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EDITORIAL
Building bridges

With its 30-year contract to manage six airports in the Northeast Region of Brazil, Aena Internacional has strengthened its leadership in the world and is helping to build new air bridges in a strategic sector vital to the development of the country's tourism and economy, while at the same time strengthening relations between Spain and Brazil.

Ineco, which provided technical support to Aena Internacional during the entire concession process, will continue to collaborate on both the Operational Readiness and Transfer and subsequent stages, thus strengthening its long history as a technical consultant in Brazil, a country in which the company is carrying out other projects such as supervision of new trains for the São Paulo Commuter network, which is also covered in an article in this issue.

Also in the international sphere, our railway specialisation has taken us to different continents, as reported in the article about the Independent Safety Assessment (ISA) carried out for the improvement of the Panama City Metro and safety studies conducted for the Makkah-Madinah high-speed line in Saudi Arabia.

In Spain, the works on the high-speed line to Galicia also involve building bridges - both figuratively, because of the crucial importance of improving connections with the Region of Galicia, and literally, because of the construction of the large viaducts and other special works that are required, including the ones described in a report in this issue on a section that presents enormous technical complexity.

We also dedicate space to innovation with the RONIN road safety tool and the implementation of a pilot project using the ground-breaking integration of BIM and GIS technology in Spain's road sector.

Ineco's commitment to building bridges between training and the exercise of the engineering profession, supporting the development and attraction of talent, has led us to organise, together with the Spanish Institute of Engineering, the first edition of the *Awards for Excellence in Engineering Student Internships*. These awards are based on performance during a series of theoretical and practical courses that will enhance the training of future engineers and enable them to contribute to increasing the prestige of Spanish engineering.

Similarly, and as part of our unequivocal commitment to the 2030 Agenda, we will be building charitable bridges with volunteer projects that we carry out in our CSR section, in which we highlight three projects already underway in India, South Sudan and Haiti. ■

"Ineco has implemented a pilot project using the ground-breaking integration of BIM and GIS technology in Spain's road sector"

CARMEN LIBRERO
President of Ineco

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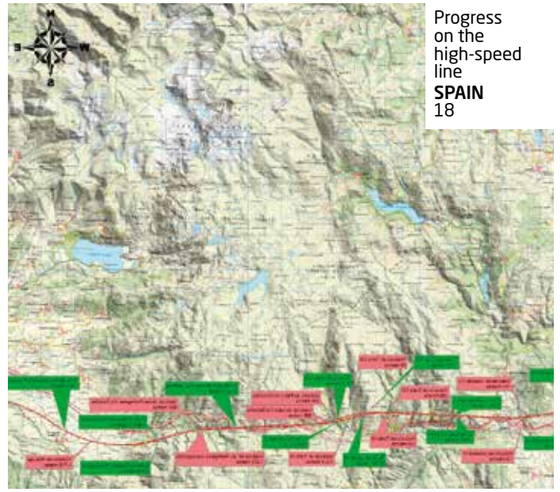

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SPAIN

PHOTO_ELVIRA VILA

Lola Ortiz, chair of the Association of Civil Engineers of Madrid, and Carmen Librero, president of Ineco, looking at the Cityneco model.

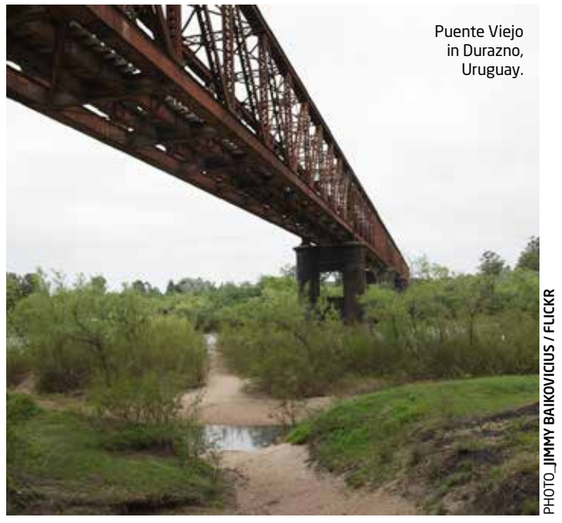
CITYNECO AT MADRID ENGINEERING WEEK AND SCEWC BARCELONA

Carmen Librero, president of Ineco, and Lola Ortiz, chair of the Association of Civil Engineers of Madrid, visited the Innovation Tunnel of Madrid Civil Engineering Week, an event that was held from 1 to 6 October and during which the company showcased its Cityneco model to demonstrate how smart cities improve urban mobility.

Under the slogan *Innovating to Make Progress*, this major event in the sector was hosted by Madrid and featured different activities with the aim of bringing engineering closer to society. The tunnel, which was situated in the centrally-located Plaza de Callao, was visited by more than 30,000 people interested in learning about technological and innovative infrastructures.

The company also participated with its Cityneco model in the Spain Space of the *Smart City Expo World Congress* (SCEWC), the main international event dedicated to smart cities, which was held at the Fira de Barcelona. Each edition of the event, which receives more than 20,000 visitors, includes participation by 700 cities and more than 800 exhibitors from around the world. The event, which was held from 19 to 21 November under the slogan *Cities Made of Dreams*, has become a major fixture on the smart cities calendar and brings municipal representatives, institutions, academic and thought leaders, research centres, companies and entrepreneurs with major decision-making power together in one place.

SCEWC 2019 focused on five main themes related to the most pressing problems cities face: digital transformation, urban environment, mobility, governance and finance, and inclusive and shared cities.



PHOTO_JIMMY BAIKOVICIUS / FLICKR

Puente Viejo in Durazno, Uruguay.

URUGUAY

RAILWAY BETWEEN MONTEVIDEO AND PASO DE LOS TOROS

The Ministry of Transport and Public Works of Uruguay has awarded Ineco consultancy contracts for the supervision of design drafting and works management on the Paso de los Toros-Montevideo railway line and access to the port. The job includes supervision of the executive project and works, including signalling and communications systems, as well as assistance in carrying out the necessary tests for the commissioning of the railway infrastructure.

The Central Railway project consists of the design, construction and maintenance of 273 kilometres of railway between the port of Montevideo and the city of Paso de los Toros, applying the highest European standards in terms of safety. Uruguay is promoting a transport infrastructure programme to strengthen its logistics platform, complementing the railways with road haulage and the port system. The commissions are the result of an agreement signed between the transport ministries of Uruguay and Spain to consolidate cooperation in the field of infrastructure and transport.

USA

EXPANSION OF WORKS AT NEWARK AIRPORT

Ineco will continue to collaborate with the company Arcadis to provide consultancy services for the operational readiness and transfer (ORAT) of the new terminal at Newark Liberty International Airport in New Jersey for the Port Authority of New York & New Jersey (PANYNJ). Terminal 1, which will replace the old terminal building A built in 1973, will feature 33 boarding gates, a new aircraft parking apron, a public car park with 2,750 spaces and new access roads.

SPAIN

PHOTO_ELVIRA VILA

In the centre of the image, Carmen Librero, president of Ineco, and Carlos del Álamo, president of the Spanish Institute of Engineering, signing the agreement in October.

COMPETITION FOR EXCELLENCE IN ENGINEERING STUDENT INTERNSHIPS

Ineco and the Spanish Institute of Engineering (IIE) have signed an agreement for the development and sponsorship of the *Awards for Excellence in Engineering Student Internships* with the aim of recognising three engineering internships carried out in companies in Spain.

The Ineco-IIE collaboration project will support interns who achieve significant and verifiable improvements in technological innovation in order to highlight the professionals who carry out such work. The award-winning work interns will be rewarded with a first prize of 4,000 euros and two second prizes of 1,000 euros each for the winner and the two runners-up, respectively.

JAMAICA

MASTER PLAN FOR IAN FLEMING AIRPORT

The Jamaica Civil Aviation Authority (JCAA) has commissioned Ineco to carry out the master plan for Ian Fleming International Airport, located in the north of the island. The airport, named in 2011 after the English writer who wrote the James Bond series of novels while residing on the island, operates commercial flights and private *jets* to and from the United States and other Caribbean islands.

The works include demand studies for different time horizons and definition of the development of the airport's terminal area, airfield and access and auxiliary infrastructures. The strategy of the JCAA is to develop the airport as a regional mini *hub* and enable it to operate larger planes than at present.

Jamaica is one of the main overseas tourist destinations for the US and Canada. Ineco has been collaborating with the JCAA on different projects for more than a decade, including the master plan for Sangster International Airport in Montego Bay.

ANALYSIS OF THE TRACK BETWEEN SAN PEDRO AND PUERTO VENTANAS

A Fepasa locomotive crossing a bridge over the Mantagua wetland on the way to the port city of Las Ventanas.

PHOTO_SEBASTIAN BETANCOUR/FLICKR

Empresa de los Ferrocarriles del Estado de Chile (EFE), Chile's national rail operator, has commissioned Ineco to carry out an analysis of the impact on the track system of the rolling stock that runs on the San Pedro-Las Ventanas section of railway. The section has a length of 45 kilometres and consists of single non-electrified track. The route begins in the town of San Pedro, crosses the Aconcagua River and runs parallel to the right bank of the river until it reaches the coast. The section continues along the coast for 20 more kilometres until it ends at the port of Las Ventanas, which is the main bulk port in the central area of the country.

The San Pedro-Las Ventanas section is dedicated exclusively to freight transportation. The main activity involved is the transportation of copper from mines located in the interior. On the return route, trains transport acid used in mines for obtaining of copper.

Ineco is also developing, together with the company Louis Berger, new technical regulations for EFE: a legal framework that will regulate all aspects of railway activity, from signalling to stations, through rolling stock, tracks and safety.

ABU DHABI

WORLD ROAD CONGRESS

Ineco participated in the Spanish pavilion at the 26th edition of the World Road Congress held in Abu Dhabi from 6 to 10 October. With the participation of more than 1,200 international experts, the Spanish pavilion hosted a presentation of Ineco's RONIN project –a tool for comprehensive road safety management– and its A-76 motorway project, in which Ineco has, for the first time in Spain, integrated BIM methodology with the GIS system on a road infrastructure.

In the image, from left to right, Ineco's Mirian Pinilla, technical manager of Road Projects, and Casimiro Iglesias, general director of National Business, together with Javier Herrero and Jose Luis Ábalos from the Spanish Ministry of Public Works, director general of Roads and minister, respectively.

LITHUANIA

DESIGN OF COMMERCIAL AREAS FOR VILNIUS AIRPORT

Vilnius Airport, the largest in Lithuania, is immersed in a process of expansion that will enable it to handle the significant increase in traffic experienced in recent years and improve the quality of service to passengers. To this end, the state enterprise Lithuanian Airports, which plans to expand the existing terminal, has commissioned Ineco to carry out a study to improve its commercial areas, which, after the renovation, will occupy the airport's current departures area.

The work includes identification of the commercial needs of passengers and reorientation of traffic flows within the terminal. The Spanish public engineering firm, which has extensive experience in planning and designing commercial areas, will carry out the design of the commercial areas and premises in accordance with technical and economic requirements, in addition to proposing recommendations for the future awarding of concessions.

Ineco has carried out similar work in El Salvador and Spain, where it has collaborated with Aena for more than 12 years on the commercial redesign of airports in operation or on new infrastructures.

PHOTO_INECO

MADRID-EXTREMADURA-PORTUGUESE BORDER HIGH-SPEED LINE

In July, Carmen Librero, president of Ineco, visited the works being carried out on the high-speed line between Plasencia and Cáceres accompanied by Ana Rojo, director of Engineering and Consulting, and Celestino Rodríguez, director of the Office of the President. Ineco is in charge of works management and technical assistance for the track assembly works on this 59-kilometre stretch of standard-gauge double track, of which 3,700 is slab mounted and the rest on ballast, plus 4 kilometres of single track branches to connect the section to the conventional network.

PERU

AIR-SIDE REFURBISHMENT AT TUMBES AIRPORT

Aeropuertos del Perú (AdP) has awarded a consortium consisting of Ineco and a local company HOB Consultores the technical file for the air side refurbishment and perimeter fence optimisation of Capitán FAP Pedro Canga Rodríguez Airport in Tumbes.

The works involve drafting the detailed construction project associated with the airport's air side refurbishment and paving improvement programme (PRMLA), with special focus on improving the condition of the paving, fence and perimeter road, and on existing airport drainage system problems.

AdP, the concessionaire of the largest airport group in the country, manages the airports of Talara, Tumbes, Chachapoyas, Iquitos, Tarapoto, Pucallpa, Trujillo, Anta, Cajamarca, Piura, Chiclayo and Pisco, all located in the north and centre of the Republic of Peru, except for Pisco.

5G NETWORK ROLLOUT IN GALICIA

INECO AND ADIF INSPECT THE INFRASTRUCTURE WITH DRONES

The Region of Galicia has been selected to launch a 5G pilot project promoted by Red.es, a state-owned entity under the Ministry of Economy and Business that promotes the advancement of digitisation in Spain. The project includes eight use cases that will be developed in this region by a joint venture consisting of Telefónica, Ericsson, Nokia, Cinfo, Idronia, TeInet Redes Inteligentes and the Fernández-Vigo International Centre of Advanced Ophthalmology. With a duration of 24 months, it has a budget of more than 11 million euros, for which a grant of more than 4 million has been applied for and will be co-funded by Red.es from the ERDF.

