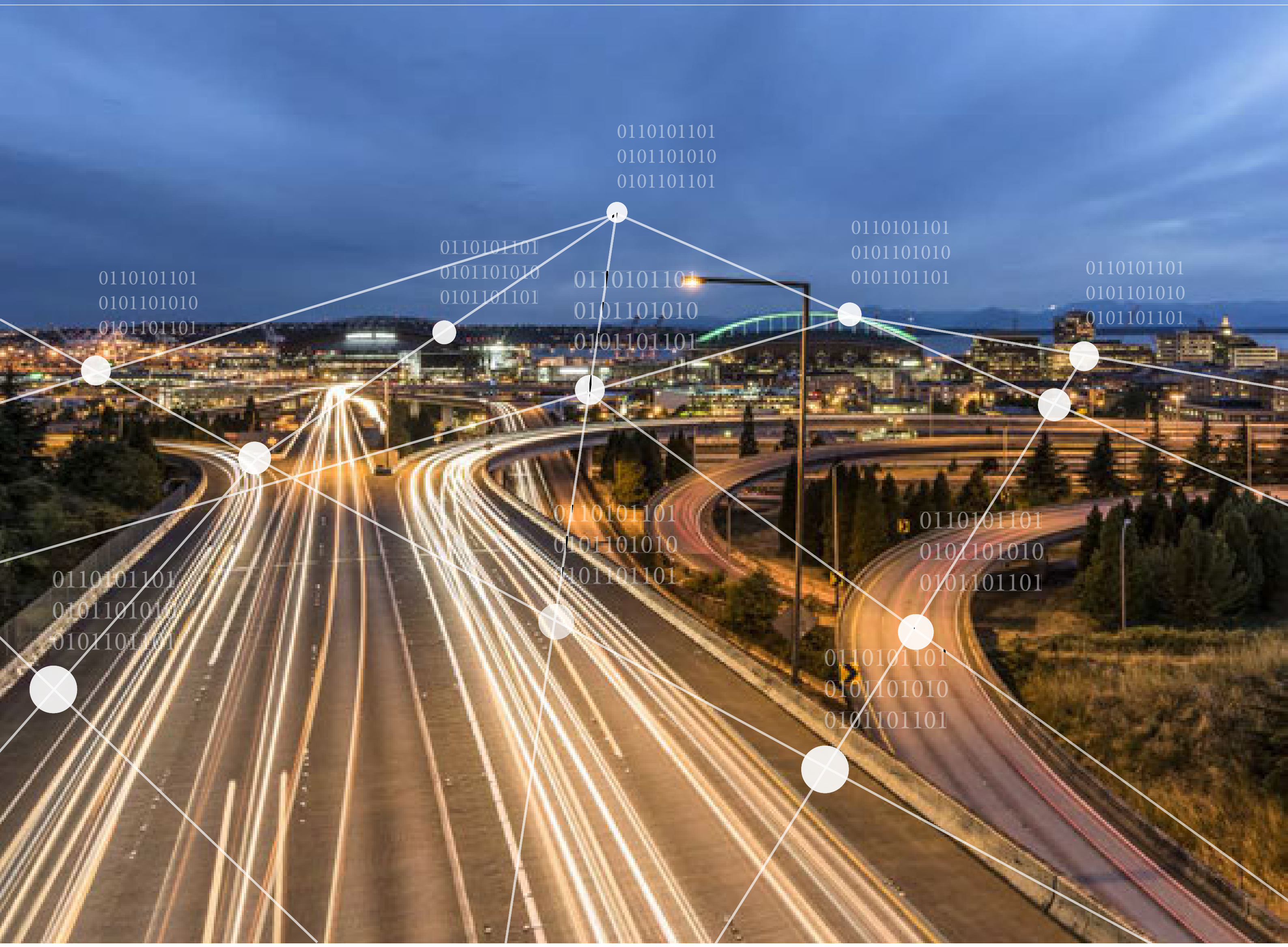
STRUCTURES

NO. 8 THE OSMOS GROUP'S MAGAZINE

BRIDGES, FROM EVERY ASPECT

REPORT P//18



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STRUCTURAL HEALTH MONITORING

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STRUCTURES
THE OSMOS GROUP'S MAGAZINE

PROVIDING PERSPECTIVE

A blend of technical magazine and business report, the corporate magazine STRUCTURES puts OSMOS's activities into perspective with the market and its players. It sheds light on the company's development and its expertise, namely in behavioral engineering for bridges, but also in the company's technological innovations and the synergies that it builds with players in the fields of construction, insurance and engineering.
Written in collaboration with the different departments, clients and partners, STRUCTURES Magazine aims to explain and demonstrate to its readers the company's unique expertise and added value in a booming market.

