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56

FEB | MAY 16

HIGH-SPEED RAILWAY IN INDIA

How to go from Delhi to Kolkata by AVE

INTERVIEW

Vinay Kumar Singh
Managing director of HSRC

+ ARTICLES

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Rafael Núñez airport (Colombia)
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EDITORIAL

The technological capacity of the Spanish High-Speed Rail (AVE)

In our first issue of 2016 we have made way for news articles and reports regarding major projects that are key to the future of Ineco and other companies from Spain. Both the study for the construction of a high-speed railway between New Delhi and Kolkata as well as the waste management contracts in Panama and Ecuador exemplify the headway made in overseas markets as a result of the years of training, work and rigour that Spanish engineering has brought to fruition in various infrastructure-related fields.

The value of these studies lies not only in their irrefutable technical and financial magnitude, but also –and almost more importantly– in the role they play in the socio-economic development of the countries where they are carried out in addition to the unique, exclusive experience that, having been designed for and applied to the Spanish market, is proving to yield excellent results in countries all around the world.

Although it was only a short time ago that we were strategizing how to export the technological capacity of the Spanish High-Speed Rail (AVE), we can now talk about some real-life examples. We are not only working in Saudi Arabia, United Kingdom and Turkey, but over the last few months, Ineco has also begun to carry out studies for the implementation of this sophisticated rail technology in both Egypt and India. We are backed by more than 30 years of experience –the first high-speed railway in Spain was inaugurated in 1992– a rail network spanning 3,100 kilometres and a series of challenges that we have successfully overcome. The work that we are carrying out in India is featured both on our front page and in an article including an interview with the managing director of the HSRC, the body responsible for the development and implementation of high-speed rail projects in this Asian country.

Tourism and air transport are also activities that carry an important weight in Spain. This is apparent in the record seen by the tourism industry with a total of 68 million visitors in 2015, wherein eight out of ten tourists arrived to Spain via one of the 46 Spanish airports. We are grateful for the participation and opinions of the secretary-general of the World Tourism Organization (UNWTO) in a report covering this topic. The aviation section of this issue also features another article which addresses the technical challenges faced in the design of control towers. Finally, I should like to mention the pages that we have dedicated to the colossal engineering project that spanned the 155 kilometres of the Atlantic Axis, crossing over rugged Galician terrain: 37 tunnels and 32 viaducts highlight the enormity of this project that has now become a reality.

With these and other articles, as well as an updated design, I am certain that we are conveying the high quality standard of Spanish engineering to our clients and readers without neglecting, of course, to inform and entertain. ■

> “We are not only working in Saudi Arabia, United Kingdom and Turkey, but over the last few months Ineco has also begun to carry out studies for the implementation of this sophisticated rail technology in both Egypt and India”

JESÚS SILVA FERNÁNDEZ
President of Ineco

CONTENTS
feb/may 2016

COVER IMAGE: **Ben Brown (www.flickr.com/photos/beenbrun).**

PHOTO_PATIER

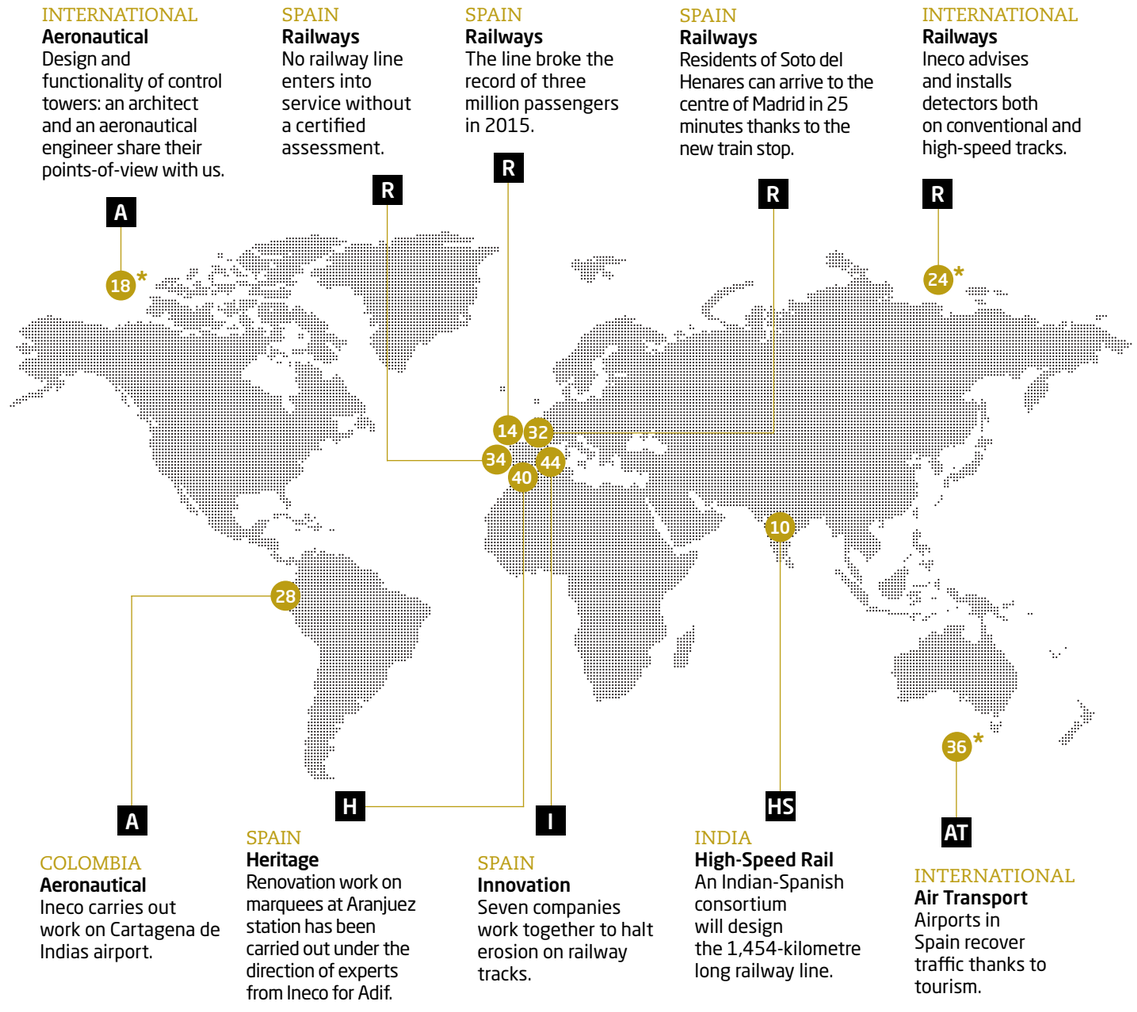
The Atlantic Axis
SPAIN
14

Tourism and air transport
INTERNATIONAL
36

TALEB D. RIFAI
Secretary-general of the UNWTO

Aranjuez station
SPAIN
40

FEATURE ARTICLES
on the map



INTERNATIONAL
Aeronautical
Design and functionality of control towers: an architect and an aeronautical engineer share their points-of-view with us.

SPAIN
Railways
No railway line enters into service without a certified assessment.

SPAIN
Railways
The line broke the record of three million passengers in 2015.

SPAIN
Railways
Residents of Soto del Henares can arrive to the centre of Madrid in 25 minutes thanks to the new train stop.

INTERNATIONAL
Railways
Ineco advises and installs detectors both on conventional and high-speed tracks.

COLOMBIA
Aeronautical
Ineco carries out work on Cartagena de Indias airport.

SPAIN
Heritage
Renovation work on marquees at Aranjuez station has been carried out under the direction of experts from Ineco for Adif.

SPAIN
Innovation
Seven companies work together to halt erosion on railway tracks.

INDIA
High-Speed Rail
An Indian-Spanish consortium will design the 1,454-kilometre long railway line.

INTERNATIONAL
Air Transport
Airports in Spain recover traffic thanks to tourism.

* International article

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RAIL CONNECTION TO LONDON-LUTON

Ineco and Capita are carrying out a study on behalf of London Luton Airport Operation Limited (LLAOL), in which Aena International is the major shareholder, on the different alternatives for a rail connection to Luton Airport, located 56 kilometres outside of London. In response to growth forecasts, the managers of this airport have proposed different alternatives for introducing a train station to the airport terminal. London Luton Parkway Station is currently located about 1.5 km from the airport terminal, meaning that this last leg of the journey must be made by bus. A new direct line straight from the Luton terminal would reduce the journey time to central London from 45 minutes down to just 25.

The project involves studying the different alternatives for a rail connection to the future airport terminal, including the preliminary design, cost analyses and the necessary timeline.

During the first six months of 2015, 5.7 million passengers travelled through London Luton Airport; it is London's fourth largest airport in terms of passenger traffic. Airport traffic has steadily increased over the past year, thus the decision to take on renovation work in order to increase airport capacity.

TURKEY

MODERNISATION OF THE SAMSUN-KALIN RAILWAY

Ineco, the Turkish company UBM and the consultancy Mott McDonald have been awarded the tender to supervise the modernisation of the railway line that operates between Samsun and Kalin. The rail line that runs from the Port of Samsun, on the Black Sea, to the city of Kalin is one of the six railway lines chosen in Turkey to improve connections between the Mediterranean and the Black Sea, to encourage regional transport development and to reduce the rate of road accidents.

Although it is not currently operational, this single-track, non-electrified line reaches a length of 378 kilometres. The updates to be carried out will afford this rail line the electrification and signalling needed to both reduce travel times and increase train frequency. The project entails monitoring and controlling modernisation of the infrastructure, the superstructure and railway line installations. The work to be carried out includes track extensions, tunnel restorations, improvements to platforms and stations, and new signalling systems and safety equipment, among others.

MASTER PLAN FOR COMPREHENSIVE WASTE MANAGEMENT IN QUITO

Ineco, in conjunction with Tragsatec –a technological subsidiary of the Tragsa Group–, will be implementing the Master Plan for Comprehensive Solid Waste Management for the Metropolitan District of Quito (Ecuador). This consultancy work is organised within the framework of the Technical Cooperation Agreement between the Municipal Town Hall of the Metropolitan District of Quito and the Andean Development Corporation (CAF, as per its Spanish acronym). To achieve the goal of establishing a sustainable management system that guarantees efficient and effective services, the following tasks will be carried out: development of waste management models, preparation of a legal framework and a financial analysis of the present situation.

Ineco has a great deal of prior experience in Ecuador, having carried out projects there such as the review and standardisation of the conditions regarding the right to use and harness water for Senagua, as well as audit work on the Pifo-Papallacta Highway enlargement project.

Furthermore, since 2013 the company has been in charge of carrying out Ecuador's Strategic Mobility Plan (PEM, as per its Spanish acronym), which encompasses the entire country and all modes of transport.

PHOTO_JAIME GOLOMBEK (FLICKR)

INECO TO LEAD PANAMA'S WASTE COLLECTION AND TREATMENT PLAN

Last November, the government of Panama entrusted Ineco with its National Plan for the Collection and Treatment of Solid Waste. This strategic plan takes into account the current state of waste collection, treatment and disposal on a nationwide level. The plan will also propose the legal framework as well as the actions required to solve current and future waste management issues in Panama. The contract represents the definitive strengthening of Ineco's role in the area of solid urban waste planning –a project that the company is also carrying out for the city of Quito (Ecuador). According to Miryam Sánchez, the technical director of Environmental and Waste Management at Ineco with 25 years in the sector, "we will draw on the great deal of experience we have in order to develop a 21st century waste management plan".

The company has an office in Panama City where it is also conducting an assessment in addition to developing a proposal for remodelling work on Cerro Patacón –Panama City's landfill.

PHOTO_MATÍAS DUTTO (FLICKR)

THE NEW 'LA PEPA' BRIDGE

Last September, the Constitution of 1812 Bridge –also known as La Pepa on account of the nickname given to the Spanish Constitution of 1812 established in Cadiz–, was inaugurated over the Bay of Cadiz. It is one of the great works of Spanish civil engineering for which Ineco was in charge of environmental management, carrying out all stages of construction while respecting the ecosystem of Bahía de Cádiz Natural Park. The project was drawn up by engineer Javier Manterola and executed by the Spanish company Dragados. This new access road to the capital of the province is, at 3,092 metres, the longest bridge on the entire Spanish road network. Furthermore, it boasts the largest span in Spain, with a main span of 540 metres, and holds second place for the largest height clearance in the world at 69 metres. The structure is divided into four interconnected sections, actually forming four separate bridges. Furthermore, it accommodates two lanes of traffic in each direction and a platform reserved for public transport (bus lane).

In the centre of the photo, the president of Ineco, Jesús Silva, accompanied by the project's Environmental director, Óscar Román, and the project head, José Manuel Cansino.

COLOMBIA

THE MEDELLÍN METRO COMMISSIONS THE SUPERVISION OF 20 CAF TRAINS

Ineco will carry out the supervision and technical management of the design, manufacture and fine-tuning of twenty new trains acquired by the Medellín Metro from the Spanish manufacturer CAF. This new acquisition will represent the manufacture and delivery –both supervised by Ineco– of a total of 36 CAF trains for the Medellín Metro. Ineco began collaborating with the Medellín Metro in 2010 after the Spanish manufacturer CAF was awarded a contract for the construction of the first 13 trains as well as the signalling equipment (ATC) for 26 driver's cabs. The purchase of all of these trains adheres to the Medellín Metro's 2006-2030 Master Plan called Confianza en el futuro ('Faith in the future'), which aims to increase transport capacity and meet the growth in demand.

