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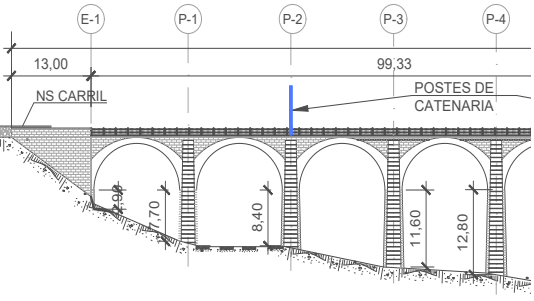
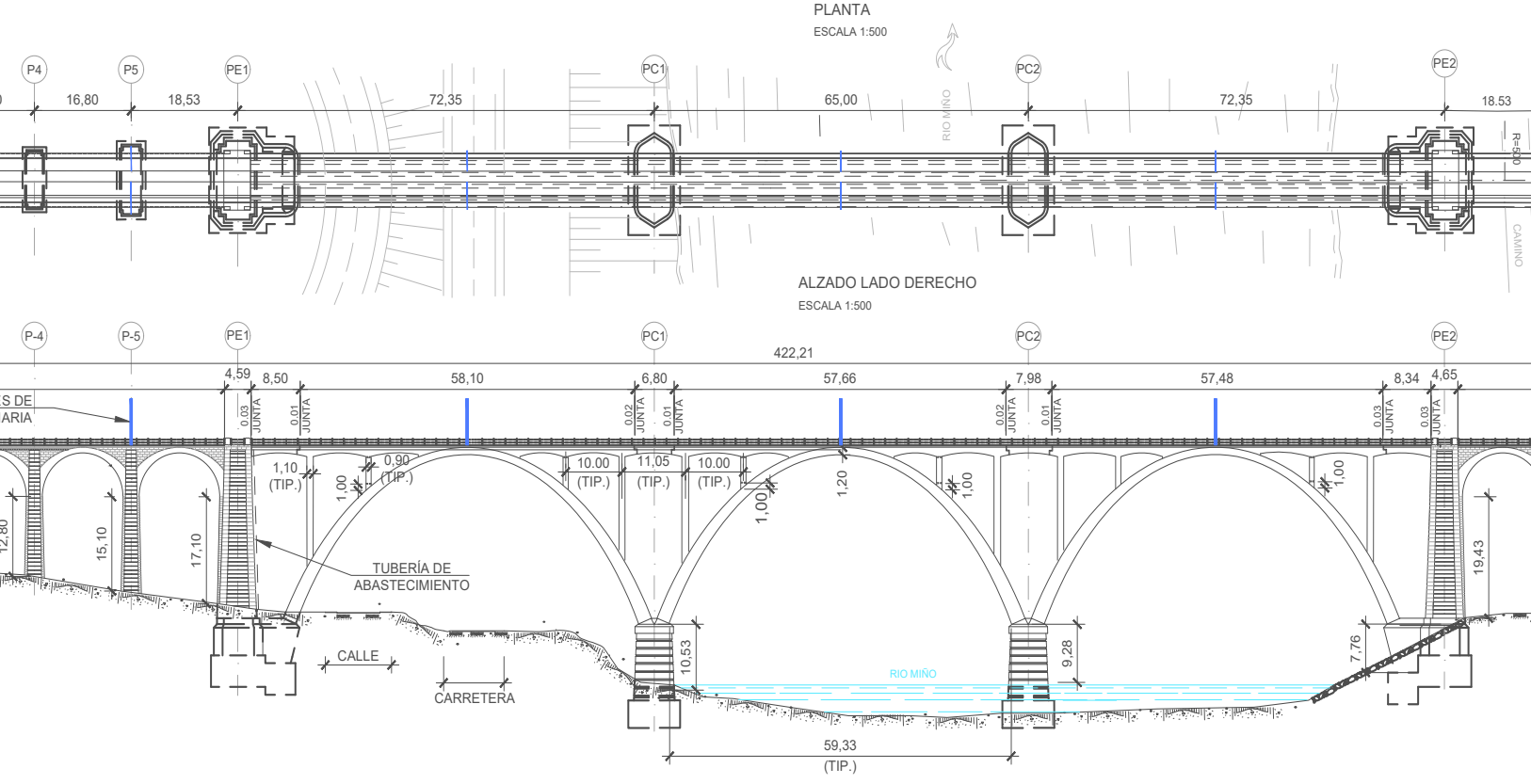
APR | JUL 22

## STRUCTURES
## Inspection and assessment

### ARTICLES





ENAIRE

# ENAIRE receives the highest score in Europe on the aviation safety key performance indicator

Recognised by the European Commission


# EDITORIAL

## *Ineco, a committed and revolutionary team*


If there is one thing that defines Ineco, it is the ability to adapt to changes and propose solutions to face future scenarios, a trait embedded in our teams. More than 4,000 professionals bring their solid experience, knowledge and innovative spirit to progress towards models in line with the times, where sustainability and digitalisation are the cornerstones on which our company's strategy is built on.

As a result, digitalisation and the application of new technologies make it possible to improve the inspection and monitoring processes for infrastructure and bridges, making progress in models for which Ineco has more than three decades of experience. An example is the innovation project developed by the company which makes use of drones and has been successfully tested for the radio aid calibration system.

The extensive experience, as well as the avant-garde and entrepreneurial spirit of the company's professionals, allow Ineco, together with other companies in our country, to integrate Spanish engineering talent into projects that are revolutionising mobility around the world. In this edition, we highlight our participation in the execution of the new tunnel under the river Thames in London, in the implementation of the ERTMS system in the Danish railway network, and in the administrative, environmental and legal management of roads upgrading program promoted by Costa Rica. All these actions are aimed at improving sustainability, safety and mobile connectivity, which translates into benefits for citizens. We noted improvements in the user experience, such as that provided by the Automatic Baggage Handling System (SATE), designed by Ineco at airports of Kastelli, in Greece and Schiphol, in Amsterdam.

The company's Architecture with gender perspective team presents designs that are committed to inclusion. This is a pioneering project in the sector that seeks to integrate this aspect and guarantee full equality in the field of infrastructures and transport. An objective that is part of our 2030 Agenda Plan, that includes the use of engineering to support the most disadvantaged, across projects deployed in Africa, Asia and America which has allowed us to provide basic services and improve the quality of life of more than 44,000 people. ■

> "The extensive experience, as well as the avant-garde and entrepreneurial spirit of the company's professionals, allow Ineco, together with other companies in our country, to integrate Spanish engineering talent into projects that are revolutionising mobility around the world"
>
> SERGIO VÁZQUEZ TORRÓN
> President of Ineco

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PHOTOS_EUSPA

## GALILEO SERVICE CENTRE CONTRACT RENEWED

SpaceOpal, the Galileo system operator under contract with the European Union Agency for the Space Programme (EUSPA), has awarded Ineco the extension of its current contract as the company responsible for the operation and maintenance of the European Satellite Navigation Services Centre (GSC) of the Galileo Programme for the next five years. Based in Torrejón de Ardoz (Madrid), the GSC provides satellite navigation services to users worldwide.

This extension ensures the continuity of Ineco's activities in the project until 2027, a period in which the GSC will incorporate new capabilities such as the provision of the Galileo High Accuracy Service (HAS), one of Galileo's main differentiating elements with regard to its competitors.

In the image, the European Satellite Navigation Services Centre (GSC), where Ineco provides operation, security, cybersecurity, integrated logistics and support services for the development of user services and applications.

**URUGUAY**

## EXPERT ADVICE FOR THE NEW CTC


PHOTO_WIKIPEDIA

Paso de los Toros station.

The National Rail Transport Directorate of the Ministry of Public Works of Uruguay has appointed Ineco as an expert consultant for the organisational structuring of the new Centralised Traffic Control (CTC) centre. Ineco will provide support for the CTC of the Central Railway for one year, advising on regulations and providing training for railway operation, safety, planning and freight transport. This is the company's fifth contract for this project, and is the most significant in the Uruguayan network in recent years.

**AUSTRALIA**

## NEW EXPANSION OF WORKS FOR NETWORK RAIL CONSULTING AND TRANSPORT FOR NEW SOUTH WALES

Ineco has expanded the services it currently provides for Network Rail Consulting in Australia as a systems integrator. The contract is part of the Digital Systems Program (DSP), which aims to upgrade signalling to European Train Control Systems (ETCS) Level 2, that is part of the European ERTMS system, for the rail operator and manager, Sydney Trains.

The new scope focuses on providing assistance in the definition of the ETCS Trackside/On board and TMS/Trackside integration test cases for the project. The main activities to be carried out by Ineco are: definition of the generic test cases list, detailed development of each test case, including traceabilitity to the DSP Requirements. In addition, Ineco, that has been present in the country for three years, continues working as part of the System Integrator supporting the Program: systems design supervision (trackside and on-board ETCS, traffic management system, cybersecurity and fixed and mobile communications); definition of Signalling Principles and technical consultancy services.

PHOTO_SYDNEY TRAINS

Sydney commuter train.


## INECO JOINS THE STEAM ALLIANCE TO PROMOTE FEMALE TALENT IN SCIENCE AND TECHNOLOGY

MITMA Group companies, including Ineco, have joined the STEAM Alliance for female talent. On 9 February, the signing ceremony of the protocol took place with the Ministers of Transport, Mobility and Urban Agenda and Education and Vocational Training, Raquel Sánchez and Pilar Alegría, respectively, and the presidents of Adif, Renfe, ENAIRE, Aena, Puertos del Estado and Ineco, Sergio Vázquez (third from the left).

Under the slogan 'Girls in Science', the Ministry of Education and Vocational Training is promoting this initiative in the public and private sectors to "*encourage the interest of girls and young women in disciplines related to science, technology, engineering and mathematics*" (STEAM).

Supporting the STEAM vocations of girls and women in education is a priority issue not only for the United Nations, which includes it in the 2030 Agenda for Sustainable Development, but also for the European Union and the government of Spain, which has included it in the Digital Spain 2025 Agenda. Meanwhile, Ineco has made equality one of the pillars of its strategic business plan.

**NETHERLANDS**

## STUDIES FOR THE NEW SCHIPHOL SOUTH TERMINAL

The Spanish-Dutch consortium KL AIR, formed by the architects Kaan and Lamela, and the engineering firms ABT and Ineco, are carrying out a new study of the sizing and location of spaces for the new South Terminal of Amsterdam-Schiphol International Airport. The study, following the impact of COVID-19 on the airport's traffic, is limited to the same plot of land where the previous design was planned, and must consider a phased development of the new terminal, adapted to its future needs.

Ineco's consultancy work will focus on the sizing of the different areas of the building, the establishment of a concept of operations and the analysis of the requirements that will form the basis of the future design.


PHOTO_JAVI VTE REJAS (FLICKR)

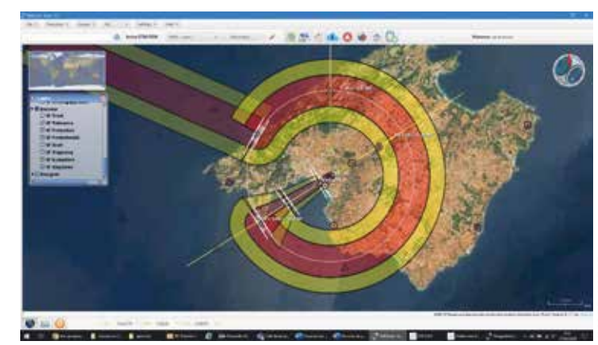
**SPAIN**

## ICAO AND AESA RECOGNISE INECO IN FLIGHT PROCEDURE DESIGN

The company has obtained recognition from the International Civil Aviation Organisation (ICAO) and the National Air Safety Agency (AESA) for the design of instrument flight procedures, which establish the trajectory of aircraft to prevent collisions.

Ineco has thus become the first Spanish company to obtain the ICAO certificate, which only 14 other companies worldwide have been awarded. The accreditation is valid for three years, for both conventional and performance-based navigation (PBN).

The National Air Safety Agency (AESA) has also certified Ineco as a provider of flight procedure design services, making it the second organisation in Spain, after ENAIRE, to have received this recognition, which is valid throughout the European Union.



IMAGE_INECO

Flight procedure designed by Ineco (conventional approach).

SPAIN

## IMPROVEMENTS TO STATIONS IN CATALONIA

Ineco is collaborating with Renfe on the Commuter Stations Plan 2019 to 2024, which includes various works to increase the capacity and performance of the network and increase comfort and accessibility to trains and stations. Among other works, the company has carried out projects and works management for the Cerdanyola-Universidad and Santa Perpetua de Mogoda stations in Barcelona. At Cerdanyola-Universidad station, which has five tracks and three platforms, access for people with reduced mobility has been improved thanks to the installation of three lifts serving the subway. At the new Santa Perpetua de Mogoda station, the main works have consisted of the construction of a main building, a subway to connect the platforms, the installation of lifts, new shelters and the development of the accesses.

Adif has also commissioned Ineco to draw up the construction project for the new Parets del Vallès railway station, which forms part of the conventional gauge line linking Barcelona, Vic and Puigcerdà. The project includes a new passenger building with lifts, a car park and an urban pedestrian connection footbridge.

New lifts at the Cerdanyola-Universitat station.

## SUPPLY CONSULTANCY AND SYNERGY STUDY FOR RAIL BALTICA

The company has added two new contracts, now numbering eight in total to date, to the work it has been carrying out since 2019 together with other Spanish companies (Ardanuy and IDOM) for the Rail Baltica high-performance corridor, which will link Estonia, Latvia and Lithuania with Europe over 870 kilometres.

On the one hand, it will provide consultancy services for the storage of supplies, including both the development of the strategy and the technical and design requirements for the materials storage bases. On the other hand, it will carry out a study of the potential synergies of the corridor to improve the design of the infrastructure, analyse future development and business opportunities, and advise national governments on EU policies and strategies.

These works are in addition to those already being carried out, such as the design of the railway accesses to Riga, the design and supervision of a 94-kilometre section in Northern Latvia, the implementation of the energy strategy and the analysis and design of the maintenance facilities along the entire line.


PHOTO_INECO

INTERNATIONAL

## ARISE+: DRONE EXPERTS FOR SOUTHEAST ASIA

The European Aviation Safety Agency (EASA) has awarded the consortium led by Bureau Veritas together with Ineco, IATA and FRACS, a contract within the international cooperation project ARISE Plus (2018-2022), funded by the European Union. Ineco will participate as a lead drone expert (see report on pp. 20-25) by defining, implementing and following up on annual work plans, strategic guidance, training workshops, seminars, etc.

ARISE Plus (EU Regional Integration Support) is the second edition of an EU technical support programme aimed at strengthening trade relations with the countries of ASEAN, the Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam).

## NEW HEADQUARTERS FOR THE MINISTRY OF FOREIGN AFFAIRS

Ineco has been entrusted with the management of the refurbishment works for the new headquarters of the Ministry of Foreign Affairs, European Union and Cooperation. Located in the centre of Madrid, it is an energy-efficient building with more than 50,000 m² of floor space, where more than 1,200 public employees will work. The building is highly flexible in its use of space and complies with EU energy efficiency directives and is BREEAM-certified for sustainability. All site information has been integrated into a Building Information Modelling (BIM), which has improved the quality of the project and optimised costs during construction and maintenance.



PHOTO_METRO MEDELLÍN

## METRO MEDELLÍN AWARD

The project to modernise the Metro Medellín trains, in which Ineco is participating, has been awarded by the Antioquian Society of Engineers and Architects (SAI) as one of the most outstanding projects in Antioquian engineering in 2021. The company, which began collaborating with Metro Medellín in 2011, is carrying out the supervision of the fleet of 42 MAN trains. The project aims to extend the service life of these first-generation vehicles, which began operating in 1995 and were nearing the end of their useful life. The first eight modernised units are already in commercial operation.

The SAI, founded in 1913, awards such prizes to works of high scientific or technical merit that represent a significant advance in the field of engineering.

EUROPE

## NEW EUROPEAN RAILWAY RESEARCH PROGRAMME

As part of the group of companies of the Ministry of Transport, Mobility and Urban Agenda, Ineco is participating in the new European railway R&D&I programme that has recently been launched and is the largest to date: Europe's Rail Joint Undertaking (ERJU), which replaces the previous programme called Shift2Rail.

In addition to the MITMA Group, ERJU has 25 other founding partners, including manufacturers, infrastructure operators and managers, and others. Its aim is to promote research and innovation projects linked to the creation of a Single European Railway Area on the continent, similar to the Single European Sky initiative in the field of air transport.

The renovation of National Route 160 between Playa Naranjo and Paquera has involved the undertaking of 96 works, including the asphalting of 21.8 km and the construction of three new bridges, canals, culverts and ditches along the entire length of the corridor.

The project to modernise the 50 km stretch between Barranca and Limonal on the National Primary Route 1 is in the middle of its construction phase.

Section of Route 160 that has already been opened.

# Investment drive on Costa Rican roads

The Costa Rican Ministry of Public Works and Transport (MOPT) has awarded Ineco the administrative, legal and environmental contract for the Transport Infrastructure Programme and promotion of Public-Private Partnerships (PIV-APP). This will continue until 2025 with improvements to road infrastructure throughout the country, which are essential for improving communications, facilitating economic development and increasing the quality of life of the country's inhabitants.

**Alberto Váscones** and **José Germán Juyar,** civil engineers

This plan includes various works on roads throughout the country, through public-private partnership models, alongside the Transport Infrastructure Programme (PIT) that Ineco has also been in charge of since 2016 and which has recently been extended until 2023. Both programmes have been financed with loans from the IDB (Inter-American Development Bank), with an investment of USD 450 million and USD 125 million respectively, as well as a contribution of USD 53 million from the MOPT. The shared objective is to increase the country's competitiveness by improving its road and port infrastructure, to reduce costs and travel times for people and goods, and to increase road safety.

