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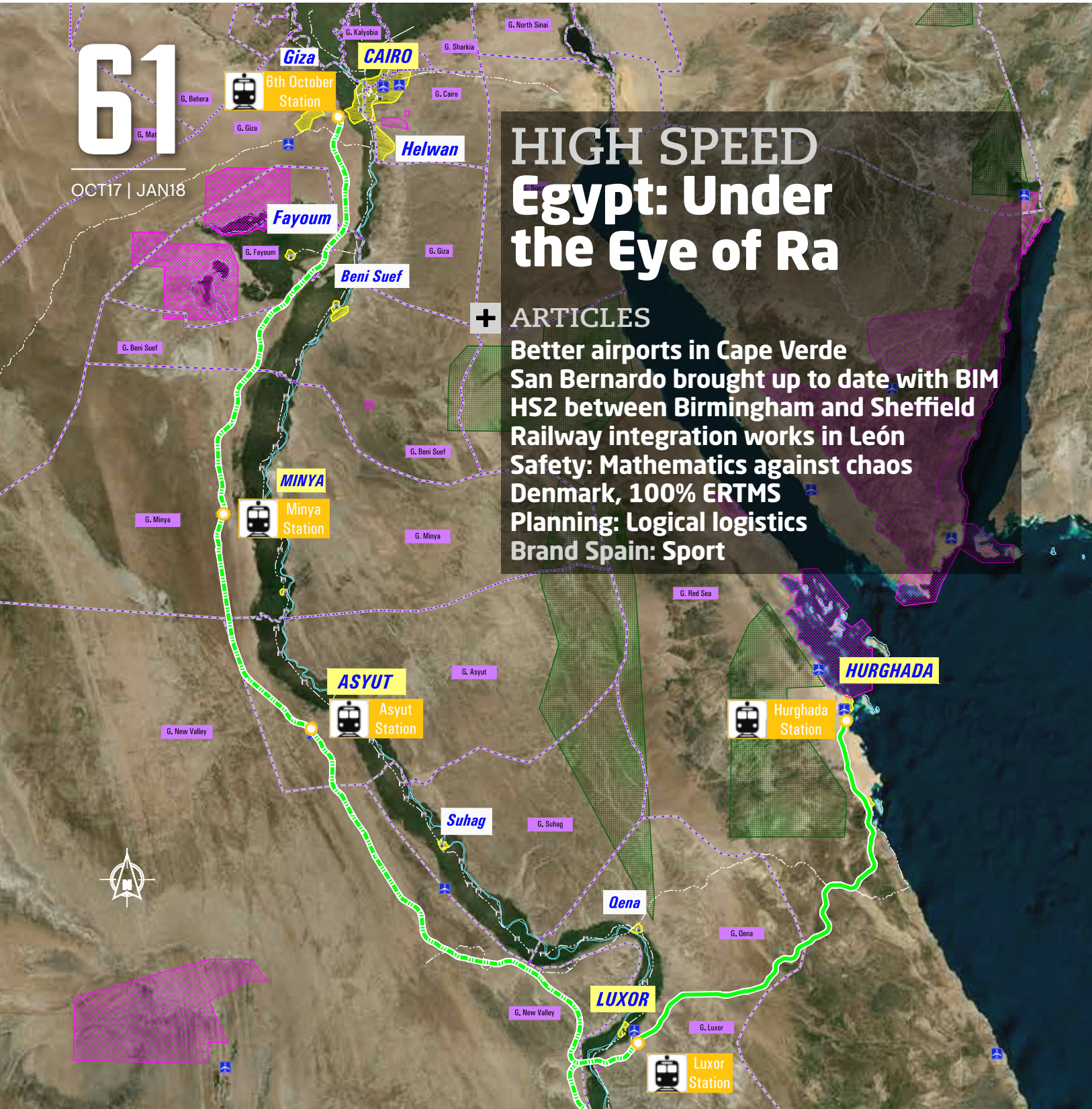
OCT17 | JAN18



HIGH SPEED
Egypt: Under the Eye of Ra

+ ARTICLES

Better airports in Cape Verde
San Bernardo brought up to date with BIM
HS2 between Birmingham and Sheffield
Railway integration works in León
Safety: Mathematics against chaos
Denmark, 100% ERTMS
Planning: Logical logistics
Brand Spain: Sport

EDITORIAL

Great teams, great jobs

We open this issue with the news of the contract awarded recently for the design of the new terminal at Schiphol Airport, a project that will make us a participant in the expansion of one of the most important airports in the world. This excellent news joins the announcements of the recent contracts to execute the master plan for the Dammam Airport and the expansion and rehabilitation of the Liberia airport. These international contracts reflect Ineco's strength and competitiveness in the aeronautical sector, and are complemented by articles covering the projects and construction supervision in two airports in Cape Verde, and the feature article on the aeronautical safety studies.

In the railway sector, the cover story highlights another large project that has already been completed: the high-speed line that our experts have designed in Egypt to connect Cairo, Luxor and Hurghada. More than 1,000 kilometres in length, it is the longest section of high-speed track ever built by Ineco, only recently surpassed by the 1,500 kilometres of another similar project, the high-speed line between New Delhi and Kolkata.

Projects such as the Indian project and this most recent project in Egypt, are enormous railway challenges that clearly demonstrate the capacity and expertise of the teams, made up of more than one hundred people who contributed to make them a reality. In total, the projects required two years of work which, in order to ensure the success of the study, involved various Egyptian public entities responsible for the implementation of the project, led by the Ministry of Transport and the National Railways of Egypt.

This study by Ineco, with the support of Adif and Renfe, exports the experience and know-how of Spanish engineering and industry in the design, construction and maintenance of high-speed lines. Experience that has pushed us to continue our participation in the development of high-performance networks, such as HS2 in the UK, in which Ineco has been awarded a new contract, projects for the installation of the ERTMS in Denmark, the railway integration works in the historic city of León, and the renovation of the San Bernardo station in Seville, all of which are described in this issue.

Lastly, we cap off this issue with a new section titled *In Closing*, in which our professionals tell us about the latest developments in their respective areas. In this case, we are starting with Rocío Viñas, our deputy director general of Cooperation and Innovation, who discusses the Spanish Hyperloop project. A closing that is aimed at sharing new developments in the sector with our readers. ■

PHOTO_ELVIRA VILA

> "The latest international contracts awarded to Ineco reflect our strength and competitiveness in the aeronautical sector"
>
> ISAAC MARTÍN-BARBERO
> Chairman of Ineco

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of the railway
network
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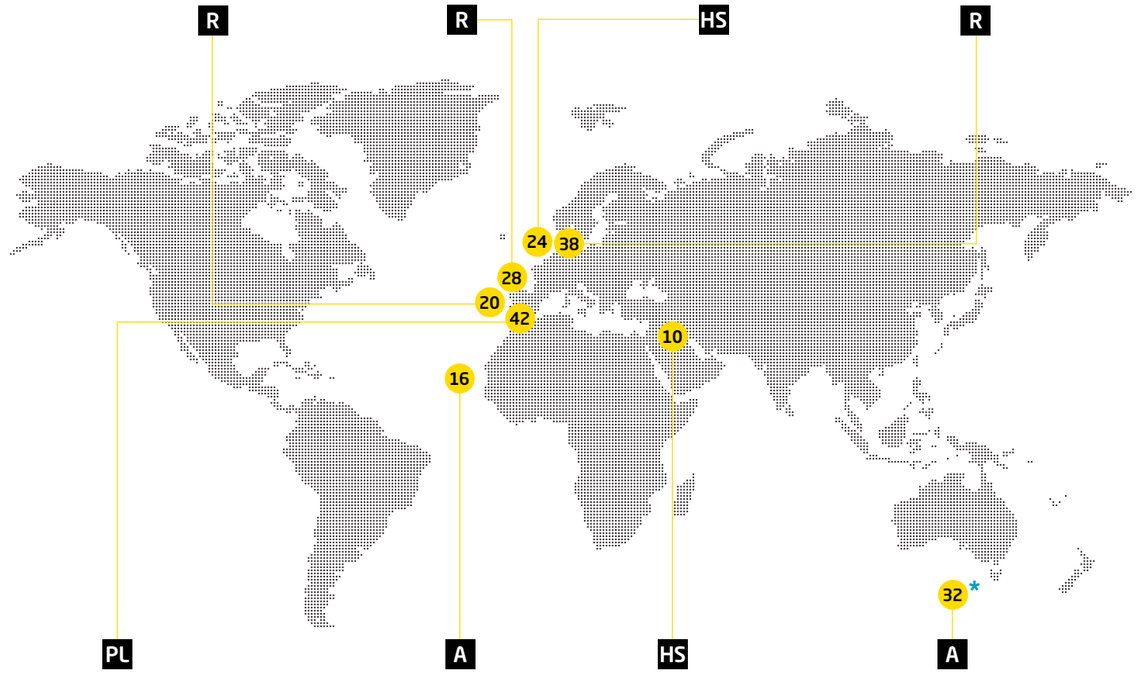
FEATURE ARTICLES
on the map

SPAIN
Railways
Ineco has worked for Adif on the modernisation of this central train station in Seville.

SPAIN
Railways
Adif and Ineco will transform the urban environment of the historical city of León.

UNITED KINGDOM
High Speed
The line will connect more than four million people to the capital city of London in just one hour.

DENMARK
Railways
Denmark will become one of the first European countries to have a full, and completely renovated, railway signalling network.



SPAIN
Planning
Ineco has extensive experience, both in Spain and internationally, in technical and economic feasibility studies of logistics centres.

CAPE VERDE
Aeronautical
Ineco will supervise the enlargement of the passenger terminals of the Sal and Boa Vista airports through 2018.

EGYPT
High Speed
Ineco has completed a feasibility study for the Egyptian government for what, starting in 2026, could be the country's first high-speed line.

INTERNATIONAL
Aeronautical
There are hundreds of factors that could affect airport operations and potentially cause an incident.

* Internacional article

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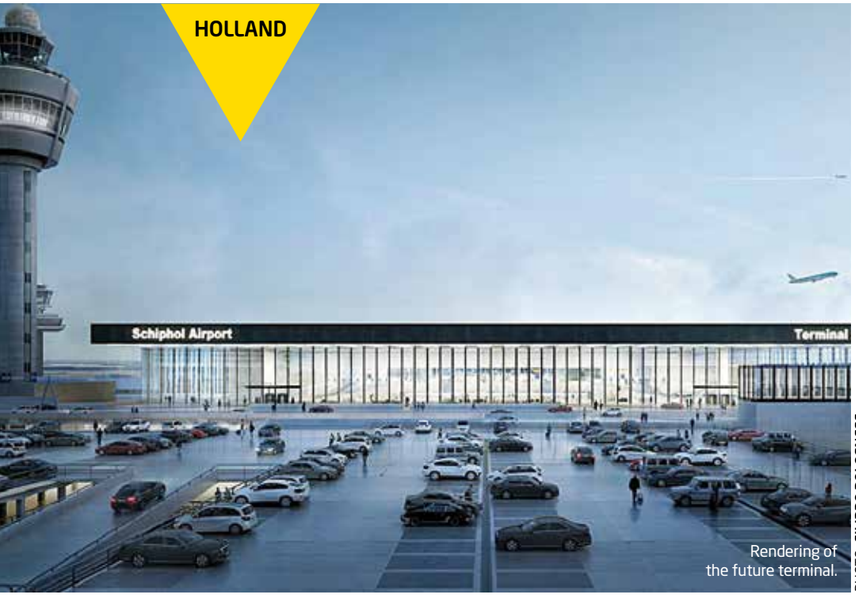


Rendering of the future terminal.

PHOTO_FILIPPO BOLOGNESE

IN COLLABORATION WITH ITS PARTNERS KAAN ARCHITECTEN AND ABT

INECO AND ESTUDIO LAMELA TO DESIGN THE NEW AMSTERDAM-SCHIPHOL AIRPORT TERMINAL

The Spanish-Dutch consortium KL AIR, formed by architecture firms Kaan and Lamela and engineering companies ABT and Ineco, has been awarded the international tender to design the new terminal at the Amsterdam-Schiphol airport, beating other prestigious firms in the final phase. The project has also been supported by the plastic artist Arnout Meijer Studio and the specialized engineering companies DGMR and Planeground.

The future terminal will cover approximately 100,500 m^2, with a capacity for up to 14 million passengers and will be located next to terminals 1, 2 and 3, to the south of the Schiphol Plaza. The works are expected to be completed in 2023. The spatial distribution of the new terminal, its design and the treatment of its façades are aimed at integrating it with Schiphol Plaza, the railway station and other possible future expansions. This will be possible thanks to the proposal's clear architecture and spatial extension.

One of the fundamental aspects of the design of the new terminal is its urban integration with the rest of the airport, which will guarantee a perfect connection between the new and the existing elements. Inside the building, the overlapping of passenger flows at different levels will make it possible to clearly distinguish the departure hall and the baggage claim area on the ground floor. Also, the access roads to the terminal will be integrated urban elements that will help Schiphol remain a "compact city".

According to the team of designers, "The main source of architectural inspiration has been to preserve the DNA of the original 1967 design designed by De Weger and Duintjers together with the interior designer Kho Liang, characterized by its abundant natural light, its simplicity and an imposing spatiality."

The new large-scale terminal will offer travellers different scenarios in an environment full of natural light. The subtlety of the proposed design will contribute to the use of the intuitive spaces without reducing its functionality.

The façades will be formed by large glass elements that will allow the views of the vibrant activity of the airport, as well as the open sky over the Dutch landscape. The sustainability criteria inherent to the design will be evident in the different materials to be used, such as the wooden flooring on the platform, and the abundant vegetation of the large patios.

The structural modularity and repetitive rhythm in the façades and on the roof will provide tranquillity and give unity to the new terminal, while at the same time providing a solid foundation for any future expansion. Integration and timelessness characterize this new link in Schiphol's evolution.

SAUDI ARABIA

SUCCESS IN THE TESTING OF THE DESERT HIGH-SPEED LINE

Last July, the high-speed train linking the cities of Makkah and Madinah in Saudi Arabia arrived in Jeddah on a test drive. On the route between Jeddah and Madinah, the train reached a maximum operating speed of 300 km/h. The Test Drive –which was attended by a number of Saudi Arabian authorities and Spain's Ministry of Public Works– began in the city of Jeddah in the direction of the King Abdullah Economic City (KAEC), where it visited the intermediate station, now completed, and the Operations Control Centre (BOCC). On its way to Madinah the train reached its maximum operating speed of 300 km/h. Approximately 370 kilometres of the 449 kilometres of the total railway line (80%) of the Al Haramain project are currently being tested. The Al Shoula Consortium is made up of 12 Spanish companies (Adif, Cobra, Consultrans, Copasa, Imathia, Inabensa, Indra, Ineco, OHL, Renfe, Siemens Rail Automation and Talgo) and 2 Saudi partners. The Consortium is in charge of the design, construction, maintenance and operation of the Haramain high-speed project.

STUDIES FOR NEWARK'S NEW TERMINAL

Ineco has collaborated with the company Arcadis on the definition of the scope of the project for the commissioning and Operational Readiness and Transfer (ORAT) of the new terminal at Newark Liberty International Airport in New Jersey, for the Port Authority of New York & New Jersey. Terminal A will replace the old building, which was constructed in 1973 and exceeded 9 million passengers, handling 10 million in 2015. The new project will increase capacity and significantly reduce travel times to boarding gates.

The company has extensive experience in ORAT in more than 20 airports, from its first works with Aena in Spain (Madrid, Barcelona, Alicante and Malaga) to the current contract, in collaboration with Aena, to carry out the Operational Readiness and Transfer of the new terminal at the airport at Abu Dhabi, the Midfield Terminal Complex, designed by KPF, which is expected to serve more than 30 million passengers. This work is included within the framework contract for the Project Management of the expansion programme and is the first contract executed by Ineco in the USA.

COSTA RICA

IMPROVEMENTS TO THE LIBERIA AIRPORT

Costa Rica's Directorate General of Civil Aviation, through ICAO, has awarded Ineco the project for the expansion and rehabilitation of the airfields of the Daniel Oduber Quirós International Airport. This is Costa Rica's second largest airport Costa Rica and its international traffic has not stopped growing in recent years –exceeding one million passengers in 2016, 30% more than in 2015– thanks to its strategic position and tourist attractions.

The awarded contract will cover the definition of the construction project for the runway expansion and the rehabilitation of the airfields. The work will be completed in a year and will include a variety of additional studies, from the development of a new traffic forecast and the topographic and geotechnical campaigns, to the specifications for the execution of the works.