Ineco has executed inspection work on railway equipment for over 20 years. The company boasts experience in technical assistance for large equipment supply, encompassing wide-ranging sectors including the construction of EMUs, DMUs and new locomotives, as well as refurbishment work on railway equipment, freight cars and auxiliary equipment such as draisines, special infrastructure maintenance vehicles and on-board equipment. Ineco was certified by ENAC (National Accreditation Entity) as a Rail Rolling Stock Inspection Organisation (Type C) in 2003 (see article pg. 34).

SPAIN

NEW OLMEDO-ZAMORA HIGH-SPEED RAILWAY SECTION

Ineco was involved throughout all stages of construction and testing on this 99-kilometre line which has reduced the travel time between Madrid and Zamora by more than 30 minutes. The company worked on the railway installations on this section of the line, including the electronic, new generation signalling control points in Medina del Campo and in Zamora; enlargement of a section of the line in Olmedo; detection systems for falling objects, hot boxes and crosswinds (see report pg. 24). In the photo we can see the Ineco signalling team working on a section of the Olmedo-Zamora line in the municipality of Toro last summer.

SPAIN

EXCELLENT PROGRESS FOR THE TENERIFE TRAM

The Tenerife Metropolitan Company (Metrotenerife), in which Ineco is a shareholder, is progressing due to a growing demand with an annual growth rate of 2.15%. After seven years in service, the Tenerife tram was on the verge of reaching 100 million passengers, ending 2014 with a record high of 99,262,891 total commuters.

The company's main commitments have been quality, timeliness and accessible mobility in addition to their new mobile app: Vía-Móvil (Mobile Track). During its first year of service, the mobile app was used over a million times by 14,000 users and was downloaded more than 30,000 times.

ABU DHABI AIRPORTS (ADAC) COMMISSIONS INECO TO CARRY OUT EXPANSION WORK ON FUJAIRAH AIRPORT

PHOTO_GEOFF POUND (FLICKR)

Ineco is managing and supervising the expansion work being carried out on Fujairah Airport in the United Arab Emirates alongside its partner PMDC (Project Management and Development Consultants). The project awarded by Abu Dhabi Airports (ADAC) will be carried out over a period of three years; the contract includes enlargement of the current runway as well as construction of a control tower, a taxiway, an electrical substation, a fire station and new navigation aids.

The Emirate of Fujairah presently finds itself immersed in a plan for tourism development in the region, in which the airport's expansion plays a key role. In addition to this project, Ineco has also been in charge of the Operational Readiness and Transfer (ORAT) of the new Abu Dhabi international airport terminal infrastructure, the Midfield Terminal Complex, alongside Aena since 2014. The company has also had the support of a branch office in Abu Dhabi since 2014 which attends to the UAE as well as to the rest of the countries that make up the Gulf Cooperation Council (GCC).

INTERNATIONAL

TRANSPORT INFRASTRUCTURE OPPORTUNITIES

During the final quarter of the year, Jesús Silva and José Manuel Tejera invited the minister of Transport of Madagascar, Jacques Ulrich Andriantiana, and the minister of Public Works of Jordan, Sami Halaseh, to the Ineco offices.

In late November, the president of Ineco, Jesús Silva, and the managing director of Infrastructures and Transport, José Manuel Tejera, travelled to Thailand, Malaysia and Singapore to meet and speak with several transport authorities about the Spanish company's experience. These three countries are currently developing ambitious projects regarding urban transport, high-speed rail lines -such as the future Kuala Lumpur-Singapore link- and airports, such as the expansion of Changi Airport, all of which Ineco is working on (see *IT52*).

The president of Ineco additionally took part in a meeting with Infrastructure and Transport ministers from both the SICA (Central American Integration System) and Spain. The meeting was held in October in Madrid and was chaired by Ana Pastor, the Spanish minister of Public Works.

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How to go from New Delhi to Kolkata by AVE

The government of the Republic of India has entrusted to the Ineco-led consortium, in which the engineering company Typsa and the Indian consultancy ICT are participating, the project of the new high-speed corridor between Delhi and Kolkata.

With the collaboration of **Félix Zapata** and **César Pérez,** civil engineers

Spanish engineering and its 3,000 kilometres of AVE has made an impression on the country with one of the most extensive rail networks in the world. A team of engineers and experts from Ineco, Typsa an ICT have been working since 2015 on examining down to the last detail the feasibility study for the future high-speed line that will connect the capital New Delhi with Kolkata.

After years of postponed initiatives, the current government –the National Democratic Alliance (NDA)– led by Prime Minister Narendra Modi, has given a definitive push to implement the high-speed line between its four main cities: New Delhi, Kolkata, Mumbai and Chennai. These four metropolises together have a population of 55 million people in a country with 1,276 billion inhabitants (one sixth of the world's population). New Delhi has a metropolitan area of around 17 million inhabitants, Mumbai, 18, Kolkata, 14, and Chennai, formerly Madras, around 6 million.

Modi has made the industrial development of the country the central focus of his mandate, represented by the 'Make in India' campaign, which aims to promote internal production and reduce dependence on foreign countries. To stimulate his economy, the construction of infrastructure, particularly railways and roads, are crucial. Since his arrival to the government in summer 2014, the Prime Minister has implemented the Diamond Quadrilateral Program, a diamond with four corners, which includes the cities of New Delhi, Kolkata, Mumbai and Chennai, separated by more than 1,000 kilometres and connected by modern rail infrastructure: the seed of India's future high-speed network. The project of this corridor covers 14 states and will serve as an economic driver as well as contributing to rejuvenate the country's very old rail network, in which every day 18,000 trains operate, around 23 million passengers travel and around 2.6 million tonnes of goods are transported.

> THE CURRENT GOVERNMENT HAS GIVEN A DEFINITIVE PUSH TO IMPLEMENT HIGH SPEED IN THE COUNTRY

Although trains are the mode of transport most used in India –the country is literally knit together with a network of 64,460 kilometres– modernisation of its infrastructure and improved travel times and safety are issues that need to be resolved, which new investments aim to remedy.

Ineco was helped in the awarding of this tender by the support and commercial coordination of the Spain Business Overseas office in India. From New Delhi, its delegate Pedro Sinués has remarked that "the ability and technical experience of Spanish companies has allowed them to achieve the Diamond Quadrilateral tender, which has placed India on the international high-speed map". "Proof of it –added Sinués– is that the consortium led by Ineco competed against 11 other international consortiums. As such, it becomes more important that two Ineco-led Spanish companies can apply their knowledge acquired in Spain to such an emblematic corridor (connecting what was the capital of India until 1911 with the current capital) and it is important in the socioeconomic structuring of the country".

The study, commissioned by the state company High Speed Rail Corporation of India Ltd. (HSRC), includes demand studies; prior analysis of route alternatives; calculation of journey times; selection

VITAL TRANSPORT
Trains are the mode of transport most used in India, with a network of almost 65,000 kilometres. The image shows the New Delhi station.

PHOTO_ **PEDRO SINUÉS**

of rail technology to implement (track gauge, track superstructure, electrification, communications and safety installations, etc.); necessary special works; regeneration and resettlement of affected populated areas; environmental analysis; rolling stock and operation and maintenance. Lastly, an economic-financial analysis will be carried out that will be used to determine the feasibility of the new line as well as the most adequate method of funding. The amount awarded is over two million euros and the execution period is one year.

THE AMOUNT AWARDED IS OVER TWO MILLION EUROS AND THE EXECUTION PERIOD IS ONE YEAR

The length of the corridor is around 1,500 kilometres and it passes through cities of great commercial, social and touristic interest, such as New Delhi, Agra (the city of the well-known Taj Mahal), Aligarh, Kanpur, Lucknow, Allahabad, Mughal, Varanasi, Sarai, Patna, Gaya, Dhanbad, Asansol, Durgapur and Kolkata. The line runs through quite a flat area, near the river Ganges, and crosses various rivers and streams, which will require the design of viaducts.

For Félix Zapata, technical director of the project and Ineco engineer, "the work basically consists of analysing the feasibility of its construction, bearing in mind its financial cost and the social advantages that it will bring. Furthermore, we will offer the most appropriate financial model for its implementation". "The works –adds Zapata– are aimed at achieving speeds and levels of comfort and safety within the modern high-speed standards. For this purpose, we will propose the most appropriate rail technology: type of track (ballast, slab track), electrification, communications and safety installations, rolling stock, specifications for the operation and maintenance of the new high-speed line, etc."

The extensive Indian rail network has great potential and its own industry, but also many challenges: only 33% of its network is electrified, there are few fibre optic networks, they lack enclosure, stations do not have ticket purchasing systems or safety controls, etc. The project includes adaptation of the current stations to high speed or, failing that, the proposal of the location and preliminary design of new stations. As such, the construction of rail infrastructure with the characteristics mentioned previously will be a very important advancement in the Indian rail network.

In 2014, Ineco conducted a feasibility study on the high-speed rail connection between Haldia and Howrah for Indian Railways, a study carried out with the Spanish companies Ayesa and Prointec, which is part of the projects planned in the Diamond Quadrilateral. Furthermore, in 2009, Ineco provided technical assistance for the works of the Mumbai metro.

1

1
From left to right, Rahul Jain and Pedro Sinués, from Spain Business Overseas; and Félix Zapata and Javier Sancho, from Ineco.

2
The sacred city of Varanasi is one of the destinations through which the line will pass.

3
View of the traffic in the centre of Kolkata, the former capital of India.

4
Diamond Quadrilateral Network: a diamond with four corners consisting of the cities of New Delhi, Kolkata, Mumbai and Chennai. This is the seed of the future high-speed network of India.

PHOTO_PARTHA SARATHI SAHANA (FLICKR)

2

PHOTO_LORENZO (FLICKR)

3

4

VINAY KUMAR SINGH

"Our technicians were impressed by the high quality of maintenance of the Spanish network"

He is one of the heads of HSRC (High Speed Rail Corporation of India Ltd.), the governmental organisation for the development of high speed in the Asian country.

What do you think Spanish technology and experience can bring to our corridor?
I am sure that, under the leadership of Ineco, a Spanish public company with extensive experience in different HSR systems, the consortium will do a fantastic job. I wish them every success in their endeavors. Furthermore, during our visit to Spain in September 2014, we noted that several different systems and technologies had been used to develop the Spanish High-Speed Rail system network, which is the second largest in the world. This knowledge will allow Ineco to provide us with comparative analyses and conclusive technical recommendations.

A RAIL EXPERT
A civil engineer with more than 15 years' experience in the sector, he has held positions as a director at Rail Vikas Nigam, the Ministry of Railways, Indian Railways, Piedmont & Northern Railway and Delhi Metro Rail Corporation Ltd. In the image, beside José Manuel Sáez, Account manager at Asia and Africa of Ineco.

What was your impression from the visit?
I believe that it was a great success. Our technical experts could see various technologies at work, used to create HSR infrastructures and operate HSR trains. The most interesting things were the gauge changing train, the different traction systems and the signalling and train control systems. The delegation was also impressed by the high-maintenance quality of the tracks and rolling stock.

Coming back to the project, what is the current service level of the existing line between Delhi and Kolkata?
The passenger trains between Delhi and Kolkata currently run at 120-130 km/h. There are various classes on offer to passengers, including First Class Air Conditioned, Two-tier Air Conditioned Sleeper, Three-tier Air Conditioned and the Three-tier Non-Air Conditioned Sleeper, as well as a general, non-reservable class. There are about 17 trains each way every day, which carry around 900-1,400 passengers each.

What kind of comfort levels and technical standards is HSRC currently considering for the new high-speed rail lines?
HSRC is a project development agency whose technical standards are determined by the Ministry of Railways. As part of Indian Railways, there is a specific organisation called Research, Design & Standards Organization (RDSO) which is helping to improve technical standards. Nonetheless, this contract includes a comparative study of the different technologies available on the international market. The most important areas include civil engineering structures, rail tracks, traction systems, the power supply system, the control system, signalling, telecommunications, rolling stock and automatic fare collection technology. The railway tariffs in India are highly subsidized.

In your opinion, what are the challenges involved in introducing high-speed rail lines with speeds up to 250km/h?
Constructing a new high-speed rail line will bring many challenges. For HSRC, the most complex task will be securing funds, acquiring land and completing the project on time. In any case, the study's conclusions and recommendations will have a big impact on this question's answer.

The number of passengers in India will continue to grow –will the Diamond Quadrilateral project address this growth? Or at the very least, will the project reduce traffic congestion?
The HSR lines will really boost the existing network's passenger capacity, as the operation will be a lot faster, with more passenger trains that will probably be more frequent. This will allow for a reduction in traffic congestion, not only on the railway network but also on the roads.

What kind of economic growth do you expect this new line to generate?
Historically, Kolkata has been a very important port city for eastern India. Nowadays it is the capital of the state of West Bengal. It was the capital of India for a short while, before the country gained independence. Linking Delhi to Kolkata via HSR will give an extra economic boost to an already economically important region. ■

Passengers give the 'thumbs up' to the Atlantic Axis

The new railway line that connects A Coruña to Santiago and Vigo has set a record for regional rail lines in Spain by exceeding three million passengers over the past year. From the beginning, Ineco has worked on this infrastructure which has breathed new life into rail transport in Galicia.

By ***ITRANSPORTE***

With more than three million travellers in 2015, according to data from the Ministry of Public Works, passengers have given the 'thumbs up' to the Atlantic Axis, a railway infrastructure designed for speeds of up to 250 km/h. The renovation, electrification and duplication of existing routes in addition to the construction of new bypasses and several viaducts, bridges and tunnels have made it possible to transition from the old, non-electrified single tracks to high-performance rail infrastructure: greater speeds, capacity, safety, frequency and comfort for passengers who save up to 58% in travel time. In addition to making renovations to the rolling stock, Renfe has also maintained fares and reorganised rail services which are now divided into "express" and "local" services to cover direct routes between large cities as well as between the urban centres near these cities.

