



SOLETANCHE FREYSSINET

# ACTIVITY REPORT

2016



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# 2016 ACTIVITY REPORT



SOLETANCHE BACHY



MENARD



TERRE ARMEE



FREYSSINET



NUVIA



SIXENSE



# **THE SOLETANCHE FREYSSINET GROUP**

Key figures  
Locations  
Governance  
Editorial  
Round Table



# **SOLETANCHE BACHY**



# **MENARD**



# **TERRE ARMÉE**



# **FREYSSINET**



# **NUVIA**



# **SIXENSE**



# SOLE- TANCHE FREYSS- SINET

## **Soletanche Freyssinet is world leader in soil, structural and nuclear engineering**

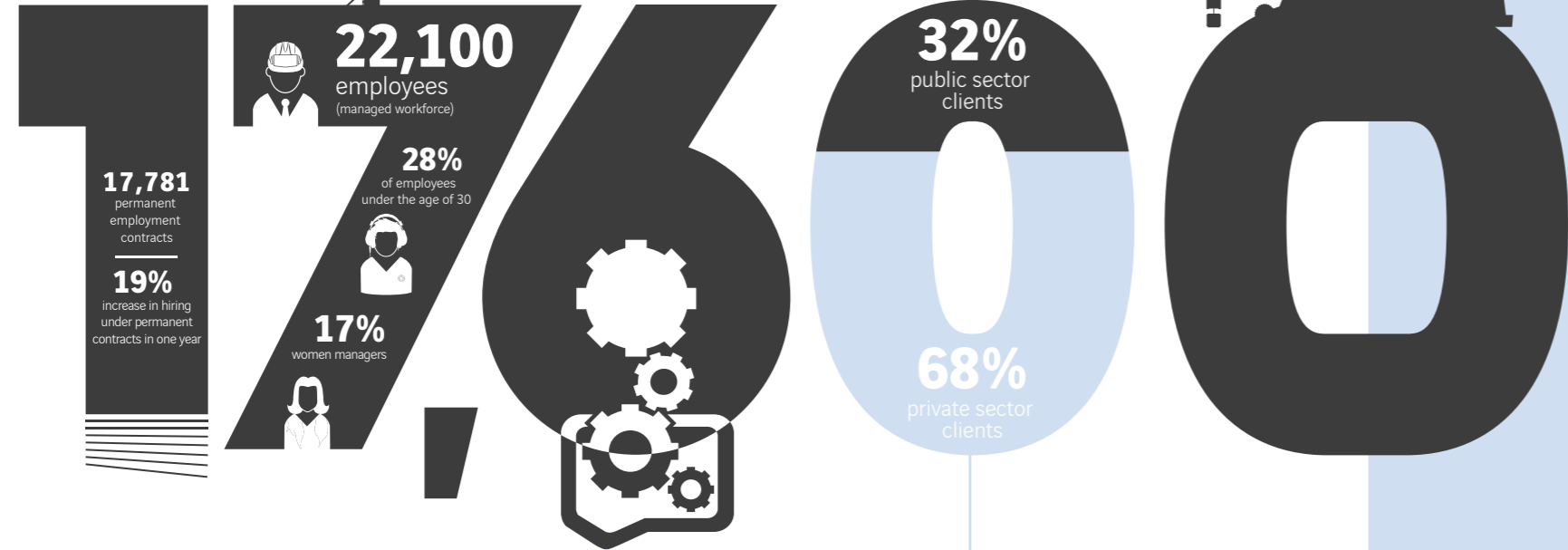
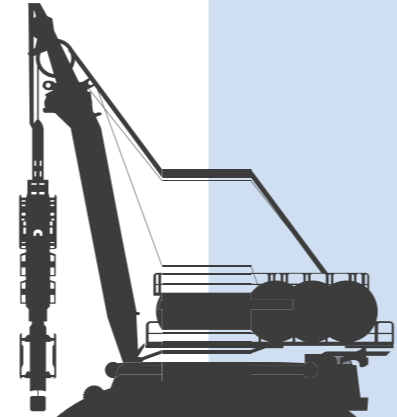
The Group brings together an unparalleled array of construction and engineering expertise. Soletanche Bachy, Menard, Terre Armée, Freyssinet, Nuvia and Sixense provide technical excellence to ensure structure performance and sustainability.

**KEY FIGURES**

**Projects:**



**57%** of the revenue of subsidiaries with environmental reporting was ISO 14001 certified at the end of 2016\*



**SAFETY, AN ABSOLUTE PRIORITY**

**5.1** Frequency Rate  
(number of lost time workplace accidents x 1,000,000/number of hours worked)



**0.22** Severity Rate  
(number of days of lost time due to workplace accidents x 1,000/number of hours worked)

**1,200 partners and subcontractors participated in 2016 International Safety Week**

**53%** of training hours dedicated to HSE topics

**SOLETANCHE BACHY  
MENARD  
TERRE ARMÉE  
FREYSSINET  
NUVIA  
SIXENSE\*\***

**An international group**

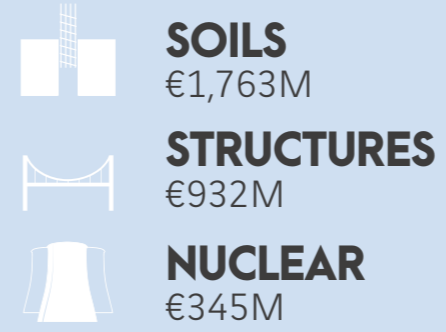
Locations in 80 countries    Operations in 120 countries    100 nationalities



**Revenue:**



REVENUE by business segment



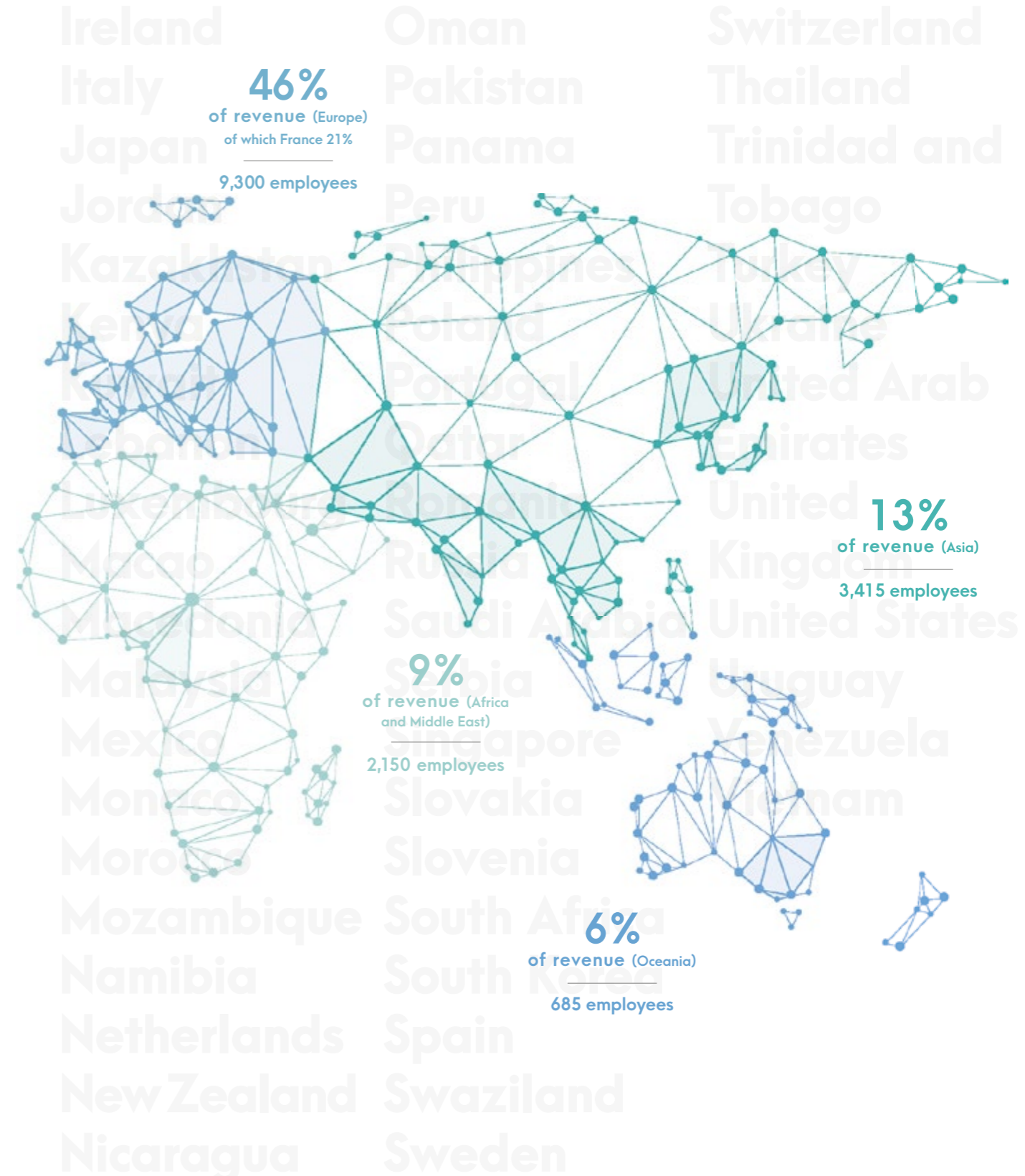
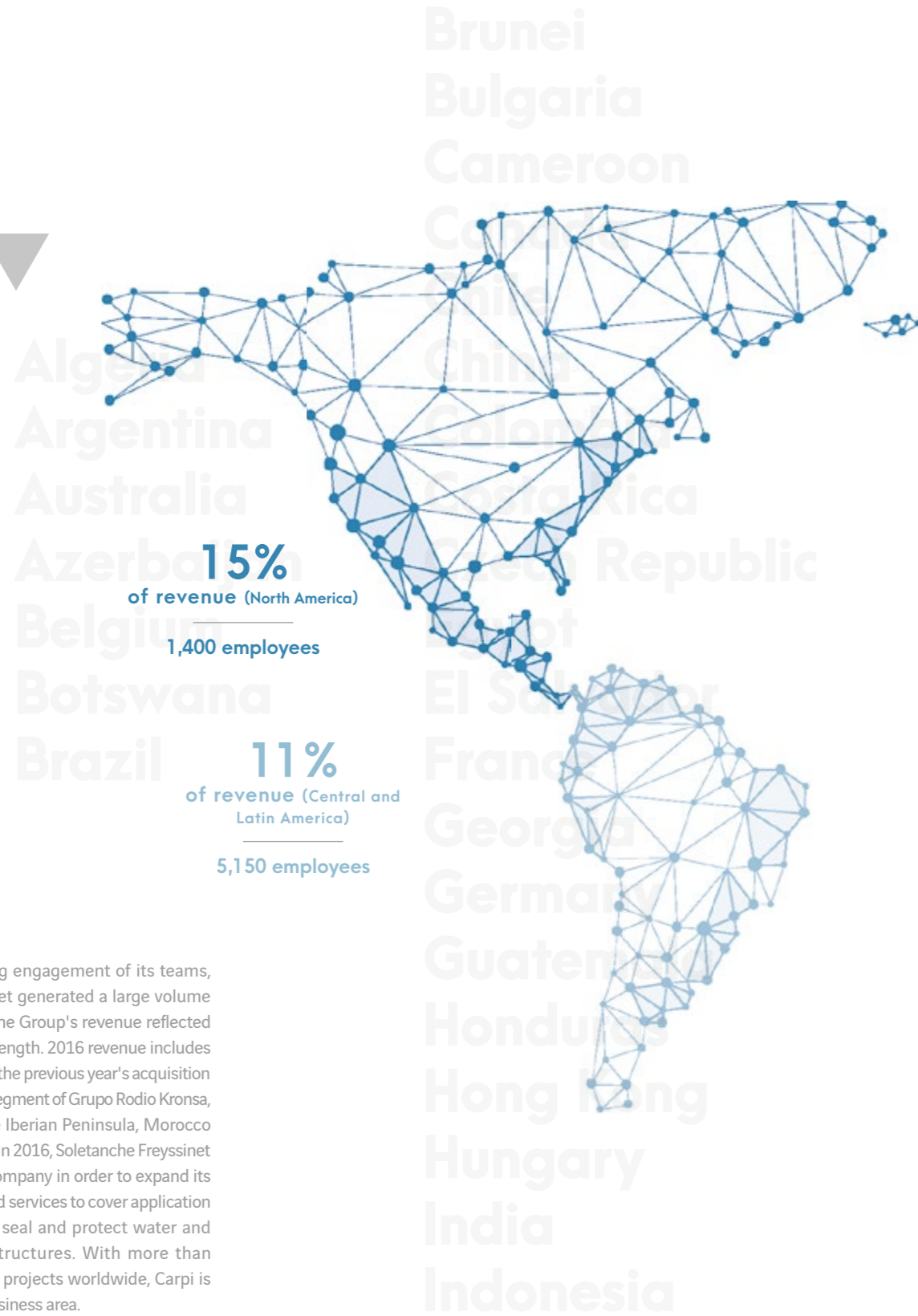
**TRAINED AND SPECIALISED TEAMS**  
**31%** of training hours dedicated to technical courses



**INNOVATION, DRIVING COMPETITIVENESS**  
**3,100** patents

\* Environmental Management System standard  
\*\* The 2016 revenue of Sixense entities is included in their respective original business areas

# LOCATIONS



## Expansion

Thanks to the strong engagement of its teams, Soletanche Freyssinet generated a large volume of activity in 2016. The Group's revenue reflected its steadiness and strength. 2016 revenue includes the full-year effect of the previous year's acquisition in the soils business segment of Grupo Rodio Kronsa, with locations in the Iberian Peninsula, Morocco and Central America. In 2016, Soletanche Freyssinet acquired the Carpi company in order to expand its range of solutions and services to cover application of geosynthetics to seal and protect water and civil engineering structures. With more than 1,300 waterproofing projects worldwide, Carpi is world leader in its business area.



**1 - ROGER BLOOMFIELD**  
Chief Executive Officer, Terre Armée

**2 - JEAN-PHILIPPE RENARD**  
Executive Vice President,  
Soletanche Bachy

**3 - MARC LACAZEDIEU**  
Chief Executive Officer, Menard

**4 - PATRICK NAGLE**  
Chief Executive Officer, Freyssinet

**5 - DIDIER VERROUIL**  
Executive Vice President,  
Soletanche Freyssinet  
Chief Executive Officer, Soletanche Bachy

**6 - BRUNO LANCIA**  
Chief Executive Officer, Nuvia  
Chief Executive Officer, Sixense

**7 - MARINE d'ANTERROCHES**  
Communications Director,  
Soletanche Freyssinet

**8 - PIERRE-YVES BIGOT**  
Human Resources Director,  
Soletanche Freyssinet

**9 - MANUEL PELTIER**  
Chairman and Chief Executive,  
Soletanche Freyssinet

**10 - MARK DEARY**  
Chief Financial Officer,  
Soletanche Freyssinet

**11 - LORENZO ALESSI**  
Quality, Safety, Environmental Director,  
Soletanche Freyssinet



## EDITORIAL



# A TALK WITH MANUEL PELTIER CHAIRMAN & CHIEF EXECUTIVE, SOLETANCHE FREYSSINET

**Soletanche Freyssinet's activity was particularly buoyant in 2016.**

**What conclusions do you draw from this performance?**

*With revenue coming in at just over €3 billion, the Group's volume held steady at its highest ever level. The slight decline from 2015 was primarily due to exchange rate differences and shifts in the schedules of several major projects. At the same time, order intake was very strong. We contracted a record €3.4 billion in new business in 2016. These results reflect the strength of our Group and our business model, which is rooted in both major operations and the smaller-scale projects regularly carried out by our companies operating close to our clients. We offer a one-of-a-kind commitment to every project: meeting our clients' requirements and delivering quality of service, operational excellence and risk control safely and on time.*

**How do you account for the Group's strength?**

*At a time of growing demand for our specialist expertise, Soletanche Freyssinet's six brands offer an unparalleled array of skills that meet the construction industry's current and future needs. Our extensive international coverage based on our network of some 270 subsidiaries softens the impact of economic crises. In 2016, when the sharp decline in oil and commodity prices slowed or halted a large number of industrial investment projects in Australia, Canada and Latin America, our activity held steady in the rest of the world. Our strength is also due to the composition of our project portfolio. In Mexico,*

*for example, where public sector infrastructure investments have been sharply cut back, our subsidiaries have compensated by shifting to the private high-rise building sector, for which we construct the foundations, and by expanding our structural repair business. There are huge requirements in the urban development, transport, water, energy and environmental sectors. We will continue to work on expanding the scope of our technical solutions and innovative services.*

**What can be done to foster innovation?**

*First you have to move beyond the conventional idea: "We must innovate to grow, to create value, to keep our competitive edge". Innovation is an integral part of our history. The companies that make up Soletanche Freyssinet were built from the start on exceptional technical innovations that have since become standard in their respective fields all over the world and have driven pivotal progress in the art of building. We are of course imbued with this culture and will continue to enrich it. Innovation often involves inventing new solutions to address new issues. I am confident, for example, that the Grand Paris Express programme in France will be an excellent case in point. To build underground metro stations (some of which are as big as underground cathedrals) in very difficult ground, we will need to use state-of-the-art geotechnical capabilities. More generally we create momentum in our R&D work by broadening and fostering collective intelligence to help spawn new ideas and share them across all our business activities.*

**Is collective intelligence the key to the digital revolution?**

*It is an important aspect. In our work within our Group and with our partners, digital tools facilitate more collaborative working methods, promote the flow of information in real time and*

*shorten the decision-making process. They also enable us to massively mobilise our teams to work on training or innovation issues and make the most of the scope and diversity of our human resources. The digital revolution also paves the way for new client services. Sensor technologies have progressed to the point where they can now collect very large amounts of data from instrumented soils, structures and machines. We can analyse the data to optimise structure design and construction methods, with the clear-cut goal of reducing overall cost. These are matters of importance in the construction industry and we are making sure we keep pace with the digital revolution. We have therefore set up a new business line, which we have called Sixense, to deliver monitoring and decision solutions for use across the entire life cycle of a structure. It builds on three capabilities: engineering, technologies and digital services. Sixense will be our main way of providing our partners with the efficient tools and services that enable the construction industry to take advantage of digital technologies. It is one way we can boost innovation to serve our business activities and our clients, and pave the way for the world of the future.*

“  
Fostering  
collective  
intelligence  
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SHARING  
NEW  
IDEAS

→ **Conversations**

Soletanche Freyssinet has always promoted entrepreneurship. The teams, and more particularly the young employees, are encouraged to come forward with their ideas and to take on responsibility. To discuss the Group's strategic goals, Manuel Peltier held a round table conversation with a number of them, who shared their experience in the field and the successes achieved in 2016. The round table also helped cultivate and foster initiative. These conversations bear witness to Soletanche Freyssinet's trademark momentum as an international Group building on its strong local roots, its outstanding experts and the values that bind them together.