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One Manager's Vision

EDITORIAL

Pâris Mouratoglou,
Chairman of EREN Group & CEO of OSMOS Group

"The EREN Group aims to invest in the industries and services of tomorrow, and to use new technologies to preserve natural resources in a lasting, profitable way. Alongside the production of renewable energies (solar farms and wind farms) and energy storage and water treatment processes, OSMOS is perfectly in line with that strategy. Optimizing the structures' operations and lifespans guarantees the improved usage of natural resources – power and the materials that make up the structures – but also of maintenance and reconstruction budgets.

By developing optoelectronics, software and mathematical models,
OSMOS contributes to the world of smart devices and big data, and helps to design the world of tomorrow. On the structural monitoring market, OSMOS enjoys high added value, since it is able to capitalize on its twofold expertise: first, in sensors capable of capturing a very large volume of extremely precise data and, second, in the algorithms that process those data.
In 2016, the teams focused on those two priority areas of development. First, considerable work was done on our technologies, to ensure they meet the highest standards that we set for ourselves for the long term. In parallel, we developed software programs to use the math applied to the structures' models.

Now supported by a range of high-performance sensors, innovative operations, and a comprehensive toolbox for optimal data exploitation, OSMOS is ready to take on the challenges that await us. At present, we want to concentrate on international rollouts, with the help of our sales and technical teams and our partners around the world. The synergies generated between the international EREN Group's different business areas, OSMOS's membership in a major group, and our substantial financial resources put us in a great position to meet those challenges."

A Growth **Market**

Solid historical partners

Since its creation, OSMOS has considered its international rollout to be a development priority, particularly by maintaining special relationships with countries that are already heavily engaged in structural monitoring (Canada, Germany and Japan) and by ramping up projects in various key sectors in those countries: bridges, tunnels, railroads, buildings, historical heritage, and so on.

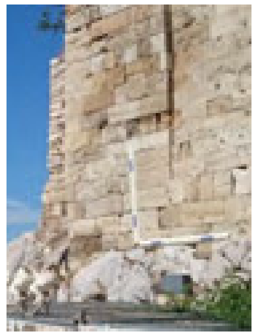
The OSMOS Group has also made use of its historical subsidiaries, particularly those in France, Belgium (for Belgium, Luxembourg and the Netherlands), Canada, Finland (for Scandinavia), Greece (for Greece and the Middle East) and Spain.

Those subsidiaries have all participated in the Group's development by acquiring prestigious business references, building special relationships with key contacts and producing a multitude of examples of technical successes. One of the many references that helped to give OSMOS credibility was the Champlain Bridge in Canada.

Since the monitoring program was launched in 2012 for Champlain Bridge in Quebec, the teams at *The Jacques Cartier and Champlain Bridges Incorporated* use 300 Optical Strands by OSMOS to continuously monitor the bridge in real time and perform monthly load testing.

A good knowledge of local issues and of each subsidiary's economic and public contacts has been decisive to the Group's development. For example, OSMOS Benelux provides very targeted solutions in the Netherlands for problems related to gas drilling and water seepage caused by low-magnitude earthquakes.

For its part, the subsidiary OSMOS Hellas (responsible for Greece and the Middle East) has proven the effectiveness of OSMOS solutions to property managers and officials responsible for historical monuments in this region, which is particularly affected by earthquakes and matters of heritage preservation.



The Propylaea of the Athenian Acropolis, monitored by OSMOS Optical Strands since July 2015

Ambitious **Partners**

In July 2015, OSMOS Hellas instrumented the Propylaea of the Acropolis, for the purpose of identifying the risks to this ancient building, associated with bad weather and active earth pressure.

Promising alliances

In some countries, the maturity of the monitoring market has inspired the OSMOS Group to pursue its international expansion through partnerships and the creation of new subsidiaries.
For the current year, the OSMOS Group nurtures the ambition of increasing the number of subsidiaries on markets that already believe in the importance of structural health monitoring when it comes to preventing risks and cutting structural maintenance costs. First in line are Italy and Japan, both countries with substantial infrastructure and many historical monuments, located in seismic zones.

The success of the 2017 strategy will also depend on the resources implemented by the OSMOS Group to quickly make the new subsidiaries as effective as the others in terms of marketing and operations. That is why the international development team's efforts will focus on establishing a solid business network and training our partners to ensure they have the necessary technical capacities.

