence with publishers and universities, and with the editor Elisabeth Kendall Thompson, an architectural critic who worked on the revisions of Polívka's translation. The documentation includes manuscripts and previous versions with corrections of the aforementioned book, as well as correspondence with **Frank Lloyd Wright, Raymond E. Davis and Richard Neutra.**

In 2022, the final text regarding the donation of the aforesaid documents to the Torroja Archive was being prepared, and the parties are scheduled to sign in person on a day of presentation of such an important collection in 2023.

Main reinforced concrete works designed and directed by Eduardo Torroja from 1926 to 1936.

KNOWLEDGE TRANSFER

" We continue working to ensure quality training for a better society "

The CEDEX Training and Documentation Unit is a structural and cross-functional component of CEDEX dedicated to the training, dissemination, and transfer of technology generated within the agency. Its activities have always been a hallmark of CEDEX abroad and essential in fostering public-private collaboration. This unit plays a key role in supporting the priorities established in the *CEDEX Strategic Plan 2020-2022* (PEC 2020-2022) through knowledge transfer. In collaboration with public and private partners, it provides high technical and scientific training and information to companies in sectors related to the activities developed by MITMA and MITERD, as well as to the respective management centres of these ministries, through national and international training programs and an extensive catalog of publications.

EDUCATIONAL COOPERATION PROGRAMS

College Education

CEDEX has 9 ongoing agreements for educational cooperation with Spanish universities, aimed at bridging the gap between university education and the social and professional reality of our environment. This completes the students' educational process by providing them with the opportunity to undertake external internships that facilitate their subsequent integration into the workforce. To achieve this, CEDEX has facilities and highly qualified professionals in various fields of civil and environmental engineering, considering the close connection between the world of the public sector and the academia to be highly valuable.

As a result, in 2022, 16 students from various universities completed academic internships at different CEDEX centres and laboratories. The workload for each internship varies between 150 and 500 hours, and the training is complemented by the preparation of a report supervised by the tutor assigned at CEDEX.

Technical Training Degrees

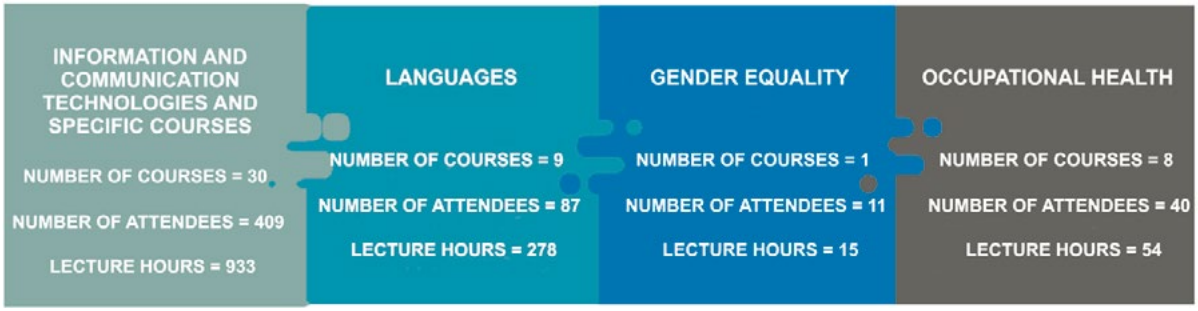
CEDEX has agreements with five secondary education institutes in the Community of Madrid for the development of internships in technical training degrees at both the intermediate and advanced levels.

Under these agreements, in 2022, 22 internships were conducted, each lasting 370 hours.

TRAINING FOR OPTIMAL JOB PERFORMANCE

The 2022 Internal Training Plan has aimed to enhance the capacities, knowledge, and skills of CEDEX staff. New training initiatives have been developed to address the identified needs within the agency's centres. This plan has emerged as a crucial element in ensuring the optimal functioning of CEDEX,

CEDEX INTERNAL TRAINING COURSES



not only in administrative aspects but also, and especially, in various specialized technical areas, in which a research and experimentation agency like CEDEX strives to be at the forefront. This is done while also upholding the right of public employees to professional and personal development and training.

A total of 48 courses were conducted, partially subsidized by INAP, with a workload of 1,280 hours and 547 registrations for training. The training activities were evenly distributed among all CEDEX centres and laboratories, and the overall evaluation by participants was highly positive. It's worth noting that all courses adapted continuously to new training technologies, conducting training activities online due to the challenges of in-person delivery. Various platforms from both CEDEX and the companies awarded the courses were used for this purpose.

Furthermore, the implementation of the SIGP (Integrated Personnel Management System) of the Public Administration in training management has been successfully established. In addition to internal training, CEDEX personnel have also benefited from training provided by MITMA, INAP, and other official entities.

COURSES

Among CEDEX's external training activities, there's a notable focus on conducting courses, seminars, and workshops aimed at a national and international specialized audience. In terms of long-term courses, the 40th edition of the **Master in Soil Mechanics and Geotechnical Engineering**, offered by CEDEX as a program affiliated with the National Distance Education University (UNED), was delivered. This program is part of UNED's training offerings and is equivalent to 60 ECTS (European Credit Transfer and Accumulation System) credits. The master program has been continuously offered since the 1980s and, in 2022, had 27 students from various nationalities enrolled. It included 560 lecture hours, including the

XXXIX Course on Wastewater Treatment and Operation of Treatment Plants.

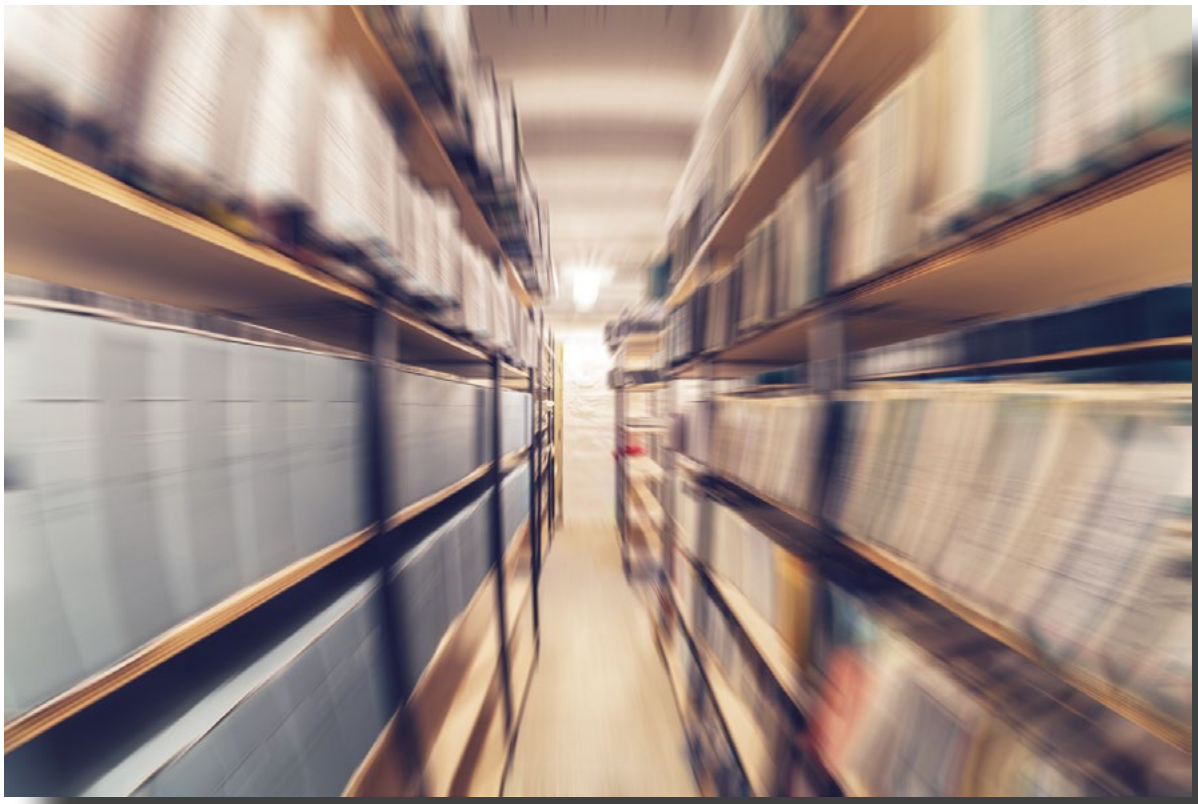
preparation of the master's thesis. The program started with online streaming lectures and concluded with in-person practical training.

One of the most prestigious courses offered at CEDEX in the field of civil and environmental engineering is the *Wastewater Treatment and Operation of Wastewater Treatment Plants Course,* which has been held since 1983. The 39th edition of this course, conducted in a theoretical-practical format, took place in-person in November. It had 50 participants and consisted of 80 hours of instruction.

EVENTS

Among the various services provided by CEDEX in 2022, the agency hosted a total of 38 events. These included meetings, platforms, conferences, workshops, and examinations, for which CEDEX facilities were chosen as venues by various institutions, both public and private, with a noteworthy attendance from the public.

22nd SEMSIG-AETESS Technical Conference.



Shelves full of paper documents stored in an archive (Source: *Shutterstock*).

DOCUMENTATION AND LIBRARY NETWORK

CEDEX provides bibliographic and documentary information services through its Library Network, specializing in civil and environmental engineering subjects. These libraries are in various centres and are coordinated from the Central Library. They function as information and knowledge management systems, providing national and international technical documentation to support CEDEX technical staff in the experiments and work conducted across different centres and laboratories.

The CEDEX Library Network made new acquisitions in 2022, including specialized monographs and various technical standards (UNE, ISO, ASTM, DIN, AFNOR, ACI, NEN, CEN-TS, etc.). These acquisitions have enabled the fulfilment of all requests for books and other documentary resources, thus enriching the library's collections. The CEDEX libraries are adapting to new technologies, and as a result, many of the newly acquired documents are in electronic format. Most technical standards and journal articles are acquired in PDF format, and there has been a growing inclusion of digital books.

Around 15 journal titles continue to be received through donations, exchanges, or from institutions and associations in which CEDEX participates. Due to the lack of subscriptions, all requested journal articles have been obtained either through open access or interlibrary loans, primarily with CSIC and university libraries.

The collective catalog of the Library Network has increased by 1,440 records, reaching a total of 133,122 titles and 168,348 volumes. The catalog includes titles of monographs, journals, maps, electronic resources, and technical reports produced by CEDEX. The catalog is publicly accessible and avail-

able for consultation through the CEDEX website at:
http://vopac.cedex.es/opac

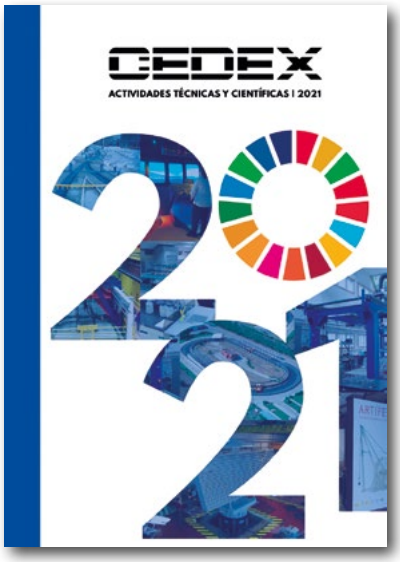
The libraries have access to the Web of Science (WOS) database, whose subscription has been renewed through FECYT. This multidisciplinary bibliographic reference database provides technicians and researchers with the opportunity to explore the published bibliography in their respective areas of interest and the impact achieved by articles published in international journals. Additionally, the libraries have been used as a tool to conduct article searches and locate information of interest for CEDEX technicians.

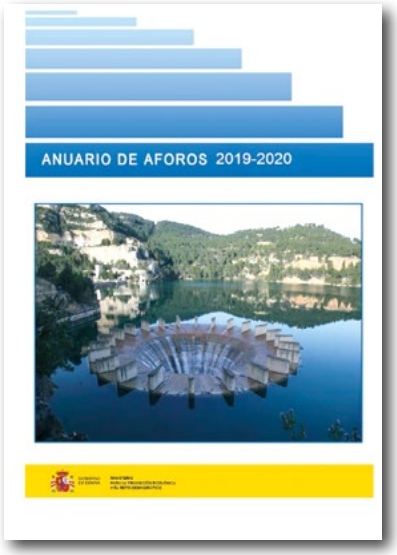
Regarding public service, in 2022, telecommuting has predominantly been the mode of service delivery. This includes sending documents via email or other internet-based file transfer services such as WeTransfer or Almacén. The latter is an application from the Ministry of Finance and Public Administrations primarily used by the Library Network for sending and receiving CEDEX technical reports. Interlibrary loans with other institutions, such as CSIC, have also been utilized to obtain journal articles. Services have been provided both in-person and online to CEDEX staff and external users, most of these being university students.

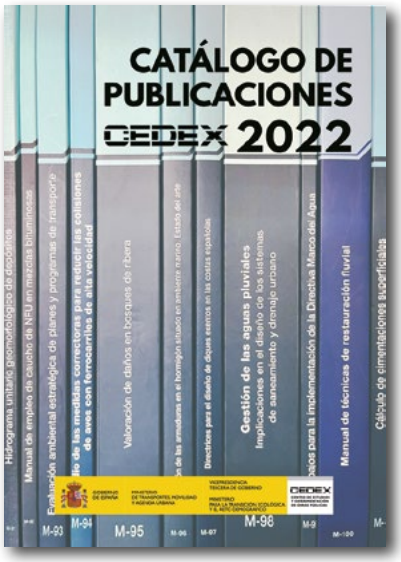
Furthermore, the libraries have also been enriched with works and publications generated from consulting documents housed in the respective Eduardo Torroja Miret and Carlos Fernández-Casado archives. These archives are managed by the Centre for Historical Studies of Public Works and Urban Planning (CEHOPU) in coordination with the Central Library.

PUBLISHING PROGRAM

CEDEX, in its capacity as Editorial Unit of the Ministry for Transports, Mobility and Urban Agenda, and within the General Plan for Publications of the General State Administration (AGE), **has continued to promote the transfer of knowledge through the technical publications of the agency and the 'Ingeniería Civil' journal in the fields of public works, civil engineering, environment and mobility.**



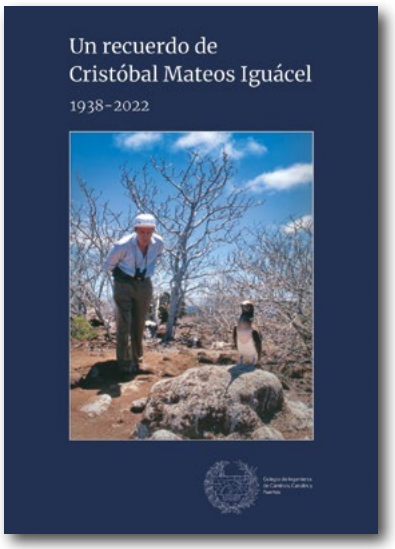


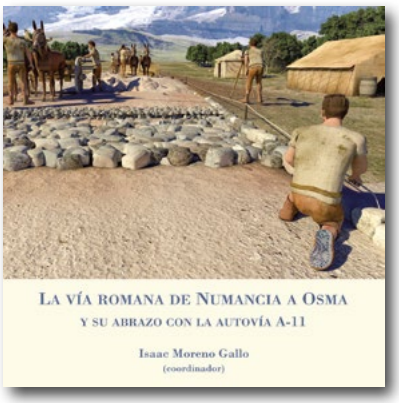


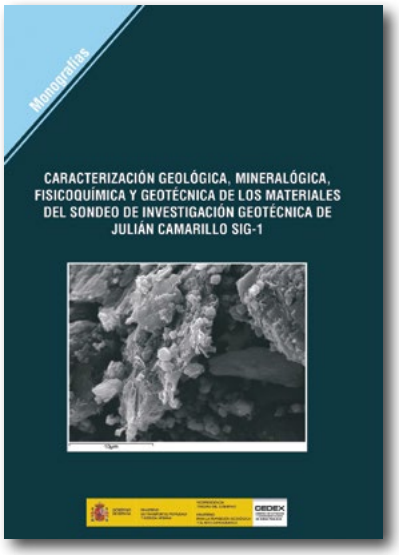
This publishing program serves as a means of communication and dissemination of the activities undertaken by the agency, benefiting both the general public and social agents. All CEDEX publications are cataloged in its *Publications Catalog*, accessible on the CEDEX website: https://www.cedex.es/publicaciones-bibliotecas/publicaciones

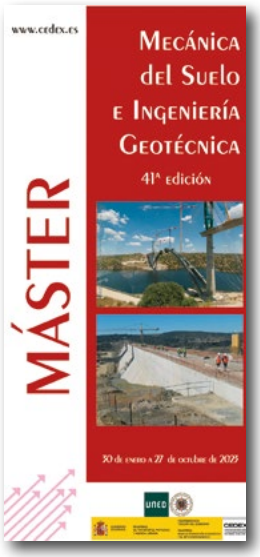
In 2022, books and monographs were continued to be published in both physical and electronic formats. Below it's listed the publications made:

- *The Roman Road from Numancia to Osma and its Embrace with the A-11 Motorway (La vía romana de Numancia a Osma y su abrazo con la autovía A-11)*
- *A Tribute to Cristóbal Mateos Iguácel (1938-2022) [Un recuerdo de Cristóbal Mateos Iguácel (1938-2022)]*
- *State of the Art on Green Public Procurement Process for Roads (M-144) (Estado del Arte sobre criterios de compra Pública Ecológica para carreteras* (Monografía M-144))
- *Geological, Mineralogical, Physico-Chemical and Geotechnical Characterization of the Materials from Julian Camarillo SIG-1 Geotechnical Experimental Borehole (M-145) [Caracterización geológica, mineralógica, fisicoquímica y geotécnica de los materiales del sondeo de investigación Geotécnica de Julián Camarillo SIG-1* (Monografía M-145)]
- *Digital Gauging Yearbook 2019-2020 (Anuario de Aforos Digital 2019-2020)*
- *XXXIX Course on Wastewater Treatment and Operation of Treatment Plants (XXXIX Curso sobre Tratamiento de Aguas Residuales y Explotación de Estaciones Depuradoras)*
- *Digital Catalog of CEDEX Publications for 2022 (Catálogo de Publicaciones online CEDEX 2022)*
- *Leaflets of CEDEX Training Courses* (Desplegables de cursos Formación CEDEX)
- *CEDEX: Actividades Técnicas y Científicas, 2021*
- *CEDEX: Technical and Scientific Activities, 2021*









'INGENIERÍA CIVIL' JOURNAL

Two issues of the scientific-technical journal *Ingeniería Civil* (200 and 201) were also published. Both issues were made available in both print and digital formats, and they can be freely accessed through the CEDEX website: https://www.cedex.es/revista-ingenieria-civil

The Publications Sales Service has sold 259 CEDEX publications, generating revenues of 5,536 euros.