**HUMAN RESOURCES:**  
SUPPORTING GROWTH



**JEAN-ROCH LUCAS - Freyssinet**  
Project Manager in Hong Kong

*Jean-Roch Lucas:* Over the past ten years, the Group has stepped up its international expansion. The profiles of its employees and the approach taken by its expatriate staff have changed. Today's young employees are more focused on projects and challenges than on careers. At Soletanche Freyssinet, there are many opportunities to move within the six entities. How does the Group facilitate and orchestrate mobility?

*Manuel Peltier:* Soletanche Freyssinet takes advantage of its economic strength and business diversity to offer its employees stimulating career prospects, varied assignments and a chance to expand their skills. Most of our managers follow this path, which we have now taken to a new level by reinforcing international mobility. The Group fosters in-house mobility by creating ways for employees to move between businesses and geographical areas. We do this by listening to employees during annual interviews and by conducting personnel reviews

for each function and business line. These enable us to collectively plan for the future of our employees and organisations.

*Alexandre Beauvilain:* The Group often gives young people opportunities to take on greater autonomy and responsibility. I worked for five years in Paris, where I had the technical and administrative support of the nearby head office. I kept this close and valued relationship going when I arrived in Perth for my first Australian project. To facilitate induction and help us acquire the knowledge we need for our assignments, what do you think of the idea of setting up a long-term mentoring system in which a young manager would have the support of a more experienced employee who could help with technical and project management issues?

*M. P.:* That is something we are going to experiment with, because the important thing, as you say, is to ensure that experience is shared and transmitted. Because our entities are geographically scattered, we need to disseminate know-how and feedback as fast and as broadly as possible. In addition, Soletanche Freyssinet has continued its training efforts. The Group supports works management by providing a standard project management training course to share our safety, quality and project profitability standards. Indeed, there are several modules to support employees at the different stages of their careers, including PM+ (Project Management+), which has been given to more than 700 trainees from nearly 40 countries. In 2016, we worked with ESSEC (a large French business school) to develop training for our subsidiary managers. In France and in other countries,

Thumbnail →

/// With international medical assistance for all employees on long or short term expatriate assignment and an international labour accommodation and welfare standards guide for foreign employees on a site, **Soletanche Freyssinet** continues to introduce its essentials. **///** Nearly 300 **Soletanche Bachy** employees received the Verticality, Joints, Mud, Concrete and Concreting rules training for which two engineers from the Materials Laboratory were temporarily seconded in the Asia Pacific region and in Latin America in 2016. Training →

## Soletanche Freyssinet's range of training programmes is worth its weight in gold

Freyssinet and Soletanche Bachy have stepped up the rollout of the Orchestra training course, as has Terre Armée in engineering. Nuvia has also set up the Nuvia Academy, which provides a broad, structured range of training programmes covering project management in general and the Nuvia project management system in particular. It is available to middle managers, site managers and project managers, who can add modules covering law, sales and marketing, and safety. Lastly, in 2016, we continued to develop training in the field, which is provided by roving instructors who go to each country.

**A.B.:** I took PM+ training in Pittsburgh with engineers from Nicholson, one of Soletanche Bachy's American subsidiaries, and I think that this range of training programmes is worth its weight in gold. They give meaning to the work we are doing together and they expand our network within our international Group. The Engineering and Young Managers seminars and the seminar organised by the Soletanche Bachy Major Projects division, which brings together expatriate staff from around the world at the end of the year, provide opportunities to get together and get to know each other.

**J.-R.L.:** By the same token, Freyssinet continued its STEP (Share – Together – Enjoy – Prospective) meetings, which are informal get-togethers where the CEO meets with 10 young managers between the ages of 30 and 35, with at least five years seniority. The STEP system, which lets them to get to know each other and share new ideas, has been



**ALEXANDRE BEAUVILAIN - Soletanche Bachy**  
Project manager in Sydney, Australia

rolled out in Europe. In another innovative move, groups spawned by the STEP meetings were asked to do a one-month study on a prospective topic. They reported back and shared their work with top management at a seminar held in London in April 2016.

**M.P.:** The foremost asset of our six brands is our people. We need to use this asset to generate collective intelligence. Every project must be developed under the best possible conditions. We are here to serve our clients, our projects and our teams and to deliver added value in an environment based on mutual trust. In a move to keep pace with growth, Soletanche Freyssinet made skills development and recruitment a priority in 2016. We created our sixth brand, Sixense, which enabled us to recruit people at the cutting edge of digital technologies. In another example in France, Soletanche Bachy set up Generation Grand Paris, a special



recruitment programme aimed at preparing the Group for the expected increase in activity in the Greater Paris area with the development of the Grand Paris regional transport system (see page 29). In a tight labour market that reflects the entire industry's need

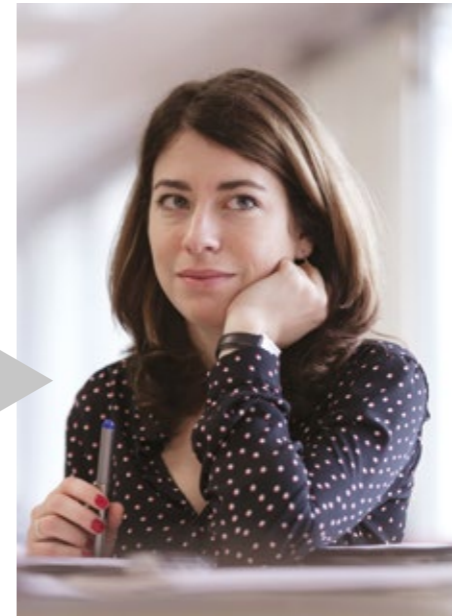
to prepare for these projects, we anticipated and broadened our sources of recruitment. We reached out to local and regional stakeholders in the areas concerned and gave presentations and organised site visits to explain our operations to job-seekers without prior experience in our business activities. We held recruitment sessions to bring in people with different backgrounds and put together a special training course for them that emphasises workplace health and safety. Meanwhile, the company invested in developing a simulator to train people in excavating operations. Clearly, the construction sector offers job prospects going forward.

was given to disseminate the fundamentals of our activities.

/// On 9 December 2016, Nuvia signed a partnership in Saclay with the French national institute for nuclear science and technology (INSTN). The purpose of the partnership is to develop common strategies for recruitment and highly specialised training of people to work in the nuclear industry in France and abroad.

/// Since the STEP meetings were introduced, 55 managers have shared their ideas for development with Freyssinet's Chief Executive Officer.

## DIVERSIFICATION: EXPANDING OUR ASSETS



**ANNE-CÉCILE GASS - Terre Armée**  
Business Development Manager in Rueil-Malmaison, France

**Anne-Cécile Gass:** There is an old saying that sums up diversification: "Don't put all your eggs in one basket". Terre Armée, which has generated nearly 80% of its revenue in road and motorway construction for more than half a century, needs to step up its expansion into other

markets, with a focus on railways, mining, port and coastal infrastructure, airports and natural hazard protection works. Is Soletanche Freyssinet also pursuing diversification as a strategic objective?

**M.P.:** Because our techniques can often be applied in several different activity sectors, diversification is a natural way for our companies to expand. We do this by skilfully combining the technologies of our entities. For example, the Menard and Terre Armée teams have carried out joint projects using Menard's Controlled Modulus Column (CMC) ground improvement technique together with Terre Armée's Reinforced Earth® walls and backfill. Synergies between our various business activities are a powerful diversification driver and enable us to gain new markets.

**A.-C. G.:** Terre Armée sales, technical and operations teams won a contract for the South Europe-Atlantic Tours-Bordeaux High-Speed Line (SEA HSL) project, which is another good example of diversification, by making a convincing case that their solution met the stringent technical standards that apply to high-speed railway lines (see page 49). We are also stepping up our activities in protection against natural hazards. From avalanche barriers in Chile and Iceland to landslide prevention, rockfall protection and erosion protection structures, Reinforced Earth® is used to protect people and infrastructure. In India, a highly competitive market, Reinforced Earth India teams developed a one-of-a-kind, innovative technical package combining Reinforced Earth®, the TerraLink™ system and other techniques used to resolve slope and embankment stability issues. This comprehensive solution gives our clients substantial added value and gives us a competitive edge. →

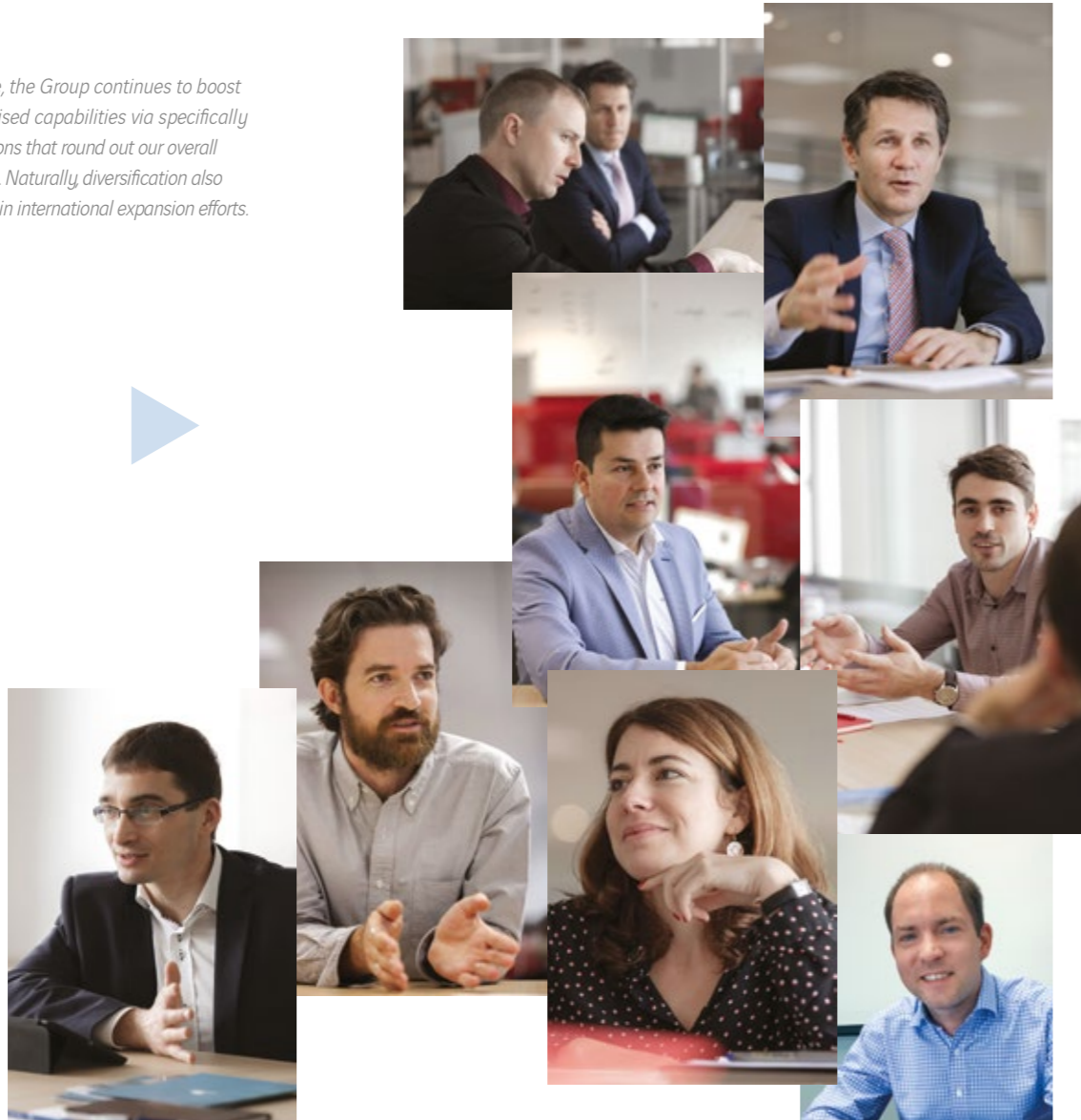


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/// Sixense continues to diversify the use of its Geoscope platform in the mining sector. It has been used for several years, especially in tunnel construction. Large mining groups install multiple monitoring sensors at their sites, and the Sixense solution offers them a comprehensive, consistent, precise and real-time overview.

/// In 2016, Nuvia continued its diversification initiatives, notably in science and research. With its partners Airbus Safran Launchers →

*M. P.: Meanwhile, the Group continues to boost its highly specialised capabilities via specifically targeted acquisitions that round out our overall range of expertise. Naturally, diversification also involves investing in international expansion efforts.*



## PRODUCTS & SERVICES: OFFERING CUSTOMISED SOLUTIONS



**TOBIAS GUSTAVSSON - Nuvia**  
Director of Nuvia Nordic AB in Norrköping, Sweden

*For example, we are broadening the radiation protection business to increasingly include the medical sector (radiotherapy facilities for use in cancer treatment, etc.).*

*M. P.: Nuvia is developing a unique range of products and vertically-integrated solutions. Within Soletanche Freyssinet, the combined engineering, products and services model is the driving force underpinning our offers.*

*T. G.: Yes, comprehensive expertise gives us an edge over our competitors, who are often specialised in a single technology or service. We come up with the solution that best meets our clients' needs while systematically focusing on responsiveness and service.*

*M. P.: In the future, we will continue to build on our strong engineering capabilities to design solutions and services increasingly tailored to our clients' requirements. Whenever possible, for example, we offer contractual solutions such as Early Contractor Involvement (ECI) or partnering, because such contracts enable us to be involved in the project very early on and to involve the client in all the important choices during the design phase, while shortening lead times and reducing project costs. We have*

*many such arrangements in the United Kingdom in areas such as decommissioning, where the project parameters are not totally known at the start. The partnership approach will spread and we are fully prepared to adopt it.*

“  
**A unique range  
of products  
and vertically-  
integrated  
solutions**  
”

*Tobias Gustavsson: We are working in a different country and a different sector, but we have the same goals in terms of diversification. Nuvia Nordic AB operates in the nuclear sector with clients such as EDF-Cyclife and Vattenfall. We are specialists in consulting in engineering, mechanics and operational radiation protection, but we have widened our offer in the fields of decommissioning and waste characterisation in response to market changes and in line with the entire Nuvia Group's move to diversify beyond our decommissioning and New Build operations. In 2016, we put together Group-wide, transnational business development teams to work on penetrating new markets.*



### Thumbnail

*/// From 16 to 21 October 2016, Soletanche Bachy, Menard, Terre Armée, Freyssinet and Sixense took part in the 9<sup>th</sup> PIANC-COPEDEC Conference in Brazil. The global port sector gathering provided an opportunity to promote the expertise offered by our entities, using a table and touch screen interactive 3D infographics to let visitors explore the Group's comprehensive range of solutions and services for this high-potential market.*

## "GLOCAL" VISION: CONSOLIDATING OUR LOCAL-GLOBAL MODEL



**JAKUB SALONI - Menard**  
Director, Menard Polska  
Warsaw, Poland

**M. P.:** Our organisational model is based on our local teams with strong local roots who are highly familiar with their markets and clients. Soletanche Freyssinet's activity is therefore handled by Polish teams in Poland and Mexican teams in Mexico, for example. Client proximity enables the teams to be very responsive. They also handle their own business development, for which they can call on pooled Group support services – including technical, engineering, equipment, product and major projects management expertise – as required.

**Jakub Saloni:** Where Menard's activity was once driven by major projects, especially in the Middle East, the current momentum in the United States and Europe is driven by regional projects of all sizes. We are careful to firmly strengthen our local roots, to penetrate even deeper into the heart of the markets we operate in, and move closer to our clients. Though it may work for Menard, is Soletanche Freyssinet's local-global model still relevant in the face of current market evolution, and how can we expand into areas where none of our brands are present?

**M. P.:** This model works well, and that's why we are continuing to strengthen it. Even so, not all of our brands have the same

kind of international presence. For each of them, there are still countries or entire geographical regions yet to be conquered. Here too, our Group's strength lies in

the fact that it can leverage in-house synergies to step up geographical expansion for some business lines. For example, the Soletanche Bachy and Menard teams worked together to place Menard's operations in Poland on a firm footing. And to this day, Soletanche Bachy, which has long operated in Latin America, is in a good position to help expand all our other business activities there.



**J. S.:** In Poland, Menard is now well established as a fully mature company. I think it is important to help the subsidiaries fine-tune their strategic positioning, to keep creating links between our various business activities and entities and to facilitate knowledge-sharing for the benefit of our clients.

“  
**Strengthen our roots close to our clients**  
”

## DIGITISATION & DIGITAL TECHNOLOGIES: FACILITATING AND EXPANDING THE CLIENT EXPERIENCE



**YOHANN RABOT - Sixense**  
Director, Sixense Mapping  
Morangis, France

**M. P.:** It is hard to tell exactly where the digital revolution will take us, but we know it will be disruptive for the entire construction sector. Soletanche Freyssinet opted to actively participate in the revolution and to design some of its own digital tools. One of the highlights of 2016 was the creation of our sixth brand, Sixense. By bringing together teams of engineers, IT experts and specialists from our business lines, Soletanche Freyssinet acquired a strong digital capability. We put together the Advitam, Soldata and Concrete companies and added the digital component to create a unique brand offering an entirely new range of engineering services. The goal is to give ourselves a strong base from which we can play a leading role in a market that will probably expand ten-fold in coming years! We have set our sights very high for Sixense – it will cover infrastructure monitoring

throughout the life cycle as well as site-specific fully digital solutions and services.

**Yohann Rabot:** Sixense Mapping, the Sixense company specialising in 2D-3D mapping, has an expanding range of digitisation services and solutions. When we digitise structures, we can better track what is happening to them throughout their life cycle to support maintenance and control risk. In 2016, we finalised the as-built survey of the SEA HSL (see page 49). This meant digitising data collected on more than 350km of track and more than 5,500 hectares by means of laser detection and ranging (Lidar) and photogrammetric soundings. Is data management in conjunction with the excellence of our business expertise going to be a focus of Soletanche Freyssinet in coming years?