MASTER PLAN FOR THE DAMMAM AIRPORT

Ineco has been awarded the contract for the development of the Master Plan for the King Fahd International Airport in Dammam, Saudi Arabia, winning against the most prestigious international companies. The one-year study will serve as a development guide for the new airport operator, DACO (Dammam Airports Company). With a horizon in 2047, this project aims to turn the airport into a regional hub and an important intermodal node for the movement of goods.

Expansion and connection with the railway freight line

The work includes the study of the expansion of all airport facilities to meet its strategic objectives, as well as the study of the connection of the cargo area with the country's main railway freight line. In addition, it will carry out the improvement and reorganization of its airspace and the development of the new Airport City and the Cargo Village, which is underway. Lastly, the Spanish company Idom will provide support as one of Ineco's strategic subcontractors for urban planning and real estate management.

PHOTO_YOSOYNUTS (FLICKR)

Dammam International Airport is the third largest airport in Saudi Arabia in terms of passengers and is managed by Changi Airport, considered one of the best in the world, and for which Ineco developed the review and design of certain instrument flight procedures.

With this contract, Ineco enters the aeronautical market in Saudi Arabia and consolidates its position in the Middle East where, in addition to participating in the development of high speed between Makkah and Madinah. It has also carried out the Master Plan for the Kuwait Airport , the expansion of Fujairah airport, and the start-up of the Abu Dhabi airport.

STUDIES FOR THE DELHI-MEERUT COMMUTER RAIL

India's NCRTC, which is responsible for the development of fast rail transport systems in the Delhi region, has awarded the consortium formed by Ineco, Egis and Egis India the contract for the studies to develop a commuter rail corridor between Delhi and Meerut. Ineco will provide consulting services to define the design parameters for the construction project of this 90-kilometre regional fast network which is expected to reach a speed of 180 km/h. Most of the route will run through tunnels and on elevated surface track.

COMPLETION OF THE STUDIES FOR THE HS DELHI-KOLKATA

Ineco, Typsa and ICT –the three partners of the consortium– have presented the final report, of the feasibility study of the high-speed line between the cities of New Delhi and Kolkata, to the authorities of the state-owned enterprise High Speed Rail Corporation of India (HSRC). In the photo, Ineco engineers Félix Zapata and Javier Sancho at the station in New Delhi.

Ineco has been operating in India since 2009 with works for the Bombay metro and studies for the HS between Haldia and Howrah, among others.

SPAIN

THE GALILEO SERVICE CENTRE NOW UNDERWAY

Ineco officials visited the facilities in Madrid to mark the start of the operations of the European User Services Centre of the Galileo Programme (GSC). From left to right Javier Gallego (Director of Systems Engineering), Carlos Hernando (Project Manager), Ramón Hernández, Silvia López, Ana Meléndez, Luis Chocano (Project Manager), Alberto Santos (Chief of Operations), Antonio Águila, Luis Negrete (Deputy Director of Operational Systems) and José Mª Berdoy (CNS-ATM Area Manager).

GERMANY

COLOGNE: TRANSPORTATION OF THE FUTURE

The hyperloop took centre stage at the 2017 Future of Transportation World Conference Technology Forum, which was held last July in Cologne, Germany. The conference was attended by José María Berdoy, manager of Ineco's CNES-ATM Systems Area. Autonomous vehicles, their safety and legal and technical aspects, were some of the most discussed topics along with the environmental sustainability of the future. More information on this transport system is available in our new section *In Closing*, on page 50 of this issue.

SPAIN

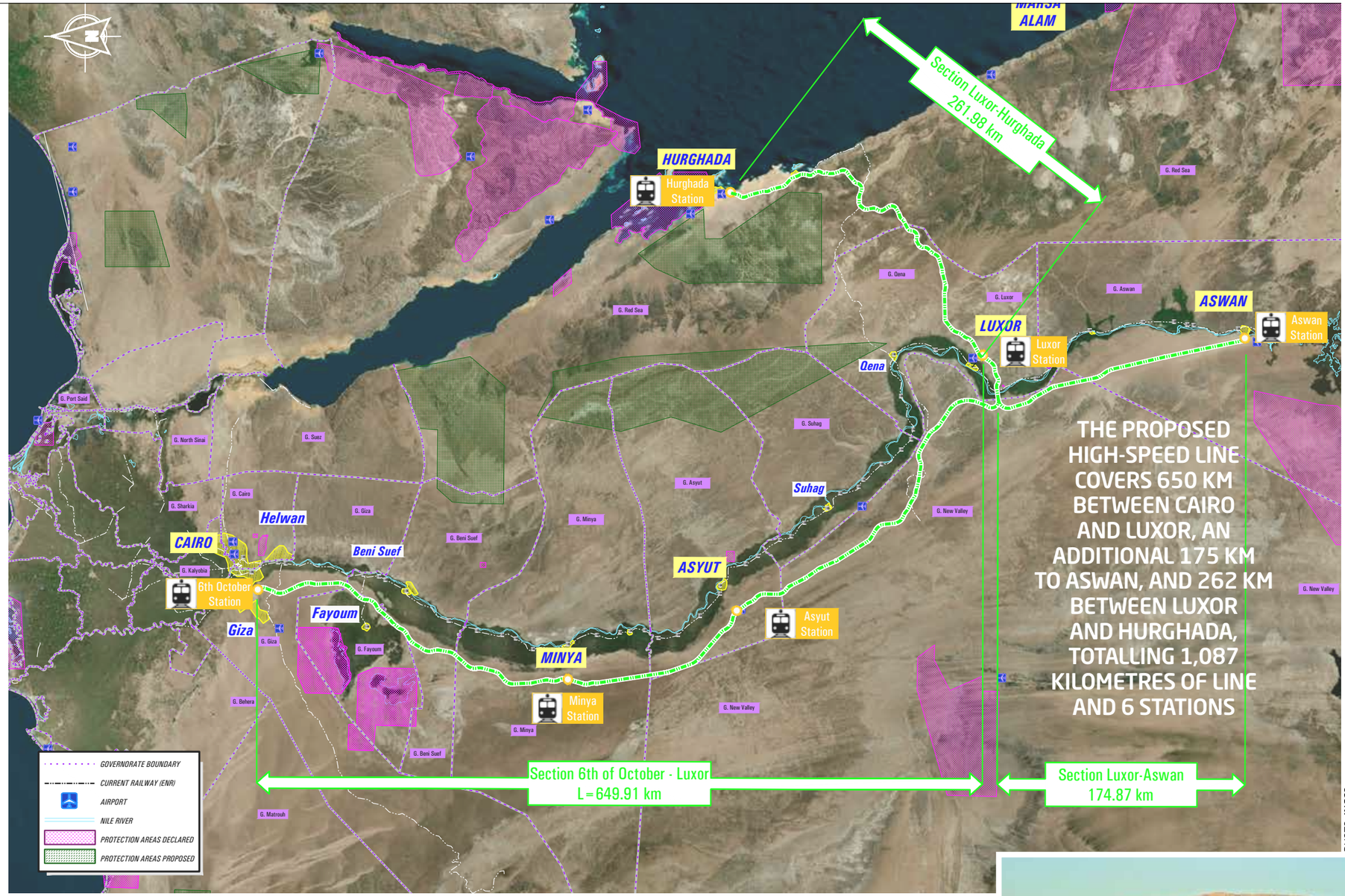
FAIRS AND CONGRESSES

This year, Ineco is collaborating as a sponsor of the 6th edition of the conferences organized by Adif (Spain's railway infrastructure administrator) in Madrid in collaboration with the International Union of Railways (UIC). Ineco engineers, Ignacio Martínez, deputy director of Information Technologies, and Jorge Torrico, BIM deputy director, will participate in two presentations. In addition, this autumn, the company is sponsoring the South Summit, an important event on innovation and entrepreneurial companies (4-6 October in Madrid) and will participate in the International High Speed Congress (4-6 October in Ciudad Real) and in collaboration with ICEX, in the Smart City World Congress (14-16 November in Barcelona).

Under the Eye of Ra

Ineco has completed a feasibility study for the Egyptian government for what, starting in 2026, could be the country's first high-speed line. The entire project covers more than a thousand kilometres connecting the capital city of Cairo with Luxor, Aswan and Hurghada, on the shores of the Red Sea, at a speed of more than 230 kilometres per hour. The study was based on the general design of the line at a scale of 1:25,000, a demand study and a socio-economic and financial profitability analysis.

With the collaboration of **Carolina Sanz**, **Ventura Fernández-Pacheco**, civil engineers and **Antonio Sancho**, architect



PHOTO_INECO

According to Ancient Egyptian mythology, the god Ra sailed his ship along the celestial Nile, which corresponded to the great royal river that gave rise to one of the earliest civilizations in the world. The great temple of Luxor, dedicated to Ra –as well as to another deity, Amon– together with the nearby enclave of Karnak, near Thebes, the ancient capital of the pharaohs, together with the great pyramids and the Sphinx of Gizeh in Cairo, constitute some of the most important archaeological legacies that reflect its greatness.

Today tourism, and the activities related to it, have become one of Egypt's most important economic engines, contributing a total of 12.8% to the national GDP and 11.6% of total jobs of the active population. Tourism policy, which originally focused on enhancing archaeological tourism around the Nile, has been diversifying in recent decades to make sun and beach tourism, mainly around Hurghada and Sharm El Sheikh on the Red Sea and Matrouh on the Mediterranean coast, one of the country's biggest attractions.

In spite of Egypt's enormous tourism potential, with the number of international visitors doubling between 2004 and 2010, with a record high of 14.7 million foreign tourists, the events related to the Arab Spring in 2011 paralysed this growth trend and caused it to fall to its current figure of 10 million. In 2010, archaeological tourism attracted 3.2 million visitors in the vicinity of Luxor and Aswan, with 30% corresponding to national tourists and 70% to international tourists. According to the internal

The River Nile as it passes through Luxor.

Computer rendering of a viaduct over the Nile.

mobility patterns analysed along the corridor, these visitors generated almost 5 million trips in the study area. Approximately 65% of the tourists reached the area through the airports in Cairo, Luxor and Aswan, while the remaining 35% came from the Hurghada region on private buses operated by tourist agencies. However, these 2010 statistics could increase significantly if the country regains political and social stability.

Aware of their potential and the importance of tourism for the economic recovery and development of Egypt, the government wants to boost the production sector and is promoting a new model in which high speed enhances

ONE OF THE MAIN DESIGN CRITERIA THAT CONDITIONED THE ALIGNMENT WAS TO MINIMIZE CROSSINGS OVER THE NILE

the synergies between cultural and leisure tourism, catalysing long-distance internal mobility within the country. The Ministry of Transport is studying two large corridors connecting the capital city of Cairo with Alexandria to the north, and to the south along the Luxor-Aswan axis and the Red Sea coast to the east. The implementation of high speed will transform Egyptian rail transport, offering connections with total travel times between key points similar to those of air travel, but with more regular service and expanded timetables, providing approximately 18 hours of daily service, plus punctuality and comfort at more competitive prices.

Egypt receives technical and financial support from the European Union to carry out its railway modernization plans. It is in this context that the collaboration agreement signed by the Egyptian minister of Transport and the Spanish minister of Economy and Competitiveness in April 2015, and the feasibility study carried out by Ineco with Adif and Renfe for the north-south corridor, financed from the Fund for the Internationalization of Enterprise (FIEM), are framed. The objective of the study, on which a multidisciplinary team with professionals of different specialities worked for 14 months, was to provide the Egyptian government with a useful tool for decision making in the process of implementing high speed in the country.

RAILWAY TRANSPORT IN EGYPT, PRESENT AND FUTURE

Egypt, the most populous country in the Arab world with more than 90 million inhabitants (according to United Nations data for 2016), is currently in the process of modernizing and improving its railway, which was the first to be built on the African continent, mostly in the second half of the nineteenth century.

According to the national ENR, Egyptian National Railways, which manages and operates the network, this network consists of 9,570 kilometres of track, mostly without electrification, with 1,466 km of double track, 20 km of quadruple track, and the rest single track. The speed of passenger trains currently ranges between 90 and 120 km/h. They have three categories and fares -first, second and third- and sleeper cars, and transport 500 million passengers annually, 1.4 million a day.

There are 705 stations, including 22 large stations. During the last decade, some of the most important stations, such as the Ramses station in Cairo and the Sidi Haber station in Alexandria, have been renovated. The infrastructure, equipment and trains for improving safety are also progressively being upgraded: the French firm Thales has been contracted to implement modern electronic signage, which, according to ENR, already exists on 15% of the lines, and the rolling stock is also being upgraded.

Luxor station.

THE OBJECTIVE OF THE STUDY WAS TO PROVIDE THE EGYPTIAN GOVERNMENT WITH A USEFUL TOOL FOR DECISION MAKING IN THE IMPLEMENTATION OF HIGH-SPEED RAIL

THE STUDY AREA

The feasibility study covers the corridor between Cairo and Luxor, and the areas from Luxor to Aswan and Hurghada. The proposed high-speed line comprises 650 km between Cairo and Luxor, an additional 175 km to Aswan, and 262 km between Luxor and Hurghada, totalling 1,087 kilometres of line and 6 stations: Cairo, 6th of October, Minya, Asyut, Luxor, Aswan and Hurghada. According to data from 2015, the population of the study area totalled 13.1 million inhabitants (14.9% of the country's population) and mobility between the different defined areas is estimated at 38.5 million trips a year. In terms of the modal distribution, 29% of the trips are made in private shared vehicles, 28% in private vehicles, 23% by railway, 17% by bus and the remaining 3% by plane. This demand for transport translates into a market of some 4.1 billion Egyptian pounds annually. In terms of door-to-door travel times, specifically for the Cairo-Luxor connection, the minimum time for the road alternative is more than 7 hours, rail more than 10.5 hours, and plane 3.5 hours. The quantification and characterization of the mobility in the study area was based on the analysis of the available information and the results obtained from a campaign of surveys and traffic counts.

Computer rendering of the cross-section: section of double track over ballast.

TOURISM, THE X FACTOR

The success of the high-speed line will depend to a large extent on the recovery and enhancement of international tourism, which according to the demand forecast model would account for between 60% and 80% of the total number of passengers, depending on the scenario. The model takes into account three possible demand scenarios, high, medium and low, in two traveller segments: local and international. In order to prepare them, we took into account the forecasts of the Egyptian government in terms of GDP growth and also analysed different hypotheses regarding the recovery and development of international tourism.

In the most optimistic scenario, the Ministry of Tourism expects to reach 20 million foreign tourists in 2020, which means an annual growth rate between 2014 and 2026 of 9%, much higher than GDP growth for that same period. In this context, passenger demand for the high-speed line would be 6.3 million per year. In the average scenario, visitor levels

WHAT THE FUTURE HOLDS FOR THE NILE'S HIGH-SPEED LINE

STRETCHES STUDIED

▶**Cairo-Luxor stretch: 650 km**, double track, max commercial speed: **240 km/h**. Structures: **47 viaducts** (21 km), **4 tunnels** (11 km): 5% of the total length of the stretch. Entry into service: 2026.

▶**Luxor-Aswan stretch: 175 km**, double track, max commercial speed: **230 km/h**. Structures: **7 viaducts** (485 m) and no tunnels: 0.3% of the total length of the stretch. Entry into service: **2031**.

▶**Luxor-Hurghada stretch:** 262 km, double track, max commercial speed: **234 km/h**. Structures: **20 viaducts** (9 km), **5 tunnels** (6 km): 6% of the total length of the stretch. Entry into service: **2036**.

STATIONS: Six: Cairo, 6th of October, Minya, Asyut, Luxor, Aswan and Hurghada.

ROLLING STOCK

Maximum speed of **250 km/h**, **8-car** compositions, **200 metres** long and a capacity of **534 passengers** per train.

RAILWAY SYSTEMS

▶Electrification: **25 Kv AC**

▶Signalling and telecommunications: **ERTMS level 2** and **GSM-R**.

CENTRALIZED TRAFFIC CONTROL CENTRE: One, located at Cairo-6th of October station.

MAINTENANCE BASES: Six.

DEPOTS AND WORKSHOPS: Two, the main depot in Cairo, with a workshop for level 1 and 2 maintenance, and **a second depot in Luxor**, with a level-1 maintenance workshop.

THE STATIONS

One of the keys to the success of high speed lies in the location and functionality of the stations, so the study proposes their location and preliminary design, taking the following criteria into account:

▶ **Location** outside the city centre to minimize complications and additional costs generated in urban areas (expropriation, tunnelling, vibrations, etc.). In the case of the Cairo station, the viability of the future connection with the Cairo-Alexandria corridor was taken into account.

▶ **Accessibility and intermodality** with other complementary modes of transport, to guarantee competitive access and dispersion times, minimizing door-to-door travel times.