Patrice Marc Pelletier

Senior Vice-President, OSMOS Group

Thanks to our SAFE ALL™ service (SAFE Works™ software suite, SAFE Analyzer™, and associated technologies and engineering services), OSMOS has become a global leader in the structural monitoring of buildings, infrastructure and industrial facilities, with its LIRIS range of innovative high-performance technologies comprising smart wireless fiber-optics devices, its iOS and Android apps, and its software packages designed to portray, analyze, interpret and manage structural health. Thanks to its subsidiaries and associated partners, OSMOS has operations in many countries and is particularly active in regions where natural disasters occur...

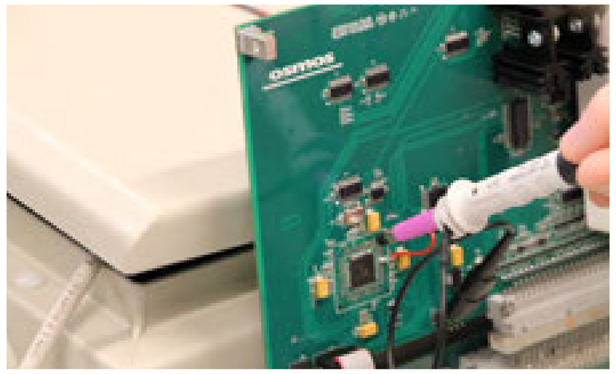
2016, a productive year

As the global structural monitoring market continues to grow – it is expected to be worth €1.7 billion in 2020 – OSMOS is pursuing its investments, in order to shore up its position.

In 2016, our investments focused on the development of new sensors and software solutions, to be able to offer an innovative, user-friendly service that is easy to install, operate, and view and analyze its data.

All of the development work on our sensors and software solutions aims to give our clients (structure managers, engineering firms and decision-makers) easy access to their structures' behavioral data.

In addition to the work done by the teams to meet expectations of continuous innovation, the R&D and Production Departments' efforts have resulted in the creation of a range of reliable high-quality sensors at competitive prices. Real evolution on the monitoring market.



The R&D teams encompass a variety of skill sets that work together to upgrade our sensors and their technological performance.

Our ranges of wired and wireless sensors were supplemented by the development of new sensors, such as the autonomous, wireless LIRIS inclinometer, which measures the angle of inclination of a structural component. In parallel, OSMOS's products are now covered by new quality and certification procedures that further bolster their competitiveness out in the field.

To ensure our clients make the most of our technologies, a software suite has also been developed. It offers numerous tools for optimizing the exploitation of the data collected by our sensors.

The interface was designed to integrate as seamlessly as possible with tools that our clients already use, facilitating their access to the key information they need to make decisions. This software development has been crucial, both to taking full advantage of the sensors' functionalities and to responding to rising demand on the market for tools to manage full inventories of structures, in line with OSMOS's business strategy.

VARIED APPLICATIONS:

Heritage
Verifications during the rehabilitation phase

Civil engineering
Counting/weighing of events

Buildings
Preventive monitoring

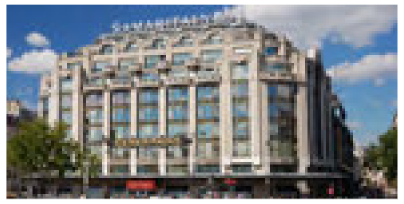
"Key Accounts" business strategy tried and tested in France

The 2016 business strategy of focusing sales efforts on key accounts, such as property companies and industrial groups, has already paid off for the OSMOS France subsidiary. The French subsidiary's success with key accounts in key sectors like civil engineering and industry validates the business model, with a 59% increase in revenue.

A large number of Departmental Councils have placed their trust in us. For example, the Ain Departmental Council has entrusted several bridges to OSMOS to improve those structures' maintenance. While some of the bridges are observed by preventive monitoring solutions designed to anticipate risks, tests were run on others, for example to evaluate the impact of convoys passing over them and their structural elements' stress resistance. In the industrial sector, OSMOS France is working to make structural health monitoring a vital component of optimized structural maintenance.

In this way, OSMOS has adopted an approach – already accepted by structure managers – that involves using data from smart devices to anticipate risks, optimize maintenance and, as a result, better meet economic and safety requirements. The French subsidiary's success with key accounts has confirmed the need to apply this strategy internationally, identify key contact people and promote the products and services that will support this market positioning.