**M. P.:** It certainly is. Our expertise in soils and structures is unique. We are able to collect data, we have the equipment to process it and we have the technical knowledge to analyse it. Investing in software engineering is one of our strategic goals. To do this, the Soletanche Bachy and Menard technical departments are structuring their big data activities with a dual purpose in mind – to boost operational



Thumbnail

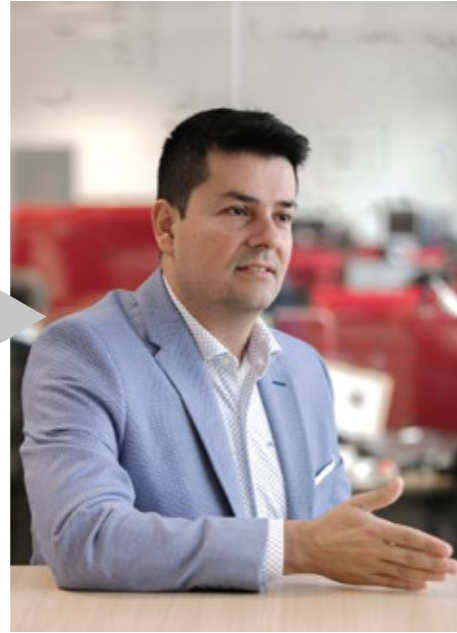
/// With the introduction of robotics on our sites, Menard and Soletanche Bachy are increasingly using automated machines that interact with each other via reconnaissance systems.  
/// In 2016, Nuvia launched NUVIA'PPS, a competition focused on mobile applications. Nine employees were awarded prizes in this first edition in categories ranging from client satisfaction to travel and safety.

## HEALTH & SAFETY: MAKING A COMMITMENT TO ONESELF AND OTHERS

↓  
excellence and to deliver new services for our clients. The new generation of smart drilling tools is able to assess the terrain and adapt according to the types of soils encountered.

**Y.R.:** In the design stage, we can already predict the behaviour of the structures according to the type of materials chosen, their use and their durability. The solutions offered by Sixense support the digital revolution in predictive maintenance, monitoring and inspection. The new technologies enable us to access previously inaccessible locations and to offer resolution on the order of a tenth of a millimetre. The power of digital technologies, the reinforcement of our structural maintenance engineering capabilities and our ability to work on the entire project life cycle are already transforming the way we work. This is indeed all about BIM (Building Information Modeling)! And Sixense now incorporates BIM in most of its tools (see page 79).

**M.P.:** BIM is now becoming standard for all structures to be built and renovated. In France, all the Soletanche Freyssinet entities have adopted the three-dimensional approach and many major projects around the world are now using BIM. With BIM, all project participants share the same detailed 3D overview of the structure to be built, including the production process and maintenance. These new tools make it possible to build structures that would have been unthinkable just a decade ago.



**DANIEL SANCHEZ -**  
**Soletanche Freyssinet**  
QHSE Coordinator for the Latin America area in Mexico City, Mexico

**Daniel Sanchez:**  
Following several years of a safety culture based on procedures and rules, we are now emphasising individual responsibility... for the benefit of everyone. Mentalities are changing. Working safely means watching out for oneself and others. We have made progress. Cimesa, Soletanche

Bachy's Mexican entity, is a case in point. Every year since 2012, the lost time workplace accident frequency rate<sup>1</sup> in the Latin America region has declined by about 20%. How are you going to keep up the momentum that has been built?

**M.P.:** Despite the hard work our teams have done, there were several serious accidents at Soletanche Freyssinet in 2016. To continue our progress toward our Zero Accidents goal, we are working to strengthen managerial responsibility and will be concentrating on major, recurring accidents. Action is being taken on two issues. To provide training for our worksite personnel in preventing falls from height, we opened our first training centres equipped

<sup>1</sup> Indicator expressed as the ratio of the number of accidents to the number of hours worked

with scaffolding and simulation modules in Latin America and Asia in 2016. The programme will be gradually introduced across the board. In 2017, we are focusing on the risk of accidents involving the hands, and on introducing "Safety is in your hands" action plans and practical measures designed to drastically reduce this type of accident. We will continue to invest heavily in training to boost our safety culture.

**D.S.:** That is one of our major projects – making safety second nature. In Chile, we have set up a risk perception test that takes just a few minutes to assess the risk awareness of the people we recruit. In 2016, the Latin American subsidiary teams continued to systematically roll out Prestart Meetings and carried out a large number of safety inspections and debriefings. In addition, they encouraged people to engage in creative team building activities and enjoyable, interactive training programmes to share the common culture based on making a commitment to oneself and others. The culture covers everyone on the site and their families. Nearly 600 employees took part in our new BBS (Behaviour-Based Safety) training programme inspired by behavioural science. But besides focusing on individual behaviour, I think we will also win the safety "battle" by working on transparency.

**M.P.:** Yes, it is crucial that top management set an example and that supervisory staff make a commitment at all levels. We strengthened our commitments in 2016 by appointing

a Group Safety Director who works with the regional coordinators – such as yourself – who are responsible for rolling out the Soletanche Freyssinet standards around the world and for encouraging the entities to share their best practices. We will continue to professionalise our safety management and at the same time ensure that we have a detailed, pragmatic overview of each country. All our subsidiaries are working to raise risk awareness and ensure that safety becomes an integral performance lever everywhere.

**D.S.:** Safety is our priority but it must not cause us to forget about health and our social and environmental commitments. In this regard, Soletanche Bachy Cimas, in Colombia, set up a broad-based social partnership campaign in 2016 called "Together". It is divided into three programmes. "Going to School Together" reduces illiteracy in our teams and boosts the autonomy of employees who left school very early. "Building Together" helps us repair or build childhood centres, particularly in Bogota. And "Succeeding Together", a corporate



volunteer programme, enables us to help employees living in difficult conditions to improve their housing.

**M.P.:** Cimas won a prize for this campaign (editor's note: awarded by the Corporación Fenalco Solidario Colombia). This illustrates the fact that we are an efficient, mutually supportive international group. Our social and environmental responsibility ties in closely with our ethical commitment. In 2016, we continued to set up a compliance programme in line with international regulations governing corruption and transparency.



### Thumbnail

/// Soletanche Bachy finalised the development of a robot handling system for drill strings. The faster, more productive, safer, more versatile tool has undergone conclusive testing.

/// In 2016, Menard set out the basics of its Home Safe campaign, which will be rolled out in 2017 with a range of tools including a logo that suggests the close links between life at work and at home.

/// In 2016, Nuvia UK was recognised for success in its safety performance by numerous respected safety authorities in the UK. Commendations included the RoSPA (Royal Society for the Prevention of Accidents) Sector Award for Engineering Services and shortlisting in the top 3 for the Sir George Earle Trophy, the premier health and safety performance award in the UK.

/// Soletanche Bachy continued to raise awareness of major worksite risks with a dedicated film, "The 5 Killers", and to roll out its "Daily Safety Cycle" campaign, which focuses on a single message: better anticipate risks at all times.

**Orchard metro station  
and associated tunnels**  
Thomson-East Coast Line,  
Singapore

### **New infrastructure to facilitate mobility**

In Singapore, Soletanche Bachy's local subsidiary helped build the new Thomson-East Coast Line (TEL), part of the Mass Rapid Transit (MRT) system. In October 2016, it completed the foundations for the Gardens By The Bay station and the associated tunnels. Other work, carried out in conjunction with the Soletanche Bachy Major Projects division and Bessac, is now under way for the Orchard metro station: 100,000 sq. metres of diaphragm walls, 7,100 metres of bored piles, 8,500 cu. metres of materials excavated under the existing station and two tunnels built, for the first time in Singapore with a tunnel boring machine (TBM). This complex work is taking place under a busy thoroughfare and requires advanced geotechnical capabilities such as the use of a retractable microtunnel boring machine (MTBM) and innovative soil mixing techniques.

# SOLE- TANCHE BACHY



**DIDIER VERROUIL**  
Chief Executive Officer,  
Soletanche Bachy

“ We never leave a site without having kept our commitments ”

**What is your view of 2016?**

2016 cannot be looked at in isolation. With the world economy affected by the decline in oil and commodity prices, the Group nevertheless maintained a high level of activity and achieved a record order backlog. With increasing numbers of projects of all sizes, growth in revenue, improved income from operations, strategic acquisitions, progress in terms of safety and a large number of innovation awards, all indicators are positive in the 2015-2016 period.

**What were the most significant projects in 2016?**

We started one of Soletanche Bachy's largest-ever ground reinforcement projects as part of the construction of the three-runway system at the Hong Kong International Airport. The project consists in reclaiming 650 hectares from the sea and calls for one of our patented processes, Geomix®. The work has to be carried out in height-restricted conditions and while the airport continues to operate. Other examples of projects in the transport sector are the Kuala Lumpur and Warsaw metros. The port projects in Colombia (Buenaventura), Trinidad and Tobago (La Brea) and France (Sète, Port-la-Nouvelle) illustrate our increasing presence in marine works. In water and sewer projects, there were the Thames Tideway Tunnel in London, the Ganay basin in Marseille and

**An iconic project?**

The Tower in Dubai. Soletanche Bachy is completing deep foundations for what is to become the world's tallest building.

**A reason to be proud?**

Safety. Mentalities are changing: safety is increasingly recognised as a way to boost performance.

**A watchword for 2016?**

Robustness. Initiated in 2016, the Soletanche Bachy strategic project will strengthen the fundamentals of our entrepreneurial culture.

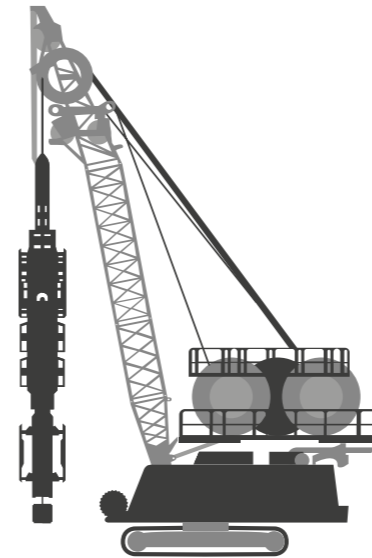
other projects in Qatar, Chile and Georgia. And then there were dams, with major projects in Chile (Chacillas), Peru (Antamina) and India (Subansiri). Lastly, we made substantial use of our expertise to build the foundations for high-rise towers, more particularly in Mexico City, Dubai and Sydney.

**How is Soletanche Bachy positioned in the outsized Grand Paris project?**

We are already actively working on it. Apart from direct programme management of the Grand Paris project, our underground works expertise is called on for the extension of Line 14 of the metro (see page 29). We were also awarded, as part of a joint venture, a works package for the Grand Paris Express, covering the Fort d'Issy - Vanves - Clamart underground station. At the same time, our ability to deploy teams and offer innovative solutions has put us in a good position in tender procedures. In January 2017, we were awarded, within a joint venture, the first Grand Paris Express major works package for Line 15 South between Villejuif-Louis Aragon and Créteil L'Échat.

**How does your range of solutions and services stand out?**

Infrastructure projects are increasingly complex and technical. In Paris as in Mexico City, a large



**World benchmark in foundations and soil technologies**

The Soletanche Bachy Group delivers comprehensive main contracting capabilities for large infrastructure projects as well as the complete range of geotechnical processes, special foundations, underground works, marine facilities and ground improvement.

**10,265**  
EMPLOYEES

**€1.525 bn**  
MANAGED REVENUE\*

**€1.800 bn**  
ORDER BACKLOG\*\*

\* Revenue including the share of revenue in jointly controlled companies  
\*\* At end February 2017

**NEW ORDERS**

- Tanjong Rhu metro station and associated tunnels, Thomson-East Coast Line (TEL), Singapore
- C18 metro station, Warsaw, Poland
- Villa Coapa, Mexico City, Mexico
- Spire London, London, United Kingdom
- Eole project, France
- Extension of D quay, Port of Montevideo, Uruguay

→ number of facilities must be built, often in a dense urban fabric that must not be disturbed. Our trademark ability is to offer innovative, customised geotechnical solutions with predetermined budgets and deadlines. Beyond our specialist expertise, we can provide general contracting or turnkey capabilities as part of an integrated range of services. But in fact, what really makes a difference is our approach: whatever happens, we never leave a site without having kept the commitment to excellence that we make to our partners.

**How can you expand this added value?**

First we can boost our design office capabilities around the world. We have the major advantage of being able to bring powerful, collaborative engineering expertise to contracting authorities' constant quest for project optimisation. With this goal in mind, we stepped up recruitment of young talent in 2016. In parallel, the company is building increasingly innovative and efficient equipment. Thanks to networked management, we can deploy equipment around the world to meet requirements.

**Are you optimistic for 2017 and the following years?**

Demand for transport infrastructure remains buoyant and global maritime traffic is steadily increasing, so that demand for port facilities and infrastructure can be expected to grow. Urban concentration is driving construction of an increasing number of skyscrapers and a race to build ever higher. And dams around the world are aging, so that major refurbishment works are in the offing. In all these areas, demand will not decline, on the contrary. Soletanche Bachy will confirm the momentum underpinning our order intake in 2016. We are already well established in more than 50 countries. We will be looking at new locations close to our future clients, notably in Latin America and Africa, to boost our ability to respond to growing demand.

# THE HYDROFRAISE® WITH GRIPPERS, CUTTING THROUGH HARD ROCK



Since Soletanche Bachy invented the Hydrofraise® in the 1970s, it has become the iconic machine used in special foundation works to drill into hard, deep geological horizons. Its greater drilling depth and power, optimised weight management, better stability in uneven terrain, and enhanced compactness to facilitate transport in containers and work in height-restricted conditions and in urban areas give the Hydrofraise® steadily increasing precision, reliability, agility and performance.

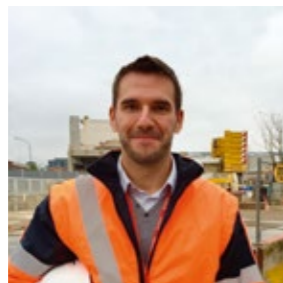
## Innovation and value creation

Building on their confidence in their technological expertise, the Group's experts took the equipment to a new level to meet expected client requirements in increasingly complex projects. In 2016, the Hydrofraise® with grippers was launched to meet geological and commercial needs.

By offering a solution for excavating very hard rock (up to 100 MPa) in the Paris area, Asia and Monaco, Soletanche Bachy in two years put into practice an idea first put forward 20 years ago. "The innovation was developed, as a collective ambition, at the instigation of top management in conjunction with the sales team, the technical design offices, the equipment department, the workshops and the works teams", says Technical Director Serge Borel. "Our integrated approach is the Group's best asset, since those who build the machines are the entrepreneurs that use them."

## An innovative concept for a world first

The Hydrofraise® with grippers has brought about a profound change in the diaphragm wall construction process. The tool is able to drill to depths in excess of 70 metres thanks to its pendulum assembly, at panel thicknesses of 1.2 or 1.8 (x2.8 metres), and socket into hard terrain. Its design is unique: an anchor module with gripper caissons – that are opened hydraulically at the top by two actuators – capable of applying 120 tonnes of thrust on the cutting tool in addition to the weight of the cutter tool, and hydraulic dampers to limit the vibration. The system is designed so that motors, plates and drums can be replaced in a matter of minutes. In the operator's cab, the human-machine interface has been completely re-designed. The control panel is equipped with a console and a PC that serves as a display and records drilling parameters using touch controls. The more intuitive screen, which displays functions appropriate for the drilling mode selected, takes us a step further in the direction of the connected machine. The data measured can be better analysed, controlled and put to use (see page 22). The Hydrofraise® with grippers won the *Trophée des TP* (public works trophy) in France in the "equipment processes" category on 23 February 2017.



### François Lhomond - SYSTRA

Responsible for works package 2, project management of the northern extension of metro Line 14 (Paris, France)

*"The Grand Paris Express project focuses on creating new lines and new stations to improve the daily lives of people living in the Greater Paris area. During the first phase of diaphragm wall works for the Mairie de Saint-Ouen station on the northern Line 14 extension, we had to cope with hard rock horizons that reduced our productivity. In the second phase, the Soletanche Bachy teams therefore brought in a novel piece of equipment, the Hydrofraise® with grippers, which enabled us to work at the planned rate, limit wear on the tool and improve excavation efficiency. The resulting productivity gain enabled us to meet the tight project deadlines. The machine performed as expected thanks to its innovative excavation method, while maintaining verticality within RATP tolerances. This first project heralds even better results in upcoming Grand Paris Express projects where we may be called on to work together again."*

■ ■  
**A Hydrofraise® suited to the Grand Paris project**  
 ■ ■



**Port of Aguadulce, SPIA and Boscoal terminals**  
Buenaventura, Colombia



**890**  
**METRES LONG**

Buenaventura, Colombia's main Pacific port, is a strategic city. Most of the Andean country's exports and imports pass through it. The port upgrade is a benchmark for progress, competitiveness and sustainability in the entire region. Via the SBCC joint venture, Soletanche Bachy Cimas, Soletanche Bachy International (the Group's Major Projects division) and Conconcreto took part in the project. Substantial technical capabilities went into designing and building the container terminal (SPIA), the bulk carrier terminal (Boscoal) and the associated reclaimed areas. Several innovations improved the efficiency and quality of the onshore and offshore works, optimised costs and accelerated the construction process. The project worked closely with the local population. Virtually the entire team was Colombian. On 2 December 2016, Boscoal received its first cargo ship carrying maize that had been loaded at the Louis Dreyfus terminal in the port of Bahia Blanca, Argentina – which Soletanche Bachy handed over five years ago.



**LOTOS refinery**  
Gdańsk, Poland

**Safe, durable oil infrastructure**

The Museum of the Second World War in Gdańsk was officially inaugurated on 23 January 2017. Soletanche Polska had excavated the site to a depth of 18 metres using a temporary thick slab cast under water, setting a world record. Meanwhile, the local Soletanche Bachy subsidiary began to work on a new project near the Pearl of the Baltic in March 2016. As part of the strategic EFRA – Effective Refining – Project, designed to maximise the volumes and quality of products obtained from each oil barrel, LOTOS, the oil exploration, production, refining and product distribution group, launched work to extend its refinery. The Italian KT – Kinetics Technology – group, main contractor in charge of building the coking and hydrogen generation units, awarded the contract to Soletanche Polska to build the 2,500 CFA (Continuous Flight Auger) piles required for both projects. The contract holds out prospects for further work in the demanding Polish oil and gas market.