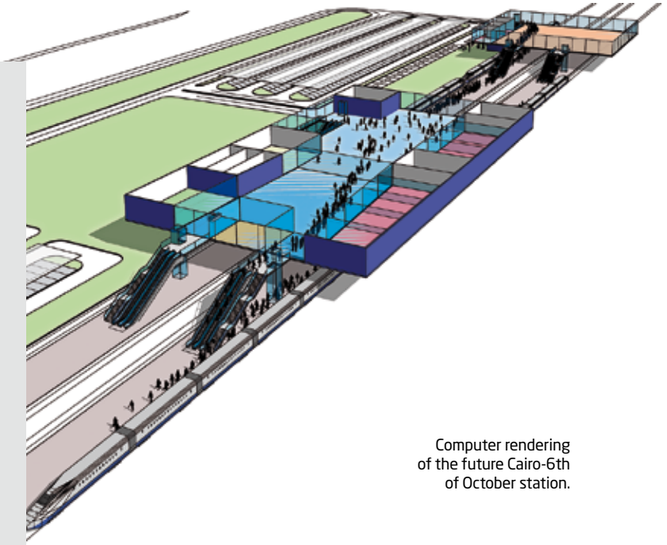
▶ **Development by phases**, based on the evolution of demand in the period taken into account (50 years). The total area required includes the conditions of maximum development.

▶ **Design from modular plans** that allow strategies for sustainable growth and minimal disruption of station operation.

▶ **Definition of sizes and types** based on the needs of travellers getting on and off at rush hour, defined by the demand study and based on international experience, and the specific railway functionality for each location.

▶ **Dimensioning of functional and operational areas** of the stations and their auxiliary spaces (retail, services, facilities, etc.), seeking to provide a level of service suitable for the type of line proposed.

▶ **Proposed type and size of outdoor areas** (parking, bus stops and taxi, drop off & pick up areas) based on the study of methods of approaching and departing from the station, suggesting growth that is compatible with the development stages of the station.



Computer rendering of the future Cairo-6th of October station.

are expected to return to 2010 levels in 2026, with annual growth of 3.4%, very similar to GDP growth, and 3.3 million passengers on the new line. The least optimistic estimate places tourist recovery a decade later, in 2036, with annual growth of 1.8%, and 2.7 million high-speed travellers.

TECHNICAL FEASIBILITY

The technical feasibility analysis is based on the definition of the alignment of the future railway infrastructure and a comprehensive design at a scale of 1:25,000. For this purpose, different alternatives were studied at a scale of 1:50,000, and the most favourable one was selected applying a multi-criteria analysis: the optimal combination between factors such as construction costs, technical complexity (evaluated based on the length of structures and tunnels and the type of terrain), environmental conditions –giving particular importance to the preservation of the archaeological heritage–, the length of the route and the travel times obtained from the simulations.

The main design criteria that conditioned the alignment were based on minimizing crossings on the Nile River, avoiding mountainous areas and lands with high geotechnical risk –with high clay, saline or gypsum content– as well as areas with archaeological and environmental protection or impacts on farmland. The two intermediate stations –Minya and Asyut– were selected for being the most populated of the route, as well as for their future growth potential according to the plans of the Egyptian government. With regard to the design speeds, on the corridor between Cairo, Luxor and Aswan, under very favourable topographic conditions, the maximum design speed is 350 km/h, while a maximum design speed of 250 km/h was chosen for the stretch between Luxor and Hurghada.

Once the most favourable alternative was identified, the Ineco team adjusted the alignment in greater detail, taking into account the analysis of the geotechnical and environmental factors, as well as comments received from the Egyptian government on future areas of development that could interfere with it. The geotechnical quality of the land of the proposed route is generally medium to high, except for some stretches, and does not interfere with protected natural areas or known archaeological areas. The potential risk of the track interference caused by desert sand was also analysed, and it it determined that part of the track design would use slab track. All these aspects will be addressed in more detail in later design phases.

Computer rendering of the Luxor station.

A GREAT TEAM. The project was carried out by more than 100 experts from different specializations: transport planning and economy, railway projects, geology and geotechnics, environment and land planning, tunnels, bridges, architecture and railway systems.

PHOTO_ELVIRA VILA

The technical feasibility analysis also included the location and preliminary design of structures and tunnels, as well as passenger stations.

As for the operating plan, which is based on the demand of the scenarios analysed, the model recommended to the Egyptian government is based on trains with a maximum speed of 250 km/h, mainly for the following reasons: lower investment cost, approximately 30% less per unit, and lower operating costs –up to 25% less, based on experience in Spain. Also, the conclusions of the demand model show that, due to the fact that the travel motive of the potential passengers is predominantly leisure and the value of time is comparatively less than in the case of forced mobility, total travel times achieved with trains with a maximum speed of 250/h would be competitive. As an example, the Cairo-Luxor connection would be covered in 3 hours, requiring a commercial speed of 240 km/h.

THE NUMBERS

The study involves development of the high-speed line in three phases. The first would include the stretch between the capital and Luxor, which would begin service in 2026; Luxor-Aswan, in 2031 and the route to Hurghada, in 2036. The study covered an evaluation period of 50 years (from 2021 to 2070), which is the norm in profitability analyses. The socio-economic and financial profitability models were based on the inputs derived from the technical design, such as CAPEX and OPEX, as well as on the results obtained from the demand model: travellers attracted and mobility matrices with and without the project. It also took into account the specific conditions of Egypt's macroeconomic framework and potential financing sources and conditions.

Summing up, it should be noted that the segment with the best results in terms of socio-economic and financial profitability is Cairo-Luxor-Aswan. The final report recommends that detailed studies focus on this corridor first, considering the results associated with the average demand scenario as more realistic. In regard to financing, the viability of the project would be contingent upon the ability of the Egyptian government to adapt to the proposed capital and debt structure, opting for multilateral financing sources in the pre-commissioning phase. In macroeconomic terms, it is estimated that during the construction phase, up to 9,800 direct jobs per year would be generated and total production of goods and services would increase by 13.9%. Once the line goes into operation, the impact on the Gross Domestic Product (GDP) would be 2.3%.

The creation of a public enterprise, preferably attached to the Ministry of Transport, is recommended to manage and operate the high-speed line. This entity would be in charge of the development, acquisition and integration of the components of the system, as well as of the overall coordination of the project. Once the line was operational, it would evolve into a control and management authority. On its part, the private sector would be responsible for the design, construction and maintenance of infrastructure and systems, the supply and maintenance of rolling stock, as well as traffic control and operation of services.

As a final recommendation, although the Cairo-Alexandria corridor was not included in the study, the Egyptian government should plan the high-speed network as a whole, in order to take advantage of the economies of scale generated by the more important corridors. ■

SAL AIRPORT
In the photo, Ginés Navarro and Diamantino Monteiro, at the Amílcar Cabral international airport on the island of Sal, in front of the new departures building.

Cape Verde, more tourism, better airports

Ineco continues its work in the archipelago so that the growing number of international visitors can enjoy the best airport facilities, which are vital to the island country. It will supervise the enlargement of the passenger terminals of the Sal and Boa Vista airports through 2018.

In collaboration with **Ginés Navarro**, **Ángel Toro**, aeronautical engineers, and **Sergio Fernández**, industrial engineer

In 2016, the airports in Cape Verde –four international airports and three for domestic flights– totalled 2,215,892 passengers, 11.5% more than in 2015. The growth of international passengers, up 22%, was especially significant. Tourism is the key engine driving the country's dynamic air-travel market, which already contributes a third of its GDP. Cape Verde is an archipelago, a former Portuguese colony, located off of Africa's Atlantic coast, approximately 500 kilometres from Senegal, and consists of 10 islands, seven of which have airfields. Its long beaches and natural riches attract more and more visitors every year, which has boosted international air transport.

Ineco has been working closely and continuously with the authorities of Cape Verde for 14 years to ensure that the airport network, managed by the public entity Aeroportos e Segurança Aérea (ASA), lives up to the growing demand for air transportation. Beginning in July 2015 to the present, the company has been supervising the most recent enlargement works of the passenger terminals of the Boa Vista and Sal international airports, which have the largest volume of tourists.

SAL AIRPORT

CLOSE TO FIFTEEN YEARS IN CAPE VERDE

Ineco has had offices in Cape Verde since 2015. The company's first works go back to 2003, with the design and management of the works of the new Boa Vista airport, which opened in 2007 and then became international (see *IT7*). Since then, a multitude of studies, projects and supervision of subsequent improvement works have been carried out; these include the review of the master plans of Sal, Boa Vista, Praia and São Vicente, in 2012, easement studies, technical and economic feasibility analysis of night operation in Boa Vista and São Vicente, etc.

The company has drafted the work projects, which focus on external renovation, enlargement of saturated areas and increased comfort and quality of passenger service. The construction is being carried out by a Spanish consortium (Acciona Infraestructuras-Aberdore), while Ineco, with a team of five people, supervises the works at both airports, each located on a different island, Sal and Boa Vista. The work is expected to be completed by early 2018.

SAL, THE MOST INTERNATIONAL AIRPORT

Of the four international airports in Cape Verde, Sal (Amilcar Cabral) is number one with 53% of the total, it is also the one that grew the most in 2016, with 914,696 passengers, 17.2% more than in 2015, according to data from ASA. Of these, almost 754,000 were international passengers.

To meet this increase in demand, provided for in the Plan that was also developed by Ineco (see *IT50*), the adaptation work of the current terminal building has been undertaken, covering a total area of 6,464.58 m². To this end, a mixed solution has been chosen, consisting of both remodelling the existing areas and building an additional 2,022.66 m² of new spaces. Likewise, the plan includes actions to improve the operating revenues of non-aeronautical activities at the airport, increasing the area allocated for shopping.

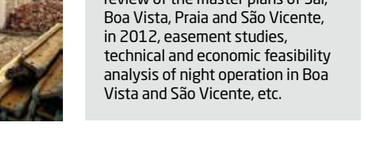
The former international departures area has been restructured, giving way to new departure lounges in a new building, around 1,110 m², built as an improvement to the air side façade towards the aircraft parking apron. This boarding area includes a new executive lounge, and 500 m² of open-air patio with a pool area from which the project gets its name: Oasis.

OF THE FOUR INTERNATIONAL AIRPORTS IN CAPE VERDE, SAL (AMILCAR CABRAL) IS NUMBER ONE WITH 53% OF THE TOTAL, IT IS ALSO THE ONE THAT GREW THE MOST IN 2016

The space that is no longer occupied by the departure lounges (1,400 m²) has become a new open-plan area for passengers after inspection and passport control, where restaurants and shops are located.

The arrivals area is being extended to the north with new structures that will house the new unified room, with double capacity, two new baggage claim areas and a more extensive passport control area. The offices of the authorities, such as the police quarters and customs offices, etc., will be located in this new area.

In order to increase comfort levels and to keep passenger service levels as high as possible, the quiet season, during which traveller flow is much less, is being used to perform works.



The more than 2,000 m² of new construction include departure lounges and a refurbished arrivals area that will double the capacity of the existing one.

A SYMBOL

The control tower at Sal airport is featured on the 200 Escudos Cape Verde currency note, which is the most frequently-used note in the country for small transactions.

BOA VISTA, CHARACTER OF ITS OWN

In 2016, Aristides Pereira Airport, in Boa Vista, saw the second largest passenger growth, with a total of 465,049, 10.2% more than the previous year, of which around 400,000 were international passengers. Traffic has been booming since the inauguration of a completely new airport in 2007, built on the old facilities, entirely planned by Ineco, which was also in charge of the technical assistance of the works.

In the image, Sergio Fernández and Carlos Alberto Vieira, in front of the terminal of Boa Vista.

IN 2016, ARISTIDES PEREIRA AIRPORT, IN BOA VISTA, SAW THE SECOND LARGEST PASSENGER GROWTH, WITH A TOTAL OF 465,049, 10.2% MORE THAN THE PREVIOUS YEAR

The original design of the facilities, structured around a central outdoor space around a pond, partially covered by tents, makes the building unmistakable and is intended to offer a pleasant welcome to the visitor, thanks also to the materials used such as limestone and wood. In 2011, the aircraft parking apron was expanded, a project drafted by Ineco.

Now it is the passenger terminal's turn, which will have 5,332 m² more space, of which 1,245 m² will be used for the arrivals area and 4,087 m² for the departures area (including 1,382 m² of baggage handling space).

The check-in area currently has six counters and a lobby area for building access that is used for passenger queues. With the expansion of approximately 1,458 m², there will be space for 12 check-in counters, plus one for special baggage.

The perimeter area surrounding the hall will be used for staff offices for the airport administrator and other companies.

At the same time, the reformulation of the current space for domestic departures and passenger control makes it possible to increase passport control booths from two to eight. For national and international departure lounge, two new spaces are generated, separated by a commercial area with independent access and a door between them that can act as a sluice-gate for boarding. In total, the commercial area in the departure lounges has increased by 382 m².

In the international area, passport control has moved from its location and the number of booths has increased by four, making six in total. The number of baggage claim areas will also be increased from two to four and the waiting area, currently very saturated, will be expanded. ■

TOURISM AND AIRPORT ENLARGEMENTS

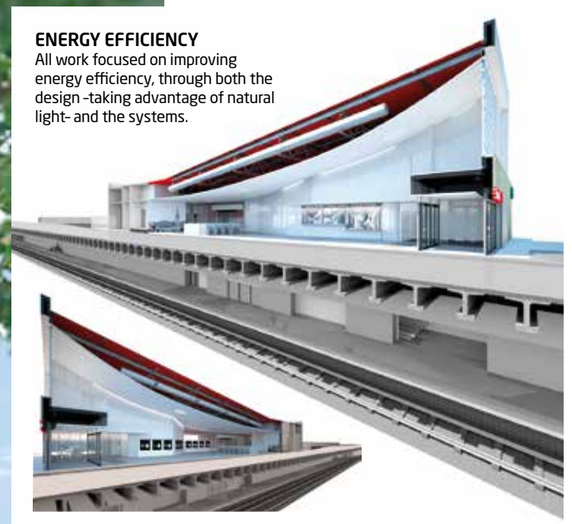
During the first two decades of this century, air traffic volume, driven by tourism, has grown steadily, which has made it necessary not only to expand airport areas dedicated to passengers, but also cargo areas, because the hotel sector has increased the demand for perishable products. As a result, for example, ASA hired Ineco in 2011 to draft the cargo terminal project in Boa Vista (see *IT38*). On the air side, the increase in tourist demand and, consequently, the size of aircraft, as well as the number of operations, has required the enlargement and renovation of runways and aprons, which in turn has affected the need to upgrade other facilities. This is the case, for example, at the São Pedro airport, on the island of São Vicente, for which ASA commissioned Ineco to perform a location study and a construction project for a new control tower after the enlargement of the runway.

BOA VISTA AIRPORT

San Bernardo brought up to date with BIM

IMAGE_INECO DESIGN FOR ADIF

MAIN FAÇADE
The building's façades, especially the main façade, received a general overhaul to improve aesthetics and energy efficiency. Two emergency exit hatches were also installed and rainwater discharge was improved with the installation of drainpipes and perimeter gutters.



ENERGY EFFICIENCY
All work focused on improving energy efficiency, through both the design -taking advantage of natural light- and the systems.

With approximately 3.5 million passengers a year, the San Bernardo Cercanías station, built in the early 1990s, needed to improve accessibility to its facilities. Ineco engineers and architects worked for Adif on the modernisation of this central train station in Seville, through which more than 200 trains and 12,000 passengers pass each day, making it the largest in Seville in terms of traffic and the fourth largest in Andalusia in the south of Spain.

By **Cristina Palmero** and **Aránzazu Azcárraga**, architects; **Ana Ibáñez,** industrial technical engineer and **Francisco R. Montón,** civil engineer and project manager

The modernisation work on the San Bernardo Cercanías station in Seville was carried out while maintaining the services of the station, which has a high degree of intermodality with other public transport in the city, such as Line 1 of the Metro, Line T1 of the tram system and various bus routes. The main objective of the project was to bring the passenger building in line with accessibility, fire safety and energy efficiency regulations, while seeking proper and feasible execution in terms of cost and completion of the works. The refurbishment also included a more rational arrangement of spaces –taking advantage of natural light– and improved transit and layout of the main hall. The exterior was also given new look that was in line with the interior modifications.

With a total of 4,710 m^2 of floorspace (1,100 m^2 in the main hall plus 3,600 m^2 for platforms), the station used to have two entrances at either end of the main façade, leaving a space in between occupied by the cafeteria, which had direct access from outside and inside, and two mezzanine storage areas connected by a walkway. The main hall originally had a ticket office and small commercial area at the centre, which split the natural flow of passengers by breaking the row of turnstiles and dividing it in two. The interior was illuminated by a large window in the façade –a key feature of the station– and the exposed, sloped roof enhanced and directed the entry of light. After passing through the turnstiles, passengers descended to the platforms via two large lateral access spaces using escalators. The platforms, which also provided access the Seville Metro, were showing their age in terms of the finish and lack of lighting, making them gloomy and unwelcoming places.