MAJOR PROJECTS IN 2016:



La Samaritaine
Work phase

LVMH

Industrial facilities

Carrefour
Shopping Mall

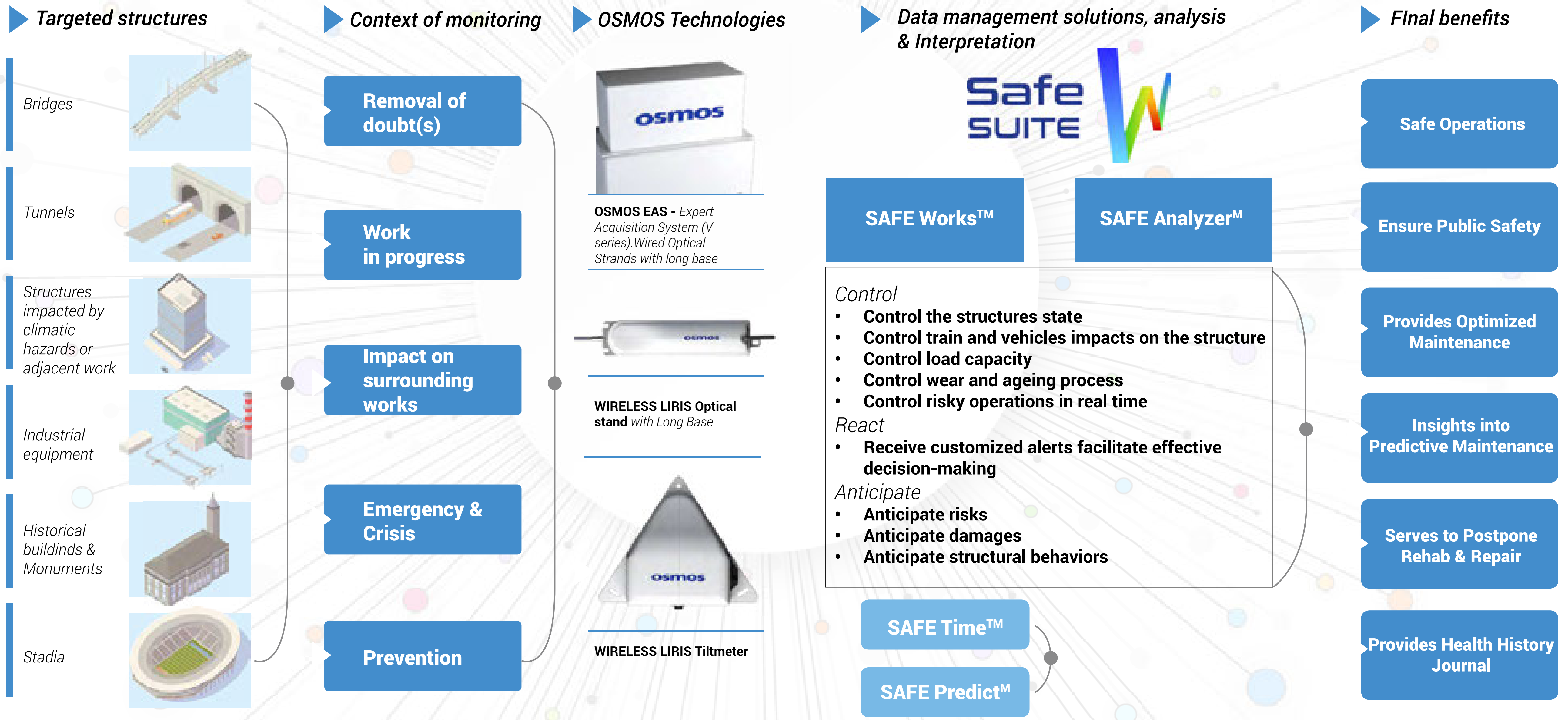
carrefourproperty

Le Nautile Aquatic Center

Jacques Chanteclair
Managing Director, OSMOS France

The strong growth in OSMOS's sales on the French market is, first and foremost, a testimonial to very involved teams that are completely focused on understanding and meeting customer needs. Thanks to new engineering tools and a "tailored" approach, we are able to satisfy the varied requests we receive from major clients. By becoming an approved supplier, they trust us with repeated orders and long-term contracts: an encouraging sign.

OSMOS **Service offer process**



From data management to predictive models?

Unlike what is offered by the classic segmentation of the monitoring market, with separate solutions for equipment, engineering, software analysis and big data exploitation, OSMOS has developed a cross-cutting portfolio of products and services, thanks to its expertise in each of those domains, from R&D to engineering, by way of industrial production. And OSMOS went a step further when it created a Mathematics and Statistics Department. Dedicated to exploiting the structural data collected, this department offers new analytical and display methods, through behavioral engineering, machine learning and predictive models. A new path to value creation for OSMOS and our clients that enriches our monitoring reports, but that will also, in the future, offer innovative analytical functions that can be accessed on the SAFE Works platform. The long-term goal is to define predictive analysis models, for example to evaluate a structure's remaining lifespan.