Ineco, which is participating as a collaborating agent, will be launching one of the cases that will be implemented in Galicia with Adif: supervision of the railway infrastructure in Orense using camera-equipped drones to collect images of the tracks to facilitate inspection and maintenance.

In order to carry out these cases, a 5G network will be rolled out to enable experimentation and innovation with the capabilities of this technology, specifically its high bandwidth and low latency; non-standalone (NSA) and standalone (SA) network architecture; network slicing; edge computing; and active antenna technology.

ARGENTINA

PASEO DEL BAJO, AWARD FOR BEST URBAN WORKS 2019

Buenos Aires' new urban motorway, the Paseo del Bajo, won the award for *Best Urban Works 2019* at the Argentine Road Association Awards, which is organised annually to mark Argentina's National Road Day. The award recognises the impact that the Paseo del Bajo has had on reducing the city's traffic congestion and improving north-south connectivity thanks to four new semi-covered lanes and the remodelling of eight surface lanes totalling more than six kilometres in length.

Ineco, in collaboration with its local partner AC&A, carried out the inspection of section B of the works (southern semi-covered trench), a semi-underground four-lane road intended for heavy goods vehicle traffic in the centre of Buenos Aires. With a length of 7.1 kilometres, it is one of the most important civil works that has ever been carried out in Argentina and has enabled the Buenos Aires-La Plata and Illia motorways to be connected and new green spaces in Buenos Aires' El Bajo district to be created.

SAFETY ASSESSMENTS ON THE HIGH-SPEED NETWORK

Accreditation as an Independent Safety Assessor has allowed Ineco to participate in the assessment of the safety processes applied by Adif to numerous service commencements, the most recent and relevant of which was the high-speed line between Antequera and Granada, which culminated last June, and the ERTMS Level 2 of the high-speed line between Valladolid and León.

Ineco is currently working on the independent safety assessment of works on the Recoletos tunnel, and on the high-speed sections Olmedo-Zamora-Pedralba; Monforte del Cid-Murcia; and Chamartín-Torrejón de Velasco. All of which are projects of maximum interest to Adif (see report on page 38)

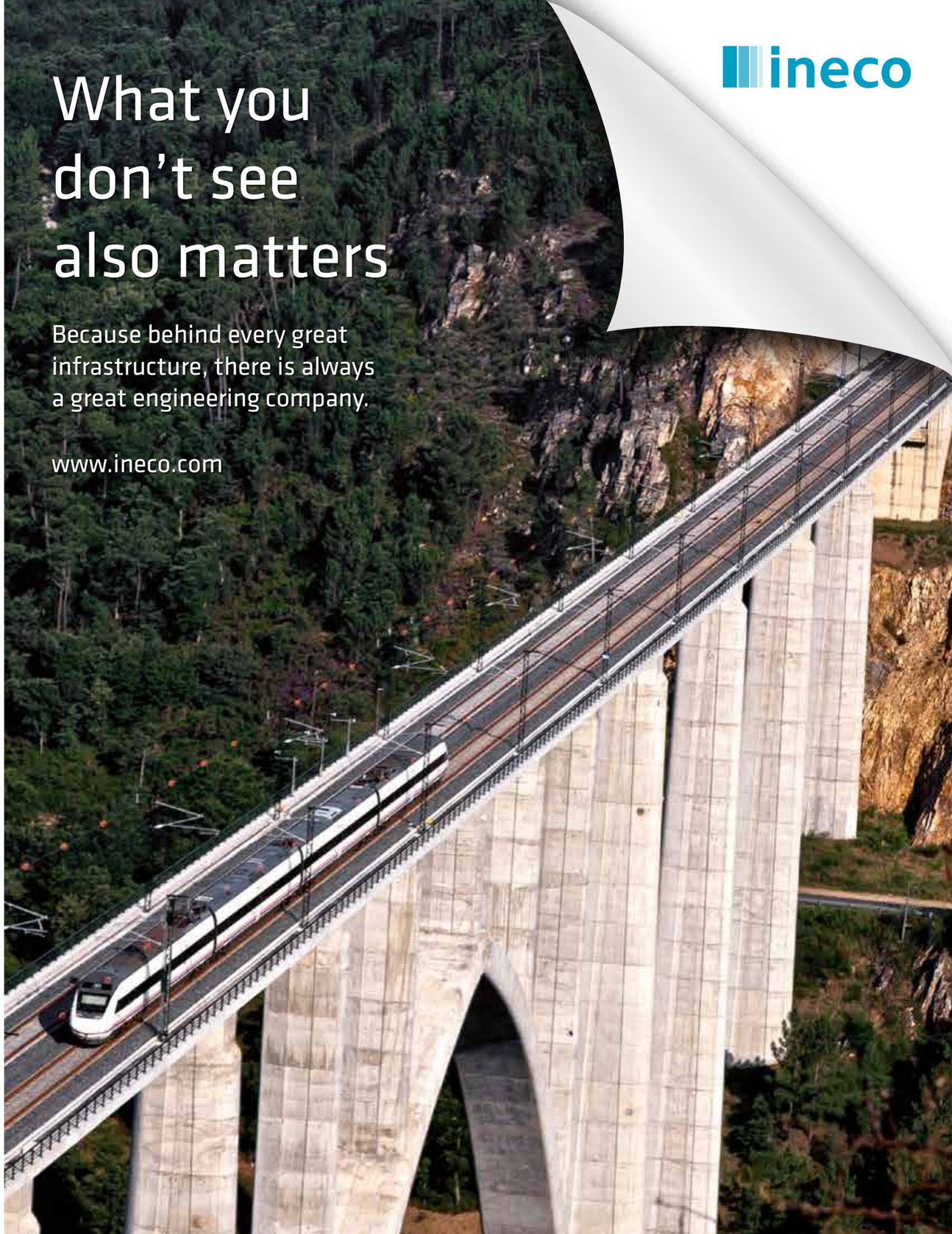
PHOTO_ELVIRA VILA

View of the high-speed section between Chamartín and Torrejón de Velasco.

SAUDI ARABIA

THE G20 INVITES INECO TO PARTICIPATE IN ITS SEMINARS

The Global Infrastructure Hub (GIH), an organisation dedicated to the development of infrastructure within the G20 group, has invited Ineco to participate in one of its seminars to be held in Riyadh, Saudi Arabia, a country that will hold the presidency in 2020. The meeting is part of the activities of the Infrastructure Working Group (IWG) of the G20, whose objectives include the strengthening of public-private relations to carry out investments. The IWG analyses different approaches, policies and joint actions for the G20 to increase infrastructure investment. Recently, the Global Infrastructure Hub visited the company's offices to find out about Cityneco and its solutions applied to mobility, the collection of real-time traffic data and the management of parking reservations. A comprehensive solution, developed by Ineco, based on different vertical developments for each of the management areas of a city or organisation.



PHOTO_INFRAERO AEROPORTOS - GILBERTO FREYRE / FLICKR

GILBERTO FREYRE INTERNATIONAL AIRPORT
Recife-Guararapes Airport, Brazil's eighth largest airport in Brazil in terms of traffic, has a 3,000-metre runway and is located 11 kilometres from Recife, the capital of the state of Pernambuco.

Aena disembarks in Brazil

Aena Internacional, the largest airport operator in the world in terms of passenger volume, has been awarded a 30-year concession to manage a group of airports in northeastern Brazil, a region with significant tourism and economic importance, especially the city of Recife. Ineco provided support throughout the entire preparation and handover process.

By ***ITRANSPORTE***

In 2010, the Brazilian government adopted a concession model through international public tendering to manage its airports, which up to that time had been managed by the state-owned enterprise, Infraero. The entity was in charge of the country's 63 main airports, accounting for 97% of the national aviation business. The first lot was awarded in 2011 and the fifth and most recent was awarded to Aena Internacional in March 2019 for a period of 30 years, consisting of a group of six airports in the Northeast Region of the country: Recife, Maceió, João Pessoa, Aracaju, Campina Grande and Juazeiro do Norte, which in 2018 accounted for 13.7 million passengers.

Ineco provided Aena Internacional with specialised technical support during the entire process prior to the bid and the handover preparation period that will end in early 2020. This means that the Spanish operator, the world's largest in terms of passenger volume –more than 280 million in total– will now manage a total of 23 airports in five countries: twelve in Mexico, one in the United Kingdom, two in Colombia, two more in Jamaica and six in Brazil. It also operates the 46 airports and two heliports in the Spanish network, through which more than 263 million passengers passed in 2018.

AIRPORTS, THE KEY TO TOURISM

The Northeast Region of Brazil is one of the country's five geographic regions, and it contains 9 of the 26 federal states: Alagoas, Bahia, Ceará, Maranhão,

PHOTO_WIKIPEDIA

The Fernando de Noronha archipelago is considered a paradise for scuba diving enthusiasts.

WITH SOME 50 MILLION INHABITANTS, THE NORTHEAST IS THE SECOND MOST POPULOUS AND VISITED TOURIST REGION IN BRAZIL AND ITS STATES OF BAHIA AND PERNAMBUCO ARE THE MOST POPULAR IN THE REGION

LOCATION OF THE SIX AIRPORTS MANAGED BY AENA IN BRAZIL

The Northeast Region, Brazil's most popular tourist region, has 9 states and occupies the largest coastal area in the country.

Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe, all of which are on the Atlantic coast. With some 50 million inhabitants, it is the second most populous region after the Southeast, with 77 million, where the large urban centres of Rio de Janeiro and São Paulo are located.

The Northeast is the most-visited tourist region in the country: the states of Bahia and Pernambuco receive the most visitors, specifically, as sun and beach destinations. Tourism is predominantly domestic, with international tourism yet to achieve its full potential for development: compared to 36.6 million domestic vacationers in 2018, the country received only 6.6 million foreign visitors, a figure that the federal government would like to double by 2021.

Improving airport infrastructure and management is key to achieving this goal, especially considering that Brazil is also the third largest domestic air market in the world, according to the International Civil Aviation Organisation (ICAO).

THE AIRPORTS IN DETAIL

1. RECIFE

Recife-Guararapes International Airport (officially Gilberto Freyre International Airport) is the eighth largest airport in Brazil by traffic volume: in 2018, 8,422,566 passengers and 55,838 tons of cargo passed through it. It is located 11 kilometres south of the city of Recife, the capital of the state of Pernambuco. It has a 3,000-metre runway and a passenger terminal that covers 52,000 square metres, in addition to a car park with 2,000 spaces.

Recife is the fourth largest city in Brazil: it has a population of 1.6 million, or 4 million in the entire metropolitan area made up of 13 towns. It has the country's largest technological park, called Porto Digital (Digital Port) and the third largest port complex, including a major shipyard that is the largest in the southern hemisphere.

Tourism is another one of the pillars of the economy of Recife. Established in the sixteenth century, it is one of the oldest cities in Brazil and one of the main destinations for both the domestic and international tourism markets. In 2018, it received 3.3 million visitors, accounting for more than half of the state's total tourism. The spectacular beaches of its coastline, which are home to the coral reefs that give it its name, the Fernando de Noronha archipelago, are considered a paradise for scuba diving enthusiasts, and celebrations such as Carnival and the Saint John festivals in June, are some of its principal tourist attractions.

PHOTO_LEANDRO NEUMANN CIUFFO / FLICKR

View of Recife from Boa Viagem beach.

INECO'S SUPPORT

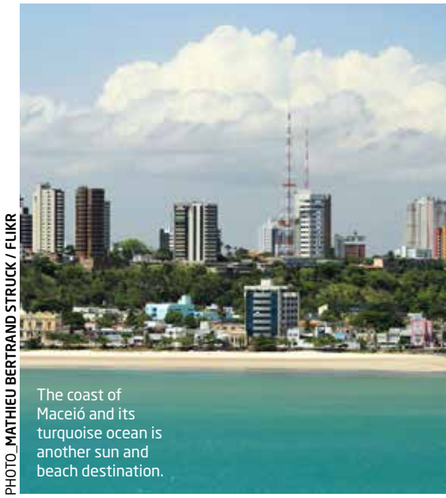
Aena Internacional commissioned Ineco to provide coordination and support office services for the preparation and monitoring of the concession project for the six Brazilian airports through the company, Aeropuertos del Noroeste de Brasil (ANB), created for that purpose. The works were divided into three stages:

1. Formalisation of the contract: The goal was to comply with the necessary requirements for the signing of the contract and its entry into force. At this stage, all pre-operational activities were organised and the first version of the overall planning of the project was drafted.

2. Operational Readiness and Transfer: This second stage needed to ensure both the fulfilment of prior obligations and operational transfer in order for Aena to start airport operations within the planned time frame. To achieve this, coordination of all of the elements involved –systems, supplies and services, floor personnel, organisation, etc.– was ensured.

3. Post-transition stage: The final stage began after operations had been taken over by ANB, until the end of services.

SPANISH AIRPORT OPERATOR, AENA, THE WORLD'S LARGEST IN TERMS OF PASSENGER VOLUME –MORE THAN 280 MILLION– WILL NOW MANAGE A TOTAL OF 23 AIRPORTS IN FIVE COUNTRIES



PHOTO_MATHIEU BERTRAND STRUCK / FLIKR

The coast of Maceió and its turquoise ocean is another sun and beach destination.

2. MACEIÓ

Zumbi dos Palmares de Maceió International Airport began operations in 1928, with a capacity for only six aircraft. In 2005, a major expansion project was carried out that involved the construction of a new 22,000 m^2 passenger terminal and the lengthening of its runway, which now measures 2,601 metres long by 45 metres wide. The main destinations are Guarulhos, Galeão, Recife, Campinas and Brasilia, and, in 2018, it registered a record 2,179,230 passengers, 5.4% more than in 2017.