For more than 15 years, Costa Rica has undertaken several programmes to improve its transport routes, a notable investment drive in infrastructures with which Ineco began to collaborate in 2004, participating in works such as the National Transport Plan, the modernisation of the airport network –with various improvements having also been carried out since then– and the research project for the implementation of a railway transport system in the metropolitan area of the capital, San José, which is now a reality.

The country's geographical location means that the 660 kilometres long Inter-American Highway has become the backbone of the country's road network.

The Inter-American Highway is a huge 48,000 kilometres long route that runs the length of the continent from Alaska to Ushuaia in Argentina. The Costa Rican section of this road is of great importance for the internal mobility of people and goods. It enters the country through the northern town of Peñas Blancas and crosses the central part of the country through San José, a stretch known as Route 1, and from here it runs to the Panamanian border town of Paso Canoas, Route 2. The enlargement and improvements on both sections are therefore a matter of national interest.

**Route 1:** Cañas-Limonal.

**Route 2:** Taras-La Lima.

The repair of the breakwater at Puerto Caldera is one of the strategic works included in the Transport Infrastructure Programme, since it is key to ensuring the competitiveness of this port terminal and the country's maritime trade.

### THE SAN CARLOS ROUTE, A KEY CONNECTION

Among the key works of the PIV-APP are those related to the San Carlos Route: they consist of the technical, economic, financial and environmental feasibility study, as well as the pre-design of National Route 35, the road to San Carlos along the Bernardo Soto-Florencia section.

The new road linking National Route 1 (Bernardo Soto road) with the city of San Carlos (Ciudad Quesada and Florencia), is made up of four sections. The first is the intersection with National Route 1, the Bernardo Soto-Sifón (South end) road; the second, the Sifón-Abundancia section, (currently under construction with four lanes in the middle section); the third, Abundancia-Ciudad Quesada; and the fourth, Abundancia-Florencia. These last two sections have been constructed under the so-called 'D+C' (design plus construction) model, works financed through the IDB (PIV-I), which have already been completed and are in operation.

This road, in its entire length (taking into account the 4 sections), is designated as a priority corridor by both the Government of the Republic and other sectors, such as the so-called 'Consensus Group for the Rescue of the National Road Network'. Its strategic importance lies in the fact that it connects the Central Plateau with a very important agricultural and productive area for the country, as well as being part of the International Network of Mesoamerican Highways (RICAM).

Puerto Caldera breakwater.

THE COSTA RICAN GOVERNMENT IS MAKING A MAJOR EFFORT TO IMPROVE THE COUNTRY'S INFRASTRUCTURE. A FURTHER STEP TOWARDS IMPROVING THIS SITUATION IS THE DEVELOPMENT OF THE PIT AND THE PIV-APP PROGRAMMES, WHICH INCLUDE A NUMBER OF STRATEGIC ROAD AND PORT PROJECTS, INCLUDING MASTER PLANS, DESIGNS AND CONSTRUCTION

**ROUTE 17: THE ANGOSTURA.** The enlargement of the Angostura road in Puntarenas is a comprehensive project that includes the widening of the road from two to four lanes, panoramic crest walls, bicycle lanes, a tourist promenade and pavements along the beach.

THE PIT AND THE PIV-APP, IN WHICH INECO IS COLLABORATING, ARE PART OF COSTA RICA'S NATIONAL TRANSPORT PLAN 2011-2035 AND INCLUDE PROJECTS FOR THE CONSERVATION AND CONTINUOUS IMPROVEMENT OF THE STRATEGIC ROAD NETWORK TO FACILITATE THE MOBILITY OF PEOPLE AND GOODS, THUS FACILITATING TRADE FLOWS AND THE ECONOMIC INTEGRATION OF THE COUNTRY

The implementation of the PIV-APP also seeks to contribute to the country's competitiveness through the improvement and environmentally sustainable expansion of the High Capacity Road Network (RVAC) in the Greater Metropolitan Area (GAM), which includes the conurbations of San José, Alajuela, Cartago and Heredia, in addition to supporting the development of road infrastructure projects through Public-Private Partnership (APP) models. The high rate of population growth and the deficit in infrastructure development contribute to road congestion, which particularly affects the Greater Metropolitan Area, where 70% of the population uses public transport. The programme aims to counteract environmental impacts, improve competitiveness and enhance the quality of life in this densely populated area of the Costa Rican capital. ■

In the image: members of the Ineco team at the offices in San José, where the consultancy for the planning, coordination and administrative, technical, legal and environmental management of the Transport Infrastructure Programme (PIT), launched by the Costa Rican government, is being undertaken.

# TOMÁS FIGUEROA

## *“Work has been carried out to the highest quality standards, major challenges have been overcome and all the projects will create many benefits for the country’s inhabitants”*

**TOMÁS FIGUEROA** is a civil engineer with 19 years of experience in the Costa Rican Ministry of Public Works and Transport. He has extensive expertise in strategic planning, management systems, programmes, projects and pre-investment studies of transport infrastructure and services. Since 2016, he has been director of the PIT and previously held the position of director of Sector Planning (2013-2014) and advisor on infrastructure management and multimodal transport services (2014-2016). He also served as head of the Road Management Unit (2010-2013), coordinator of the study ‘National Transport Plan of Costa Rica 2011-2035’ and in various projects of corridors and road improvement programmes in the country.

**How much is the total investment of the MOPT in the country’s roads and ports and what percentage corresponds to the Inter-American Development Bank?**
Investment in road infrastructure works currently amounts to USD 1.55 billion, mainly from the Exim Bank of China, the Central American Bank for Economic Integration (CABEI) and the Inter-American Development Bank (IDB). The amount of recourse for the latter is around 46% of the total investment. There are currently no significant investments in ports, although the Moín Container Terminal in the Caribbean has recently been put into operation.

**What progress would you highlight regarding the PIT?**
The commencement of operations of the improvement of National Route 160, between Playa Naranjo and Paquera, in April 2021, has meant a change in the mobility dynamics of the North Pacific peninsular area and has provided important support to tourist activity. Through the commencement order for the improvements of the ferry terminal in Puerto Paquera, the connectivity of several cantons and districts by land or sea to the rest of the country will also be improved. Finally, the execution of the Angostura project will further improve mobility to and from the peninsula.

Furthermore, we will soon put into operation the Limonal-Cañas section of National Route 1, with the widening of the Route 1 from two to four lanes. These works also have a very positive impact on national and international land connectivity.

**What about new projects envisaged within the PIV-APP?**
The PIV-APP is a programme that has public-private partnership (PPA) from various fields at its core. Firstly, the construction of interchanges and improvements of Taras-La Lima on National Route 2, which is located in one of the areas of greatest demand in the Greater Metropolitan Area and in a major hub for the development of industrial and technological activity, which is attracting national and international companies. With this work, which is part of a comprehensive project to improve National Route 2 from San José to Cartago, we will improve the three km of the entrance to the city of Cartago. This government contribution to a potential private initiative for the improvement of the entire road corridor generates greater confidence and lower fees, which would make the initiative socially viable.

On the other hand, there is the San José-San Ramón Corridor Trust Fund’s Non-Delayable Works (OBIS) package 4, which both in its dynamic benefits, as well as its structuring, shares many characteristics with what was outlined above regarding Taras-La Lima. It consists of the construction of five interchanges (San Ramón, Naranjo, Grecia, Río Segundo and Juan Pablo Segundo), which will complement other OBIS packages that constitute the government’s contribution to the comprehensive development of the Trust Fund and will help with the viability, confidence and social acceptance of the project, among other aspects.

Finally, this programme also includes a component of consultations and studies to support and strengthen institutions in the area of public-private partnerships (APPs).

**Your country forms a key stage of the Pan-American Highway. Is there institutional collaboration on infrastructure connecting Panama and Nicaragua? If so, in which projects?**
Both within the Secretariat for Central American Economic Integration (SIECA) and the Mesoamerica Project, the development of two corridors (Pacific and Atlantic) and their interconnections, from Puebla, Mexico, to Panama City, has been contemplated.

The investment in the PIT contributes close to USD 270 million in infrastructure, improving the Route 1 from Barranca to Cañas -just over 70 km - doubling the roadway from two to four lanes, incorporating all modernisation and road safety features and meeting the highest design standards. This will improve vehicle operating costs and substantially reduce travel times.

In logistics studies developed by the IDB, based on Costa Rica’s National Transport Plan 2011-2035, it has been determined that the main land logistics corridor in Costa Rica is that which runs between the Greater Metropolitan Area and the Peñas Blancas border. The 70 kilometres being upgraded on the Route 1 are part of this corridor.

Finally, within the scope of SIECA and the Mesoamerica Project, there is support and coordination between the different countries that belong to them. In the case of SIECA, the Central American region, and in the case of the Mesoamerica Project, from Mexico to Colombia and the Dominican Republic.

In the Mesoamerica Project, Costa Rica coordinates the Transport Commission and is supported by multilateral cooperation agencies.

THE INVESTMENT IN THE PIT BRINGS NEARLY USD 270 MILLION INCLUDING MAJOR IMPROVEMENTS TO THE INTERAMERICANA NORTE, COSTA RICA’S MAIN LAND LOGISTICS CORRIDOR, WHERE THE CARRIAGEWAY WILL BE DOUBLED TO FOUR LANES ALONG 70 KM

**In a country with such a wealth of fauna and biodiversity, how do you plan to reconcile works and extensions with the conservation of the different ecosystems?**
All programmes under development, including road projects, have considered, from the study and design stagea, the identification of biological corridors. Where these interact with the roads being upgraded, ‘hot spots’ have been identified where wildlife overpasses or subways have been implemented. Considerations have also been taken to adapt the design of bridges, where required, as well as to protect riverbeds.

**The terrain and the high levels of rainfall are conditioning factors for the construction of roads. What conclusions have you drawn from these years of experience? How does it affect construction and subsequent maintenance?**
Indeed, although our country is not very large, it stands out for the richness of its diversity. Therefore, when carrying out projects, we frequently encounter unforeseen events, including geologically unstable areas that have created problems when disturbed due to water, weight or other factors.

The study of the New San Carlos Road is an example in which all the variables necessary for adequate design and risk management are included; and specialists from various fields have been brought in to look for ways to improve the conditions that were originally proposed for the road and which caused problems.

With regard to the management of rainfall conditions, design standards have been adopted in new works to enable requirements to be adequately scaled. However, the operation and maintenance of the National Road Network remains a challenge due to the large number of roads that need to be upgraded.

**Which projects are expected to be completed by 2022?**
The improvement of the NR 1 between Limonal and Cañas and that of La Angostura, on the NR17.

**And which project are you most satisfied with?**
It is very difficult to choose one of the works. Work has been carried out to the highest quality standards, major challenges have been overcome and all the projects bring us closer and create many benefits for the country’s inhabitants. All of them have been defined for a decade in the National Transport Plan and are part of a roadmap to follow in order to be competitive. ■

# A tunnel under the Thames to relieve London's congestion

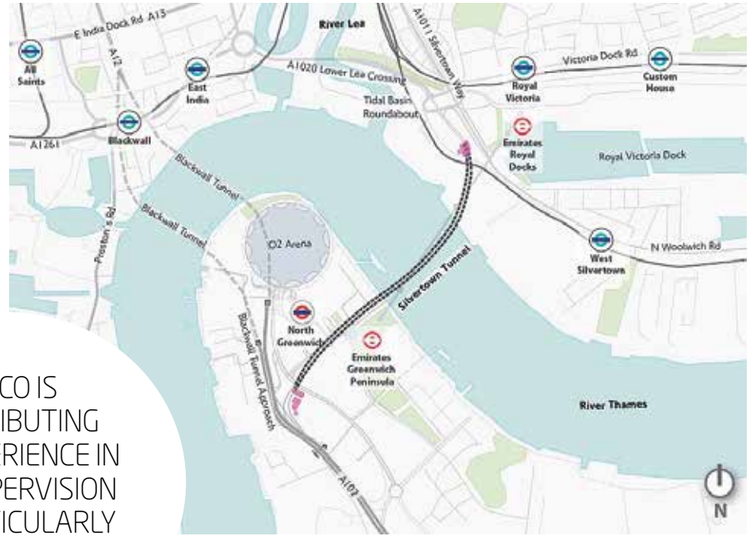
The arrival of the tunnel boring machine in the capital city of London is a crucial step in the construction of this major project beneath the River Thames: 1.4 kilometre twin road tunnels will provide a major relief to congested transport in the east of the city. Ineco is acting as an Independent Certifier, bringing its extensive experience in the supervision of particularly complex tunnels.

**Ernesto de Zárate** and **Pedro Feijoó,**
civil engineers

**THE LAUNCH CHAMBER**
It is made up of four adjacent shafts with two counterforts on each side, between shaft and shaft, which give it a peanut-shaped ground plan. This structural layout was chosen instead of a rectangular geometry due to the conditions of the ground, occupation requirements, depth and, mainly, to avoid resorting to long lateral anchorages, which would have interfered with the construction of the second tube as it passes through the north side of the shaft until it reaches the extraction shaft.

PHOTO_RIVERLINX

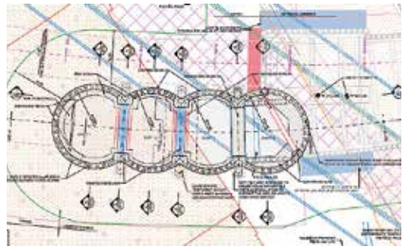
INECO IS CONTRIBUTING ITS EXPERIENCE IN THE SUPERVISION OF PARTICULARLY COMPLEX TUNNELS




General layout of the route of the tunnel under the River Thames.

The new tunnel will be the first infrastructure to be built across the Thames since 1991, increasing public transport provision sixfold upon its commissioning. The project, which is being undertaken by London's public transport authority Transport for London (TfL), is the largest road investment in this area of the city in the last 30 years. It includes the design and construction of 1.4 kilometres twin bored tunnels under the River Thames, which, together with the cut-and-cover tunnels at both ends, add up to a total tunnel length of 2 kilometres. The design also includes the necessary road works and junctions for tunnel access. With a budget of more than one billion pounds, the project has been awarded to the RiverLinx consortium, which is responsible for its design, execution, financing, operation and maintenance. RiverLinx is made up of Spanish operator Cintra, construction companies Ferrovial-Agroman and BAM Nuttal, engineering firms SK E&C, designers Ayesa, Arup, Cowi and financiers Aberdeen Standard Investment and Macquarie Capital.

In turn, RiverLinx has contracted Ineco/RPS joint venture as an Independent Certifier throughout the design and construction process. As such, Ineco is participating in the construction of the



The tunnel section, in each tube, will have an internal diameter of 10.66 m, with a carriageway width of 7.30 m with two lanes of traffic, elevated walkways on both sides of 1.20 m and a traffic gauge of 5.35 m.

The tunnel boring machine was manufactured in Germany by Herrenknecht. It is 82 m long and weighs about 1,800 tonnes.

In addition to the tunnels, the works include the design of the accesses and the connecting roads with the existing network.

PHOTO_RIVERLINX

IMAGE_RIVERLINX

Infographic of the entrance to the tunnel from the Greenwich Peninsula.

From left to right, Justin Molloy (TfL), Pedro Feijoó (Ineco, IC), Stuart Lewis (TfL) and Manuel Garea (RiverLinx CJV), in the Greenwich area.

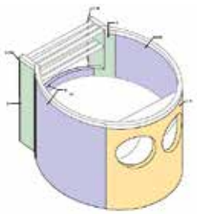
tunnel, bringing its extensive experience in the supervision of particularly complex tunnels. The contract is being executed through a joint venture with the company RPS, in which Ineco has a 57% shareholding. Both companies will provide support as an Independent Certifier until the commissioning of the new tunnel. The design phase started in 2020, with work scheduled for completion in 2025.

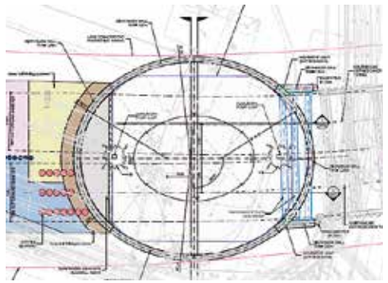
### LESS TRAFFIC JAMS, BETTER CONNECTIONS

Currently, the only means of crossing the Thames in this area of the city is the Blackwall Tunnel, which has been in service for over 120 years, with very high levels of congestion (over 48,000 vehicles per day in each direction) and gauge limitations. It is estimated that more than one million hours of congestion are generated each year due to tunnel capacity constraints, with an economic impact of 10 million pounds each year.

The new tunnel will be the first road crossing under the River Thames since the Queen Elizabeth II Bridge opened on the outskirts of London more than 30 years ago. It is estimated that the tunnel's area of influence will see an increase in population of 650,000 people and the creation of 286,000 new jobs by 2036. Once operational, it will enable a six-fold increase in public transport capacity in this area of London. Today, due to the limitations of the tunnels, there is only one bus service that allows crossing between the two eastern neighbourhoods of the city. The new tunnel will have one bus lane in each direction, allowing an increase to 37 bus services per hour. All services will also be operated with zero-emission vehicles.

TfL estimates that improving congestion in and around Blackwall will significantly reduce journey times. Studies predict that, without the Silvertown Tunnel, both traffic and emissions from congestion in the Blackwall Tunnel would increase in the coming years, such that morning rush hour delays in east and south-east London could increase by more than 20% on average. The new infrastructure will help to improve air quality in this area of the city by reducing congestion and increasing the flow of public transport, as well as making connections north and south of the river more resilient.