There is still a long road ahead to predictive statistical models based on our solutions, but the Math Department is already exploiting our monitoring data. The coefficient of thermal expansion method aims, for example, to isolate the thermal component (linked to temperature variations) from the mechanical influence. A tendency can be derived from this, representing the mechanical effects exercised on the structure. Conversely, another method consists of using the strong correlation between deformations and temperature variations to detect anomalies. For its part, the fatigue projection method consists of studying structural responses (fatigue) to a periodic number of events repeated over a very long period of time. An analysis of statistical events enables a study, using all of the mathematical methods previously described, of the behavior of structures subjected to dynamic stress, as is the case of bridges, for example. This method entails observing the intercorrelations between the different variables of dynamic events.

FIELD REPORT

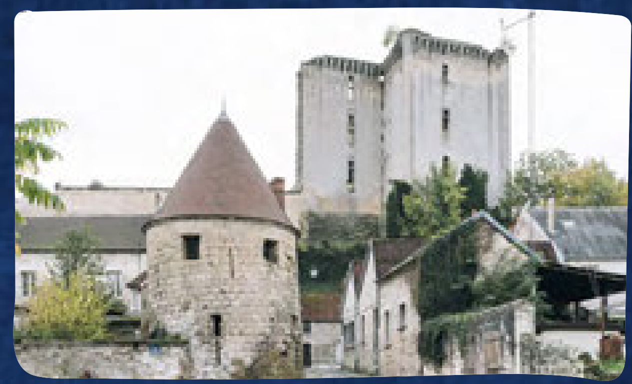
A PROJECT FROM A TO Z

Château de la Ferté-Milon

Registered as a historical monument since 1862, the Château de la Ferté-Milon is located in the village of the same name, in the Aisne Department of Picardy. Of the original château, commissioned by Louis I of Orléans in 1393, only the immense façade measuring 200 meters long by 38 meters high remains today.
An unusual structure that OSMOS has been monitoring on behalf of the Regional Directorate of Cultural Affairs (DRAC) for Nord Pas-de-Calais Picardy since August 2015. Explore the project through testimonials from the different actors involved in its monitoring.

1. Back-ground

On multiple occasions over the past 20 years, blocks have become detached from the rocky tables on which the North ramparts of the château were built, arousing a special interest from DRAC Nord Pas-de-Calais Picardy.

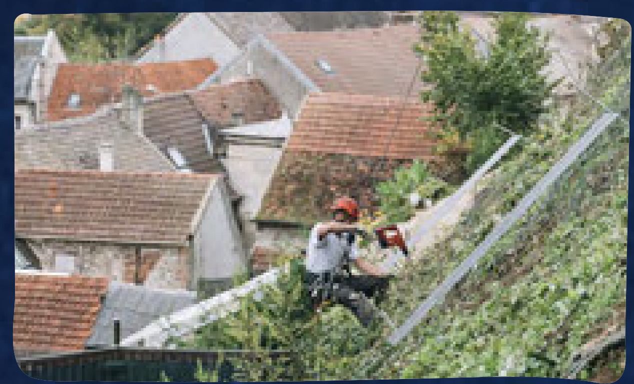


Yann Hego

The DRAC engineer of cultural and heritage services explains:

"After the episodes of the detachment of blocks of rock, a number of campaigns were launched by the State, which owns the monument, to restore the wall's masonry-work (project owner: DRAC-CRMH Picardy; project manager: Chief Architect for Historical Monuments). In 2012, a block weighing several tons fell away and was caught and held by the protective netting that had been installed, protecting the land and the homes located below the ramparts. Nevertheless, while waiting for completion of an exhaustive study for the definitive reinforcement of the North ramparts and their bedrock, alert measures on the imminent risk of further rockfall were necessary to the safety of the local residents."

2. Visit to the site



For the first visit, Anthony, the sales representative for the region, visited the site with Yoann, the engineer. Although certain characteristics are shared by some of the structures already being monitored by Anthony, including a number of other registered historical monuments (churches, cathedrals and ramparts), other features make the Château de la Ferté-Milon project a unique one. First, its history, with its series of episodes of localized rockfall and restoration campaigns, but also its geographic location, with the presence of nearby inhabitants and hard-to-access monitoring areas.