Maceió is the capital of the state of Alagoas and has a population of 1.1 million inhabitants. Its economy is based on commerce, agriculture, especially the cultivation of sugar cane, and industries such as chemicals and food and the extraction of natural gas and oil, among others. It is also the third most visited national tourist destination for sun and beach holidays.

AENA, WHICH HAS BEEN LISTED ON THE SPANISH STOCK EXCHANGE SINCE 2015, CREATED ITS SUBSIDIARY AENA INTERNACIONAL IN 1998 TO DEVELOP ITS BUSINESS ABROAD

3. JOÃO PESSOA

João Pessoa-Presidente Castro Pinto International Airport is 12 kilometres from the city centre. In 2018, it handled 1,414,896 passengers, according to data from Infraero. It has a 2,515-metre-long runway and a 9,000-square-metre terminal, with parking for 600 vehicles.

João Pessoa is the capital and main financial and economic centre of the state of Paraíba. It has just over 800,000 inhabitants, and 1.2 million if the 11 municipalities of the metropolitan area are counted. Commerce and, above all, sun and beach tourism are the most important economic sectors, and it also boasts an outstanding heritage of well-preserved Baroque buildings, such as the sixteenth-century Convent of Saint Francis, now converted into a cultural centre. The entire old town has been listed as a national heritage site. According to data provided by the state government of Paraíba, the city, the easternmost city in the country, is ranked the 10th most visited in Brazil.

PHOTO_WIKIPEDIA

PHOTO_JANINE MORAES / FLICKR

Above left, the Convent of Saint Francis in João Pessoa; above right, the Saint John Festival in Campina Grande, which is held in June and brings together around one million people every year.

4. ARACAJU

Located 12 kilometres from the city centre, Aracaju-Santa María International Airport handled 1.1 million passengers in 2018. In addition to regular flights, it also operates helicopter flights that transfer personnel to the oil rigs off the coast of Sergipe and Alagoas. The runway measures 2,200 metres in length and the passenger terminal covers 9,321 square metres, with 199 parking spaces.

The city of Aracaju, capital of the state of Sergipe, has a population of almost 649,000 people. Its economy is based on services and industry. Regarding tourism, the city and its surrounding area offer high-quality hotels and infrastructure, but the influx of visitors is less than in other areas. The city has a popular Oceanarium that receives 120,000 visitors a year.

5. JUAZEIRO DO NORTE

Orlando Bezerra de Menezes Airport is located 6 kilometres from the city of Juazeiro do Norte in the Cariri region, south of the state of Ceará. In 2018, it recorded 563,895 passengers, representing an increase of 3.96% compared to the previous year, and 1,567 tons of air cargo. It has a 1,940-metre-long runway and a 1,000-square-metre terminal, with parking for 230 vehicles.

The city of Juazeiro do Norte, with a population of approximately 272,000 people, is the second most important city in the state and one of its main industrial and commercial centres. It particularly stands out for its footwear industry, which is highly significant throughout Brazil and especially in the Northeast Region, which accounts for 48.8% of national production, more than 85% of which goes to the domestic market. Juazeiro is part of a group of nine municipalities in which around 300 companies from the sector are concentrated.

Much of the city's tourism is religious and closely linked to the origins of the city, which was founded by a Catholic priest named Father Cicero, to whom a miracle was attributed in the late nineteenth century, as a result of which 2.5 million pilgrims visit the city every year to venerate its founder and patron saint. Religious tourism, mostly Catholic, but also evangelical and other denominations, is the fastest growing segment in Brazil, according to data from the Ministry of Tourism, and generates 8.1 million trips every year within the country.

Another important sector in Juazeiro do Norte is ecotourism related to the protected areas of the Araripe Plateau –a national forest, nature reserve and geological park– where, among other Cretaceous remains, the highest concentration of pterosaur (flying dinosaur) fossils in the world has been found.

PHOTO_OTÁVIO NOGUEIRA / FLICKR

Cultural-religious tourism is of great importance to Juazeiro do Norte, where frequent pilgrimages take place with the aim of increasing awareness of local folklore to keep it alive.

6. CAMPINA GRANDE

Campina Grande-Presidente João Suassuna Airport, in the state of Paraíba, accounted for 168,278 passengers in 2018, 11.98% more than in 2017, the fourth largest percentage increase of Brazil's 53 main airports. Located 6 kilometres from the city centre, it operates regional and national and general aviation flights, as well as some military training flights. The runway measures 1,600 metres and the passenger terminal has an area of 2,500 square metres with parking for 203 vehicles.

The city of Campina Grande has a population of 407,472 inhabitants, according to official 2018 figures, which increases to more than 638,000 if the 19 municipalities of the metropolitan area are counted. Its main economic activities are mineral extraction, software development, commerce, agriculture, livestock, processing industries and services. The city also hosts one of the most well-attended festivals in Brazil: the festival of Saint John (Gran São João do Mundo), which is held during the month of June and brings together around a million people every year. ■

TWO DECADES MANAGING AIRPORTS

Aena, which has been listed on the Spanish Stock Exchange since 2015, created its subsidiary Aena Internacional in 1998 to develop its business abroad. Today, in addition to Brazil, Aena Internacional's activities extend to four other countries:

▶ **United Kingdom.** Since 2013, Aena has held a 51% stake in the capital of the concession company of London Luton Airport, ranked fifth in the country in terms of number of passengers, with a total of 16.6 million in 2018.

▶ **Mexico**. Aena Internacional has a stake in Grupo Aeroportuario del Pacífico (GAP), which operates 12 airports: Aguascalientes, Bajío, Guadalajara, Hermosillo, La Paz, Los Mochis, Manzanillo, Mexicali, Morelia, Puerto Vallarta, San José del Cabo and Tijuana, which in 2018 accounted for 44.9 million passengers.

▶ **Jamaica.** Since 2015, GAP has owned 74.5% of the shares in MBJ Airports Limited, the operator of Sangster International Airport in Montego Bay, which in 2018 accounted for 4.5 million passengers. Also in 2019, GAP was awarded a 25-year concession for the capital's Norman Manley International Airport, Kingston, with 1.6 million passengers in 2018.

▶ **Colombia**. Aena Internacional currently holds stakes in the concession companies of the airports of Cartagena de Indias (Sociedad Aeroportuaria de la Costa SA, SACSA, 37.89) and Cali (Aerocali, 50%), which in 2018 recorded 5.5 and 4.9 million passengers, respectively. Between 1997 and 2012, it also operated the concession for Ernesto Cortissoz Airport in Barranquilla.

Since its creation, Aena Internacional has been able to rely on the specialised consulting and engineering services of Ineco. The company has had experience in all of the countries where Aena operates, including Brazil, where its first projects date back to the 1970s and 80s. More recently, it has carried out feasibility studies and preliminary projects for regional airports on behalf of the Brazilian Secretariat of Civil Aviation (2013) and, for Aena, prior studies for the fourth round of concessions of four Brazilian airports.

With a presence in Colombia since the 1980s, especially in the railway field, Ineco has been carrying out different works on Colombia's three airports since 2008, both in terms of planning (updating of master plans) and drawing up projects and supervising expansion works. (See *ITRANSPORTE 48, 56* and *63).*

Since 2011, the company has also been drafting and updating the master plans of GAP airports. Ineco's first job at Sangster goes back to 2008, with the updating of its master plan, which was subsequently followed by others projects such as building a new fire brigade building, upgrading the runway, updating the master plan, redesigning the check-in area, etc. (see *ITRANSPORTE 24* and *62).*

In 2016, Ineco, together with the British company, Capita (with which it has worked since 2012 on the HS2 high-speed line between London and Birmingham), produced a study of alternatives for a new rail access to the airport, located 56 kilometres from London.

Building the AVE high-speed line to Galicia

The construction works on the AVE high-speed line between Madrid and Galicia represent one of the greatest technical challenges ever faced by Adif Alta Velocidad: the rugged terrain of the Galician region poses an engineering challenge that requires remarkable precision. In this article, different experts from Ineco and Adif Alta Velocidad describe some of the main works on one of the most complex sections of the line.

By the Ineco construction managers **Arturo Pastor, Iago Rodríguez-Lorasque and Noela Cobo,** technical engineer **Jesús Pena,** and environmental worksite managers **Iñaki G. Seoane, Enrique M. Agüera** and **Luis Álvarez-Pardiñas,** with the collaboration of **Raúl Correas,** deputy director of Construction V at Adif Alta Velocidad
Photos: **Adif**

The arrival of high-speed rail in this region in northwestern Spain had its first historical milestone at the end of 2011, with the entry into operation of the 150-kilometre stretch between Ourense, Santiago and A Coruña. After the service commissioning of the line between Olmedo and Zamora in 2015, all that remained to complete the connection between Galicia and the centre of the Iberian Peninsula was the construction of three sections totalling approximately 230 kilometres: Zamora-Pedralba de la Pradería, Pedralba de la Pradería-Taboadela and Taboadela-Ourense.

THE DIFFICULT ROUTE BETWEEN PEDRALBA AND OURENSE

Built for the most part on two separate tracks, the 101-kilometre section between Pedralba and Ourense crosses the different mountain ranges that form the Central Ourensan Massif, a route that the AVE will be able to cover thanks to the construction of 32 viaducts and 31 tunnels, many of them bi-tube, or with one tube for each track. More than 60% of the route was either underground or over viaducts and required special works: in total, the section has almost 11 kilometres of viaducts, the longest of which is the Requejo viaduct (1.72 km), and 126 kilometres of tunnel (62.45 km on the right-hand track plus 55.87 km on the left-hand track and 7.84 km of double track), the longest being the O Corno tunnel (8.6 km).

The works that are covered in this report belong to this complex route between Pedralba and Ourense, which Adif Alta Velocidad constructed to provide the highest levels of railway technology, with standard-gauge double track (1,435 mm) throughout the route, and designed for speed limits of up to 350 km/h, with 2x25 kV 50 Hz alternating-current electrification, ERTMS Level 2 and Asfa traffic control systems, and a GSM-R mobile communications system.

MADRID-GALICIA HIGH-SPEED LINE. The Madrid-Galicia HSL is co-financed by the European Regional Development Fund (ERDF), ERDF/Cohesion Fund 2007-2013 and Spanish Multiregional OP 2014-2020.

THE WORKS THAT ARE COVERED IN THIS REPORT BELONG TO THE COMPLEX 101-KILOMETRE ROUTE BETWEEN PEDRALBA DE LA PRADERÍA AND TABOADELA, WHICH THE AVE WILL BE ABLE TO TRAVEL THANKS TO THE CONSTRUCTION OF 32 VIADUCTS AND 31 TUNNELS, TO CROSS THE MOUNTAINS OF THE CENTRAL OURENSAN MASSIF

FIVE OF THE MOST NOTABLE WORKS

This section features a number of infrastructures that stand out for their complexity, either in terms of the construction methods used, their dimensions or their environmental characteristics.

1. THE JACKED CAISSONS OF THE REQUEJO TUNNEL

TWO CAISSONS 80 AND 100 METRES LONG JACKED UNDER THE CONVENTIONAL RAILWAY TRACKS COMPLETE THE REQUEJO TUNNELS

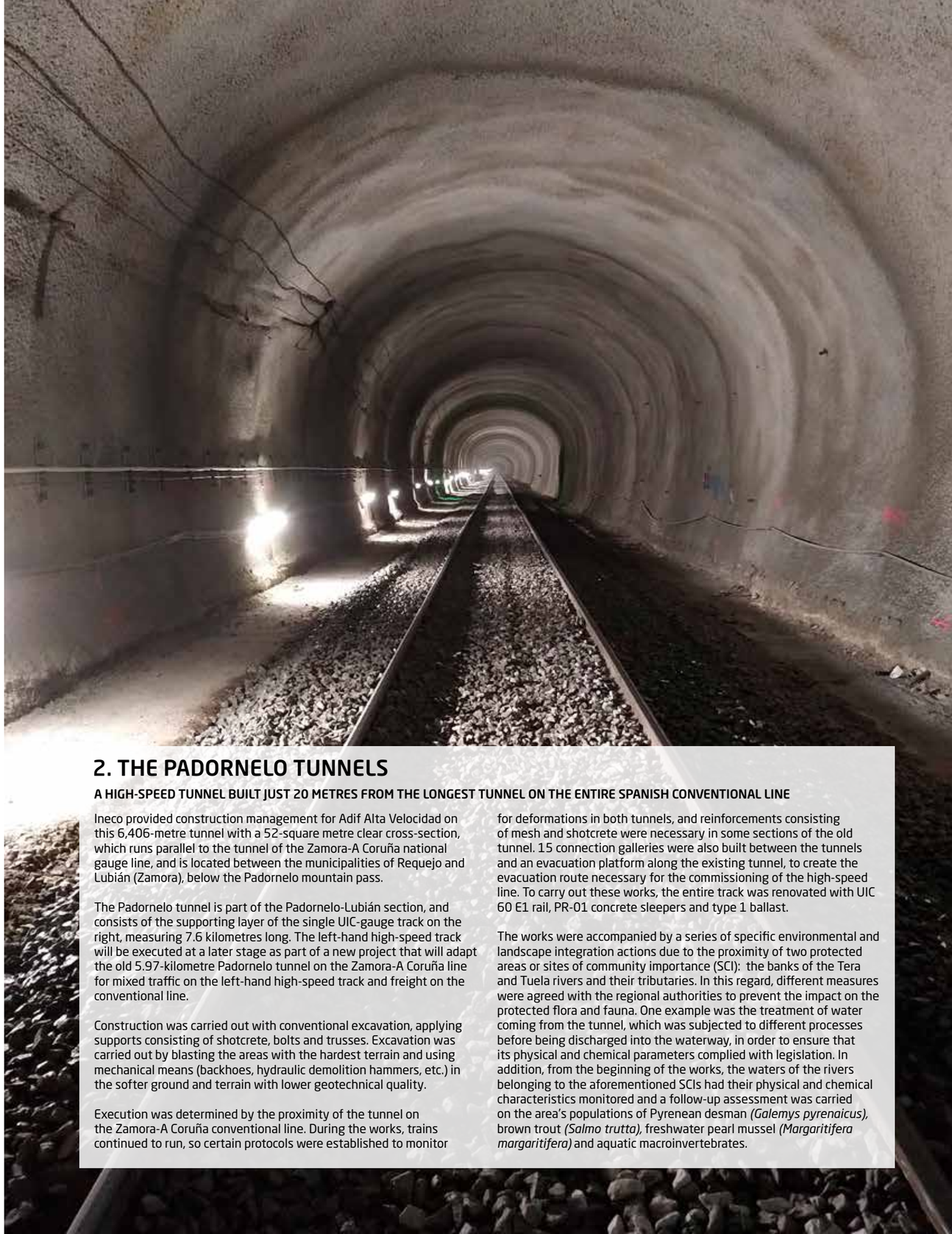
Several kilometres from Pedralba, the AVE works are progressing through the mountains of the Sanabria region with several notable actions, including the construction of the caissons jacked into the Requejo tunnel, structures built *in situ* at the western opening of the Galicia side and jacked under the railway tracks, allowing Adif to maintain rail service on the Zamora-A Coruña national gauge line, which intersects with the new high-speed line at this point.