**Serving the sustainable city**

In February 2016, ahead of the contractual schedule, Bachy Soletanche Vietnam completed the construction of about 26,900 sq. metres of diaphragm walls, 203 bored piles and 240 plunged-in steel columns. In an innovation in Vietnam, it built 62 shaft grouted barrettes and plain barrettes, of which some had 1.5 by 4 metre dimensions and 71 metre depths. The work was carried out for a mixed-use development in lot 5.5 of the new Thu Thiem area in Ho Chi Minh City. Developed by Dai Quang Minh Corporation, it will have four underground levels, a seven-storey shopping centre and an 18-storey office tower. At a time when Vietnam's economic capital is reinforcing its urban renewal and sector planning strategy, the goal is to make this urban area into a new service sector hub in Ho Chi Minh City and to make the large Southeast Asian metropolis into a model sustainable city.

**Dai Quang Minh property complex**  
Ho Chi Minh City, Vietnam



**West < > East tramway line**  
Nice, France



**26 MINUTES**

Starting in 2018, it will take 26 minutes to travel from Nice Côte d'Azur Airport to the port in Nice via the city's new 11.3km tramway line with 20 stations. Soletanche Bachy France, working with Soletanche Bachy Tunnels and Bessac as well as others within the Thaumasia joint venture, is handling design studies and civil engineering works for the 3.2km underground section under a contract covering a 9.8 metre diameter bored tunnel, four underground stations, entrance and exit shafts, fitting and finishing, equipment and testing. The tunnel is being built to efficiently serve the city centre while safeguarding its architectural heritage. Soletanche Bachy faces the challenges of complex geology with highly variable soil and a small construction site in the centre of the city with shallow foundations and particularly sensitive built structures. To carry out the project, 150 workers are on site and 11 different rigs have been set up along the alignment. By the end of 2016, more than 75,000 sq. metres of walls and just over 1,440 linear metres of tunnel had been completed.

**Motorway and railway safety**

In British Columbia, Agra Foundations and Nicholson Construction, respectively Soletanche Bachy subsidiaries in Canada and the United States, worked to stop a landslide that was creating an obstacle to the operation of a railway and threatening Highway 99, the "Sea-to-Sky Highway". The two companies jointly designed and implemented a two-stage solution. Between June and October 2016, they installed 250 fully grouted micropiles and 30 strand passive anchors connected by a concrete waling beam. The mountainous topography made it necessary to carry out substantial prior earthworks to create access roads and work platforms. During the work, experts from Sixense monitored the slope in real time, using measurements to validate the effectiveness of the micropiles and anchors.



**Fountain Slide**  
British Columbia, Canada



**Patriotismo 230 tower**  
Mexico City, Mexico

**A LEED certified project**

After building the foundations and underground levels of the Insurgentes 838 tower for the ROUZ property group, Soletanche Bachy's subsidiary in Mexico was called on to apply its high-rise building expertise to the Patriotismo 230 project. The project has a surface area of 3,924 sq. metres and includes the construction of eight underground parking levels and the foundations of a 22-storey office building. The project has obtained the LEED high environmental quality label. The Cimesa teams proposed an alternative solution to replace conventional underground level construction: the top down method. They first demolished the walls of the existing underground levels, and then built 8,140 sq. metres of diaphragm walls around the perimeter with a capping beam. In the last phase, the core was excavated, provisional anchors were installed, 810 linear metres of piles were bored, 1,535 sq. metres of foundation barrettes were installed and post-tensioned underground floors were built together with Freyssinet.

Val de Siagne middle school  
Pégomas, France

### Helping to build knowledge

In France, Menard is helping to build the eco-responsible Pégomas middle school, which notably comprises 3,700 sq. metres of classroom buildings and a 1,500 sq. metre gymnasium. The facility will accommodate 600 students when it opens at the start of the 2018 school year. It is located in a valley in which the alluvial soil is made up of highly compressible silt and sand clay to depths of up to 40 metres. To cope with the soil, the Menard teams reinforced it by installing rigid inclusions, with 6,746 sq. metres of Controlled Modulus Columns under the road backfill and retaining walls in the common areas, as well as 5,444 sq. metres of bi-modulus columns built according to a Menard process under the foundations of the school, the common areas and the gymnasium. Between September and November 2016, Menard's alternative technical solution made it possible to deliver the project on time.



# MENARD



MARC LACAZEDIEU  
Chief Executive Officer,  
Menard

# Working and acting close clients

**Could you explain the slight decline in Menard's activity level in 2016?**

The decline was above all due to a smaller volume of major projects, notably in the Middle East. In North America, the momentum continues and although activity came in slightly under the record year of 2015, it stood 50% above the 2014 level. In addition, the Group had an excellent year in Europe (40% growth). The projects that contributed to revenue included the new Annacis Island wastewater treatment plant in Canada, the Barangaroo project in Australia, the Turkmenbashi seaport in Turkmenistan, the Capital District project in Abu Dhabi and our work on French (A304), Polish (S7) and American (I-295) highways.

**In Europe, growth took place against a backdrop of crisis and therefore strong competition in a mature market. What was driving the growth?**

In France and Poland, and to a lesser extent in Germany and the United Kingdom, Menard has a strong commercial presence, with well-established networks in the regions and very active teams in the field. There is therefore a recurring flow of projects. They may not be as high profile

**A watchword for 2016?**

*Consolidation.* While activity held steady, we worked on our organisational structure to reinforce our local roots.

**A reason to be proud?**

The efficiency and agility of our local teams in Europe, the result of the groundwork we have been doing for several years.

**A key project?**

The largest wick drain contract ever awarded in the United States – the container port in Charleston, S.C.

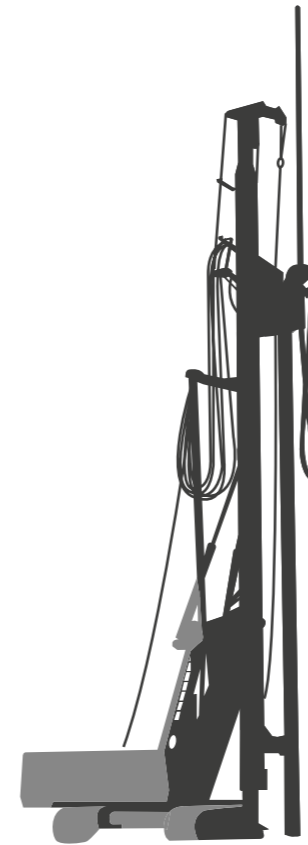
as major projects, but they generate strong volume and enable us to establish close working relationships with our clients. In France, our teams carried out more than 400 projects with an average value of €70,000 in 2016.

**Menard's trademark is its ability to handle projects of all sizes...**

Absolutely. The Group is known for its ability to handle complex geotechnical problems on large infrastructure projects in France and abroad. The other pillar of our strategy consists in contracting projects day by day offering our clients competitive prices with optimum quality. We operate and take decisions close to our clients around the world. That is our strength now and will be an even greater strength going forward. This is the business model we have adopted for Menard.

**Is your integration of the soil remediation activity in 2016 one of the ways you are expanding your added value for clients?**

Yes, we had carried out some remediation projects in Romania and in France, but we had never developed the activity as a separate business line.



**Key ground improvement provider**

The Menard Group develops foundation solutions based on ground improvement and reinforcement technologies. Its treatments eliminate the need for the deep foundations traditionally used to support surface structures. The Group also offers expertise in soil remediation and treatment of contaminated soils to rehabilitate polluted sites.

**1,000**  
EMPLOYEES

**€250 m**  
REVENUE

**980**  
PROJECTS

**NEW ORDERS**

- New international airport for Mexico City (NAICM), Mexico
- Panama power plant and LNG project, Colón Province, Panama
- Newton middle school, Lima, Peru
- Emirati Neighbourhood (package 4), Madinat Zayed, Abu Dhabi, United Arab Emirates
- Prologis Ports Elizabeth-Triport project, Elizabeth, N.J., United States
- Offshore urbanisation project, Larvotto, Monaco

→ With the integration of Remea (formerly Sol Environment), Menard now has the full range of expertise required. We are rolling it out internationally in 2017 via our network. We started operating in Poland last year, and today we have a fully operational structure there.

**How do you see your markets developing in the medium term?**

The combination of urban development and environmental constraints is creating huge opportunities. The soils that remain to be treated around the world are of increasingly poor quality and often highly polluted. Clients are now inclined to consider alternative solutions to conventional methods that are often excessive. Our construction techniques are optimised alternatives to standard solutions. They meet the expectations of building and civil engineering companies faced with economic constraints that want their partners to think outside the box.

**What are your new expansion priorities?**

There are regions in the world that remain to be "conquered", especially in Africa and Latin America, where Menard is just getting started. The effort is bearing fruit in Mexico and in Colombia and we are now gaining a foothold in Guatemala and Central America. However, our goal is not to set up a large number of locations but rather to consolidate our activities in accordance with our European model. We are boosting our penetration of markets where Menard is already operating – North America, Asia, Australia and the Middle East – and we are making a special effort in Egypt and Turkey, two densely populated countries with huge needs beyond major projects.

**Safety remains Menard's major focus...**

The results have improved substantially compared to 2015. The culture is changing, and we are concentrating especially on equipment mobilisation and demobilisation, which call for increasingly rigorous preparation. Menard's performance depends first and foremost on the safety and well-being of our employees. This is the whole point of the Home Safe plan launched in 2016 (see page 22).



# MENARD HIVES: COLLECTIVE BY NATURE

Projecting 10 years ahead, what are the major challenges that Menard must tackle on an international level? That was the question put to all the company's employees in 2016. To arrive at an answer, Menard experimented with a new way of working together in which each employee becomes a potential source of innovative ideas for the company. Objective: to go beyond technical innovation by generating collective intelligence.



“  
The  
limits?  
Our own  
imagination!  
”



**Natalia Rucinska - Menard**

Geotechnical and environmental engineer for the Middle East and Central Asia region

*"Company employees thinking about idealistic solutions to resolve the problems of tomorrow - that is a recipe for an animated discussion! The hives were a lot of fun, and a rare opportunity to get together with many colleagues. It encouraged us to think differently without saying: "No, that could never work." We all had to move outside our comfort zone to consider ideas that are not necessarily part of our day-to-day responsibilities. Thanks to this approach, everyone could come up with original ideas without the risk of criticism. The sky was the limit! This was the first time we had been asked to contribute to such an unconventional process. Nonetheless, it retained the Menard spirit, revolving around creativity, innovation, and entrepreneurship. Encouraging innovation by giving staff the chance to be creative is perfectly in tune with our values."*

**Participative innovation**

Around this forward-looking vision, focusing on the key needs ahead, each employee could contribute directly to the development of the company by posting their "innovation challenges" on a dedicated online platform. In the last quarter of 2016, more than 200 challenges were collected in the areas of technology, safety, environment, organisational structure, and business models. After this initial stage, the selected ideas were assembled into 12 challenges. A series of "innovation hives" were organised, during which participants including management and site representatives brainstormed in small groups to find the solutions to meet these challenges. The first hive session took place in France in December 2016. This was followed by sessions in Poland, then Dubai for teams in the Middle East, and lastly by the United States for the North American continent. This was an unprecedented exercise for Menard, the gatherings bringing together some 300 employees. In this second phase, each participant had an opportunity to voice his or her views and outline what he or she felt were the most promising channels for innovation.

**Menard's people: a source of fresh ideas**

This interactive format involving decidedly collaborative workshops was directly inspired by the Menard spirit, involving high-quality work in a good working atmosphere. The company believes in servant leadership, according to which the manager must serve his or her team. It also encourages employees, notably the younger ones, to be creative, pragmatic, and autonomous. Entrepreneurial because they are enterprising; enterprising because they are entrepreneurs. In 2017, the hive experiment continues online, with employees invited to hone selected innovations and to come up with concrete solutions for the implementation of key actions, thought up together and shared by all, which will drive the company's commitment in terms of innovation in the years ahead.

**Annacis Island wastewater treatment plant**  
Delta, British Columbia, Canada



1.5

MILLION CU. METRES

In June 2016, following 21 months of work, Menard, working in a joint venture with JJM Construction, completed the reinforcement of about 1.5 million cu. metres of soil as part of the extension of a wastewater treatment plant. In a demonstration of its agility, Menard's Canadian subsidiary proposed reliable alternative solutions for excavating 180,000 cu. metres of materials, relocating existing utility lines and carrying out ground improvement. After painstakingly implementing nine test phases, the team settled on a construction method, rigorous planning and a technical solution geared to the constraints of the site. Anti-liquefaction treatment was applied via vibrocompaction and installation of stone columns, while adjacent structures were protected with a 30-metre-deep Cutter Soil Mixing (CSM) wall over a length of 480 metres as an alternative to the jet grouting solution initially planned by the engineers. In another development, Sixense experts continuously monitored settlement during construction to avoid incidents and damage to the existing facilities in the vicinity of the site and to enable the plant's work to continue unabated.

**Siemens plant**  
Cuxhaven, Germany



**"One of Siemens' largest projects in Germany in recent years"**  
Joe Kaeser, President and Chief Executive Officer of Siemens AG

The days when the arrival of the shrimpers and the noise of the canning plants set the pace in the German fishing port of Cuxhaven are long gone. Today, with the majority of container ships continuing on to Hamburg, the city has specialised in renewable energy and more particularly in assembling wind turbines to be installed offshore. As part of the construction of a plant to manufacture components for new-generation offshore wind turbines, Siemens (which has undertaken a major restructuring of its activity portfolio) awarded a contract to Menard's German subsidiary to treat 130,000 sq. metres of soil. Up to five rigs were used over a period of four winter months to carry out dynamic replacement and install wick drains in soft clay soil. To cope with the project's location near a rainwater runoff pipe, the solution was altered to include stone columns. The plant, covering an area equivalent to 24 football pitches, will employ 1,000 people.



**O-Bahn city access project**  
Adelaide, Australia

**The Australian teams implemented 58 jet grouting columns**

The columns were installed to stabilise the soil in the heart of Adelaide and to support the creation of priority lanes and a tunnel for the O-Bahn guided busway. Created in the mid-1980s to relieve traffic congestion in the city, the O-Bahn continues to modernise and adapt to new patterns of mobility and the growth of new neighbourhoods. In addition to the jet grouting columns (with diameters ranging from 1.2 to 1.6 metres), 36 temporary ground anchors were installed. A cyclone with winds gusting at 140km/h and heavy precipitation disrupted the work. Between September and October 2016, Menard made its expertise and professionalism available to its client McConnell Dowell, coping with the complex weather and ground conditions, carrying out the project near road traffic and removing muddy spoil via vacuum trucks so as to protect the environment and avoid unpleasant site impact on local residents and motorists.

**Metro Point Logistics Center**  
Ridgefield, New Jersey, United States



14,000 LM

New Jersey is a diversified industrial region with access to the sea, railway links, a network of SMEs working with prestigious universities and a large consumer market. As multimodal hubs proliferate, Menard completed specialist works on the Metro Point Logistics Center in June 2016. The hub has two warehouses with 19,000 sq. metres and 8,000 sq. metres of floor area respectively, 56 loading docks and 208 parking spaces. The teams taking part in the project simultaneously applied three techniques: installation of Controlled Modulus Columns (CMCs), deep dynamic compaction and rapid impact compaction (RIC). Six weeks of compaction works were carried out at the same time the CMCs were installed – a challenge that Menard successfully met. The teams adapted the technique to fit the area's geological makeup and were thus able to optimise the budget and lead times. In a last innovation, standard penetration tests (SPT) using a penetrometer were supplemented with Menard pressuremeter tests, which are often carried out in Europe but are little used in the United States.

**The Suez Canal has connected the Red Sea to the Mediterranean for the past century and a half**

To accelerate economic development in the strategic region, a free trade zone is under construction in the East Industrial Area of Port Said, the undisputed hub of the eastern Mediterranean. In September 2016, Menard signed a contract with the Egyptian Armed Forces Engineering Authority (EAAF) under which the Group's subsidiary in Cairo is working as main contractor to carry out ground improvement and reinforcement works at the site. The team faces a triple technical, logistical and production challenge. They need to treat 8 million sq. metres of soft clay soil to expedite the consolidation process and improve load bearing. Following a campaign of testing and soil reconnaissance, work to install prefabricated vertical drains (PVD) to a depth of 25 metres got under way at the end of 2016. Nearly 20 rigs are currently working at the site.



**East Industrial Area - Free Trade Zone**  
Port Said, Egypt

**Accelerating the valley consolidation**



At a stone's throw from Kuala Lumpur, Menard completed work in February 2016 to improve the soils on which a factory is to be built for UMW Aerospace, the aeronautical arm of Malaysia's UMW conglomerate. The manufacturing plant will produce fan cases for Rolls Royce aircraft engine. It is to be built in a valley whose lowest point is at +41 metres and highest point exceeds +80 metres. As an alternative to the conventional layer-by-layer compaction method, Menard's Malaysian teams came up with an innovative solution to accelerate fill in the valley. It combines dynamic compaction and dynamic replacement. After filling the site to establish the final hard surface at +65 metres, 82,650 sq. metres of soils were compacted. The solution not only cut the project's lead time from four to two months, it also met the demanding differential settlement and post-construction subsidence criteria.