Ineco collaborated in the execution of these projects which have revitalised railway transport in Galicia. According to data from the Railway Observatory of the Ministry of Public Works, the A Coruña-Santiago route is one of the top five regional rail lines for traffic in all of Spain. The Businessmen's Association of Galicia (Círculo de Empresarios de Galicia) considers that the growth in traffic along this route –a growth of more than 90% between 2008 and 2013– is "a fact that must be directly attributed to the improvement in infrastructure and the implementation of a high-performance rail line on this route of the Atlantic Axis".

In April 2015 the Santiago de Compostela-Vigo section was inaugurated –the third of the three sections that make up the majority of this route which represents a milestone in the modernisation of the Galician railway. The territory of this region is characterised by a great dispersion of populated areas: few big cities –concentrated in costal areas–, many small, isolated areas –especially inland– and very rugged terrain. In addition to these characteristics we can also mention the natural geographical barriers that separate Galicia from the Meseta –barriers that have historically stood in the way of constructing land transport infrastructures, both road and rail.

A FAR-REACHING PROJECT

The Axis, spanning 155 kilometres, runs along Galicia's Atlantic Coast and connects the main areas of industrial and economic activity as well as universities, areas which fuel the demand for transport. The pre-study phase is already underway for the connections A Coruña-Ferrol (63.2 km) to the north of the Axis, in

RECORD NUMBER OF PASSENGERS
With more than three million travellers in 2015, according to data from the Ministry of Public Works, passengers have given the 'thumbs up' to the Atlantic Axis, a railway infrastructure designed for speeds of up to 250 km/h.

PHOTO_ RENFE OPERADORA

PHOTO_ RENFE OPERADORA


PHOTO_ RENFE OPERADORA


PHOTO_ RENFE OPERADORA

To the left: Atlantic Axis passengers arriving at the Santiago station. Above the text: 3D computer-generated picture of the Arcade station. Centre: the interior of a 599 series regional rail line train. Below: load tests being carried out on the Ulla river viaduct. On the next page: map of local train service.

addition to Vigo-Border of Portugal (22.1 km) in the far south of Galicia. The route also connects Santiago with Ourense in the east where this section links up with the high-speed access route to Madrid which is currently under construction.

Initial work on the transformation of existing infrastructure into a modern, high-performance, rapid railway corridor began in 2002. Work was carried out in phases and consisted in installing, along the entire route, a double track with multi-purpose sleepers that will later allow for the change from the Iberian gauge to the standard gauge. The line has also been electrified to 25 kV at 50 Hz, and bypasses have been constructed which have shortened the route by almost 22 kilometres. New sections of the line, owing to the land's rugged terrain, required several structures: 37 tunnels –totalling a distance of more than 60 kilometres– and 32 viaducts that span a total of 14.9 kilometres. The majority of these structures are located along the section between Santiago and Vigo. This was the most complex part of the route to construct and was the last to begin operating, following both A Coruña-Santiago in 2009 and the Santiago-Ourense connection in December 2011.

INECO HAS WORKED IN CONSTRUCTION & ENVIRONMENTAL MANAGEMENT & MONITORING, PROJECT DRAFTING, INSPECTIONS & STRUCTURAL TESTING

In addition to the work concerning electrification, platforms and route corrections (bypasses), adapting the line to new, high speeds also required the remodelling of stations at A Coruña, Santiago de Compostela, Pontevedra, Uxes, Villagarcía de Arousa and Arcade-Apeadero, as well as the construction of new stations: Cerceda-Meirama, Ordes, Padrón-Barbanza, Redondela High Speed and Vigo-Urzáiz, as well as the "temporary" Vigo-Guixar station.

INECO ON THE ATLANTIC AXIS

Throughout these years, Ineco has offered their services to the Ministry of Public Works, Renfe and Adif in these highly technical and complex activities, just as they did for the rest of the rail network. Ineco was thus responsible for carrying out tasks regarding the management, coordination and surveillance of construction work, the environmental management of different sections along the whole of the Axis, and the drafting of architectural plans (stations) and railway installations (signalling, safety, telecommunications, etc.). The company also conducted a number of studies in addition to inspections and structural load tests, some as exceptional as that of the Ulla viaduct (see *IT*54).

Ineco furthermore provided assistance in the management and coordination of tunnel construction work, such as the Vigo access tunnel measuring 8,266 metres long which was carried out using tunnelling machinery, and in the installation of safety systems: electrical installations, ventilation, fire protection systems, etc.

Also worth mentioning in relation to architectural work is the drafting of the construction project for the Vigo-Guixar station which, starting in 2011, has operated as the sole station following demolition of the old building while the new terminal was constructed (in the same location). The Guixar station is a two-storey passenger building boasting 1,000 square metres of space, three platforms measuring 285, 165 and 100 metres long for long-distance and regional rail trains, parking, and bus and taxi stops. When the new Vigo-Urzáiz station began operating in 2015, the Ministry of Public Works decided to keep the Guixar station open to freight transport as well as to local trains.

Ineco also carried out a project, completed in 2010, to standardise architectural elements such as marquees, enclosure gates, decorative elements and locks at nine stations: Redondela, Pontevedra, Padrón, Ordes, Cerceda, Uxes, Pontevedra-Universidad, Arcade and Vilagarcía de Arousa. New passenger buildings were also designed for the latter two stations.

THE 155-KM LINE HAS REDUCED THE AVERAGE TRAVEL TIME BETWEEN A CORUÑA AND VIGO BY 58% AND IS ONE OF THE MOST WIDELY TRAVELLED ROUTES IN SPAIN

With regard to new sections of the line, Ineco coordinated the construction of the Ordes bypass in the province of A Coruña, a section that, over a span of just 7.2 kilometres, required two tunnels and a handful of viaducts. The Vilagarcía-Padrón bypass located between Santiago and Vigo stands out for its complexity, reaching a length of 26.1 kilometres. The company provided technical assistance throughout the management of construction work as well as during the environmental management, control and surveillance of several subsections. The bypass was one of the corridor's most complex sections with seven tunnels and a dozen viaducts, including one which crosses the Ulla river (spanning a distance of 16 kilometres) and another that crosses over the Sar river –the longest on the Axis- measuring 2.4 kilometres.

Ineco also played a role during each of the phases of development of another high-performance railway connection: the line which links the Atlantic Axis to Ourense from Santiago (see *IT*18 and 44). The company was highly involved in all of the stages of development of this 150-kilometre section of the line, from project drafting to drawing up operations and maintenance plans, as well as during the construction phases including construction and environmental management services, technical assistance, surveillance and coordination services, etc. Since it entered into service in December 2011, the Santiago-Ourense corridor has also contributed to improving railway connections with the Meseta by reducing existing conventional service travel time by 50 minutes. ■

SERVICES OFFERED

▶ **Express services:**

TRAINS: S-121 of the Avant series (regional rail lines).
STOPS: A Coruña-Santiago de Compostela-Vilagarcía de Arousa-Pontevedra and Vigo, and stops at the new stations of Padrón-Barbanza, Redondela AV and Arcade.
SEATING CAPACITY: 50% increase from 185 to 282 passengers per train.

▶ **Local services:**

TRAINS: diesel engine railcars of the 599 and 596 series (regional rail lines).
STOPS: the different trains stop at the following stations: Uxes, Cerceda-Meirama, Ordes, Osebe, Padrón, Pontecesures, Catoira, Portela, Pontevedra-Universidade Vilagarcía de Arousa, Arcade, Cesantes, Redondela-Picota and Redondela Pontevedra, Santiago de Compostela and Vigo-Guixar.
SEATING CAPACITY: 40% increase.

Source: *Ministry of Public Works and Renfe*

ATLANTIC AXIS FACT SHEET

▶ **Total operating distance:** 155.6 kilometres (A Coruña-Vigo), 21.8 fewer kilometres than before construction work.

▶ **Track:** Iberian-gauge double track with multi-purpose sleepers, adjustable to the standard gauge.

▶ **Electrification:** 25 kV at 50Hz alternating current.

▶ **Signalling system:** originally the digital ASFA system (Automatic Braking and Announcement of Signals) was used. In July 2015 Adif commissioned a temporary business association (UTE in Spanish) to carry out the installation and maintenance of the European Rail Traffic Management System (ERTMS) for the next 20 years.

▶ **Maximum train speed:** 250 km/h.

▶ **Reduction in travel times:** 58% average decrease: A Coruña-Vigo, between 80 and 95 minutes depending on the train, compared to 120 minutes before construction work was carried out; Santiago-Vigo, 55 minutes (95 minutes pre-construction), and Vigo-Pontevedra (15 minutes, compared to 36 before).

Source: *Ministry of Public Works, Adif and Renfe*

All under control

In these pages, the architect Bruce Fairbanks and the aeronautical engineer Roberto Serrano reflect on the types of control towers. They are both professionals, experts in aeronautical projects with more than 20 years' experience, and they offer us their personal approach in different but complementary disciplines.

ARCHITECT VS. ENGINEER
Bruce Fairbanks and Roberto Serrano in the offices of Fairbanks Arquitectos, located on Gran Vía, in Madrid.

BRUCE FAIRBANKS
His work is characterised by the search for architectural expressiveness through the meticulous integration of functional elements and construction systems from the start of the design process. In Spain, he has designed the control towers for the airports of Madrid, Málaga, Barcelona and Santiago de Compostela, amongst others. He has also designed five control towers in Algeria, and the control tower for Bogotá airport.

ROBERTO SERRANO
Since 2000, he has been working for Ineco in the airport building area, from which he has participated in enlargements of almost all airports in Spain (Madrid, Barcelona, Palma de Mallorca, Menorca, Valencia, Girona, Jerez, Ibiza, Santander, Málaga, Gran Canaria, etc.) and has carried out different types of projects in the airports of Odessa (Ukraine), Montego Bay (Jamaica), Cartagena de Indias (Colombia), Tikrit (Iraq), Kastelli (Greece) and Chiclayo (Peru).

PHOTO_ELVIRA VILA

BRUCE FAIRBANKS

"To create a unique symbol for each place"

Bruce Fairbanks, founder of Fairbanks Arquitectos, has accumulated extensive experience in the design of airport buildings since 1996 when he won the tender for the construction of the Madrid-Barajas control tower.

Presently in the world of airports there is a trend to promote the control tower as a symbol, an image that represents the airport and a reference point for the arrival in, and departure from the city where it is located. This trend has created increased interest in architectural execution in the design of control towers in addition to their functional requirements. It is precisely the individuality of these requirements that significantly affects the type of building, such that throughout history there are various examples of "types" of tower designs, which, once designed, were repeated in various airports: one notable case is the leoh Ming Pei control tower. It was designed between 1962 and 1965 with the objective implementation in 70 airports, although in the end 16 were built. The concept of locating in upper levels strictly that which was necessary was developed, putting the maximum amount of functions in the base building, which was adapted to the specific characteristics of each location. As such, the tower could be prefabricated and repeated with standardised equipment, giving the airport network an image of safety since a controller could work in any location without having to adapt. The tower was designed with 5 standardised heights (18-46 m) in accordance with visibility requirements in each location. The control tower's cab is pentagonal so there are no parallel façades and so as to avoid reflections. In Spain, in the 1970s, Juan Montero Romero, an aeronautical engineer, built a tower, which was repeated in several cities: Málaga, Alicante, Valencia, etc.

Converting control towers into airport landmarks and reference points for cities is a challenge in the work of an architect: creating a symbol, always unique for each location, which meets all of the requirements for the optimal functioning of the tower. The location, the height of the control room, its form and the layout of its structural elements are some of the first elements to define. Control towers typically have a base building and a shaft that supports the upper floors, which are designed to adapt to the control operations. Given the form, with an upper part and a lower part and the height of the type of building, in my opinion it is essential to incorporate the construction process into the design of the tower, and this is what I have done in those which I have designed. This design comes from an analysis of the functional aspects, the programme and the location. To create a landmark, the architect must find within the functionality the characteristics that can distinguish one tower from others and strengthen them to create a unique tower with its own character in each case.

> "TO CREATE A LANDMARK, THE ARCHITECT MUST FIND WITHIN THE FUNCTIONALITY THE CHARACTERISTICS THAT DISTINGUISH ONE TOWER FROM OTHERS"

ANALYSIS OF FOUR CASES

THE FOLLOWING EXAMPLES OF CONTROL TOWERS SHOW DIFFERENT CONCEPTUAL APPROACHES TO DESIGN THIS BUILDING TYPE AND THE ELEMENTS THAT DIVERSIFY ITS DESIGN.

PHOTO_ ANDREW NASH

1962. DULLES AIRPORT, WASHINGTON DC.
EERO SAARINEN
The Dulles tower has all of the equipment rooms at a height, elegantly assembled by Saarinen with two juxtaposed bodies. The form of the tower is integrated with that of the terminal building, also designed by the same architect.

PHOTO_ TOM BALLARD

1992. JFK AIRPORT, NEW YORK
PEI COBB FREED & PARTNERS
The upper part of the JFK tower, 97.5 metres in height, contains only the aerodrome control cab and half way up the shaft there is the platform control room, which takes the same form as the upper levels.