OUTSTANDING PROJECTS

OUTSTANDING PROJECTS / CET

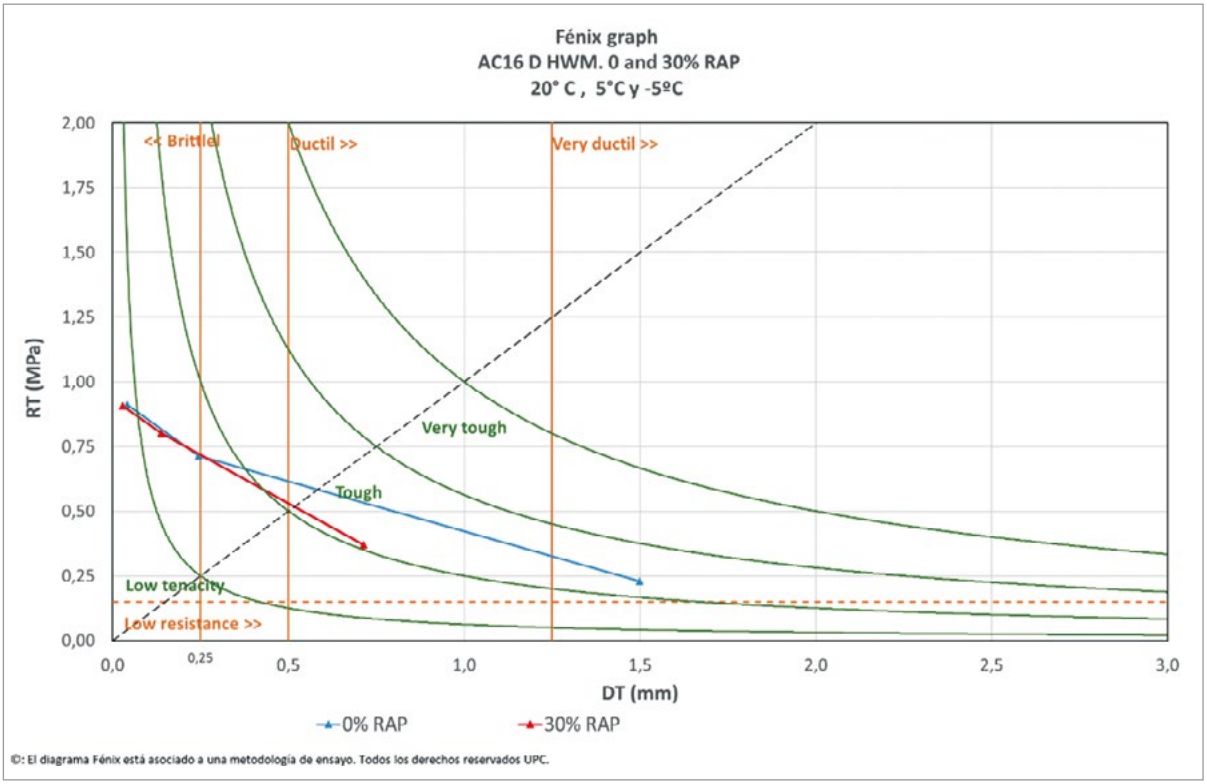
CHARACTERIZATION OF HALF WARM BITUMINOUS MIXTURES WITH RECLAIMED ASPHALT PAVEMENT (RAP)

Contact: maria.sanchez@cedex.es

Throughout 2022 the Transport Research Centre's Laboratory for Materials has been working on the characterization of the properties of half warm bituminous mixtures manufactured with emulsion and reclaimed asphalt pavement (RAP).

With the objective of performing more **sustainable bituminous mixtures**, whose manufacture generates fewer greenhouse gas emissions than hot asphalt mixtures, the Laboratory for Road Materials has carried out a study to characterize the properties of **half warm asphalt mixes**. These mixtures have been manufactured with emulsion instead of bitumen, which significantly reduces mixing and laying temperatures from 150-160 °C (hot bituminous mixtures) to 90-100 °C (half warm asphalt). In addition, to reduce the need quarry aggregates and to provide an outlet for milled material produced in road rehabilitation works, mixes have been produced with 30 % of reclaimed asphalt pavement (RAP). Some tests have been performed to check how the incorporation of this material affects the properties of the half warm bituminous mixes.

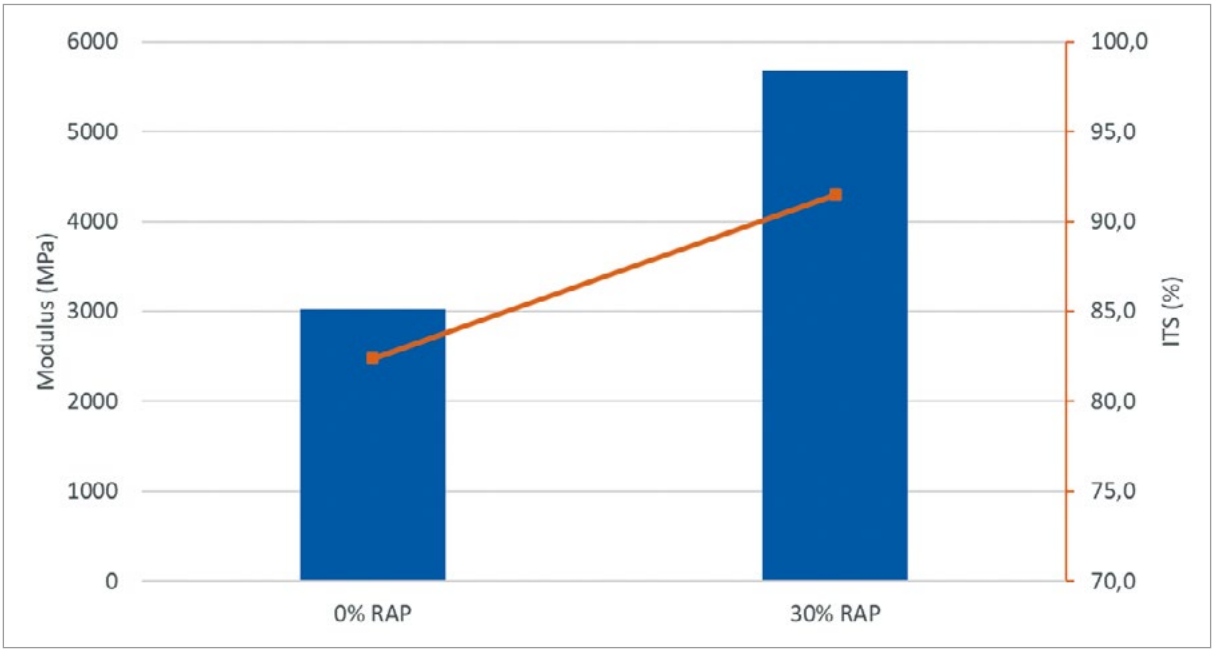
> Half warm asphalt mixes manufactured with RAP are an important step towards the decarbonization of road construction and maintenance, making the pavement sector more sustainable



Fénix Graph. Half warm mixes with and without RAP.

For its characterization, common tests used for the design and control of bituminous mixtures have been carried out, but others have also been added. These provide more information about the behaviour of the material under different stresses, such as: determination of the density and void content, sensitivity to water both in indirect traction and compression, measurement of deformation in the rolling test, determination of the resilient modulus, and Fenix test.

The graphs show the good performance of half warm mixes, with and without RAP.



Resilient modulus and indirect tensile strength chart.

OUTSTANDING PROJECTS / CET-LCEYM

VERIFICATION OF QUALITY AND CONDITION INDICATORS ON FIRST-GENERATION HIGHWAYS

Contact: jorge.carnerero@cedex.es

In 2022, CET and LCEYM, of CEDEX, have continued to check the quality and condition indicators of the first-generation freeways, a project of great relevance for the proper management of these roads, under a shadow toll regime.

Operations regarding the first generation of freeway concessions highlighted the fact that the quality and condition indicators of service defined in their contracts are difficult to apply. Since 2015, specialized technical support has been provided by CEDEX to the Directorate-General of Roads (DGC) of MITMA, aimed at achieving a proper application and checking of several indicators. To this end, management assignments have been signed between MITMA and CEDEX to carry out the different works.

The technical support provided by CEDEX includes advising the DGC and checking the values of the different parameters measured by the concessionaires, as well as monitoring the results of the indicators obtained.

The indicators monitored are as follows:

Testing by CEDEX FWD for the verification of indicator 4. Highway A-2 concession, in the province of Zaragoza.

Indicator	
1.	Pavement. Slip resistance
3.	Pavement. Surface regularity (IRI)
4.	Pavement. Structural capacity (flexible, semi-flexible y semi-rigid)
6.	Pavement. Cracking and other surface deterioration
7.	Cracking in concrete pavements
21.	Road markings. Retroreflection
24.	Vertical signaling and beaconing

SOME RELEVANT FIGURES IN 2022:

- ✓ Verification of 7 quality and state indicators in 11 concessions
- ✓ More than 100 verification reports of the different indicators monitored
- ✓ More than 1,000 km of highway auscultated with the CEDEX SCRIM device
- ✓ More than 500 km of highway auscultated with the CEDEX Laser Profilometer device

Highway A-2 Concession in the province of Zaragoza.

OUTSTANDING PROJECTS / CEH

METHODOLOGICAL GUIDE FOR HYDROLOGICAL STUDIES OF FLOOD EVENTS IN DAMS

Contact: antonio.jimenez@cedex.es

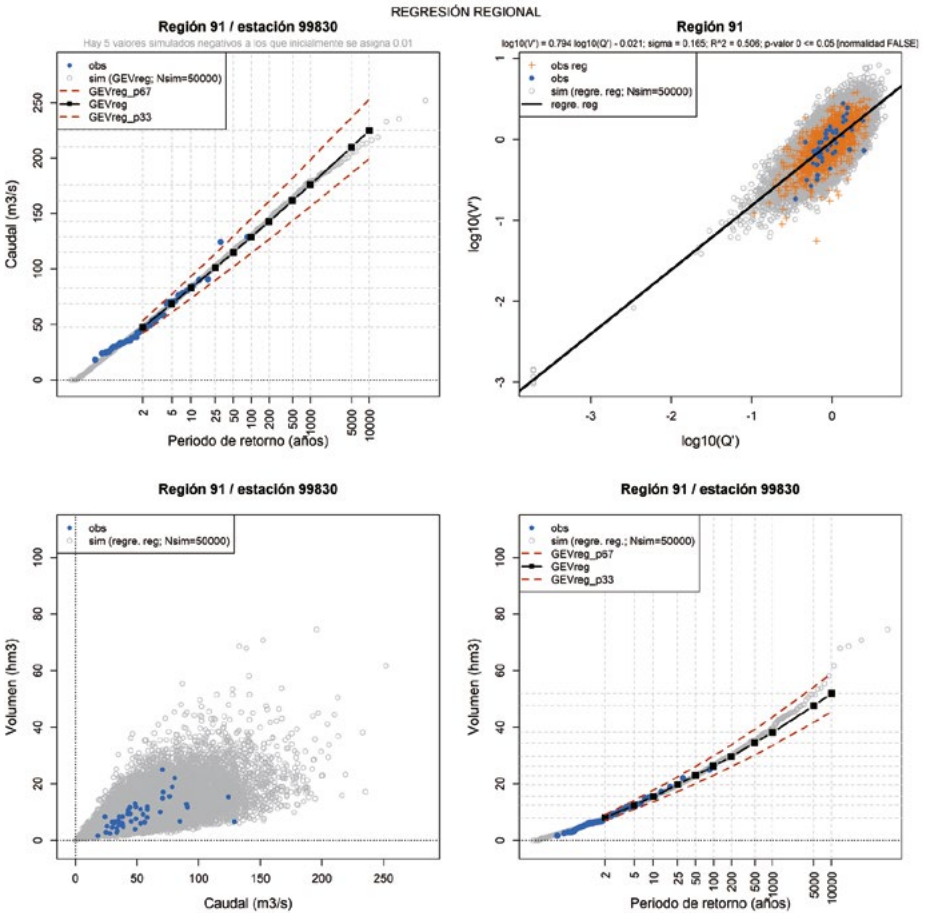
The Centre for Hydrographic Studies is drafting a guide to establish recommendations and methodologies for carrying out hydrological studies on extreme flood events in dams. These hydrological studies are required to analyse the hydrological safety of new dams and to review the safety of existing ones.

As a result of the approval of the *Technical Safety Standards for Dams and Reservoirs* (Royal Decree 264/2021, of April 13), which is provided in the Regulation of the Hydraulic Public Domain, and considering the high number of studies required to review the safety of the existing dams, the Directorate-General for Water (DGA), of the Ministry for Ecological Transition and the Demographic Challenge (MITERD), requested CEDEX to elaborate a methodological guide that establishes a calculation baseline for the project flood and extreme flood that are contemplated in those regulations.

The recommendations included in this guide try to answer to the singularities faced by hydrological studies during extreme flood events in dams, among which we should mention the need to extrapolate the quantiles to very high return periods; the need to consider the flood volume along with the peak flow and, in some cases, even the statistical dependence of both variables; the need to determine seasonal floods, which must be done consistently with annual floods; and the consideration of the possible impact of climate change, an aspect included in the current regulations.

To support the selection of methodologies included in the guide, various studies are being carried out, among which it's worth mentioning the updating the statistical regionalization of maximum annual flows and flood volumes, as well as their statistical dependency relationship, carried out in previous works; the contrast of different procedures for obtaining maximum instantaneous flows from average daily flows; the calculation and tabulation of the confidence intervals associated with the frequency laws of maximum flows and rainfall; the analysis

Spillway of the El Villar Dam.



Stochastic generation of flow-volume pairs to calculate the maximum level in the reservoir. Alloz Dam.

of different procedures to obtain the maximum level in the reservoir; and the development of methodologies for the consideration of snowmelt in the hydrometeorological modelling of floods, etc.

The draft guide currently available has been structured as follows. After the introduction and purpose of the guide (section 1), section 2 presents the current legal framework for the hydrological safety of dams and the different aspects that this framework establishes. Next, in section 3, a compilation and analysis of the methodologies used in other countries is carried out, which allows to establish the international framework and the baseline to the methodologies to be applied in Spain. Section 4 lays out the different aspects of the dam that must be considered when selecting the methodologies to be used, such as the hydrological information available, the size and characteristics of the catchment or the characteristics of the dam, and the reservoir. Section 5 provides recommendations for the preparation of hydrological studies of floods based on the specific characteristics of each dam. Finally, section 6 illustrates the methodological proposals made through their application to a series of case studies.

As a consequence of the approval of the Technical Safety Standards for Dams and Reservoirs, the preparation of hydrological studies will be required to review the safety of existing dams

The guide will contribute to providing homogeneity to the different studies, allowing their comparison and the consistency of their results

Methodologies are proposed to address the unique aspects of dam hydrology, such as extrapolation to very high return periods, consideration of the statistical dependence between peak flows, and flood volumes and the calculation of seasonal floods

OUTSTANDING PROJECTS / CEH

ANALYSIS OF THE MURCIA NORTHERN HYDRAULIC INFRASTRUCTURE

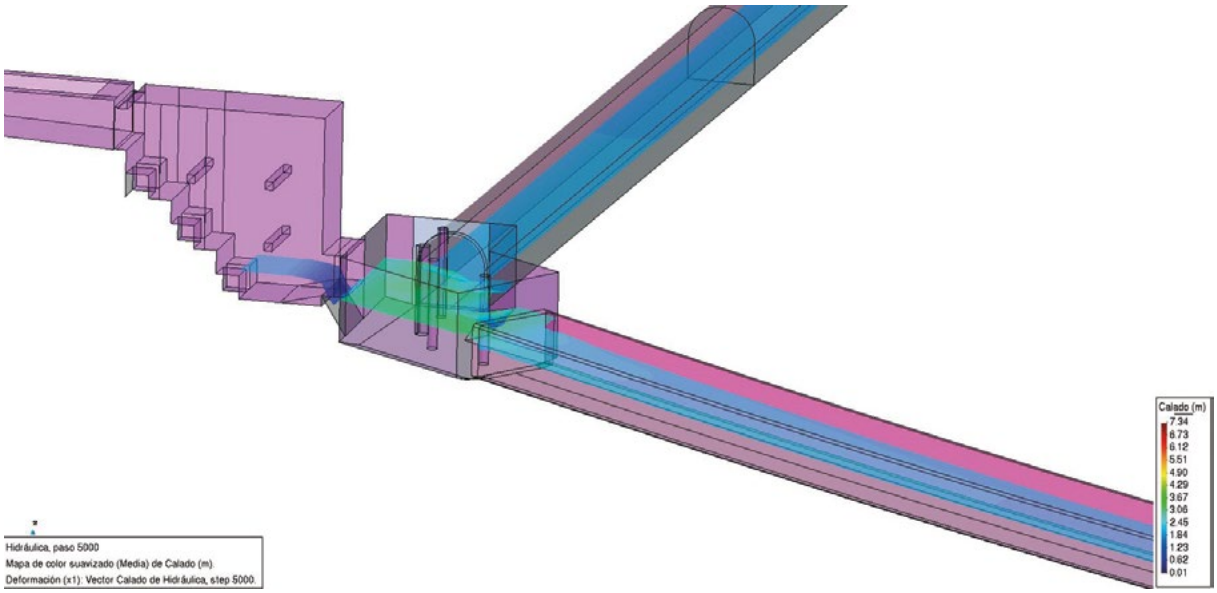
Contact: david.lopez@cedex.es

In 2021, the General Directorate for Water (DGA) commissioned CEDEX to analyse the behaviour of an important hydraulic infrastructure that's planned in the northern area of the city of Murcia. The Hydraulics Laboratory has worked on this study during 2022 using complex 2D and 3D numerical models, with the strategy of undertaking detailed studies of some of the planned actions using physical models in 2023.