After studying all of the possibilities, the decision was made to create a single entrance and direct the flow of passengers to a single row of turnstiles; move the commercial area, cafeteria and ticket office to the sides of the main hall; and expand and refurbish the mezzanine storage areas and turn them into offices for Renfe. This large space was enhanced with an expansive curved ceiling that levitates over it and serves as the main chan-

PHOTO_ **INECO**

BIM technology makes it possible to view different design, material and cost options. On the right, the existing façade.

Turnstiles in a single row.

MAIN HALL

The primary aim was to completely rearrange the main hall, including a new passenger service area, creating a single open space to facilitate the movement of users and passengers.

To do this, a suspended ceiling was created to cover the entire main hall with insulation and integrated LED lighting, and turnstiles were expanded and relocated in a single line to facilitate routing.

In addition, sidewall and flooring finishes were renovated to improve distribution and organization of the movement of passengers to both platforms.

nel for light entering through the large window in the façade and also reduces noise inside by absorbing sound.

ACCESSIBLE PLATFORMS AND NEW FACILITIES

In terms of the platforms, the use of new materials for the modernisation and refurbishment of the entire space was maximised. The suspended ceilings, light fixtures and sidewalls were removed and replaced with a sloped suspended ceiling that collects water from the tunnel slab and channels it to the side. This was reclad with cladding with substructure fixed to the existing cavity wall, creating a new chamber for water collection. The flooring (slip-resistance 3) on the platforms and platform edges was removed and replaced. The lighting was replaced by a continuous linear LED lighting system on the edge of platform.

Fire doors, two new lifts for the platforms and new emergency exit doors were installed, and the electrical system, communications room and electrical panels were renovated.

SURVEYING WITH A 3D LASER SCANNER

New design technologies were used to create a functional concept that prioritizes accessibility and order in the flow of passengers. From the beginning of the Ineco project, BIM (Building Information Modelling), software from Revit was used, and it proved to be a highly useful tool in terms of improving coordination with structures and facilities, and generating a model that would also facilitate rapid understanding by all participants in order to streamline resolution of design details and issues. As a starting point for modelling the initial state of the station, a 3D laser scanner was used to survey the entire exterior and interior of the building, including the main hall, technical rooms and platforms. The three-dimensional laser scanner automatically measures a large number of points on the surface of an object in order to generate a data file. The points measured by the device are compiled into a point cloud georeferenced to the UTM coordinates. In this case, the laser also took georeferenced photos with a built-in camera and a specific program then allowed the integrated display of the point cloud and images in order to identify and locate elements, and obtain length and area measurements, among many other functions. The cloud provided a virtual replica of the station in the project's computers that could be used as a tool for navigation and continuous consultation throughout the project, and to serve as a basis for the station's parametric modelling in a program that supports BIM workflow.

DETAILED PLANNING MADE IT POSSIBLE TO MAINTAIN ALL TRAIN SERVICES DURING THE EXECUTION OF THE WORKS

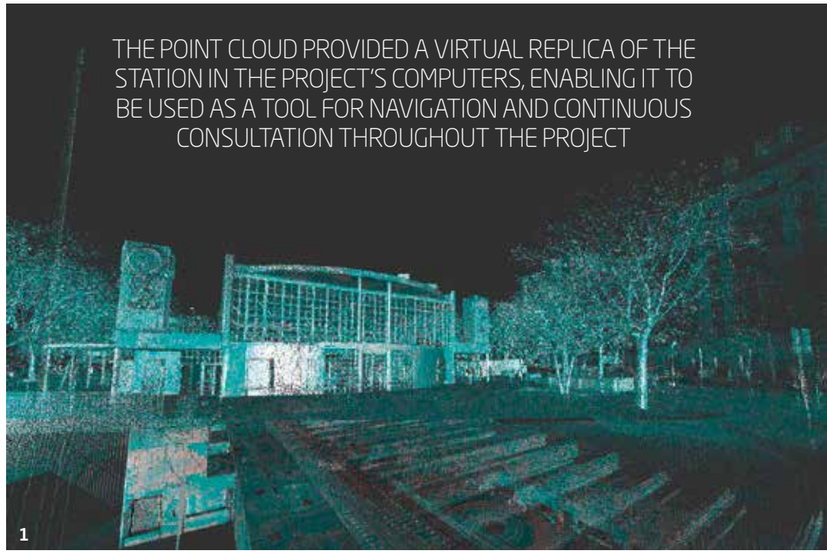
NEW LIGHTING AND ELECTRICAL SYSTEM

Information from the 3D laser scanner was used to improve data collection at the site. The generated files were used to obtain data on elevated elements, such as the diameter of main hall ducts, the size of platform grilles and the position of safety and passenger information elements. The work also included the installation of new systems for the renovation of the main hall and platforms. Any that were in good condition were kept and ventilation outlet and intake elements were adapted to the new suspended ceilings. Although the platform evacuation, use and occupation conditions were not modified, the capacity and condition of the emergency exits were analysed during the project stage.

The electrical system was completely overhauled, from the station's transformer unit, and including new distribution boards and halogen-free wiring to bring the installation in line with the 2002 Low Voltage Regulations. New lighting was also proposed to adapt the system to the new distribution and the minimum requirements set out in the Building Regulations (CTE DB SUA) and Royal Decree 1544/2007 of 23 November concerning accessibility. This equipment was designed with a system to regulate and control each area, including a system to take advantage of natural light in the main hall. All of the proposed work was aimed at improving energy efficiency in the station; for example, the planned loads in the main hall are lower than the existing loads due to the reduction of usable area in the main hall and primarily the improvement of insulation of the roof, with the installation of a suspended ceiling with integrated insulation, and cladding of part of the exterior façade with an external thermal insulation composite system.

Another improvement in energy consumption was the installation of ventilation programmers on the platforms connected to a detection and control centre, CO detection elements, opacimeters and thermostats in order to reduce fan operating times. Finally, in the project stage, the energy certification of the building was simulated for reference using the CE3X v1.3 program, which is recognised by the Ministry of Industry and the Ministry of Public Works. This study confirmed the improvements and the existing building's classification was upgraded. ■

THE POINT CLOUD PROVIDED A VIRTUAL REPLICA OF THE STATION IN THE PROJECT'S COMPUTERS, ENABLING IT TO BE USED AS A TOOL FOR NAVIGATION AND CONTINUOUS CONSULTATION THROUGHOUT THE PROJECT



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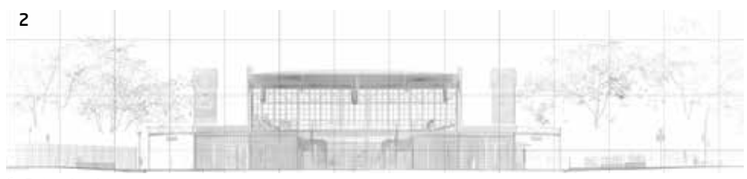
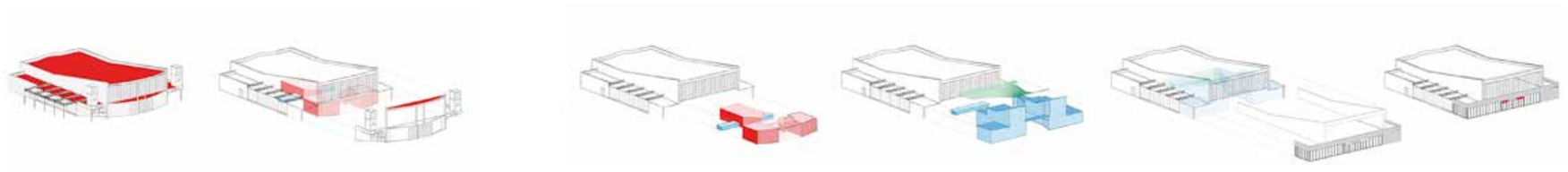


2

1. Point cloud.
2. Section of the point cloud of San Bernardo station.

CONCEPTUAL DEVELOPMENT OF THE BUILDING

In the image, the conceptual development of the processes and actions carried out, pulling out the main façade, the existing interior uses, reorganizing and putting the uses under a large suspended ceiling and, finally, inserting the main façade and side cladding.



The future HS2 high-speed train will bring the lands of Robin Hood and the Peak District National Park (pictured) closer to the country's capital.

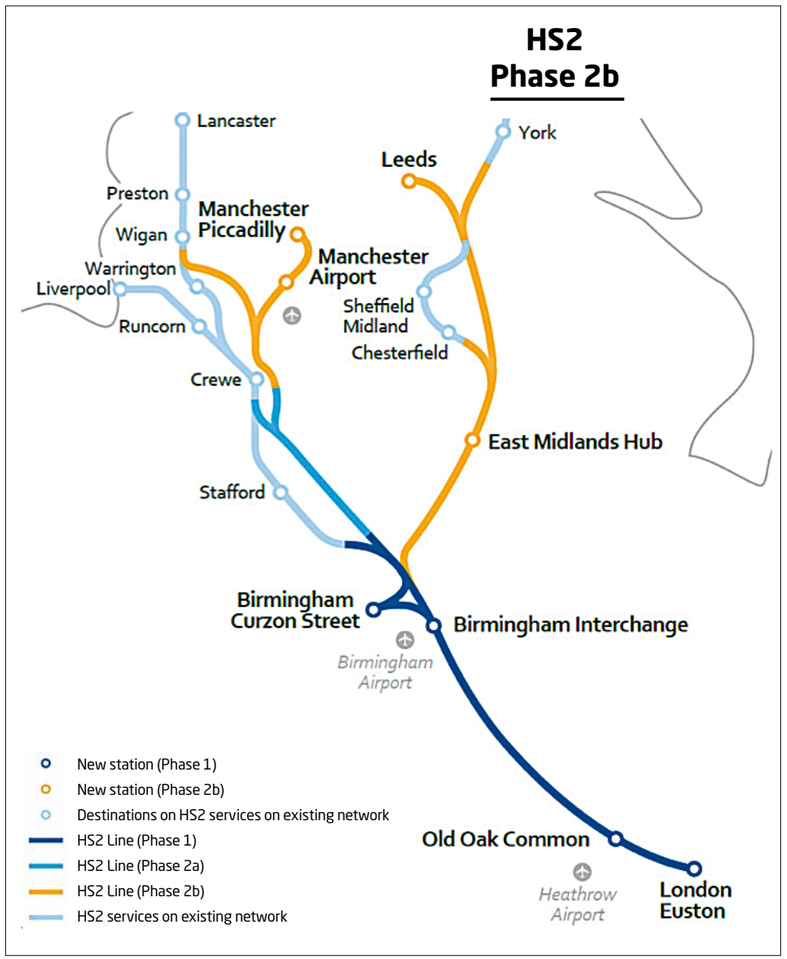
HS2 Phase2b Lot2 = High speed between Birmingham and Sheffield

ROBIN HOOD
The trains on the HS2 will travel even faster than the arrows of the Medieval English hero and will bring to the region and its inhabitants the wealth for which - according to the legend - Robin Hood fought, from his hideout in Sherwood Forest.

The UK government has awarded Ineco, in consortium with US-based Aecom and British company Capita, the contract for the preliminary design of civil works and environmental impact studies for Lot 2 of Phase 2B of the HS2 high-speed line. The line will connect more than four million people to the capital city of London in just one hour.

With the collaboration of **Patricia Ronda,** agricultural engineer, **Juanra Hernández** and **Jaime Escobar, civil** engineers

The Spanish public engineering company has been awarded a new contract for the high-speed line (HS2) that will link London with Manchester and Leeds. Ineco, together with US-based Aecom and British company Capita, will be responsible for the preliminary design of civil works and environmental impact studies for Lot 2, a section of Phase 2B of the project (Crewe-Manchester and Birmingham-Leeds). This work will be carried out in a section that is approximately 90 kilometres long, from the access to Leeds and extending to the Phase-1 connection that ends at Birmingham, all the way to the south of Sheffield. The UK government has been revealing details of the second phase of the HS2 project after a period of negotiations and consultations with the public through its official website, where it provides step-by-step reports on all the projects and decisions taken.



In the image, from left to right, Geoff Kneen, former managing director of Capita; Pablo Ramos, director of the Northwest Europe account of Ineco and John Longthorne, AECOM's director of Bridges and Structures for Europe.

PHOTOS_STEVE COLDRAY, ARRAN BEE (FLICKR)

The new route will link Birmingham with Manchester and Leeds via two Y-shaped branches: one heads northwest towards Manchester with two stations planned at Manchester Airport and Manchester Picadilly; and the other branch heads northeast towards Leeds via the East Midlands and a spur off the main-line to serve Sheffield. It is estimated that this new phase will generate between 48,700 and 70,300 jobs, as well as the construction of 5,200 to 7,600 homes. The rail operations of Phase 2 of HS2 will begin by 2033, although the government plans to advance the West Midlands-Crewe section (Phase 2A) by a few years to 2027 "so that the North and Scotland feel the benefits that the high-speed rail will bring to the people and populations".

Under this agreement, the company has consolidated its presence in the United Kingdom, where it has collaborated in Phase 1 of HS2, between London and Birmingham, since 2012, participating in the preliminary design of a section together with the British company Capita. The first phase, 225 kilometres long, is expected to start operating in the 2026. HS2 will have a high-speed network equipped with state-of-the-art technology: trains up to 400 metres long, carrying a thousand passengers, and travelling at speeds close to 360 km/h, transporting thousands of residents of the North, Midlands and South of the United Kingdom with fast travel times, smart ticketing systems and other optimum levels of comfort. In total, it is expected that 14 trains per hour will run in each direction

Consult the interactive map *http://interactive-map.hs2.org.uk/* for updated information on the line and stations.

THE LINE WILL FEATURE THE NEW EAST MIDLANDS HUB STATIONS, IN TOTON, AND SHEFFIELD MEADOWHALL

AWARD FOR INECO'S DESIGN OF THE 'HS2 BIRMINGHAM DELTA JUNCTION'

In 2014, Ineco received an award for its work in designing the 'HS2 Birmingham Delta Junction'. Located 14 kilometres from Birmingham, this junction provided the challenge of a wide range of structures and highly complex sections, with the main line coexisting alongside the Birmingham inbound and outbound lines and the connection to Leeds. The work corresponds to Phase 1 of the project, in the *Country North Section*, a 75-kilometre section with two tracks designed for a top speed of 400 km/h. The award was presented by the Be Inspired Awards 2013 of Bentley Systems in the category *Innovation in Rail and Transit*. International recognition of this excellent project carried out by the company's railway experts.


Birmingham


Nottingham


Derby


Sheffield

FROM BIRMINGHAM TO SHEFFIELD

A 90-kilometre route full of history

The route of the future HS2 high-speed train continues northwards, connecting the central and eastern regions of England to London in less than two hours. It will also connect towns with a rich medieval past and an important industrial legacy. Landscape, cultural heritage, biodiversity, water, noise and vibration, and waste are key aspects in defining the project, together with the quality of life of its inhabitants.

The line from West Midlands-Birmingham to Leeds, the right-hand side of the Y, runs through the wooded regions of the East Midlands and South Yorkshire, lands with towns founded in the Late Middle Ages that have managed to adapt to the changing times through knowledge and technology. The preliminary design of the civil works and environmental impact studies must include each and every one of the elements of the overwhelming natural, geographical, and cultural heritage contained in the fields and cities, while ensuring the quality of life of the inhabitants. As in other regions of the United Kingdom, both regions have extensive public transport networks to serve the large population that resides in large metropolitan areas on the outskirts of the cities. Here we present some of the cities that will be served by this section of high-speed HS2 in which Ineco is participating.

BIRMINGHAM IS THE SECOND MOST POPULATED CITY IN THE UNITED KINGDOM AFTER LONDON

BIRMINGHAM

The West Midlands is home to around 2.5 million people, half of whom live in Birmingham, the UK's second most populous city after London. It played a decisive role in the industrial revolution, a time from which it still maintains 56 kilometres of canals, even more than Venice. It was bombed in World War II, and after years of decline, surprised the world with a well-designed urban renewal including examples of avant-garde architecture. It has bus, metro, tram and minibus services adapted to provide accessibility to people with reduced mobility using the latest technologies. The international airport is 16 kilometres away by highway and expressway, and has its own train station –Birmingham International Station– with frequent service to the central station, Birmingham New Street. Musical tradition, gastronomy, sporting events, multi-ethnic culture and commerce, as well as its legendary universities, are all part of its current identity.