3. Needs

After an examination of the needs, in terms of the type of information to collect and the technical constraints, a business proposal was accepted by the client. The first year of monitoring was used to observe the retaining ramparts, built on a friable block of rock. Four Optical Strands, installed on the lower part of the ramparts, measure deformation, while eight inclinometers mounted on electrolevels measure the differential movement and the rotation of the parent rock.

Anthony Roche

The OSMOS sales representative who supervised the project affirms:

"Thanks to the coordination of a team of installers and cablers, coupled with guidance from Morad, the installation manager, we were able to meet the clients' needs very quickly, despite the complicated access and the constraints associated with the neighbors. The expert acquisition station's cables were drawn along the lower part of the ramparts, accessible via a local resident's backyard, while the cablers installed sensors from the top of the ramparts, once the install zone had been cleared."

Anthony Roche, OSMOS Sales Representative

4. Installation

The presence of vegetation on the parent rock and the existence of private properties below the ramparts made it difficult to install the sensors. However, thanks to the work of the OSMOS team, Anthony, Yoann and Morad, the installation manager, and the service providers Pons and Coexia, installation took just four days, once Yoann from the engineering office had defined the precise locations for the sensors.

5. Observation

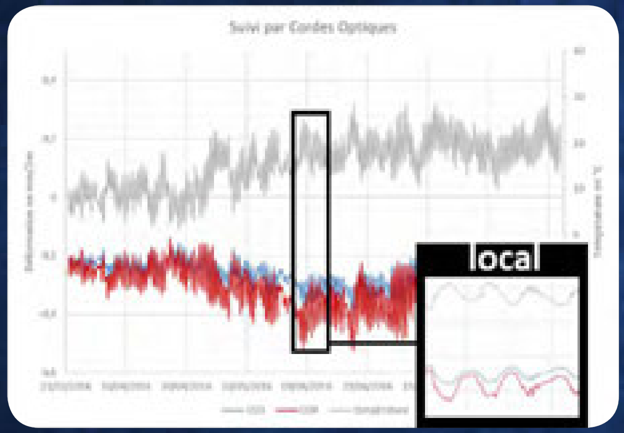
The monthly monitoring reports prepared by OSMOS's engineering office, based on the continuously collected data, fulfilled three goals. First, to obtain information about the structure's basic behavior, particularly with regard to the evolution of deformations under fluctuating temperatures. Second, the OSMOS engineers' analyses identified areas more sensitive to heat variations that might require their special attention, to study the possible reversibility of the deformations. Third, the first year also yielded the conclusion that the entire instrumented section was generally changing with the seasons.

Yoann Dufour

The engineer was in charge of analyzing the data:

"The monitoring we have performed since late October 2015 has enabled us to confirm, at present, the normal behavior of the materials in place (ancient masonry on one side and friable blocks of rock on the other) and to monitor the active zones with greater precision. Thanks to the history obtained from the first months, we can now define alert thresholds for abnormal phenomena. The continued monitoring will allow us to gather more information on the observed trends and to determine whether or not the static stabilization will last."

6. Analysis



Behavior of the masonry-work:

The data evolve with daily and seasonal temperature cycles (see curves). There is no particular trend, other than the one linked to thermal fluctuations, which is logical behavior for a structure of this type (ancient masonry).

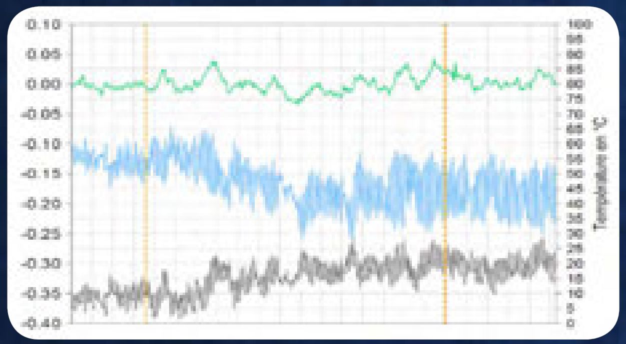
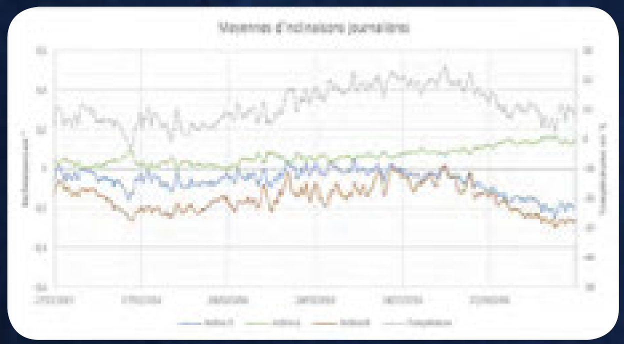


Figure: Temperature curve (gray), measured deformation (blue) and corrected deformation (green). The deformation/temperature learning period is delimited by the orange dotted lines.