The hydraulic infrastructure known as the Murcia northern Interceptor is a structure focused on protecting Murcia against flooding. The structure collects the flows of the channels in the northern area of Murcia and diverts them through an underground conduct, but with open channel operation, to the Segura River.

It's a unique hydraulic structure on which, to date, numerous technical studies and projects have been written, highlighting the construction project promoted by the Segura River Basin Authority in 2018. Given the hydraulic complexity of the Interceptor, during the review of the technical documents, the need to carry out complementary hydraulic studies was identified using 2D and 3D physical and numerical models. The DGA commissioned CEDEX in 2021 to carry out these hydraulic studies by the Hydraulics Laboratory to define the infrastructure.

The Interceptor has an approximate length of 6,800 m, and along its route it intercepts five boulevards, with an incorporation work being planned for each of them. The design flow of the interceptor ranges between 31.7 m^3/s at the beginning and 118 m^3/s in its connection with the Segura River channelling (corresponding to a return period of 50 years).



2D modelling with Iber of the Interceptor as it passes through the work to take over the Rambla del Espinardo.

The work began by checking the projected design. The hydraulic capacity of the Interceptor was analysed using the Iber model (2D):

- Several sections of the Interceptor that would come under load during the evacuation of the design flows corresponding to the 50-year return period were identified
- The shortage of adequate guards to guarantee the necessary air flow in the sections was determined
- The insufficient capacity at the confluence with the Segura River channelling in the interceptor unloading work was confirmed

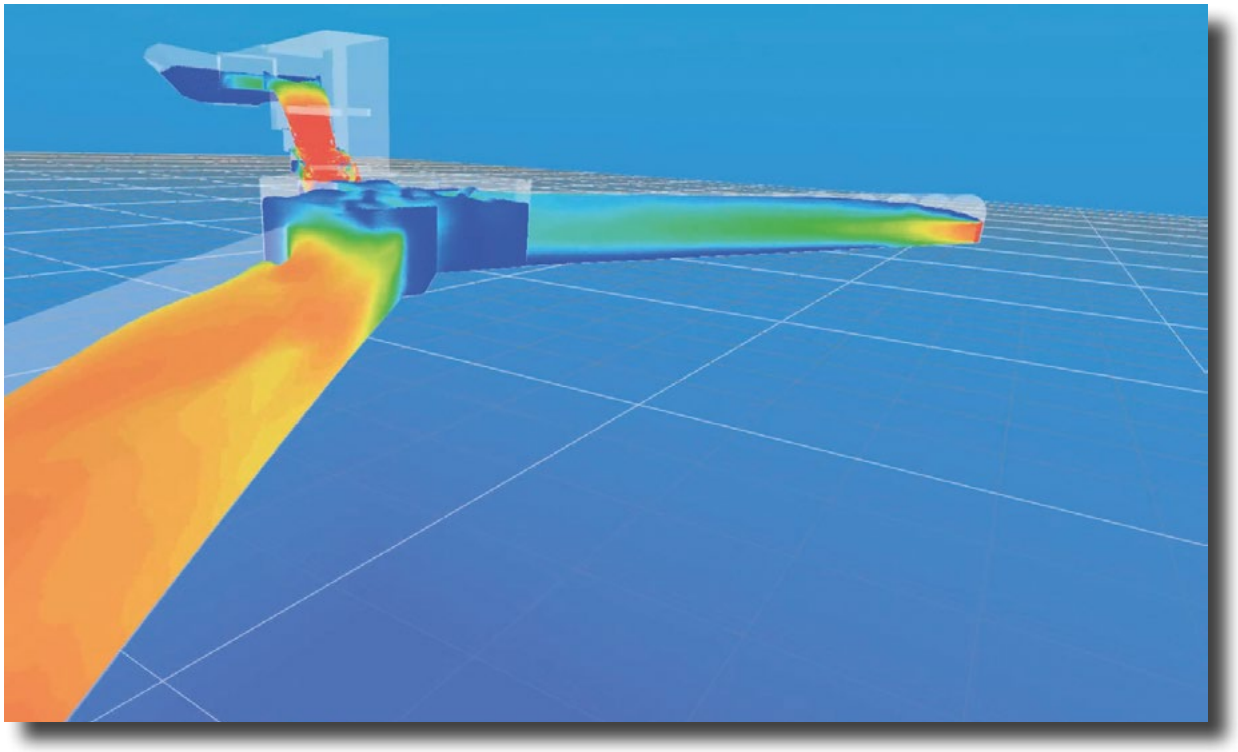
The next step in the analysis focused on the modelling with SPHERIMENTAL (3D) of the intake structures of the different boulevards, detecting different problems (losses at the mouths, transitions that could be improved, take offs in rapids, lack of flow guidance, etc.), although all of them can be considered as rectifiable by introducing improvements in their hydrodynamic design.

To try to solve the problems related to the insufficient capacity of the interceptor, the possibility of designing a series of lamination structures at the entrance of the intercepted streams that reduce the flows circulating through the interceptor has been studied, so that its initial dimensions could also be reduced, always guaranteeing the hydraulic safety of the infrastructure.

The designs of some of the mouthpieces and these lamination structures remain to be verified through physical modelling.

In 2022, the Hydraulics Laboratory developed part of the work included in a commission that the DGA entrusted to CEDEX in 2021 for the analysis of the hydraulic behaviour of the interceptor in the northern area ofthe city of Murcia

The work has been carried out through 2D and 3D numerical modelling, with plans to develop complementary analyses through physical modelling



3D modelling with SHERIMENTAL of the work to take over the Rambla de la Bernala.

OUTSTANDING PROJECTS / CEH

RIVER MOUTH POINT DELIMITATION ACROSS THE SPANISH COASTLINE

Contact: mcarmen.angel@cedex.es.

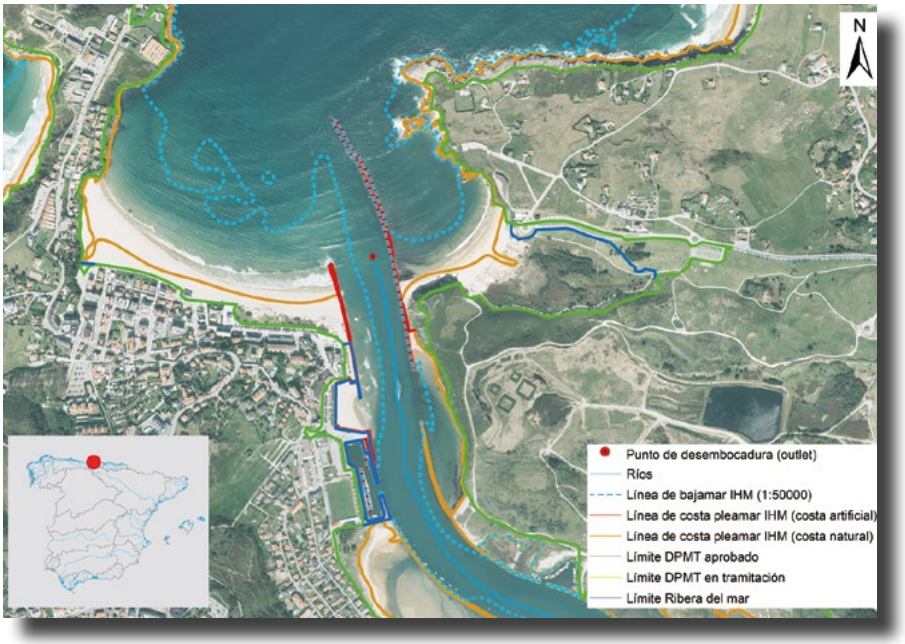
The Centre for Hydrographic Studies (CEH), of CEDEX, was requested to establish the location of all river mouth points across the Spanish coastline by the Directorate-General for Water (DGA). The study is framed within the collaboration in research and development in hydraulic resources and infrastructures.

This study is motivated by the requirements of the European INSPIRE Directive to compile a database with the river mouth points (outlet nodes).

The Navy Hydrographic Institute (IHM) is the agency responsible for the registration of the coastline in the Official Cartographic System. In respect of nautical cartography, the coastline is defined as a double line, comprised of the high tide line (horizontal line delimited by the maximum advance of the tide, towards land), and the low tide line (delimited by the hydrographic zero or heeled low tide). Consequently, the coastline defines the transition zone between land and sea with lines that broaden when tides are noticeable and merge into a single line where tides are not significant, or where there's a permanent artificial construction or vertical terrain.

Thus, a river mouth is based on a wide range of transition zones. The challenge that comes with the application of the INSPIRE Directive is to pinpoint a river mouth within this area, since currently there's no common criteria. Nevertheless, there are different administrations that have established mouth points based on their own criteria.

In this work the criteria to be considered have been established, as well as the geographical delimitation of the mouth point for rivers defined as a body of water in Spain.



Saja River. River mouth. Estuary with the presence of artificial elements at the mouth (breakwater, dike or port).

The methodology in place begins with a classification according to the hydrological characteristics, followed by the geology of the environment, the coastal dynamics, and, finally, the human or anthropic factor that modifies or conditions it. An analysis is carried out on a selection of each class and then extrapolated and applied the criteria to the rest. This is how rias and estuaries with or without a confining barrier are considered, estuaries with the presence of artificial elements at the mouth (breakwater, dam or port), estuaries with coastal arrow and/or with artificial elements, estuaries with mouth in a bay; simple mouths open to the sea or the beach, differentiating whether or not they have artificial elements; deltas which, in turn, are classified as developed and deltaic fans with and without artificial elements; and, finally, simple mouths to lagoon or wetland. Depending on the slope into which the river flows, some typologies will predominate over others.

For each of these types, the criteria are defined to locate the river mouth point based on aspects such as the stability of the channel, the existence of confining barriers, the presence of artificial elements, etc.

Not only is the identification of these mouth points important because of complying with the INSPIRE directive, but it also allows the IHM to update the closure of the coastline in the mouth areas. Likewise, it provides the DGA with the basis to derive the drainage network and delimit the hydrographic basins for its application in Spanish hydrological planning.

The INSPIRE Directive is complied with by having a database with the points of the rivers mouths, which also serves to delimit hydrographic basins and update the coastline

The methodology consists of classifying the mouths and establishing criteria for delimiting the end point of the river for each typology

As a result, there's a geographical database of 280 mouths in the Spanish peninsular territory and in the Balearic Islands

Geographic representation of the considered river mouths.

OUTSTANDING PROJECTS / CEH

GUIDE FOR SELECTION OF TREATMENT TECHNOLOGIES

Contact: ignacio.rio@cedex.es

The Cooperation Fund for Water and Sanitation (FCAS) has published the guide developed at the Centre for Hydrographic Studies for the selection of urban wastewater treatment technologies.

This guide integrates part of the experience acquired during the last 10 years in sanitation and treatment projects in Latin America, and aims to provide basic knowledge, both to designers and administration technicians, to make an adequate selection of treatment technologies.

The guide is divided into two parts. The first one addresses the general issues that are required to know to tackle the selection of water treatment technologies in a project. It analyses the context in which this analysis will be addressed, identifying all the interrelationships with other studies, and exposing the basic concepts of multicriteria analysis, its basic and different options. The second one describes the proposed methodology, specifying all the steps to achieve an adequate evaluation and providing recommendations, examples and learned lessons that can be useful for the technician who faces this task.

Three annexes are included as complementary elements of this methodology: The first addresses baseline studies in each case. The second focuses on the knowledge about treatment technologies. And the third presents a practical case to illustrate the application of the methodology.

The highlights of this guide are a very substantial improvement in the conceptual analysis of what decision making systems can provide; an improvement in designing the proposed methodology; and the orientation of methodologies towards a more sustainable service.

Additionally, a series of treatment process design tools have been developed, which are complementary to this guide. The guide is available for free download on the AECID website.

OUTSTANDING PROJECTS / LIF

ERJU: MOTIONAL PROJECT

Contact: daniel.molina@cedex.es

The flagship project of ERJU's FP1, called MOTIONAL (acronym for Mobility Management in a Multimodal Environment and Digital Enablers), focuses on the improvement and modernization of the planning and operational management of goods and services, and it's considered of vital importance for achieving the European objective of making the railway the preferred means of transport in the future.

The developments of MOTIONAL for railway traffic management, focused on interoperability, resilience, and the ability to adapt to different needs and integrate with the rest of the services, including those of the last mile, are key to the Single European Railway Area (SERA).

Currently, railway traffic is managed at both regional and national levels with legacy systems with a poor level of digitization and integration with the rest of the actors involved in the global process of transport management and planning.

Through the development of functional requirements, specifications and innovative technological solutions and taking advantage of the potential of digitization, MOTIONAL will facilitate the path towards the implementation of the future European Railway Traffic Management System (ERTMS), to make the railway the main axis of a multimodal system for passenger and freight transport. The activities planned to achieve the objectives are framed in two major lines of work: The first (Workstream 1) presents three major areas of interest: planning activities, operation/regulation and, finally, integration with other means of transport. The second (Workstream 2), on the other hand, will be responsible for providing digital enablers for all ERJU projects.

BIM modeling of a track section.

The specific topics in which the LIF participates are summarized as follows:

- Development of planning simulators considering the feedback from traffic operation/regulation systems
- Development of improved traffic operation/regulation systems based on new technologies (ATO) and real-time feedback from train operations
- Application of system modelling methodologies in the railway field
- Preparation of digital twin environments
- Conceptual model and data semantics in the railway field

OUTSTANDING PROJECTS / LIF

ERJU: R2DATO PROJECT

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To respond to the growing demand in passenger and freight transport, the ERJU's FP2 project called R2DATO (Rail to Digital Automated up to Autonomous Train Operation) focuses on digitization and automation to develop the New Generation of ATC (Automatic Train Control), providing scalable capabilities in the automatic (and up to autonomous) digital operation of trains (DATO, for its acronym), so that it increases the capacity of current railway networks.

Certain concrete results of the R2DATO project will be available in 2025 in key areas: ATO, Hybrid Level 3 of ETCS (HL3) and Mobile Cantonments, absolute satellite positioning systems (ASTP), digital technologies (5G connectivity and ICT platforms in onboard equipment), and guides and methods for the development and effective rapid migration towards DATO throughout Europe.

The objective of the LIF, as part of the MITMA membership participating in this FP2-R2DATO project, is to evolve the ERTMS system by implementing new functions and modules (ATO, HL3, ASTP, TMS), which will improve the digitization and automation of railway services. And specifically, to increase the testing and validation capabilities of signalling systems and equipment in the railway laboratory.

LIF participates in 12 of the 48 Work Packages that make up this project. The laboratory's priorities in these working groups are as follows:

- Integrate, validate and verify in the laboratory the ATO (Automatic Train Operation) equipment for GoA4 automatic driving (up to a maximum level, that is, without a driver) in the ERTMS system
- Increase the capacity of the lines by integrating, validating and verifying in the laboratory the ERTMS level 3 equipment that uses mobile cantonment
- In order for the functions mentioned in the previous points to be carried out, it will be necessary to industrially develop an ASTP module that provides safe positioning information to the train. Therefore, the laboratory will integrate, validate and verify this new ASTP module. Likewise, the necessary digital maps and the use of satellite receivers will be verified and tested
- Integrate, validate and verify in the laboratory the developments of future telecommunications (ACS and FRMCS) that will be used in railway systems
- Application to demonstrators. Specifically, regional demonstrator in FMRCS (2027) + capacity increase demonstrator with ERTMS level 3. (synergy with FP6 project)

R2DATO Project representation.

OUTSTANDING PROJECTS / LIF

ERJU: FUTURE PROJECT

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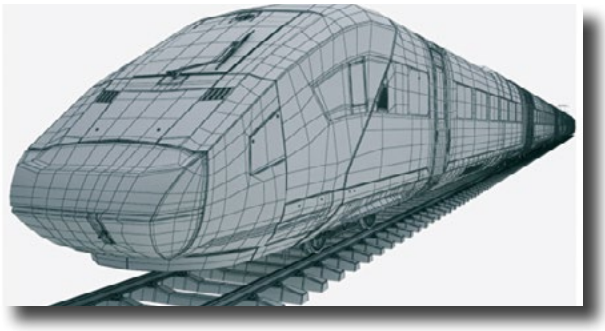
The project that encompasses the objectives of ERJU's FP6 is called FUTURE and its basic objective is to revitalize and reduce the cost of train operation on regional railway lines through the application of digital technologies.

The participation of the LIF in the Adif membership focuses on providing innovations in terms of digitization and test platforms for control command and signaling assets, methodologies, solutions, developments, and services contributing to making regional rail profitable, attractive and safe.



Digital model of a railway vehicle.