From Curzon Street station you can take the HS2 trains to the south, –arriving in London in just 49 minutes– to the northwest, to Manchester, or to the northeast towards Sheffield and Leeds.

NOTTINGHAM

Nottingham was also highly prominent during the industrial revolution, particularly in the production of lace, and it still conserves many beautiful large industrial buildings from that period, along with a commercial tradition that attracted many international brands almost as renowned as the Sheriff of Nottingham (such as the Boots laboratory and Raleigh bikes). With more than 300,000 inhabitants and 650,000 in the suburbs and metropolitan areas, it is well connected, including the East Midlands International Airport, highways, trains and trams and a car rental service managed by the city. The largest bus service is owned by Nottingham City Transport (NCT), which has 330 vehicles, 67 routes and transported 50 million passengers in 2015. NCT has been recognized on multiple occasions as the UK's best bus operator *(Route One Large Operator of the Year 2016)*. Nottingham Castle, the huge market square (Old Marquet Square) and nearby Sherwood Forest, home to Robin Hood and the famous 800 year-old Major Oak, along with Southwell Minster Cathedral, are some of its tourist attractions.

SHEFFIELD, FURTHER NORTH, HAS MORE THAN HALF A MILLION INHABITANTS

Nottingham will be approximately 10 kilometres by highway and 12.4 kilometres by expressway from the future high-speed East Midlands hub station in Toton, where the high-speed rail section will connect to the entire region.

DERBY

With some 200,000 inhabitants, Derby has a good rail connection that it inherited from its important industrial role in Victorian times. Its central station, Derby Station, began operating in 1840 in a Victorian building with an imposing façade, with only the old clock remaining today. Formerly the largest railway station in England, it retains good north-south connections and adjoining towns. For its part, Derby shares the East Midlands airport, which is 23 kilometres away by highway, with the metropolitan areas of Leicester and Nottingham. Its monumental past is undoubtedly one of its greatest attractions, reflected in cathedrals, churches and palaces, as well as spectacular gardens such as the Derby Arboretum –England's first public park– Kedleston Hall Garden and Elvaston Castle Country Park, both next to mansions located on the outskirts of the city.

Derby will be 17 kilometres away from Toton's future high-speed station, the new East Midlands Hub, by the A52 highway.

SHEFFIELD

Bathed by the River Sheaf, Sheffield is part of the county of South Yorkshire and proudly bills itself as a green city due to its many trees. With more than half a million inhabitants, it also stands out for its student atmosphere, with two large universities that attract more than 50,000 young people per year from around the world, and good sports facilities, the result of a long tradition in sports such as football and cricket. Sheffield is also privileged to be within walking distance of the Peak District; the gardens and the luxurious 18th-century Chatsworth Palace; and in the city centre, an immense botanical garden with its remarkable Victorian glass pavilions. The nearest airport –Doncaster Sheffield, originally built for the military– is located 29 kilometres from the city and saw its first commercial flight in April 2005 to Palma de Mallorca. The city, accessible on foot, has three tram lines and several buses. It is connected by train and highway.

The inhabitants will be biggest beneficiaries of the north-south connections provided by the high-speed railway line, which is expected to be connected to a station within the city in around 2033. ■

PHOTOS_**NEIL HOWARD, ADAM CLARKE, ALAN FEEBERY, ROB (FLICKR)**

HIGH-SPEED RAIL IN 12 COUNTRIES

INECO HAS MORE THAN 25 YEARS OF EXPERIENCE IN HIGH-SPEED RAIL SINCE ITS PARTICIPATION IN THE DESIGN AND CONSTRUCTION OF THE LINE BETWEEN MADRID AND SEVILLE WHICH OPENED IN 1992 (SEE *IT59*).

▶ In addition to its work on HS2 in the United Kingdom and the 3,000-km AVE network in Spain, it has also been, or currently is, a participant in the construction of other high-speed lines on different continents.

▶ It is currently working as part of a Spanish consortium to design and build 444 kilometres of high-speed rail between Mecca and Madinah in Saudi Arabia (see *IT42);* as well as the first high-speed line approximately 1,000 kilometres long between Tehran and Mashhad in Iran; the project for a new high-speed corridor between Delhi and Kolkata (see *IT56)* and another between Howrah and Haldia (see *IT46),* both in India, and the modernization of the line between Ankara and Istanbul in Turkey (see *IT46).*

▶ Some of the company's many studies include work in Argentina on projects for a high-speed line between Buenos Aires, Rosario and Cordoba. Ineco has also performed several studies for a high-speed line between São Paulo and Rio de Janeiro; in Mexico, a corridor between Mexico City and Querétaro; in Bulgaria, the modernization of a line between Vidin and Sofia (see *IT29);* in Kuwait, a high-speed corridor between the Gulf countries, and in Portugal, provided assistance for a high-speed line. In addition, the company has worked in connection with France for high-speed lines on both the Figueras-Perpignan and the Vitoria-Dax routes (see *IT47).*

▶ Lastly, Ineco is also working on several European projects related to high speed, either as an adviser in the implementation of the ERTMS system in European corridors (see *IT53)* or on other projects such as GRAIL, MOWGLY, BOSS and OPTIRAILS.

IMAGE OF LEÓN'S NEW RAILWAY STATION
Adif has begun work on a tunnel project to provide continuity to the León-Asturias line along the old railway track.

IMAGE_URBAQ ARQUITECTOS

Beneath the heart of León

The railway integration works that Adif has begun with the collaboration of Ineco will transform the urban environment of the historical city of León and prevent delays caused by the cul-de-sac design of the existing temporary station. Among other works, the project includes the building of a tunnel for a one-kilometre-long section of track, the construction of a pedestrian walkway, and the restoration of the canopy of the old station.

By **Javier García de Muro**, civil engineer

The railway network in the city of León and the surrounding area is currently based around a *cul-de-sac* station. This means that trains to and from Madrid or Gijón that stop in León are forced to reverse out of the station and use the 'southern link' in order to continue on their way, requiring a delay of around twenty minutes. To solve this problem, Adif has started tunnel works to provide continuity to the León-Asturias line along the old railway track that crosses the city to correct the station's *cul-de-sac* arrangement. By doing this, trains to and from Asturias will be able to cross the city without the need for any reversing manoeuvres.

Ineco is in charge of the monitoring and supervision work and management for Adif high-speed, including the preliminary analysis of the selected project, the Supervision and Monitoring Plan, works supervision, geometric monitoring and coordination of the surveying and supervision works, preparation of site layout verification reports, collaboration on the drafting of projects and preparation of as-built projects for the completed works. The company is also involved in the drafting of the construction and electrification projects.

In the first phase of the project, which will last for more than two years, the old corridor will be transformed into a tunnel between concrete walls with Iberian gauge tracks –scheduled for conversion to standard gauge– which will connect the existing Iberian gauge track that extends to the west of León's temporary station (Line 130 Venta de Baños-Gijón Cercanías, Palencia-León section) with the double track of the León-Variante de Pajares section (Line 130 Venta de Baños-Gijón Cercanías, León-Gijón section). The work will also involve enlargement of the provisional station, construction of an underground station with new platform, and creation of a superstructure and electrification system.

OBJECTIVE: TO PROVIDE CONTINUITY TO THE LEÓN-ASTURIAS ROUTE
The aim of the tunnel works initiated by Adif is to provide continuity to the León-Asturias line using the old railway track that crosses the city to correct the station's *cul-de-sac* arrangement. By doing this, trains to and from Asturias will be able to cross the city without needing to perform any reversing manoeuvres.

THE PLATFORM IN DETAIL

1. GEOMETRIC CHARACTERISTICS OF THE STANDARD PLATFORM SECTION

▶ **Above-ground platform**

- Gauge 1,668 mm
- Minimum distance between track centres 3.808 m
- Minimum platform width 13.30 m
- Ballast shoulder 1.10 m
- Minimum ballast thickness below sleeper 0.35 m

▶ **In tunnel:**

- Minimum distance between track centres 3.808 m
- Vertical height 6.50 m
- Minimum horizontal width 10.00 m
- Distance between track centre and concrete side wall 3.00 m

2. TRACK ELEMENTS:

▶ **UIC54 rail**: the rail to be installed both on slab and ballast will, in principle, be 54E1, and will arrive on site in long lengths of 270 m or short lengths of 18.00 m. The total length of rail to be supplied is 6,557.96 m.

▶ **PR01 sleepers**: the sleepers to be installed on ballast will be PR-01 multi-purpose pre-stressed concrete (valid for 1,668 mm and 1,435 mm gauges). The spacing between sleepers will be 0.60 m. The total number of this type of sleepers to be supplied is 3,605 units.

▶ **EDILON EBS-SS 54E1 HR Pol with 25mm TRACKELAST STM/RPU/ Blue mat**, multi-purpose bi-block, in principle, for 54E1 rail and 0.60 metre thick slab. The block is integrated into HA-30 and HM-20 concrete slab.

▶ **Type 1 crushed-stone ballast**: this track ballast will be obtained from approved quarries and will be used for track beds and track liftings. A total volume of 3,109.40 m^3 of ballast will be supplied, with 1,554.70 m^3 will be for track beds and the rest transported by hopper for track liftings.

▶ **Track devices (ballast)**: a total of three multi-purpose track devices will be installed.

PLANNED WORK

Infrastructure: civil engineering tunnel works

▶ 1,166 metres **of track box will be constructed between concrete walls**. The 590-metre long section of line will feature a **cover slab** that will be constructed using the cut-and-cover tunnel system. The width of the box will range from 10.00 metres at the platform access and exit areas to 18.50 metres in the station itself. The height of the covered area is 6.5 metres along its entire length.

▶ Execution of a **central platform** 9 metres wide and a usable length of 410 metres.

▶ **Safety installations in the tunnel**, featuring signalling, emergency lighting and ventilation systems. A total of 5 emergency exits have been defined, in addition to access from the station.

▶ Regarding **drainage**, a drainage plan has been drawn up for the railway platform, featuring a network of collectors under the cover slab. A pumping system with a well will be used to extract the water collected by the drainage network and accumulated at the low point.

Track superstructure

▶ Execution of **1,636 metres of double track**. **1,180 metres** of this will be **slab track,** with the remainder laid on **ballast**. **3 track devices** will also be installed.

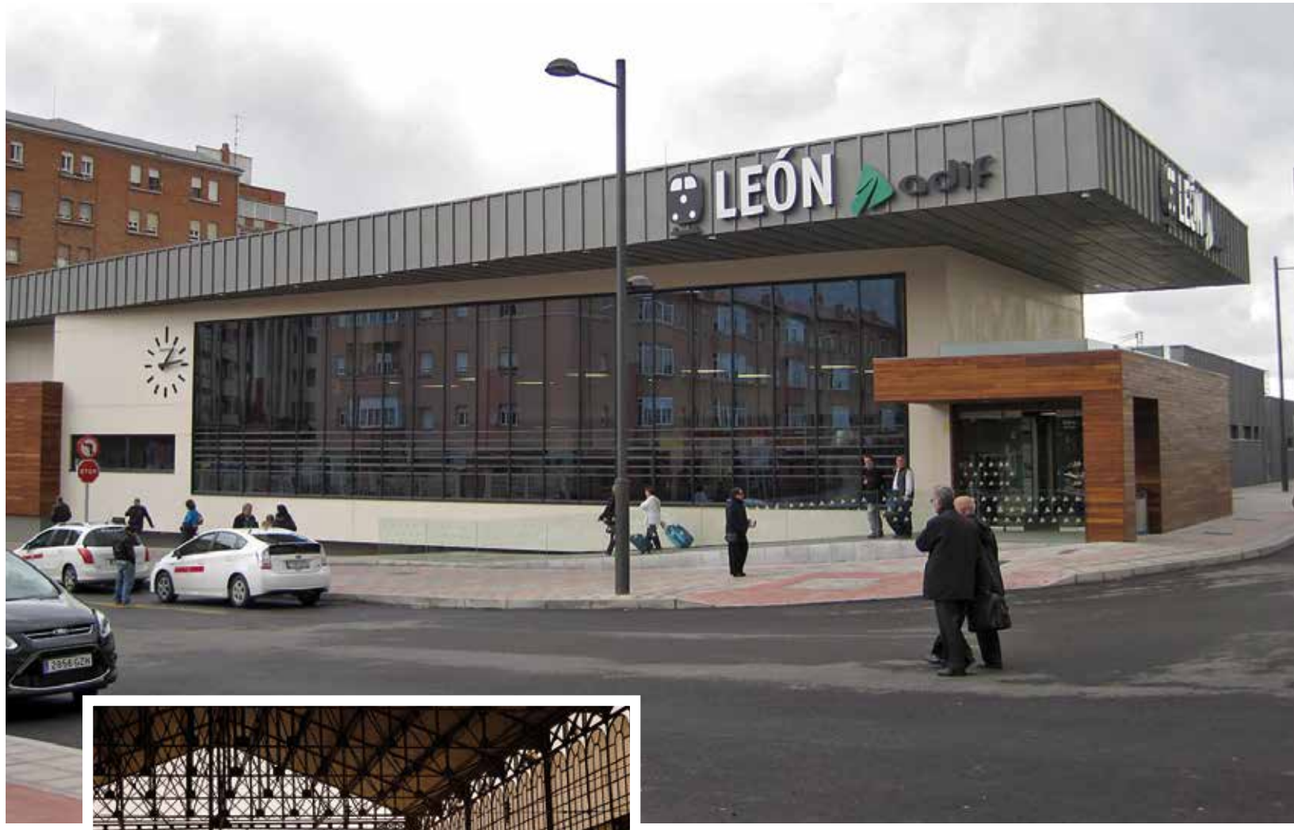
▶ **Demolition and construction of rail facilities and services** at the site.

Electrification system

▶ Work will be done to **replace the existing track electrification system** and track devices for the access track to the locomotive workshops and to the planned track that will connect the tunnel works with the Iberian gauge track that currently allows access to León station (3G).

Station building

▶ **Interior renovation and extension of the current passenger building**: the station will undergo internal modifications to rearrange its layout, and will be extended to the west to encompass the new underground railway track. As part of this extension, a vertical access space will be created with a new underground platform.



The photo above shows the existing temporary station that will be expanded. Design by the architect Fernando Liébana.

The photo on the left shows the canopy of the old station building constructed in 1862 and in service until 11 March 2011.

▶ **Reconfiguration and enlargement of the station's access road**: the area will be provided with a taxi stand, bus stop, kiss&ride area and parking reserved for ambulances and emergency vehicles. A new 76-space car park will also be created.

▶ **The upper slab of the tunnel works will be paved** to create a pedestrian walkway from Avenida del Doctor Fleming to the station. This walkway will run below the canopy of the old station's passenger building and will feature different covered skylights that will provide natural light and facilitate ventilation and extraction of fumes from the underground platform. This longitudinal walkway will integrate the space by removing the barrier created by the existing surface railway, providing a connection between the existing population centres on either side of the railway corridor above the new underground railway platform.

▶ **Restoration of the canopy of the old station's passenger building**. The canopy's metal structure will be restored by cleaning and the application of a protection system. The missing polycarbonate panels in the western façade will also be replaced and the lighting system will be renovated.

Installation of the new superstructure: type and reinforcement

The new track will be installed on ballast and concrete slab:

▶ **Installation of track on ballast** in the tunnel's uncovered section and secondary track centres.

▶ **Installation of the 3 track switching and crossing units on ballast**.

▶ **Installation of** EDILON EBS-SS 54E1 HR Pol with 25mm TRACKELAST STM/RPU/Blue mat and slab 0.60 metres thick in the tunnel section.

All track installations will have a conventional gauge of 1,668 mm in phase one, and standard gauge in the future. The total track installation length is 3,598.33 metres, of which, 1,274 metres is track on ballast and the remaining 2,325 slab track. ■

Mathematics against chaos

There are hundreds of factors that could affect airport operations and potentially cause an incident: incorporation of aircraft with larger fuselages, the placement of cranes or a new building in the surrounding areas of an airport, a runway with an excessive slope, a poor drainage system, a shed or a nearby tree mass, an area with strong winds, etc. There are also strict regulations and procedures to prevent and manage each event.

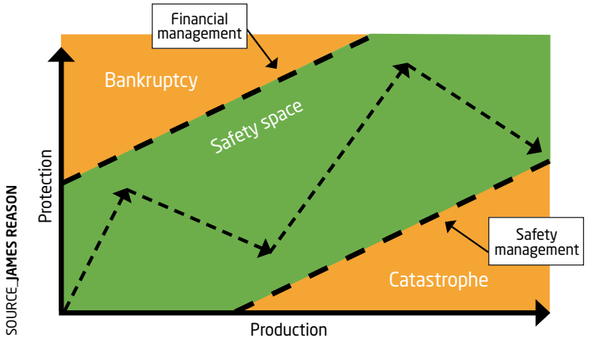
By **Sara Gª Ramos**, mathematician

Nothing in an airport is superfluous. Everything is controlled and that is how it should be because, although it impossible to guarantee absolute safety, risks can be eliminated or mitigated to an acceptable level without causing injury to people or damage to property. Aeronautical safety studies are designed precisely to consider each and every one of these cases in order to identify, prevent and minimize any risk of accident or incident at airports, either on the land side or on the airside. Thanks to this work done by the entire aeronautical community, today's world air transport has very high levels of safety, and is constantly reviewed through an ongoing process of hazard identification and risk management.