The rotation chamber, where the tunnel boring machine will turn around once the southbound tube has been completed in order for the second northbound tube to be completed, is made up of D-walls oval-shaped shaft.

### GEOLOGY UNDER THE THAMES

London sits geologically in a basin that formed 65 million years ago, with limestone bedrock overlain by layers of clay, sand and gravel. The stratigraphy of the area corresponds to the following formations according to depth:

- **Anthropic fills,** with a thickness of 2-4 m.
- **Alluvial.** A stratum about 4.5 m thick located on the banks of the river.
- **Quaternary terrace deposits.** Terraces formed by sandy gravels 5-8 m thick, on the banks of the river, overlying the London Clay Formation.
- **London Clay.** Stiff to very stiff clays that form the river bed with a thickness of 5 to 12 m.
- **Harwich formation.** Between the London Clay and the Lambeth Group formed by silty-sandy clays between 2-4m thick.
- **Lambeth Group.** Lower silty-clayey compact to very compact stratum.

The tunnels, except for the entrance and exit sections, will run mainly through the clays of the London Clay, Harwich and Lambeth Group formations, all of which are characteristic of the city. The tunnel overburden, while variable, will be between a minimum of 5 m and a maximum of 23 m, with an average overburden generally just over one diameter.

THE NEW TUNNEL WILL BE THE FIRST ROAD CROSSING UNDER THE RIVER THAMES FOR MORE THAN 30 YEARS

### DESCRIPTION OF THE WORKS

In addition to the tunnels, the works include the design of the accesses and the roads connecting them to the existing network, which are largely developed using open cut and cut-and-cover techniques by means of slurry walls, sheet piling, micropiles and *in-situ* walls.

The tunnel is made up of two tubes built with an EPB TBM (Tunelling Boring Machine) of 12 m in diameter to accommodate a cross section with two unidirectional lanes of 3.50 m for each tube, with one of the lanes being exclusively for the circulation of buses, including double-deckers, and freight transport.

The tunnel boring machine was manufactured in Germany by Herrenknecht. It is approximately 82 m long, weighs around 1,800 tonnes and will have a cutting surface of almost 12 m.

Following the execution schedule, the tunnel boring machine will start boring the first tube (southbounds) from Silvertown, where the launch chamber is located, turn around in North Greenwich at the rotation chamber and continue boring the second tube back to Silvertown to the extraction shaft. The infrastructure will include seven cross passages connecting the tubes at 150 m spacing.

Overall, the construction team will manage a total excavation of 600,000 m³ and 100% of the extracted material will be transported by river, minimising the impact of construction traffic on neighbouring communities and roads.

The project also incorporates maintenance buildings and road works and surface links, including an overbridge and a pedestrian and cycling bridge. The works are expected to be completed in the first quarter of 2025 and will be located within the ultra-low emission zone. ■

## CHALLENGES OF THE INDEPENDENT CERTIFIER ROLE

**Pedro Feijoó,**
civil engineer

Both TfL and the RiverLinx consortium jointly agreed to appoint Ineco-RPS JV as an Independent Certifier for the design, construction and implementation of the safety equipment for the Silvertown Tunnel Project tunnels.

The main purpose of the services to be performed is to issue a Permit to Use Certificate, a document confirming that the project has been carried out in accordance with the requirements specified in the Project Agreement between TfL and RiverLinx, at the end of the execution of the works. This includes the technical and administrative specifications of the entire design and construction process, independently certifying their fulfilment. To this end, the necessary inspections and audits shall be carried out and the previously established quality processes shall be supervised, including the tunnel's equipment and installations (lighting, ventilation, fire-fighting equipment, signalling, etc.).

The inclusion of a third party certifying the work therefore implies being recognised as an impartial assessor who, in addition to specialist knowledge, has the necessary experience in management, regulations and quality control.

In its role as Independent Certifier for the Silvertown tunnel, Ineco is bringing more than 20 years of experience in the design and execution of this type of infrastructure. The company has extensive experience in similar major projects, particularly in the design, inspection and construction management of tunnel works, such as those carried out for the Spanish high-speed AVE network, which include the tunnels of Pajares, Abdalajís, Guadarrama, Bolaños and the most recent tunnel between Atocha and Chamartín. It was also involved in the plan to bring 310 tunnels on the National Highway Network into line with European standards, or in international projects such as the Haramain in Saudi Arabia, the British HS2 high-speed network, the Paseo del Bajo road in Buenos Aires, or the Rodoanel Mario Covas in São Paulo.

The work, in a joint venture with the company RPS, began in early 2020 and will be completed once the services are scheduled for completion in April 2025. During the course of these duties, both Ineco and RPS will rely on their teams of experts from the Dublin and Madrid offices, while also maintaining a continuous presence at the worksites involved in this major project.

PHOTO_JONATHAN LAMPEL FROM UNSPLASH

# DRONES: THE GOOD AND THE BAD

The enormous potential and myriad applications of unmanned aerial systems (UAS) are matched by their possible misuse or illegal use. In order to limit security risks, governments and international organisations are working intensively on its regulation, as well as in monitoring and detection systems. This article features experts from Ineco, EUROCONTROL and the Ministry of the Interior who discuss the opportunities and threats posed by drones.

Ineco has been using drones for years and has been working on the development of advanced applications, such as the calibration of radio aids or the remote inspection of railway lines and structures. It also participates in European R&D&I projects such as TERRA (ground technologies), IMPETUS (information services) and DOMUS (flight demonstrations), and is currently involved in AMU-LED, which will study the safe use of drones in urban environments until 2023. The company is also part of the EUROCAE WG-115, which, together with its North American equivalent RTCA SC-238, focuses on defining technical requirements for drone detection and neutralisation systems. ■

**DRONE-BASED RADIO NAVIGATION AID CALIBRATION SYSTEM**

## Living up to expectations

Ineco, in an internal innovation project, has developed and successfully tested a system for calibrating radio navigation aids with drones that is cheaper, more manoeuvrable and more accessible than current systems, while maintaining accurate results. After three test campaigns and more than 60 flight hours, the system has demonstrated that it lives up to expectations.

**Víctor M. Gordo**, aeronautical engineer
**Iván Beneyto**, telecommunications engineer

Radio navigation aids (VOR, ILS, DME) are ground-based equipment that communicate with airborne aircraft via radio signals, thereby ensuring the safety of air navigation by providing the necessary positioning and guidance signals to keep aircraft adequately separated from the terrain and obstacles. In order to ensure that the functioning of the equipment remains optimal, certain parameters relating to the quality of the signal they emit, such as power, modulations, response delays, etc., must be regularly calibrated. This is currently done using aircraft crewed by specialist pilots and personnel.

There are several limitations to the use of manned flight that do not apply to the use of drones, or RPAS (Remotely Piloted Aircraft Systems). On the one hand, their costs are high and their availability is limited due to the fact that few aircraft of this type exist. This means that they can be heavily used and that equipment can only be checked from time to time, typically with one calibration per year and radio navigation aid. On the other hand, they have reduced manoeuvrability in the air and their presence has an impact on air traffic, making it difficult to carry out certain checks.

**TEST CAMPAIGNS**
In order to test the efficiency of the system, several test campaigns have been carried out at Logroño-Agoncillo and Vigo airports, as well as at several air navigation facilities around Madrid.

Although it is not possible to fully replace manned flight today, since RPAS autonomy is limited and there is no integration with conventional aviation. This technology is poised to become operational as a maintenance support service to enable spot checks and increased spacing between calibration flights.

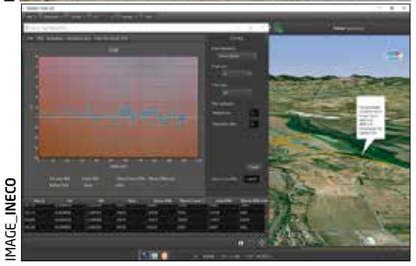
Over the last few years, Ineco has created its own system for calibrating radio navigation aids using these unmanned vehicles. The system consists of various on-board equipment (so that the drone can analyse the radio signal from the radio navigation aid and send the data back) and equipment on the ground (receiving station), in addition to the analysis and representation software that has been developed.

The platform used is a coaxial octocopter fitted with a Pixhawk 2.1 Cube autopilot system, offering a range of 30 minutes and capacity to carry a payload of up to 2 kg, equipped with GPS+Galileo+GLONASS and EGNOS Navigation system, as well as RTK (Real Time Kinematic) positioning. The on-board systems include antennas, an SDR, or software-defined radio, as well as a microcomputer that analyses the digitised RF signal to calculate the relevant radio navigation aid parameters. The ground system consists of two elements: an RTK base that corrects the drone's position within a margin of error of centimetres, and a control station that manages all the system's components.

PHOTO_INECO

Data is sent in real time via an MQTT (Message Queue Telemetry Transport) broker installed on Ineco's servers. This broker broadcasts messages to clients via a publisher/subscriber arrangement with latencies of less than two seconds. The visualisation of this data, as

PHOTO_**INECO**



IMAGE_**INECO**

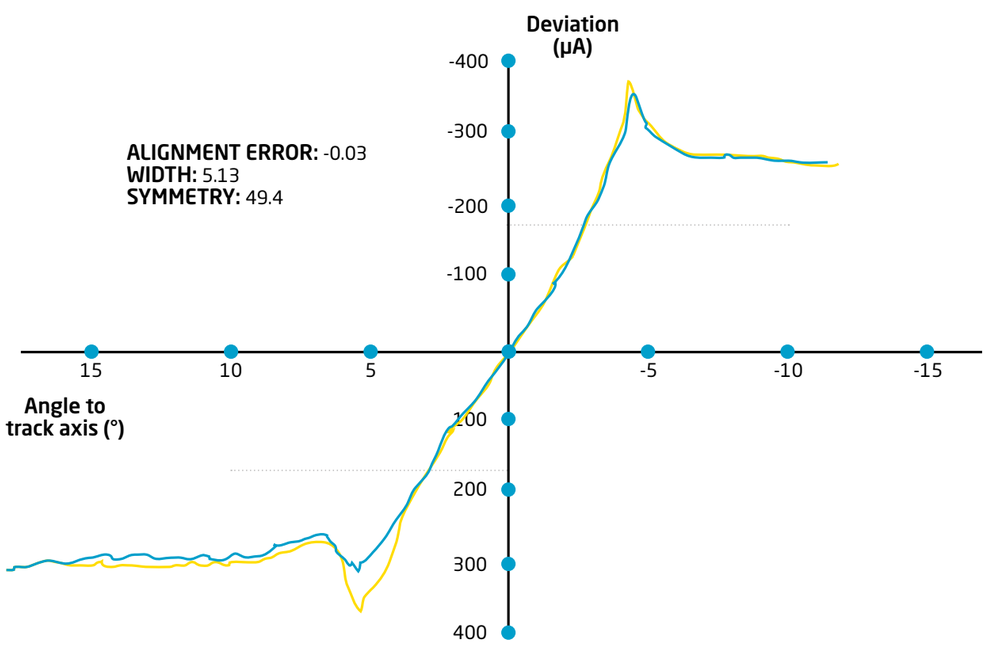
In the image above: Iván Beneyto, Ignacio Díaz de Liaño and Víctor Gordo. In the lower image: display of results together with the position of the RPAS (in 3D) in real time, in the tool developed by Ineco.

well as its storage, is handled by a results console developed in NavTools, Ineco's air navigation tools package. This console makes it possible to view the records obtained by the equipment on board the drone in real time, displaying how the parameters that define the correct operation of the radio navigation aid, such as the difference in depth of the modulations, power, alignment error, signal structure, etc., evolve along the flight path. The console can also be used to save the received data and to display and analyse the flown trajectory and the data obtained.

In order to assess the efficiency of the system, several test campaigns have been carried out at Logroño-Agoncillo and Vigo airports, as well as at several navigation facilities around Madrid (Perales de Tajuña, Navas del Rey, Castejón and Villatobas), where different types of aids, ILS (Instrument Landing System) and DVOR (Doppler Very-High-Frequency Omnidirectional Range) were tested by means of radial, vertical and horizontal flights, orbits and approaches depending on the type of radio navigation aid.

The system has made it possible to record the typical parameters of these radio navigation aids, confirming that they were within the ranges established by ICAO for more than 95% of the time, thus complying with current regulations. The results obtained were also compared with those recorded by a conventional calibration aircraft, showing a high correlation, thus corroborating the correct operation of the system; laboratory tests were also carried out using a signal generator, confirming that the system can measure with an error of less than 1%. The most important milestones during these tests are listed below:

- 3 test campaigns in an airport environment.
- 0 ATC incidents.
- More than 10 DVOR verifications.
- More than 10 ILS verifications (LLZ and GP).
- More than 60 cumulative flight hours.
- >95% of the time within ICAO limits.
- Verifications of up to 20 minutes.
- Approaches up to 2 km in length.
- Flights up to 120 metres high.
- Positioning error <1 metre.
- Real-time latencies <2 seconds. ■




**RESULTS VALIDATION**
Comparison of drone radio navigation aid calibration results (blue) revealed a high correlation with those of a conventional aircraft (yellow), which corroborates the correct functioning of the system.
***Source: Ineco***



# C-UAS: a reality check on rogue drones

**Julia Sánchez**, UAS specialist, EUROCONTROL

The unmanned aircraft system (UAS/drones) market is rapidly and significantly expanding. What started as an exclusively military domain is now aiming at the private and public civil sectors with numerous applications, that will create new jobs and economic benefits. However, the use of drones raises a number of issues: they can also be dangerous weapons and have become an attractive tool for terrorists and criminals.

A growing phenomenon, is the number of incidents at and around airport facilities. Some actions have already taken place due to the potentially damaging effects of drones' colliding with other airspace, disrupting aerodrome operations (e.g. such as the incidents at Barajas in February 2020 or Gatwick in December 2018), attacking critical and sensitive infrastructure (e.g. government buildings, nuclear power plants, urban areas) or even people on the ground.

As a consequence of this, the use of UAS has become a double-edged sword. The potential threat that drones pose to safety, security and privacy has led to the development of Counter UAS (C-UAS) measures to counteract any drone incursion into controlled and uncontrolled airspace.

In Europe, the European Commission is committed to supporting EU member states in mitigating the threats posed by non-collaborative UAS, in line with the EU Action Plan to Support the Protection of Public Spaces, the European Commission's counter-terrorism unit has created two interest groups: Protection of Public Spaces (PPS) and C-UAS,.

EASA's (European Aviation Safety Agency) Counter-UAS Action Plan was included in the European Plan for Aviation Safety (EPAS) in 2021. It concerns educating drone operators and pilots, raising awareness to prevent the misuse of drones around aerodromes, preparing aerodromes against drones' incursions, advising aerodromes to consider those C-UAS measures necessary for ensuring the safety and security of aerodrome operations (airborne and ground), encouraging adequate incident reporting, and supporting the assessment of the safety risk drones pose to manned aircraft. The deliverable of the second objective of the Action Plan is a guidance manual called *Drone Incident Management at Aerodromes*, although only the first part is publicly available.

Faced with these actions, there is also the necessity to choose the right C-UAS technology depending on the threat scenario. EUROCAE, the European Organisation for Civil Aviation Equipment, has established the Work Group WG 115 in order to develop standards for the safe and harmonised implementation of anti-UAS systems at airports and ANSPs. These standards will describe the performance of the system (e.g. minimum level of detection required), interoperability and interfaces with stakeholders. EUROCAE WG 115 jointly with RTCA SC-238 Counter UAS published its first deliverable, the *Operational Services and Environment Definition (OSED) for C-UAS in controlled airspace*. The scope of this is to introduce the overall capability of a C-UAS system, including capabilities for the detection of unauthorised UAS. EUROCONTROL is highly involved in WG 115 and will continue to support it and contribute to future deliverables, that are expected to be published by the end of 2022.

The European Commission is committed to supporting EU member states in mitigating the threats posed by non-collaborative UAS. EUROCAE has established the Work Group WG 115 in order to develop standards for the safe and harmonised implementation of anti-UAS systems at airports and ANSPs.

As EUROCONTROL's activities touch on operations, concept development, research, safety and security, and performance improvements, we are providing key services and contributing experts in the domain to C-UAS-related research projects from European Commission's Directorates-General for Migration and Home Affairs and Transport (DG Home and DG Move); the European Aviation Safety Agency (EASA), the European Organisation for Civil Aviation Equipment (EUROCAE), Work Group 115, as well as the international air transport (IATA) and airport associations (ACI).

Furthermore, there are also some limitations to C-UAS technologies in the aviation context, since might interfere with other systems currently in place. Interoperability must therefore be ensured with other systems (e.g. navigational aids, and primary and secondary radars at airports), as well as an interface with appropriate ATM and UTM (U-space) systems to enable the exchange of information necessary for the safe operations. Finally, any technical C-UAS solution must be complemented by procedural measures and clear protocols that depend on the threat level presented by the rogue UAS, to define who does what and when. The C-UAS should also be able to distinguish between authorised and unauthorised drones. A variety of technical C-UAS solutions and technologies are continually emerging. The selection of the right C-UAS depends on the features and specific characteristics of the environment. Actions in response to an illegal UAS, such as mitigation and neutralisation technologies, can carry important risks, and their deployment will fully depend on the national legislation of the country concerned. At the international level, the International Court of Justice (ICJ) mentions that countermeasures must never involve the use of force. Initiatives to improve C-UAS response capabilities could include the development of an official registry or database that allows the rapid classification of a drone as a threat, and the development of a catalogue of best practices when employing C-UAS to know which technology would be more suitable and how to use it, with a clear description of the chain of command to be followed and any legal advice that could be required depending on the type of threat. ■

# Counter-drone systems to protect public safety

**Enrique Belda**, Deputy Director General of Information and Communications Systems for Security and Director of CETSE
**José Cebrián**, Chief Inspector of the R&D&I Area and Director of the SIRDEE Office; **Manuel Izquierdo**, Director of the SIGLO-CD Project

The technological growth in drones, the large number of commercial models and their multiple applications, together with the reduction of purchase and maintenance costs and the ease of operation and legislative development, mean that more and more public and private organisations, individuals and companies are using this type of aircraft. For this reason, the authorities must be prepared in two respects: as users, including the emergency services, and as guarantors of security, both by preventing their reckless use or non-compliance with the rules of manufacture, sale and use (safety), and by preventing their criminal use, in the most serious case, for terrorist attacks (security).