The priorities of the project are summarized as follows:

- Development of specific components and cost-effective technologies based on digital platforms such as reduction of infrastructure elements, wireless components that optimize energy consumption
- Collaborative definition of test interfaces and adapters between CCS/TMS technology equipment and ETCS test benches and modules
- Incorporation of digital information layers of railway signaling and infrastructure assets
- Application to specific demonstrators. Specifically, regional demonstrators in ATO and FRMCS (2027) + management studies and capacity increase with Hybrid Level 3 ERTMS (HL3)
- Physical demonstrator of low-cost ERTMS for regional lines, including engineering rules with simplification of features, as well as public and/or satellite communications replacing GSM-R and satellite location (GNSS)

The key objectives in the revitalization and capillarity effect of these regional lines that the FUTURE project will address are:

- Decrease in investment costs (CAPEX)
- Decrease in operational costs (OPEX) – Productivity Optimization (Cost per train/km)
- Increase in safety
- Improvement of customer services
- Customer satisfaction
- Finally, the lines of action of the project are framed in the following 5 blocks:
- Appropriate solution for the Regional System (TRL 6)
- Benefit development of the CCS system (TRL 6-7)
- Optimized railway assets (TRL 7)
- Sustainable rolling stock (TRL 5)
- Adapted customer services that improve the experience (TRL 7)

OUTSTANDING PROJECTS / LIF

AGREEMENT WITH ADIF ON LOW-COST REGIONAL ERTMS

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The Railway Interoperability Laboratory (RIL/LIF), of CEDEX, signed an agreement with Adif in 2022 to provide it with technical support in the pilot test of low-cost ERTMS N1 and N2 that will be carried out by Adif.

One of the pending challenges of the ERTMS throughout Europe, and more specifically in Spain, is its deployment on the conventional network that allows the gradual elimination of old class B systems (proprietary national systems) with the increase not only in interoperability, but also in security that this entails.

In Spain, all the lines of the conventional network, with the only exception of some commuter lines in Madrid and soon in Barcelona, are equipped with the ASFA system, which both in its old analog version and in the most modern one called digital, presents important deficiencies as it is a driving aid system, which delegates much of the safety responsibility to the driver, not being strictly a safety system comparable to FAIL SAFE systems (safe against failure).

Therefore, it's essential to start the path of replacing ASFA with a safety system that, in accordance with European Union Directives, can be none other than the ERTMS. However, the main handicap for the start of this deployment throughout the network is the high cost of the ERTMS, which makes it unfeasible to undertake an investment of this magnitude.

Thus, both the Innovation Department of Adif and the LIF proposed the initiative to present a project to the funds of the Recovery, Transformation and Resilience Plan (Next Gen Funds) with the aim of achieving applications of the ERTMS in which, by eliminating some of the features requested for high speed, an acceptable cost level would be achieved that would allow planning its deployment

throughout the conventional network. Adif presented this proposal and its financing was approved through these funds for an amount close to €16M.

For this, **the LIF has signed with Adif the agreement titled "Order for technical advice on a new 'ATP ERTMS' system, specifically intended for non-main railway lines throughout its development cycle: definition, engineering, installation and testing on a pilot line of the general interest railway network of Adif"**. The tasks that the LIF will carry out in it are as follows:

- Advice and validation of the ERTMS functionality to be implemented on the pilot line
- Advice and validation of the contractual documentation necessary for the acquisition of the necessary technical equipment
- Technical advice during the tendering processes for technical solutions
- Evaluation of offers
- Preparation of the laboratory for the new technologies tested
- Conceptual definition of the tests

- Integration of the successful bidder's equipment in the LIF
- Definition and formalization of the tests (on track and in the laboratory)
- Execution of the test campaign in the laboratory
- Execution of the project by the successful bidder
- Second test campaign in the laboratory
- Final tests on track
- Support in commissioning

Through this agreement, which amounts to €550,340.00, the LIF will provide technical support to Adif in defining the functionality of the ERTMS for both N1 and N2, the engineering rules and laboratory and field tests, with the ultimate goal of demonstrating the viability of a low-cost application of the ERTMS that includes new features, such as satellite positioning (GNSS), virtual beacons, telecommunications via public and/or satellite networks, in order to reduce track equipment and ERTMS features and thus reduce both installation (CAPEX) and maintenance (OPEX) costs.

The line selected by Adif for the deployment of this ERTMS pilot has been the León-Guardo metric gauge line. This selection has been carried out through a thorough study by Ineco on the typology of this type of regional lines in Spain. The line has advantages because it has a complex orography in which the new technologies to be used will be rigorously tested, such as positioning and satellite communications or the use of public networks for RBC-EVC communication in the N2 of the ERTMS. This project is a very important challenge for the LIF and, mainly, for Adif, as it can demonstrate the viability of starting to deploy the ERTMS on the Spanish conventional network.

Regional train at Leon Railway Station.

OUTSTANDING PROJECTS / LIF

RAILGAP PROJECT

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The RAILGAP (RAILway Ground truth and Digital mAP) project is a European innovation project funded by the EUSPA (EU Agency for the Space Programme), within the H2020 Program, which aims to implement new methodologies and develop tools that allow for high-precision ground data and digital maps of railway lines.

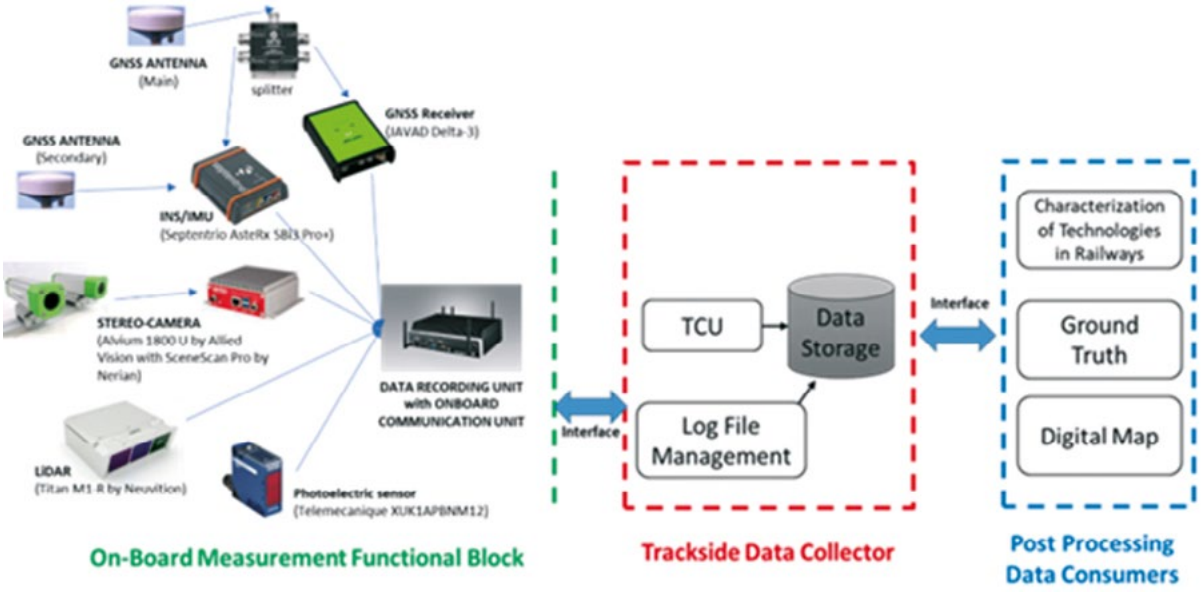
The project contributes to the evolution of the ERTMS system by providing solutions for the implementation of new functionalities in train positioning with unprecedented reliability and efficiency in railway operations.

The project faces this challenge by using commercial trains to capture large volumes of data from Spanish and Italian railway lines, with the aim of overcoming limitations in terms of mileage derived from specific project test campaigns carried out so far.

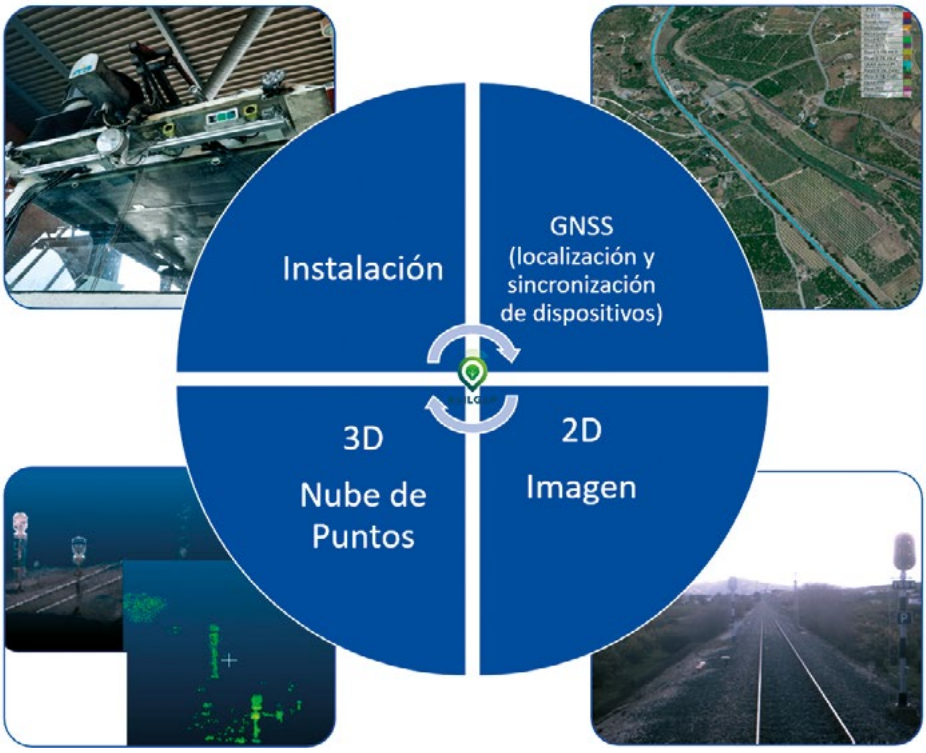
Simultaneously, in laboratories techniques and tools are applied that meet the quality and performance standards of the sensors installed on the trains with the aim of processing and analysing the information obtained in the field, especially in complex areas (tunnels, urban canyons, entrenched areas or with abundant vegetation).

CEDEX, through its Railway Interoperability Laboratory (RIL/LIF), has played an active role in defining the project's requirements and architectures, as well as coordinating the definition of specifications for track test campaigns.

This situation has resulted in the development by CEDEX of an automatic data acquisition system that integrates and synchronizes five sensor technologies (GNSS, IMU, stereoscopic cameras, LiDAR, and photoelectric



Architecture of the data acquisition system developed by CEDEX and information flow in the project.



Example of the information collected in real time during the performance of the tests on track.

sensor) specially adapted to the peculiarities of rolling stock in Spain (maintenance draisine) and the railway lines under study.

Within the development of methodologies and tools for the identification of ground data and high integrity and precision digital maps, CEDEX will be responsible for coordinating the design specification of a comprehensive database of digital maps that includes the topology of the tracks and signalling elements in a standardized format.

In this context, the LIF considers that the standardization of formats is one of the keys to achieving interoperability and usability of data. This position is based on experience in previous projects, such as the definition of the European testing standard for ERTMS (Subset-076 and Subset-085) and the evaluation of the scalability of data formats in the field of railway signalling, in the VITE (Virtualisation of the Testing Environment) and GATE4Rail (GNSS Automated Virtualized Test Environment for Rail) projects. Therefore, the RAILGAP project takes a step forward in the European initiative that drives the evolution of ERTMS through the implementation of GNSS-based technologies to reduce the life cycle cost of rail transport, increase rail capacity, reliability and punctuality and minimize energy consumption per passenger/km.

Project website: https://railgap.eu/

OUTSTANDING PROJECTS / CEPYC

HANDBOOK ON CLIMATE CHANGE INTEGRATION IN COASTAL PROJECTS - PART 1

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This Handbook presents practical criteria on the inclusion of climate-change-related aspects within projects carried out by the Directorate-General of the Coast and the Sea, as well as a support tool for decision making on coastal adaptation management. The first part of the Handbook, which frames initial knowledge that will serve as a basis for the rest of the document, has been completed.

The **Spanish Strategy for Climate Change Adaptation in the Spanish Coast** lays out general targets, consisting of the increase of coastal resilience to climate change. To do this it also aims, as one of its specifical objectives, to ensure that necessary information and methodology are gathered during coastal project design to reach risk reduction milestones. The **Handbook on Climate Change Integration in Coastal Projects** is aligned with both objectives and, for pursuing them, a first part has been carried out which contains a literature review on international publications; a list of the related legal and planning tools; as well as an initial assessment on different impacts of climate change according to coastline diversity in Spain.

The **literature review** presents a collection of national handbooks and publications from other countries (United Kingdom, United States, Australia, India, and Canada), and analogous international documents (PIANC) on Climate Change adaptation, not only including the main examples from coastal engineering but also some studies from civil engineering and architecture fields. Several ideas have been drawn from these documents on management of climate data uncertainty; identification of impacts depending on the project type; risk-based design; adaptable and resilient solutions; as well as on appropriate planning horizons and cost-benefit analysis, among others.

Legal and planning tools with an influence on the main topic have been identified, covering both international, European, and regional scopes.

In the **preliminary analysis of climate change impacts**, the **projections** from the last IPCC (6AR) report, published in 2022, have been taken into consideration, which

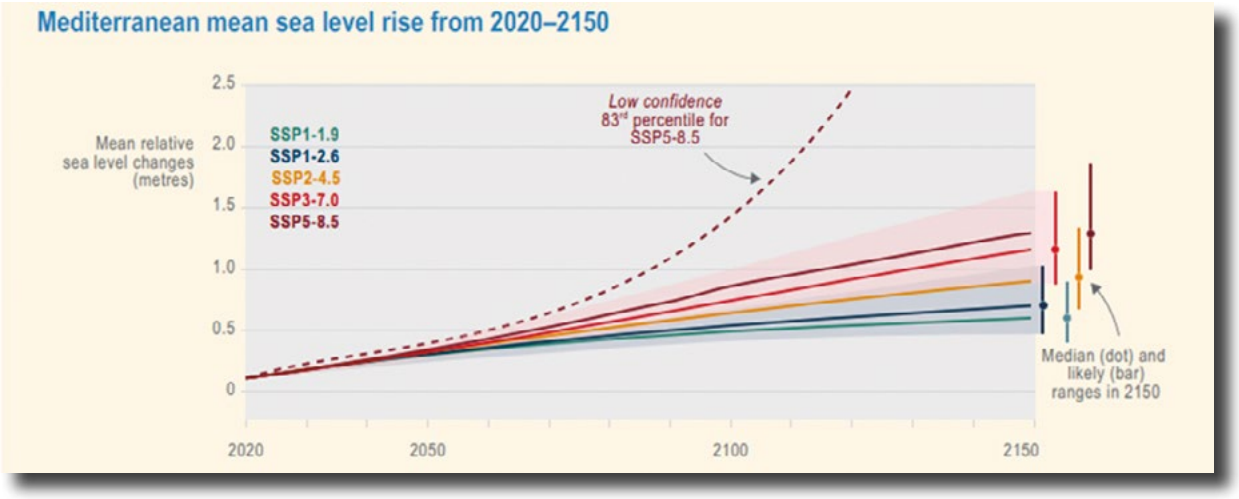

Figure 1. Mediterranean Sea level projections (Source: Sixth IPCC report (AR6).

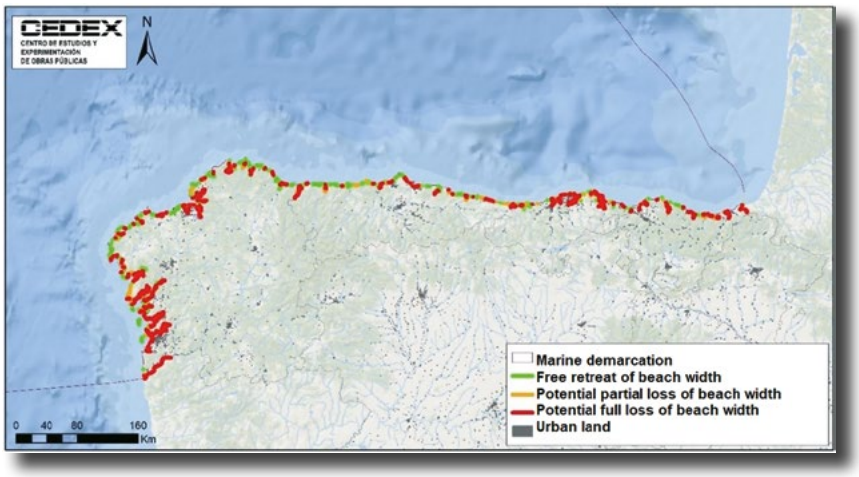

Figure 2. Natural coastline under potential free retreat, and full or partial loss of beach width due to urban land restrictions and sea level rise in the North-Atlantic Spanish Marine Demarcation (Source: Spanish Maritime Spatial Planning).

identify Sea Level Rise (SLR) as the most determining climate factor (figure 1).

Other factors have been analysed, such as **coastal morphology** (natural and manmade coasts and their subtypes, according to CEDEX mapping for the Seashore Plan – Plan Ribera); **impacts on natural coastline** considering land use restrictions to coastal retreat (following illustrative criteria from Maritime Spatial Planning (MSP) – Planes de Ordenación Espacial Marítima – figure 2); **impacts on manmade coastline** depending on its classification (flexible, semi-rigid and rigid – figure 3); and existing **types of projects**. Regarding the latter, an initial and qualitative assessment on the level of impact depending on the different types of hard coastal structures has been undertaken.

From the results of this preliminary analysis on potential **impacts on coastal works** by accounting for the aforementioned factors and the degree of wave exposure, it has been found that many longitudinal works along the Spanish marine demarcations are located close to beaches with a higher potential for retreat, so it can be expected a higher risk of scouring, overtopping, structural damage and loss of functionality for coastal works, especially in the most wave exposed areas. On the other hand, the specific impacts that could happen due to their distinctive features have been described for each marine demarcation.