The rapid development of new technologies introduces factors that did not previously need to be taken into consideration. The advance in business models is focused on the construction of increasingly large aircraft that must operate at airports with all safety guarantees. These constraints generate added difficulty to maintain the quality standards that have been achieved. This is a constant effort, and in many cases it is necessary to propose alternatives, for example, aeronautical safety studies that guarantee an equivalent level of safety.

In general, these studies will be used in cases where the correction of a deviation is not feasible or is technically, operationally, environmentally or economically excessive, and the safety degradation can be overcome by means of procedures that offer reasonable, practical solutions.

The airport operator, airlines and air navigation providers have their own safety management systems, but it is of little use if each group pursues its own objectives in a way that is not coordinated with the other agents involved in the operation. The different safety management systems have to be integrated to form part of an interlocking system in which all pieces operate in a synchronized manner.



SOURCE_**JAMES REASON**

INTERNATIONAL REGULATIONS

In the Convention on International Civil Aviation (1944), also known as the Chicago Convention, the main rules of aeronautical law were laid down in order to achieve adequate safety in air transport: at the end of World War II it was important to review the international agreements on civil aviation in a period of consolidation and development of the world aviation sector, and commercial aviation in particular.

The Convention was the seed of the International Civil Aviation Organization (ICAO), a specialized agency of the United Nations created that same year to promote the safe and orderly development of international civil aviation around the world. The ICAO established, and continues to establish, the necessary standards and regulations for aviation safety, efficiency and environmental protection worldwide. Strengthening the safety of the global air transport system is its primary objective. The ICAO Global Aviation Safety Plan (1998) was developed to reduce the number of accidents regardless of the number of flights.

As the increase in air traffic leads to an increase in the risk of accidents, a progressive improvement in safety management has become necessary in order to maintain adequate safety levels. Its objective is to progressively reduce the number of accidents regardless of the growth of air traffic, taking into account that:

▶ No human activity or human-designed system can be totally free of risks and errors.

▶ The elimination of all accidents (and serious incidents) is impossible.

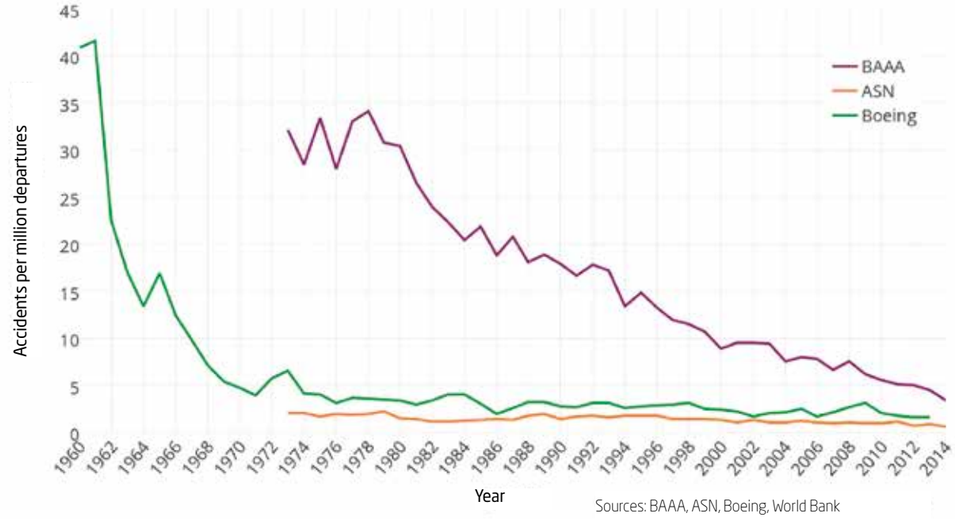
▶ Failures will continue to occur, despite the most successful prevention efforts.

▶ Risks and errors are acceptable in an implicitly secure system, provided they are under control.

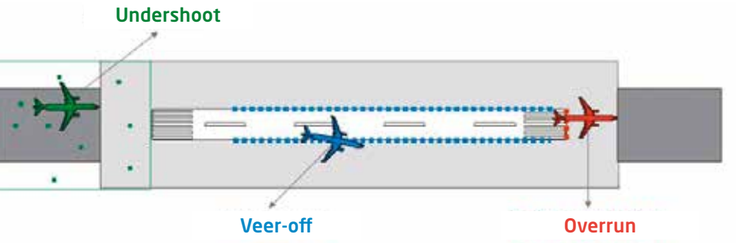
> THE LEVELS OF SAFETY GUARANTEED BY GLOBAL AIR TRANSPORT TODAY REPRESENT AN ACHIEVEMENT BASED ON THE DETERMINATION AND EFFORTS OF THE AVIATION COMMUNITY AS A WHOLE

The levels of safety that global air transport guarantees today represent an achievement based on the determination and efforts of the aviation community as a whole. Safety must be a dynamic process that is adapted constantly, while maintaining the objectives achieved with the goal of achieving the lowest possible risk, without forgetting the progressive adaptation to the changes that will be taking place.

In this regard, the ICAO document *Procedures for Air Navigation Services* –Aerodromes (PANS-Aerodromes) (Doc. 9981), first edition 2015–, details the operational procedures to be applied by aerodrome operators to ensure safety,



ACCIDENTS BY NUMBER OF AIRCRAFT MOVEMENTS
The graph shows the progressive decrease in accidents per million aircraft departures since the implementation of the first safety management processes in the late 1970s. Sources: Aviation Safety Network (ASN), Bureau of Aircraft Accident Archives (BAAA).



especially when it is not possible to fully comply with the required technical specifications.

It is important to note that the cost (economic, operational, environmental, etc.) of any action must be balanced against the safety benefit, so as to generate the least possible socio-economic impact without compromising the equivalent level of safety.

According to Article 15 of the Convention on International Civil Aviation, all aerodromes open to public use under the jurisdiction of a Contracting State must provide uniform conditions for all aircraft of all other Contracting States. Likewise, Articles 28 and 37 of the same Convention provide that each State shall provide in its territory airports, other air navigation facilities and services in accordance with the Standards and Recommended Practices (SARPs) developed by ICAO. Airport operators must therefore have an airport certificate in order to be able to operate, and in the case of newly built airports or where new runways are to be put into service, this is a prerequisite before opening to traffic. The loss or modification of the certificate will result in the loss or immediate modification of the authorization to admit air transport. The certificate accredits the ability of both the infrastructure and the operator to carry out air transport operations.

SAFETY MUST BE A DYNAMIC PROCESS THAT IS ADAPTED CONSTANTLY WITH THE GOAL OF ACHIEVING THE LOWEST POSSIBLE RISK LEVELS

In Spain, the Aviation Safety and Security Agency (AESA) is the aviation authority responsible for granting the certificate and monitoring any problems or deviations. Within the required documentation, are the aeronautical safety studies whose purpose varies from the justification of the fulfilment of the requirements to the evaluation of the deviations detected.

Ineco has been carrying out this type of study in Spain for over 10 years, working in air navigation, for all airports and heliports in the Aena network, as well as at other international airports in countries such as Mexico, Israel and Italy. Also, during this period Ineco has supported the certification processes at the airports and heliports of the Aena network - guaranteeing results and procedures.

MATRIX FOR CLASSIFICATION OF FREQUENCY OF OCCURRENCE (PROBABILITY)

	PROBABILITY	QUALITATIVE DEFINITION	QUALITATIVE DEFINITION
5	Frequent	Likely to occur many times (has occurred frequently)	$>10^{-3}$ per operation
4	Occasional	Likely to occur sometimes (has not occurred frequently)	$>10^{-5}$ and $<10^{-3}$ per operation
3	Remote	Unlikely, but may occur (rarely occurs)	$>10^{-7}$ and $<10^{-5}$ per operation
2	Improbable	Very unlikely to occur (not known to have occurred)	$>10^{-9}$ and $<10^{-7}$ per operation
1	Extremely improbable	Almost inconceivable that the event will occur	$<10^{-9}$ per operation

RISK CLASSIFICATION MATRIX
The risk matrix is a two-dimensional representation of the safety risk that relates the severity to the frequency of occurrence for each type of event.

	SEVERITY / PROBABILITY	A CATASTROPHIC	B DANGEROUS	C SIGNIFICANT/ MAJOR	D INSIGNIFICANT/ MINOR
5	Frequent	UNACCEPTABLE	UNACCEPTABLE	UNACCEPTABLE	TOLERABLE
4	Occasional	UNACCEPTABLE	UNACCEPTABLE	UNACCEPTABLE	TOLERABLE
3	Remote	UNACCEPTABLE	UNACCEPTABLE	TOLERABLE	ACCEPTABLE
2	Improbable	UNACCEPTABLE	TOLERABLE	ACCEPTABLE	ACCEPTABLE
1	Extremely improbable	TOLERABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE

AERONAUTICAL SAFETY STUDIES

The objective of an Aeronautical Safety Study is to try to analyse an aeronautical problem, to determine possible solutions and select the most acceptable option, without adversely affecting safety. In short, the purpose of these studies is to:

- ▶ Detect the causes of the problem and evaluate the possible impact on the safety level.
- ▶ Present alternative means to ensure the aircraft operations safety.
- ▶ Evaluate the effectiveness of each alternative.
- ▶ Recommend procedures to act on the causes and/or diminish the effect or the occurrence of the consequences.

INECO HAS BEEN CARRYING OUT THIS TYPE OF STUDY IN SPAIN FOR OVER 10 YEARS, WORKING FOR ALL AIRPORTS AND HELIPORTS IN THE AENA NETWORK, AS WELL AS IN OTHER INTERNATIONAL AIRPORTS IN COUNTRIES SUCH AS MEXICO, ISRAEL AND ITALY

To achieve these objectives, the studies are based on a technical analysis. Technical analyses seek to justify deviations based on the possibility of achieving an equivalent level of security by other means. In addition, these analyses are generally applied in situations in which the cost of correcting issues that violate standards is excessive, but the negative effects on safety can be overcome by procedures that offer practical and reasonable solutions.

An aeronautical study may be conducted when aerodrome standards cannot be strictly met as a result of development or extension. This study is most frequently undertaken during the planning of a new airport or during the certification of an existing aerodrome.

MATHEMATICAL STUDIES TO DETERMINE THE PROBABILITY OF AN EVENT

Risk analysis can be focused qualitatively or quantitatively involving mathematical models and input by groups of experts who contribute their knowledge to the process.

Quantitative models are a set of analytical techniques based on mathematical arguments used to assign probability of occurrence to a given fault or event in order to evaluate the level of risk associated with a given operation.

Runway excursion is the most frequent and catastrophic accident with respect runway operation. For this reason, a specific *Mathematical model for the assessment of runway excursion probabilities* has been developed for this type of incident.

SEVERITY AND PROBABILITY METRICS

The accident database's statistical model is based on the collection and processing of accident data in order to establish the quantitative relationships necessary to evaluate the safety of a system. The creation of a database with statistics on accidents, incidents and events and their analysis, makes it possible to determine the probability of occurrence for the most frequent events in an airport.

The tables show some examples as a guide, taking into account the international ICAO standard, severity classification matrix and probability classification matrix. ■

AIRPORT OPERATION
Good coordination of procedures between pilots, ATC and other personnel.

CLIMATOLOGY
Visibility, the cloud ceiling, the wind intensity, torrential rains, etc. are factors to take into account.

OBSTACLES
Both the control towers and nearby buildings, as well as any other obstacles, must be marked and illuminated.

WILDLIFE CONTROL
The wildlife that exists within the airport environment, especially birds, can produce serious damages.

FIRE FIGHTING AND RESCUE
Airports should provide the appropriate level of protection.

PLATFORM VEHICLES
The movement of vehicles and handling equipment must be under control at all times.

AIR NAVIGATION SERVICES
Air navigation aids is essential in airport operations.

RUNWAY CONFIGURATION
All risks must be foreseen in the design of runways

TRAINING SEMINARS
In 2012, Ineco gave a Safety Seminar with Aena Internacional in Mexico. In the centre of the photo, from left to the right, Sara García Ramos, mathematician and author of this article, and Rosario González, aeronautical technical engineer, both from Ineco.

SAFETY FACTORS TO TAKE INTO ACCOUNT :
In addition to hazards and risks, there are also mitigating and aggravating factors, such as:

▶ The procedures for coordination between pilots, air traffic controllers and airport staff affect the operation; proper coordination of these procedures can minimize the risks.

▶ Wildlife, especially birds, in an airport environment, can cause serious economic and safety issues.

▶ Runway design: dimension, shoulders, strips, strength, signalling, lighting, etc., must be taken into account in any possible risk, especially before a runway excursion.

▶ Airports should provide the appropriate level of fire protection and rescue, depending on their category.

▶ Air navigation assistance is essential in airport operations. Having the right assistance based on the type of operation allowed at the airport minimizes potential risks.

Denmark, 100% ERTMS

By 2023, Denmark will become one of the first European countries to have a full, and completely renovated, railway signalling network. Spanish public engineering company Ineco and the Cedex research centre have been collaborating with the Banedanmark railway infrastructure manager since early 2017 on the F-Bane project to upgrade the signalling on the Danish railway network.

By **Beatriz Sierra** y **Francisco Mayoral**,
industrial engineers

In 2012, Banedanmark launched its Signalling Programme (SP) that includes the renovation of the entire railway network in its territory. The commitment to technology, which will mean replacing all the existing equipment and systems, was approved by the Danish Parliament in 2009 and will involve an investment of around 2.5 billion Euros. With the introduction of this new signalling system, the Danish government expects to be able to increase the performance and quality of its rail operation and serve around 70 million passengers by 2030.

The signalling system to be installed is ERTMS level 2 in version 3.4.0 of Baseline 3. This is the European rail traffic management system promoted by the European Commission, which is being implemented on the nine core network corridors of the Union. Its objective is to establish a common language throughout the European railway network, a project that brings significant improvements in railway operation, allowing the internal and cross-border traffic of all trains with greater capacity, improved safety and lower costs. Since 2015, Ineco has been in charge of the supervision and monitoring of the ERTMS deployment plan on the European core network corridors until 2020 (see *IT*53, *IT*59).

Ineco engineers Francisco Mayoral and Alfonso Martínez at Charlottenlund station.

196 TEST CASES AND TWO PILOT LINES

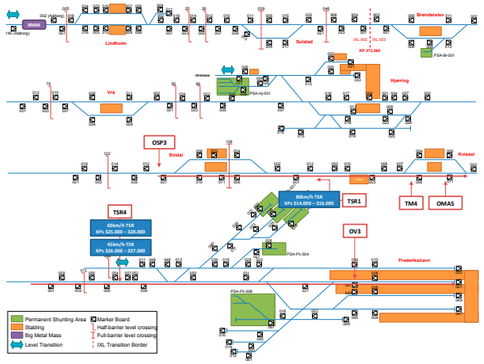
Spain has 2,150 kilometres of railway lines equipped with the ERTMS system, including 656 kilometres with level 2 ERTMS. Ineco and Cedex's extensive experience and technical knowledge of ERTMS has made it possible for Banedanmark to rely on the Spanish entities to develop the test specification of this system for the Danish track application.

In compliance with Banedanmark's operational requirements, Ineco and Cedex produced 196 generic test cases that test the ERTMS functions to be implemented in the lines. In addition, they have designed the operational scenarios for the two pilot lines (EDL EAST and EDL WEST) equipped by Alstom and Thales, respectively. These indicate the specific location in the infrastructure at which the developed test cases will be carried out. A test scenario is a sequence of test cases that reproduce a series of situations that a train could encounter on a journey along a line. They reproduce situations ranging from nominal conditions, such as a commercial traffic at maximum speed, to severely degraded situations that simulate the different failures that may occur in the equipment and its interfaces. These test cases and scenarios are applicable for both on-site and laboratory tests.

During the month of July, Ineco carried out a first test campaign in the JTL laboratory (Joint Test Laboratory) created by Banedanmark as part of its renewal programme. This laboratory has both simulated and real equipment (RBC, on-board equipment, GSMR and GPRS connection, signalling control point, control centre interface and even a level-crossing). In terms of software, the same versions installed on the track are installed in the laboratory, so many of the functional tests can be performed more comfortably.