PHOTO_ BRUCE FAIRBANKS

1997. ADOLFO SUÁREZ MADRID-BARAJAS AIRPORT
BRUCE FAIRBANKS
The Adolfo Suárez Madrid-Barajas control tower had the specific feature of a 400 m^2 equipment room located at a height. To resolve the transition between the shaft of the tower and the projection, an inverted half sphere was adopted, with a floor for air conditioning equipment being inserted in the support. The octagonal shape defined for the cab is extended throughout the top of the building, the structural design of a central column and 8 perimeter columns is repeated on all levels. Another particular feature of the tower is the construction system designed as an integral part of the design. The shaft is built with prefabricated segments assembled in spirals, which, on the inside, contain the service ducts and circumscribe the emergency stairway. The upper floors were built with a metallic structure on the floor and subsequently hoisted onto the shaft. The system allowed the tower to be built in nine months, without using scaffolding.

PHOTO_ JAVIER AZURMENDI

2004. BARCELONA-EL PRAT AIRPORT
BRUCE FAIRBANKS
The functional requirements were similar to those of Barajas, with the exception that a large part of the equipment is located in the base building. The resistant structure is defined independently from the functional elements of the shaft, which was developed as a representative design element. An eight-pointed hyperbola generated from the octagonal shape of the cab holds the upper floors. The hyperbola links the tower with Catalan Modernism and Antoni Gaudí, who used this form in many of his designs, including on the domes of the Sagrada Familia. The construction system is a representative part of his design. The assembly of the hyperbola, built with prefabricated concrete girders, was guided by a central aluminium structure designed to contain the elements of the shaft. The upper floors were built on land and hoisted into position, supported by the eight points of the hyperbola, consolidating the whole structure when it was under load.

ROBERTO SERRANO

“In the future, it will not be necessary to view operations”

Roberto Serrano has participated in more than 50 aeronautical projects, amongst them, the NET and SAT control towers of Madrid-Barajas airport and the new control tower of Eldorado airport (Bogotá).

Although the first control towers date back to the 1920s (in 1921, Croydon airport in London was the first in the world to introduce air traffic control), it was from the 1930s that they became commonplace, due to the fact that growing aircraft traffic made controlling and managing it necessary. At that time, in which technology was nothing like the current systems, the need to visually supervise aeronautical operations around the airport was met by placing the control room (cab) in an elevated and predominant position of the airport (control tower).

To date, the first steps in designing a control tower involve establishing its site and the height of the cab. Internationally, to meet the viewing requirements from the cab, the recommendations of the Federal Aviation Administration (FAA) are applied. The optimum height and location of a control tower is the result of weighing up many considerations. The view from the cab requires the air traffic controller to be able to distinguish the aircraft and vehicles that circulate in the manoeuvring area, as well as aircraft that fly over the airport, particularly in take-off and landing paths. The objective is to have the maximum visibility possible and avoid the sun, external light sources and reflections from adjacent buildings affecting the visibility of the controller.

With regard to the location, we must consider the potential effects of local weather: flood areas or areas susceptible to fog. Its compatibility with the potential future development of the airport must also be studied, thereby avoiding the need to relocate the tower before the end of its life cycle. Insofar as possible, the tower and its buildings should be located on the landside of the airport, thus avoiding access through the airfield and facilitating the entry of staff. Furthermore, the location should be such that it does not affect the quality of the signals of the airport’s radio navigation aids (ILS, VOR, DME, etc.), or communication systems. The minimum height required for the control tower can be obtained with the aid of the FAA visibility analysis tool, ATCTVAT (Airport Traffic Control Tower Visibility Analysis Tool), in accordance with the physical conditions of the airport.

> “NOWADAYS, TECHNOLOGY ALLOWS A PRACTICALLY BLIND LANDING”

Once the position and height has been determined, the infrastructure is designed, and generally includes a cab and an antenna field, which, located on the roof of the cab, normally has communications antennas, radio relays, and other electronic and lightening protection elements. Furthermore, there are areas for staff, equipment, power, air conditioning, etc.

In an era in which technology provides information to pilots to allow a practically blind landing, is it necessary to keep air traffic controllers in a high position so they can see these operations? In the future, air traffic control rooms will probably be in buildings that are more similar to those of offices or air traffic control centres than the current towers. ■

THE FUTURE HAS ALREADY BECOME REALITY

PHOTO_ **SAAB**

PHOTO_ **SAAB**

2015. CONTROL TOWER OF ÖRNSKÖLDSVIK AIRPORT, SWEDEN
Recently, Örnsköldsvik airport in Sweden replaced its control tower with high-tech cameras. Signals are sent to controllers stationed in Sunvsal airport, located around 150 kilometres away, from a 25-metre mast with 14 high-definition cameras. The high performance of these cameras eliminates blind spots, provides information in rain, fog or snow and, along with a whole series of weather sensors, microphones and other devices, it allows controllers to feel as if they were beside the runway. The Swedish Transport Agency approved remotely operated towers on 31 October 2014. Six months later, the first airplane landed in Örnsköldsvik airport using the remote tower services.

Whistle-blowers on the track

Falling object, crosswind and fire detectors and even sand and snow detectors. These small devices installed on the track are critically important for rail security. Since the 1980s Ineco has carried out their design, planning and installation assistance both on conventional and high-speed lines.

With the collaboration of **Mª Teresa García**, telecommunication engineer, **Francisco Perrino** and **Pedro Acosta,** industrial engineers

The performance of a rail line may deteriorate for various external reasons that result in the slowing down, or, on occasion, the stoppage of trains. Therefore, in order for trains to circulate in optimum conditions of safety and comfort, it is necessary to implement complex detection systems that provide an alert for each event in real time.

The reliability and safety of the detectors is fundamental since they avoid external circumstances such as the fall of an object or the detachment of a slope putting rail traffic in danger. In short, these indicators at all times supervise the conditions of the alignment and infrastructure, the environmental conditions and the state of trains, and they also inform the control centre so that the appropriate measures are taken in the operation of the train.

The commissioning in Spain of around 3,000 kilometres of high-speed rail –the second in the world in terms of length after China- has made Spain a leader in the use of detection systems and technologies. Since the 1980s Ineco has been carrying out risk analyses, planning the installation of working equipment and applying regulations. Furthermore, Ineco collaborates with

> THE COMMISSIONING IN SPAIN OF AROUND 3,000 KILOMETRES OF HIGH-SPEED RAIL HAS MADE SPAIN A LEADER IN THE USE OF DETECTION SYSTEMS AND TECHNOLOGIES

technologists, clients and suppliers in the development and analysis of systems to be installed in each line, as well as supervising them.

The aim of the installation of these systems is to adapt train traffic to the conditions of the environment, protect the alignment from damage and correct tendencies that affect the quality of the service through dynamic preventive maintenance.

In Spain they are patented products that are normally approved by the Government. As such, Adif has approved products and patents of some subsystems such as field elements of falling object detectors (patent no. 200402885 and no. 200500650), and crosswind detectors (patent no. 200800322).

In addition to the auxiliary detection systems themselves, there is other equipment that is in charge of assembling all of the information supplied by each track detector. This assembling equipment is normally installed in the technical buildings associated with signalling control points and its function consists of receiving, assembling, processing and sending the information of each detector to Control and Regulation Centres (CRC) and to the Traffic Control Centre (TTC) to be monitored.

MAIN AUXILIARY DETECTION SYSTEMS

1

2

3

4

1. Hot Axle Box and Hot Wheel Detector (HABD/HWD)
Track sensors that supervise the temperature of train axles and brakes.

2. Dragging Equipment Detector (DED)
They are installed at strategic points of the track and their main function is to monitor that no element is hanging from trains that may affect the infrastructure.

3. Vehicle Fall Detector (VFD)
Falling object detectors in the tunnel detect when an object falls onto the track and they report automatically. Below, the configuration of a hot box detection system installed on high-speed lines in Spain.

4. Crosswind Detector (CWD)
A crosswind control system in a lattice tower. Its main function is to monitor the speed and direction of the wind in each zone.

▶ **Vehicle Fall Detector (VFD).** Its main function is to detect when an object falls onto the track. It is installed on overpasses and tunnel exits; if something is detected, it automatically notifies the signalling system to order the immediate detection of the train. Furthermore, the detector notifies the Control and Regulation Centre (CRC) and the Traffic Control Centre (TTC).

▶ **Fire Detection System (FD).** It is installed in long tunnels and its function is to monitor the temperature at each point of the tunnel, detect sources of heat and even fires. Currently, gas detectors are installed both to detect a hypothetical fire and high levels of CO and NOx (generated by diesel trains) that could affect the health of the tunnel maintenance staff.

▶ **Crosswind Detector (CWD).** It is installed in strategic points of the line; its main function is to monitor the speed and direction of the wind in each zone so the speed of trains can be adjusted to the prevailing wind conditions at any given moment.

▶ **Snow Detection System (SD).** It is installed close to the track, normally at high altitudes and it monitors snow cover, automatically notifying agents of the control centre in cases in which snow cover may affect the speed of trains.

▶ **Dragging Equipment Detector (DED).** It is installed in strategic points of the track and its main function is to monitor that trains that circulate on the line do not carry any hanging elements that may affect the infrastructure (normally elements that can hit sleepers or other elements on the track). In this case the system automatically informs traffic agents in order to immediately detect the train.

▶ **Flat Wheel Detection System (FWD).** It has a series of sensors that detect both the state of the wheels and the weight of each train axle, informing the traffic agent of any anomaly.

▶ **Hot Axle Box and Hot Wheel Detector (HABD/HWD).** The HABD/HWD system consists of a series of sensors installed on the track that supervise the temperature of the train's axles and brakes and detect the possible seizing up of brakes. If the threshold temperature is exceeded, the system sends a signal that orders a reduction in the speed of the train or even its immediate stoppage in the event of extreme temperatures. In Talgo trains with bogies, track detection is not valid and it is necessary to use on-board detection systems.

▶ **Pantograph Monitoring System (PMS).** It consists of a series of sensors that at all times monitor the behaviour of the pantograph with the contact wire of the catenary when a train passes. Specifically, it monitors the pantograph-catenary interaction by detecting the elevation of the contact wire. The aim is to detect possible anomalies in the train pantograph that may cause irreversible damage to the catenary. In the case of an out-of-range measurement, the PMS system sends an alarm signal so that the appropriate measures can be taken, even stopping the train.

EXPERTS IN DETECTION SYSTEMS

“Whenever there is a risk factor, an auxiliary detection system that mitigates it must be developed”

Grupo Cobra is a Spanish company with more than 15 years’ experience in the installation of auxiliary detection systems. These projects are led by Susana de la Viuda and Leonardo Peig, who coordinate a large qualified technical staff team in delegations within and outside of Spain.

AN EXPERT TEAM
Since its creation in 1944, Grupo Cobra has developed to become a worldwide reference with the capacity to develop, create and operate industrial infrastructures that require a high level of service. In the top photograph from left to right, Susana de la Viuda, Roberto Muñoyerro and Leo Peig.

What type of track detectors are indispensable for circulating at high speed?
Detectors that, directly and immediately, can affect the use of a high-speed line are vehicle fall detectors, hot axle box and hot wheel detectors, crosswind detectors and pantograph monitoring system.

Approximately, how many sensors are installed per 100 kilometres of track?
Different criteria are followed depending on the type of detector that we are talking about. For example, vehicle fall detectors are installed on overpasses and tunnel exits. Hot axle box and hot wheel detectors are installed on the track every 35 kilometres. With regard to crosswind detectors, it is necessary to firstly identify where they must be located; as such, prior wind studies are carried out in zones travelled through. Dragging equipment detectors are usually located at the exit of maintenance bases or ports for loading and unloading goods.

In how many countries have these systems been installed?
Thanks to the experience achieved in the national sphere, we have been able to implement these systems beyond our borders, for example in France and Saudi Arabia.

In which countries are these components manufactured?
Practically all detection systems –except hot axle box detectors, which are German in origin– have been developed in collaboration with Spanish technology SMEs. At the Grupo Cobra, we provide our financing and also the possibility of implementing the products in the most state-of-the-art rail environments.

How do you assess the technological capacity of Grupo Cobra compared to the international standard?
We have taken advantage of the extensive development of Spanish high-speed rail, which is the priority environment for the implementation of this type of system, and we have provided technological innovations that have been developed to the international projects in which the ACS Group participates. We also have a test bench that is unique worldwide, which puts us in a superb and enviable position with respect to the rest of the sector.

Is there much left to innovate in detection systems?
Of course, definitely. Whenever there is a risk factor, an auxiliary detection system that mitigates this risk can and must be developed. ■

“We have a test bench that is unique worldwide, which puts us in a superb and enviable position with respect to the rest of the sector”

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RELEASE THE BAR TO HOLD THE TROLLEY

On the rise

The Cartagena de Indias airport has grown and has been renovated to accommodate increased and farther-reaching traffic that requires larger and heavier aircrafts. Ineco has thus taken on the design and coordination of an expansion project that includes strengthening operational safety.

With the collaboration of **David Gutiérrez** y **Roberto Serrano,** aeronautical engineers; and **Martha Sofía González, María José Mercado** y **Rafael Calvo**, civil engineers

Four million passengers in 2016: this is the growth forecast for the Rafael Núñez airport in Cartagena de Indias according to SACSA, the concession company. Majority-owned by the Spanish company Aena Internacional, in 2011 SACSA embarked on a project to improve and expand airport facilities, both on ground and in the air, in order to adapt airport capacity to the growing demand. Ineco recently updated the airport's Master Plan which plans for expansion work until 2020 and has also designed and coordinated construction work (see *IT48*). Five years ago, work began on passenger terminal building renovations and expansion; work then continued on the design and surveillance of work on the runway, aprons, the perimeter road and the new FBO terminal for general aviation services.