The Ministry of the Interior, and more specifically the Secretary of State for Security, has been working from two perspectives: the legal perspective, including collaborations, action protocols and agreements with other bodies, and the technological perspective, seeking and applying the best existing solutions both for fleet control and to prevent and, where appropriate, neutralise their malicious use.

The Security Technology Centre (CETSE) is the headquarters from the Subdirectorate General of Information and Communication Systems for Security (SGSICS). The R&D&I Area of the Subdirectorate is made up of two departments: R&D&I, European Projects and CoU (Community of Users), and Drones and Counter-Drones, SIGLO-CD Directorate (Global Counter-Drones System).

In 2019, the Secretary of State for Security (SES) ordered the design and implementation of a technological platform to protect against alleged unlawful acts, as well as intrusions into personal space, use by organised crime and possible terrorist actions.

In 2016, a working group was set up at the Secretary of State for Security focused on finding solutions to the malicious use of this type of aircraft. Following an analysis of the market, it was concluded that there are no global solutions to address all situations –most of them are isolated–, that there are many different scenarios with very different characteristics, that there is a lack of legislative regulation in counter-regulatory systems and that these systems may cause possible collateral damage. From the outset, the following phases were established to deal with a potential threat:

- **Detection:** something strange is detected, but initially it is not clear whether it is a drone, where it is going, what its intentions are, etc.
- **Identification:** discern whether it is indeed a drone and obtain as much data as possible from the drone, including the pilot's position.
- **Tracking:** give indications of where it is going and possible intentions.
- **Neutralisation:** if necessary.

Enrique Belda, Deputy Director General of Information and Communications Systems for Security and Director of the CETSE, describes the centre as a "factory of technological solutions", among them, the Global Counter-Drones System (SIGLO-CD).

PHOTO_MINISTRY OF THE INTERIOR

ILLUSTRATION_DRON SILENT FLYER, COURTESY: HTTP://FLYGILDI.COM/

- **Intelligence:** all these phases must have a certain amount of intelligence to help the operator make decisions in real time.

In 2019, the Secretary of State for Security (SES) ordered the design and implementation of a technological platform to protect against allegedly unlawful acts (reckless flights or flights with illegal intent), as well as intrusions into personal space, use by organised crime and, in the most serious cases, possible terrorist actions. The Subdirectorate General of Information and Communication Systems for Security (SGSICS) was in charge of implementing the so-called Global Counter-Drones System (SIGLO-CD).

On 11 July 2019, the Secretary of State for Security signed the emergency resolution declaring the procurement of a global system service. Phase 0 began with the aim of detecting, identifying and tracking commercial drones in the metropolitan area of Madrid and, if necessary, neutralising possible threats to State institutions located in the capital, such as the Royal Palace of Madrid, the Government Presidency, the Congress and the Senate, among others. From the outset, the system has been designed holistically, continuously evolving to adapt to constant technological innovations and to improve the detection, identification, tracking and neutralisation of the majority of drones, regardless of the technology they use.

The client-server architecture is built around a central server (Headquarters) which transmits information to the different detectors via a virtual private network (VPN), through which the neutralisation equipment can be activated, if necessary. SIGLO-CD also has different sites or control centres from where suspected unauthorised drone flights are monitored, each of which has an assigned administrator. In the control rooms, users (advanced or end-users) can manage the information obtained by the detection systems covering the assigned surveillance areas, in accordance with the competences associated with their respective profiles.

Activity in the sector is constantly growing: in 2020, more than 7,500 drone flights were detected over the urban area of Madrid, of which almost 95% were of the brand DJI. By 2021, the figure had increased to more than 12,000 flights.

Both detectors and neutralisers are considered as peripheral devices of the central server housed in the Security Technology Centre (CETSE), in order to provide its different users with drone detection, identification, tracking and neutralisation data in real time. It also stores information and manages communications.

The detection systems that were initially selected are passive, since they are deployed in an urban environment. They obtain the brand, model, serial number or tracking data of the most widespread commercial drones on the market. Its coverage radius is more than 15 km per antenna, which means that a few sensors can cover large areas.

Over the next three years (2022-2024), the global system is scheduled to be extended to most of the national territory, in order to manage different emergencies in a coordinated manner. It will also ensure compliance with U-Space standards. It is also collaborating with other institutions, such as the Spanish Professional Football League, with whom an agreement has been signed for the installation of detection and neutralisation systems in sports stadiums.

Activity in the sector is constantly growing: in 2020, more than 7,500 drone flights were detected over the urban area of Madrid, of which almost 95% were of the brand DJI. By 2021, the figure had increased to more than 12,000 flights. ■

Næstved station.

PHOTO_FLAUS_NOERGAARD (FLICKR)

# Passed the test

After four years of testing and commissioning, the Danish rail network now has six operational lines equipped with the ERTMS Level 2 European rail signalling system. Jens Holst Møller, chief engineer of Signalling Systems Integration at Banedanmark, the Danish railway infrastructure manager, explains in this report the details of the process, in which Ineco has been collaborating since 2017.

**Rebeca Fernández,** telecommunications engineer,
**Alfonso Martínez** and **Francisco Mayoral,** industrial engineers

Denmark has been one of the pioneer countries in the renewal of the ERTMS Level 2 signalling system. Six lines, totalling more than 350 kilometres, are already equipped with the system: the EDL (Early Deployment Line) EDL East North, EDL East South and EDL West; and the RO (Roll-out), RO7 East, RO8 West and RO5 West. Ineco has been working with the Danish rail infrastructure manager Banedanmark on the roll-out since 2017, which is expected to be extended to the entire network by 2030.

ERTMS (European Rail Traffic Management System) is the rail traffic management system that the European Commission is introducing in the nine main corridors of the Union's territory, where more than 20 different signalling systems operate, which the Commission calls 'Class B systems'. In practice, this means that whenever a train crosses from one country to another, the locomotive, driver and even the whole train may have to be changed. The solution is a common system, ERTMS, which brings great improvements in railway operation, allowing the internal and cross-border traffic of all trains with greater capacity, more safety and lower costs.

Denmark, with just under 6 million inhabitants in a territory of about 43,000 km$^2$, has the eighth highest per capita income in the world and an extensive and efficient land transport network – urban, road, maritime and rail– which is in the process of expansion and renewal with an ambitious investment programme. As far as railway is concerned, the network's operation, with

more than 2,600 kilometres in standard gauge (1,435 mm), is liberalised and has both public and private operators.

In terms of infrastructure, the Banedanmark, which reports to the Ministry of Transport, is responsible for managing maintenance, the construction of new stretches and the supervision of safety systems. The improvement and modernisation programmes focus mainly on the complete overhaul of electrification and signalling. According to Banedanmark, "the new signalling systems" –(CBTC, Communication Based Train Control, for the Copenhagen commuter and ERTMS for the national network)– "will cause fewer delays, and will allow an increase in speed and number of trains", with "an 80% decrease in signalling-related delays on main and regional lines, and a 50% decrease on the Copenhagen commuter lines."

Jens Holst Møller, chief engineer of Signalling Systems Integration at Banedanmark, explains that "following the renewal of the signalling systems, six lines with a total length of 353 kilometres have been put into commercial operation with ERTMS Level 2." He also adds that "a new 56-km high-speed line has been built with ERTMS Level 2, although it has been temporarily put into service with a Class B signalling overlay due to operation of trains without ERTMS. This line is planned to be put in service with ERTMS end of 2022".

PHOTO_MARTA CARNERO (FLICKR)

Copenhagen central station.

"THE PERFORMANCE OF THE ERTMS L2 BASED SIGNALLING SYSTEM IS VERY GOOD AND END-USERS ARE VERY SATISFIED."

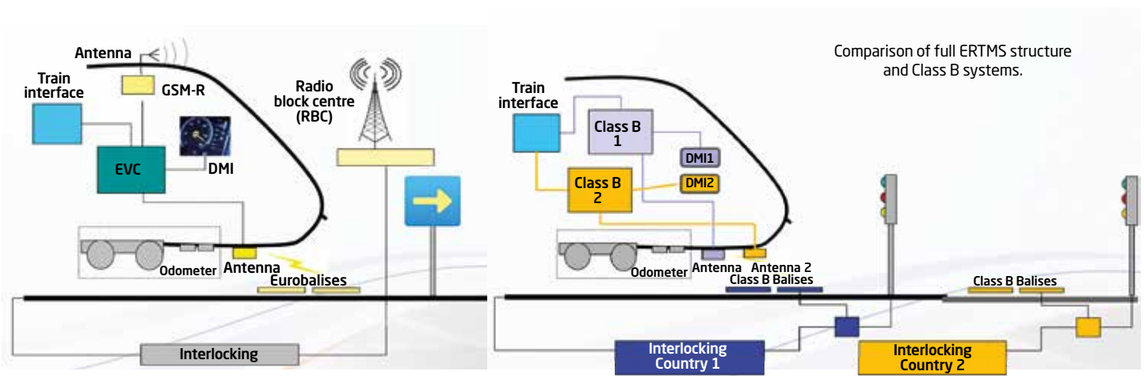
**Jens Holst Møller,**
Chief engineer of Signal Systems Integration at Banedanmark

According to Holst Møller, "the rest of the lines will have its signalling renewed and put into service with ERTMS Level 2 over the next eight years. The conversion of the national rail network to ERTMS Level 2 is expected to be completed in 2027 in the west of Denmark (Jylland) and in 2030 for the east."

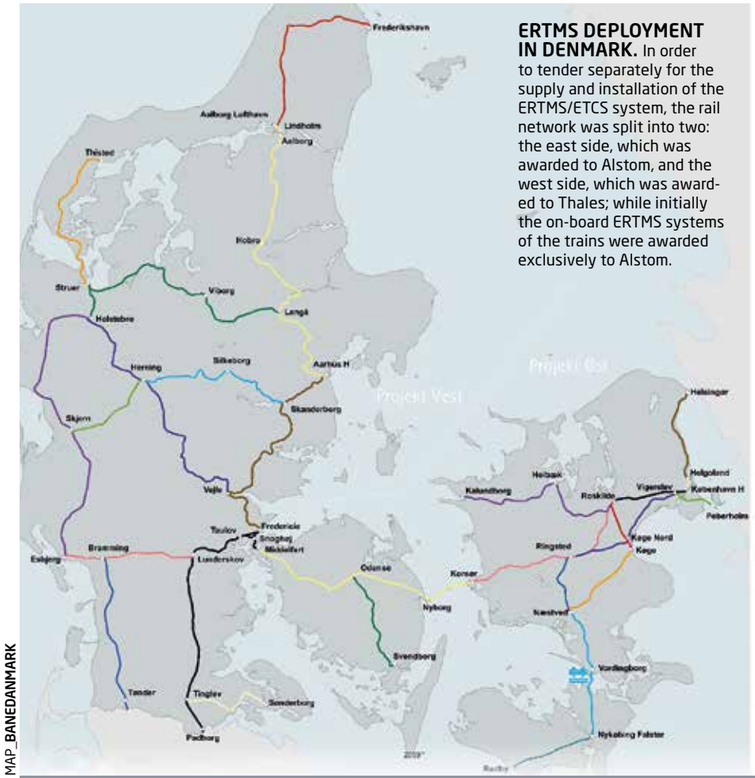
A complete system change such as this does not come without its complexities and, according to Banedanmark's top engineering manager, "the main challenges have been the development of the generic ERTMS applications, both on-board and on-track, as well as the industrialisation of the roll-out."

In particular, he explains that "the installation of the on-board systems has taken much longer than expected due to development time for the generic onboard system, classical challenges with retrofitment of older rolling stock and slow industrialisation of installation processes," and, in addition, "a major renewal of the Danish fleet is underway; the installation of ERTMS covers all existing passenger trains that are not due for renewal." The total number of trains yet to be retrofitted is around 300, of which more than half have already been put into service with ERTMS Level 2. All existing trains will be equipped by Alstom under the on-board equipment contract, but new trains are being supplied with the ERTMS system of the operator's or manufacturer's choice."

All in all, the bottom line is positive, as Holst Møller concludes: "The performance of the ERTMS Level 2 based signalling system is very good following the completion of the initial stabilisation, and end-users are very satisfied." ■




IMAGE_INECO




MAP_BANEDANMARK

**ERTMS DEPLOYMENT IN DENMARK.** In order to tender separately for the supply and installation of the ERTMS/ETCS system, the rail network was split into two: the east side, which was awarded to Alstom, and the west side, which was awarded to Thales; while initially the on-board ERTMS systems of the trains were awarded exclusively to Alstom.

- EDL n Frederikshavn - Lindholm
- R8 Struer - Thisted
- R5 Langå - Struer - Holstebro
- R4 Vejle - Holstebro
- R7b Herning - Skandeborg
- R6 Esbjerg - Holstebro
- R7a Skjern - Herning
- R1b Aarhus - Aalborg Lufthavn
- R1a Fredericia - Aarhus
- R2 Lunderskov - Esbjerg
- R11 Bramming - Tønder
- R3 Fredericia - Middelfart - Padborg
- R10 Tinglev - Sønderborg

- EDL n Roskilde - Køge
- EDL s Køge - Næstved
- R10 Odense - Svendborg
- R7b Fase 1: *Næstved - Rødby*
- R7b Fase 2: *Storstrømsbroen mv.*
- R1 Vigerslev - Ringsted
- R4 Vigerslev - Peberholm
- R8 Roskilde - Kalundborg
- R5 Korsør - Middelfart
- R9 Helgoland - Helsingør
- R7x Femernforbindelsen
- R3 Roskilde - Korsør
- R7a Ringsted - Næstved
- R2 København - Roskilde
- R11 København - Helgoland

Deployment map of the ERTMS signalling system on the Danish network: lines have been classified as EDL (Early Deployment Line) or pilot lines, where the renewal programme started in 2018, and RO (Roll-out), which is planned to be completed in 2030.

## COLLABORATION BETWEEN INECO AND BANEDANMARK

In Spain, Ineco has been supporting Adif and Renfe for many years in ERTMS infrastructure and train-track integration tests prior to the commissioning of new lines and trains. Since 2015, the company has also been in charge of the supervision and monitoring of the ERTMS deployment plan in European corridors. The company's extensive experience was precisely the reason why the Danish rail infrastructure manager Banedanmark entrusted it with the testing strategy for the commissioning of the system on its network. The first step was two pilot lines, called EDL West and EDL East North. Thus, since the beginning of 2017, Ineco has been collaborating with Banedanmark on the signalling renewal project (Signalling Programme), which includes the installation of ERTMS.

Within the initial contract (in which CEDEX, the Centre for Studies and Experimentation of Public Works, part of the Spanish Ministry of Transport, was also involved), a generic ERTMS Level 2 test specification was developed for the two pilot lines, based on functional requirements and Danish operational rules and scenarios. Ineco also carried out laboratory testing campaigns and an analysis of the results, while also defining a testing strategy to be carried out for the commissioning of future lines. In March 2018, following the conclusion of the first contract, Banedanmark and Ineco signed a framework partnership agreement until January 2022, when the partnership was renewed again until the end of 2025.

During these four years, the company has participated in the definition, execution, analysis and reporting of campaigns on lines such as: RO1 East (NLCR, Copenhague - Ringsted), RO4 West (Vejle/Skanderborg - Herning - Holstebro), RO5 West (Langå - Struer - Holstebro), RO7 East (Næstved - Rødby), RO8 West (Struer - Thisted), belonging to both the eastern part (Alstom) and the western part (Thales) as well as in the test campaigns for the new data and generic versions of the RBC of the pilot lines (including the southern part of the EDL East between Køge and Næstved).

Maintenance of the generic test specifications has also been carried out, adapting them to the new functionalities deployed on the lines, whilst support has been provided in updating them to the new version of the European ETCS Baseline 3 Release 2 specifications (SRS 3.6.0).

SILVIA DOMÍNGUEZ
telecommunications engineer

# ERTMS AT INECO, IN SEARCH OF CONTINUOUS IMPROVEMENT THROUGH DIGITALISATION

Control-command and signalling systems consist of all the on-board and infrastructure equipment necessary to ensure the safe operation of vehicles running on the network. They are therefore the key to the operation of a safe, efficient, interoperable, robust and reliable European railway service.

ERTMS is the signalling standard endorsed by the European Commission. This standard defines the automatic train protection system through the exchange of information between the ERTMS systems installed on the rolling stock and those installed on the infrastructure.