This intersection of the high-speed line with the conventional track was resolved by constructing two reinforced concrete caissons measuring 8.5 metres high and 8.5 metres wide on the inside, with lengths of 79.5 metres for the caisson for the right-hand track and 100.5 metres for the caisson on the left.

In their final position, the caissons form the cut and cover exits of the Requejo tunnels. The execution procedure included the shoring of the conventional track and the construction of engineering structures on a sliding platform close to their final location prior to subsequent relocation by means of a hydraulic jacking across the track to their final positions.

The shoring consisted of a metal structure that allowed the caisson to be moved without affecting the track, ensuring its stability. Due to the shoring work, trains had to run at a speed limit of 30 km/h during the works, as opposed to the normal speed of the route in this area of over 100 km/h. The speed restriction was necessary as a safety measure because the level and alignment of the track in this situation can generate movements that are not compatible with higher speeds. Given the jacking lengths, the caissons were divided longitudinally into two sections that were jacked successively, each with a corresponding battery of 15 hydraulic cylinders with a force of 300 tons per cylinder. At the same time that the successive 50- centimetre thrusts were carried out, the earth was removed by mechanical means, ensuring that the stability of the tracks was not compromised, until the structures reached their final positions.

In the foreground, shoring of the track. Behind, crossways, one of the two caissons already executed. In the background, the opening of the Requejo tunnel.



2. THE PADORNELO TUNNELS

A HIGH-SPEED TUNNEL BUILT JUST 20 METRES FROM THE LONGEST TUNNEL ON THE ENTIRE SPANISH CONVENTIONAL LINE

Ineco provided construction management for Adif Alta Velocidad on this 6,406-metre tunnel with a 52-square metre clear cross-section, which runs parallel to the tunnel of the Zamora-A Coruña national gauge line, and is located between the municipalities of Requejo and Lubián (Zamora), below the Padornelo mountain pass.

The Padornelo tunnel is part of the Padornelo-Lubián section, and consists of the supporting layer of the single UIC-gauge track on the right, measuring 7.6 kilometres long. The left-hand high-speed track will be executed at a later stage as part of a new project that will adapt the old 5.97-kilometre Padornelo tunnel on the Zamora-A Coruña line for mixed traffic on the left-hand high-speed track and freight on the conventional line.

Construction was carried out with conventional excavation, applying supports consisting of shotcrete, bolts and trusses. Excavation was carried out by blasting the areas with the hardest terrain and using mechanical means (backhoes, hydraulic demolition hammers, etc.) in the softer ground and terrain with lower geotechnical quality.

Execution was determined by the proximity of the tunnel on the Zamora-A Coruña conventional line. During the works, trains continued to run, so certain protocols were established to monitor for deformations in both tunnels, and reinforcements consisting of mesh and shotcrete were necessary in some sections of the old tunnel. 15 connection galleries were also built between the tunnels and an evacuation platform along the existing tunnel, to create the evacuation route necessary for the commissioning of the high-speed line. To carry out these works, the entire track was renovated with UIC 60 E1 rail, PR-01 concrete sleepers and type 1 ballast.

The works were accompanied by a series of specific environmental and landscape integration actions due to the proximity of two protected areas or sites of community importance (SCI): the banks of the Tera and Tuela rivers and their tributaries. In this regard, different measures were agreed with the regional authorities to prevent the impact on the protected flora and fauna. One example was the treatment of water coming from the tunnel, which was subjected to different processes before being discharged into the waterway, in order to ensure that its physical and chemical parameters complied with legislation. In addition, from the beginning of the works, the waters of the rivers belonging to the aforementioned SCIs had their physical and chemical characteristics monitored and a follow-up assessment was carried on the area's populations of Pyrenean desman *(Galemys pyrenaicus),* brown trout *(Salmo trutta),* freshwater pearl mussel *(Margaritifera margaritifera)* and aquatic macroinvertebrates.

View of the western tunnel opening. The tunnels were designed to integrate with the hillside as much as possible.

3. THE ESPIÑO TUNNELS

TWO LARGE HIGH-SPEED TUNNELS CONSTRUCTED USING EIGHT SIMULTANEOUS EXCAVATION FRONTS

The Espiño tunnels are unique in that they were excavated simultaneously from four fronts: in addition to the two end fronts, there were also two intermediate excavation fronts. To do this, an intermediate gallery was built that ended in a large cavern, from which four additional fronts could be started for excavation in the direction of Madrid and Ourense. The large number of fronts reduced the excavation times for the tunnel.

The bi-tube tunnel runs through the municipalities of A Gudiña and Vilariño de Conso in the province of Ourense. With approximately 8 kilometres on each track and connections between tunnels every 400 metres (20 emergency galleries), it is one of the largest tunnels in the section.

Both tunnels were excavated using the New Austrian tunnelling method, with top-heading and bench, from the eastern tunnel opening, from the western tunnel opening and from the intermediate galleries of attack towards both tunnel openings. The right-hand track has an exact length of 7,924 metres including 30 and 40-metre artificial tunnels in each of the openings for improved visual integration into the hillsides. The remainder (7,854 m) was mine excavated, that is, under natural terrain. The left-hand track has an excavated length of 7,838 m underground, to which 30 and 36 metres respectively were added to each of the openings as artificial or cut-and-cover tunnels, giving the left-hand Espiño tunnel a total length of 7,904 m. Cut-and-cover tunnel structures were also included for improved visual integration into the hillsides.

The presence of metal sulphides and carbonaceous matter in some slatey rock required the use of technosols to treat some of the excavated material in the waste sites. This technique made it possible to control the oxidation of these sulphides, which are capable of generating acidic water, thus creating a reducing environment and also decreasing oxidation kinetics. Technosols also act as a buffer, adsorbing any heavy metals that may be present in the runoff water in the form of leachate, and are eutrophising, which promotes eventual environmental integration.

SOME OF THE EXCAVATED MATERIAL WAS TREATED WITH TECHNOSOLS, ARTIFICIAL SOILS THAT ARE USED TO COMBAT SOIL CONTAMINATION. IN THIS CASE, TO CONTROL SULPHIDE OXIDATION AND ABSORB HEAVY METALS

4. THE BOLAÑOS TUNNELS

THE ONLY TWO TUNNELS ON THE MADRID-GALICIA LINE EXECUTED BY TBM

The Bolaños tunnels are the only ones on the entire line executed by a TBM. Bi-tube by design, they form part of the Vilariño-Campobecerros section, and consist of a 6.96-kilometre right-hand track and 7.91-kilometre left-hand track. The route runs through the municipalities of Vilariño de Conso, A Gudiña and Castrelo do Val, in the province of Ourense.

Both were executed using a TBM with the exception of the first 55.91 metres of the western opening and the first 15 metres of the eastern opening on the right-hand track and the first 76.13 metres of the western opening on the left-hand track, which were executed by conventional methods to move beyond a fault.

The dimensioning of the tunnel cross-section was limited by compliance with the UIC's health and comfort criteria to ensure high-quality high-speed passenger transport. Following these criteria, the final open cross-section of the tunnels was 52 square metres. The excavation cross-section of the TBM was 9.80 metres in diameter, with 37-centimetre-thick segments of precast reinforced concrete lining with an internal diameter of 8.76 m. The concrete in the segments contains polypropylene fibres as a fire protection measure. The gap between the TBM excavation and segment lining was filled with two-component mortar, a mixture of conventional mortar with hydrated bentonite and silicate.

The waterproofing of the precast lining was achieved by fabricating the segments with a low-permeability concrete; installing a double waterproofing seal at the segment joints; and injecting the two-component mortar into the space that remained between the excavated surface and the ring of segments. The injected voussoir is the primary waterproofing, since, in practice, it is the first barrier encountered by groundwater on its way towards the interior of the tunnel, with secondary waterproofing being that provided by the seals.

The two tubes are connected by 18 galleries, one of which is used specifically for installations. The cross-section of the galleries has an open width of 4.70 m and a lining of 25 cm of plain concrete, with the addition of polypropylene fibres as a fire protection measure.

During the tunnel excavation, a large amount of water was generated by the construction processes, and it was necessary to treat it in a large treatment plant in order to comply with the parameters required by the competent bodies. The suspended solids present in the water were removed using a separation process, with the help of coagulants and flocculants. The pH was adjusted through the use of CO_2 (for basic process water) or caustic soda (for acidic process water).

Assembly of the 230-metre-long, 2,900-ton TBM in May 2015.

THE TUNNELS MEASURE 6.9 KILOMETRES (RIGHT) AND 7.9 KILOMETRES (LEFT). TO WATERPROOF THEM, SPECIAL CONCRETE, DOUBLE JOINTS BETWEEN SEGMENTS AND TWO-COMPONENT MORTAR BETWEEN THE EXCAVATED SURFACE AND LINING WERE USED

5. THE TEIXEIRAS VIADUCT

A 100-METRE-HIGH CENTRAL ARCH OVER THE ARROYO TEIXEIRAS

The Teixeiras viaduct, for which Ineco was in charge of works and environmental management, is without a doubt the most spectacular structure on the entire Madrid-Galicia HSL.

The deck of the Teixeiras viaduct was executed using self-launching formwork, and has a length of 508 metres distributed in eight spans (56 m + 4x66 m+56 m). Its uniqueness lies in the construction procedure chosen to negotiate the Arroyo Teixeiras with maximum respect for the environment. The foundations of the central piers (which are more than 90 metres high) are shared by two half arches, which were erected and angled inward to meet at a fixed point under the deck, providing a separation between piers of 132 metres, equivalent to two spans, which, in addition to minimising the impact on the environment, gives the structure greater transparency and beauty. The Arroyo Teixeiras, a tributary of the Támega River, has protected riverbank vegetation and, on the surrounding slopes, a forest consisting of native species with large chestnut and oak trees.

The construction of a large structure like the Teixeiras viaduct requires large auxiliary areas to house the facilities that support the construction: from large cranes to site huts; from storage yards to vehicle car parks. For this site, ways of minimising the impact of this area were studied thoroughly. Detailed analysis was carried out on the opening of roads with steep slopes to reduce their grade, areas of auxiliary facilities on bends or between foundations, work platforms adjacent to jobs with strict occupation limits, etc. All of these installations were located on both hillsides that, in addition to being very steep, had soils made up of highly fragmented materials with high potential for displacement of soil that would reach the waterway below in the case of rain.

In order to prevent or mitigate the effects that this soil displacement could have on the water quality of the Arroyo Teixeiras, an ingenious anti-displacement system was implemented, basically consisting of a network of pipes (concrete ditches, pipes, sandpits, settling pools, intermediate reservoirs, etc.) deployed along the access roads to the foundations, which converge at pumping reservoirs located very close to the waterway. To reduce earthwork and facilitate subsequent integration, metal containers were used as pumping reservoirs so that they could be easily removed after the completion of the works.

In the event of heavy rain, sediment-laden runoff was redirected –by means of powerful pumps– to a treatment system located at the height of abutment 2 of the structure, expanding the response capacity in the case of a heavy rains. In this treatment system, coagulants and flocculants were also be used to accelerate separation if necessary.

PROTECTION OF THE ENVIRONMENT DETERMINED BOTH THE DESIGN AND CONSTRUCTION PROCEDURE, IN ORDER TO MINIMISE THE ENVIRONMENTAL IMPACT

The central piers are over 90 metres high, with two half-arches that provide a separation of 132 metres between them.

Load tests: ready for action

Prior being put into operation, Ineco carried out the load testing of 25 structures and inspection of 70 bridges for Adif on the Olmedo-Pedralba section of the Madrid-Galicia high-speed line.

By **Pablo Sánchez Gareta,** civil engineer

Laser device.

Data acquisition equipment.