The increase in traffic at the airport is associated with the tourism and industrial activity in this city –located on the coastline of the Caribbean Sea–, whose characteristic, walled historic quarter has been a UNESCO World Heritage Site since 1984. The city stands out as a domestic holiday destination, and although the number of international arrivals has increased, the majority of the city's air traffic is mainly domestic with connections to the capital, Bogotá, as well as to main cities such as Medellín and Cali. In terms of international flights, top destinations include southern Florida in the United States in addition to Chile, Venezuela and Spain.

In order to drive the tourism sector, the airport operator and local entities such as Corporturismo and the Cartagena City Council are committed to implementing additional long-distance routes both to North America –the city's main source of outbound tourism– and to Europe –especially to Germany and Spain. Airlines are thus operating larger aircrafts, in turn requiring airports to provide greater capacity as well as increased safety and security –both operational and physical. Since all work must be carried out without interfering with airport operations, Ineco also conducted a study on the different stages of construction in order to minimise the effects as much as possible.

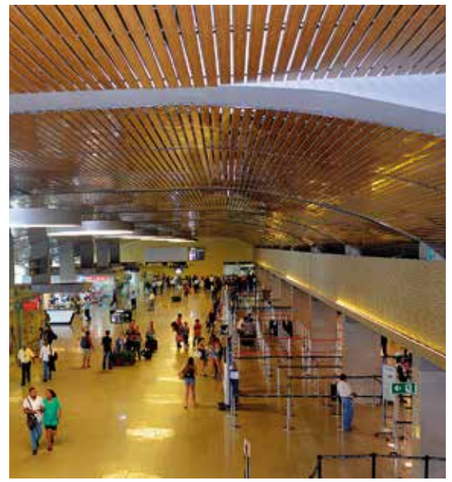
GREATER PASSENGER AND AIRCRAFT CAPACITY

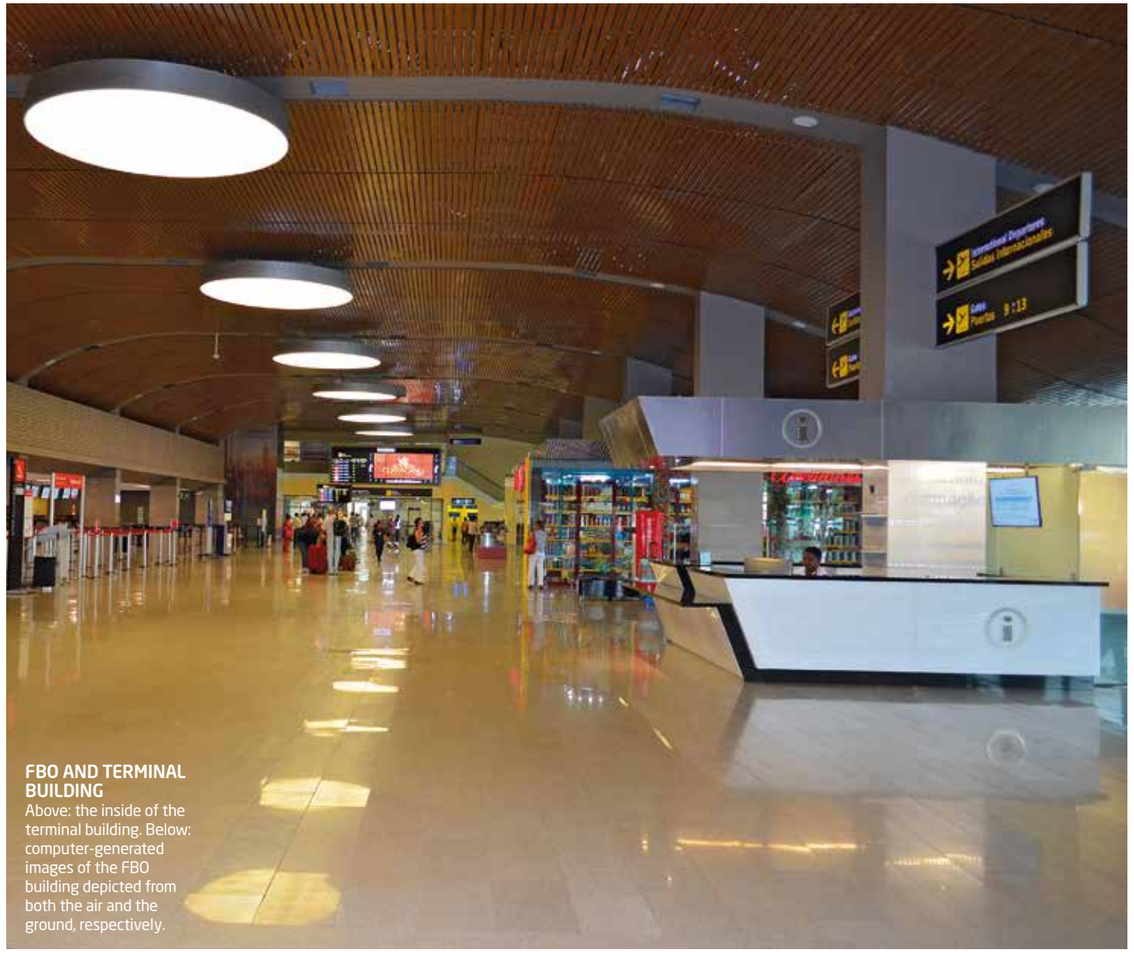
Thus, the construction work that was carried out at Rafael Núñez airport met these requirements: the current terminal building which was expanded from 2011 to 2013 has grown from 10,491 m² to 19,370 m². Expansion of the international hall is currently under way. The runway in addition to the main and secondary (or ECO) aprons were repaved between 2013 and 2014 to repair damaged areas and to increase their load bearing capacity. The axis of the turnaround area was modified to make it easier for large aircrafts to move around, and signalling and traffic guidance equipment was also improved.

With regard to the runway, Ineco designed and coordinated the installation of an asphalt mix that had never before been used in Colombia: a discontinuous, BBTM-11 bituminous mixture (with additional fibres) in a 4-cm screed used on 1,740 metres of the runway's 2,540 total metres. The asphalt not only improves friction conditions on the wearing surface, but it also facilitates drainage and prevents hydroplaning.

On both aprons, a P-401 bituminous hot mixture with a maximum aggregate size of ¾" was used with a BMIII modified asphalt, with varying thicknesses of 5 to 12 centimetres. The landing gear stop-way was also reinforced with 33-cm concrete slabs. Since there are fewer demands with regard to reinforcements on the perimeter road and pedestrian areas, a MDC-2 bituminous hot mixture with B60/70 asphalt was installed.

EXPANSION WORK
Five years ago, work began on terminal building renovations as well as on the design and surveillance of work on the runway, aprons, the perimeter road and the new FBO terminal for general aviation services. Here, the ECO (or secondary) apron can be observed. Below, the main apron and the terminal building.





FBO AND TERMINAL BUILDING
Above: the inside of the terminal building. Below: computer-generated images of the FBO building depicted from both the air and the ground, respectively.

COLOMBIA'S FOURTH MOST IMPORTANT AIRPORT

Rafael Núñez airport has seen its traffic volume quadrupled since 2004 and is currently the fourth most important in Colombia behind El Dorado airport in Bogotá, Alfonso Bonilla Aragón airport in Cali –Ineco worked on both of these airports (see *IT46* and *48*)– and José María Córdova airport in Rionegro. In 1996, the Colombian company Sociedad Aeroportuaria de la Costa S.A. (SACSA) took over management of the airport, and the Spanish company Aena Internacional entered into the picture two years later after acquiring 37.89% of the capital. Aena Internacional is also a partner operator. Aena Internacional participates in the management of 15 airports in three different countries: one in the United Kingdom (Luton), 12 in Mexico (Grupo Aeroportuario del Pacífico) and two in Colombia: one in Cali and one in Cartagena de Indias.

GENERAL AVIATION ON THE RISE

In addition to the aforementioned interventions which are of vital importance in terms of aircraft safety, the increase in general aviation traffic was kept in mind. Private and military flights represent more than 90% of traffic at this airport, while the remaining percentage is represented by executive flights, school flights, etc. Although general aviation represents less than 1% of the total passengers who use this airport, it corresponds to 30% of airport operations and is expected to grow an average of 3.9% by 2020, totalling some 26,000 passengers and 14,000 operations.

THE GROWTH FORECAST PREDICTS THAT RAFAEL NÚÑEZ AIRPORT WILL SEE FOUR MILLION PASSENGERS IN 2016

Therefore, construction work was carried out on a new FBO general aviation terminal in 2014 (Fixed Base Operator, a company from the United States in this case), as agreed upon in the draft that had previously been drawn up by Ineco. The new terminal, located in the eastern part, boasts three different areas: airport authority, border control and entry/exit of passengers and baggage; a surveillance area that covers access areas both to and from air and ground, as well as security checkpoints; and a passenger waiting area.

The project included the construction of a new, stand-alone building with an electrical substation, a hydraulic pump room and a drinking water supply in addition to a handling office. Shared with the secondary apron, a new perimeter road was also constructed with direct access from Vía del Mar, the road that connects Cartagena de Indias with Barranquilla.

ONGOING WORK

Rescue and fire fighting services (RFFS) are fundamental elements when it comes to increasing an airport's capacity. Aeronautics and airline regulations require that the capacity of these services must be rigorously determined by the size (total length and fuselage width) of the aircrafts that normally operate at the airport. Therefore, airports are categorised on a scale of 0 to 10; Rafael Núñez airport falls into category number 7, meaning that this airport would need a minimum of two fire-fighting vehicles, one fire chief and four firefighters.

Nonetheless, the new facilities designed by Ineco provide for the possibility, also foreseen in the regulations, of increasing these resources if, with prior notification, the airport needed to occasionally accommodate aircrafts corresponding to higher categories. For this reason, airport sheds have space for four vehicles: three fire engines and one light-weight commanding vehicle.

Seeing as this airport operates 24 hours a day, the RFFS requires staff to cover three shifts; thus, the new building has the appropriate facilities for said staff to rest in addition to offices, warehouses, technical areas and a car park. In front of this building there will be a paved clear zone that will allow for aircrafts to transition to the military area. Additionally, there will be two water deposits each containing 30,000 litres of water supply for the fire engines, and said fire engines will also be provided with a new access road, thus facilitating their arrival to the runway in under three minutes. Ineco is overseeing the construction work and is also monitoring compliance with the Operational Safety Plan.

Another ongoing project coordinated and monitored by the company includes the enlargement of the runway safety strip; in some areas, this strip does not meet the required distance of 75 metres between the runway axis and the border of the airport. To meet this requirement, ground is being gained from the area of vegetation by reinforcing it with 5-metre long micropiles. ■

Above: part of the Ineco and SACSA team that carried out the different expansion projects at Rafael Núñez airport. Below: the new FBO (Fixed Base Operator, a company from the United States, in this case) general aviation terminal, as agreed upon in the draft that had previously been drawn up by Ineco.

FLEXIBLE MODULES
The modular structure eliminates the need for interior pillars (open plan) and it can be easily adapted to any type of station.

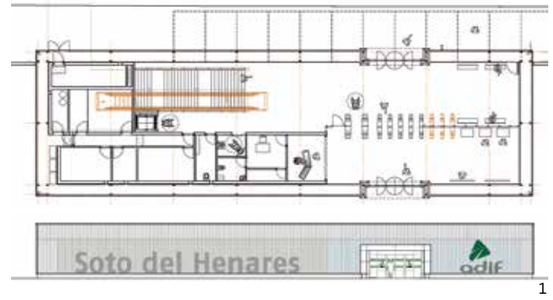
Transparency and simplicity

A versatile modular structure of porticos with a 'light box' night effect: this is how we can describe the new halt of the Soto del Henares commuter train station in the Madrid municipality of Torrejón de Ardoz, designed by Ineco.

With the collaboration of **Félix Expósito**, architect and project designer

Since last August, more than 20,000 residents of this new construction zone have been able to reach the centre of Madrid in 25 minutes thanks to the new halt, without having to go to the centre of Torrejón de Ardoz. Located in this Madrid municipality of 127,000 inhabitants in the north-east of Madrid, the new station belongs to the C7 commuter line and serves the districts of Soto del Henares, Mancha Amarilla and Zarzuela, a zone near the Hospital of Torrejón and the new Casablanca industrial estate. Ineco has carried out the architectural, structural and installation design, as well as construction management for Adif. It is a modular structure of porticos that eliminates the need for interior pillars (open plan) and can be easily adapted to any type of station. The main building, direction Alcalá de Henares, has a rectangular floor, a foyer with waiting areas, automatic ticket vending machines and six fare-gates, with the possibility of increasing this number to nine. It also has a space for offices, toilets and utility rooms.

INECO HAS CARRIED OUT THE ARCHITECTURAL, STRUCTURAL AND INSTALLATION DESIGN, AS WELL AS CONSTRUCTION MANAGEMENT FOR ADIF



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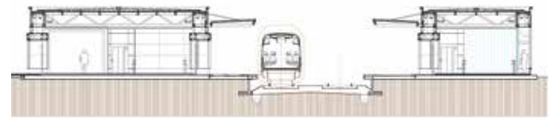

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1. Floor.
2. Section.
3. View of the halt of Soto del Henares station.

A MODULAR AND EXTENDIBLE DESIGN

The halt has two buildings, one for each direction. In the interior, all uses are distributed by independent building volumes ('building within a building'). The station was designed with a capacity to receive 6,000 passengers a day, although the modular structure facilitates its future expansion.