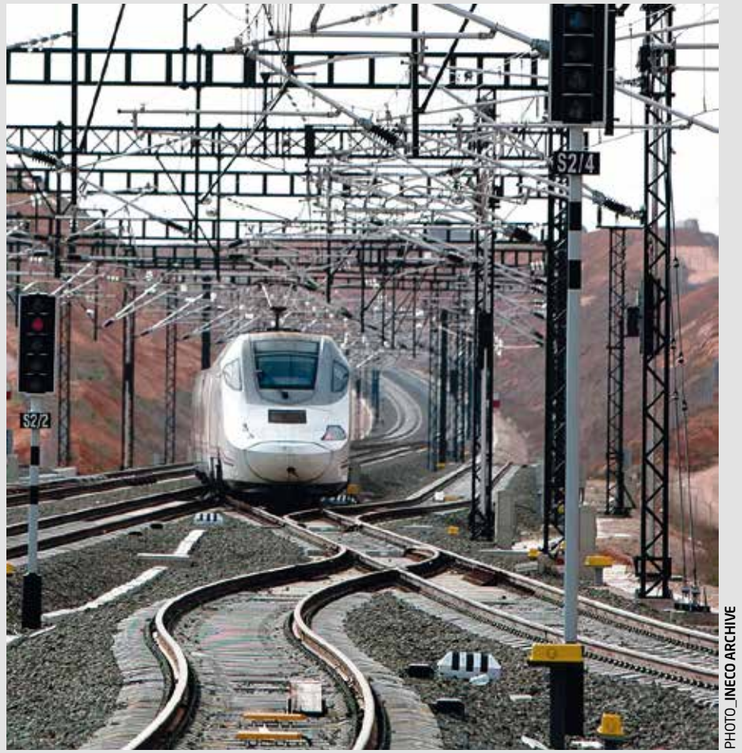
The implementation of the ERTMS system allows a series of improvements in railway operation, such as the interoperability of the different types of trains running on different infrastructures, improved safety levels and improved traffic capacity on railway lines.

Ineco has always been involved in the European projects and working groups that have shaped the ERTMS system, working in collaboration with industry, users, regulatory bodies and safety agencies. We currently lead the management of ERTMS implementation in Europe, participating in the working groups in charge of defining the future of control, command and signalling in Europe. Our company relies on in-depth technical knowledge of the ERTMS system and extensive experience gained in large-scale projects to manage the various ERTMS projects.

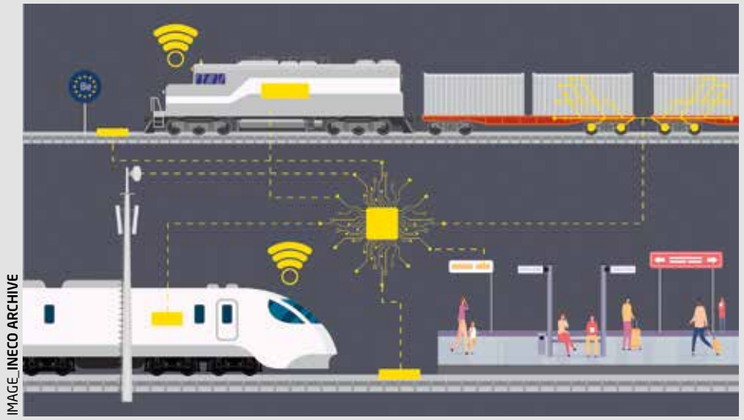
New technologies are ready for use in the rail sector with enormous potential to improve passenger and freight services. Digitalisation, together with automation, is the most effective way to increase performance and capacity with less investment in new infrastructure. Thanks to the experience gained and the projects in which the company has been involved, we can say that we are able to take full advantage of the digitalisation of the system and even anticipate the needs of the sector.

Specific examples related to our ERTMS testing work are the virtualisation of ERTMS test campaigns, their parameterisation and automation in the analysis of results. These optimisations are part of the internal processes of innovation and continuous improvement that we apply to the projects in which we are already carrying out ERTMS tests, both in Spain and abroad: Portugal, Israel, Australia and Denmark.

Ineco has developed the necessary methodologies for the virtualisation of ERTMS test campaigns in order to adapt to the health protection measures resulting from the COVID-19 crisis that make it difficult to be physically on-site. This solution has been achieved through improved execution scenarios: the definition of test cases with alternative locations, the analysis of remote records by ERTMS specialists, as well as increased virtual monitoring of tests. In addition, the virtualisation product for a complete validation of the ERTMS system will minimise the physical presence of expert resources, increasing efficiency and reducing the number of personnel on the train.




PHOTO_INECO ARCHIVE



IMAGE_INECO ARCHIVE

The implementation of the ERTMS system allows a series of improvements in railway operation, such as the interoperability of the different types of trains running on different infrastructures, improved safety levels and improved traffic capacity on railway lines.

We are also working on improvements not only in the execution of tests, but also in their design and analysis. As part of our project, we have searched for parameters and algorithms to improve the design and planning of tests in order to make their execution much more efficient. We have also developed solutions to automate the analysis of results. The use of machine learning tools has made it possible to study a large amount of evidence accumulated throughout the extensive international experience of Ineco's ERTMS team, leading to a highly satisfactory result that has made it possible to obtain very significant correlations.

Another crucial aspect is interoperability, which is defined as the ability of a railway system to allow the safe and uninterrupted running of trains meeting the required performance. At Ineco, we are currently participating in different ERTMS design and integration projects in Spain, for new deployments, as well as projects in Israel and Australia.

For more than 20 years, we have been involved in the development of ERTMS interoperability specifications. Not only did we participate in the first lines of the system deployed in Spain that have been in service since 2006, but for more than 10 years we have been carrying out the technical monitoring of all ERTMS projects financed by the European Commission. This has provided us with a unique system vision for its design and interoperable integration that incorporates the technical vision with its operational concept. We have also developed unique solutions based on our experience: for example, the methodology for assessing the impact of ERTMS on railway capacity. In this respect, it is generally accepted that ERTMS operating levels increase capacity; Level 2 more than Level 1 and Level 1 more than a traditional signalling system such as ASFA (national Class B system). However, following the analysis carried out on the network as part of the ERTMS deployment plan in Spain, it has been concluded that the results are not universal and are related to the type of line.

> FOR MORE THAN 10 YEARS, INECO HAS BEEN CARRYING OUT THE TECHNICAL MONITORING OF ALL ERTMS PROJECTS FINANCED BY THE EUROPEAN COMMISSION

Finally, it should be stressed that ERTMS is the backbone of railway modernisation, an advantage of which is the possibility of evolution and innovation with a limited economic impact because it is a digital system. The opportunity for this evolution lies in incorporating new technologies and gaining a vision with a wider technical scope than is currently the case, in particular in the interoperable aspects of control, command and signalling systems.

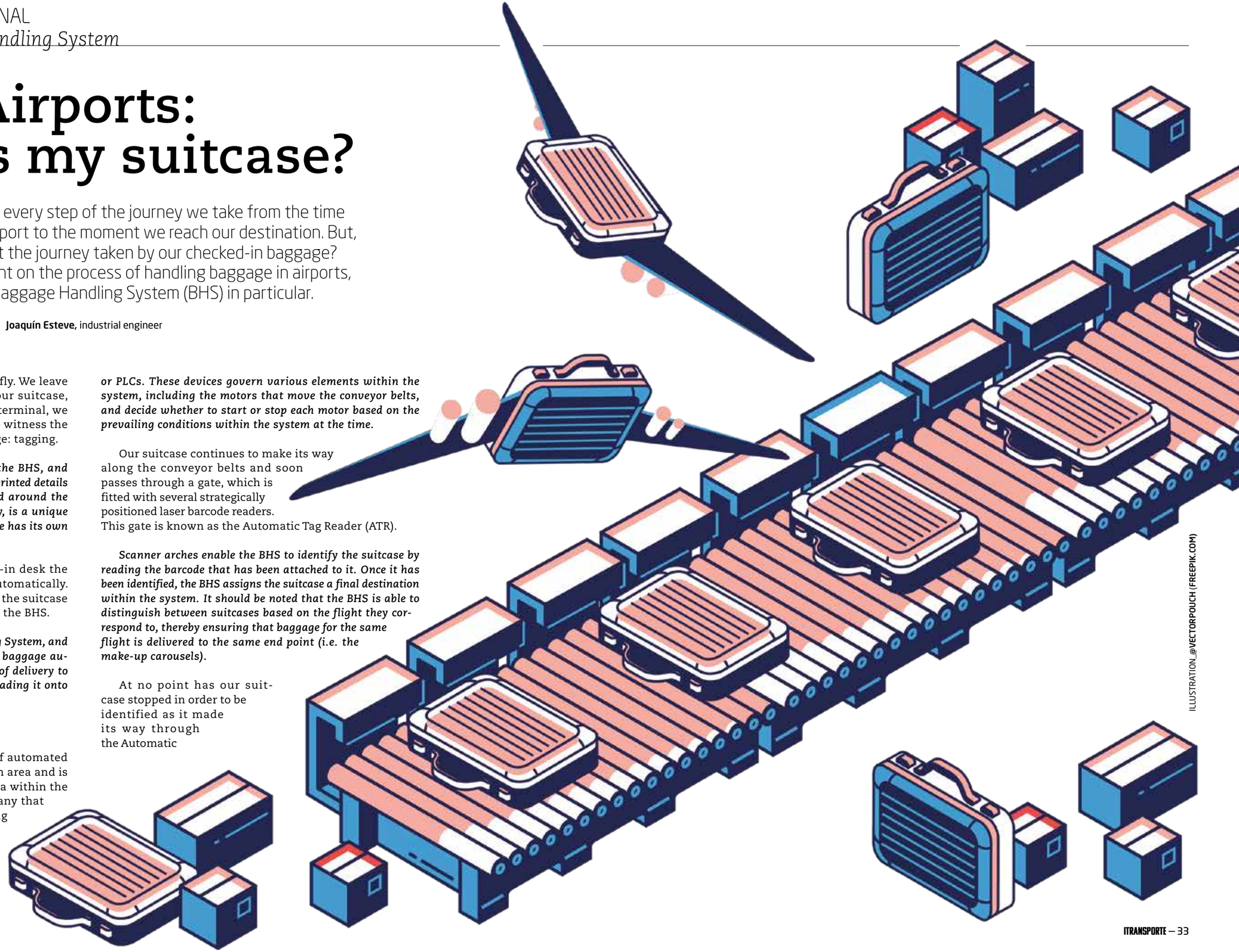
This is therefore an excellent opportunity to establish a single European system, with common functional interfaces and operational concepts to build a future single European railway network and make it internationally known and exportable.

This construction of a modern, harmonised, robust, reliable and interoperable European railway system is the main objective of the ERJU (Europe's Rail Join Undertakin) initiative, the successor to the previous initiative, Shift2Rail, in which Ineco is actively participating and which is in line with the EU's Sustainable and Intelligent Mobility Strategy. This also aims to respond to customer needs, maintain safety and digital security, improve operational efficiency and performance, reduce costs, support the competitiveness of the European railway industry and increase the speed of adoption of innovative solutions. ■

# Airports: where's my suitcase?

As passengers, we know every step of the journey we take from the time we enter our departure airport to the moment we reach our destination. But, what do we know about the journey taken by our checked-in baggage? This article will shine a light on the process of handling baggage in airports, and the role of the Baggage Handling System (BHS) in particular.

**Joaquín Esteve,** industrial engineer



ILLUSTRATION_@VECTORPOUCH (FREEPIK.COM)

## CHECKING IN OUR SUITCASE

The big day is finally here! It's time for us to fly. We leave everything neat and tidy at home, pick up our suitcase, and head to the airport. When we get to the terminal, we make our way to the check-in desk, where we witness the first stage in the journey taken by our baggage: tagging.

*The tag serves to identify our baggage in the BHS, and normally consists of a sticker bearing a series of printed details and a barcode. This sticker is usually wrapped around the handle of our suitcase. The barcode, by the way, is a unique reference and ensures that every item of baggage has its own exclusive identification code.*

In addition to the tag, at the same check-in desk the size and weight of our suitcase is checked automatically. After the tag has been attached, and provided the suitcase is within the permitted dimensions, it enters the BHS.

*BHS stands for Automated Baggage Handling System, and comprises a series of elements that convey our baggage automatically from the check-in desk to the point of delivery to the handling agents, who are responsible for loading it onto the plane. (See Figure 1).*

## OUR SUITCASE MAKES ITS WAY INTO THE BHS

Our suitcase enters the system via a series of automated conveyor belts. It leaves the airport's check-in area and is taken to a technical and rather industrial area within the same building. The suitcase is now one of many that are currently within the system, and are being conveyed in an orderly fashion along the multitude of conveyor belts that snake their way through the facility.

*The BHS controls the progress of the baggage using Programmable Logic Controllers, or PLCs. These devices govern various elements within the system, including the motors that move the conveyor belts, and decide whether to start or stop each motor based on the prevailing conditions within the system at the time.*

Our suitcase continues to make its way along the conveyor belts and soon passes through a gate, which is fitted with several strategically positioned laser barcode readers. This gate is known as the Automatic Tag Reader (ATR).

*Scanner arches enable the BHS to identify the suitcase by reading the barcode that has been attached to it. Once it has been identified, the BHS assigns the suitcase a final destination within the system. It should be noted that the BHS is able to distinguish between suitcases based on the flight they correspond to, thereby ensuring that baggage for the same flight is delivered to the same end point (i.e. the make-up carousels).*

At no point has our suitcase stopped in order to be identified as it made its way through the Automatic

PHOTO_INECO

Ineco is currently working on the design of the BHS for the international airports of Schiphol (Amsterdam), pictured, and Dammam (Saudi Arabia).

Tag Reader. The transit process is continuous, except for a couple of occasions when the system stopped the suitcase at a junction, so that an item of baggage from another line ahead of us could join the belt.

### BAGGAGE INSPECTION

All of the baggage that enters the BHS is inspected, in order to ensure the safety and security of people, aircraft and the airport facilities. Our suitcase continues to make its way along the conveyor belts, heading towards a large machine in the distance that appears to be swallowing up all of the baggage in front. This is the baggage screening machine.

*Baggage screening machines examine every single item of baggage that enters the BHS. They are equipped with advanced technological features designed to detect elements that might cause harm to people and property, such as weapons and explosives.*

A small curtain marks the point where the inspection process begins. As with the identification process, our suitcase does not stop during the inspection process, and after a few seconds it emerges from the machine and passes through a second curtain before continuing its journey through the facility.

*At the end of the inspection, the machine sends the result to the BHS, which incorporates this result into the data it has for the item of baggage in question. This data is vital, as the BHS must ensure that the only suitcases to reach the planes are those that have been 'cleared' (i.e. they have passed the inspection).*

So, with the inspection result now linked to its data file, our suitcase continues on towards a critical decision-making point in the system. Here, there is an electromechanical device that separates the 'cleared' baggage from the rest, sending it along one belt and the 'non-cleared' baggage along another.

*At this decision point, the BHS is able to verify the inspection status of each item of baggage. If –and only if– a suitcase's status is shown as 'cleared', the system will allow it to continue on towards the final destination. In all other cases, the system will divert the baggage so that an additional inspection can be carried out.*

As our suitcase does not contain any dangerous items, it was 'cleared' during the first inspection and can now make its way to the final destination. Behind it, at the decision point, other suitcases that were not so lucky are diverted onto a different line, where they will be subjected to a new inspection.

PHOTO_JOAQUÍN ESTEVE

Early baggage storage line with stacker crane operation, Alicante airport.

### BAGGAGE CLASSIFICATION AND FINAL DESTINATION

Because it classifies baggage by flight, the BHS helps to make airport operations more efficient. Our suitcase is now nearing the end of its journey. The line it is now travelling on has a multitude of junctions leading off to different locations, such as early baggage storage, manual encoding stations, make-up carousels, and docks for 'problem' baggage.

*Early baggage storage is a temporary destination for baggage that has been introduced into the system but whose flight does not yet have an assigned make-up carousel. It is a sub-system that is of tremendous help to airports that handle high volumes of baggage for connecting flights, when there can be a difference of many hours between the arrival and departure flights.*

Our suitcase continues on past the entrances to the manual encoding stations, as the BHS has not lost track of it at any point. It also goes past the entrance to early baggage storage: the make-up carousel for our flight is now ready to receive baggage, so there is no need to store the suitcase within the system temporarily. When our suitcase reaches the junction for the make-up carousel assigned to our flight, the system activates a switch to send it along the right track. During this final stage in its journey, the baggage is carefully deposited onto the make-up carousel.

*Make-up carousels are electromechanical elements that form a closed circuit, into which all the baggage for a particular flight is deposited. The baggage trains are positioned alongside the make-up carousels, in order make the process of loading the baggage onto the trains as efficient as possible.*

Once the suitcase has reached the make-up carousel, it is out of the hands of the BHS and becomes the responsibility of the handling agent. Via the baggage train, the agents transport our suitcase to the plane and load it into the hold. Sometimes, if we look through the plane window, we can see this process taking place.

### SUMMARY AND FINAL THOUGHTS

Figure 2 shows the processes that a suitcase passes through after it has been checked in.

The BHS has a number of technical solutions, contains many more elements and carries out many more processes than those described in this article. Ineco is aware of this complexity and takes the specific nature of each project into account. This enables the company to provide tailored services for the domestic and international markets. ■

**FIGURE 1**

**BHS**

A series of elements that convey our baggage automatically from the check-in desk to the point of delivery to the handling agents.