Effects of temperature changes:

The engineering office has a correction algorithm that it uses to eliminate the temperature component from the collected measurements. This makes it possible to observe changes in structural health, independent of that external factor.

Here, although the measured magnitude of deformation varies, there is no general trend in its evolution (see the green curve, which shows good stability).



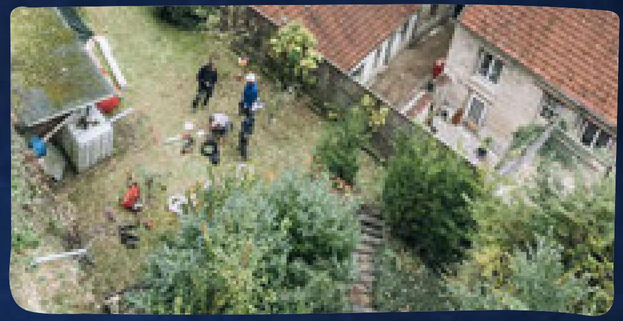
Since the first monitoring phase (observation), the different instrumented zones on the bedrock have been evolving with more or less sensitivity to climate conditions. However, zone 6 (green curve) shows a trend that is independent of those factors. This slow but steady drift reveals atypical behavior.

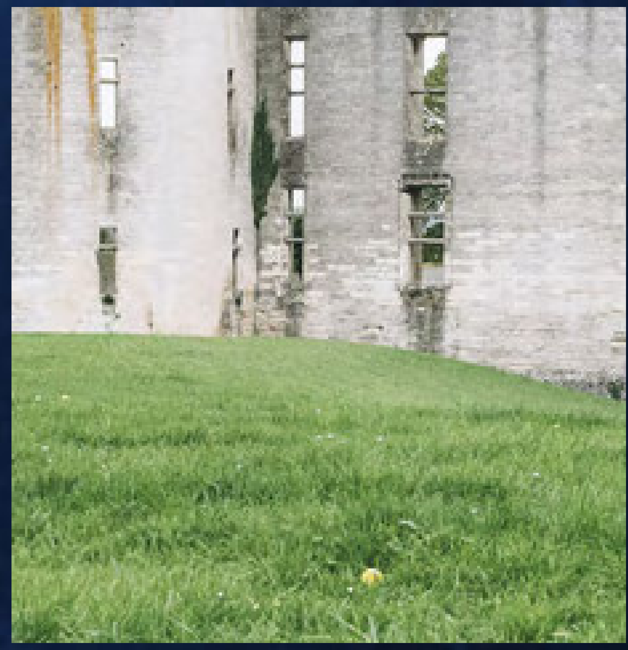
Although the magnitude remains low for the time being, it will be important to monitor this "sensitive zone" with heightened attention.

7. Collaboration

Once the first year of monitoring yielded its conclusions, it became apparent that preventive monitoring needed to be prolonged, to track the behavior of the ramparts and their parent rock and to prevent any deterioration that might pose a risk to the homes down below. In addition, while awaiting the launch of work projects and at the advice of the Chief Architect for Historical Monuments, OSMOS's monitoring allowed DRAC to enhance its knowledge of the structure and the geotechnical risks, such as subsidence, that could affect the conservation of a portion of the ramparts.

An additional sensor was installed on the structure, and a system was set up to simplify automated information-sharing between the OSMOS teams, DRAC and the various stakeholders.





RÉSIDENCE GASTON PINOT 75019 PARIS

Résidence Gaston Pinot is made of 18 four-story buildings dating back to the 1930s.

After tilting was observed in one of the buildings, readings were taken by a surveyor that confirmed the building's displacement. Geotechnical studies then determined that the clayey soil and its drying out, caused by the site's redevelopment, were the source of the displacement. Resin was then injected, to reinforce the soil bedding.

However, the client was concerned that the deeper gypseous soil would dissolve under the injected areas, so OSMOS was consulted to characterize the problems associated with any such dissolution of gypsum and to identify the at-risk zones.