Ricobayo reservoir.

During the months of March and April 2019, a team of seven specialists from Ineco carried out an important task for Adif Alta Velocidad prior to the commissioning of the new Olmedo-Pedralba de la Pradería section: load testing and inspection of the bridges and viaducts over which the complex route of the Madrid-Galicia HSL runs, all with satisfactory results.

Load tests were carried out on a total of 25 structures, in addition to the main inspections of 70 bridges (14 viaducts, 2 pergolas and 54 underpasses). In the case of the bridges, and since they were newly constructed, the data collected during the inspections provides a baseline situation (zero state) for subsequent analysis and monitoring of the evolution of the structure.

During the tests, which are compulsory for all new bridges with spans 10 metres or longer, actions of actual use of the works are reproduced under controlled conditions.

The Ineco team, from left to right: Jorge Benito, Amadeo Cano, Pablo Martín-Romo, Javier Ortiz, Pablo S. Gareta and Carlos Sánchez.

In other words, checks are carried out to ensure that the bridge is safe, well built and able to withstand the loads of the trains that will travel over it over time. For these verifications, static and dynamic tests are carried out with loaded trains running at different speeds. Data collected by sensors installed on the structure is analysed and the actual and expected responses are compared. The results are sent to the Railway Safety Agency, which is responsible for authorising the entry into operation of the section.

One of the most representative structures that was tested was the Ricobayo viaduct over the reservoir of the same name, measuring 368 metres long and consisting of four spans of between 50 and 155 metres long. For the test, 2 locomotives and 20 hopper wagons loaded with ballast weighing a total of

LOAD TESTS WERE CARRIED OUT ON A TOTAL OF 25 STRUCTURES, IN ADDITION TO THE MAIN INSPECTIONS OF 70 BRIDGES (14 VIADUCTS, 2 PERGOLAS AND 54 UNDERPASSES)

1,863 tons were used. On the spectacular viaduct over the Tera River, measuring 645 metres long and consisting of nine spans of between 60 and 75 metres, two trains with eight hopper wagons each, weighing a total of 1,536 tons, travelled at speeds of between 10 and 80 km/h. ■

From left to right, engineers Noelia Sánchez, head of the ACO unit, and Marta González, manager of the gauge-changer works in Pedralba, Zamora.

GAUGE MATTERS

WHILE THE ZAMORA-OURENSE HIGH-SPEED SECTION WAS BEING COMPLETED, A GAUGE CHANGER WAS BUILT IN PEDRALBA DE LA PRADERÍA TO ENABLE TRAINS TO TRAVEL ON TRACKS WITH TWO DIFFERENT GAUGES WITHOUT STOPPING. INECO MANAGED THE WORKS, AS IT IS DOING IN THE TABOADELA CHANGER AT THE OTHER END OF THE SECTION.

By **Marta González** and **Noelia Sánchez,** civil engineers

Ineco is managing works for Adif Alta Velocidad on the Pedralba de la Pradería gauge changer in Zamora, a railway facility that allow uninterrupted travel by trains between Madrid and Galicia, automatically switching from high-speed track in standard gauge (1,435 mm) to conventional track in Iberian gauge (1,668 mm). In addition, at the opposite end of the section, works have also begun on another changer in Taboadela, Ourense, also managed by Ineco.

A gauge changer is a railway facility that allows trains equipped with variable-gauge axles or semi-axles to automatically change their gauge while travelling at a constant speed (approximately 15 km/h) and without the need for human intervention. In Spain, where the high-speed network in standard gauge coexists with the conventional Iberian gauge (see IT22 and IT57), these systems are essential to enable trains to switch from one to another at points where both exist. This is the case of the Pedralba-Taboadela-Ourense section.

The Pedralba gauge changer is a TCRS3 dual gauge changer, that is to say, suitable for both CAF and Talgo technology. Works included the installation of points that connect the Zamora-A Coruña conventional line to the changer at kilometre 112/405. The installations consist of a metal structure with a main trench where the gauge-change platform is located, equipped with a video recording system. On both sides, there are two observation trenches that allow inspection of the rolling system, which also has an automatic de-icing system for Talgo train wheels. This is a temporary solution until the next high-speed section is put into service, at which point the platform and equipment will be dismantled and moved to another changer.

BRIEF HISTORY OF A GROUND-BREAKING TECHNOLOGY

- The first gauge changers were installed in Spain in 1968 in Irún and Portbou to allow Talgo trains to travel to Paris and Zurich.
- Gauge changers spread at the same time as the high speed network; the first generation included different types for each of the two variable rail technologies in Spain (RD by Talgo and Brava by CAF). The dual system, which was suitable for both, was developed later. Adif installed the first third-generation system (TCRS3) in 2009.
- For more than twenty years, Ineco has participated in the design of most of the different generations of gauge changers. Currently, it is also responsible for the maintenance and operation of more than twenty automatic gauge changers throughout Spain.

Technology and innovation for the Renfe Space

Ineco was in charge of the project and construction management for a new space that highlights the combination of digital tools and technology. From queue management to lighting and public address systems, the new Renfe Space provides maximum coordination and personalisation of passenger services.

By **Catalina Bezares,** civil engineer, and **Nike Picón,** architect

PHOTO_PATIER / RENFE

The Granada railway station is located in the Los Pajaritos neighbourhood, inside the ring road formed by Avenida de la Constitución, Camino de Ronda and Avenida de Fuente Nueva. Since 2015, the station has been undergoing a major refurbishment to enable it to accommodate the arrival of the Madrid-Córdoba-Granada high-speed line. The works have included redevelopment of the forecourt and surrounding area, enlargement of the station including the construction of a new building, new platforms, expansion of the car park and refurbishment of the existing passenger building, which was built at the beginning of the twentieth century. One of its side areas in the east wing has been renovated to create an innovative Renfe Space to house the company's Sales Channel, Service Centre and Atendo service.

The idea behind the project was to design a single open area to provide passengers with service in different zones, but all part of a common space. The interior volume, which does not reach the ceiling, defines the different uses of the space, separating the Atendo area located next to the entrance and the Service Centre, and leaving the Sales Channel area at the back defined by a Renfe corporate panel.

AN INTERPLAY OF LIGHTS

The suspended ceiling creates a taller island in the single space, an interplay that gives it certain fluidity, and in which the different kinds of lighting highlight the common area, different service areas and each of the counters, framed by alcoves featuring Renfe's corporate image.

> AN OPEN SPACE DESIGNED WITH SEPARATE AREAS AND EQUIPPED WITH SERVICE POINTS FOR PEOPLE WITH DISABILITIES, EACH WITH A MAGNETIC INDUCTION LOOP FOR PEOPLE WITH IMPAIRED HEARING

The side that overlooks the platforms was conceived as an interior façade where the waiting area is located, maintaining the existing gaps that frame the views of the platforms, and with areas of the building's exposed brickwork.

This Renfe Space combines technology and innovation. It includes a queue management system for the available services with multiple options for users to take their turn for ticket sales or customer service, depending on their needs. The system is linked to Renfe's image and advertising management system, as well as to the public address and lighting of the service points, which provide information to users who require assistance.

Another built-in system is the *Digital Addressable Lighting Interface* (DALI) which makes it possible to adapt the lighting to the number of people in the space and the time of day, with 3 possible configurations: day, night and semi-night. Each of the areas also has a service point for people with disabilities, which includes a magnetic induction loop for people with impaired hearing. The latter consists of a communication system for hearing-aid users. The magnetic loop reduces background noise significantly, thus improving intelligibility. The result is that the user receives clear sound with the proper volume.

The Granada Renfe Space combines the essence of the station with innovation, enabling the accessibility and integration of all of the users of the station's services. It will operate every day from 6:15 am to 11:30 pm.

This project paves the way for other locations such as the future Renfe Space in the Vigo-Urzáis station. ■

Predicting to prevent accidents

The RONIN comprehensive road safety management tool helps reduce accidents and optimises predictive maintenance of the road network. Developed by Ineco, it was a nominee for the 2019 Ponle Freno Awards and in 2018 won a an SDG prize awarded by the Rafael del Pino Foundation and the Spanish Global Compact Network.

By **Iván Hernández,** Advanced degree in Management Computing Engineering

PHOTO_JUANEDC / FUCKR

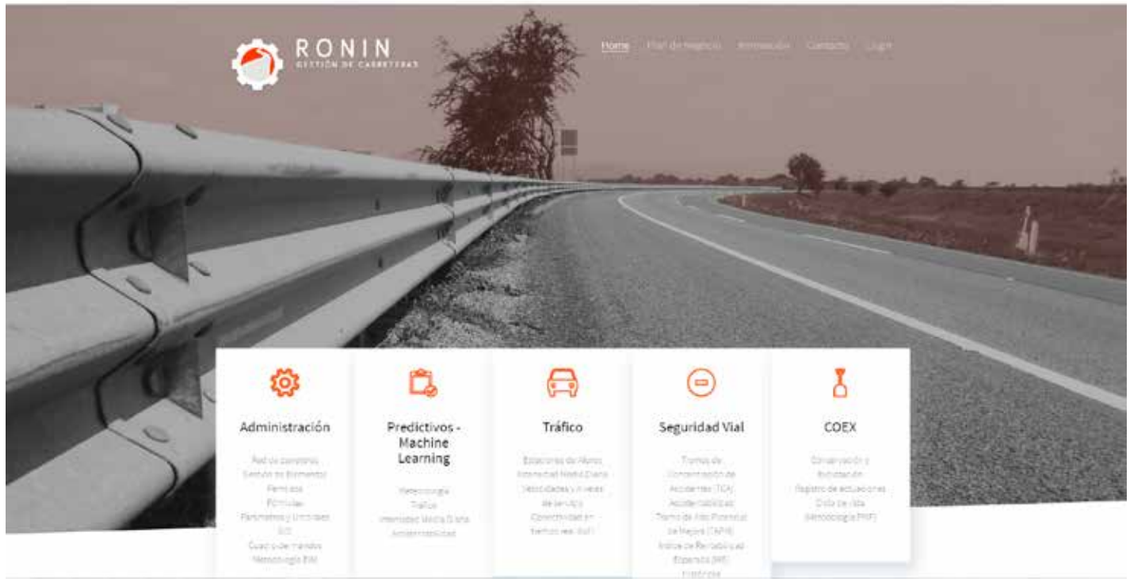
Ineco's RONIN innovation project was one of the three nominees for the 2019 Ponle Freno Awards, selected from among 105 proposals entered in the *AXA Road Safety Innovation and Development category.* This category recognises innovative products or designs that represent new scientific/technological developments in the improvement of road safety and that show a high potential for industrial transfer, enabling them to be put to use for the benefit of road users and society in general. The Ponle Freno Awards are an initiative of Atresmedia and AXA and aim to recognise people, institutions and initiatives that contribute to promoting road safety and, consequently, help reduce the number of accidents on Spain's roads.

Prior to this award, RONIN won first place for Sustainable Development Goal 9 *Industry, Innovation and Infrastructure,* for helping to reduce accidents and optimise the predictive maintenance of the road network. The prize was awarded by the Spanish Global Compact Network, the most important initiative for the sustainability of the private sector promoted by the United Nations and Rafael del Pino Foundation. This award is part of the go!SDG Awards, which highlight the role of business and social entities in Spain when it comes to using innovation to achieve the UN's Sustainable Development Goals (SDGs). These are awards that highlight initiatives that are already underway and have proven results, and serve as an inspiration for the Spanish private sector as a whole, encouraging intersector collaboration and dialogue.

Previously, in its prototype stage, the tool was a nominee at the 3rd edition of the Innovation in Road Infrastructure Awards organised by the Spanish Road Technology Platform at *Innovacarretera 2017,* in the category of best R&D project, among more than 50 proposals. *Innovacarretera 2017* was the 4th edition of the biannual *Road Infrastructure Sector Technology Demonstration Fair,* an event that brings together public authorities and companies in the same field in an updated format of live demonstrations of innovative products and services with road infrastructure applications.

A POWERFUL TOOL FOR ROAD SAFETY

RONIN, innovative software developed by Ineco, facilitates the making of strategic decisions in the field of infrastructure safety, serving as a powerful tool for public authorities and road operators, with



RONIN DASHBOARD
To supervise and monitor the road network, RONIN has an analysis system consisting of dashboards with key performance indicators (KPIs).

TEAM PHOTO
In the phoyo, Josué García, Damaso Iván Hernández, Rafael Ibáñez and Alejandro Rodríguez, members of the Ineco team that developed RONIN, with Mª Sonia Álvarez and Manuel Francisco on the screen in the background.

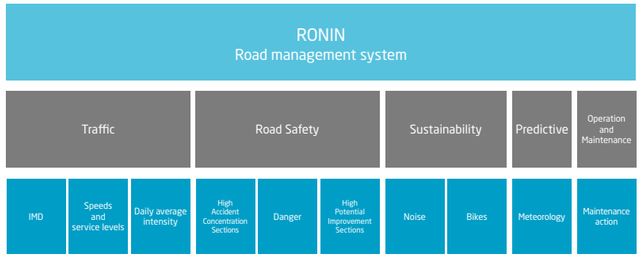
a notable impact on users of one of the principal means of transport. The software –designed to manage the road network– includes accident prediction models based on the weather, date and traffic flow.