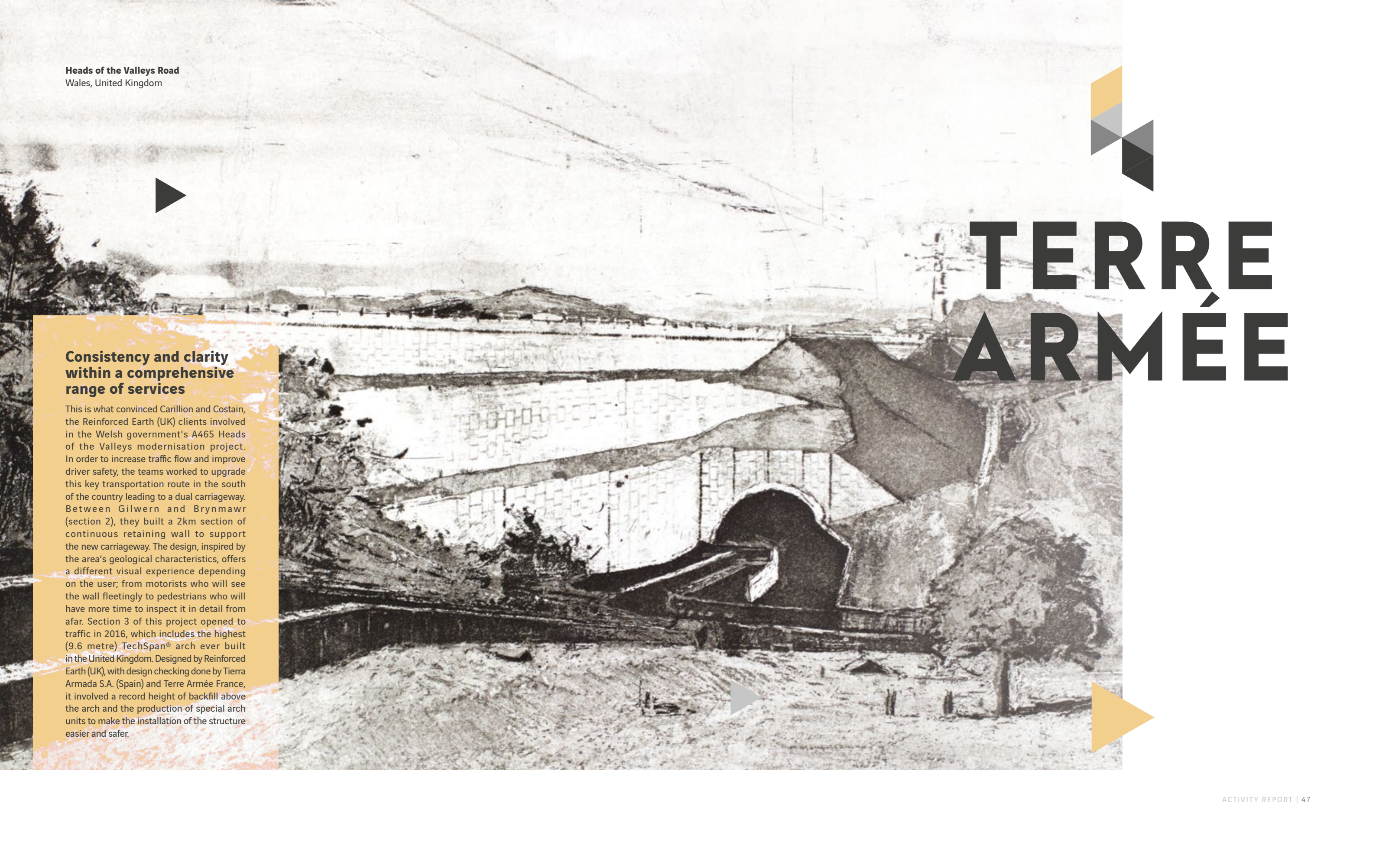
**UMW Aerospace Serendah Factory**  
Selangor, Malaysia



# TERRE ARMÉE

## Consistency and clarity within a comprehensive range of services

This is what convinced Carillion and Costain, the Reinforced Earth (UK) clients involved in the Welsh government's A465 Heads of the Valleys modernisation project. In order to increase traffic flow and improve driver safety, the teams worked to upgrade this key transportation route in the south of the country leading to a dual carriageway. Between Gilwern and Brynmawr (section 2), they built a 2km section of continuous retaining wall to support the new carriageway. The design, inspired by the area's geological characteristics, offers a different visual experience depending on the user; from motorists who will see the wall fleetingly to pedestrians who will have more time to inspect it in detail from afar. Section 3 of this project opened to traffic in 2016, which includes the highest (9.6 metre) TechSpan® arch ever built in the United Kingdom. Designed by Reinforced Earth (UK), with design checking done by Tierra Armada S.A. (Spain) and Terre Armée France, it involved a record height of backfill above the arch and the production of special arch units to make the installation of the structure easier and safer.







**ROGER BLOOMFIELD**  
Chief Executive Officer,  
Terre Armée

# Three main business lines: Retain, Cross, Protect

## 2015 was a year of revival, how do you view the results of Terre Armée in 2016?

While the global economic context remained difficult, we continued our dynamic of revival and in fact accelerated it. The proof is in the Group's revenue and operating profit, which increased 18% and 30% respectively compared to the previous year. Our business growth was primarily focused in the United States, which provided a large part of the Group's overall business thanks to a substantial number of orders at the beginning of 2016. The Reinforced Earth Company (RECo) achieved some fantastic results in 2016 with an increase of 60% in operating profit, the result of several major projects such as the expansion of the Interstate 4 in Florida (I-4 Ultimate) and State Highway 183 in Texas. Our activity also grew substantially in Canada thanks to projects signed in 2015 for the Turcot Interchange in Quebec and the Regina Bypass in Saskatchewan, under Public-Private Partnerships (PPPs). Furthermore, we are growing our presence outside of North America and across the globe, with the exception of Europe where the market conditions remain tight.

## A key moment this year?

The inauguration of the French SEA High-Speed Line (SEA HSL) between Tours and Bordeaux on 28 February 2017. Our teams took part in Europe's biggest rail construction project!

## A watchword for 2016?

*Transition.* This took physical form in the business diversification that the whole Group has been working towards.

## A reason to be proud?

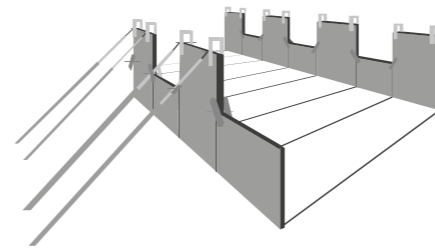
Our substantial progress in terms of safety: only one lost time workplace accident was recorded last year.

## How do you explain these upbeat results?

In order to differentiate ourselves in increasingly competitive markets, we are building on our fundamental assets: "Excellence in Client Care", and innovation. The quality of our service is a significant asset. On PPP and design-build projects, the care we take in identifying our clients' needs, offering customised solutions and meeting budgets, deadlines and safety measures, represents clear added value. Those who regularly call on our services have understood this. It is up to us to persevere in making these qualities known to new partners.

## Following the invention of Reinforced Earth®, French engineer Henri Vidal needed all the tenacity he could muster to turn his technological breakthrough into an entrepreneurial success story in the 1960s. That is the underlying principle of innovation...

Absolutely, innovation plays an integral part in our past, our present and our future, which is how we aim to respond to any new needs in changing markets. Reinforced Earth India, which celebrated 10 years in 2016, undertook projects in India using technologies →



## World leader in retaining structures

The Terre Armée Group, which introduced the Reinforced Earth® technique, has unrivalled experience in reinforced backfill and soil-structure interaction. Its techniques are applied in fields ranging from roads and motorways to railways, industry, the environment and hydraulic engineering.

**800**  
EMPLOYEES

**€215 m**  
REVENUE

**18%**  
GROWTH IN 2016

## NEW ORDERS

- NEON project, Las Vegas, Nevada, United States
- Structures for the Z-Morh tunnel, Jammu and Kashmir, India
- Los Angeles Rams stadium, Inglewood, California, United States
- Southwest Transitway, Winnipeg, Manitoba, Canada
- Toowoomba Range Crossing, Australia
- Second Iquique access road, Alto Hospicio, Chile

→ never seen before in the field of construction on steep and uneven ground stabilisation and protection against erosion. In France, our teams were heavily involved in the successful South Europe-Atlantic High-Speed railway Line (SEA HSL), for which they built Reinforced Earth® walls, which passed a series of tests for durability, reliability and deformability, thus demonstrating the suitability of this technology choice (see page 49).

## What can be done to help promote the diversification of Terre Armée's business?

We hold a strong position in our traditional markets, but we want to strengthen our position in other sectors, such as railway and hydraulics (water works), through new applications of our current technology and in the development of new related products (see page 17). We also want to re-launch our activities in the mining sector, notably in Canada, South Africa and Australia.

## How does the strategic "TA 2020" plan that you launched in 2016 provide clarity to your offer?

We restructured ourselves into eight regional poles, and we are working from a strong strategic plan which defines the platform and framework of our market positioning. Indeed, we are focusing on three distinct business lines: "Retain", for our retaining wall technology, "Cross", for highway and river crossings, and "Protect", for protection services. Our solutions for crossings include our TechSpan® precast concrete arch and our TechBox™ precast framework technologies. As for our protection services, this is likely to be our biggest area for growth in the future and we are investing in research and development for multiple coastal protection and erosion control solutions, as well as avalanche and rockfall protection barriers.

## What is the outlook for the coming years?

With an order backlog for 2017 already roughly equal to our revenue in 2016, the year is off to a promising start. Beyond these indicators, our success depends on our expertise, as well as the ingenuity and the passion of the men and women who make up the Group. Terre Armée will continue to invest so that its teams can keep coming up with the innovative, reliable and durable solutions who are the key to its success. The Orchestra technical training we introduced in 2016 is also a part of this effort.



# SEA HIGH-SPEED LINE: A TRANSFORMED TEST



On 5 August 2016, the train carrying out high-speed testing on the French new South Europe-Atlantic line between Tours and Bordeaux reached the speed of 352km/h and crossed one of the eight structures built with Reinforced Earth® retaining walls along the tracks. With commercial service set to start on 2 July 2017 (at an operating speed of 320km/h), the tests carried out over the summer marked the end of a technical and human marathon.

## A world first in railway construction

Terre Armée innovated by proposing the first-ever use of its retaining walls along railway lines used by high-speed trains. Its teams worked for nearly three years on an alternative technical solution that is as reliable as the baseline solution and accommodates the demanding design and approval process at Réseau Ferré de France (now SNCF Réseau). A total of 11 structures were built using the Reinforced Earth® retaining wall solution, with nearly 8,500 sq. metres of facings and 20 walls including 16 very high structures (up to 12.70 metres) at the ends of grade separations. The height, and above all the 352km/h train speed supported by the walls, are a record for Terre Armée. The Reinforced Earth® design took account of the high sensitivity of the infrastructure to deformation caused by passing high-speed trains (the "track twist" criterion, i.e. 15mm of distortion per 3 metres of track) and the full range of railway sector requirements with respect to access for maintenance purposes and structure stability and load bearing conditions.

## An unrivalled level of design studies for a reliable and durable solution

To meet the exacting requirements, an unprecedented number of studies were carried out. Geotechnical and seismic validation was performed as was a digital simulation of vibrations caused by high-speed trains in order to study the effect of compression and shear wave propagation on the backfill as trains pass. The Reinforced Earth® structures are adapted to a variety of roadbed conditions. The flexible retaining structures make it possible to carry out optimised soil reinforcement works that incorporate consolidation times. This either eliminates the need for deep foundations, as in the Monts structure, south of Tours, or replaces them with rigid inclusions. In addition, Reinforced Earth® offers high resistance to static and dynamic loading and can therefore be used to build high structures without particular constraints. The process facilitated construction of structures along the alignment and eliminated the need for heavy protective temporary barriers.

Lastly, a detailed monitoring programme was set up for each structure to detect any deformation in the facings over time. Instrumentation was also provided in the retaining walls along the tracks on which trains travel at 352km/h. A special campaign was carried out to specifically measure stresses and accelerations during the testing phases to gain unprecedented feedback prior to the start of operations.

“  
Better control of the multiple interfaces between activities  
”



### Christophe Persoz - COSEA

Deputy Director of the Infrastructure sub-consortium (SGI) at COSEA, in charge of design and build of the SEA High-Speed Line, France

*"In the course of our work with Terre Armée, we were first reassured by a lightweight, reliable and durable solution that gave us flexibility in construction scheduling and better control of the multiple interfaces between activities. The main advantage of the solution is that it can be rapidly implemented, which optimises costs and supports on-time delivery based on unrivalled expertise in structural engineering, construction and material management. The Terre Armée teams were persevering, consistent and very energetic. The project involved completing a series of analyses and studies, finding a correctly dimensioned solution and obtaining the permit approval – an obstacle course requiring endurance and performance. We also appreciated the uninterrupted availability of the operational teams, who were attentive and supported us throughout the process with a straightforward, strong partnership."*

**B2 viaduct on the E75 motorway**  
Demir Kapija-Smokvica, Macedonia



25  
METRES

It is the maximum height of the Reinforced Earth® retaining walls along the access to the B2 viaduct carrying the E75 motorway at Demir Kapija in southern Macedonia. Terre Armée France teams were in charge of replacing the first southern spans of the viaduct, which crosses a railway line and the Vardar River. The construction of the very high wall was spread over more than a year and the installation of 7,100 sq. metres of TerraClass® facing panels was completed in October 2016. The project, carried out for Egis in a joint venture with IRD Engineering, is part of the broader construction of nearly 29km of lines carried out by the Greek company Aktor (Ellaktor Group) as part of the European Union's transport infrastructure development programme, the Trans-European Transport Network (TEN-T).

**North West Corridor express lane project**  
Atlanta, Georgia, United States



Improving mobility and simplifying life for motorists around Atlanta

This is the double challenge taken up by The Reinforced Earth Company USA (RECo) under the auspices of the Georgia Department of Transportation (DoT). Under a large design-build programme covering 48km of toll lanes conducted in a joint venture with Eurovia, the local subsidiary provided MSE retaining walls to maximize the narrow space available along parts of I-75 and I-575, northwest of Atlanta, to construct additional lanes that are reversible depending on peak periods of traffic flow. The teams supplied 59,300 sq. metres of Reinforced Earth® walls and 22,300 sq. metres of precast facing panels for 16 structures. Deliveries of concrete wall panels, steel reinforcing strips and other materials needed for the walls were precisely phased to adapt to the constraints of a very limited on-site "laydown" area, and to contribute to the overall productivity and performance of the site. The lanes are set to open in May 2018.

**Combating water shortages**



Despite the abundant rains of the monsoon, water shortages are declared in dozens of provinces in Thailand every year. The authorities therefore introduced development programmes in the early 1990s to improve management of the available water resources. The Muak Lek reservoir, about 100km from Bangkok, is designed to supply water to the inhabitants of Wang Muang district and boost fishing, agriculture and tourism. The Reinforced Earth Company (RECo) is taking part in this huge project by helping to build the road that travels along the edge of the reservoir. It is 2.730km long and made up of nearly 9,000 sq. metres of TerraSquare® panels. Reinforced Earth® retaining walls are built along 1.320km with a maximum height of 11 metres. RECo's design, supply and installation expertise significantly reduced the cost of construction in terms of chosen fill and compaction works. The second phase of work started in October 2016.

**Muak Lek reservoir**  
Saraburi Province, Thailand

**La Concordia Bridge**  
La Concordia, Chiapas, Mexico

**Building in a seismically active area**

Tierra Armada de México is building a cable-stayed bridge abutment for construction group EPCCOR. The structure is a key part of the motorway that will connect Rizo de Oro and La Concordia in southeastern Mexico. This is the first bridge of its type to be built in the Chiapas region. In December 2016, the abutment's Reinforced Earth® walls reached the required height (21 metres) for the construction and launching of the superstructure to begin. The teams will then finalise the 3,500 sq. metres of the wall, which will have a top height of 26 metres. The Group's Mexican subsidiary provided the expertise needed to combine the design requirements with a construction process geared to the constraints of the region that will prevent the effects of seismic acceleration on the structure throughout its life cycle.



After five years of work, Reinforced Earth Company Ltd. (RECo) in Canada has delivered close to 38,000 sq. metres of TerraClass® retaining walls as part of the biggest-ever completed Public-Private Partnership (PPP) in Ontario. In July 2016, this vast road infrastructure project won the Environmental Achievement Award from the Transport Association of Canada (TAC). RECo Canada teams contributed to building this 11km green highway, helping to reduce the impact for residents on the towns it passes through, to ensure the safe movement of people, goods and services and improving traffic flow on this major trade link with the United States. It will link the cities of Windsor and Detroit by connecting the Canadian Highway 401 to the American Interstate 375. RECo Canada took charge of the design and supply of retaining walls for 71 structures along this entirely excavated highway, which includes 11 tunnels. The company used cellular concrete for the embankment, given the poor quality of the foundation soil. All staff received safety and environmental training so they would be aware of the constraints of the local ecosystem, and a construction timetable was drawn up to respect protected species living in the zone. Many recreational trails, including ten pedestrian bridges with TerraClass® retaining systems, and green spaces were created for hikers and cyclists to enhance this busy highway.

**11 km**

**January 2017: the first diamonds from the Liqhobong mine sold in Antwerp**

A yield of one million carats a year is expected over the 15-year life of the open pit diamond mine high up in the Maluti mountains in northern Lesotho, which lies at an altitude of 2,330 metres. In February 2016, Reinforced Earth South Africa (RESA) worked on the development of the mining complex, where it was awarded the contract covering design and supply of drawings, equipment and technical assistance for the construction of the site's primary crusher plant. The contract includes construction of 796 sq. metres of Reinforced Earth® walls with TerraClass® concrete facing panels using high-adherence galvanised steel reinforcing strips and 498 sq. metres of retaining walls for the main treatment plant. RESA developed innovative "compressible panels" suited to the logistical challenge of bringing in equipment over a 12km mountain road and cast on site by the contractor in charge of the project, Stefanutti Stocks.