Drawing **conclusions**, it can be highlighted the value of the ideas extracted from the literature review; the already existing integration of climate change adaptation within legal and planning tools; the need for considering results from local and regional risk assessment reports, as well as from the most updated SLR projections and local data; the influence that diverse morphology, climate and land uses in the rear have on the severeness of impacts on coastal works; and the ease that using the marine demarcations as spatial limits for the analysis brings to the understanding of impacts under such a variety of conditions.

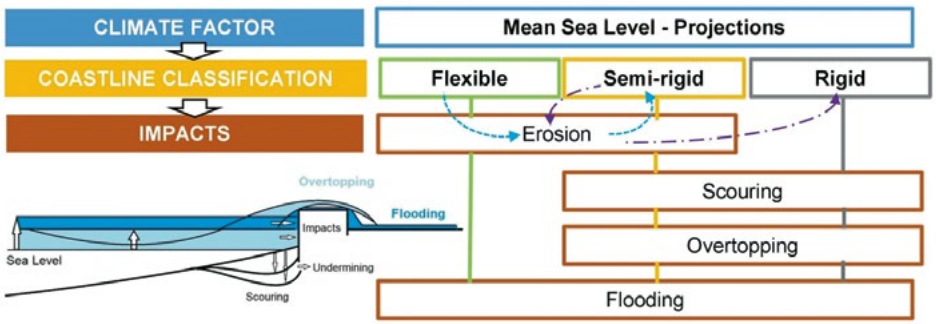

Figure 3. Methodology for the assessment of Climate Change impacts in coastal areas (Source: IAHR 2022).

OUTSTANDING PROJECTS / CEPYC

NUMERICAL STUDY ON THE RECONSTRUCTION PROJECT OF THE BANCHA WEST BEACON OF THE PORT OF PASAJES

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The Port Authority of PASAJES (APP), commissioned the Centre for Port and Coastal Studies (CEPYC), of CEDEX, to verify the structural behavior obtained in the physical tests carried out on the signaling beacon proposed as a reconstruction of the previously existing one, which failed during the storm on February 9, 2016.

In the tests carried out in physical model for the Reconstruction Project of the Bancha Oeste Beacon of Pasajes Port, it was concluded that the greatest efforts in the anchorages occurred at low tide, rather than at high tide, despite the initial forecasts of the contractor and authors of the design and project of the new beacon tested.

Additionally, and outside the scope initially foreseen of the study, preliminary numerical simulations were carried out reproducing the monochromatic wave that produced the greatest longitudinal force for a significant wave height of 11m, both at low and at high tide. The model used, FLUENT, is the CFD (Computational Fluid Dynamics) code, developed by ANSYS. The results of these simulations confirmed the results obtained in a small-scale physical model.

In order to complete a final check of these results with irregular waves, a new numerical simulation was conducted at the request of the APP, with a smoothed particle model (SPH), more realistic for free surface problems. The model used was DualSPHysics, developed in open source by several institutions worldwide, including the University of Vigo.

The irregular swell reproduced was that referred to the calculation wave defined in the project, characterized by a peak period of 18s and significant wave height of 10.78m. The water levels considered was the corresponding to low tide (BMVE), -0.25m, and maximum equinoctial high tide (PMVE), +5.35m

The projected solution is a jacket type structure, which is composed of three distinct parts:

- Tripod: three metal tubes of circular section of 800 mm of outer diameter and 30 mm thickness, placed with an inclination of 12° on the vertical
- Shaft: metal tube of circular section with an outer diameter of 1,200 mm and thickness of 30 mm
- Knot: piece of steel that joins the shaft to the legs of the tripod

The total height of the beacon is 24.82 m, between -7.62 m and +17.2 m. On this last level the beacon lantern would be arranged

The emplacement of the project area is characterized by a highly irregular bottom arrangement (figure 1).

In these simulations the moment obtained in the direction Y perpendicular to the direction of propagation of the wave, at high tide, was 11814.02 kN·m for the maximum wave, 11891.24 kN·m for the numerical simulation VOF, and 16990.19 kN ·m recorded in the physical experimentation (figure 1).

For the low tide condition, the moments obtained were 23841.80 kN·m, in the SPH

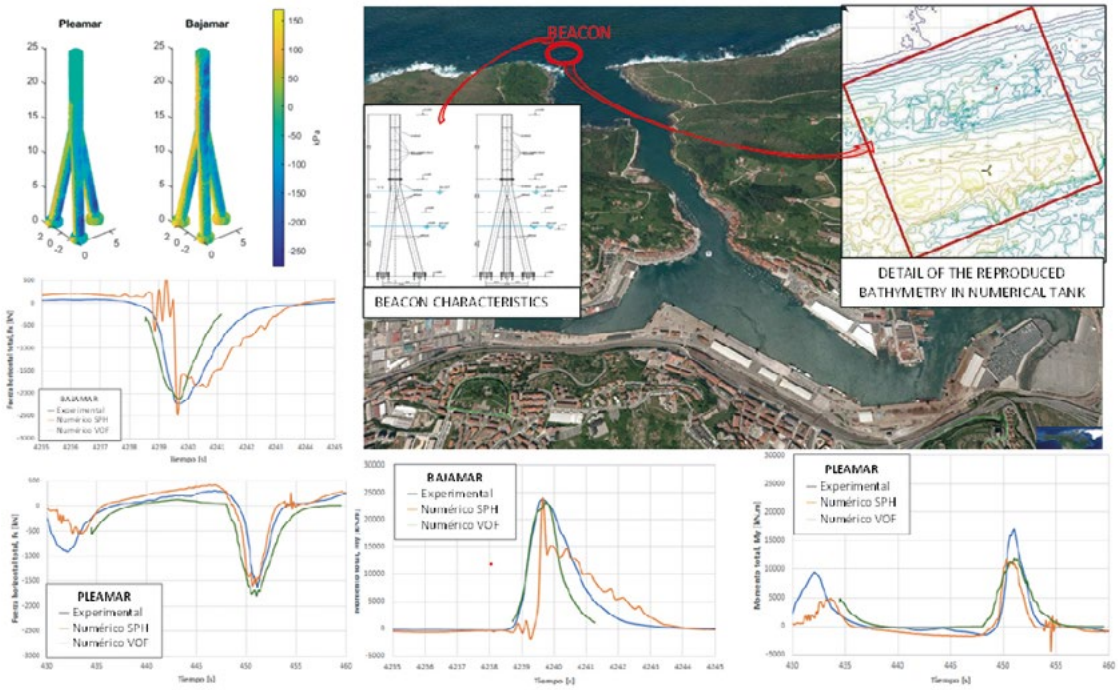

Figure 1. Location and characteristics of the project area. Comparison of physical and numerics model (Fluent, DualSPHysics) results.

numerical simulation for the maximum wave and 23605.24 kN·m for the VOF numerical simulation, compared to 23074.71 kN·m recorded in physical experimentation.

It's remarkable the coincidence between the three results, ratifying that the most unfavorable condition for the calculation of stresses on the structure is produced at the low tide condition, and not with high tide level, as concluded in the report of experimental tests.

The distribution of pressures obtained, for each of the tidal conditions studied, at the moment in which the maximum horizontal force occurs (see figure 1 yellow areas represent maximum pressure values), coinciding with the surface of the beacon opposite to the direction of advance of the waves, highlights the validity of this type of models to provide the distribution of the forces to which the beacon is subjected along its structure, complementing the information that can be extracted from the physical model.

OUTSTANDING PROJECTS / CEPYC

SHIP MANOEUVRING SIMULATION STUDY FOR THE OPTIMISATION OF THE ACCESS AND BERTHING LIMIT CONDITIONS FOR LARGE SHIPS IN THE PORT OF EIVISSA

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The Port Authority of the Balearic Islands (APB) and the public organism State Ports (PE) have commissioned CEDEX's Centre for Port and Coastal Studies (CEPYC) to carry out a ship manoeuvring simulation study to analyse the berthing and departure limit conditions in the Botafoc dock for six different types of cruise ships, one ferry, and one tanker..

The aim of this study was to determine the berthing and departure limit conditions for the chosen vessel types. The environmental conditions of the simulations were based on the conclusions of the report "Study of the climate and internal agitation of the port of Eivissa associated with possible improvements that could be introduced in its northern docks" (November 2022), which was conducted by the Climate and Maritime Studies Unit of the CEPYC. A total of three meteorological scenarios were simulated and defined on the basis of the most statistically representative wind and wave associations. In these scenarios, the weather conditions (significant wave height and wind and current speed) have been worsened in successive simulations until reaching the condition in which it wasn't possible to berth or leave the port.

The following vessels have been selected as type vessels: A Ro-Pax ferry of 230 m length overall, 31 m beam and 7 m draught, representing the future ferry traffic of the port. A tanker like the larger ones operating in the port, with 182 x 25 m and three loading conditions. Three azimuthally propelled cruise ships with dimensions 339 x 39 x 8.5 m, 294 x 32 x 8 m and 270 x 32 x 8 m. Three conventionally propelled cruise ships with dimensions 333 x 38 x 8 m, 300 x 38 x 8 m and 260 x 31 x 8 m. These six cruise ships represent the current and future traffic of this type of vessel in the port of Eivissa.

The access and departure manoeuvres have been carried out for the berths of the Botafoc South Jetty (N°3 and N°4) and the Botafoc Dock Quay. At the beginning of the study, the simulations were undertaken with the current bathymetry of the port to later include a new plan with the north berth of the South Jetty (N°3) dredged to 14 m, allowing for the berthing of cruise ships with greater draught.

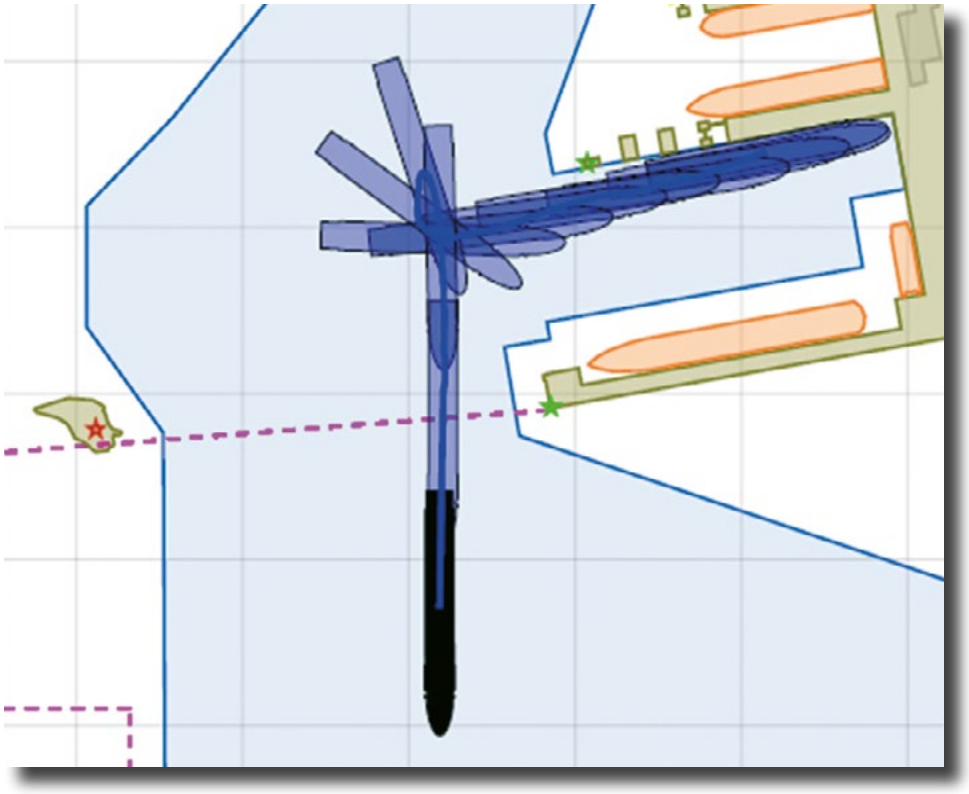
The access and departure simulations have been executed with different strategies, starting points (pilot embarkation point "Eco" or "Sierra") and berthing band, to determine the most complicated manoeuvring conditions for each vessel.

Emergency manoeuvres have been performed with each of the vessels, where the tug has been piloted on a second manoeuvring bridge connected to the main bridge. The purpose of these simulations was to determine whether the existing tug in Eivissa had sufficient power to cope with an emergency, with the vessel without power once it had passed the point of no return on its access to the port, or without propulsion and steering while it was turning around in the harbour.

The analysis of the results of the simulations has been carried out using a risk analysis methodology divided into 4 parts:

1) Risk assessment associated with the navigable area, where the distance of passage to shallows, obstacles and moored vessels is assessed. 2) Risk assessment associated with the reserve of means of manoeuvre, where the time of use of the means of manoeuvre above a certain threshold is penalised. 3) Risk assessment of the nautical personnel performing the manoeuvre, where they indicate the sensations and difficulties during the simulation. 4) Risk assessment by the study director, who assigns the final risk score (from 1 to 5) to the manoeuvre.

The study was done with the POLARIS real-time ship manoeuvring and navigation simulation system available at CEDEX's Centre for Port and Coastal Studies.



Departure manoeuvre of a "Constellation" type cruiser (300 m length) from the N4 berth of the Botafoc South Jetty in a southerly wind of 35 knots.

OUTSTANDING PROJECTS / CEPYC

DESIGNATION OF A PARTICULARLY SENSITIVE SEA AREA (PSSA) IN THE NORTHWESTERN MEDITERRANEAN SEA

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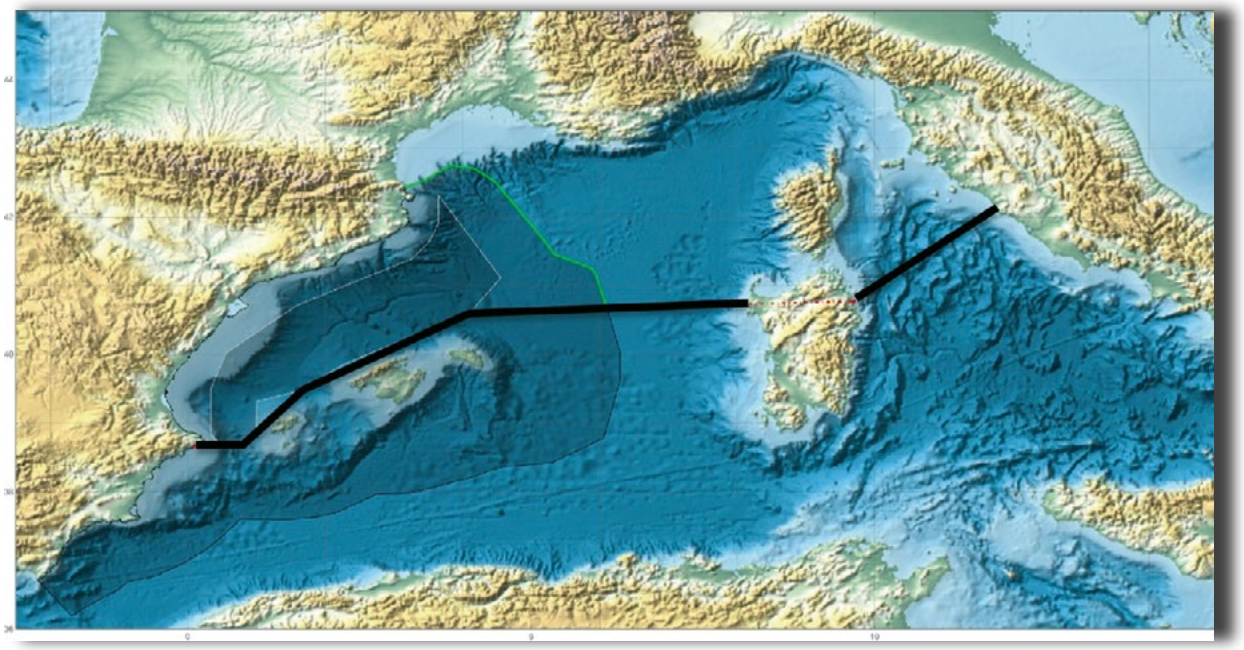
The designation of the NW MED Marine Sensitive Area proposed by Spain, France, Italy, and Monaco aims to protect cetaceans from the risk of collisions with ships.

Throughout 2022, France, Italy, Monaco and Spain have worked together on a proposal of designation of a PSSA in the Northwestern Mediterranean Sea to minimize the risk of ship collisions with cetaceans and the ship-generated pollution, and to increase awareness on a critically important area for the fin whale and the sperm whale, to effectively protect biodiversity from maritime transport threats. The proposed PSSA encompasses the whole Pelagos Sanctuary and the Spanish Cetacean Corridor, which are already designated as Special Protected Areas of Mediterranean Importance (SPAMIs) under the Barcelona Convention and the UN Mediterranean Action Plan dedicated to the conservation of cetaceans.

In Spain, the process has been carried out jointly by the Directorate-General of the Merchant Marine (DGMM) and the Directorate-General for Biodiversity, Forests and Desertification (DGBBD), which cover issues related to navigation and safety at sea, on the one hand, and the protection of biodiversity on the other. In this context, CEDEX supported the DGBBD by conducting and analyzing studies, and attending international meetings and working groups. All this, in order to prepare the proposal, as well as to give answer the public consultation process of the draft proposal, analyzing the allegations made by public administrations and other stakeholders (maritime transport sector, academia and NGOs).

Finally, in its last session in December 2022, the Marine Environment Protection Committee (MEPC) agreed in principle to the designation of the Northwestern Mediterranean Sea as a PSSA, subject to the further development and approval of the proposed associative protective measures by the Sub-Committee on Navigation, Communications and Search and Rescue (NCSR) and the Maritime Safety Committee. The proposed measures include recommended measures, such as reducing speed, increasing look out, and reporting of cetacean sighting and collisions.