One of the main capabilities of the RONIN tool is the automatic calculation of accident black spots using formula management and black spot calculation parameterisation functionalities based on the Guidelines of the procedure for the management of accident black spots and State Road Network's safety classification, which makes it possible for the different available calculation methods to be applied to comply with Royal Decree 345/2011 of 11 March, providing a major benefit to drivers, who can easily consult critical information about sections of road with high risk of accidents in real time. The system incorporates accident prediction models (random decision forests) based on the weather (connection with the AEMET API), date and traffic flow or any variable that can be provided through online services, which are used to reduce the accident rate while optimising road network maintenance, with the ability to integrate future road maintenance variables considered to be of great interest. As a result, the degree of accident risk is obtained, making it possible to rank the probability of an accident occurring on a road section in the short term (1, 2 or 3 days).

RONIN INCLUDES ACCIDENT PREDICTION MODELS BASED ON THE WEATHER, DATE AND TRAFFIC FLOW

In terms of road maintenance and operation, the RONIN tool enables public authorities to optimise expenditure based on greater efficiency of use of the limited resources available to them, investing them in locations where a greater risk of accident has been identified. In addition, the programme is scalable, allowing the incorporation of other modules, such as assistance in the management of improvable elements and identification of sections with high potential for improvement, which allow for longer-term planning of road improvement programmes and expected rate of return (ERR), adapting them to new regulations and, ultimately, improving their safety.

Lastly, it is possible to manage the road inventory and generate reports in editable format. ■



RONIN tool modules and features.

WHAT IS RONIN BASED ON?

RONIN is a comprehensive road management web application that enables the efficient management of any road network over the course of its life cycle. The solution is based on a configurable and expandable inventory, in which all road elements are registered independently with their corresponding attributes, providing a fully scalable solution. The tool focuses mainly on road safety, specifically accident reduction, by facilitating early decision making through predictive models for infrastructure improvement, and is able to record, represent and analyse the different attributes that determine the safety of the network. Its main features are the following:

- **Road manager**
- **Self-administration**
- **Road safety**
- **- accident black spots**
- **Parameterised formulation**
- **Accident prediction**
- **Real-time data**
- **Dashboard**
- **Web application - GIS**
- **Tracking over time**
- **Role-based safety**
- **Multi-language**
- **Customisable queries**
- **Predefined reports, in editable format**

FEATURES

The tool's many features include the monitoring and operation of traffic count plans, speed control and annual traffic levels of service . In the case of traffic counts, it includes a file for each count and its historical data; direct connection with count points; use of geographic information system (GIS) data and export to ETRS89 and WGS84 projection systems. Its most notable features are the following:

1. Traffic
- Traffic count stations
- Average daily intensity
- Speeds and service levels
- Real-time connectivity (IoT)

2. Road safety
- Accident black spots
- Accident rate
- Section with high potential for improvement
- Expected rate of return (ERR)
- Historical - Evolution - Comparative

3. Sustainability
- Bicycle capacity and noise analysis

4. Predictive - Machine Learning
- Meteorology, traffic, ADI – historical
- Proposal of standard actions

5. Maintenance and operation
- Record of actions (preventative and corrective)
- Life cycle (PMP methodology)

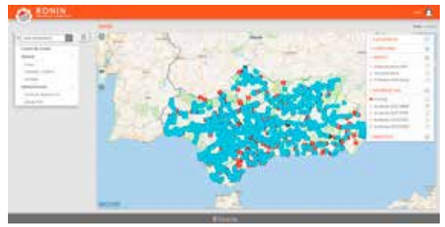
6. Administration
- Road network – administration, provincial services, maintenance and operation
- Elements – types – attributes
- Administration (user, road network, GIS layers, formulation, calculations, thresholds)
- Dashboard (customised by role)
- Export to Excel, Word, GIS

TRAFFIC IN SPAIN AND RONIN SIMULATION IN ANDALUSIA

Spain, with 80 million tourists each year, has a death rate of 39 per million inhabitants, the same as Germany, with 49 per million inhabitants being the average death rate in the EU. In 2018, according to data from the DGT, there were 102,299 traffic accidents with victims, in which 1,806 people died and 138,609 were injured, 8,935 of which required hospitalization.

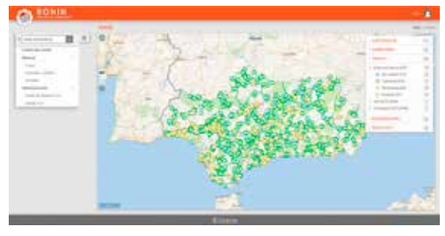
The Ineco team that developed RONIN used simulated data on the roads of Andalusia in its presentation. Different screenshots of the tool are shown below:

Number of accidents per year.



Accident risk prediction.

Average daily intensity by category.



Traffic count stations classified by type.

PHOTO_INECO

PHOTO_ANTOINE 49 / FLICKR

Above top, presentation in Qingdao, China, of the first train of the 2500 series manufactured in the facilities of CRRC Sifang for the São Paulo Metropolitan Railway Company (CPTM). In yellow vests, Ineco technicians Carlos Castaño and Raúl G. Palacio. Above bottom, entrance of the Port of Qingdao, from where the trains that leave the factory are shipped.

From China to São Paulo

Ineco is carrying out technical assistance and supervision on the eight new 2500 series trains that the company CRRC Sifang is manufacturing in Qingdao, China, for the São Paulo Metropolitan Railway Company (CPTM). The work is being carried out by the Consorcio Supervisor 8 Trenes (CS8T), which is made up of Ineco, Ineco do Brasil, Ebei and MetroEng.

By **Enrique Monfort,** industrial engineer and **Raúl G. Palacio,** electronic engineer

PHOTO_SÃO PAULO STATE GOVERNMENT

PHOTO_SÃO PAULO STATE GOVERNMENT - DIOGO MOREIRA / FLICKR

Above top, unloading of the first Temoinsa-Sifang 2500 series train on its arrival at the Port of Santos, Brazil. Above bottom, Luz Station in São Paulo. CPTM's 'Expresso Aeroporto' trains run between this station and the airport.

The São Paulo Metropolitan Railway Company CPTM, a company linked to the Secretariat of Metropolitan Transport of the State of São Paulo (STM), is continuing with its project to expand the city's Line 13, known as Jade, a 12.2-kilometre route that will connect the city centre with Guarulhos International Airport and is expected to carry 130,000 passengers every weekday. The Chinese-Brazilian consortium Temoinsa-Sifang is manufacturing eight new trains for this line which are specially designed with extra space for transporting the luggage of future users. The manufacture in China and the delivery and assembly of the trains is being carried out under the supervision of the CS8T Spanish-Brazilian consortium made up of Ineco, Ineco do Brasil, Ebei and MetroEng.

The rolling stock, which is being manufactured at CRRC Sifang's facilities, was purchased by the State Government of São Paulo in September 2017 for 316.7 million reales with 85 million euros of financing from the European Investment Bank (EIB). With each train equipped with eight carriages, this fleet

PHOTO_SÃO PAULO STATE GOVERNMENT - DIOGO MOREIRA / FLICKR

CPTM trains at Luz Station.

Carmen Librero, Chairwoman of Ineco, at CPTM's facilities in Presidente Altino, São Paulo, accompanied by Enrique Monfort, project manager at Ineco do Brasil, Ignacio Fernández-Cuenca, General Manager of International Business at Ineco, and Vladimir Mello Jr., engineer at Ineco do Brasil. On the right, Carlos Castaño and Raúl G. Palacio.

In February 2018, work on the viaducts of Line 13 at the entrance to Guarulhos International Airport was completed.

PHOTOS_SÃO PAULO STATE GOVERNMENT - DIOGO MOREIRA / FLICKR

Line 13, also known as Jade, operated by CPTM, is 12.2 kilometres long and connects Engenheiro Goulart Station in São Paulo to São Paulo-Guarulhos International Airport, located in Guarulhos.

will provide shuttle services between São Paulo's International Airport, the largest in Latin America, and the city of São Paulo.

In January 2019, a team of Ineco technicians travelled to the facilities of CRRC Sifang –a public railway manufacturer based in Qingdao, China– to oversee the delivery of the first train in the 2500 series. The rolling stock is very much in line with the latest acquisitions of STM/CPTM, which feature distributed traction and steel boxes, and complementing the recent deliveries of 30 Hyundai trains and 35 trains from the Spanish company CAF, both also financed by the EIB. This will give CPTM a more modern and versatile fleet, which will be put into service over the next two years. After disembarking at the Port of Santos, the new rolling stock is transported by road to CPTM's facilities for dynamic track testing.

The assembly of the eight trains in CRRC Sifang's factory is slated for completion in the first months of 2020, and CPTM will then continue with the acceptance and commissioning of the vehicles, which must be completed by the beginning of 2022.

The work of the CS8T Consortium includes reviewing the vehicle design and supervising static and dynamic testing, which will be ongoing both at the factory and on the track until the trains are put into service. To this end, Ineco technicians are carrying out manufacturing inspection activities at CRRC Sifang's facilities and static and dynamic testing both at the factory in Qingdao and at CPTM's facilities in Presidente Altino, São Paulo. A team of technicians from Ineco has also carried out a design review from its offices in Spain.

The supervisors have to make sure from the outset that the assembled rolling stock meets the technical specifications and needs of CPTM. They also need to have a detailed knowledge of international and Brazilian railway regulations, as well as the regulations that apply to each of the main and auxiliary elements of the structure –boxes, axles, wheels, etc.– equipment and systems: traction, braking, train safety, passenger information, driving, emergency, etc. The supervision process must guarantee reliability and the technical compatibility of all elements.

Ineco has extensive expertise in this field, as well as professionals with specific knowledge of each of the components that make it possible for a train to operate safely and comfortably for users. This experience extends to all varieties of rolling stock from all suppliers: Alstom, Bombardier, CAF, Siemens, etc. ■

European standards for Panama and *Haramain*

Ineco has completed the Independent Safety Assessment (ISA) for the improvement of Line 1 and new Line 2 of the Panama City Metro, and the safety studies for the high-speed line between Makkah and Madinah in Saudi Arabia. The company has extensive experience in Spain, which it has exported abroad for the first time.

By **Laura L. Brunner**, bachelor's degree in Physical Sciences, and **Jorge Merino**, industrial engineer

ATOCHA CONTROL CENTRE (OCC)
OCCs direct and coordinate Spain's high-speed traffic in real time. From them, signalling, electrification, communication, passenger information and energy systems, among other aspects, are controlled. In the image, the central OCC located in Puerta de Atocha station in Madrid.

PHOTO_**PABLO NEUSTADT / INECO**

INECO EXPORTS ITS EXTENSIVE EXPERIENCE IN RAILWAY SAFETY STUDIES

A railway system is made up of different subsystems: very broadly, the track with all of its equipment, the power system, with overhead lines and substations, the rolling stock and all of the signalling, control, command and communications elements that make it possible for trains to operate. Each of these subsystems must work safely and, to ensure this, starting with the project design phase and following stages, through commissioning and subsequent maintenance, different safety studies and tests need to be carried out on aspects ranging from subsystem specifications, detection of possible hazards and the likelihood of occurrence, to actions to be undertaken to mitigate the risks and fully certify that the whole system is safe and complies with the regulations.

These safety activities for the commissioning of all or part of a railway system (whether newly built or modified, for example, due to modernisation), are carried out following a 'V-shaped life cycle', because the activities run in parallel but not necessarily at the same time, starting in the design stage and converging again during commissioning. Different individuals (designer, verifier, validator) are responsible for each activity. The different kinds of safety studies are organised into the following phases: concept and definition of the system, risk assessment, identification of safety and application requirements, and, finally, design and implementation.

The main report produced is the Independent Safety Assessment (ISA), which, unlike other jobs, such as risk assessment, can only be performed by assessors accredited by an ENAC (National Accreditation Entity), such as Ineco. This report is essential for guaranteeing to a third party –the operator or railway authority– that a new line or the modification of an existing line is safe and can be put into service or continue operating.

Ineco, which has extensive experience in Spain in the field of railway safety studies, especially in high speed, as well as in other fields, has exported its knowledge: for the Panama City Metro, it carried out ISAs for the new Line 2 and extension of Line 1, a job that took two years. It also carried out safety studies on the first high-speed line in Saudi Arabia, between Makkah and Madinah *(Haramain High Speed Railway project)*, which went into operation in October 2018.

Both the *Haramain* (which means 'two holy cities' in Arabic) and Panama City Metro projects were carried out in accordance with the safety regulations that apply to Spanish railway lines, that it to say, the standard CENELEC EN 50126 *(Railway applications - specification and demonstration of reliability, availability, maintainability and safety, RAMS)*, which applies to all subsystems that make up the rail system: train signalling and protection, telecommunications, traffic control centre, power supply, protection and safety, track and rolling stock.

PANAMA CITY METRO ISA

More than 8 million passengers a month use the two operating lines of the Panama City Metro. In 2014, the opening of the first suburban line, with a length of 15.8 kilometres, revolutionised public transport for the city's more than 880,000 inhabitants. Growth in demand has made it necessary to expand its capacity by adding 6 new trains to the 20 existing ones, and expanding the number of carriages from three to five, which in turn made it necessary to modify tracks and facilities, purchase new supplies and carry out other supplementary works.