**Liqhobong Mine**  
Butha-Buthe District, Lesotho



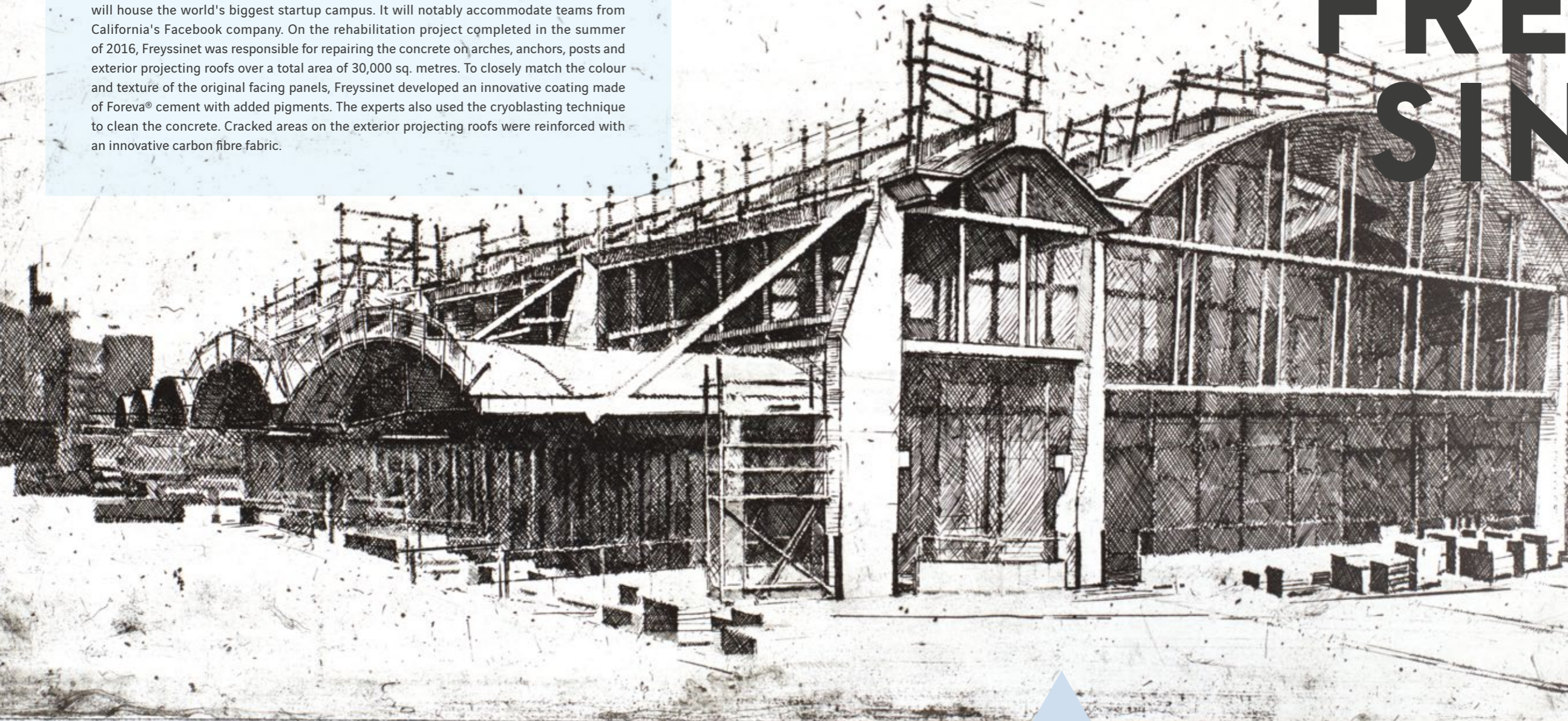
**The Rt. Honorable Herb Gray Parkway**  
Ontario, Canada

Station F  
Paris, France

### **Freyssinet moves towards the future in the footsteps of its founder**

Designed by Eugène Freyssinet at the dawn of the patented prestressing era, the eponymous building (Halle Freyssinet), which is included in the supplementary list of historic monuments, will house the world's biggest startup campus. It will notably accommodate teams from California's Facebook company. On the rehabilitation project completed in the summer of 2016, Freyssinet was responsible for repairing the concrete on arches, anchors, posts and exterior projecting roofs over a total area of 30,000 sq. metres. To closely match the colour and texture of the original facing panels, Freyssinet developed an innovative coating made of Foreva® cement with added pigments. The experts also used the cryoblasting technique to clean the concrete. Cracked areas on the exterior projecting roofs were reinforced with an innovative carbon fibre fabric.

# FREYS- SINET





**PATRICK NAGLE**  
Chief Executive Officer,  
Freyssinet

# Providing earlier and earlier client support

**Was 2016 another growth year for Freyssinet?**

Activity held steady at a high level. In 2015, we had signed several large contracts. In 2016, Freyssinet's global network of subsidiaries carried out these projects and undertook new ones. On 26 August 2016, the third Bosphorus crossing, the Yavuz Sultan Selim hybrid cable-stayed suspension bridge was inaugurated in Turkey. It set several records and introduced a number of innovations (see page 59). Other sources of satisfaction were the cable-stayed roof of the Vodafone Arena in Istanbul, Turkey, the prestressing for the Hebron Oil Platform in Canada, the 12km deck for Line 1 of the Ho Chi Minh City metro in Vietnam and our work on the TMCLK viaduct in Hong Kong and the Santa Monica (Train II) wind turbines in Brazil, which is ongoing. These diverse projects illustrate Freyssinet's ability to apply its expertise in different sectors, ranging from engineering structures and buildings, to energy and transport infrastructure. Another noteworthy highlight was the expansion of our repair activity. The Ewijk bridge in the Netherlands, the Ayala bridge in the Philippines, the port of Melbourne in Australia and the Viceroy building in Dubai are examples of our teams' commercial and technical responsiveness in the field of rehabilitation and reinforcement.

**Cause for satisfaction in 2016?**

Having had an opportunity on several occasions to share the successes of our teams around the world.

**A priority for 2017?**

*Safety.* We have an absolute duty, both collective and individual, to protect people on our sites. I will do my utmost to keep this a reality everywhere.

**Your commitment in 2017?**

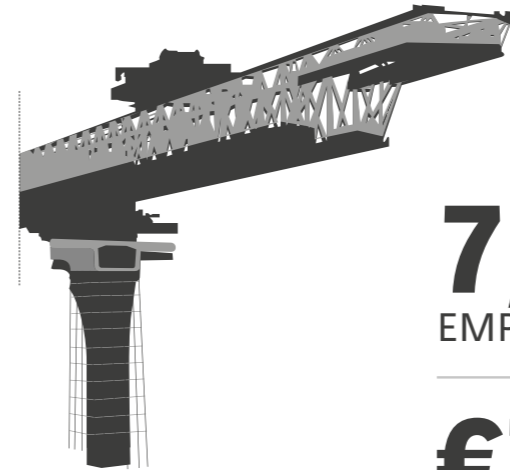
To look beyond the need initially expressed by the client in terms of expertise, products and services.

**Is repair a promising business for the future?**

We have a dual strategic focus. First, we are consolidating our core business, namely prestressing and stay cables. We will strengthen our positions by concentrating on projects with strong technology content. Second, we are concentrating on repair work, which already accounts for more than 40% of our overall volume of activity and up to 90% in mature markets such as France, the United Kingdom and Australia. More and more contracting authorities want to maintain or reinforce their existing assets rather than build new infrastructure. This activity ranges from basic repairs to high-end technical solutions. Lastly, Freyssinet is developing a new range of ready to build structures which notably include very tall concrete wind turbine towers.

**Could you give an example of these high-end solutions?**

The patented ElevArch® technique was trialled in the United Kingdom in 2016. Hundreds of bridges across railway lines in the United Kingdom have arches that are too low to accommodate the overhead power lines being installed to electrify the rail network. →



**7,500**  
EMPLOYEES

**€750 m**  
MANAGED REVENUE\*

\* Revenue including the share of revenue in jointly controlled companies

**World benchmark in construction and repair of structures**

Post-tensioning, construction methods, cable-stayed structures, structural accessories, structural reinforcement, concrete repair, reinforcing steel protection, earthquake protection and specialised maintenance – the Freyssinet Group makes its specialist services available in two major fields: construction and structural repair. Covering the design of structures, the production of materials and equipment and their implementation on site, the Group offers integrated technical solutions for a wide variety of structures.

**NEW ORDERS**

- Extension of the Tsentralnyi Stadion (central stadium), Volgograd, Russia
- Repair and cathodic protection of oil tanker quays in Port Bonython, Australia
- Repair of the Pánuco tunnel along the Durango-Mazatlán motorway, Mexico
- Reinforcement of a car park at Gatwick airport, London, United Kingdom
- Rehabilitation of bridges along Interstate 895 – Arthur V. Sheridan Expressway, New York, United States
- Heavy handling operations (Autoripage®, Autofonçage®) on several structures along the future Grand Paris Express line, France

→ After closely analysing the requirements with the client, Freyssinet UK devised and patented a technique that involves cutting the arch free from its abutments and wing walls so it can be jacked skywards to enlarge the space below it. The solution was successfully trialled in October 2016. This low-cost system has been developed to considerably reduce the amount of time during which a line has to be closed to a few hours rather than the several weeks it would take to completely rebuild the bridge or lower the rail line. I am confident that this bridge lifting system will be applied in many places around the world.

**You were appointed Chief Executive Officer of Freyssinet in July 2016. What are your impressions as head of the Group?**

I am resolutely optimistic. I have been with the Group for several years but taking the helm changes your perspective. I have visited a large number of subsidiaries around the world over the past few months to meet our teams. Everywhere I went, I saw potential for expansion. We have excellent employees, our network has a good presence on all continents and our ranges of technologies and services are outstanding assets. The world construction and repair markets will continue to grow in coming years.

**Will you be emphasising organic growth?**

We will not limit ourselves to that. We will look for opportunities to acquire companies that make strategic sense. At the end of 2016, we acquired the Carpi company, which specialises in waterproofing geomembranes for hydraulic dams and canals (see page 8). That acquisition creates strong synergies with our business lines and opens up a new market. But Freyssinet is not attempting to expand in all directions. Our priority, in my view, remains adapting our business model, which must evolve to enable us to provide our clients with earlier project support, and continuing our innovation efforts to provide an increasing number of solutions. To do this, Freyssinet has the support of a rock-solid organisation and in particular its project managers and teams of supervisors working around the world.



# THE INTEGRATED APPROACH: THE INNOVATIVE COMMON FEATURE



Innovation consists in devising, designing and marketing a high value-added breakthrough product. At a time when contracting authorities are seeking comprehensive turnkey solutions, from design studies to project closeout, Freyssinet focused on integrated innovation in 2016. This is the combination of innovations in design, equipment and construction methods that defines the company's added value and makes it possible to deliver high quality structures on time, with optimised costs and quantities of materials.

## Serving operational excellence

In designing viaducts for the Northern Marmara Highway project in Turkey, Freyssinet teams reduced the quantities of materials used by 45% while accelerating the pace of construction. The quantity of concrete was cut by 35% and steel 50%. This was achieved by using an innovative seismic design suited to the specific features of the structure, which has 80-metre-high piers, and the incremental launching method to build the deck, which is rarely employed at these heights, as well as viscous dampers in the abutments. In 2016, the integrated innovation method was used in several areas of activity, including cable-stayed stadium roofs, ultra-high performance fibre reinforced concrete (UHPFRC) repairs, and earthquake-proof structures.

## Integrated service: structure, products, methods and works

For the Çallı bridge in Antalya, the teams once again combined innovations. For the project, which was handed over in a record seven months, Freyssinet proposed an extrados based alternative solution combined, for the first time, with a special deck and tower isolation system. The use of elastomer isolators with lead cores limits the forces transmitted in the extrados cables. Another innovation on this viaduct was the use of extrados 1,960 MPa strand stay cables. This unusual steel grade was first used in the construction of the Yavuz Sultan Selim Bridge. Inaugurated on 26 August 2016, the structure earned Freyssinet a number of records: the highest towers (322 metres), widest deck (59 metres) and longest span for a combined road and rail bridge (1,408 metres). Further innovations, such as special dampers and deviator saddles, were also devised for the project. In 2016, Freyssinet continued to innovate by introducing new cathodic protection systems and stay cables with unprecedented fire and blast resistance. The potential of these technologies will only be fully exploited when they are integrated in a virtuous circle of innovations that offer clients technical and implementation capabilities.



**Ömer Güzel - Yapı Merkezi Construction and Industry Inc.**  
General Structural Design Coordinator

*"The Awash-Kombolcha-Hara Gebaya (AKH) line is an important railway project that will link the central part to the northern part of the country. This project will reflect the identity of Ethiopia and will be an exemplary model for Africa with a potential volume of 17 million passengers in 2030. Freyssinet's Turkish subsidiary Freysaş has provided comprehensive support with fast and efficient solutions for a creative and optimal design of the seven bridges, responding in particular to seismic demands. All solutions are provided under the coordination and thorough validation of the Freyssinet Technical department. The steel piers are connected to the reinforced concrete pedestals via Freyssibar which provide a safe and time-efficient solution. The superstructures are isolated with the utilisation of PDS devices which provide a quantitative efficiency on the substructure. The longest viaduct with a length of almost 615 metres and a radius of 800 metres in the superstructure was erected with ILM over 52-metre-high steel piers."*

“ A creative and optimal design ”

**TMCLK viaduct**  
Tuen Mun - Chek Lap Kok, Hong Kong



2,639  
SEGMENTS

That is the number of prefabricated segments that will be erected by Freyssinet for the viaduct that will connect Lantau Island to an artificial island, currently under construction to extend Hong Kong's International Airport. Freyssinet will also supply and install 7,000 tonnes of post-tensioning, bearings and movement joints. In 2015, Freyssinet commenced the deck erection, and on 12 January 2017, the 1,000<sup>th</sup> segment of viaduct was completed. Specially-designed equipment was used, notably two launching gantries, each 200 metres long, and two pairs of lifting frames. Precise planning for each task was required, since the viaduct passes over roadways and railway lines, and is in a flightpath, which means restrictions on the use of marine cranes and short suspension in traffic (four hours) to allow placement. To meet the challenges of a restricted and busy site requires erecting segments in several places simultaneously, with the appropriate number of mobile, multi-skilled teams, capable of operating in different environments with various construction methods. This viaduct is one of the two major contracts being undertaken by Freyssinet in Hong Kong, along with the Liantang 3 (LT3) viaduct.



**Clemenceau Medical Centre**  
Amman, Jordan

**The biggest repair project within the Middle East**

In the Al Abdali neighbourhood of Amman, Freyssinet's Jordanian subsidiary is working with the Major Projects department to design, supply and carry out the strengthening works for a 125-metre-high tower, its ancillary buildings and four underground levels. Between February and December 2016, the Freyssinet teams helped transform the residential building into a specialised medical complex. The work involved 25,000 linear metres of bonded carbon fibre fabric (Foreva® TFC-H) structural strengthening and 2,000 tonnes of dry shotcrete. Freyssinet also carried out the preliminary overall structural studies focused on behaviour and stability and helped define the repair and demolition schedule. To meet safety, productivity and quality requirements, the teams designed, as a "shotcrete lifting platform", a concrete handling and supply system for the shotcrete machines. The technical and logistical innovation made it possible to pump the dry mixture through pipes to a height of nearly 125 metres, with the double advantage of having equipment that could be used in a limited site footprint with expected storage capacity (containers, compressors, air tanks and dryers, silos, etc.) and facilitating day-to-day coordination with the partners and the other companies working at the site.





**Nouvelle Route du Littoral coastal highway viaduct**  
Reunion Island, France

At the end of 2018, the offshore new coastal highway viaduct will become France's longest structure of its kind. Freyssinet is helping to build the seven consecutive decks making up the major structure on Reunion Island by installing post-tensioning systems. In order to minimise risks and climate contingencies related to marine works and to maximise environmental protection, special construction methods are being used and 95% of the structure is being prefabricated on dry land. The piers and special segments are transported and installed offshore using a self-elevating megabarge named Zourite. By the end of 2016, all the segments of the first viaduct had been prefabricated and installation work was under way. The first of the 48 spans was completed in January 2017 with the prestressing of some 100 tonnes of strands. Meanwhile, Freyssinet is designing, supplying and installing the cathodic prevention system to protect the 48 viaduct spans from corrosion. Freyssinet experts, assigned full-time to provide support for the project now in full swing, designed the system, which involves flush point anodes for submerged areas and ribbon anodes embedded in the surface coating for tidal areas.

**5,400 METRES**

**Caltex refinery**  
Kurnell, Australia



**Professionalism and attention to detail**

These were the two main qualities that oil company Caltex Australia Limited identified in the teams from Freyssinet's Australian entity, when it picked the company for remedial maintenance at its Kurnell oil terminal. In 2016, Freyssinet Australia staff began carrying out weekly surveillance and maintenance operations on the pipelines which carry high-pressure liquid petroleum products from the Kurnell refinery to its various terminals in Newcastle, thus saving some 45,000 trips by tanker truck per year. The contract covers patrols, surveys, repairs and work supervision for third party activities, meaning Freyssinet can demonstrate its technical expertise on a weekly basis in terms of cathodic protection, painting, blasting, and coating, and prove its dedication to meet the safety and reliability demands in the fuel distribution sector. As the first three-year maintenance contract won by Freyssinet Australia, this operation opens fresh prospects for growing remedial and repair activity, notably in the petrochemical sector.

**Becoming a major player in renewable energy infrastructure**

In Brazil, Freyssinet continued work on the Trairi II wind farm. The company designed and built the foundations and 36 prefabricated prestressed concrete wind turbine towers, which reach a height of 120 metres. Each tower is made up of 32 precast concrete segments, cast using a match-casting technique, and assembled on site using a special lifting device that erects the tower in sections in an inverted manner (the lower tower sections are inserted below the upper tower sections once the latter have been assembled and lifted). Experts in the Technical department developed the innovative lifting device, called Eolift®. The result is a faster construction method that is less sensitive to the effects of wind. After segments erection, the towers are fitted with external post-tensioning cables and electromechanical components, some of which (ladders, platforms, lifts and cable supports) being designed, supplied and installed by Freyssinet. The site teams designed the precast yard, precasting moulds and other specific equipment, and defined the main operating procedures on site. The last lifting operation took place on the Ouro Verde 5 tower on 9 December 2016.

**Trairi II wind farm**  
State of Ceará, Brazil



**US 131 – Bridge over the Muskegon River**  
Big Rapids, Michigan, United States

**10 November 2016: Freyssinet received an award from the International Concrete Repair Institute (ICRI) in recognition of the excellence of its rehabilitation work on a bridge**

Built in 1982, over the Muskegon River in Michigan, this 180-metre box girder bridge was showing signs of deficiencies. Freyssinet proposed several remedial measures, including modification of the piers, supply and installation of eight flat jacks, diaphragm retrofits, crack injection, external post-tensioning within the box girders, articulating concrete blocks, joints and epoxy overlay. This alternative solution, involving flat jacks, concrete corbels composed of steel reinforcement, 45 MPa concrete, and external post-tensioned steel bars, added strength and load carrying capacity, thus allowing the bridge's lifespan to be extended without having to replace structural elements. The Freyssinet teams made their technical expertise available to deliver a project with controlled costs, delivered ahead of schedule, and carried out in close cooperation with local authorities. Meticulous scheduling of the work made it possible to reduce the number of scheduled traffic detours required to complete repair and strengthening work on the bridge that is part of a popular travel route taken by thousands of weekend vacationers.

**HELCZA complex**  
Plzeň, Czech Republic



# NUVIA

## A new era in the nuclear sector

With several Nuvia entities taking part in the major ITER project in Cadarache, France, the ITER Organization has selected Nuvia teams in the Czech Republic to carry out cyclical resistance testing for ITER EU primary first wall components. A unique experimental complex was created to perform the tests. Called HELCZA (High Energy Load Czech Assembly), the technology can test components subjected to high temperature flux and in direct contact with the plasma. From cameras to vacuum units and sensors, the machine was comprehensively designed and built by Nuvia CZ as a contribution to the construction of the world's largest-ever tokamak. Over the next several years, about 30 panel variants will be tested.