In the implementation process of the ZMES, measures will be reviewed and coordinated between countries, giving the opportunity to CEDEX to apply its capacities to support the development of this area for the protection of the marine biodiversity.



North of the black line, area covered by the NW-MED Particularly Sensitive Sea Area, approved by MEPC-79 in December 2022, and covering much of the waters of the Mediterranean in Italy, France, Monaco, and Spain. The image shows the Levantine-Balearic Marine Region, the Cetacean Migration Corridor (white line) and the NE border of the Spanish waters of the ZMES (green line).

OUTSTANDING PROJECTS / CEPYC

SPANISH MARITIME SPATIAL PLANS: ANALYSIS OF HUMAN USES AND ACTIVITIES AT SEA

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The effective management of the marine space requires knowledge of the current situation of the different sectors in the maritime environment and the forecasts of future potential development.

Maritime spatial planning in Spain has had a complex development, lasting several years, which has been articulated on the basis of a participatory process, and where all sectors and interested individuals have been accommodated.

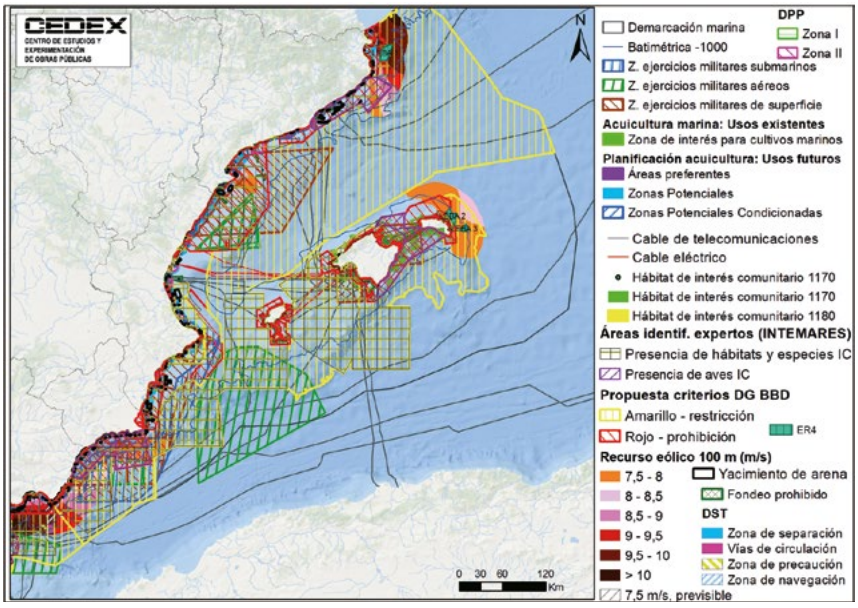

Figure 1. Map of uses and activities in the Levantine-Balearic Marine Region.

One of the pillars of this process is the extensive analysis of uses and activities in the five marine regions. This task has been carried out by CEDEX, resulting in a first version of the diagnosis in the summer 2021. The work gives support to the Spanish Directorate-General of the Coast and the Sea (DGCM), and analyses the current and potential uses and activities, through their characterization, distribution, and evolution, as well as their socioeconomic importance. It also contains a study of the land-sea interactions. Finally, it details the possible synergies and conflicts between the activities identified and the demands of future activities.

This initial diagnosis was submitted to public consultation between June and September 2021, receiving more than 200 responses. During the last months of 2021 and 2022, we've collaborated with the DGCM in the analysis and resolution of the responses related to the diagnosis, participating in meetings, updating documents and geographic information if necessary, and re-performing interaction analyses if considered relevant. Collaboration with DGCM has also been provided in the development of maps that set the spaces reserved for the different activities or uses, the main outcome of the planning process. All this updated geographic information has been published in the INFOMAR viewer (http://infomar.cedex.es/).

The development of the whole process has culminated in the publication of RD 150/2023, of February 28, which approves the maritime spatial planning plans of the five Spanish marine demarcations.

OUTSTANDING PROJECTS / CETA

SUPPORT TO MITERD FOR COMPLIANCE WITH ENVIRONMENTAL NOISE LEGISLATION

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WEBSITE OF THE NATIONAL INFORMATION SYSTEM ON NOISE POLLUTION

The Area of Environmental Noise, in the exercise of its functions as high-level technical assistance and innovative development to the Ministry for Ecological Transition and the Demographic Challenge (MITERD), implements, maintains and continuously provides new data to the website of the Basic Information System on Noise Pollution (SICA).

SICA, constitutes the necessary database to directly transmit information to the public regarding ambient noise. SICA follows the regulation of Royal Decree 1513/2005 of December 16, which develops Law 37/2003 of November 17 on Noise.

In 2022, new guides, instructions and studies from the concerned authorities related to rounds 3 and 4 of Environmental Noise Directive (END) have been added to the website. Additionally, information from the *Conferences on Environmental Noise and Action Plans against Noise*, held in July and November 2022, has been incorporated. The website has registered nearly 40,000 visits in 2022 (110 daily visits), which highlights its usefulness for the general and specialized public, complying with the basic principles of the legislation on access to environmental information.

Entry page to SICA website (https://sicaweb.cedex.es/).

OUTSTANDING PROJECTS / CETA

MONITORING THE POTENTIAL IMPACT OF THE BELLÚS RESERVOIR ON GROUNDWATER IN THE SURROUNDING AREA

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The management of the Bellús reservoir is strongly conditioned by a limit on its water level imposed in its operating rules to prevent the impact on the quality of nearby urban supplies in the Sierra Grossa groundwater body.

After these rules have been applied for decades, studies performed by the Area of Isotopic Applications of CETA at CEDEX concluded that this impact could be assessed with an Environmental Monitoring and Surveillance Plan, and that the limit of the water level could be relaxed provided that the results of this plan so indicate. This plan has been included in the operating rules and requires periodic monitoring on the effect of the reservoir water on the aquifer water. For the application and evaluation of this plan, the Júcar Basin Authority commissioned CEDEX to confirm the water tightness of the Bellús reservoir.

The work, carried out in the period 2019-2022, consisted of (i) design and supervision of the construction of new boreholes equipped as multi-piezometers; (ii) selection and conditioning of existing water points to be included in the monitoring network; (iii) installation of continuous electric conductivity-temperature-pressure/water level recording probes; (iv) water sampling and analysis for chemical and isotopic parameters; (v) application of tracing and dating techniques to assess the transit time of water in the aquifer; and (vi), differential gauging in the Albaida river to study the hydraulic connection reservoir-aquifer-river.

The survey in numbers	
Water bodies involved	2 river, 1 reservoir y 2 groundwater
New piezometers	8 (3 double and 2 single piezometers)
Monitoring network points	39
Continuous sampling points	15
Isotope sampling campaigns	15
Isotopic determinations	233 $\delta^{2}H$ and $\delta^{18}O$, 149 tritium, and 7 $\delta^{13}C$ and ^{14}C
Hydrochemical sampling campaigns	4
Hydrochemical samples	76 for major and minor ions, and 52 for organic and emerging pollutants

The results of the study help to conclude that:

i. chemical and isotopic tracers have allowed to characterise differences between water groups, as well as their possible interactions.

ii. the waters of the Sierra Grossa groundwater body (including supply wells) haven't undergone substantial changes in their chemical and isotopic composition. Some minor changes in the quality or quantity of water supplies are not related to the reservoir.

iii. the aquifer is divided into compartments, which makes it difficult the connection between the water from the reservoir with the supply points.

iv. there are minor losses from the reservoir to the adjoining aquifers on both banks, somehow greater on the right one, but limited to the immediate surroundings of the reservoir's downstream boundary.

v. it has been possible to confirm, by means of differential gauging and mass balances, that there are no important losses from the Bellús reservoir to the Albaida river, and that groundwater discharges to the Albaida river downstream of the Bellús dam condition the good quality of the river water, having the same value that was measured before dam construction.

Upwelling borehole used as a piezometer and sampling point located in an aquifer downstream of the Bellús reservoir.

OUTSTANDING PROJECTS / CETA

IMPLEMENTATION OF THE NATIONAL STRATEGY FOR GREEN INFRASTRUCTURE, ECOLOGICAL CONNECTIVITY, AND RESTORATION ON THE SPANISH COAST

Contact: manuel.colomer@cedex.es

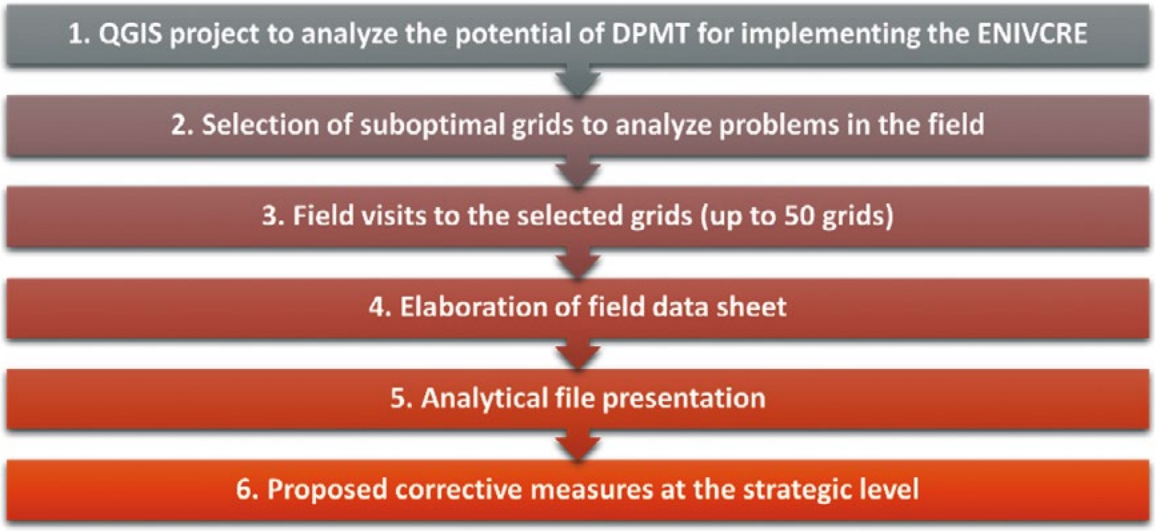
This project aims to collaborate and coordinate with the Directorate-General of the Coast and the Sea (DGCM), of the Ministry for Ecological Transition and the Demographic Challenge (MITERD), to identify the requirements of the National Strategy for Green Infrastructure, and Ecological Connectivity, and Restoration (ENIVCRE) in the area of the Terrestrial Maritime Public Domain.

ENIVCRE GOAL 1: Reduce the effects of fragmentation and loss of ecological connectivity caused by changes in land use or the presence of infrastructure in terrestrial, fluvial, coastal, marine, and urban areas.

CAPACITY OF THE COASTLINE TO IMPLEMENT GREEN INFRASTRUCTURE

To analyze the capacity of the coastline to implement the ENIVCRE, the adequacy of the coastal strip to accommodate the elements that make it up [natural and semi-natural areas (nodes), natural and artificial connectivity elements (connectors), multifunctional zones, and urban components (barriers that can generate fragmentation)] was assessed.

With this objective in mind, a Geographic Information System project is being conducted to inspect the state of the coastal strip, establish its connectivity characteristics, and deduce its capacity to accommodate green infrastructure elements.



In a first review, the Spanish coast was divided into 36,270 grids of 500 m sides in which it was assessed, based on land uses (SIOSE, 2014), its degree of alteration, obtaining:

· 10,207 (28.1 %) grids with a degree of alteration above 20 % (in which the effort of adaptation to accommodate green infrastructure would be high)

· 26,063 (71.9 %) grids with a degree of alteration below 20 % (with a good potential for implementing green infrastructure)

· Of these, the grids at the threshold (degree of alteration between 19 and 20 %) will be analyzed, where the impacts will be characterized and measures to implement green infrastructure will be proposed

OUTSTANDING PROJECTS / CETA

STUDY FOR THE MORPHOLOGY NATURALIZATION OF THE SOTO DE LAS CUEVAS LAGOON (ARANJUEZ) BY MEANS OF SEDIMENTARY FILLING

Contact: francisco.m.cortes@cedex.es; maría.diaz@cedex.es

The Area of Environmental Restoration of CETA has carried out, at the request of the Directorate-General for Biodiversity and Resources of the Community of Madrid, a specialized study on the possible alternatives for the extraction of sediment from the banks of the Jarama river in Aranjuez for the geomorphological naturalization of the Soto de las Cuevas lagoon basin.

In this study, a multifunctional action has been proposed in the Soto de Legamarejo (left bank of the Jarama river) with the double objective of: i) obtaining sediment for filling the lagoon; and ii), improving the vertical connection with the hyporheic zone and the lateral connection of the river with its floodplain. The proposed alternatives were modeled with IBER 2D and the effects on flooding and on the hydrological reconnection of the land modification area were evaluated. The results showed slight reductions in the flooded areas

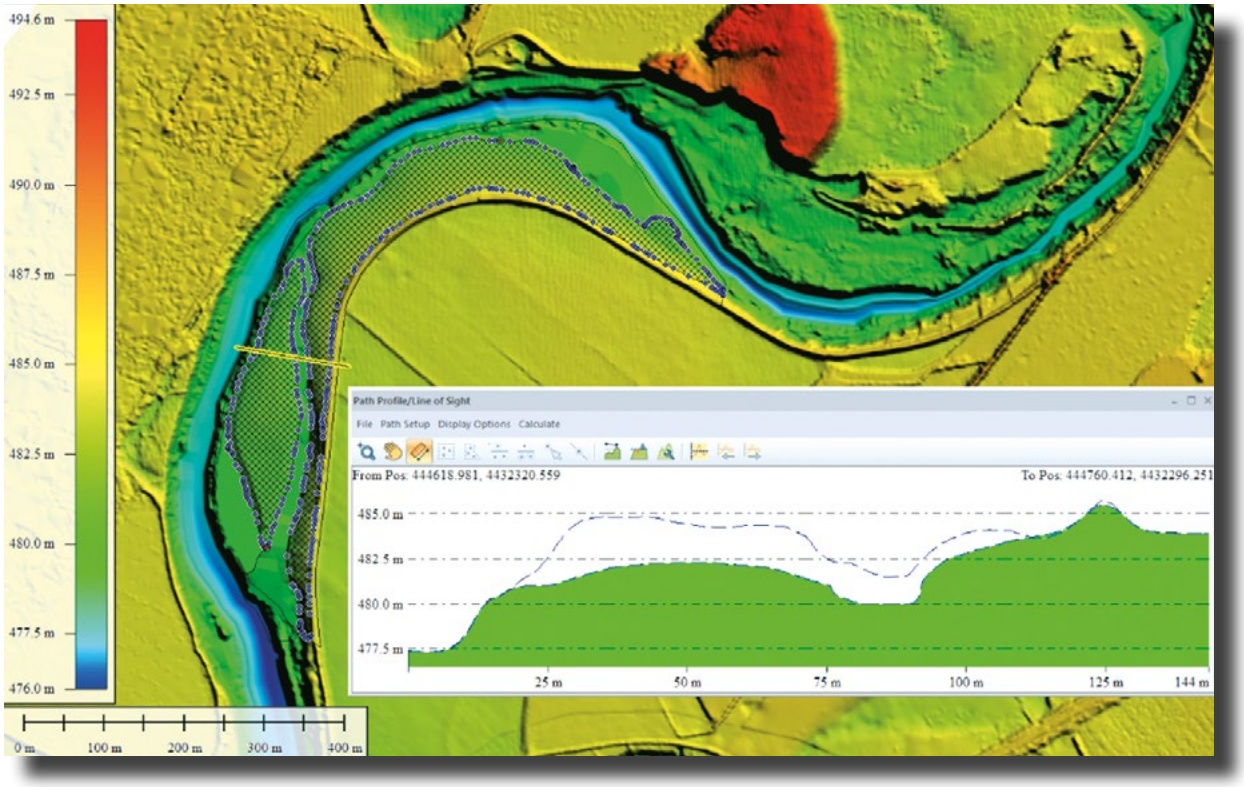
Current view of accumulated sediment and a disconnected secondary arm on the Jarama river left bank.

downstream and an evident improvement in the hydraulic reconnection of the secondary channel, even with low flows.

This study highlighted that, by undertaking in parallel the geomorphological naturalization of an artificial lagoon and of a disconnected riverbank, it's also possible to expand selective flood zones, promote lateral and vertical hydrological reconnection, and increase habitat heterogeneity.

The study covers the execution of a series of geomorphological and vegetation improvement actions:

- Removal of 350 m^3 of breakwaters and debris on the Jarama riverbank
- Removal of 110,000 m^3 of sediment and bank re-profiling (9 % average slope)
- Backfilling of the lagoon basin with 102,000 m^3 from the sediment removal: bank level raising and re-profiling (33 % average slope)
- Plantation of 10,000 native plants on the Jarama riverbank



Plan and profile of the geomorphological naturalization proposal: sediment removal, bank re-profiling and recovery of the secondary arm.