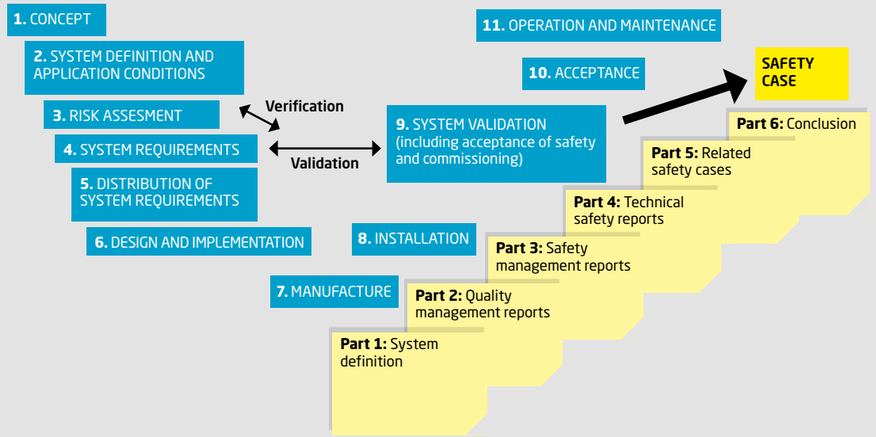
In addition, in January 2019, the new 21-kilometre Line 2 was partially opened to provide a service to pilgrims from all over the world who attended the World Youth Day, presided over by Pope Francis. For nine days, with no notable incidents, the line section, consisting of five of the sixteen stations,

WHAT DOES AN ISA DO AND HOW DOES IT WORK: THE V-SHAPED LIFE CYCLE

▶ The **verifier** ensures that the conditions are correct to move to the next phase of the V-shaped life cycle.

▶ The **validator** verifies that the physical system is behaving as anticipated in the design phase.

▶ The **assessor** verifies that the system safety management process is being carried out in accordance with the regulations and initially established plans. To do this, the assessor carries out an **evidence-based** analysis whose purpose is to reach **conclusions.**



PHOTO_MARIO ROBERTO DURÁN ORTIZ (WIKIPEDIA)

A station on Line 1 of the Panama City Metro.

PHOTO_DANIEL BENITO (INECO)

The high-speed line between Makkah and Madinah began commercial operation in October 2018.

INECO IS PRESENT IN ALL PHASES OF THE SAFETY LIFE CYCLE, FROM THE START OF THE PROJECT TO VALIDATION

transported 2.6 million people. On 28 January, once the event was over, the line closed again for works to complete it, and it officially opened in April.

To make the process possible with full safety guarantees, since 2015, Ineco has been carrying out the Independent Safety Assessments (ISAs) on both lines for the company Alstom. On the one hand, for the adaptation actions aimed at expanding the capacity of Line 1, and, on the other, for the subsystems of the newly constructed Line 2: track, rolling stock, signalling system, power supply, supervision and control of trains, communications and SCADA (supervisory control and data acquisition), among others.

SAFETY STUDIES FOR THE MAKKAH-MADINAH LINE

The so-called 'Pilgrims' High Speed Railway' made its first official trip on 25 September 2018 and began commercial operation in October. Ineco was one of the 12 Spanish companies (the others being Renfe, Adif, Talgo, Consultrans, OHL, COPASA, Imathia, Dimetronic, Indra, Cobra and Inabensa) and two Saudi firms in the consortium that was awarded the international contract to build the second phase of the project in 2011.

After phase 1 (civil works for the construction of the track platform and stations), which was awarded to another consortium, phase 2 included track and overhead line installation, electrification, control centres, supply of 35 trains, and operation and maintenance of the line for a period of 12 years.

The new 450-kilometre line is the first high-speed line in Saudi Arabia and the entire region. It is designed for speeds of up to 320 km/h and connects the two holy cities of Islam, Makkah and Madinah, with five stops in total. It has a double track in standard gauge (1,435 mm), 25 kV, 60 Hz electrification and is equipped with the ERTMS level 2 signalling system.

As one of the project tasks –supervision of track assembling, train traffic tests, etc.– Ineco also carried out safety studies associated with phases of the project, always applying Spanish CENELEC regulations.

In the concept and definition phase, the technical specifications of the track, overhead lines, signalling, telecommunications, installation and maintenance bases, signalling control points, operation control centres (OCCs), high- and low-voltage electrification and RAMS requirements were prepared. Based on this, a safety plan for the system was generated.

In the risk analysis phase, a hazard log was created to manage hazards, including a description of each hazard, its status (open, controlled, cancelled transferred or closed), initial and final assessment, the person in charge, etc. The EN 50126 standard provides a detailed list of all possible hazards, establishes the levels of probability (from frequent to unlikely) and severity (from insignificant to catastrophic), and classifies them (from acceptable to intolerable).

In the stages that followed, identification of requirements and traceability, the development of the hazard log continued, establishing the safety requirements for the signalling, track, station and power subsystems. After the analysis, the corresponding mitigation measures were established and applied in order to reduce the detected risks to acceptable levels.

In the design and implementation phase, the standard stipulates the need for a design 'safety case', which is a detailed report that, once validated by an Independent Safety Assessor (in this case, the Italian company ITALCERTIFER), gives the green light to the operation and maintenance of the infrastructure. In the Haramain project, Ineco produced, among others, the safety case for the signalling control points and auxiliary detection systems (detectors and concentrators), as well as for the management of rolling stock interfaces with the rest of the subsystems. ■

EXPERTS IN RAILWAY SAFETY

Ineco has extensive experience in engineering, railway safety facilities and equipment and rolling stock, and knowledge of the safety processes and procedures of the main railway suppliers. It participates in all phases of the safety life cycle, from the initial stages of concept and definition of the system, to validation, which includes final safety acceptance for commissioning, both for new infrastructures and on-board equipment, and modification of existing infrastructure.

In 2009, it obtained its first accreditation from the ENAC (Spanish National Accreditation Entity) as an independent safety assessor for both infrastructure and rolling stock, with number 76/EI058, which it has subsequently renewed. This accreditation is also valid in the 100 countries with which the ENAC has reciprocal recognition agreements. Ineco has also been certified by the ILAC (International Laboratory Accreditation Cooperation) as an inspection entity for the independent safety assessment of railway applications at the international level.

Some of the more important work carried out in Spain on track subsystems (specific applications) includes the assessments of the safety processes applied by Adif (the Spanish railway infrastructure manager) in the commissiong of a large part of the high-speed lines equipped with ERTMS. The most recent are the Antequera-Granada line, opened in June 2019 (see *ITT66*) and the installation of the ERTMS level 2 signalling system on the Valladolid-León line. Work is also continuing on other lines that are still under construction, such as the Olmedo-Zamora-Pedralba sections of the high-speed line to Galicia; Monforte del Cid-Murcia; and the connection between Chamartín station and Torrejón de Velasco in Madrid. The company previously worked on other lines in the network, such as Madrid-Lleida-Barcelona (opened between 2003 and 2008); Figueras-Perpignan (2011); Córdoba-Málaga and Madrid-Valladolid (2006-2007); and Madrid-Valencia (2010).

Ineco has also carried out safety assessments on modifications to conventional lines with ERTMS, such as those on Madrid's Cercanías network, and the Castellbisbal-Mollet and Castellbisbal-Cantunis branches in Barcelona, where a third wire was installed in 2010 to allow the running of trains on two track gauges. One of its more recent jobs is the safety assessment on the modernisation of the Recoletos tunnel in Madrid.

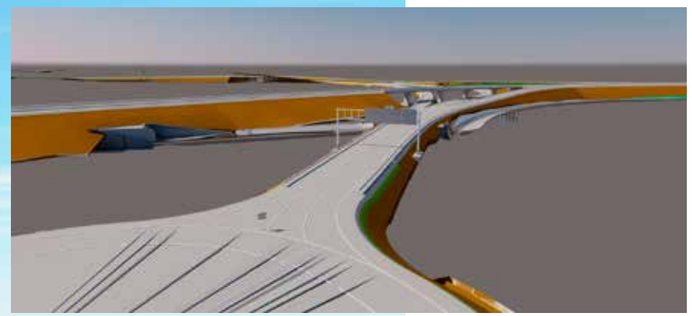
And in regard to assessments of on-board equipment, some of the more important include the ones carried out for the installation of ERTMS level 1 equipment in Cercanías Civia (I, II, III and IV) and 446, 447 and 450 series electric multiple units. In terms of high-speed rolling stock, the company has worked on the S-120 and S-121 units manufactured by CAF.

Independent assessments have also been carried out on safety cases of generic products, such as radio block centre (RBC) devices, the ASFA Digital on-board system, an object-on-track detection system and trackside signalling using LED lights.

BIM-GIS integration in the A-76

Ineco has taken another step towards digital transformation in drawing up projects, applying the BIM methodology and integrating it into a GIS (*geographic information system*) environment in the management of the Villamartín de la Abadía-Requejo section of the Ponferrada-Orense A-76 highway construction project, which it is drafting for the General Directorate of Roads, part of the Ministry of Public Works.

By **Miriam Pinilla** and **Agustín Roldán,** civil engineers,
Mirela Vladovic, telecommunications engineer, **Laura Martín,** geographer,
with the collaboration of **Raquel Veneros,** technical architect



COORDINATED MODELS
Image of the BIM models of the junction between the A-76 and A-6, obtained from Navisworks. It was found that all BIM models in IFC format generated by the different BIM tools were coordinated and did not clash with each other.

ALL IN ONE
This three-dimensional image, obtained from Infraworks, shows different BIM models -viaducts, cross-drainage works, alignment- coordinated with each other thanks to the use of interoperable formats, which can be easily consulted.

The A-76 highway is one of the first road projects in which the BIM (building information modelling) methodology has been applied, a field in which it is not yet very well developed. This has led to an evolution from two- to three-dimensional models with associated information, and working in a collaborative and digital environment that centralises all of project information and makes it possible to overcome existing constraints in terms of information exchange.

The virtual preconstruction of the first of the slip roads of the Villamartín de la Abadía-Requejo section, that of the future A-76 highway connecting to the A-6 highway, was chosen because it is a good representative case. It is a complex slip road in which the lanes of the A-76 separate to connect to the A-6, allowing all possible movements directly. Its design was determined by the topography of the land; additional carriageways connecting to the N-VI and LE-158/15 roads; and the configuration of the A-6 highway's existing entries and exits. In terms of its most characteristic features, the project has a total length of over 10 kilometres, requires the construction of 11 structures and involves the channelling of the Arroyo de los Valtuilles.

A 3D model was created with geometric and non-geometric information, put together as a puzzle in which the models provided by the disciplines of layout, road surface, land, drainage, structures, affected services and signalling, signs and defences are added using interoperable formats that allow the integration of

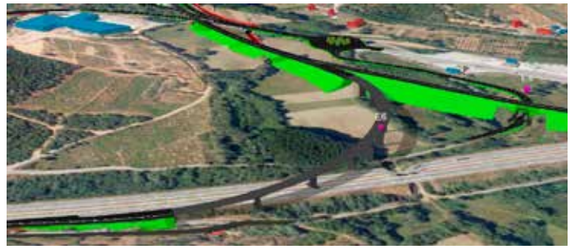
Above top, image of the BIM-GIS integration display, which offers an overview of the 'digital twin' of the slip road between the future A-76 highway and the A-6, which has made it possible to put it in context in its real territorial environment. Above bottom, LIDAR vegetation.

digital information from a broad ecosystem of tools with which the aforementioned disciplines work.

A GROUND-BREAKING PROJECT IN SPAIN

In the A-76 project, the BIM world was connected to geographic information systems, for the first time in Spain and virtually the first time in Europe. What both worlds have in common is that they combine geometric elements associated with alphanumeric data (attributes) and, therefore speak a common language. BIM intrinsically focuses on the three-dimensional model of the infrastructure, and GIS, among other aspects, ensures that all other elements are correctly referenced to real coordinates. But the most important thing is that GIS allows the elements to be related to each other, enabling a multitude of analyses to be performed between the data, based on either spatial (spatial topology) and/or semantic relationships.

This provides BIM with an endless number of GIS variables (both 2D and 3D) that it did not have previously and which are essential in all phases. GIS has also contributed to facilitating the understanding of the project and its integration into the environment, without limitations of extension and on multiple scales, in the same three-dimensional scenario. This has been the common framework where all of the elements have fitted together: environmental data, results of hydraulic, noise, fauna, expropriation, land registry studies, etc. The scenario become progressively richer as more data has been integrated, all with spatial reference (coordinates), generating a live and virtual model that is being referred to as the 'digital twin'.



GIS tools also provide geospatial analysis capabilities in order to feed the BIM model with data that traditionally has not been taken into account, such as solar radiation and the volume of shadows generated by the infrastructure, which can now be studied, as shown in the upper left image, in which the shadow generated by the E-6 structure for a given day and time can be seen. Above right, the acoustic footprint.

BIM-GIS INTEGRATION ULTIMATELY ENABLES:

- **Enhancement of the BIM model,** so that the dataset and 3D models can interact and relate both geometrically and analytically, what is commonly known as topological data analysis. This means that 3D models (IFC files) coexist with all other data models regardless of their origins, as long as they are properly georeferenced.
- **Visual and intuitive integration of any kind of data that can be spatially referenced:** from engineering models originating from BIM to clouds of LIDAR points, prioritising in the multitude of georeferenced three-dimensional data that is able to coexist within a single scenario, and in turn, in different scenarios simultaneously.
- **Refine the model from the planning phase** or develop alternatives with LOD2, through to later, more detailed phases in the same GIS environment..
- **Application of GIS geospatial analysis tools** to feed the BIM model.
- **Creation of a digital twin.**

THE BIM METHODOLOGY HAS BEEN LINKED TO GEOGRAPHIC INFORMATION SYSTEMS, RESULTING IN LIVING 3D MODELS THAT ARE CONNECTED TO A PHYSICAL ENVIRONMENT, IN WHAT IS COMING TO BE REFERRED TO AS GEODESIGN

ACCESSIBLE THANKS TO A 3D GIS VIEWER

All information is accessible through an online 3D GIS viewer. Customers, technicians, collaborators, contractors or interested users can intuitively consult all of the information of the project by scanning a QR code with a mobile phone, or using the URL and an internet connection via mobile, tablet or computer. The display provides easy and intuitive universal accessibility, making it a new tool for decision making, and also a very powerful communication instrument throughout the different phases of the project.