**BRUNO LANCIA**  
Chief Executive Officer,  
Nuvia

# A major nuclear New Build player

**How did your markets shape up in 2016?**

The year was fairly stable overall, with significant differences from one country to the other. In France, we experienced strong growth driven primarily by the design-build Epure project in which we are helping to put up a new nuclear radiography facility. In the United Kingdom, the diversification of our activities in EPC and turnkey projects involving the construction and maintenance of waste treatment facilities has compensated for the decline in the decommissioning market. In the rest of Europe, business remains brisk in the Czech Republic following a record year in 2015, while in Sweden, the announcement that a number of reactors are to be shut down has curtailed development.

**The nuclear industry, in which time is measured in decades, is less sensitive than other sectors to the impact of economic crises...**

That is true, but there is another side to that coin: in a more buoyant economy, without leverage effects, the sector does not experience very strong growth. And in this market, which is by nature quite stable, investment strategies are closely predicated on political decisions. Against that

**A good success in 2016?**

Recognition of our capabilities and experience in EPC (Engineering, Procurement and Construction), notably at Hinkley Point.

**An iconic project?**

HELCZA for the complexity of the device and the passion of the teams involved (see page 64).

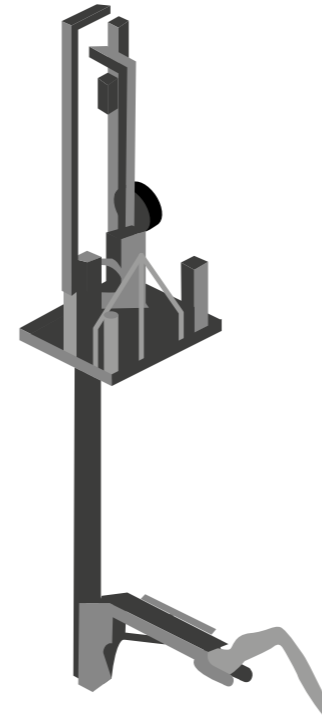
**A watchword for 2016?**

*Convergence*: the variety of our complementary expertise, activities and locations in 12 countries is an asset for our employees and a one-of-a-kind advantage for our clients.

backdrop, EDF's decision to build two new EPR reactors at Hinkley Point near Bristol has given the sector a new lease on life in Europe and sent a clear message of support for the carbon-free energy source to the international community. Nuvia's participation in this important project confirms its status as a major nuclear New Build player.

**One of Nuvia's strengths is that it works across the entire life cycle of a nuclear facility. Its scope of work in France illustrates this perfectly.**

We are indeed involved in the "Grand Carénage" overhaul programme designed to make EDF's fleet of power plants even safer. We are handling heavy maintenance operations such as condenser retubing works in Cattenom and turnkey construction at power plant sites. Nuvia is also involved in a novel programme in France: the start of decommissioning of the reactor vessel at Chooz A in the Ardennes, together with Westinghouse Electric France. Over a number of years, the project will call for broad capabilities ranging from civil engineering to mechanical engineering and radiation protection. →



**Nuclear specialist**

The Nuvia Group works throughout the life cycle of nuclear facilities, from construction to operation, maintenance and decommissioning. The Group's expertise covers three major areas of nuclear activity: engineering, services and works, and products. It includes safety and security in all its activities, which cover civil engineering, mechanical engineering, waste management and radiation protection, including nuclear measurement, and fire and flood protection.

**2,535**  
EMPLOYEES

**€345 m**  
REVENUE

**NEW ORDERS**

- Five-year renewal of the operating contract for nuclear facilities at the CEA's site in Valduc, France
- Supply of NUVIA Tech Protection biological protection systems at the EPR in Taishan, China
- Renewal of the project management contract for decommissioning the Kozloduy nuclear power plant, Bulgaria
- General contract covering the European Spallation Source (ESS), a proton accelerator used to create neutrons, Sweden
- Project engineering for equipment at the new hospital centre in Condrieu, France

→ Outside the nuclear power plant fleet, the Epure project launched at the CEA (French Alternative Energies and Atomic Energy Commission) site in Valduc and the international ITER project in Cadarache are demonstrating our teams' ability to carry out major design-build projects.

**What other activities are you developing in 2016?**

Safety and security of the facilities are ongoing challenges that require excellence on the part of all industry participants. In this spirit, we are expanding our facility protection and nuclear measurement product lines around the world under the NUVIA Tech brand. In parallel with our longstanding activities in the nuclear sector, we are continuing to broaden our capabilities in other sectors. For example, Nuvia is increasingly involved in the healthcare sector in Europe through its design and production of radiation measuring equipment.

**Have you made any noteworthy progress in innovation?**

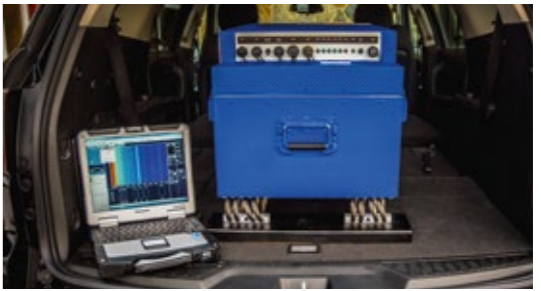
At the Sellafield site in the United Kingdom, our teams developed an innovative system for decommissioning a chimney at a nuclear facility (see page 73). The latest dismantling work got under way in January 2017. In 2016, we signed two strategic R&D partnerships with CEA Tech to design and develop new nuclear measurement equipment.

**Is international expansion still on the Nuvia brand's agenda?**

As a major source of carbon-free power, the nuclear industry can expect a promising future. More and more countries are including nuclear power in their energy mix or are preparing to do so. There have never been as many new power plant projects. But the centre of gravity is shifting from North America and Europe to Asia and the Middle East. We will consolidate our business in our current areas of operation, but we are also going to accompany this historic evolution by giving ourselves the ways and means of operating in key countries.



# SIRIS AT THE SERVICE OF SAFETY



In Canada, Pico Envirotec built on its geolocation and nuclear measurement expertise to develop SIRIS (Stand-off Integrated Radiation Information System), which detects and identifies radiation at a distance. It is suited to the detection of illicit radioactive materials and meets key requirements of the civil defence and military authorities.

## An innovative remote radiation detection system

At a time when the threat of nuclear terrorism is taken very seriously, SIRIS can detect neutrons, identify isotopes (from both artificial and natural sources) and detect high doses. It uses sensors and the new isotope identification algorithms developed by Pico Envirotec experts in 2016 to locate radioactive sources in complex environments. "The system consists of a detection module and a laptop computer for data acquisition and system setup," says Ian Newkirk, Production and Client Service manager at Pico Envirotec. The detection unit is a reinforced case containing two scintillation detectors, a Geiger-Mueller tube, a solid neutron detector, a multi-channel analyser (MCA) and an uninterruptable power supply (UPS)." As such, SIRIS is an integrated tool that can be used to dynamically or statically collect data as well as to display it in real time via customisable audio and visual alarms, and to control processing and analysis.

## Accurate evaluation and swift localisation

Rapidly searching for and locating chemical, bacteriological, radioactive, nuclear and explosive (CBRNE) substances is a key civil and military defence issue. In 2016, the Canadian teams at Pico Envirotec continued to develop SIRIS in close cooperation with the United States Department of Defense and came up with new solutions meeting needs on the ground, for example to track illegal trafficking in radioactive materials. The system can not only locate the sources of radiation but establish a reliable distinction between potential threats and radioactive materials that normally occur in nature. So SIRIS is an ideal tool for use in security patrols.

Highly trained and solid technical experts



**John "Jack" O'Neil - The JGW Group**  
Vice-president

*"SIRIS is an innovative detection system that is particularly well suited to the safety needs of homeland security groups such as customs and border patrol, local and national law enforcement agencies, first-responders to CBRNE (chemical, bacteriological, radioactive, nuclear and explosive) attacks, the military, special research departments, teams in charge of special events and personnel responsible for protecting high-value buildings, assets and iconic sites. As a special partner of Pico Envirotec, we worked together to accelerate the launch of SIRIS on the U.S. defence and security markets. The technical experts at the Nuvia subsidiary in Canada are highly trained and solid. Not only do they help to improve the product by offering increasingly sophisticated and cutting-edge innovations, but they also facilitate marketing. Building on longstanding expertise in customised, mobile (airborne and land-based) radiation detection systems, they are responsive to clients seeking simple, user-friendly solutions."*



**Nuvia Structure**

In 2016, three years of advanced calculations and testing of the bearings designed to support the cryostat in Cadarache were completed. The cryostat is the heaviest component of the future ITER nuclear fusion reactor and the largest - at 16,000 cu. metres - stainless steel high-vacuum pressure chamber ever built. The bearings, which must withstand sharp dilation and rotation under load as well as very low temperatures, were tested on an outsized test bench in Italy. Nuvia Structure and Nuvia Process worked

in a joint venture with Westinghouse Electric France for EDF to build the waste processing unit at the Chooz A reactor in the Ardennes region. A crucial step in this major event in France in 2017: the underwater decommissioning of a pressurised water reactor (PWR) vessel. This year, teams from Nuvia Structure also helped build the first two Emergency Diesel Generators (EDG), with one goal: to reinforce the safety of the facilities in the post-Fukushima era. In parallel, they carried out major maintenance operations such as **condenser retubing works at Cattenom** and the replacement of steel-core reinforced concrete pipes at several nuclear power plant pumping stations.



**Nuvia Access**

The new Nuvia France subsidiary specialising in equipment to provide secure access to work areas operates upstream from the other Group entities. Its expertise in such things as scaffolding, coatings, logistics, containments and protection helps with bids on turnkey projects. 2016 projects included the **design and installation of access equipment to partly replace the CBAT (steel core reinforced concrete piping) equipment at EDF's Paluel power plant**; the containment of infrastructure prior to asbestos removal at the French Alternative Energies and Atomic Energy Commission's (CEA) Gramat centre and rail borne tarpaulins placed on facilities in the military port of Cherbourg.

**Millennium**

In 2016, the Millennium teams rounded out their range of scientific modelling and calculation and statutory analysis and inspection solutions by adding high value-added solutions covering fire, multi-physical calculation, as well as human and organisational factors (HOF) in risk assessment, in the nuclear industry. They also broadened their design range to include expertise in nuclear facility and component design projects, and undertook active participation in the Franco-British Epure project in Valduc. The company reinforced its partnerships with CEA, EDF, and AREVA and extended the scope of its work with the National Radioactive Waste Management Agency (ANDRA). Millennium also carried out extensive nuclear physics studies to optimise **the facilities of the future ARCHADE** (Advanced Resource Centre for HADrontherapy in Europe) cancer treatment centre in Caen (see page 79), other medical facilities using particle accelerators and the accelerator system called AGLAE (for *Accélérateur Grand Louvre d'Analyses Élémentaires*) which remains the world's only facility dedicated to the study of heritage objects to be located in a museum laboratory.



**Nuvia Support**

Nuvia Support coordinates and manages activities such as logistics, radiation protection and facility operation services. In 2016 it continued to deliver solutions in line with the objectives of nuclear operators. In addition to multiannual **global site work assistance at the Cruas, Dampierre and Penly power plants**, the teams worked on EDF's nuclear fleet to carry out decontamination work, using equipment specially designed and developed by Nuvia.



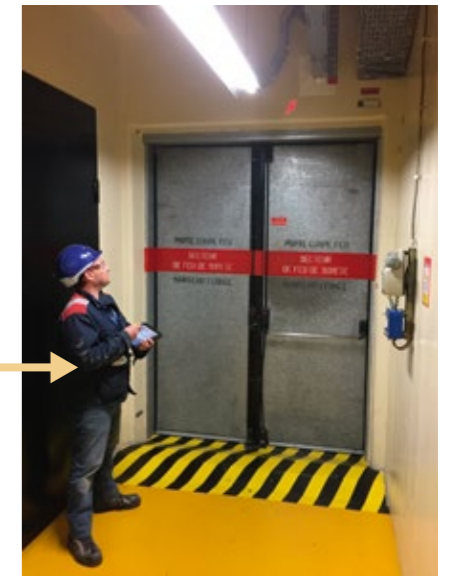
**Nuvia Process**



At the CEA site in Marcoule, France, remote operators at Nuvia Process implemented the MAESTRO slave arm manipulator to dismantle highly radioactive equipment and in-cell pipework in a highly radioactive environment. This is the **first "active" pilot project using the MAESTRO arm**. The innovation more broadly illustrates the expertise of the teams that resulted in the renewal of several multi-year contracts in 2016, including plant operation of the Marcoule tritium workshop (ATM). Nuvia Process began laser cutting operations on the R7 evaporator in La Hague, completed dismantling and decontamination of Room 60 at Marcoule and took samples in highly radioactive tanks at the two sites. Lastly, the dismantling of the plutonium technology workshop (ATPu) and the chemical purification laboratory (LPC) in Cadarache, which were commissioned in the 1960s, was completed in December 2016. Overall, this amounted to 400,000 hours of work since the decree authorising shutdown was issued in March 2009, making this one of France's most extensive dismantling projects involving plutonium.

**Nuvia Protection**

Nuvia Protection, market leader in protection of sensitive industrial sites, consolidated its order backlog in passive fire protection by securing a major contract to seal penetrations at EDF's fleet in operation. A digital solution was proposed for this project: the **introduction, at eight sites, of digital tablets to monitor operations**. The subsidiary continued its technical development work, which led to qualification of new products for ITER, and signed new contracts in Belgium, South Korea, China, India and Japan.





### Nuvia CZ

In addition to the successful HELCZA project (see page 64), Nuvia CZ conducted brisk business in 2016. Many software development projects are under way for data acquisition and radiation monitoring systems, including continuous improvement of the DAQIS, MonRaS and RaMon measuring, management and inspection tools. Tests carried out on the SuperNEMO demonstrator at the Modane underground laboratory (*Laboratoire Souterrain de Modane*, where research is carried out on the neutrino, the dark matter in the universe) were successfully completed. In other developments, the solutions devised by Nuvia CZ to improve monitoring and minimisation of tritium and <sup>14</sup>C radionuclide discharges and to optimise material clearance were implemented at the operational Ukrainian nuclear power plants.

In 2016, the Czech NBC Defence Institute (University of Defence), Air Force and Air Defence Military Technical Institute called on the systems used to monitor radiation in emergency situations, which were developed by Nuvia CZ. A new piece of mobile and stationary on-board equipment used to monitor radiation drew the attention of various security stakeholders. Representatives of the police, the fire brigades, the armed forces and the emergency services as well as universities, research units and government agencies discovered the device at a special presentation meeting held in June 2016, where the installation of **helicopter-borne radiation monitoring equipment was a particular attraction.**

Lastly, Nuvia CZ boosted its solutions and services in all business areas. For example, the company offered new neutron scintillation detectors (NuDET) and a metrology device that can be used to characterise radioactive waste (NuMUM), developed in partnership with the European Commission's science and knowledge service, the Joint Research Centre (JRC) in Ispra, Italy. In 2016 a device was also designed with the Nuvia Process teams and developed to monitor laundry and clothing contamination for the CEA in Marcoule, and a monitoring and sorting portal gate was developed for a Saudi partner to combat illicit traffic in nuclear materials.

### SEA and MED

SEA, which specialises in radiation protection equipment and nuclear measurement, is continuing to promote its flagship product around the world: the portable NuCoMo contamination meter. The two Nuvia subsidiaries in Germany, SEA and MED, offer to adapt **the range of hand, foot and clothing (HFC) contamination monitors** to clients' needs.



### Nuvia UK

In a difficult nuclear business environment in the United Kingdom, Nuvia UK has shown strong resilience and held up particularly well in its historically strong legacy waste management and decommissioning markets. In Cumbria, at the Sellafield site, the final phase of the Sellafield Export Facility project was successfully completed, including on-site installation and inactive commissioning. **Nuvia Group has begun work on dismantling a 120-metre-high chimney**

that rose 60 metres above the United Kingdom's main nuclear fuel processing facility. To carry out this operation, a self-climbing platform (SCP) was attached to the outside of the chimney. In November 2016 it began its vertical sliding operation that enabled teams to gain access to the structure to begin cutting. The teams had received special training in this crucial stage of the works. In addition, Nuvia's operations staff assigned to the site is continuing demolition work under the comprehensive dismantling plan, supporting progress on the Sellafield decommissioning mission.

The year's successes included delivery of a design project at Aldermaston in Berkshire, for the Atomic Weapons Establishment (AWE) and the extension of a 24 hours a day, 7 days a week on-call assistance service contract between the UK Border Force and the Nuvia health physics team.



In New Build, following the investment decision taken by EDF, the Nuvia Group will take part in building the two EPR type reactors in **Hinkley Point**. It will work with Rolls Royce to supply **turnkey subassemblies for the power plant's coolant treatment system: the primary circuit boron recycling and the liquid waste systems.** The Group is also well positioned to take on further major EPC projects at the site, and with other New Build developers.

**Metro Line 5**  
Bucharest, Romania

# SIXENSE

## Final stretch

In 2016, Sixense continued to work on the metro extension project in Bucharest for the Metrorex public company. The teams supplied and installed a complete detection and monitoring system, and they continue to carry out uninterrupted real-time monitoring of site impact on the environment. This is a particularly innovative project in the country that marks the first application of automatic geotechnical instrumentation technologies. The project includes monitoring of ground deformation, buildings and structures in the vicinity of the works via nearly 30 precision Cyclops and Centaur 3D systems. The Atlas monitoring technology, used for the first time in Romania, is based on analysis of satellite images made up of 230,000 measuring points, is used to track ground settlement. Experts monitored groundwater by means of piezometers and tracked ground deformation by placing inclinometers in drill holes or extensometers along the tunnel boring machine (TBM) alignment to measure settlement during and after passage of the TBM as it carries out excavation works. All data is centrally compiled in a single software platform, Geoscope, which is used to process, display, report and archive data, and issue automatic alerts. This is a major step forward in risk management. This is the final stretch for the construction work on the first section of Line 5, which started in 2011. The new line will cross the city west to east and is expected to carry more than 19 million passengers per year.