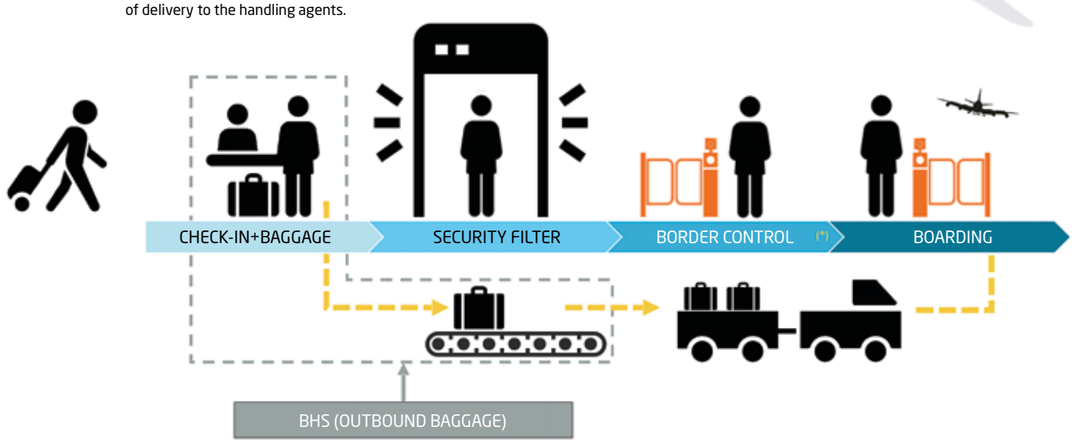
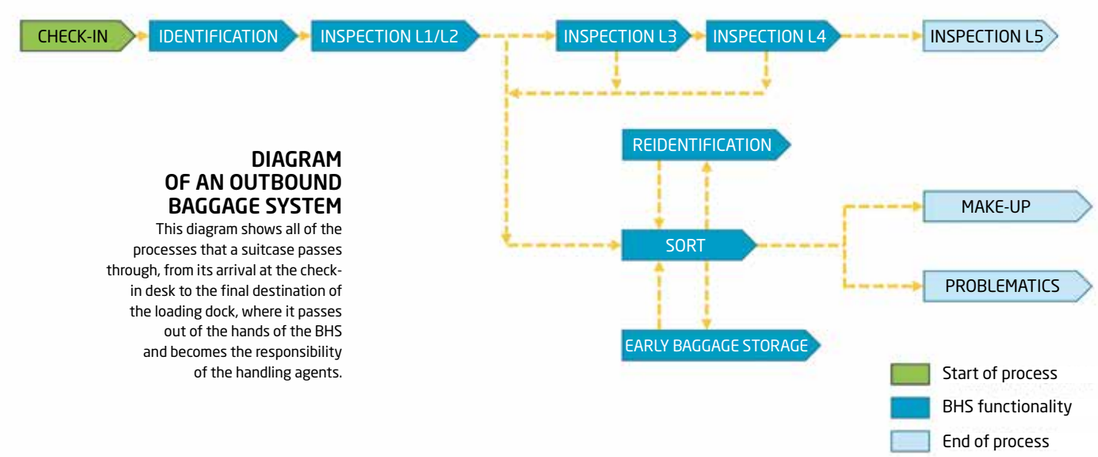



**FIGURE 2**

**DIAGRAM OF AN OUTBOUND BAGGAGE SYSTEM**

This diagram shows all of the processes that a suitcase passes through, from its arrival at the check-in desk to the final destination of the loading dock, where it passes out of the hands of the BHS and becomes the responsibility of the handling agents.



**ROBERTO CALONGE**
Industrial engineer at Ineco and an expert in BHS and ORAT

# BHS: A KEY ROLE IN BAGGAGE HANDLING

Baggage Handling Systems (BHS) are among the most complex and extensive facilities within the airport terminal. Their transport systems can reach extreme lengths (for example, the BHS line at Terminal 4 in Adolfo Suárez-Madrid-Barajas Airport is over 80 kilometres long, while the line at Terminal 1 in Josep Tarradellas-Barcelona-El Prat Airport is over 20 kilometres long), while some systems can process more than 5,000 items of baggage in a single hour. Moreover, the constituent elements of the system extend to almost every level and area within the terminal building.

The dimensions of the system are so staggering that industry experts often describe an airport terminal as an BHS with a building on top. Hyperbole aside, an BHS plays a key role in handling checked baggage and is designed to ensure that each passenger's suitcase is loaded into the hold of the correct plane on time and is delivered to the passenger as quickly as possible at the destination airport, while observing all of the necessary security procedures along the way.

In all of the terminal design projects in which it has taken part, Ineco has addressed the need to design an BHS (in terms of both transportation system layout and technology) that is adapted to suit the specific operating needs of each airport. For example, the design of an BHS for a hub airport such as Schiphol focuses on minimising the processing time for baggage on connecting flights, in order to ensure that those with a short space of time between flights *('hot transfer bags')* are processed quickly, while those with longer connection times are temporarily placed in an early baggage storage (EBS) until they can be made-up for the flight, i.e. loaded onto baggage trains or placed in containers to be taken from the terminal building to the plane.

In the case of Schiphol, a combination of transportation technologies were chosen: conveyor belts for baggage that does not need to be transferred between terminals, and an ICS *(Independent Carrier System)* for baggage that does, as an ICS allows for greater speed and tracking precision than a conveyor belt system. In contrast, for an origin/destination airport such as Kastelli on the island of Crete, the design focuses on minimising the transportation time between the check-in desks and the make-up carousels.

Designing a successful BHS –and the success of the baggage handling process as a whole– always hinges on understanding the interests of the actors involved. The following two examples help to illustrate this point: at Rosalía de Castro-Santiago de Compostela Airport, it is necessary to provide automated transportation for bicycles between the check-in desk and the baggage train area, as bicycles are a mode of transport used by pilgrims. Meanwhile, at Costa del Sol-Málaga Airport, it is necessary to provide transportation for golf bags, as golf is one of the activities that draws visitors to the area.

When designing airport terminals, Ineco –which has a team of BHS experts– takes the operation as a whole into account, in order to ensure that the needs and expectations of the actors involved are satisfied in full. The baggage handling process at an airport is an example of a supply chain in which various organisations are responsible for particular parts. Consequently, efficient design throughout the transportation chain –and especially for the interfaces between sub-systems– is vital in order to ensure that every item of baggage is delivered to its owner without unnecessary delays at the destination.

The design of an BHS must therefore enable the efficient transportation of baggage while minimising capital expenditure and the costs of operating and maintaining the system. It must also ensure that the system is available almost 100% of the time, and that the baggage is transported to the correct make-up carousel. In order to achieve this latter aim, a high degree of precision is required to identify each item of baggage (by reading the data on its tag) and track it as it moves through the facility before final delivery to the make-up carousel.

For the ramp handling companies, which are responsible for loading the baggage onto the carts and containers, transporting it to the aircraft and loading it into the hold (and vice versa), the operational logic of the BHS must take the working requirements of each company into account. For example, one company may require that flight make-up begins 120 minutes before departure, while another requires that it begins 150 minutes before departure. It is also necessary to ensure an ergonomic design for the baggage loading and unloading operations.

Lastly, hold baggage represents an important part of an airline's business, as passengers may have to pay for each item of checked baggage. (This can be an extremely important factor for airlines that follow a low-cost model.) Baggage that is not delivered to the passenger at the destination airport has a high cost for the airline, as locating and sending the baggage to the passenger's home can multiply by a factor of 10 the amount of work needed to transport baggage under normal conditions; additionally, there is the risk of losing the passenger as a customer for future flights.

The baggage handling industry is an extremely dynamic one, undergoing constant evolution in order to introduce new technologies that can help to deliver baggage to the passenger at the destination airport as efficiently and cost-effectively as possible, while minimising the environmental impact. Ineco has been a witness to (and continues to take part in) this evolution and has worked on each stage of a number of BHS projects: process planning and drawing up the basic and detailed designs for the system; developing the technical specifications and bid assessment criteria; monitoring and supervising construction; Operational Readiness and Airport Transfer (ORAT), including the development of operating and contingency procedures; operational testing and monitoring, maintenance, and process reengineering.

At present, the industry is undergoing a revolution in terms of the technologies and business models used, which Ineco is able to introduce into its designs when necessary. Noteworthy examples include:

▶ Obligatory baggage tracking at a minimum of four points *(*check-in, loading onto the aircraft, unloading at the transfer area, and delivery to the passenger), in accordance with IATA Resolution 753.

▶ The gradual implementation of baggage identification and tracking using RFID technology (as IATA has indicated to its members) and OCR identification, both of which are designed to support the traditional process of identification and tracking by reading the barcodes on the bag tags. Some companies are even developing identification and tracking processes based on computer vision and artificial intelligence.

▶ The extension of the baggage handling process beyond the airport, with check-in and final delivery taking place off-terminal, so that passengers do not need to hand over or pick up their baggage at the terminal.

▶ The introduction of self-service models for both baggage check-in and delivery to the passenger at their final destination.

▶ The use of XML-based messaging between the BHS and the airlines' DCS systems, in order to make communication between the two systems more reliable.

▶ Automation of the tasks of loading and unloading baggage, including autonomous vehicles thereby reducing the risk of injury to the handling agents when they perform these tasks.

▶ Providing passengers with real-time information on the status of their baggage via the airlines' own apps.

The emerging ideas that are being developed in the industry, and which Ineco is following with a view to incorporating them into its projects, include the de-linking of the itineraries of the passenger and their baggage, in order to make better use of aircraft hold space; the use of e-commerce distribution networks within cities to transport baggage from the passenger's home to the airport terminal, and vice versa; and the possibility of processing hold baggage at air cargo terminals.

THE FUTURE OF THE INDUSTRY WILL INVOLVE NEW BAGGAGE IDENTIFICATION AND TRACKING SYSTEMS, WHICH MAY EVEN USE COMPUTER VISION AND ARTIFICIAL INTELLIGENCE

The company has a team of experts that specialise in BHS and airport baggage handling, with extensive experience of projects at varying scales and with different operational requirements. The team has worked with a variety of technologies and business models and has the capacity to design the most efficient handling system for each airport, including BHS.

The new baggage identification and tracking systems (including those that use computer vision and artificial intelligence), automation, and the extension of the check-in and delivery processes off-terminal, are just some of the examples of the revolution that the industry is currently undergoing. ■

# Measures to ensure a long life

The longevity of a bridge, viaduct, or any other structure depends on a multitude of factors, such as the construction materials and techniques used. Maintenance also plays an extremely important role. Ineco is a pioneering Spanish company that boasts nearly 30 years of experience in the field of structural monitoring and inspection.

**Leendert de Haan,** civil engineer and expert in structural assessment and pathology

Since time immemorial, building new structures has always been more glamorous than maintaining and improving existing ones. Although today's construction materials are diverse, high quality and more sophisticated than those of times past, they also require more maintenance than –for example– the iconic stone structures built by the Romans.

In order to define a suitable maintenance programme that will maximise a structure's service life, which begins as soon as the construction work has come to an end, it is necessary to carry out a study. First, it is vital that you obtain data on the real condition of the structure. To do this, you need to go out into the field, visit the structure in question and perform an inspection. In Spain, there are specific guides and instructions that define the different types of inspection. Is the case, for example, the *Instruction for the Technical Inspection of Railway Bridges* (ITPF-05), which defines three types of inspection: basic, main and special. There are similar documents for other types of structures.

**VIADUCT OVER THE RIVER MIÑO** on the Taboadela-Ourense section of the Madrid-Galicia high-speed line, taken by Ineco's drone. Since 2016, the company has had its own drone, which is operated by AESA (National Air Safety Agency) certified professionals.

PHOTOS+3D INFOGRAPHIC+DIAGRAM_IINECO

## NOTABLE PROJECTS

Some of the most recent projects include:

- **Treatment of infrastructure elements (bridges, tunnels and earthworks) on the Monforte-Ourense-Lugo section.** This section, which is nearly 110 kilometres long, is divided into 10 multidisciplinary projects, including track, overheadline and installations. Since 2018, more than 200 people have worked on these projects.
- **Reinforcement of the viaduct over the River Miño in Ourense (AVE Madrid-Galicia).** This project was carried out 2018 and involved the specification of reinforcement works for the deck section using composite materials (carbon fibre). This historic viaduct is over 400 metres long, incorporating three central 60-metre arches and a total of 14 spans. Prior to defining the actions to renovate and reinforce the structure, Ineco carried out a drone inspection.
- **Renovation of the Martín Gil viaduct on the Zamora-A Coruña line.** When it was built, this unique viaduct boasted the world's longest concrete arch, measuring 192.4 metres across the central span. Ineco inspected the viaduct using a drone equipped with both a conventional camera and LiDAR system.
- **Study of crown wall pathologies in the Levante breakwater, port of Málaga.** Ineco inspected the entire crown wall –a reinforced concrete structure some 1,200 metres long– and drew up a corrosion report. This project was carried out in collaboration with the Eduardo Torroja Institute, part of the Spanish National Research Council (CSIC).

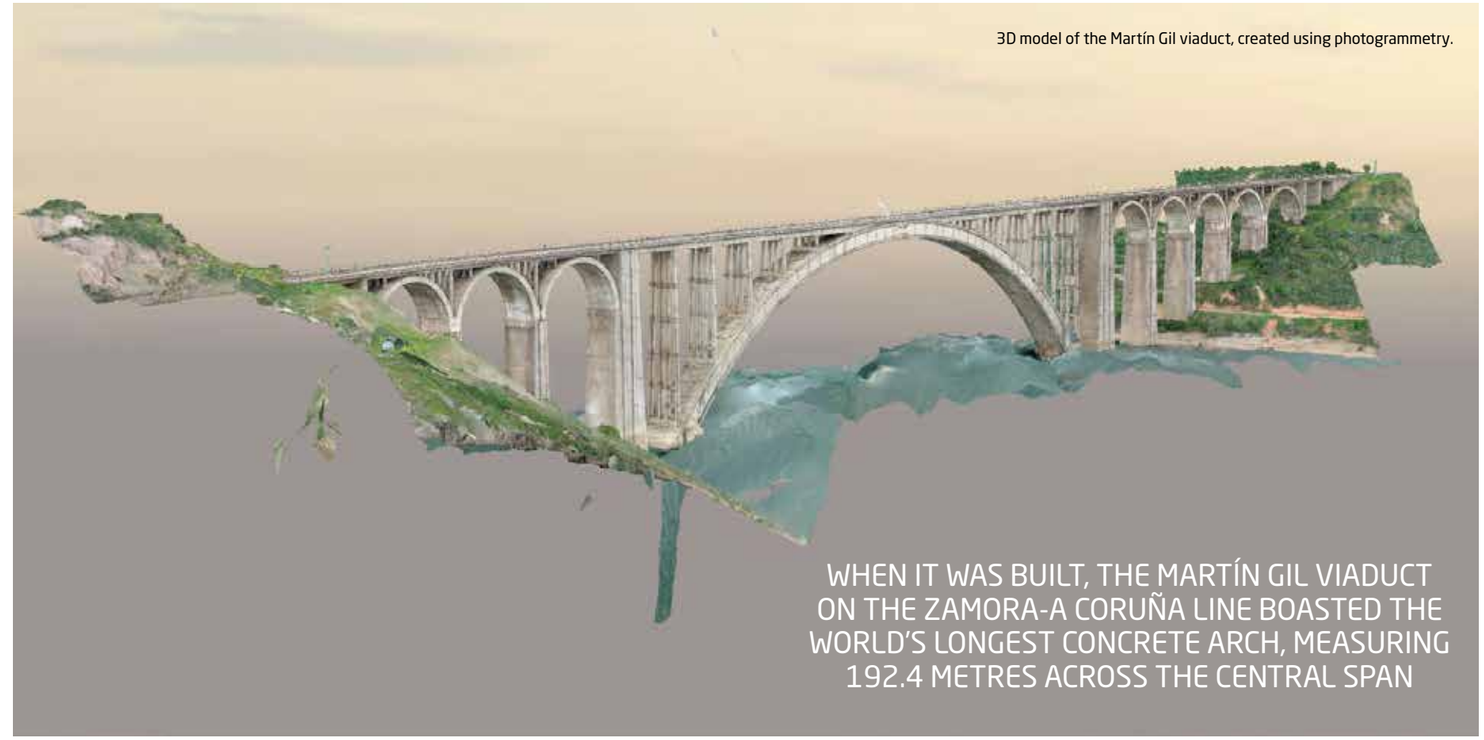
These inspections are visual and the information obtained regarding the functional condition and durability of the structure depends, in large part, on the skills and capacities of the inspector. In the university environment, the focus on new construction has resulted in a lack of learning and knowledge with regard to how existing structures behave over time. This, combined with other factors, makes the assessment process more complex.

Examples of these other factors include the extremely wide range of structural types and materials (concrete, steel, hybrid, stone, composite, etc.) and the many different pathologies generated by mechanical, chemical or physical causes. In addition to these factors, there is also the fact that the majority of structures are not designed to be inspected; many of their elements are hidden or difficult to access. Another of the inspector's enemies is adverse weather conditions, which can make outdoor work very complicated.

Ineco started to carry out inspections of railway bridges in the 1990s. It has been a member of the Association for the Repair, Reinforcement and Protection of Concrete (ARPHO) since 2010 (when the Association was created); and a member of the European Association for Construction Repair, Reinforcement and Protection (ACRP) since 2020.

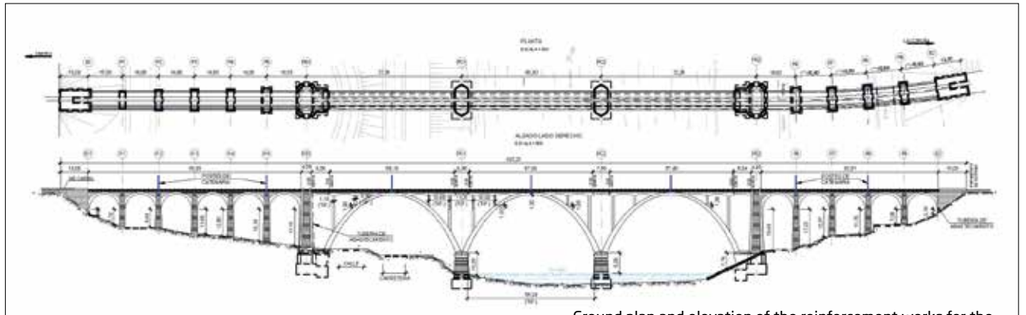
Today, Ineco's structural inspection specialists not only provide services to external clients, but also work on a cross-departmental basis within the company, helping all of the different units –including those specialising in airports, railways and roads– to perform analyses on all types of structure: from bridges and stations to airport terminals and port facilities. The work is usually carried out in two stages: a field inspection, which often includes a series of tests; and an office-based stage, in which the inspection report and plans for structural retrofitting and strengthening are prepared.