OUTSTANDING PROJECTS / CETA

OPERATIONAL MODELING OF DISPERSION OF AIR POLLUTANT EMISSIONS BASED ON SAMOA-2

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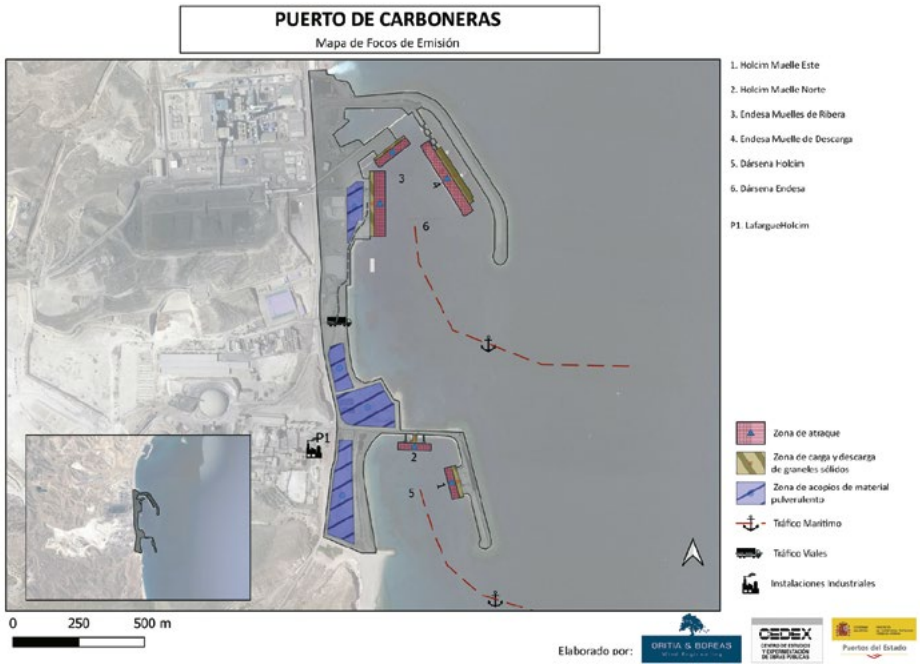
CEDEX, in collaboration with State Ports (PE), the wind engineering company, Oritia & Boreas and 16 Port Authorities, is working on the implementation of operational modeling of the dispersion of atmospheric pollutants within the SAMOA project in each of the ports that managed by said Port Authorities.

The project begins with the modeling of the physical port environment, to which information on polluting emissions into the atmosphere from both port activities and other activities that are located in its vicinity for logistical reasons is incorporated. The atmospheric dispersion model becomes a tool that allows us to know in advance the contribution to atmospheric pollution of port activities in cities near the port.

The use of this type of model helps to improve port management operations, berthing/maneuvering of ships, and unloading of goods. It's a further step in the objective of

Working group participating in the projecto for the dispersion of atmospheric pollutants that affect the port environment, based on SAMOA:

- State Ports (PE)
- Port Authorities (16 ports participate in the exercise, which includes a visit to the ports, with analysis of responses to a form on environmental problems in air pollution)
- Wind engineering specialist company (Oritia & Boreas)
- CEDEX



Schematic plan of sources of emission from docks, industrial activities and land transport of the port of Carboneras.

improving the efficiency of the port system, with the consequent savings in operating times, which translates into a reduction in energy consumption-carbon footprint and emissions into the atmosphere of different pollutants such as SO_2, NO_x, PM10, PM2.5 (particulate matter), etc. All these instruments result in the improvement of air quality and, therefore, in the public health of port cities.

This work was implemented through a survey that was distributed and completed by each Port Authority, and has served as a script to understand and contrast in a face-to-face visit the problems of each port in terms of atmospheric pollution, and the response of environmental, and public health authorities. to this reality. This project has finished in 2022 and the resulting product is described in the figures.

Simulation of dispersion of pollutants (NOx) in one day of operation.

OUTSTANDING PROJECTS / LCEYM

DIGITAL MODEL OF EL ATANCE DAM (GUADALAJARA)

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In 2022, a methodological proposal has been developed for the creation of digital models of dams with updated information in real time.

BIM (*Building Information Modeling/Management*) is a collaborative work methodology for project and construction management. Its objective is to centralize all the information of the work in a digital model created by all the agents involved.

As part of a proposal for the application of the BIM methodology in dam works for the Directorate-General for Water, of the Ministry for Ecological Transition and the Demographic Challenge, the Area of Studies and Auscultation of Structures of the Central Laboratory for Structures and Materials has digitized the El Atance dam in Guadalajara.

Through the application of 3D scanning techniques and BIM modeling, a digital model of the dam has been generated that contains accurate and updated information. This model is a faithful reflection of reality, both in its dimensions and in the state of conservation of its different elements.

As an added value, the results of the "Study of the concrete of the dam", carried out by the Area of Materials Science, have been included in the model. In this way, the mechanical and physical characterization data of the concrete, as well as the damage surveys undertaken, are available for consultation.

General view of the virtual model, overlaying the 3D point cloud and the BIM model.

This digital model of El Atance dam will serve as the basis for its management in the service phase; it will work as a collaborative inventory, facilitating access for the different agents involved, who are, in turn, in charge of keeping it updated.

It will also serve as a temporary record, since it allows control of the dam's life cycle, making it possible to consult its status in previous phases.

Likewise, through the model it is possible to access remote control platforms for operation and manipulation of all types of equipment and facilities (opening and closing of valves, zone lighting, video surveillance cameras, etc).

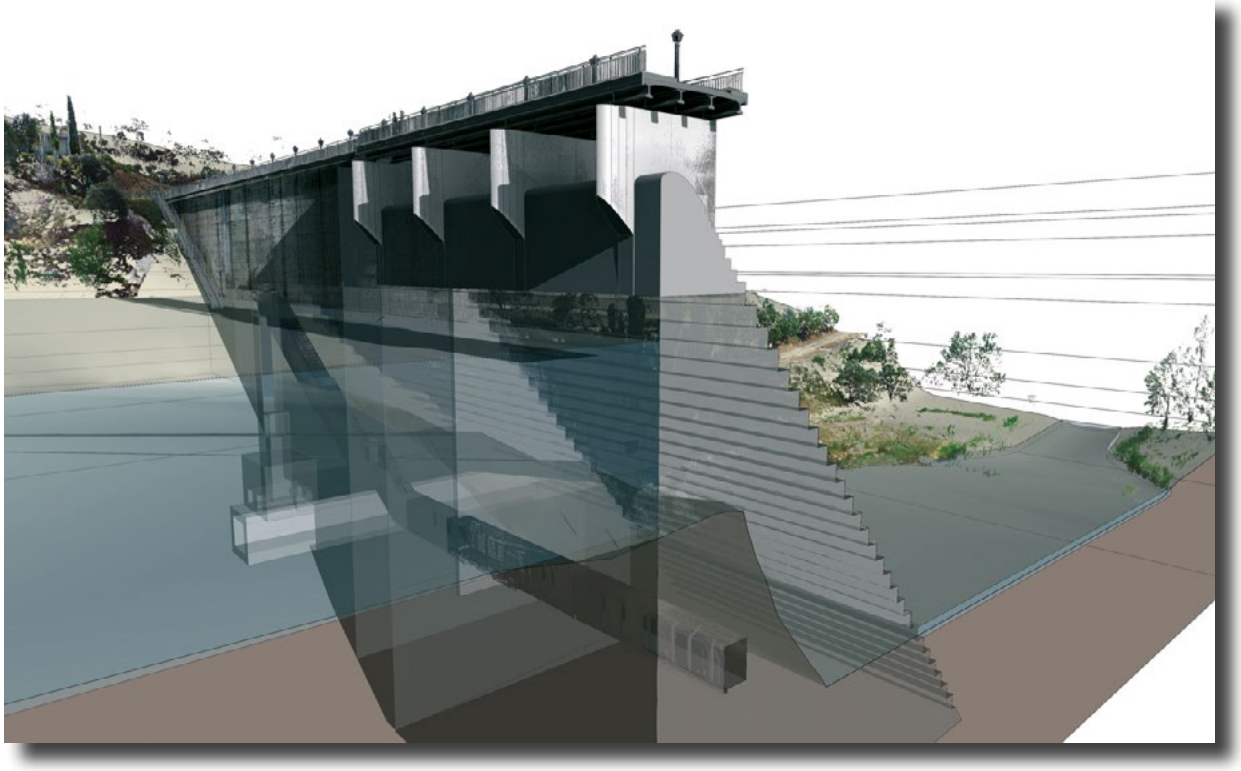
Lastly, with the intention of going one step further in research, the linking of the digital model with a real-time prey monitoring system has been proposed, using sensors that feed it updated information, thus creating its digital twin.

Thus, the twin will allow the collection, analysis and diagnosis of the captured data to reflect the real-time behavior of the dam, and what is more important, to predict its future behavior through predictive simulations.

A digital model of El Atance dam, in Guadalajara, has been generated, with accurate and updated information

Linking this model with dam monitoring systems will allow its behavior to be reflected in real time

Therefore, this digital model will serve as the basis for the management of the dam in the service phase.



Cross section of the spillway, showing the upstream elevation and the dam bottom outlet.

OUTSTANDING PROJECTS / LCEYM

DURABILITY STUDY OF THE SOUTHWEST DOCK IN ESCOMBRERAS, IN THE PORT OF CARTAGENA

Contact: victor.lanza@cedex.ex

The study of the corrosion processes in the concrete of the Escombreras dock wall has allowed to highlight how essential is to place the concrete correctly, as well as selecting the suitable one for the construction of a port work. Otherwise, it won't be possible to obtain durable structures in a particularly agressive marine environment.

Following the request by State Ports, the Area of Material Science of Central Laboratory of CEDEX developed the study of corrosion pathologies of the reinforced concrete in the Escombreras dock wall of the port of Cartagena.

This study started with the visual inspection of the structure and the field evaluation of the concrete, as well as the corrosion state of its reinforcement through ultrasonic, resistivity, half-cell potential, and corrosion intensity measurements.

Then, in the laboratory, it's carried out the physical and mechanical characterization of the interior and, also, the cover of the extracted cores. Experimental work is completed with chloride penetration profiles.

The obtained results showed that the concrete achieved the durability regulatory requirements (referred to dosage and permeability). According to the chloride profiles, the structure should have exceeded the 50-year service life set in the design.

Compaction defects in the concrete cover (surface trails).

Advanced corrosion due to lack of cover.

Nevertheless, the concrete presented compaction deficiencies as whole layers with exposed aggregates or trails on reinforcement. Exposed reinforcement with advanced corrosion was observed in poorly vibrated zones. This corrosion must have quickly developed at the beginning of the dock service life being exposed to marine environment.

In addition, although the average cover thickness complied with the project and the regulations, the state of reinforcement corrosion was also very advanced in those specific areas where the required cover wasn't reached.

Therefore, the study of this dock demonstrates that to guarantee the durability of these maritime structures, it's necessary the correct selection of materials according to regulatory recommendations, as well as an adequate cast of concrete, especially its cover. Compacting, curing, and guaranteeing the concrete cover thickness are, thus, essential operations to obtain a durable reinforced concrete dock wall.

Section 2 of the dock, 781 m long and 45 m depth of water, is made up of 22 caissons

The height of the crown wall above the 0 of the port is 8.00 m

The dock entered into service in 2004

10 concrete cores extracted from the crown wall have been tested

OUTSTANDING PROJECTS / LCEYM

STUDY OF ALTERNATIVE REINFORCEMENTS FOR CONCRETE REINFORCEMENT IN AGGRESSIVE ENVIRONMENTS

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In 2022, the study of alternative reinforcements to the traditional corrugated bars of carbon steel or non-alloy steel has been carried out with the aim of increasing the durability of reinforced concrete structures and, thus, extending their service life.

Reinforcement corrosion is usually the main cause of concrete deterioration. Due to corrosion of the steel, the reinforced concrete element can suffer structural damage owing to the loss of section of the rebar. Moreover, oxidized steel reinforcement can increase in volume causing expansive forces that can lead to longitudinal cracks in the concrete along the reinforcement, and concrete cover spalling.

One of the most harmful agents for traditional reinforcements are chlorides, because they destroy the passivating layer that protects the steel surface from corrosion. The exposure of the reinforcements is more critical in environments where the presence of these compounds is greater and more likely, as is the case of port structures, due to exposure to seawater, and that of bridge decks in areas with frequent frosts, and to exposure to de-icing salts.

As part of the assignment from Puertos del Estado for the investigation of very high durability concrete in port works, the Area of Construction Products, of the Central Laboratory for Structures and Materials, has carried out the study of alternative materials to avoid the problem of corrosion in concrete reinforcement.

Typical damage to coastal structures.

The properties of three alternatives have been revised to compare them with those of traditional steel rebars:

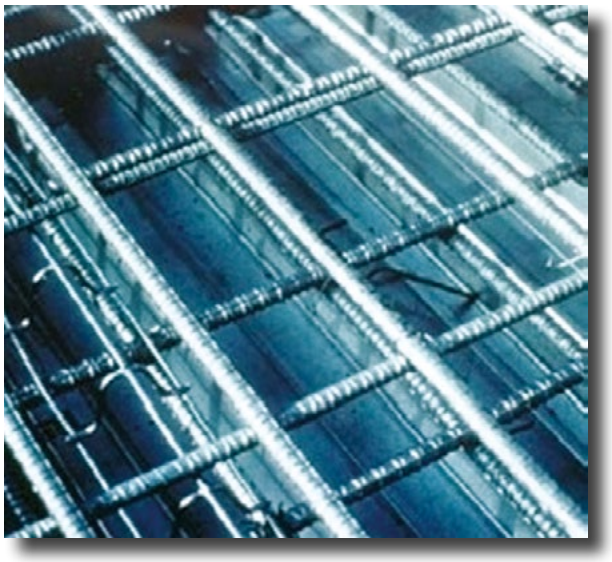
- Galvanised steel
- Stainless steel
- Glass-Fibre reinforced polymers

The improvements that contribute to the durability of the concrete have been analyzed. Its advantages and disadvantages have been reviewed, taking into account the different uses and applications.

A first approximation of the global costs during the service life of the structures has also been made, considering both, the construction phase and the service phase, and a summary of the most relevant and well-known structures, located in the marine or coastal environment, has been made.

Regulations, information from manufacturers and designers, as well as recent research have been reviewed.

Galvanised steel and GFRP rebars.



Stainless steel rebar.

OUTSTANDING PROJECTS / LCEYM

STUDY OF THE CONCRETE OF THE TENTUDÍA DAM

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In 2022, the Directorate-General for Water (DGA) has commissioned the Central Laboratory for Structures and Materials to carry out the study of the concrete of the Tentudía dam, in the province of Badajoz.

In June 2019, the DGA and CEDEX signed the specific Hydraulic Resources and Infrastructure Research and Development Program for 2021. Section II.10 "Specialized technical support for construction management in specific matters such as structures, geotechnics, hydrology and hydraulics" of this program includes the action "Monitoring of the state and pathologies of concrete used in dams".

Within the framework of the aforementioned action, and commissioned by the Sub-Directorate General for Infrastructures and Technology, of the DGA, a study of the concrete of the Tentudía dam in the province of Badajoz has been undertaken with the objective of determining the current state of the concrete of the dam.

In the first place, a study of the documentation provided by the Property has been carried out to extract the maximum information from the concrete placed in the structure. Subsequently, a visual inspection of the dam has been conducted, taking water samples (both from the reservoir and from the leaks in the upper and lower galleries), and making the extraction of nine concrete pieces, both from the wall and from the galleries of the dam, for evaluation at CEDEX's Central Laboratory for Structures and Materials. Tests have been performed to determine the chemical

Tentudía dam.

Dam gallery.

and mineralogical composition of the concrete, the possible existence of pathologies of chemical origin, as well as physical-mechanical tests such as determination of the speed of ultrasound, scanning electron microscopy, compressive strength, water permeability, determination of open porosity, and penetration of water under pressure.

The analysis of the results obtained makes it possible to evaluate the state of the concrete of the Tentudía dam at present, and to recommend any remedial action if necessary.

The construction of the dam was completed in 1988

It's a gravity dam with a straight plan, with a triangular section

It has two levels of galleries

It has a height above foundations of 40.2 m in its central part and a total length in crown of 184.70 m

9 concrete pieces extracted from the wall and galleries of the dam have been tested

OUTSTANDING PROJECTS / LG

GEOTECHNICAL PATHOLOGY AT KM 648+500 OF THE N-420, ESCUCHA BYPASS (TERUEL)

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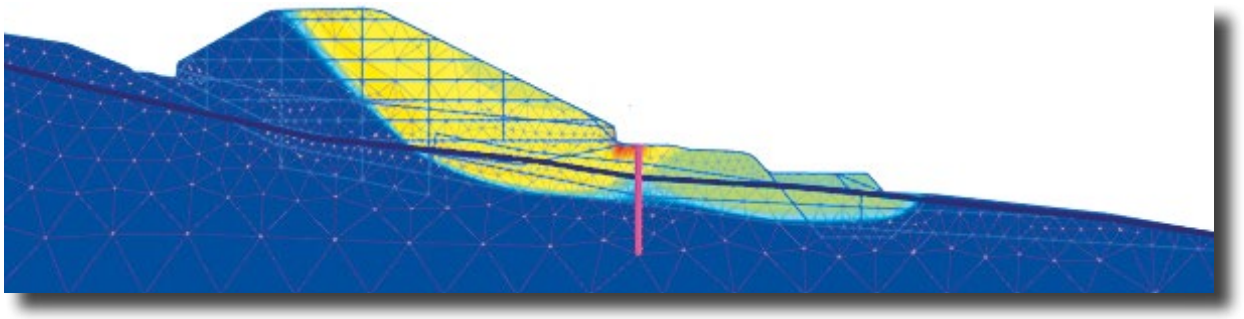
Deformations and cracks were detected on the N-420 bypass as it passes through the town of Escucha (Teruel), which significantly affected the roadway on a 180 m long embankment section. During an initial visit, investigation and auscultation work was carried out to determine the origin of the pathology and obtain the necessary information to adopt corrective measures. These works consisted of the installation of 135 m of inclinometric line. In addition, 29 DPSH tests were carried out on the berms of the road and surface movements were controlled with topography through 186 points distributed between the roadway, embankment and natural terrain. The results allowed for the geotechnical characterisation of the ground, and the identification of the type of movement that was occurring. This consisted of a landslide fundamentally in the contact between the rocky substrate, and the eluvial with a depth of up to 20 m.