THIS INNOVATIVE NEW SOLUTION ACHIEVES THE FOLLOWING:

- **Improvement of the technical quality** of the project and the solution as a whole, by making it possible to see what is not normally seen thanks to the digital twin, which contains all of the disciplines that include construction elements. Being one of the first, if not the first project designed with this technology and at this level in Spain, the project is expected to lay the groundwork for the development of future methodologies and standards that can be shared and implemented in other projects.
- **Improved environmental integration** of the project.
- **Exploration of the potential** for the consultation and visualisation of the results through the online 3D GIS viewer for better understanding and consistency of the project.
- **Optimisation of coordination** between the disciplines involved, by having a common information environment in which all of them coexist. This represents a breakthrough in the use of digital collaboration tools and seeks to overcome existing obstacles regarding the exchange of information between the software of each discipline thanks to the use of interoperable formats.

Through this viewer, BIM and GIS democratise and make the project more accessible in a simple, transparent way, and without the need for training or knowledge of the specific software, which will undoubtedly contribute to its implementation in other projects. This accessibility will result in economic and time savings in the transmission of information to the different parties interested in all phases of the design, as well as decision making.

Especially in public investment projects that are of general interest to the public, social consensus is vital from the early stages in order to streamline future administrative procedures. This new behaviour paradigm is consolidated thanks to technological advances, thus generating new mechanisms for public participation. ■

Carmen Librero, president of Ineco, at an event on 12 November with representatives of the three NGOs, the Fundación Lealtad and the first participants in the professional volunteer programme.

Technical knowledge at the service of the most vulnerable

For a number of years now, Ineco has had a professional corporate volunteer programme in collaboration with several NGOs from the Fundación Lealtad: employees put their technical knowledge at the disposal of charitable projects in developing countries in favor of those most in need.

By **África Jiménez**, bachelor's degree in Business Administration, and **Beatriz Vázquez**, economist
Photos: **Elvira Vila**

The highly qualified nature of Ineco's workforce, the company's main asset, has enabled it, in its social action initiatives, to focus on activities in which it can best contribute by providing greater added value and which are also aligned with the organisation's strategy, based on the ongoing improvement of the capabilities of its employees. For a number of years now, Ineco has had a professional corporate volunteer programme in collaboration with various NGOs belonging to the Fundación Lealtad, in which employees put their training and technical knowledge at the disposal of charitable projects in developing countries.

The three projects selected in 2019 will be 100% funded by Ineco and will benefit from the supervision and management of the company's technical teams. They are scheduled for the first half of 2020 and will improve the living conditions of more 22,000 people.

1 INDIA. Construction of a community centre in Rascola/Kudusuru. The project, led by Itwillbe, promotes the creation of a safe place where educational activities for children and training for adults can be carried out to develop the potential of the community. In its first 5 years, the centre will have a positive impact on the lives of more than 300 children and teenagers from several neighbouring villages, reducing division between castes and deterring young people from becoming involved in crime by occupying them with more beneficial activities. Education levels will increase, reducing illiteracy rates and paving the way to secondary education. It will be a safe learning space for boys and girls to develop their talents and skills.

2 SOUTH SUDAN. Refurbishment of a maternity and paediatric ward at Bor Hospital. This is a project led by Doctors of the World, whose team in Bor has identified different needs in the patient, maternity and paediatric wards. Its goals are to improve the essential hygiene conditions of the facilities that are being supported in Bor State Hospital; prevent and control infections; and provide quality medical care to the population. Hygiene conditions (including water, sanitation and waste management), electricity and ventilation are essential for one of the major hospitals of the region. The work will be carried out in parallel with the training of workers in the hospital to ensure proper upkeep of equipment and facilities.

3 HAITI. Improved access to water and sanitation in the Moulin community health centre in Gros-Morne, Artibonite. Led by Cesal, the aim is to contribute to the improvement of the service by renovating the drinking water system, installations and toilets. The need has been identified by Cesal, which has 11 years of experience in Haiti developing several projects related to health and nutrition. This rural health center serves more than 6,000 people in the area.

The action is part of a larger multisector programme funded by the EU which aims to respond to the problem of food and nutrition security by supporting, outfitting and refurbishing six health centres as key elements in the prevention of maternal and child malnutrition and the improvement of comprehensive treatment, with special attention given to support of pregnant women and nursing mothers. ■

In the first edition of Ineco Day, held in June 2019, money was raised for the four charitable microprojects which combined will benefit more than 900 people. In the image, the charity market.

INECO DAY

Hospitalised children, young sufferers of congenital heart disease, refugees and the elderly were the social groups selected by Ineco's employees to receive the funds raised during a charity concert and market held in June.

Recognised for their compliance with the 9 Principles of Transparency and Good Practice of the Fundación Lealtad, with which Ineco has had a cooperation agreement for the last decade, four national and international non-profit organisations have received 3,000 euros each to carry out microprojects. Menudos Corazones, Pequeño Deseo, Entreculturas and Grandes Amigos were the four microprojects selected through a vote among the company's employees. The common thread of the four proposals is that they are aimed at some of society's most vulnerable groups: sick children and teenagers, elderly people living alone but not by choice and refugees.

PHOTO_LIDIA AMIGO / INECO

Wind turbines... not giants

Spain's wind-power sector, ranked fifth in the world in terms of generation capacity and fourth in terms of wind turbine exports, is one of the strongest and most technologically advanced in the world.

By ***ITRANSPORTE***

One of the most famous passages of Miguel de Cervantes' novel comes in Chapter VIII, when Don Quixote encounters the windmills of the plains of La Mancha and attacks them, believing them to be giants, despite the warnings of Sancho Panza. The knight and his steed, Rocinante, come out on the losing end and are dragged by the blades of the windmill.

This is quite the opposite of what has happened to the Spanish wind power sector, which is one of the strongest in the world. Today, the traditional windmills of La Mancha, now major tourist attractions, coexist with more than 20,000 state-of-the-art wind turbines spread over more than 1,100 wind farms across the country, which now produce 19% of the electricity consumed per year in Spain. Generating 23,484 megawatts of power every year, Spain is ranked fifth in the world and second in Europe for installed wind power, although it is not Castilla-La Mancha, but Castilla y León (followed by Galicia) that is the region with the highest installed power. Wind is now the primary source of renewable energy in Spain, and the second largest in the energy mix.

Wind power is produced when horizontal air currents (vertical ones do not have sufficient dynamic energy) move the blades of a wind turbine. This kinetic energy (caused by movement) is transmitted to a turbine, which transforms it into electricity. This passes through a power line to a distribution substation that is part of the grid, and from there to the end user. To be able to install a wind farm, the average wind speed in the area needs to reach at least 21 km/h.

Spain has been a pioneer in the development of wind energy. In April, 1984, it became the second European country after Greece to install a wind farm, located in Garriguella (Girona). This early rollout, together with favourable geographical and weather conditions, has made the Spanish wind power sector one of the strongest and most innovative in the world. Investment in R&D has reached 7.25%, much higher than the national average, and Spain is ranked sixth in the world and third in Europe for wind power patent applications.

And global demand is growing every year: the urgent need to slow climate change, replacing fossil fuel energy sources with clean and renewable energy, and constantly improving wind turbine technology, has fuelled major global growth in the sector. By 2021, the International Energy Agency (IEA) expects that 28% of the world's energy demands will be met by renewable energy sources.

Among these, wind power is number one and already satisfies 5% of the world's electricity demand. Currently, according to the World Wind Energy Council, global installed power exceeds half a million megawatts; in 2017 alone, it increased by 52,573 megawatts, the third largest increase since the record year of 2014. In Europe, wind power now supplies 12% of the continent's electricity and a third of this is produced in Spain

ECONOMIC IMPACT

According to data from the Spanish Wind Energy Association (AEE), Spain's principal wind power industry association, in 2018, the sector contributed 3.39 billion euros, or 0.31%, to Spain's GDP, between direct and indirect contribution, and employed 22,578 people. Consisting of more than two hundred companies present in over 35 countries, the Spanish wind power sector encompasses all of the links of the value chain: from equipment manufacture –there are 207 manufacturing centres in 16 of the 17 autonomous communities– to installation, commissioning and maintenance. The sector's rapidly increasing exports, which in 2018 were worth 2.3 billion euros are particularly notable: Spain is the fourth largest exporter of wind turbines in the world, behind China, Denmark and Germany. ■

CLEAN... BUT NOT HARMLESS

Despite being a 'clean' energy, wind power production is not without its environmental impacts. Indeed, installing a wind farm requires a favourable environmental impact statement from the authorities, which is not always obtained.

On the one hand, the use of wind power reduces polluting emissions –25 million tonnes of CO_2 in 2018, according to the AEE– and reduces the cost of acquiring fossil fuels (1.5 billion euros, the cost of 9.2 million tonnes of oil equivalent).

On the other hand though, wind farms can cause different kinds of environmental problems. The most significant are impact on landscape due to the characteristics of the facilities (machinery at altitude, high locations, large number of devices); acoustic issues (noise); disturbance of land; and especially, the death of birds and bats that fly into the wind turbine blades.

Ecological organisations denounce these impacts while the industry proposes more powerful wind turbines –which could mean smaller numbers– and even bladeless turbines, such as the one being developed by a small Spanish company located in Ávila.

PHOTO_SPANISH WIND ENERGY ASSOCIATION

PHOTO_LIDIA AMIGO / INECO

PHOTO_LIDIA AMIGO / INECO

PHOTO_ESTEYCO

PHOTO_SPANISH WIND ENERGY ASSOCIATION

THE CHALLENGE OF OFFSHORE WIND FARMS

There are two kinds of wind farms depending on their location: onshore and offshore. The latter generate more energy thanks to stronger and more constant winds, but their installation costs are between 30 and 50% higher than onshore farms. At the moment, Spain only has one offshore facility operating in a prototype phase: a 5-megawatt wind turbine called Elisa located off of Grand Canary Island, which began producing electricity in April 2019. There is one major reason for this slow rate of development: the Spanish coastline is too rugged and its waters too deep; it has no continental shelf like other countries such as the United Kingdom, Germany, Denmark and Sweden. Despite this, Spanish companies are still leaders in offshore wind farm technology.

JOSE MARÍA LLORENTE

“2019 has been a record year for emblematic projects”

This civil engineer manages one of the company’s most dynamic departments: some 35 professionals from different disciplines who handle more than 600 bids a year to win projects around the world.

PHOTO_ELVIRA VILA

EXTENSIVE INTERNATIONAL CAREER

At Ineco since 1999, Chema Llorente has a bachelor’s degree in civil engineering from the Polytechnic University of Madrid and a master’s in infrastructure management and financing from the IESE Business School, having also attended its management development programme. Most of his professional career has been spent in the areas of consulting and international business development, where he has been in charge of projects in Kuwait, Jordan and Brazil. Prior to his current position, he was Latin America business director and Europe, MENA and MeDA director.

Ineco’s Tenders Subdivision handles a wide variety of bids both in Spain and abroad covering all areas of specialisation, working under strict deadlines and in close coordination with the company’s engineering, financial, business, legal, purchasing and personnel departments. It is staffed by a results-orientated team and although the work may be stressful and comparable to a roller coaster ride, it is compensated by the fact that each success is celebrated with great solidarity and companionship.

1 IF A PARTNER DROPS OUT A WEEK BEFORE SUBMITTING A BID, DO YOU PANIC?
Not really. We usually lead bids, so we can find compatible partners quickly thanks to our capacity and commercial knowledge.

2 CAN A TIMELY WITHDRAWAL BE A VICTORY?
Yes, because it enables Ineco to avoid bigger problems such as embarking on projects that are complicated in terms of financing or deadlines. It’s always a well-considered and consensual decision in the company.

3 LAST YEAR WAS NOTABLE FOR ITS EXTENSIVE INTERNATIONAL ACTIVITY. WHAT WAS THE RATIO?
The number of tenders has more or less stayed the same in recent years, but apart from the Haramain contract in 2011, we’ve increased in terms of emblematic projects abroad. In this sense, it was a record year.

4 RECENT TENDERS INCLUDE AUSTRALIA, LATVIA, KUWAIT, SAUDI ARABIA AND URUGUAY. WHICH OF THESE ARE YOU MOST PROUD OF?
What makes us most proud is the ability to reach different continents with lots of projects. Australia was particularly satisfying because it involved breaking into a new country with the implementation of the highly advanced ERTMS system.

5 WHICH ONE CAUSED YOU TO LOSE THE MOST SLEEP?
Two particularly stand out for giving me sleepless nights: the first was a project we won, HS2 in the UK, and the other, one we lost, Ho Chi Minh Airport in Vietnam. That said though, I usually sleep well knowing that the team makes every effort possible –sometimes late into the night– on all bids.

6 WHAT WOULD YOU SAY TO YOUNG PROFESSIONALS TO ENCOURAGE THEM TO WORK IN THIS FIELD?
That it is a very interesting area for acquiring knowledge across many different disciplines and in a very short period of time. ■

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