Laboratory tests provide a number of advantages over field testing. On one hand they do not have to interrupt the existing commercial traffic, they do not require real trains, and involve fewer personnel. All of these factors reduce campaign times, and consequently the cost, of the test phase within the processes to commission infrastructure

INECO HAS DEVELOPED CLOSE TO 200 TEST CASES FOR THE ERTMS LEVEL 2 APPLICATION THAT IS GOING TO BE DEPLOYED IN THE RAILWAY NETWORK IN DENMARK BETWEEN 2018 AND 2023



The figure shows a representation of scenario 7 in the EDL WEST equipped by Thales. This initial campaign on the EDL WEST railway line will be followed by another on the EDL EAST.

PHOTO_F. MAYORAL / INECO

Copenhagen Central Station.

or trains on a specific infrastructure. Consequently, the objective is to replace as many field tests as possible with laboratory tests, reducing field tests to a minimum. In this sense, the test campaign carried out by Ineco allowed the verification of the real possibilities that the laboratory can provide to reproduce the different situations that may occur in the normal operation of the trains on the track.

The current support contract for the Danish railway signalling programme includes other activities such as developing validation infrastructure strategies for the upcoming lines to be put into operation. This is the definition of the subset of test cases to be performed, depending on whether or not it is a new type of train to be put into operation on an already operational track, or if, on the contrary, it is the same type of train that will run on a new track but one that is designed with the same principles as an infrastructure that is already in operation.

Banedanmark intends to upgrade its infrastructure from the current ERTMS version 3.4.0 to 3.6.0 which is already available in European specifications. Ineco will also support the update of the test specifications to this new version.

FEATURES OF THE F-BANE PROJECT	THE DANISH NETWORK (F-BANE + S-BANE)
▶ETCS baseline 3 maintenance release 1 ▶Modern network with a centralized signalling system ▶2 infrastructure contracts ▶All on-board equipment ▶GSM-R voice and GPRS ▶Specific transmission module (STM), Danish and Swedish ▶Traffic Control Centres ▶New operational rules	▶2,700 trains/day ▶40,000 daily departures ▶+ 190 million passengers ▶+ 15 million tonnes transported ▶Lines: 2,132 km / Tracks: 3,240 km ▶Bridges: 2,342 ▶Signalling control points: 480 ▶Stations: 307 ▶Level crossings: 1,096

The map shows the ERTMS deployment plan on the main and regional railway lines, and the commissioning dates.

NOELIA MEDRANO

"We plan well in advance to avoid affecting commercial activity"

With more than 15 years of experience in railway signalling, Noelia Medrano (Madrid, 1978) has been in Banedanmark, Copenhagen for 2 years, and is responsible for the functional and operational field tests on all the lines in the country.

What benefits will the new ERTMS signalling bring?
Passengers will enjoy improved punctuality, increased capacity and shorter trips on some lines. By 2030, we expect to double the number of passengers and reduce delays by 80%. In addition, we will have a more safer and better controlled network with real-time information and more economical maintenance. In short, there are only advantages!

What are the major challenges of the Signalling Program with regard to ETCS?
Although a priori it seems simple because there are only two suppliers involved and the network seems small compared to other European networks, this is the first project that will put ETCS Baseline 3 into operation. On the other hand, most of the lines under renovation currently have commercial operations that must be maintained. This means that both the installation work and the track test phases have to be planned very early, around six months prior to the work, in order to interfere as little as possible in the commercial operation.

What systems are affected by the renovation?
In addition to the new signalling (new points, axle counters, interlockings, GSR-M, RBC, etc.), other programmes are being carried out on some lines, such as the catenary installation or civil engineering activities. The entire fleet of commercial and freight trains will be also upgraded.

A GREAT EXPERT
Currently the Operations Site Test manager of the Fjernbane Project, on which Ineco is collaborating. Previously, she was responsible for ERTMS and CBTC Testing at General Electric, for 3 years in Paris, and responsible for the development of ERTMS Level 2, at Dimetronic (now Siemens), for 11 years in Madrid. For Noelia it has been very enriching to work in different countries, since although the ETCS system is a standard, the way it is applied is different for each operator.

Is it complicated to adapt to high speed?
The topology of the existing lines is not the most appropriate for the implementation of high speed. On many of them there are a large number of level crossings, crossings for pedestrians or cattle, etc. All this requires a large number of people and organizations involved to ensure safety during testing. For example, until the level crossings are fully tested, police presence may be required during the tests to ensure that no vehicles cross the road.

What is the main objective of the JTL?
The Joint Test Laboratory is designed to run the largest number of tests prior to on-site testing, and minimize the risks and the cost of the field testing.

Who uses the JTL and what kind of tests are performed?
The suppliers –Alstom and Thales– and the SP testing department are the ones that work in the JTL. The suppliers are responsible for demonstrating the integration of their subsystems (e.g., RBC, IXL, and TMS), while BDK is the final integrator and is therefore responsible for end-to-end testing to demonstrate the behaviour of all of the subsystems together. In addition to functional and integration testing, much emphasis is placed on operational testing, i.e. how the end user (a driver or operator) uses the system. ■

Logical logistics

The cars we drive, the clothes we wear, and the fish we eat reach us by means of a process known as the supply chain, in which efficient and well-planned logistics centres play a fundamental role. Ineco has extensive experience, both in Spain and internationally, in technical and economic feasibility studies of this infrastructure that is vital for the transport of goods.

ITRANSPORTE, in collaboration with civil engineers **Esther Durán** and **María López-Mateos**

PHOTO_**DHL**

PHOTO_**ELVIRA VILA**

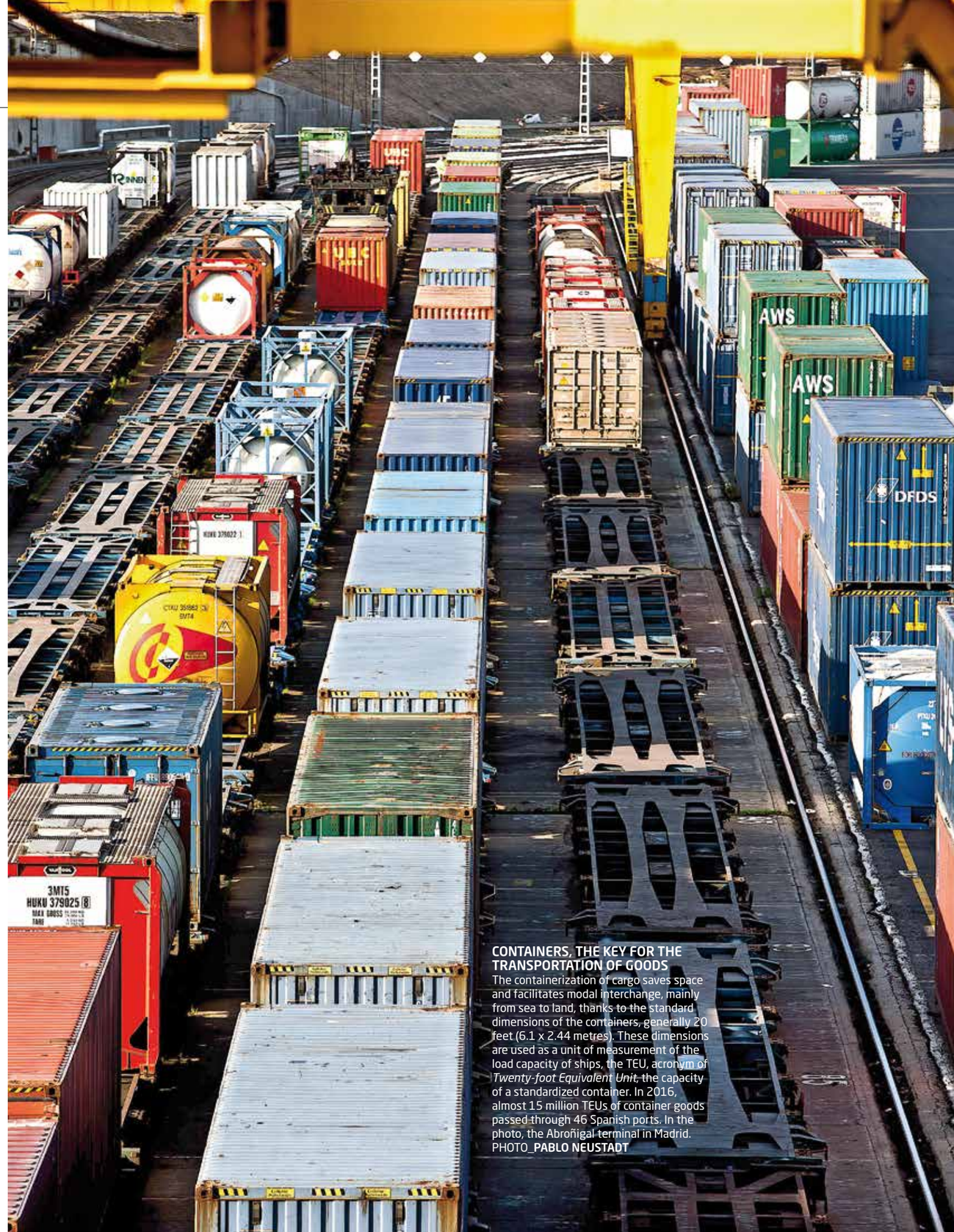
PHOTO_**INDITEX**

When you feed your pet, buy a bouquet of fresh flowers, dress a salad or fill up your vehicle, you are at the end of a long chain that could have begun far away. Some products –certainly those such as flowers– will have arrived from their place of origin by air; others, such as salt, animal feed or fuel, may have arrived by sea, road or rail.

But in all cases, in order to satisfy the needs of the end consumer, these products need to travel through the supply chain in the best conditions of safety and quality, and in the shortest time possible. The World Trade Organization emphasizes that logistics is particularly crucial "for the electronics and pharmaceutical sectors, fashion garments and motor vehicles, where time is an important factor."

The logistics chain covers various economic sectors and all stages of production and distribution, from the supply of raw material to the arrival of the finished product to the end consumer. In this complex network land, sea and air transport infrastructure is especially important, and they must also be interconnected as efficiently as possible. This is the function of transport centres, the hubs of the supply chain: they receive large volumes of goods and are modal interchange points, where the cargo goes from one mode of transport to another, from one phase of the supply chain to another; for example, bulk cargo is packaged, if it is solid, or distributed in trucks or tankers if it is liquid.

Located at road and rail nodes, airports and ports, logistics facilities can provide different services, depending on the type of centre in question: from simple modal interchange to services for the storage, distribution and consolidation of goods (bringing together cargo from different suppliers that has the same destination reduces costs), sanitary control and customs, labelling, packaging, parking, administrative management, electronic traceability, procedures and permits, etc.



CONTAINERS, THE KEY FOR THE TRANSPORTATION OF GOODS
The containerization of cargo saves space and facilitates modal interchange, mainly from sea to land, thanks to the standard dimensions of the containers, generally 20 feet (6.1 x 2.44 metres). These dimensions are used as a unit of measurement of the load capacity of ships, the TEU, acronym of *Twenty-foot Equivalent Unit*, the capacity of a standardized container. In 2016, almost 15 million TEUs of container goods passed through 46 Spanish ports. In the photo, the Abroñigal terminal in Madrid.
PHOTO_**PABLO NEUSTADT**

In order for the transport chain to flow, and keep logistics costs –which according to the World Trade Organization can account for 20% of the total cost of production in the countries of the OECD– from going through the roof, logistics areas and terminals must have sufficient capacity to meet the demand and be strategically situated in the territory, as well as correctly dimensioned and managed. Since these are large and complex facilities, they require major investment to build them or to expand existing ones.

But this is only the first step: the key is to determine whether they will be profitable in the long term, which requires the rigorous analysis of all foreseeable costs, expenses and revenue. To do this, several factors must be taken into account, such as estimated traffic, land prices and financial formulas, among other things, which will reveal whether the project will be profitable or not. Hence the relevance of this type of study, covering operational, technical, economic and financial aspects, as a basic decision-making tool for project developers, both public and private.

INECO'S EXPERIENCE

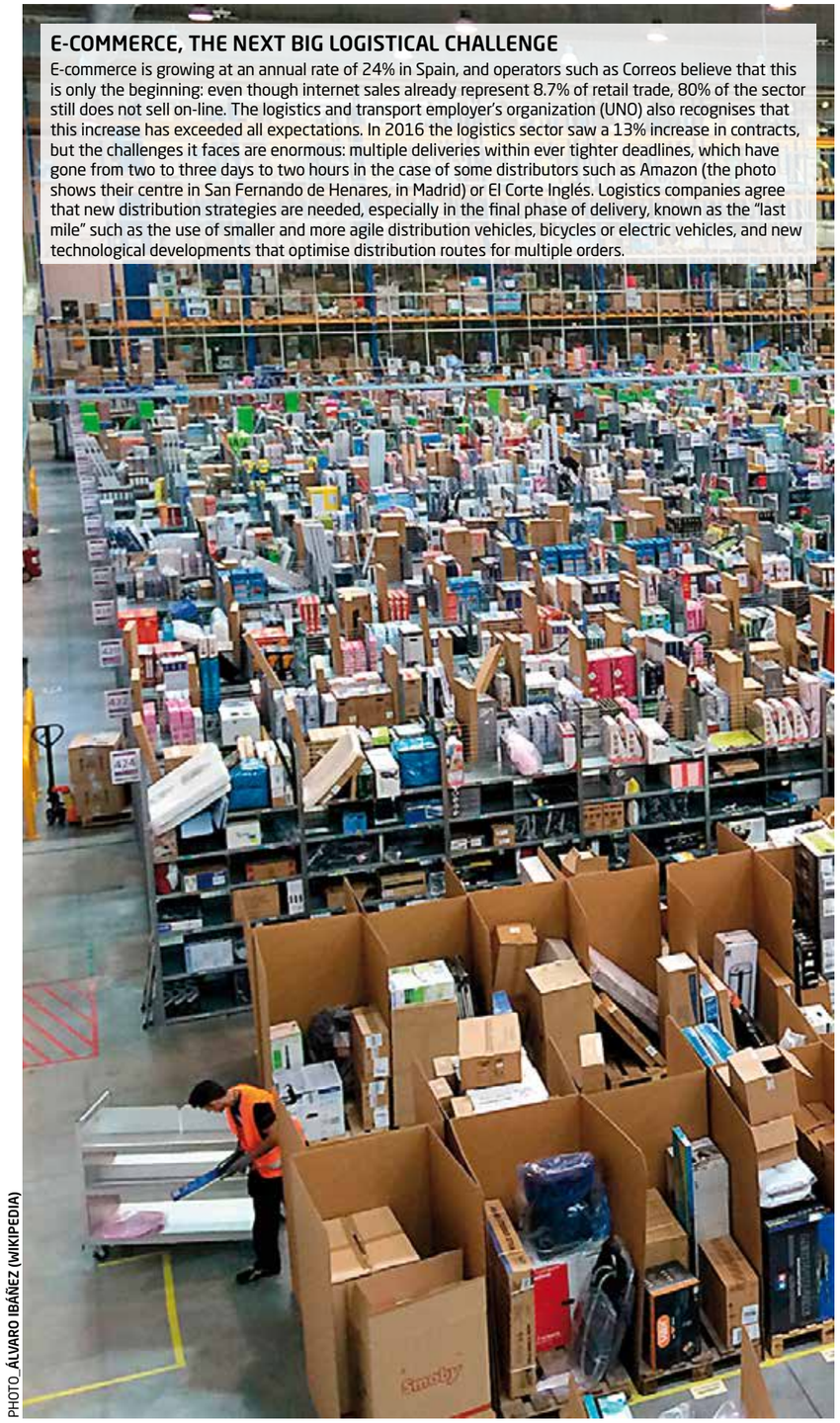
Since the 1990s, Ineco has performed a multitude of feasibility studies, both inside and outside Spain, for all types of transport infrastructure projects related to goods, both new construction and expansions and renovations, including multimodal corridors, business parks, industrial areas and logistics terminals.

The latter include the projects carried out in recent years for the Spanish Ministry of Public Works and several Regional Governments, such as the Basque Country, Andalusia, Asturias and Castilla-La Mancha, planning the construction of several logistics areas in their territories.