GOLDEN RATIO

The geometry of the buildings is based on the golden ratio of a two-metre square, which forms rectangles of 2.8282 x 2m. When doubled they create a module of 5.6564 x 2m, and from the division of this module come all of the internal distances between porticos and different spaces are created.

A LIGHT BOX

The main building is laid out as a rectangular prism with two façades, which provides a maintenance area between them. While the "skin" tinges the interior-exterior light ('light box' effect), the outer layer generates permeability and allows the design to be changed.

PLATFORMS

The platform edges are 1.75 metres from the track centres, with a width of 5 metres and a length of 210 metres, with 6 metre slopes at each end. Thanks to the 80 metres of canopy extending from the buildings, passengers are always sheltered when they access the platforms. ■

OTHER STATIONS DESIGNED BY INECO

Ineco has extensive experience in drawing up architectural designs, as well as in construction management and technical assistance and the preparation of feasibility studies in different types of stations, both overground and underground.

▶ In Cercanías (commuter rail) we should highlight, amongst others, projects such as the Miribilla station in Bilbao, built at a depth of 50 metres; the two in the Málaga airport access and a few others in the Valencian town of Alboraya, all of which are also underground, or the modern Cercanías halt of the Manuel-Énova bypass of the high-speed line to Levante.

▶ With regard to modular stations, in 2009 it developed an innovation project taking a small halt in the north of Madrid, Las Zorreras, as a reference. A similar solution was also planned, the predecessor of that of Soto del Henares, for the Las Margaritas-Universidad station, in Getafe, in the southern zone of Madrid. Abroad, in 2011, eight modern modular stations were designed for the Bogotá Western Corridor in Colombia.

▶ With regard to the renovation of historical stations, we can highlight the design and construction management of the historic façade of Atocha (2012), that of the full renovation of Aranjuez station (2008) currently underway, or the modernisation works in around twenty Catalan stations (2009).

▶ As well as architecture projects, we can also highlight other services, such as technical assistance for the work of the new La Sagrera-Meridiana commuter station in Barcelona (2010) or the prior feasibility studies for the Belgrade light rail in Serbia, with 25 stations, 10 of them underground; or for the São Paulo commuter network in Brazil, which included the construction of nine stations and the renovation of 65 others.

▶ With regard to highspeed stations, Ineco has carried out around twenty projects, both in construction management and in drawing up architectural designs: this is the case for the stations of Puente Genil, Camp and Antequera-Santa Ana (2007), that of Vigo-Guixar or the projects in nine other stations of the Galician Atlantic corridor in 2010 (report on page 14). Ineco has also worked in the construction management to adapt stations in the whole network for high speed: Santa Justa in Seville, Sants in Barcelona, Atocha in Madrid, Toledo, Zaragoza, A Coruña, Santiago and Ourense in Galicia, etc., as well as in that of enlargement of the Atocha railway complex and its new AVE terminal, begun in 2010.

76/EI058: safety with identity card

To guarantee that a product or service is safe and complies with all of the regulations, an independent assessment by specialists approved by the Spanish National Accreditation Entity (ENAC) must be passed. With regard to rail lines, Ineco has pioneering accreditation in the sector, which it has just renewed and extended.

By ***ITRANSPORTE***, with the collaboration of **Laura L. Brunner**, Bachelor of Science in Physics

How can we ensure that a taximeter is reliable or that a nuclear facility is safe, that a bulletproof vest is really bulletproof or that the MOT that reviews a vehicle does not act arbitrarily? In Spain, more than 1,600 entities ensure that many products, procedures and services available in the market comply with the regulations of their respective sector. A Spanish government body, the National Accreditation Entity (ENAC), is responsible for authorising who guarantees the safety of consumers and end users. Entities must renew their accreditation every year, demonstrating that they comply with the strict requirements of independence, rigour and transparency that are required for this work.

RAIL LINES

The wide range of products and services subject to receiving a certification endorsed by an ENAC entity covers any type of production and different types of entities, such as testing or calibration laboratories, inspectors, or certifiers and environmental verifiers from practically any sector: industry, energy, environment, health, agriculture and food, research, development and innovation, telecommunications, tourism, services, construction, transport, etc.

The inspection activity of Ineco falls within the latter, specifically within railway, and in 2009 it obtained its first ENAC accreditation as an 'independent safety assessor' with the number 76/EI058 (see *ITRANSPORTE* 40). In 2015, it was renewed and extended to the fields of rolling stock, energy, infrastructure, maintenance and exploitation and traffic management. The company has a multidisciplinary team consisting of professionals accredited by ENAC. The work of the entities certified by ENAC, moreover, is not only valid in Spain, but also in the over 70 countries with which it has mutual recognition agreements, including the European Union, United States, Canada, China, Japan, Australia, Brazil, India, United Arab Emirates and Mexico, amongst others.

WHY AN INDEPENDENT SAFETY ASSESSMENT?

In addition to rolling stock, since the beginning of rail at the end of the 19th century, the main rail elements related to safety have been signalling systems, in order to avoid the greatest risk of all: collisions between trains. From manual signals to lights, to digital systems and radio without physical signals on the tracks –as is the case for ERTMS level 2–, the different control, command and signalling systems (ASFA, LZB, ERTMS, etc.) have evolved to become more complex and sophisticated, always with the objective of guaranteeing the safe circulation of trains.

The current rail lines –conventional and high speed–, are very complex infrastructure that consist of a large number of elements and undergo very extensive legal and technical regulation that requires a high degree of specialisation by the inspectors. From the time they are planned until they are commissioned, European and international regulations require verification that each and every one of the elements and subsystems work correctly, from the simplest, such as the ventilation of a tunnel, to the most complex, such as software.

For this purpose, two types of safety study are carried out. On one hand, risk analyses, in which threats are identified that could bring the system to a potentially dangerous situation and work is being carried out on mitigation measures or barriers to avoid them. They can be carried out in any stage of the project and seek to detect the weak points of the system. Moreover, and on a higher level, there is the type of study known as ISA (Independent Safety Assessment). Unlike risk analyses, ISA can only be carried out by an accredited entity. They are essential to guarantee for a third party –the operator or rail authority– that a new line or modification of an existing line is safe and can begin or continue to be used. ■

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1
In 2009, Ineco obtained its first ENAC accreditation as an 'independent safety assessor' with the number 76/EI058.

2
Current rail lines are very complex infrastructure. European and international regulations require verification that each element and subsystem works correctly.

3
In addition to the rolling stock, since the beginning of rail at the end of the 19th century, the main rail elements related to safety have been signalling systems.

4
There are two types of safety study: risk analysis and the ISA (Independent Safety Assessment), which can only be carried out by an accredited entity.

4

EXPERIENCE

Ineco has worked for more than a decade carrying out independent safety assessments in the Spanish rail network, a task which it pioneered. It is currently working in Saudi Arabia, for the Haramain project, where it is carrying out the ISA for on-board ERTMS systems that will equip the Makkah-Madinah line.

PHOTO_ **NASA**

With open arms

Once again this year Spain has beaten its tourism record, with 68 million visitors in 2015, increasing the traffic and revenue of Spanish airports. Aena's Traffic Forecast Office, in which a team from Ineco works, analyses the evolution of demand so the Spanish operator may anticipate the arrival of visitors.

By ***ITRANSPORTE***, with the collaboration of **Ana Pascual** and **Patricia Varela,** aeronautical engineers

Spain is the third most popular tourist destination in the world in terms of revenue and for another year it has beaten its own record by exceeding 68 million visitors in 2015, three million more than the previous year. According to all of the analyses carried out, a factor that has benefited the sector is the situation of political instability from 2011 in Mediterranean destinations such as Tunisia, Egypt and Turkey. They all compete with Spain, which mainly receives European tourists: seven out of ten are British, French, German or Italian although, in relative terms, the increase in arrivals from the US and Asian countries is notable. According to Turespaña data, almost 80% of the total number came by air (half on a low-cost airline); a determining factor in this figure is that the Balearic and Canary Islands, for example, which are amongst the most touristic destinations in the world, are islands. As such, in 2015 all of the 46 airports in Spain registered more than 207 million passengers, 5.9% more than the previous year.

Besides the two major Spanish airports, Adolfo Suarez Madrid-Barajas and Barcelona-El Prat, which between them accounted for 41.7% with 86.5 million, more than 101.7 million passengers –49.1% of the total– were counted in the 14 airports classified as

DURING 2015, EIGHT OUT OF TEN VISITORS CAME TO ONE OF THE 46 SPANISH AIRPORTS

"touristic", coinciding with the most touristic destinations: the Balearic Islands, Palma de Mallorca, Ibiza and Menorca; the Valencian community, with Valencia and Alicante airports; Andalusia, with Málaga and Seville; the Canary Islands, with the airports of Gran Canaria, Tenerife South, Lanzarote, Fuerteventura and La Palma; and Catalonia, with Girona and Reus airports.

They all underwent processes of improvement and enlargement in the 2000s in order to increase their capacity, closely linked to the growth in tourism, known as the Barajas Plan, Barcelona Plan, Levant Plan, Málaga Plan, Canary Islands Plan, etc. During this time, Ineco has provided its services to the Ministry of Development and Aena in the planning and execution of the activities. Since 2008 it has also been in charge of the Traffic Forecast Office, which plays a key role in airport planning. A few times a year, a team of engineers and

PHOTO_ **PABLO NEUSTADT**

TOURISM IS GROWING
Spain has again beaten its own record, by exceeding 68 million visitors in 2015, three million more than in the previous year. According to Turespaña data, almost 80% of the total came by air; a determining factor in this figure is that the Balearic and Canary Islands, for example, which are amongst the most touristic destinations in the world, are islands.

PHOTO_ **PABLO NEUSTADT**

PHOTO_ **PABLO NEUSTADT**

PHOTO_ **MADRID CITY COUNCIL**

PHOTO_**HOTELESTURISMOYVIAJES.COM**

technicians updates the forecasts, and this is carried out with a macroeconometric model called PISTA (Integrated Prognosis of Air Traffic Systems), also developed by Ineco, with a specific methodology based on the concept of a 'network' and independent models for the national and international segments, based on significant economic variables. Furthermore, in preparing the specific forecasts for each airport and for the short-medium-term, other factors are taken into account such as competition from other means of transport (mainly AVE), the existence of other airports in the area of influence, changes in offers from airlines (new destinations, greater frequency, new models of airplanes used, etc.), special events (sports competitions, summits, etc.) and others.

SINCE 2008, INECO HAS ALSO BEEN IN CHARGE OF THE TRAFFIC FORECAST OFFICE, WHICH PLAYS A KEY ROLE IN AIRPORT PLANNING

Not only are volumes of passengers, operations and goods for each airport in the network forecast, but the design values (DHP, design hour passengers; and DHA, design hour aircraft) that are essential for adequate planning of the infrastructure are also considered, since they allow detection of the needs that airports will have and, furthermore, when it will be necessary to carry out the activities. The results of the traffic forecasts are used to prepare Aena's business and investment plans, as well as to design commercial strategies in airports and, as such, they are very important. ■

PHOTO: PABLO NEUSTADT

SPANISH AIRPORTS
The set of 46 Spanish airports in 2015 recorded over 207 million passengers, 5.9% more than the previous year, a fact that has meant that Aena achieved the second best year ever.

OTHER MEANS

Although air is by far the most popular means of transport (it is chosen by almost 80%) amongst international tourists, more than 18% use road and 1.4% sea. Cruises are growing in popularity year on year worldwide and also in Spain, where in 2015 Spanish ports, with those of Barcelona, the Balearic Islands and the Canary Islands at the head, have received around 8 million visitors, according to data from the Ministry of Development.

MORE TOURISTS, MORE AIRPORT REVENUE

The positive evolution of the aviation market has a significant impact on the national economy, since, according to Spanish government data, air transport supports 7% of the Gross Domestic Product, it generates 140,000 direct employees and 440,000 if indirect employees are included. On one hand, because part of aeronautical revenue comes from the rates that the operator (Aena, in the case of Spain) charges airlines per passenger and, on the other, through the commercial revenue, i.e., shops, restaurants, car parks and other non-aeronautical spaces and services that are licensed to third parties (see *IT54*). This item accounts for more than a quarter (25.7% in 2014) of Aena's total revenue, which in 2014 increased to 3.165 billion euros, 8% up on the previous year.

TALEB D. RIFAI

"Spanish tourism is strong thanks to the professionalism of individuals and institutions"

Since January 2010, Taleb Rifai has been the secretary-general of the United Nations World Tourism Organization (UNWTO), whose headquarters have been in Madrid for four decades. Born in Jordan in 1949, he has a Bachelor's degree in architecture from Cairo University, and a PhD in urban design and regional planning from the University of Pennsylvania (USA) in 1983.

To what extent does improved transport infrastructure influence tourism demand?
Infrastructure not only related to transport, but also to electricity and water, amongst others, have a vital relationship with the quality of tourism of a country. The extent thereof is linked to access to the country and to the services that tourists who visit it can enjoy. As such, both investment in the development of new infrastructure and the maintenance of already existing infrastructure is a strong determinant of the competiveness of the tourism sector.

In Spain, 80% of international tourists travel by airplane. Does AVE have any opportunity to gain prominence?
Not only AVE, but also the whole Spanish rail network, which is of a high quality. This is particularly evident in terms of the diversification of demand throughout Spain and the promotion of segments such as sports and ski tourism or cultural and gastronomic tourism.