Drafting the design project and carrying out the construction work only marks the start of a structure's service life, although it is a very important stage that creates the base for long-term functionality and durability. However, no structure can exist forever. With a well-defined plan, proper execution with suitable materials and strict supervision during construction, plus preventive and corrective maintenance throughout the structure's service life, it is possible to reach an age of more than 100 years. However, whether modern buildings can match the longevity of Roman structures remains to be seen! ■



3D model of the Martín Gil viaduct, created using photogrammetry.

WHEN IT WAS BUILT, THE MARTÍN GIL VIADUCT ON THE ZAMORA-A CORUÑA LINE BOASTED THE WORLD'S LONGEST CONCRETE ARCH, MEASURING 192.4 METRES ACROSS THE CENTRAL SPAN



Ground plan and elevation of the reinforcement works for the viaduct over the River Miño in Ourense (AVE Madrid-Galicia).

## RESEARCH INTO "SMART" BRIDGES

Technological advancements have opened up new possibilities for structural inspection. Ineco, along with the universities of Córdoba and Granada, are part of the consortium for the Smart Bridges project, which over the next three years will explore how the maintenance of railway bridges can be improved using smart technologies. This was one of the projects selected during the call for applications organised by the State Research Agency, which reports to the Spanish Ministry of Science and Innovation.

At present, the methodologies for extending the service life of bridges via structural health monitoring (SHM) are still at an early stage of development. The project will explore the development and application of these SHM methodologies, including the use of smart sensors, achieving energy independence for the longterm monitoring system, and using data to make structural prognoses and maintenance-related decisions. In terms of use cases, a number of key railway bridges in Spain's high-speed network will be identified and their original designs compared to their current load scenarios, with a view to developing an SHM system. This will make it possible to improve the bridges' safety systems while reducing their operating and maintenance costs.

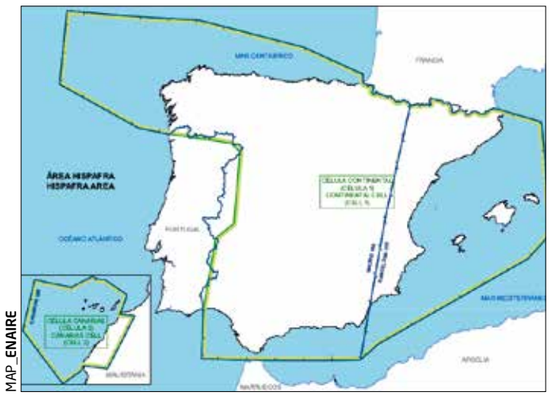
Crown wall of the Levante breakwater in the port of Málaga.

The Martín Gil viaduct.

# HISPAFRA: freedom in the air

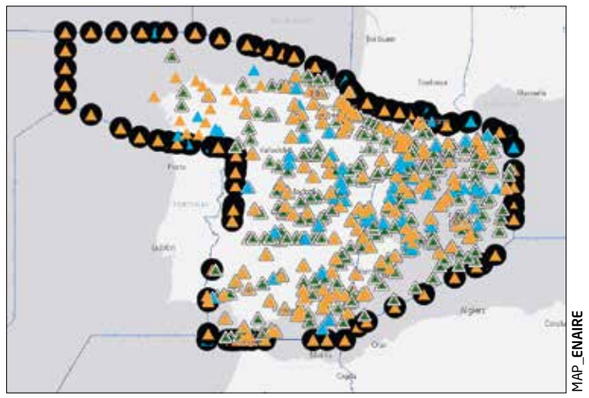
Ineco is participating in HISPAFRA, a project that aims to implement free route airspace within Spain. It is a nationwide project involving the General Directorate of Civil Aviation, the National Air Safety Agency, the Spanish Air Force and ENAIRE, in collaboration with EUROCONTROL.

**Pilar Calzón, Marta Gabaldón** and **Javier Luengo,** aeronautical engineers




MAP_ENAIRE

Area of application for the HISPAFRA project (free route airspace in Spain).



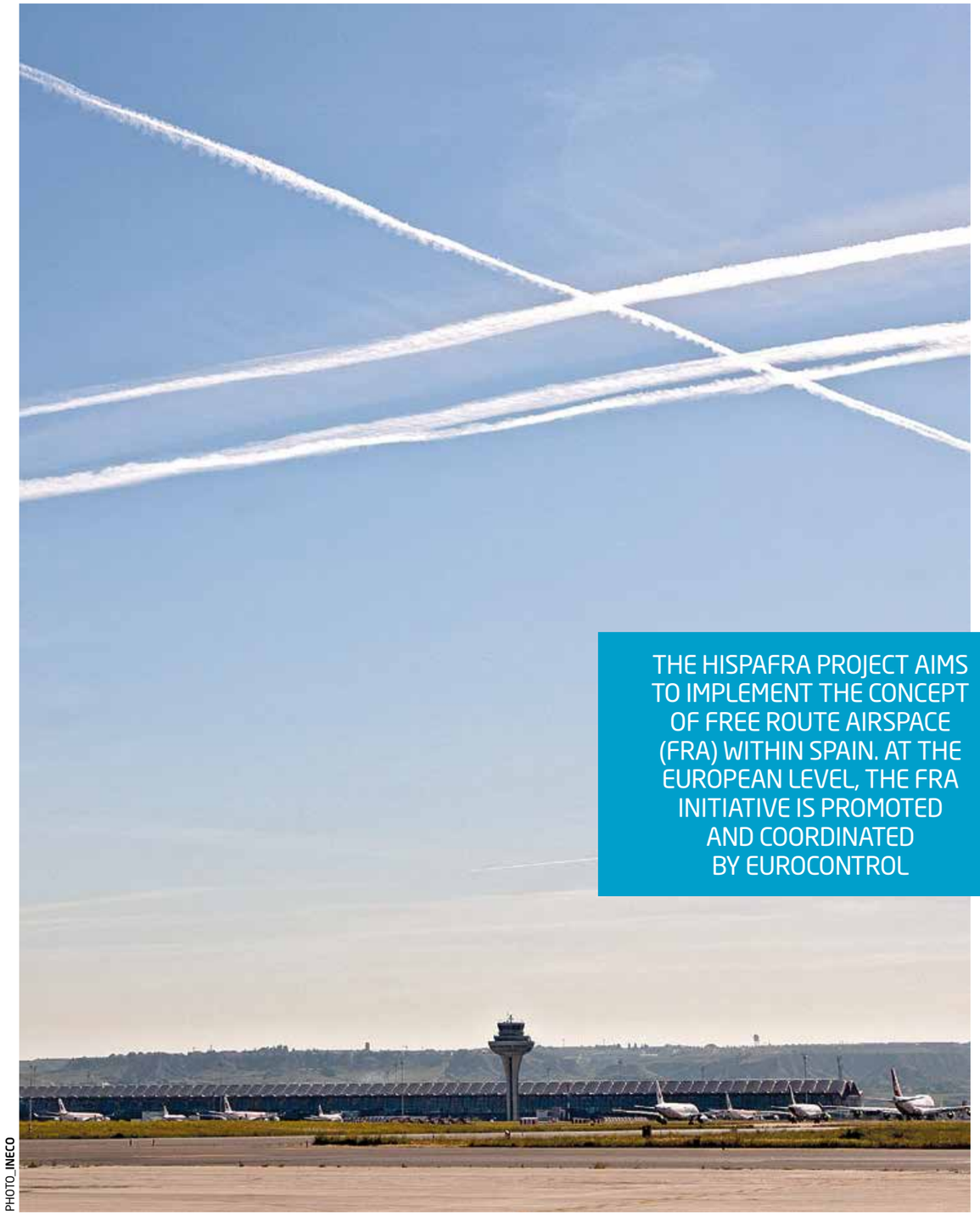
MAP_ENAIRE

Entry, exit and intermediate points in free route airspace.

The HISPAFRA project aims to implement the concept of free route airspace (FRA) within Spain. At the European level, the FRA initiative is promoted and coordinated by EUROCONTROL, in accordance with the stipulations of Commission Implementing Regulation (EU) 2021/116 of 1 February 2021. It is a nationwide project in which Ineco is supporting the ENAIRE Director of Operations and helping to coordinate all of the bodies involved, which include the General Directorate of Civil Aviation, the National Air Safety Agency, the Spanish Air Force and ENAIRE.

Until now, airlines and airspace users have defined their flight plans using a network of waypoints and segments published in aeronautical charts. The pre-pandemic growth in air traffic across Europe has meant that this network of segments and flight paths has become more expansive and complex. In turn, this has made it possible to manage air traffic within the capacity of the network without impacting negatively on safety.

Free route airspace is a concept in which airspace users are able to draw up flight plans in line with their companies' interests, and freely establish connections between waypoints within a particular volume of airspace without reference to the existing published routes. However, they must still adhere to certain rules with regard to connectivity between the waypoints in question. The concept can be compared to the experience of a driver at a junction with traffic lights and a junction with a roundabout: while the traffic lights oblige the driver to stop completely, at the roundabout the traffic flows more freely and the driver can choose where to exit, in accordance with certain pre-defined rules. Although the FRA concept does not imply the ab-



PHOTO_INECO

THE HISPAFRA PROJECT AIMS TO IMPLEMENT THE CONCEPT OF FREE ROUTE AIRSPACE (FRA) WITHIN SPAIN. AT THE EUROPEAN LEVEL, THE FRA INITIATIVE IS PROMOTED AND COORDINATED BY EUROCONTROL

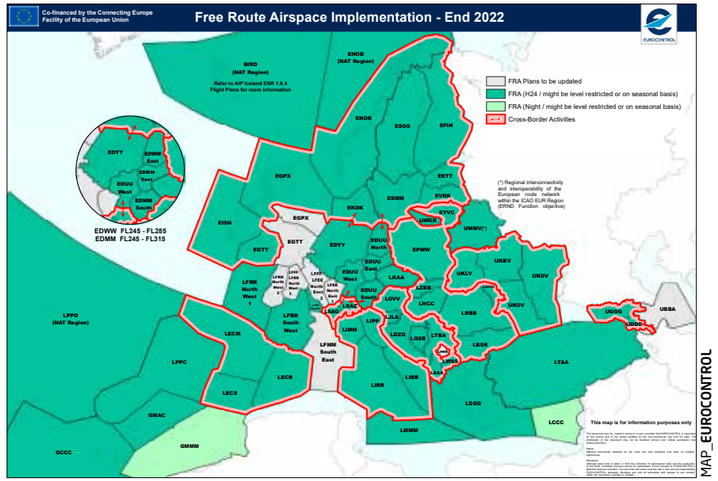
sence of rules, it does allow for greater dispersal of air traffic in comparison to structured airspace (thereby reducing "traffic jams") and offers users greater flexibility when planning the optimum route between waypoints within the airspace. In turn, this enables them to plan flights that are more efficient, flexible and environmentally sustainable.

However, the increased flexibility in flight planning offered by the FRA concept results in greater dispersal of flight routes and increased uncertainty as to where conflicts that require controllers to separate the aircraft may occur. For this reason, and when dealing with complex airspaces, the FRA concept explored by the SESAR (Single European Sky ATM Research) initiative recommends that user defined segments should be based on published waypoints in high complexity airspaces (although the routes free route segments themselves do not need to be published) and controllers should be supported with advanced conflict-detection tools, as the aircraft's whereabouts are no longer as predictable as they would be in structured airspace.

The FRA concept only applies during the flight plan stage, i.e. before the plane has left the ground. Once the flight plan has been submitted and approved, the flight becomes subject to that plan and to authorisation from air traffic control (ATC), which will continue to ensure that the aircraft remain separated from each other (as it does at present).

### THE PHASES OF HISPAFRA

The implementation of HISPAFRA has been divided into different phases: in each phase the restrictions become more flexible and new functionalities are incorporated into the control system, while maintaining appropriate levels of capacity and safety. The European regulations stipulate that the initial phase must be implemented before 31 December 2022 and the final stage by December 2025, along with a cross-border element involving at least one other Member State. After this date, rollout of the FRA concept will continue and there will be greater cross-border implementation between Member States, thereby enabling a more flexible European airspace and more efficient planning on the part of airlines.

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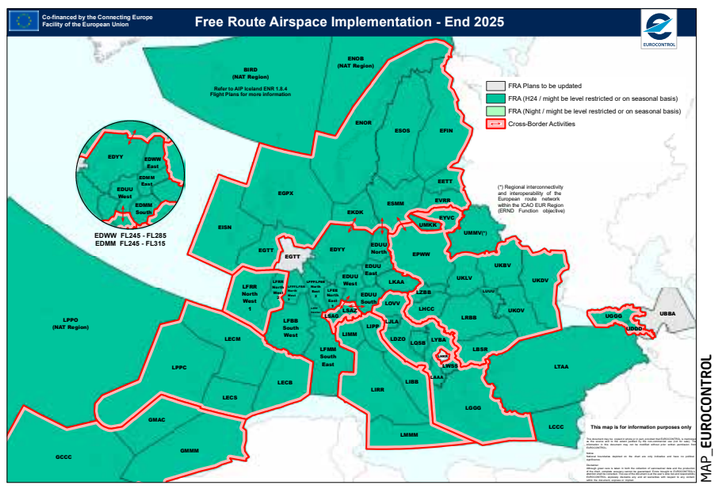



MAP_EUROCONTROL

**MAPS OF FREE ROUTE AIRSPACE IMPLEMENTATION, 2022-2025.** The European regulations stipulate that the initial phase must be implemented before 31 December 2022 and the final stage by December 2025, along with a cross-border element involving at least one other Member State. After this date, rollout of the FRA concept will continue and there will be greater cross-border implementation between Member States, thereby enabling a more flexible European airspace and more efficient planning on the part of airlines.

> ALTHOUGH THE FRA CONCEPT DOES NOT IMPLY THE ABSENCE OF RULES, IT DOES ALLOW FOR GREATER DISPERSAL OF AIR TRAFFIC IN COMPARISON TO STRUCTURED AIRSPACE, THEREBY REDUCING "TRAFFIC JAMS"

For phase 1 of HISPAFRA, two FRA cells have been defined: the continental cell, comprising the Iberian Peninsula and the Balearic Islands; and the Canary Islands cell. These cells will enter into force on 21 April 2022.

Existing published routes will not be eliminated during this initial phase; rather, airspace users will have the additional option of drawing up FRA plans that make use of these existing routes. This will enable the transition towards a free route approach for all, without changing the way in which ATC operates and with the aim of maintaining the same levels of capacity and safety, while enabling users to gradually adapt their systems in preparation for the subsequent phases.

Looking ahead to these subsequent phases, in which free connection between a greater number of waypoints will gradually become more flexible, ENAIRE is developing and deploying a series of new functionalities for its ATC system. These functionalities enable controllers to determine, ahead of time and with increased precision, whether a particular flight level or direct route presents an air traffic risk, prior to granting ATC clearance for separation provision. Examples of the tools available include Medium-Term Conflict Detection (MTCD) and Tactical Trajectory Management (TTM).

### MORE FLEXIBLE PLANNING

Collaboration has also begun on the study process for the subsequent phases of the HISPAFRA project. While still allowing airlines to prepare flight plans in structured airspace or FRA, and without making changes to the ATC system, the aim is to make the connection between certain FRA waypoints more flexible (whether within the same control centre or between different control centres) in comparison to existing structured routes, thereby gradually expanding the range of planning options available to users.

Over time, HISPAFRA will introduce more flexible planning options, while making changes to the ATC system in order to be able to detect conflicts. This will allow users greater flexibility, while maintaining appropriate levels of capacity and safety.

Finally, the project will introduce the possibility of eliminating restrictions with at least one neighbouring state (so-called 'cross-border FRA'), thereby enabling users to plan flights between different Member States as though they shared a single airspace. To achieve this, the ATC system for each Member State must have interoperability functionalities, adapted in line with the FRA concept.

Airspace is changing, and Ineco is at the forefront of these changes with a team of experts that are helping to define the FRA significant points, the FRA concept of operations, the ATC system requirements, and the implications these developments may have for the ATC procedures to keep safety at sustainable levels within the context of the increasingly air traffic demand. ■

### FREE ROUTE: A MORE SUSTAINABLE EUROPEAN SKY

Establishing a free route airspace offers a range of environmental, economic and operational benefits: according to EUROCONTROL, the implementation of free route operation throughout all of Europe would result in a saving of some 500,000 air miles, 3,000 tonnes of fuel and 10,000 tonnes of carbon dioxide per day, which would equate to monetary savings of around 3 million euros per day. It would also bring other benefits such as more stable routes, spatial dispersal of conflicts and a reduction in the workload of air traffic controllers thanks to a more flexible network.