Once the pathology had been identified and characterised, the stabilisation works considered were: treatment with earthworks, treatment with mortar piles, treatment with Jet-Grouting and with a pile screen. Furthermore, a simple pile screen was recommended and implemented. According to the available measurements, the movement of the instability is slowing down significantly, although it hasn't completely stopped. In landslides involving large volumes of material, instantaneous cancellation of the movements cannot be expected.

Finally, it has been recommended to reconstruct the roadway when the deformation velocities in the inclinometers are less than 10-15 mm/year.

View of the section of the N-420 with geotechnical pathology.

Execution of a pile screen for the correction of instability.



Breakage kinematics obtained with a single pile screen in profile F-F'. FS = 1.27.

OUTSTANDING PROJECTS / LG

TECHNICAL ASSISTANCE FOR THE PROJECT OF THE RAILWAY ACCESS TO THE NORTH QUAY OF THE PORT OF GIJÓN

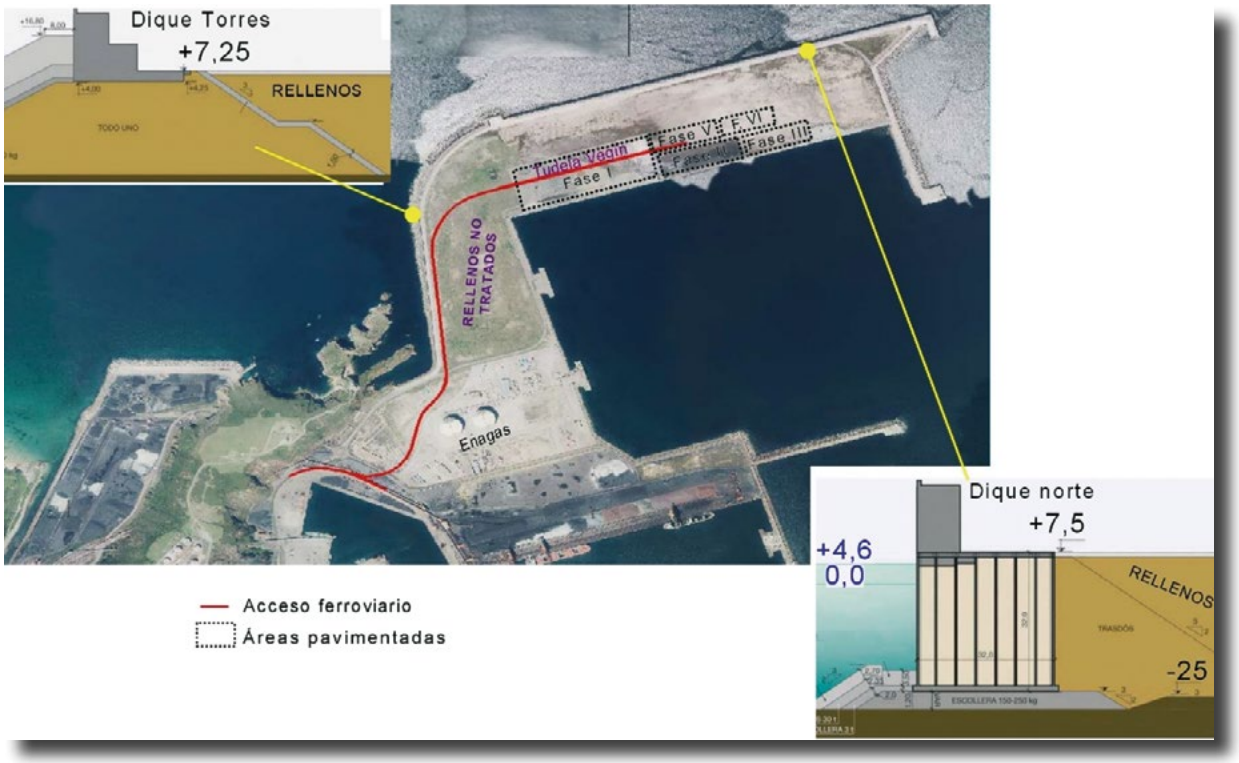
Contact: enrique.asanza@cedex.es

The Geotechnical Laboratory advised the Gijón Port Authority on the project for the railway access to the north quay. The route, about 2.2 km long, runs over fills reclaimed from the sea up to 30 m thick.

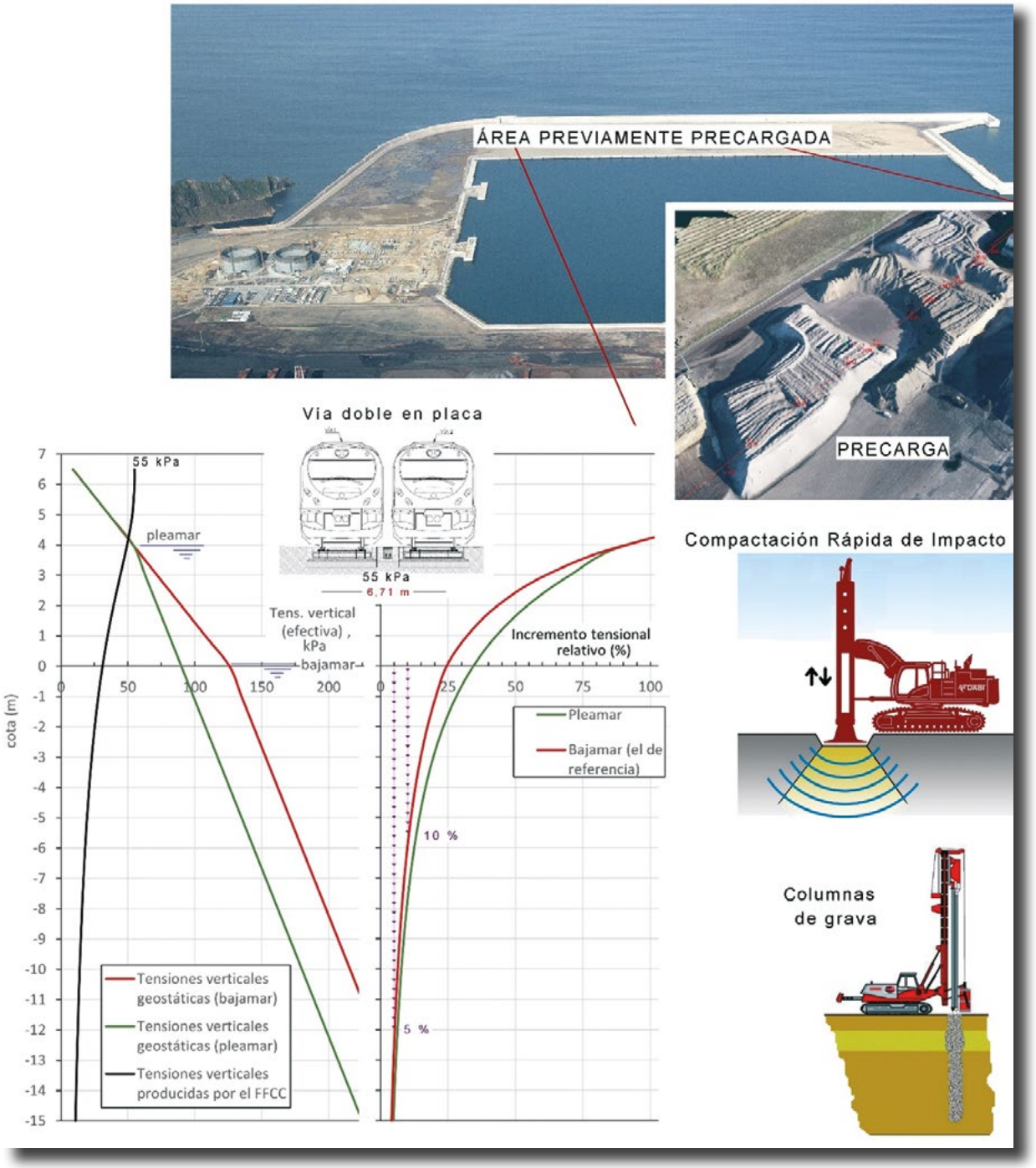
The first third of the route runs through an unpaved area and borders an area under exploitation to the north; the central third of the route has a first sub-section which runs parallel and close to the Torres dock, and another which is a 90° curve; the final third, between the north dock and the quay, is intended for solid bulk and is paved in several phases, by means of a layer of compacted thick slag. In addition, there's evidence that the hydraulic fills were preloaded with slag or similar bulk materials in part of this section (unlike the previous ones, which were consolidated only by their own weight).

The railway track is of Iberian gauge. Both the central and initial sections are designed as a single track on ballast, while the final third is divided and designed as a slab track.

The Gijón Port Authority requested an assessment of the suitability of the two techniques established in the draft of the project for the improvement of the fillings: a treatment of gravel columns for the sections on ballast and dynamic compaction, using the variant of compaction by rapid impacts, for the section on slab track. It also requested guidelines for the procedures for monitoring and validating the execution of the treatments.



Layout of the railway access to the north quay of the port of Gijón and dock sections.



Composition: general view with preloads with historical stockpiles; influence of the railway track overload with depth, at high and low tide; and techniques contemplated in the project.

OUTSTANDING PROJECTS / LG

PROTECTION AGAINST LANDSLIDES ON THE BEACH OF ALOJERA (VALLEHERMOSO-LA GOMERA)

Contact: javier.gonzalez@cedex.es

On the beach of Alojera, located in the municipality of Vallehermoso, **in the west of the island of La Gomera, frequent landslides occur naturally,** both on the cliffs that border the beach on both sides and on the road that provides access to it. This beach has an approximate area of 280 m in plan and is located at the foot of a rocky slope with a semicircular shape, with a maximum difference in height of about 140 m. From a geological point of view, it's a recent volcanic rock massif in which the mechanisms regulating the relief haven't yet had enough time to regularise the slopes and produce a certain degree of surface stability. For this reason, there are steep slopes, a very abrupt orography and a high degree of fracturing. In order to study both the phenomenology of the landslides and to take appropriate measures to mitigate them, a digital terrain model was made using 999 photographs taken with a drone and processed with the Agisoft Metashape program, obtaining a cloud of 111,153,745 points (figure 1).

In this way, a detailed topography of the entire area was obtained, from which rockfall **simulation calculations** were carried out on the entire slope with the Rocfall 8.0 program. In order to calibrate the program parameters, the main landslide source areas and the areas affected by landslides were identified during the two visits to the area. The results show the trajectories of rock falls down the slope and their energy at each point, which is an **essential tool** for the location and sizing of protection measures against landslides. With the results of the rockfall calculations, a series of measures have been proposed to mitigate the risk of landslides, which consist of 670 linear m of dynamic barrier of up to 3,000 kJ of energy and 5 m in height, and 4,100 m^2 of cable nets with a support force of 60 kN/m^2. These proposed measures have been designed **to minimise the risk** of landslides affecting both the access road to the area and buildings and the beach in the areas closest to the rocky cliffs.

Figure 1. Digital terrain model produced from drone photogrammetry.

OUTSTANDING PROJECTS / LG

STUDY OF TENSILE STRENGTH ON ROCKS BY DIRECT TENSILE TEST

Contact: mauro.muniz@cedex.es

This is a work on the development of the direct tensile test on rocks. Specific equipment was designed and put into operation to study the different aspects that condition the goodness of the results, the size of the sample, and the slenderness of the specimens. This work has been completed with statistical studies and three-dimensional numerical models that allow different details of the test to be analysed.

The study revealed a number of deficiencies in the existing test standards and it was felt that they needed to be updated and expanded. For this work, a working group was formed within the International Society of Rock Mechanics (ISRM) to draft an updated version of the ISRM Suggested Test Method. This group, led by the Geotechnical Laboratory of CEDEX, is made up of researchers from prestigious international centres in the field such as York University (Canada), RISE Research Institutes (Sweden), Svensk Kärnbränslehantering Aktiebolag (Sweden), KTH Kungliga Tekniska högskolan (Sweden), Universidad de Vigo (Spain), Technische Universität Bergakademie Freiberg (Germany), and Technische Universität Graz (Germany).

Direct tensile test on a low slenderness granite specimen.

Numerical simulation of direct tensile fracture of a rock sample.

The updated standard is based on an intercomparison test in which two rock types have been tested in laboratories in Spain, Germany, Sweden, and Canada.

OUTSTANDING PROJECTS / LG

STUDY OF CRITICAL SPEED IN RAILWAY SECTIONS, AWARDED WITH THE TALGO AWARD FOR TECHNOLOGICAL INNOVATION

Contact: jose.estaire@cedex.es

Critical speed is the train speed that produces a resonance-like condition in the underlying medium, having consequences on the stability of the infrastructure and the safety of passengers. This study develops a reliable, simple and robust calculation method to calculate the critical speed. It includes a theoretical model, which is the basis of the method, the geophysical measurements necessary to apply it, and the study of the response of the track according to the critical speed.

Knowledge of the critical speed of railway sections makes it possible to design new high-speed lines with high design speeds (400 km/h), making it possible: to respond to high demands in congested corridors; to increase the speed of conventional lines; to improve the response and quality of the railway system; and to reduce maintenance work and costs. The method is a breakthrough as it's simple and relies on land properties directly involved in the problem.

The study of this phenomenon has led a group of technicians from the CEDEX Geotechnical Laboratory being awarded the 19th Talgo Prize in the Technological Innovation category.

The winners of this award were José Estaire, Inés Crespo, Javier Moreno, Ángel Tijera, Rubén Ruiz, and Natalia Montero, thanks to their work entitled "Determination of the critical speed of railway sections".

Reflecting the interest aroused by the critical speed phenomenon is the large number of people who attended the Technical Seminar on this subject held at CEDEX on 6 May, which was opened by a representative of Adif and in which the authors of the proposal participated as speakers. The method developed was used for the first time in the California HSL project, during the CEDEX-Dragados collaboration phase, which was responsible for the construction of some of the sections.

Group of technicians from the Geotechnical Laboratory awarded the Talgo Prize for Technological Innovation.

Presentation of the Talgo Award at the gala.

OUTSTANDING PROJECTS / CEHOPU

TRAVELING EXHIBITION 'ARTIFEX. ROMAN ENGINEERING IN SPAIN'

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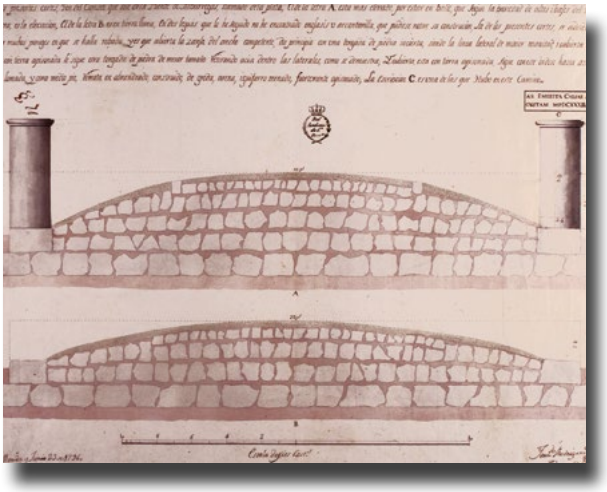
The exhibition *Artifex. Roman Engineering in Spain* is part of the Itinerant Exhibitions Program of CEHOPU, through an adapted version of the original edition, inaugurated at the Archaeological Museum of Madrid in 2002. Subsequently it has been presented, with a more than remarkable result, in more than twenty venues of the national territory.

In 2022 it was inaugurated in the **Cloister of the Convent of San Francisco,** in the Riojan town of **Santo Domingo de la Calzada,** remaining open until December of the same year.

The contents of the exhibition bring the public closer to the important technical legacy of the Roman world.

Ctesibio Roman piston pump.



Section of the Roman road.

Roads, bridges, ports, lighthouses, aqueducts and dams, works of which abundant remains and a rich heritage remain in Spain, tell us, on the one hand, of the technical level reached by Roman civilization and its own cultural heritage, and, on the other, reveal a whole network of essential infrastructures in the organization, supply and cultural and military extension of the Roman Empire.

The exhibition is made up of mixed panels of text and images, which incorporate a varied photographic and documentary repertoire. In addition, there's a large group of models from the CEHOPU collection and objects illustrating the different techniques and mechanisms of the works on display.

The organization has been carried out jointly by CEHOPU and the Cathedral of Santo Domingo de la Calzada, in collaboration with the Juanelo Turriano Foundation and the Government Delegation in La Rioja.

OUTSTANDING PROJECTS / CEHOPU

TRAVELING EXHIBITION 'ARS MECHANICAE. MEDIEVAL ENGINEERING IN SPAIN'

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The exhibition *Ars Mechanicae. Medieval Engineering in Spain* brings together the essentials of technology and engineering in this long period of Spanish history: cross vaults, water wheels, the astrolabe, gunpowder, nautical cartography, astronomy, water and windmills or the introduction of the rudder in boats. Some of these achievements are endowed with peculiar characteristics, derived from Spain's condition as a "frontier of Europe", which constitutes an enriching element of our history during the period under consideration.

In Villareal (Castellón) is to be found one of the most emblematic hydraulic works of the medieval period. The **Azud de Villareal** was built by the Arabs, presumably in the 10th century.

When James I founded the municipality of Villarreal in 1274, he granted its inhabitants the right to take water from the river Mijares. The construction, using wooden boxes filled with sand taken from the riverbed itself, suffered significant deterioration, so successive reconstructions were carried out, the last in 1518.

At present, the weir continues to fulfill its function to raise the water level at the intake feeding the irrigation canals managed by the local Irrigation Community. The exhibition was inaugurated on December 2, 2022, at the Hall of the local Irrigation Community, thanks to the agreement signed by CEDEX, the Irrigation Community and the Juanelo Turriano Foundation, with the collaboration of the City Council.

Morella Aqueduct.

Noria Salinas de Imon *in situ*.

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