What is Spanish tourism's strength?
It is difficult to highlight just one strength when there are so many that deserve to be mentioned. I think that the first point is the training and professionalism of the individuals and institutions within it. In Spain, these individuals and institutions are responsible for a tourist who visits Spain for the first time coming back again and again in the future. This is an achievement that few countries have managed. The work carried out in recent years to diversify traditional beach tourism in other segments such as rural or cultural tourism is also a milestone that deserves to be recognised.

What do you think we should invest in?
There is always room for improvement. In this regard, continuing to work on developing segments such as gastronomy or maintenance and integration of infrastructure to make the experience of tourists more comfortable are areas that deserve continuous attention.

AN ARCHITECT AT THE HELM OF WORLD TOURISM
Trained as an architect specialising in urban design, Taleb Rifai has been managing director of one of the largest companies in his country and a minister in its government on many occasions in different areas: Tourism and Antiquities, Information and Planning, and International Cooperation.

Will we lose tourism when stability is recovered in the north of Africa and the Middle East?
It is very unfair to think that the development that Spanish tourism has experienced has anything to do with the potential crises that other destinations are experiencing. Spain has devoted itself to tourism, it has done its work well for various decades and, as such, it has obtained these notable results that improve every year. The recovery of the area would be good news for all and would not harm anyone in any way. The slogan of the tourism sector is: "what is good for my neighbour is good for me".

Do you see Spain as an upmarket and even a luxury destination?
I see Spain as a top destination in many segments that are consolidated, such as luxury tourism, but also in more recently appearing segments such as shopping tourism.

Do you think it is feasible to put limits on mass tourism in order to avoid the degradation of destinations?
There is nothing that we could call mass tourism, only the arrival of many tourists and the inability to manage it. We must develop appropriate strategic tools that help to avoid decongestion in accordance with which areas and, of course, measures guarantee the protection and sustainability of the natural and cultural heritage, as well as making the sector profitable for the local populations.

Which new areas in the world do you think will gain outgoing as well as incoming tourism?
According to our Barometer, Europe continues to be the most visited region with a 5% increase. Asia and the countries of the Pacific, Latin America and the Middle East are growing at a rate of 4%. This reflects the fact that emerging countries have significant expectations to consider for the future. In fact, China is now the first country in terms of outbound tourists. ■

Riveting structures

By employing the traditional technique of riveting, riveted-steel marquees that have been affected by corrosion at Aranjuez station –a historic building dating back to the 19th century– have regained their full splendour. Construction work entrusted to the temporary business association (UTE in Spanish) Restauración Estación de Aranjuez has been carried out under the direction of experts from Ineco for Adif. The project is part of the Ministries' of Public Works and Culture "1% Cultural" programme.

By **Lucía Esteban,** architect and project director

The renovation work is part of the comprehensive restoration project drawn up by Ineco in 2008 which sought to remedy shortcomings while remaining consistent with the historic character of the architecture. These large, riveted iron structures were built as a result of the Industrial Revolution during the 19th century and are epitomised by the Eiffel tower. Spain lagged a bit behind other cities with regard to the use of iron in architecture and engineering as can be seen in countless examples from Paris, London, Amsterdam, Belgium and Germany in addition to Boston and New York in the United States.

With all of this, transport infrastructure in 19th-century Spain such as stations, bridges and viaducts requiring versatility, luminosity, spaciousness and low prices were easily adapted to the engineering of iron which was best received by engineers of that time period as well as by architects. Examples of riveted iron infrastructures in Spain include the Atocha and Delicias railway stations, the Catalonia Railway Museum, the Valencia railway station and the Aranjuez railway station –the main feature of this article. Furthermore, some quite representative buildings include Sabatini's Royal Firearms Factory in Toledo and the Geological and Mining Institute of Spain, in addition to bridges and viaducts such as the prominent Triana Bridge.

SPANISH TRANSPORT INFRASTRUCTURE IN 19TH-CENTURY SUCH AS STATIONS, BRIDGES AND VIADUCTS REQUIRING VERSATILITY, LUMINOSITY, SPACIOUSNESS AND LOW PRICES WERE EASILY ADAPTED TO THE ENGINEERING OF IRON

THE RENOVATIONS
In order to carry out the renovation work it was necessary to disassemble the framework of the marquees and take them to a repair shop. Once the marquees were repaired, they were set in place in a new foundation before finally lining them and installing gutters.

Aranjuez station is one of the most characteristic vestiges of the industrial age of the 19th century. The earliest railway facilities at Aranjuez were built in 1851 for the line connecting Madrid with Alicante, popularly known back then as the 'Tren de la Fresa' (The Strawberry Train) and whose name is now in use once again for tourist services. This station also provides service to the C3 Madrid-Aranjuez commuter rail line. It is the second oldest railway line in Spain (the oldest is the Barcelona-Mataró line, 1943) and is one of the monuments of the Royal Sites of Aranjuez, a Unesco World Heritage Landscape Site since 2001. This line originally reached all the way to the Royal Palace. The original station faced towards the palace on grounds of the company's prestige and the fact that they needed support from the monarchy. Nevertheless, this location caused so many problems affecting train traffic that it became necessary to build a new station with a completely different layout. The platform marquees are living proof of the iron beams and framework –signs of progress from that time period– that were used to construct public buildings such as stations, markets, factories, libraries and bridges.

RIVETING IS THE PROCESS OF JOINING TOGETHER SEVERAL METALLIC PIECES USING RIVETS –ELEMENTS SIMILAR TO SCREWS BUT WITHOUT THE THREAD– CONSISTING OF A CYLINDRICAL SHAFT AND A HEAD

THE TECHNIQUE OF RIVETING

The steel marquees, roofed by fibre cement and fluted glass, were built around 1851 to provide shelter over the station's three platforms which were later renovated around 1980 in order to adapt them to the trains and general regulations at that time. As can be observed in the images,

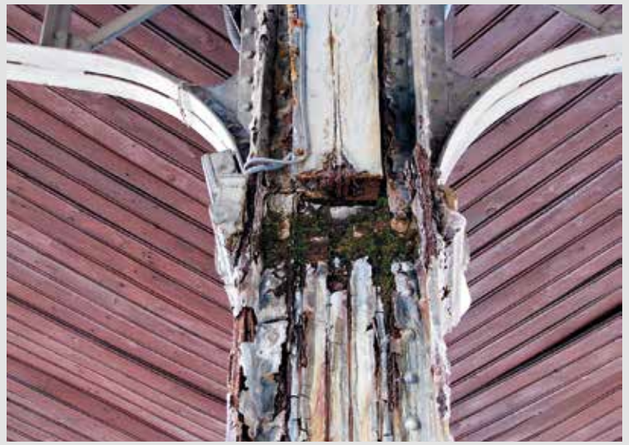
The marquees over the access platform to tracks 1 and 3 are of the 'gull wing' type (gaviota in Spanish). They provide shelter over the entire width of the platform (6.40 m) and run along the 160 m shared by both platforms, equalling a sheltered horizontal surface area of 977 m².

the marquees suffered from corrosion problems that affected their structural framework, foundation and ornamentation due to an unsatisfactory roof water drainage system, thus causing damage to the suspended wooden ceiling and corroding the metal. Rehabilitation and restoration of these marquees was a year-long, painstaking process that rediscovered the traditional technique of riveting.

Riveting is the process of joining together several metallic pieces (metal sheets and/or profiles) using rivets. Rivets are elements that are similar to screws –but without the thread– consisting of a cylindrical shaft called a shank or the body, and a head normally shaped like a spherical cap, such as the rivets utilised for the marquees at Aranjuez station. These rivets are manufactured from ductile, malleable and durable metals such as copper, aluminium, some alloys and mild steel, such is the case with the rivets presented herein.

To join together metal pieces made from steel, rivets are used –also made from steel– whose quality and characteristics can vary. Holes are drilled just once, piercing through two or more pieces, after having assembled, clamped and tightly screwed said pieces together. Once the holes have been drilled, the pieces are separated from each other in order to eliminate metal scrap, remnants and sharp edges from the surface. The diameter of the holes, save for exceptional cases, is made 1 millimetre larger than the diameter of the body of the rivet. Selecting the length of the body of the rivet is very important: after the rivet is placed in a furnace and uniformly heated to a temperature between 950 and 1,050 °C in order to allow for its moulding, the riveting process is carried out by introducing the heated rivet into the hole on the pieces which are to be joined together. The body of the rivet should be cast and forged in order to form the shop head of the rivet. This piece must completely fill the hole. To form the shop head, either a riveting machine applying uniform compression is utilised, or a pneumatic hammer with a riveting pin or a bucking bar is used, always held steadily in place. These tools –not the direct strike of a hammer– are used to form the rivet's second head. Both the furnace and the riveting machine need to be located close to the area where the riveting is to take place so as to avoid significant cooling of the rivet before it is set into place. The pieces that are joined together must lie perfectly flush and tight against each other to ensure a union without bending or warping. Afterwards, the rivet is introduced into the pieces that are being joined together, and the body of the rivet is forged. This process is carried out using a pneumatic hammer and a bucking bar on the spherical head of the rivet. ■

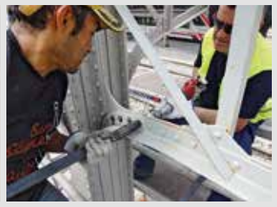
BEFORE & AFTER



▶ The framework of all of the marquees is metallic, consisting of columns and longitudinal, Pratt truss beams, with sections made from rolled steel sheets and profiles joined together with rivets.

▶ Tensile, resistance and chemical composition testing is run on the old metal prior to restoration.

▶ Weldability testing is then conducted before finally reinforcing the metal and increasing its resistance to vibrations.



Competitive edge

Thanks to the global interest in high-speed rail construction in arid environments with extreme climates in Asia, the Middle East, South America, Australia, and even some areas of the United States, a group of companies has formed a consortium with a research focus on how to reduce the impact of sand, high temperatures and strong temperature gradients on rail infrastructures.

By **David Oliver,** civil engineer

The Arid Lap project is financed by the Centre for the Development of Industrial Technology (CDTI), a Spanish public institution, through the Feder-Innterconecta Andalucía 2013 Programme. As suggested by the title –"Minimizing the effects of extreme climates on high-performance rail infrastructures in arid zones"– the aim is to develop technological solutions to minimize the negative impact of the meteorological conditions particular to arid zones on the operation of high-performance rail lines. The project focuses on the impact of sand (both airborne and suspended), and of high-temperature gradients and their consequences for rails and overhead line.

In 2013 and 2014, the universities of Granada, Seville and Madrid, the region of Andalusia, in the south of Spain, and the Málaga Rail Technology Centre all served as testing ground for trials with drones, temperature sensors, sand traps, weather stations, measuring systems, sand containment barriers and a large range of innovation projects.

Analysis of the impact of the environment on rail infrastructures in countries with arid climates showed that wind and suspended sand, as well as extreme temperature gradients, may prevent the line from functioning correctly, on account of abrasion, erosion or the accumulation of sand on the tracks, the wearing down of materials, etc. With a view to tackling these issues, the committee has focused on developing technology to predict and pre-empt the influence of weather conditions on the infrastructure and rolling stock, so that there is sufficient time in advance to take countermeasures.

The project's results will take the form of technical scientific knowledge, which will pave the way for new engineering services and methods on the market for predicting adverse weather conditions and quantifying them when constructing infrastructures in arid environments. Adapting these services to arid conditions will allow for new systems and design recommendations. In short, this will make it possible to optimize the design, construction and maintenance of elements such as rails, railway platforms, catenaries, ballasts, telecommunication systems and security systems.

> INECO PARTICIPATED IN THIS PROJECT IN CONSORTIUM WITH THE COMPANIES ADIF, ELECNOR DEIMOS, ABENGOA, NERVADOS, OHL AND WIN INERTIA, WORKING COLLABORATIVELY TOGETHER

TEAMWORK

Ineco participated in this project in consortium with the companies Adif, Elecnor Deimos, Abengoa, Nervados, OHL and Win Intertia, working collaboratively together whilst simultaneously focusing their own research on a specific area. It also collaborated with the project University of Granada, the CSIC´s Experimental Station of arid zones, the University of Seville's Research Foundation, the Complutense University of Madrid, the Andalusian Association for Research and Industrial Cooperation and the Andalusian Foundation for Aerospace Development.

Ineco, Elecnor Deimos and Adif, together with Fada-Catec, have worked on three campaigns flying drones to determine their usefulness in detecting sand, rocks and obstacles on the track, anomalies in catenary cable compensation, cracks, water yields and landslides. Studies have also been conducted on: whether UAV (Unmanned aerial vehicle, or drone) flights are compatible with high-speed environments, inspecting limited-access viaducts, and generating orthophoto maps and high-resolution digital models of the terrain.

In terms of the impact of the environment on the infrastructure, Ineco and OHL have analysed the geomorphological risks and ecological processes in desert areas. Ineco and Adif have analysed the lines in operation, their problems and the solutions that have been adopted. Ineco and Abengoa have carried out a study on the requirements and responses to take into account for the track devices in the face of adverse weather conditions in desert areas.

SANDSTORM
Analysis of the impact of the environment on rail infrastructures in countries with arid climates shows that the wind and suspended sand, as well as extreme temperature gradients, may prevent the line from functioning correctly. See image: sandstorm in Colorado, USA.

PHOTO_MICHAEL BRASHIER (FLICKR)

SEVEN COMPANIES, 14 R&D PROJECTS

1. INECO: FORECASTING MODELS, DRONES AND WEB PLATFORM

Ineco, together with the University of Granada, has developed a mesoscale meteorological model for forecasting wind and aeolian sand transport. It is essentially an application that, at least 48 hours in advance, is able to communicate the wind's direction and intensity at specific relevant locations, as well as the levels of airborne sand associated with the wind levels at these locations. To this end, the company has installed a weather station and sand traps, to be used to calibrate the model, at the Doñana Biological Reserve dune field in Huelva.