PHOTO_PIQSELS.COM

### SUPPORTED BY INECO

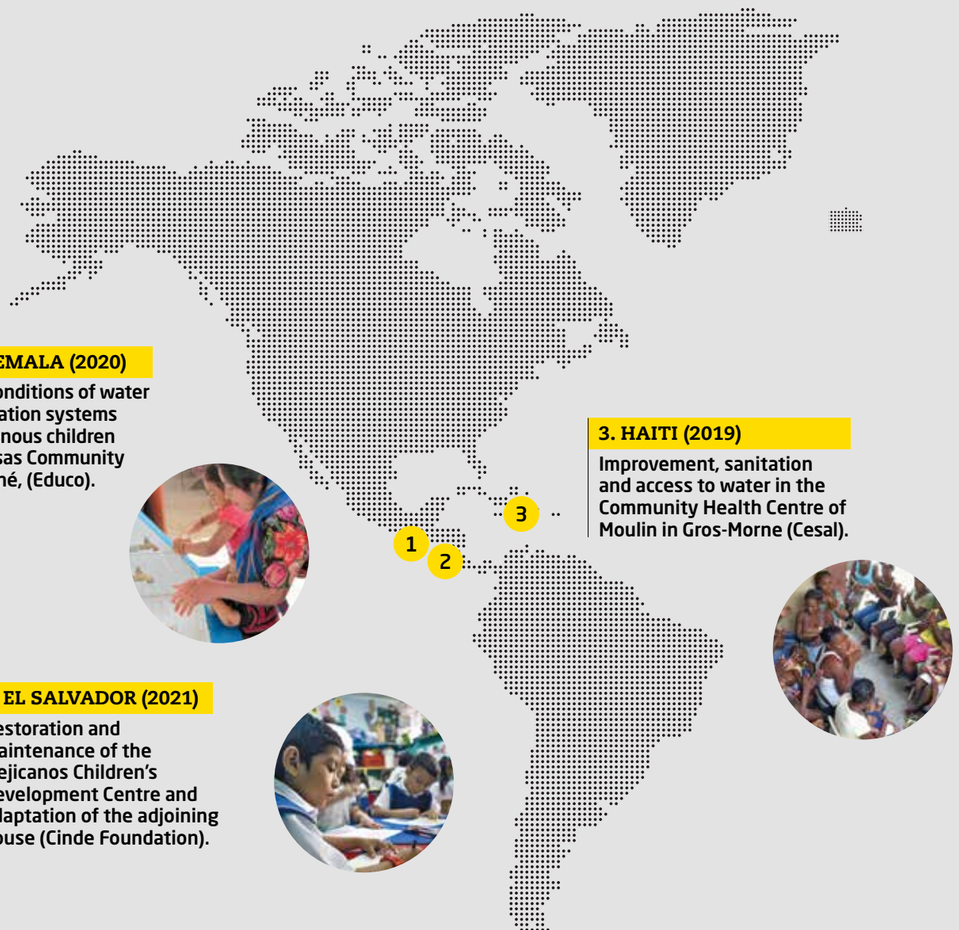
Since 2019, the company has helped ENAIRE to implement HISPAFRA by carrying out a range of actions:

- Publication of FRA information via AIP (Aeronautical Information Publication), in accordance with the implementation guides provided in EUROCONTROL's ERNIP (European Route Network Improvement Plan) and in coordination with all of the actors affected by the change.
- Collaboration with ENAIRE's Director of Operations on the development of tools for the automated transition (during this initial phase, owing to the large volume of data for the current structure) towards the definition of HISPAFRA points (in AIP Spain) and the rules governing the restrictions on flexible connection to these points, via direct entry in the Route Availability Document (RAD).
- Support for the changes introduced by the reviewers and the discoveries made during the pre-validation processes carried out on EUROCONTROL's systems, prior to the implementation of HISPAFRA.
- Support for the maintenance and updating of the operational concept for HISPAFRA, and attending (and preparing materials for) internal and external coordination meetings.
- Support for coordination with the ATC centres of neighbouring Member States, so that the internal operational documentation for ATC is in line with the operational concept for HISPAFRA.

# Willingness to serve

During the last three years, the Ineco *IngenioSOS* programme has developed, together with different NGOs accredited by the Lealtad Foundation, nine projects in different countries in Asia, Africa and America. The selfless contribution of 45 company professionals from different specialties has meant directly improve the lives of more than 44,000 people.

**África Jiménez,** deputy director of Institutional Relations and CSR




**1. GUATEMALA (2020)**

Worthy conditions of water and sanitation systems for indigenous children in Las Rosas Community in El Quiché, (Educo).



**2. EL SALVADOR (2021)**

Restoration and maintenance of the Mejicanos Children's Development Centre and adaptation of the adjoining house (Cinde Foundation).



**3. HAITI (2019)**

Improvement, sanitation and access to water in the Community Health Centre of Moulin in Gros-Morne (Cesal).



**4. CHAD (2021)**

Promotion of healthy learning spaces for children in the Guéra region (Entreculturas).

**5. SOUTH SOUDAN (2019)**

Refurbishment of the maternity and paediatric ward at Bor Hospital (Doctors of the World).

**6. D R OF THE CONGO (2021)**

Solar energy for the General Reference Hospital of Kanzenze (Democratic Republic of the Congo), (Recover Foundation).

**7. KENIA (2020)**

Design and implementation of an online coordination and monitoring system for work with female genital mutilation (FGM) clubs and schools (Kirira Foundation).


**8. ETHIOPIA (2020)**

Energy supply of the Meki maternal and child clinic (Pablo Horstmann Foundation).



**9. INDIA (2019)**

Construction of a community centre in Rascola (ITWILLBE).

By the year 2000, there were fewer than 100 Iberian lynxes left, and the species was considered virtually extinct. However, the latest data in May 2021 revealed a population of over 1,100 animals.

PHOTO_KONRADS BILDERWERKSTATT (FLICKR)

# Back from the brink

Paleontological remains indicate that one and a half million years ago, the Iberian lynx roamed throughout the Iberian Peninsula. However, little by little its territory was reduced to a handful of scattered areas in Extremadura, southern Portugal and Andalusia. The *Lynx pardinus* is an endemic species that typically inhabits the Mediterranean forest environment and is one of the world's four lynx species, along with the Eurasian lynx *(Lynx lynx)*, found in northern Europe and much of Asia; the Canada lynx *(Lynx canadensis)*, found in North America; and the bobcat or red lynx *(Lynx rufus)*, found in southern Canada, the USA and northern Mexico.

They are all classified as 'Least Concern' by the International Union for Conservation of Nature (IUCN) with the exception of the Iberian lynx, which suffered a drastic fall in numbers from the 1960s onwards and especially during the 1980s and 1990s. Moreover, the sparse historical records indicate that the population was not particularly large to begin with. This was the conclusion reached by the first experts who called attention to the species' plight, as a result of which it was declared "Critically Endangered" in 1986. By the turn of the 21st century there were less than 100 individuals and the species was considered all but disappeared.

However, the Spanish central government and regional administrations, along with the Portuguese government and various public and private organisations, institutions and NGOs, were able to join forces and respond. 1999 saw the approval of the National Strategy for the Iberian Lynx, based on the creation of *ex situ* captive breeding centres to produce animals that could subsequently be released into the wild. The first such centre, El Acebuche, was opened in 1992 in Doñana National Park. At present there are five of these centres: three in Andalusia (El Acebuche, La Olivilla in Jaén and the Zoobotánico in Jerez de la Frontera), one in Extremadura (Zarza de Granadilla, in Cáceres) and another in Portugal (Centro de Silves).

At the same time, action was taken to protect and restore the Mediterranean forest environment and rabbit populations. This latter species, which is currently the focus of another recovery programme (LIFE Iberconejo), is a vital food source not only for lynx but also for around 40 other species, including the Spanish imperial eagle (also threatened).

In addition to the organisational difficulties, there were also scientific challenges arising from the conservation of such a small –and therefore genetically limited– population. The European LIFE programme provided over half of the funding for successive projects which, two decades later, achieved a miracle.

The *ex situ* programme has led to the formation of 12 lynx populations in the Spanish autonomous communities of Andalusia, Castilla La Mancha and Extremadura, plus another two in Portugal. In 2020, the symbolic figure of 1,000 individuals was exceeded following a record number of births, while the latest data in May 2021 revealed a population of over 1,100 animals.

The next target is outlined in the Lynx-Connect project, which has been approved by the European Commission and will run until 2024. The aim is to link up these population centres safely while combating poaching, illegal hunting and the risk of vehicular injury, which has caused the death of at least 150 of these precious animals since 2002. Facilitating the natural mobility of lynxes will make it possible to unify the population and increase genetic diversity, which is key to saving the species. In 2019, the experts in the Lynx Working Group calculated that this will only be possible (and even then, the species would remain vulnerable) if by 2040 the current population has tripled to between 3,000 and 3,500 individuals, of which around 750 must be breeding females. ■

> Twenty years ago, there were barely 100 individuals left, but thanks to conservation efforts the wild population of the Iberian lynx has now grown to 1,100. Although it remains at risk of extinction, the growth of its small population –along with those of the bearded vulture, imperial eagle, Cantabrian brown bear and Iberian wolf– is an encouraging outcome of the efforts to conserve the wildlife of Spain and Portugal.
>
> ***ITRANSPORTE***

## HOPE FOR IBERIAN WILDLIFE

Over the last 25 years, Spain –which is home to more than 85,000 species of animals, plants and fungi– has managed to save its so-called "big five" endemic species from extinction (although they remain vulnerable): the Iberian lynx, brown bear, imperial eagle, bearded vulture and Iberian wolf.

▶ The example of the **bearded vulture** *(Gypaetus barbatus)* is similar to that of the lynx: 25 years ago there were just 30 breeding pairs of this enormous carrion-feeder, whose wingspan can exceed three metres. Today, it has a population in excess of 1,000 and can be found in the southern Pyrenees, the Sierra de Moncayo in Aragón and the Sierra de Cazorla in Jaén (Andalusia), which is home to at least five pairs. It has also been reintroduced to the Picos de Europa, and there are plans to bring the species back to the Sierra de Gredos (Ávila) in 2022.

▶ The **Spanish imperial eagle** *(Aquila adalberti)* is considered one of the world's most threatened birds of prey. By the late 1970s there were fewer than 50 breeding pairs left; however, that figure has since grown to more than 600.

▶ Another success story is the **Cantabrian brown bear** *(Ursus arctos pyrenaicus)*. Two decades ago there were barely 50 individuals left in the wild; now there are 330, mostly found in western Asturias, with another 30 in northern León, Palencia and southern Cantabria and a number of others in the Pyrenees of Huesca and Catalonia.

▶ With regard to the **Iberian wolf** *(Canis lupus signatus)*, there are estimated to be around 300 packs, together accounting for 2,000-2,500 individuals. Practically extinct in southern Spain, 95% of its population is concentrated in Asturias, Cantabria, Galicia and Castilla y León, where numbers have recovered since the 1990s. The species is now expanding north of the River Duero. As its territories are shared with human activities such as livestock farming, the wolf's conservation is controversial and requires not only protective measures (in early 2021 the government added it to the List of Wild Species Subject to Special Protection, effectively imposing a hunting ban) but also support for the activities affected: in 2020 alone, for example, around 2,600 farm animals were lost through attacks by wolves. Conservation organisations such as the WWF campaign for coexistence and recommend compensatory and preventive measures, such as rapid payments for farmers in the event of attacks, the use of electrified fences and mastiff dogs, the reintroduction of shepherds and the promotion of extensive livestock farming, among others.

BEARDED VULTURE

PHOTO_F. QUEBRANTAHUESOS

SPANISH IMPERIAL EAGLE

PHOTO_CAM

CANTABRIAN BROWN BEAR

PHOTO_NEUSITAS (WIKIPEDIA)

IBERIAN WOLF

PHOTO_SUSO MARTÍN (CENTRO DEL LOBO IBÉRICO)

IBERIAN LYNX

PHOTO_FRANK VASSEN (FLICKR)

## PORTRAIT OF A NATURAL TREASURE

The Iberian lynx is the smallest of the four lynx species, with an average weight of around 14 kilos. It is a solitary animal that is usually active at dusk and is characterised by its tufted ears and ruff, along with its spotted coat, whose patterns are unique to each individual. From an ecological perspective, its role as an apex predator at the top of the food chain also makes it an "umbrella species", as it controls the numbers of smaller predator species and reduces the pressure on the main prey species, the European rabbit, which is also the main food source for other species such as the Spanish imperial eagle. The Iberian lynx has gone from being a virtually unknown species to a national symbol of conservation, a magnet for nature tourism, and an international success story that has been hailed by the IUCN and awoken interest in conservation programmes for other threatened feline species, such as the snow leopard (India, Mongolia) and the Florida panther (USA).

# Towards a more inclusive design

Ineco's Architecture with a Gender Perspective team is made up of specialised technicians who, in addition to drafting projects, standardise design criteria from a gender perspective, centralising knowledge and transferring this information to ensure equal opportunities.

The members of the Architecture with a Gender Perspective team are responsible for incorporating concepts and visions into the design of transport infrastructures that meet all social needs. In the picture, Pablo Galán, Aixa Márquez, Antonio Sancho and Raquel Alonso.

PHOTO_ELVIRA VILA (INECO)

> "Our ultimate goal is achieving a 100% accesible infrastructures for a 100% of the users"
>
> ANTONIO SANCHO,
> Building project manager

Architecture and urban planning with a gender perspective aim to build inclusive and egalitarian spaces, taking into consideration the diversity of the people who use public space and focusing on the tasks or needs traditionally linked to women. Both disciplines are envisaged as a service to society. Thus, its purpose is to achieve that the needs of the different social groups are taken into account when planning urban space, housing and environmental quality. Ineco, which integrates these objectives in the company's CSR, has promoted the development of a team of specialists to apply the concepts of gender architecture in the projects that require it, in addition to integrating the knowledge and promote collaboration with other disciplines. ■

## CORE PRINCIPLES

1 **ORIENTATION.** KNOWING WHERE YOU ARE AND HOW TO GET WHERE YOU WANT TO GO.

2 **VISIBILITY.** OPEN SPACES, WITHOUT RECESSES OR HIDING PLACES, THAT ALLOW US BOTH TO SEE AND TO BE SEEN.

3 **VITALITY.** THE MIX OF USES WITHIN A SPACE ALLOWS IT TO BE PERMANENTLY INHABITED, MEANING THAT IT WILL BE PERMANENTLY 'MONITORED'.

4 **SURVEILLANCE.** FORMAL SECURITY.

5 **MAINTENANCE.** SPACES AND FACILITIES MUST BE CORRECTLY PRESERVED AND HAVE A PROPER MAINTENANCE.



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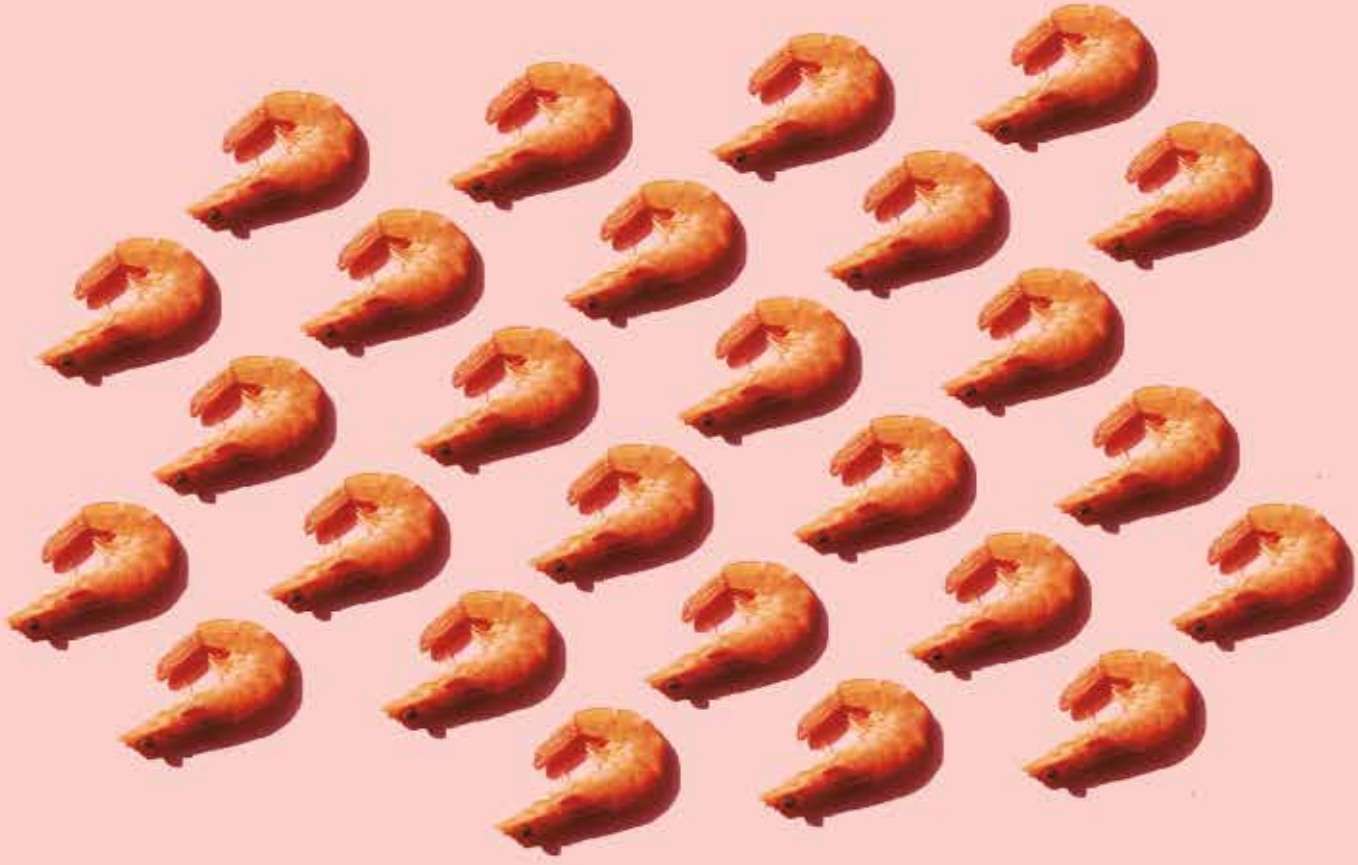

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