Also in Spain, in 2010 Ineco carried out a feasibility study for the new business park of the Foronda Airport (Vitoria) in the Basque Country, which specializes in air freight, and

E-COMMERCE, THE NEXT BIG LOGISTICAL CHALLENGE

E-commerce is growing at an annual rate of 24% in Spain, and operators such as Correos believe that this is only the beginning: even though internet sales already represent 8.7% of retail trade, 80% of the sector still does not sell on-line. The logistics and transport employer's organization (UNO) also recognises that this increase has exceeded all expectations. In 2016 the logistics sector saw a 13% increase in contracts, but the challenges it faces are enormous: multiple deliveries within ever tighter deadlines, which have gone from two to three days to two hours in the case of some distributors such as Amazon (the photo shows their centre in San Fernando de Henares, in Madrid) or El Corte Inglés. Logistics companies agree that new distribution strategies are needed, especially in the final phase of delivery, known as the "last mile" such as the use of smaller and more agile distribution vehicles, bicycles or electric vehicles, and new technological developments that optimise distribution routes for multiple orders.



PHOTO_ÁLVARO IBÁÑEZ (WIKIPEDIA)

LOGISTICS CENTRES IN SPAIN

The freight transport sector is of great importance to the economies of countries, because of its capacity to generate employment and wealth. In Spain, according to official data, logistics and transport contribute approximately 5.5% of the Gross Domestic Product (GDP) and employ more than 850,000 people. The Ministry of Public Works, in 'Spain's Logistics Strategy', classifies logistics centres as follows:

▶ **Road transport centres:** these have a logistics department and a department for providing services for people and vehicles, administrative centres for transport companies and freight contracting centres. In Spain there are 80, including the Transport Centre of Gijón, the Transport City of Navarra and the Transport City of Santander. In most cases, these are managed by a single administrative board and private partners.

The type of freight transported by road is heterogeneous, covering both raw materials, as well as finished, bulk or packaged products.

According to statistics from the Ministry of Public Works, in 2016 the largest volume of goods transported by road in Spain corresponded to raw or processed minerals and construction materials (417 million tonnes), followed by food and fodder (245), machinery, vehicles, and other manufactured items (251), agricultural products and live animals (158, a figure similar to the 'other goods' item), and petroleum products, 57. In total, nearly 1.3 billion tonnes.

▶ **Rail freight terminals:** Madrid-Abroñigal, León Mercancías and Zaragoza-Plaza. State-owned to date, in most cases, the Spanish rail infrastructure administrator, Adif, assumes both the

PHOTO_GERMÁN NAVARRO

management and the provision of services to business users.

In Spain, rail is used mainly to transport steel products and materials (coils, steel, rails, pipes, etc.), wood, paper, solid bulk (coal, cement, cereals) and liquid bulk (fuels, chemical products), containerized cargo and automobiles. However, its share in the freight transport sector is very small (around 2% of the tonnage) and less than the European average. In total, in 2016, more than 28.5 million tonnes of goods were transported by rail, virtually all within Spain. Intermodal traffic accounted for nearly nine million tonnes.

▶ **Port logistics centres:** As a peninsula, Spain is the European country with the longest coastline (more 7,800 kilometres) and has 46 ports, governed by 28 port authorities coordinated by the public body Puertos del Estado. 58% of exports and 74% of imports pass through these ports, arriving and departing for distribution by road (93%) or rail. Port activity accounts for 1.1% of Spanish GDP, generating more than 35,000 direct jobs, and a further 110,000 indirect jobs.

It is managed under a landlord model: the public sector is the owner of the infrastructure, which it cedes to the private sector, which acquires and maintains the superstructure and deals with port operations and the employment of labour.

In 2016, according to the Ministry of Public Works, Spanish ports exceeded their all-time record, handling 507.7 million tonnes of freight, more than half of which was solid bulk (cement, coal, grain, minerals, etc.) or liquids, the most important being oil, and the rest, general goods, most of which is carried in containers, which, also in line with world trends, reached a record of almost 15 million TEUs. Containerization of cargo saves space and facilitates modal interchange, since the different transport modes and systems are adapted to the standard sizes of the containers.

The port logistic facilities include the rail port terminals, which connect to the railway network. These include the terminal in Spain's largest port in terms of volume of goods, Algeciras, and others in Alicante, Valencia or Barcelona. The type of management is generally established by an agreement between the different port authorities and the railway manager.

On the other hand, the Logistics Activity Zones (LAZ) are linked to sea ports and are dedicated to the storage distribution of goods and other value-added services. These usually have complex management models involving various public and private agents. Of particular interest are the LAZs in Algeciras, Valencia and Barcelona.

▶**Dry ports:** intermodal freight terminals are located inland and are connected to one or more ports by the railway network. They offer the possibility of conducting customs controls on goods upon arrival at the facility, rather than at the seaport, which speeds up operation. They mainly move containerized cargo.

PHOTO_DHL

The main Spanish dry ports are Azuqueca de Henares, in Guadalajara; the Dry Port of Coslada, in Madrid, which connects by railway to the ports of Valencia, Algeciras, Barcelona and Bilbao, and the Sea Terminal of Zaragoza. Several agents are involved in their management, both public, such as the port authorities, and private.

▶ **Air freight centres:** these are industrial and service zones located around major airports. Depending on their size, they can have multiple terminals, where different companies from the aeronautical and other sectors can operate. They often have business centres and other services. These are currently managed by Aena, the state airport operator.

The goods that are transported by air are very specific, and are characterised by their low volume and high added value: these include live animals, cut flowers, perishable products such as seafood, valuable goods, express parcel services, fashion items (the Inditex Group in Zaragoza is a prime example), etc.

The most important air freight centre, according to Aena statistics, is the airport of Barajas, Madrid, which with almost 416,000 tonnes in 2016 (9% more than the previous year) accounts for more than 50% of national air freight traffic, followed by Barcelona-El Prat, with almost 133,000 tonnes, 13.5% more than 2015. The Zaragoza airport, which like the one in Vitoria, specialises in freight, is in third place with almost 111,000 tonnes; it had the biggest growth in 2016 with an increase of 29%. The three centres operate 24 hours a day, seven days a week.

before that, several projects related to the intermodal logistics platform in Zaragoza (PLAZA) that connects air, land and rail transport (see *IT*26 and 35). Between 2011 and 2012, on behalf of the Ministry of Public Works, the company analysed the rail connections of the Spanish ports, the existing traffic and the improvements that were required (see *IT*41).

Overseas, Ineco is currently performing the feasibility study of the future logistics platform 'Zona ILCO' in the region of Santo Domingo de los Tsáchilas in Ecuador. Furthermore, in 2012, on behalf of the Ecuadorian Government, it concluded the 2013-2037 Strategic Mobility Plan, analysing all of the country's transport infrastructure from the intermodal point of view, and proposing, among other possibilities, the construction of new ports and the extension of a landlord management model similar to the one implemented in Spain were included (see *IT*48).

In 2012, the company carried out an economic and financial study in Colombia to determine the profitability of adapting the Santiago Vila Airport, in the city of Flandes (Tolima), for international air freight (see *IT*49). In Medellín, in 2010, Ineco concluded a technical, legal and financial study to determine the feasibility of the reopening of the old railway line of Valle de Aburrá and adapting it for the transportation of passengers, goods and solid urban waste (see *IT*37).

In Latin America it also carried out a feasibility study of the Corinto–Monkey Point Multimodal Railway Corridor, Nicaragua (2013), which included the preliminary designs and alignment of two rail port terminals and a multi-modal terminal near the capital, Managua. Other recent international work includes the 2012 project for the Public Authority for Industry (PAI), of Kuwait (see *IT*48): the company carried out the conceptual design and provided comprehensive advice for the tendering process for the project and work on a new 5,000 m² industrial area to the southeast of the capital. ■

KEYS TO THE FEASIBILITY OF A LOGISTICS TERMINAL

A feasibility study of an intermodal logistics terminal includes the following:

1. Analysis and diagnosis of the current situation: the socio-economic characteristics of the study area are examined, as well as the existing transport infrastructure, its main centres and production sectors, the current demand for goods, and possible effects on the environment. Finally, a diagnosis is prepared.

2. Territorial and transport system planning: the national or regional documents that relate to the infrastructure planning, as well as the urban soil classification are studied .

3. Estimation of the future demand for goods: an estimation of the growth in traffic, as well as the possible modification of the distribution model, is prepared. It is usually taken into account that expected demand will not be reached in the first year of operation, which is considered an initial maturation or *ramp-up* period.

4. Analysis of the technical feasibility of the terminal:

4a. Functional analysis: an intermodal logistics terminal is usually made up of two distinct functional areas:

- **Intermodal area:** this area includes the intermodal rail terminal and associated services. This is the zone where the goods change their method of transport.
- **Logistics area:** dedicated to handling goods and other specific distribution activities, as well as the storage and consolidation of freight.

4b. Technical and railway operating conditions: rail connection type of the terminal, gauge, electrification, etc.

4c. Design of the intermodal and logistics area.

5. Analysis of the economic feasibility of the terminal: different economic scenarios are considered and modelled, and the investments, costs and operating revenues are calculated. The main parameters of profitability of the project (TIR, VAN, etc) are obtained as a result of this economic modelling.

6. Terminal development and management models: they depend on the development strategy, the land regime, the complexity and profitability of the initiative, and the applicable legal framework.

PHOTO_**PABLO NEUSTADT**

INECO AND LOGISTICS
In recent years the company has worked on logistics infrastructure projects in Spain, Ecuador, Colombia, Nicaragua and Kuwait.

PHOTO_**ELVIRA VILA**

PHOTO_**ELVIRA VILA**

Chosen for glory

Spaniards shine atop the podium of today's international sports, including tennis player Rafa Nadal, swimmer Mireia Belmonte, high jumper Ruth Beitia, F1 driver Fernando Alonso, the national women's basketball team or skater Javier Fernández, among others.

By *ITRANSPORTE*

Spain's first Olympic Games, held in Barcelona in 1992, marked a milestone for Spanish sports. The 22 medals as well as the organizational success bolstered the international image of a country that had been fighting to integrate itself into the modern world. Today, 25 years and 6 Olympic games later, the list of athletes and teams that have reached the top tier in the world of sports –and not only in the area of the Olympics– is a long one.

It is important to emphasize the presence of women, such as swimmers Mireia Belmonte, gold medallist in the 200-metre butterfly in Rio 2016 and Budapest 2017, and Teresa Perales, who has won a total of 26 Paralympic medals; high jumper Ruth Beitia, first Spaniard to win an Olympic gold medal in track and field; tennis player Garbiñe Muguruza, winner of the French Open (2016) and Wimbledon (2017), and the first Spanish Olympic badminton champion, Carolina Marín, also two-time world champion, and three-time European champion. Some of the best teams include the national basketball and rhythmic gymnastics teams, both current Olympic runners-up, among others. In recent years, the national synchronized swimming teams have also achieved great success, with names such as Gemma Mengual and Ona Carbonell, as well as athletes in rhythmic gymnastics, sailing, water polo and handball.

Of all the sports figures, Rafael Nadal stands out as one of the all-time best for his impressive array of trophies, including 16 Grand Slam titles. He is the tennis player with the most victories of the French Open (10), the most important tennis championship on clay, and has two Olympic gold medals, 30 Masters 1000 tournaments and 4 Davis Cup victories with the Spanish team. In addition to his sporting career, fans and the general public praise his attitude and professional ethics, which are fundamental values in the sport. His sporting quality and international projection place him in the select group of great world-renowned Spanish athletes, such as the golfer Seve Ballesteros, who died in 2011, or the cyclist Miguel Induráin from Navarre, now retired, a five-time winner of the Tour de France and two-time winner of the Giro d'Italia, which, together with the Vuelta a España, constitute the three world's three major cycling competitions. Other figures have followed in his wake, such as Alberto Contador, who has confirmed his retirement but was the first Spanish cyclist to win three Grand Tours in stages.

In basketball, the brothers Pau and Marc Gasol, both NBA players (the former currently with the San Antonio Spurs and the latter with the Memphis Grizzlies) are the most internationally known figures. Since the 2006 World Cup in Japan, the national team, with its unrepeatable generation of players, has won medals in several European championships, the Olympic silver medal in Beijing 2008 and London 2012, and the bronze medal in Rio 2016.

Madrid's Javier Fernández is another athlete who has broken moulds in ice skating, a sport that is not especially well rooted in a Mediterranean country like Spain. World champion in 2015 and 2016, five-time European champion in 2013, 2014, 2015, 2016 and 2017, and national champion multiple times, he is the best skater in the history of Spain and is ranked number four in the international classification after the World Cup 2017, held in Helsinki.

Motor sports have also produced world-famous figures such as rally driver Carlos Sainz, world champion in 1990 and 1992; Formula One driver Fernando Alonso, and MotoGP rider Marc Márquez, who at just 24 years of age, has won World Motorcycle Championship titles in three categories: 125cc (2010), Moto2 (2012) and three-time world champion in MotoGP (2013, 2014 and 2016). Other champions that must be noted in this section include: Jorge Martínez Aspar, Sito Pons, Álex Crivillé, Dani Pedrosa, Jorge Lorenzo, Pol Espargaró and Maverick Viñales, among others. Special mention should be made of the recently deceased Angel Nieto, a pioneer in this sport in Spain with his '12+1' world championships.

Lastly, there is Javier Gómez Noya, a Spanish professional triathlete, a five-time world champion and silver medallist in London 2012. ■

FOOTBALL'S HONOUR ROLL

Spain also excels on the global stage of football, one of the most popular spectator sports, especially in Europe, Africa and Latin America. It is also booming in Asia, and particularly in the Middle East, where the World Cup will be held in Qatar in 2022, and in countries such as China, where it is estimated that there are over 100 million followers of Real Madrid, and Japan, the country that is home to the multinational Rakuten, which sponsors FC Barcelona.

These are just a few examples that demonstrate the reach of a sport that at its maximum level, moves millions of euros, from the signing of players to the revenues and the television audiences.

Spain has two of the best known and most international football teams: Barcelona and Real Madrid, which are also considered the richest clubs in the world, along with England's Manchester United. The turnover of both clubs in 2016 reached 620 million euros, income obtained from the summer tours overseas and the sale of merchandise, and both clubs have growing numbers of followers on the five continents: Barcelona has 117 fan clubs outside Spain and 11.4 million followers on Twitter, while Madrid has more than 200 fan clubs and 24.7 million followers. Members of both teams were part of the national team that won the 2010 World Championship held in South Africa, another milestone for the national sport.

The teams in the Spanish league have won the most European competitions, well above those from the English, German and Italian leagues. The television audiences for the final of Europe's top competition, the Champions League of 2017, totalled around 350 million people in 210 countries, three times more than the Superbowl (111.3 million viewers).

ROCÍO VIÑAS TORMO

"We will approach the Hyperloop the same way we approached high speed"

Ineco's head of Innovation did not hesitate to lend her support the young Spanish team that competed in the global competition organised this summer by Hyperloop One.

PHOTO_ELVIRA VILA

1 WILL WE GO FROM HIGH SPEED TO HYPERLOOP?
We will enjoy both technologies; they are compatible.

2 ARE SPAIN'S ENGINEERS READY?
Of course. Spain is a leading country in transport and infrastructure and has extensive experience in PPPs, the possible model of Hyperloop One.

3 HOW IS INECO CONTRIBUTING TO THE PRIMEX PROJECT?
We supported them in Amsterdam because they're good and they submitted a good project.

4 CONNECT EUROPE AND AFRICA... IS IT AN ECONOMICALLY PROFITABLE DREAM?
It will eventually become profitable. All revolutionary technology has transformed societies, and new businesses will even emerge.

5 AND POLITICALLY?
Disruptive technologies transform the world and don't stop at political barriers. If we create these barriers, other countries will move ahead of us.

6 NOW WE WON'T BE ABLE TO LOOK OUT THE WINDOW...
We'll have both options.

7 SO HAS THE REVOLUTION ARRIVED?
It will be a reality. There are scientific companies and teams around the world investing funds and time to make it possible. ■

MADRID-TANGIER IN HYPERLOOP

Rocío Viñas has a degree in Law, a Diploma in Business Sciences and a Master's in Tax Law (CEF) and has been supporting Spanish industry in international markets for 20 years. At Ineco, -where she arrived from the department of Infrastructure, Health and ICT at the Spanish Institute of Foreign Trade- she has been collaborating with Primex in its participation in the *Hyperloop One Global Challenge*. The aim of the project is to demonstrate the economic, political and social benefits of a connection between Madrid and Tangier using Hyperloop technology. Developed by a team of more than 25 people from the University-Enterprise Foundation (FUE in Spanish), it was one of the 35 semifinalists from the more than 2,600 projects submitted, and the route between Madrid and Tangier is one of the nine selected by Hyperloop One for its international competition.

Hyperloop technology promises to add a radical twist to transportation around the world. The first tests in the United States of the capsule levitating within a vacuum tube have been so encouraging, that they are getting closer and closer each day to travel speeds of up to 1,200 kilometres per hour. The project received the support of the Ministries of Public Works and Environment, the Ministry of Transport, Housing and Infrastructure of the Region of Madrid, the Moroccan Embassy and the Al Akhawayn University.