Ineco also developed the web platform MARTE, bringing together all results from the various activities that form Arid Lap. In this way, MARTE manages monitoring information, alarms and predictions. The tool manages and processes data registered by the sensors on the Córdoba-Málaga high-speed rail line, specifically at Málaga station (sensors to detect sand build-up, rail temperature, rail stress, overhead line temperature and stress), as well as at the Doñana weather station. Furthermore, alerts are sent when the sensor thresholds are exceeded. There is a unit for spatial visualization and integrating the satellite, drone and aerosol (suspended particulate matter) images generated during the project.

2. ABENGOA: SENSOR AND ALERT SYSTEMS. PROTECTIONS IN SENSITIVE ELEMENTS OF THE INFRASTRUCTURE

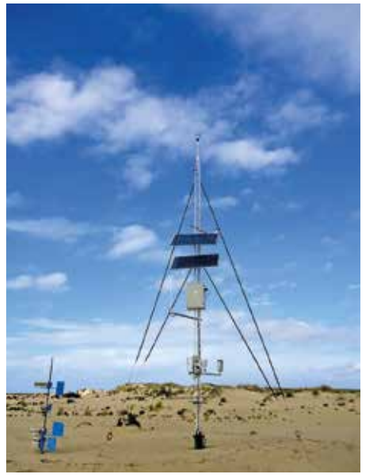
As leader of the consortium, Abengoa actively participated throughout the project, focusing on studying the electrical insulator distances in environments with high levels of sand/dust in the air, and on developing sensor system methods to monitor and supervise the state of rails and overhead line in real time. Their aim is to send alerts when the values exceed those which limit operability and safety.

The technological development team for the department of Railway Engineering at the Rail Technology Centre (CTF) in Málaga has also conducted research on systems which prevent sand from accumulating on the junctions. These can be elevated structures which replace the ballast, or wind acceleration structures. They are designed to protect the hinged sections, and the greasy sections of elements that require lubrication in the overhead contact line, from the negative effects of a build-up of sand, extreme changes in temperature and water condensation. Lastly, they also designed new mechanisms for protecting elements of the compensation system for pulleys and counterweights against arid environments.

PHOTO_ **INECO**

3. WIN INERTIA: ELECTRONICS AS A SOLUTION. SAND SENSORS AND COMMUNICATIONS

This Andalusian company has developed a sand build-up sensor, which measures both the weight and height of the accumulated sand. They have also simultaneously developed a concentrator system, which collects information in situ from the sensors (both the Abengoa ones and the Win Inertia ones), and then sends it to MARTE to be managed.



4. ELECNOR DEIMOS: AEROSPACE TECHNOLOGY FOR RAILWAYS

They have focused their involvement on applying new aerospace technologies. They primarily developed on three lines, using satellite images to identify and quantify adverse conditions in arid zones for the first line, as well as identifying the changes that might arise, as concentrated aerosol images. These allowed them to evaluate their use in studying the risks associated with dust in the infrastructure in advance, or high-resolution Deimos-2 images in order to estimate the technical viability of using algorithms to detect changes to pinpoint the spread of sand and dust.

They also used images from drones to achieve sub-centimetre resolution, which makes it possible to semi-automatically detect, from the difference in height, the rock fall on the track. Lastly, Elecnor Deimos has developed an infrastructure for processing, storing, distributing and visualizing images from satellites, UAVs and related products based in cloud technologies, integrated with the control application MARTE, which was developed during the project.

In order to prevent sand from accumulating on the railway tracks, work has been done on various lines, for example with different kinds of sensors, mathematical models to predict sand movements, weather station data and satellite images, monitoring tools, containment systems and new erosion-resistant materials. See image: a railway track in the Namibian desert.

PHOTO_ **VINCE42 (FLICKR)**

5. OHL: ECOLOGICAL RECOVERY AND CONTAINMENT SYSTEMS

OHL and Nevados jointly developed a containment system which produces a "trampoline" effect, concentring and projecting the natural flow of air with suspended sand around the sides of the rail infrastructure. Using 2D simulations and trials in wind tunnels, they have come up with a design which prevents the sand from moving forwards (with wind speeds below 15 m/s), or throws away and above the track, owing to its aerodynamic design (speeds greater than 15 m/s). At the same time, OHL have carried out a critical analysis on applying ecological recovery to the railway environment in arid areas.

6. NERVADOS: CONCRETE KNOW HOW. PREFABRICATED AND PERSONALIZED

Nervados has taken on the challenge of optimizing the design part and modelling of the prefabricated concrete barrier that impairs performance, as well as the manufacturing, transportation and concrete spreading processes. They have researched the need for concrete which is resistant to erosion and extreme temperatures, both when being manufactured and when put to use. At their facilities, they have carried out the entire prefabricated concrete piece project, with the exception of manufacturing the moulds.

7. ADIF: VALIDATING NEW TECHNOLOGIES, RADAR SOUNDING WITH GPR AND DRONES FOR RAILWAYS

Adif, meanwhile, has been responsible for the integration and validation, in a high-speed environment, all systems developed by the other partner companies, establishing the requirements of each development and installing sensors at María Zambrano Station and MARTE application in the Rail Technology Centre, both in Málaga, and facilitated the use of its infrastructure for testing drones for railway applications. Furthermore, they have carried out tests to detect the ballast contamination level using a Ground Penetrating Radar (GPR), which demonstrated this non-destructive sounding technique to be a good solution. ■

Inspiring hotels

Whether it is in the best zone of the city, by the sea or in the middle of nature, the Spanish hotel sector offers accommodation that combines uniqueness and luxury.

By ***ITRANSPORTE***

PHOTO_HOTEL CONSOLACIÓN

Accommodation is a vital part of the experience of any tourist and it often affects the choice of the destination. Spain has 16,000 hotels, 14,000 rural tourism establishments, 150,000 holiday apartments and more than a thousand campsites, with offers that stand out due to their exquisiteness and originality. According to a recent study by the Trivago search engine, Spain, with 335 establishments, is the seventh country worldwide in terms of number of five star hotels, only surpassed by China, Turkey, Mexico, Italy, India and Greece. Luxury is a booming sector all around the world and accommodation in this category has found new ways to offer the absolute best to customers, including elements such as architecture, interior design, landscape and signature cuisine.

MICHELIN STAR HOTELS

Contemporary haute cuisine is one of the great features of the five star Spanish hotel sector. In fact, a significant number of restaurants distinguished with five Michelin stars are found in hotels: in Madrid, Ramón Freixa, in Hotel Único; DiverXo of David Muñoz, in the NH Collection Hotel; Santceloni of Óscar Velasco, in Hesperia; or Kabuki of Ricardo Sanz, in Hotel Wellington. In Barcelona, Abac hotel-restaurant of Jordi Cruz; the creative restaurant of Sergi Arola, in Hotel Arts; or that led by the team of the Chef Martín Berasategui (who has seven Michelin stars), in the new and exclusive Monument Hotel.

This successful symbiosis between signature cuisine and the hotel sector also occurs in the Hard Rock Hotel in Ibiza: for around 1,500 euros per person a maximum of 12 diners can enjoy 'Sublimotion', an interactive and multisensorial gastronomic show designed by Chef Paco Roncero. In Sardón de Duero in Castilla León, there is the Abadía-La Retuerta gourmet hotel, under the leadership of Chef Andoni Adúriz, with its triple dining options.

ARCHITECTURE AND LANDSCAPE

Another concept of luxury is that of the space and the environment: some establishments choose to offer the visitor their unique architecture as another element of the landscape, whether it is natural or urban. Examples of these include Marqués de Riscal hotel, designed by the architect Frank Gehry (architect of the Guggenheim Museum in Bilbao), surrounded by vineyards, or Hotel W **(02)** in Barcelona, an ultramodern skyscraper in the form of a sail. Hotel Viura in Villabuena de Álava combines a modern building with historic surroundings. In other cases, it is the building itself that has a monumental value, such as Villapanés Palace in Seville; the former fortress that is home to Cap Rocat hotel in Mallorca; or the 96 Paradores Nacionales, 45 of which are located in castles, monasteries, palaces or historic sites.

> "Spain has 16,000 hotels, 14,000 rural tourism establishments, 150,000 holiday apartments and more than a thousand campsites"

At the other end of the spectrum there is the Spanish chain Room Mate, which has avant-garde interior design, new technologies –it provides free Wi-Fi and iPad hire, amongst other services– and, above all, central locations in each city. Aimed at a young urbanite public, it is present in Madrid, Barcelona, Oviedo, Granada, Málaga and Salamanca, as well as in Miami, New York, Mexico City, Florence, Amsterdam and Istanbul.

Ecology and luxury go hand-in-hand in the Vivood Landscape Hotel (Alicante), a 'landscape hotel' that combines its sustainable architecture integrated into the environment with exclusive services and activities in the natural setting. In Les Colls Pavellons **(03)** (Girona), the guest sleeps in a glass cubicle without furniture in the middle of the forest; but those who prefer a desert landscape can opt for just as unusual accommodation such as Aire de Bardenas (Navarra), or Hotel Cueva, with its underground bedrooms, in the middle of the Monegros Desert (Aragon). Lastly, Hotel Consolación **(01)** (Teruel), offers its avant-garde 'kubes' located next to the 14th century shrine that gives it its name, in a wooded oasis of pine, almond and olive trees. ■

02 PHOTO_HOTEL W BARCELONA

03 PHOTO_LES COLLS PAVELLONS

04 PHOTO_JUMEIRAH PORT SOLLER

THE LUXURY OF WELLBEING

Although beauty, health and relaxation treatments are services that are traditionally available in hotels, the current trend is moving towards making them the number one feature of the establishment and the customer's experience .This is the case for Sha Wellness in the Alicante town of Altea, or Jumeirah Port Soller **(04)** in Mallorca, owned by the group that manages the famous Burj Al Arab in Dubai, which is, to date, the only seven star hotel in the world.

05 PHOTO_WWW.CABANASENLOSARBOLES.COM

GLAMPING

Even the camping sector has an offer that goes beyond convetional, which ranges from establishments with services and facilities that are more typical of a luxury resort, such as Marjal Costa Blanca in Alicante -awarded as the best in Spain- to others that are part of the glamping trend, a portmanteau of glamour and camping: enjoy nature without abandoning comfort. There are many options: treehouses -Cabañas en los árboles **(05)**, in Zeanuri; Basoa suites, in Navarra- Bedouin tents or Mongolian yurts -Casa de Laila or Cloud House, in Malaga; Refugio Mames, in Alicante or Lanzarote Retreats, in the Canaries-, bubbles for seeing the stars -Mil Estrelles, in Girona-, safari cabins, former railway carriages or gypsy wagons -Casa del Mundo, in Alicante; Vagón Rural, in Murcia- and even caves or huts with contemporary decoration and equipment: Braña La Code, in Asturias; or Casas Karen, in Cádiz.

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Ineco has extensive experience in transport engineering:
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Ineco is a global leader in transport engineering and consultancy. For over 45 years, its expert team of around 2,500 employees has been contributing to the development of infrastructures in the aviation, railways, roads, urban transport and ports sectors in more than 50 countries. Thanks to our technical specialisation, our activity has diversified into new markets and we have reinforced our presence in those where we are already established. Our high-level technological capability allows us to offer the most advanced and cost effective solutions to the projects we work in, both for private and public sectors. ■

MODES

Aviation · Railways · Roads · Urban Transport · Ports

PROJECTS

- ▶ High Speed Makkah-Madinah. **Saudi Arabia**
- ▶ Operational readiness and airport transfer of the new MTC terminal of Abu Dhabi airport. **UAE**
- ▶ Strategic Mobility Plan. **Ecuador**
- ▶ Spanish High-Speed network. **Spain**
- ▶ HS2 high speed. **United Kingdom**
- ▶ Modernisation of the airport network and reorganisation of airspace. **Spain**
- ▶ CPTM lines, São Paulo. **Brazil**
- ▶ Supervising Agent Guadalajara-Colima highway. **Mexico**
- ▶ Airport Expansion Project Management and Master Plan update. **Kuwait**
- ▶ High-speed train Istambul-Ankara. **Turkey**
- ▶ Heathrow Winter Resilience Programme. **United Kingdom**
- ▶ Strengthening of Civil Aviation. **Nepal**
- ▶ Shadadiya industrial complex project management. **Kuwait**
- ▶ National Transport Plan. **Costa Rica**
- ▶ Expansion and improvement of the Spanish railway stations. **Spain**
- ▶ Muscat's Public Transport Plan. **Oman**
- ▶ Studies for high-speed train Haldia-Howrah. **India**
- ▶ Works on the Spanish port network. **Spain**
- ▶ Mário Covas Ring-road, Northern section project coordination, São Paulo. **Brazil**
- ▶ Tram line 4 in Tallinn. **Estonia**

INECO IN THE WORLD

AFRICA
Angola, Algeria, Cape Verde, Egypt, Ethiopia, Kenya, Mali, Morocco, Mauritania, Namibia, Uganda

AMERICA
Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Jamaica, Mexico, Nicaragua, Panama, Peru, Venezuela

ASIA
India, Iraq, Jordan, Kazakhstan, Kuwait, Nepal, Oman, Philippines, Qatar, Saudi Arabia, Singapore, UAE

EUROPE
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OCEANIA
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*Source: Aena, based on ACI-Mundo figures.

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