**BRUNO LANCIA**  
Chief Executive Officer,  
Sixense

# Focus on the entire infra-structure life cycle

**How does the creation of Sixense in September 2016 affect Soletanche Freyssinet?**

The launch of a brand covering a new business line and reflecting the decision to position the Group around the world is an unusual event in an industrial group. However, this new brand was not created from scratch. It brings together 10 specialist companies with more than 20 years' experience, some of which, such as Soldata, already have an international reach. They are all grouped under a common identity and strategy.

**Why did you bring them together?**

Each had its own expertise, but all these companies are working in the same field – optimisation and monitoring of infrastructure, soils and their environment. The goal is to give them more visibility, and to continue to expand them, within their business activities, in France and abroad. And above all, by combining their expertise, we are building new services and solutions for our clients in which digital technology is the flagship component.

**A watchword for 2016?**

*Creation*: since we launched our new worldwide Group.

**Your figure for 2016?**

6, of course! The 6 in Sixense, the sixth Soletanche Freyssinet brand that gives our clients a "sixth sense" in understanding their structures.

**Your ambition for Sixense?**

To be a Group of world-class excellence in digital solutions and consultancy specialising in infrastructure design, construction and operation.

**In what way is the Sixense solution different from that of its competitors?**

Many companies specialise either in digital technologies, in engineering or in a specific stage in the life cycle of an infrastructure project. Sixense supports its clients throughout the structure's life cycle, with the goal of enhancing its reliability and durability. To do this, its services include diverse engineering and state-of-the-art digital solutions that can be used to optimise design-build construction, analyse the structural behaviour over time, anticipate changes and make the right risk-cost trade-off at any point in time. In addition, we offer not only innovative tools but also the services that go with them, in other words analysis, advice and technical support. In digitally modelling data collected by the sensors installed in structures, we are making predictive maintenance a reality. The scope of work that is opened up is huge. The point is to avoid failures and deterioration before they occur. This detailed knowledge of structural behaviour also makes it possible to optimise the design of new installations. It amounts to a virtuous circle based on digital instrumentation and data mining – the "big data" approach... →



**Expertise at the heart of digital services and solutions**

The Sixense Group offers digital services and solutions specialising in infrastructure, soil and the environment in order to understand, analyse, anticipate and optimise clients' investments. Sixense's principal mission is to provide support to designers, builders, operators and infrastructure owners in order to successfully overcome three challenges facing them: construction project management, asset management, risk management.

**21**  
COUNTRIES (LOCATIONS)

**600**  
EMPLOYEES\*

\*Number of Sixense employees in the first quarter of 2017

**NEW ORDERS**

- Monitoring and instrumentation on the Eole project, La Défense, France
- Monitoring and instrumentation, Purple Line, Maryland, United States
- Asset management software for Anglo American's mines in South America, North America, Africa and Oceania
- Asset management software for all bridges in the province of Ontario, Canada
- 3S seismic operation, extension of metro Line 14, Paris, France
- Monitoring of waterproofing coating works (composite skin) on the extrados of EDF reactor buildings at nuclear power plants in Flamanville and Civaux, France

**Another goal: developing collective intelligence...**

Our digital tablet and smartphone based solutions optimise construction project management, as in Digital Site (see page 79), and infrastructure management, monitoring and maintenance, as in ScanPrint (see page 82). With this type of devices, which are fully adaptable to the needs of our clients, all project stakeholders are able to share information and feedback in real time across distances. Not only do we thereby increase overall intelligence to serve the project, but we substantially shorten decision-making circuits. Another advantage of these solutions is that they ensure "zero paperwork" and data collection.

**What are the new market opportunities for Sixense?**

Buildings, transport infrastructure, energy and nuclear, environment, functional facilities, mining – in all these sectors, there is extensive construction, increasing attention to investment optimisation and a need to control interaction between infrastructure and its environment. In addition, more and more building is being carried out in built-up areas. Take for example the Grand Paris projects. This type of work has major impact in terms of noise, vibrations, shifting terrain, utility network relocation, traffic management and environment. The activities and solutions Sixense offers address all these complex issues.

**Do you have priorities for rollout?**

Digital solutions are a core component of our offer. We have therefore set up the Sixense Digital company, in a startup spirit, to centralise our expertise and solutions in this field. We started by rolling out our tools and platforms in France, where we are well established. We will rapidly be rolling out our business internationally. Meanwhile, our subsidiaries will expand their portfolio by providing the entire Group range of solutions and services, notably in Western Europe, North America, Asia, Australia and the Middle East. We will then broaden the network by expanding into new countries.





# DIGITAL SITE: THE BIM-CENTRED WORKSITE



Because 2D drawings have so far been used in most cases to monitor works, it has not been possible to manage information in three dimensions or by object. With Digital Site, Sixense has developed a collaborative tablet or smartphone based tool that supports 3D and hence the use of BIM (Building Information Modeling) in the field. This has brought about a profound change in worksite monitoring, from design to Full Completion Guarantee. In 2016, Digital Site was used on the ARCHADE project in Caen, France (see testimonial opposite). The teams also used BIM to track execution of work on the Saint Gobain high-rise in La Défense, and on smaller-scale projects such as the Emerald wastewater treatment plant in Petit-Quevilly.

■ ■  
**We have boosted quality and reliability in information sharing**  
■ ■



**Donatien Favreau – Sogea Nord-Ouest**  
Works Engineer, Sogea Nord-Ouest, lead company of the design-build-maintain consortium for the ARCHADE project (Caen, France)

*"Building a hadrontherapy research and treatment centre, which uses an innovative particle acceleration technology to treat cancer, involves very exacting quality of execution and controlled production. We therefore set up a 100% BIM programme from the design phase. Because we were making full use of BIM resources, Digital Site was the construction project management tool suited to our issues: building a structure subject to severe constraints, a complex technical synthesis and flows of information involving a large number of participants. Digital Site can extract meaning from a substantial mass of data. Above all, it can manage information, unify it, circulate it and archive it. It has been exciting to watch the development of Digital Site, help improve it based on wide-ranging, constructive discussions with Sixense experts and make use of the further development potential of the already powerful tool, as part of a win-win partnership."*

**Responsiveness serving productivity**

Beyond the objective of "zero paperwork", the "BIM to site" system is now a reality at a time when building information modelling is prompting us to rethink the entire industrial process and the relationships between the stakeholders. Operators, architects, design engineers, builders and maintenance companies share the same database in which the structure to be built is modelled in space and described in detail at the various phases of its life cycle. By going beyond the known borders of the BIM experience, Digital Site enables works teams and QHSE personnel to carry out quality control, Full Completion Guarantee items and Defect tracking and monitoring by directly working on the model contained in their tablet. Participants can notify defects more easily and often earlier, in the design stage or even during factory quality controls. They can anticipate nonconformities and set up dynamic planning to boost productivity.

**Centralised information accessible to everyone**

"By avoiding double data input and using the documentary management system to ensure traceability of activities and manage the document life cycle, Digital Site generates substantial reliability gains," says Rodolphe Chabannaud, Director, Sixense Digital. "All participants have access to the same level of information, which is centrally collected in a single tool, virtually in real time." Lastly, the system automatically generates a large number of contractual documents, forms and slips, and helps produce the as-built records. It also helps to ensure consistent information sharing between the operator, general contractor, builder and investor. By making detailed analysis of the data and statistics collected available, Sixense has entered the era of big data and is already working to make this project overview, obtained in a few clicks, into an added value that can be used for many purposes, including anticipating, predicting and planning maintenance with great precision.

**Thames Tideway Tunnel, East Section**  
London, United Kingdom



**Towards environmental excellence**

The Thames Tideway Tunnel in London consists of excavating 25km of tunnel and several shafts to cope with overflows of untreated sewage that currently flows into the River Thames. The Sixense team was involved early on to provide structural and environmental expertise, and an integrated monitoring service on this vast project, which is being built by a consortium comprising Costain, VINCI Construction Grands Projets and Bachy Soletanche (CVB). The works are being carried out in the heart of the capital where issues relating to local residents' sensitivities, urban density and property pressures are acute, meaning the effective management of ecological and environmental issues is crucial to the success of the project. In 2016, Sixense rolled out a unique environmental monitoring tool that integrates data from automatic sensors and manual measurements to provide real-time analysis coupled with a dynamic alarm system. The company also acts as consultant to the consortium by carrying out provisional and forecasting calculations, and approving solutions to manage risks involved in the operation, notably in terms of noise and air quality. In this project, carried out in an occupied site, community outreach is an essential part of the works scheduling and organisation process. Using the Geoscope software platform has allowed information to be shared depending on the different phases of work, and enabled better communication between the various stakeholders in the project. In a separate innovation, in partnership with CVB, Sixense is studying the implementation of a technique for detecting gaps and cavities in the annular tunnel space in order to ensure quality of injection following passage of the tunnel boring machine (TBM). This further illustrates its expertise in anticipating and monitoring the impacts of large-scale sites in complex urban environments.

**Yavuz Sultan Selim Bridge**  
Istanbul, Turkey

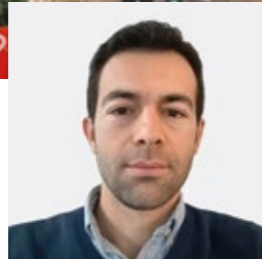
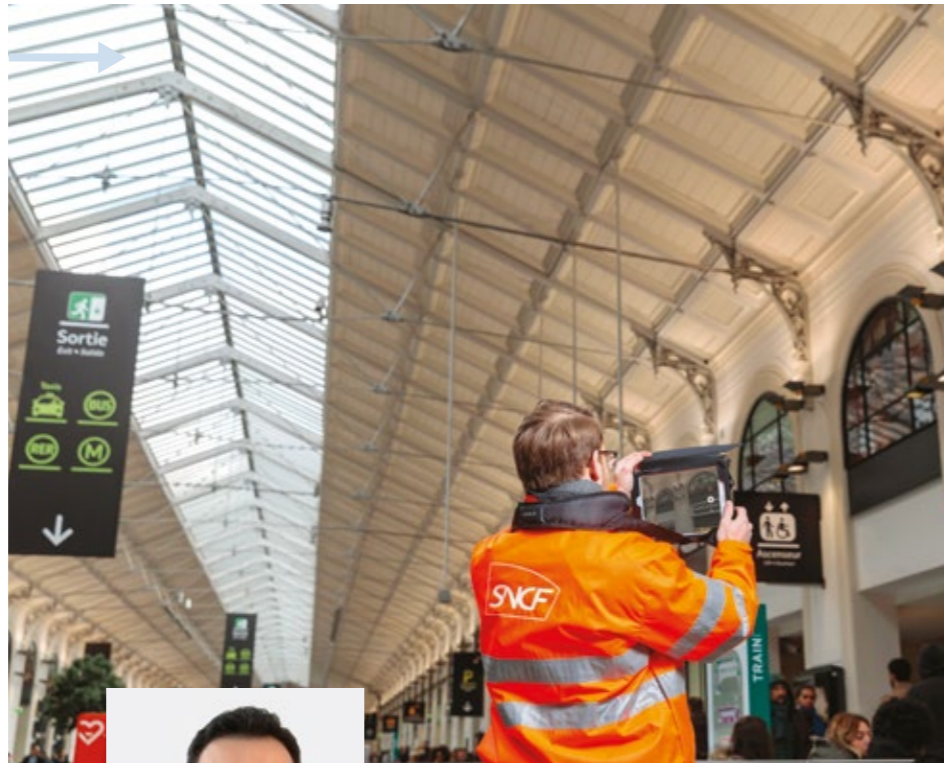


**1,000**  
**MEASUREMENT**  
**CHANNELS**

The Sixense subsidiary dedicated to infrastructure monitoring and management solutions handled monitoring operations on the third Bosphorus bridge (see page 59) and then, when construction had been completed, measured tension in the hangers and stay cables and carried out a modal analysis of the structure. The work consisted primarily of implementing a continuous monitoring system made up of more than 1,000 measurement channels with accelerometers, differential GPS sensors, inclinometers, weather met stations and temperature, humidity and displacement sensors. The sensors were installed on the support cables, stay cables, expansion joints, deck, and towers culminating at a height of 322 metres. The indicators used to monitor the structural condition of the bridge and the proper operation of the monitoring system itself are particularly innovative; they detect abnormal bridge ageing and issue alerts. The same function is performed with respect to damage due to an earthquake or breakdown in the monitoring system. Another advantage is that the combination of the EverSense® monitoring solution and Sixense's ScanPrint SHM (Structural Health Monitoring) management tool integrates the measurements and processes them simultaneously and continuously. This combination gave clients Hyundai and South Korean Engineering Construction unified structure data in the same software package and will do the same for ICE, the company operating the bridge and its toll motorway.

**SNCF VGM application**  
France

In 2016, the Sixense teams helped us develop a modern, integrated software package to digitise our control system and optimise management, monitoring and maintenance of our platforms and buildings. Their agility and experience enabled us to set up the SNCF VGM mobile app using ScanPrint software and to implement it in under three months. The application is in the running for the SNCF Group trophies and has already won Gares & Connexions and SNCF Mobilités trophies. Today, 34,000 goods are recorded in the application's inventory and more than 200 of our agents are patrolling our stations, equipped with tablets. With this tool that has been adapted to our needs in terms of personalisation, display and notation for works, we carry out our technical inspections, safety audits and incident feedback in an efficient and documented manner. A total of 60,000 photos were taken and 2,900 inspections were carried out in 2016. The result is centralised data, more precisely targeted interventions, more efficient schedule management, optimisation of time allocated for inspections, a hierarchically organised maintenance base and therefore, ultimately, optimised costs. We are already thinking about improvements in 2017 that will enable us to integrate our structures that make up stations and to include new functionalities reflecting feedback from users.



Pelayo Villanueva  
National Engineering Structure  
Adviser, Gares & Connexions,  
SNCF (France)

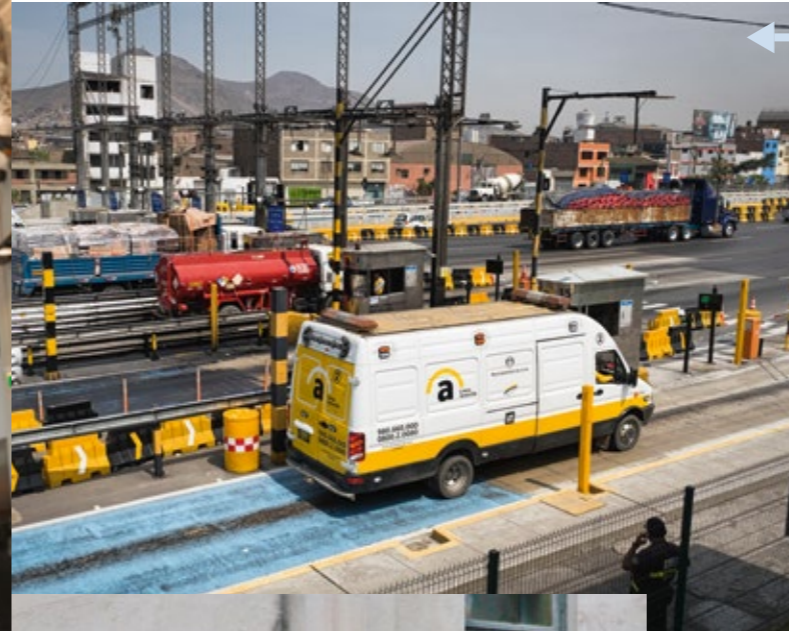
**In April 2016, EDF's engineering division covering assets in operation and under deconstruction and the environment (DIPDE) asked Sixense to inspect 24 units within 10 nuclear power plants**

As part of the basic civil engineering preventive maintenance plan and their fire action plan, the new five-year contract covering three sites in Normandy, three in eastern France and four in the Rhône-Alpes region, gives 35 Sixense employees dual inspection and consultancy responsibilities. Building on the successful partnership on the CPO unit in Fessenheim and Bugey that demonstrated the engagement and rigour of the operational staff, Sixense carries out periodic inspections, classifications and alert reports concerning civil engineering risks (concrete strength, waterproofing, cracks, etc.) and fire safety systems (sealing, passive protection, loss of fire sectorisation integrity, etc.). The teams are thus contributing to ensuring the first component of a broader strategy aimed at extending the life of the French nuclear fleet and ensuring its continuous improvement, at a time when the need for preventive maintenance is a focus of attention as part of the post-Fukushima nuclear safety programme now being implemented.



**10 nuclear power plants**  
France

**Línea Amarilla highway**  
Lima, Peru



**An urban motorway with 12 viaducts and a road tunnel**

In 2016, VINCI Highways acquired 100% of the LAMSAC company, the concession holder in charge of financing, building, operating and maintaining the 25km Línea Amarilla toll section of the Lima ring road until November 2049. By acquiring a project that was already more than half completed, the VINCI Concessions subsidiary was taking on a large challenge. The standard section now in operation is a thoroughfare with average traffic of 139,000 vehicles per day in 2016. Soletanche Bachy took part in the construction of a number of structures, while Sixense experts worked with the VINCI Concessions technical teams during the bidding phases in May and June 2016, and during completion of work on the section. They were charged with providing advice during the transition between the builders, with drawing up a report on the condition of the existing structures and a list of issues to be taken into account when completing the works. Based on data collected during on site assessments and reviews of project files, a maintenance plan was drawn up. It takes account of the initial condition of the asset, environmental and traffic conditions, and assumptions with respect to deterioration and associated maintenance of the structures and bridge equipment. In addition, the Sixense teams were given a specific audit assignment to assess the conformity of a part of the road tunnel on the Línea Amarilla. It was completed in November 2016 and combined the expertise needed to verify the calculation of the section's stability as it passes under the Rimac River and to analyse the risks relating to durability and maintainability throughout the concession period.



**City Rail Link**  
Auckland,  
New Zealand

**15  
ROBOTISED  
STATIONS**

In Auckland, Sixense is working on the City Rail Link (CRL) new underground rail line. The project, which consists in building two rail tunnels and connecting them to existing tracks, is being carried out under and around one of the city's large stations, the Britomart Transport Centre. As part of this project, Sixense handled the infrastructure monitoring network primarily composed of 15 robotised Total Stations using laser measurement and more than 1,000 measuring points to monitor buildings and pavement deformation around the sites. The team is also using piezometers, inclinometers and stress gauges to track the movement of the retaining walls and anchors during excavation works. This real-time monitoring is made possible thanks to the digital platform, Geoscope, and its capability to trigger alarms. Sixense is carrying it out to ensure site safety and reassure local residents.



SOLETANCHE FREYSSINET

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