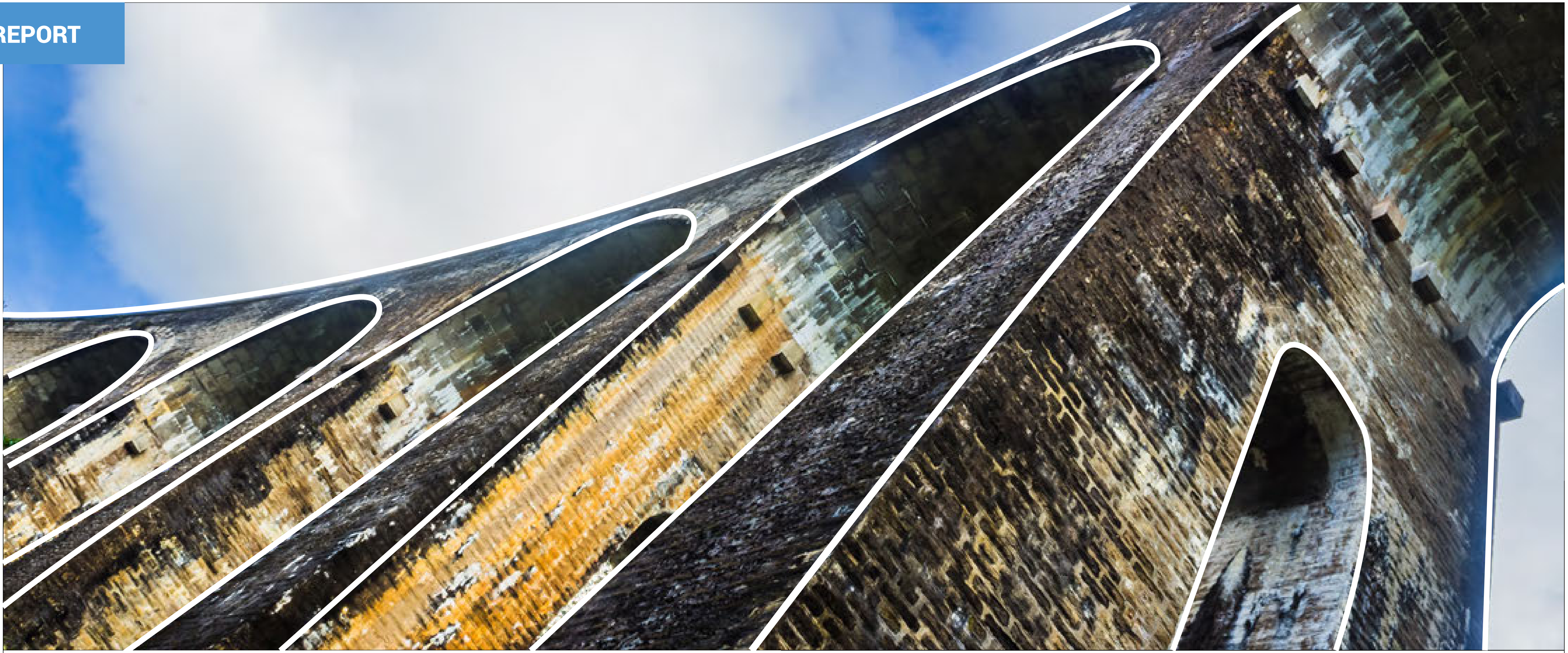
Patrick Lézin

OSMOS Engineer in charge of the project

This project was an opportunity to collaborate with the client, to optimize how soil issues and their structural impact were monitored, as a variation on traditional topographic monitoring. The precise technical framework made it possible to create an original portrayal of the data, with a degree of precision that is hard for a theodolite to achieve. From a technical perspective, the most satisfying accomplishment was highlighting, first, the appearance of problems and then, their stabilization.

osmos on site

REPORT



BRIDGES, FROM EVERY ASPECT

BEHAVIORAL ENGINEERING FOR BRIDGES USING **OPTICAL STRANDS**

Solid knowledge of a bridge's mechanical engineering is crucial to optimizing its maintenance and its use. In fact, since the sole purpose of bridges is to bear loads between two points, they are usually scaled as closely as possible to the originally expected loads. However, uncertainties about the initial calculation assumptions and the aging of the structure can alter its actual behavior, compared to its theoretical behavior imagined at the time of its design. Additionally, many old bridges are in operation, despite the fact that both their theoretical behavior and its alignment with their current functioning are unknown.

To accurately qualify the actual behavior of civil engineering structures over time, OSMOS offers an approach that combines continuous measurements taken on-site with statistical analyses and recalculation models. The exhaustiveness of the measurements taken over time provide a view of the actual effects of different phenomena on the structures: moving load, temperature variations, vibrations, effects of wind, etc. Pertinent interpretation can then identify the bridge's real characteristics and study their evolution over time, as well as the possible uses.

UNDERSTANDING THE REAL EFFECTS OF LOADS

Fleurville Bridge in the Ain Department

Acquisition system on Fleurville Bridge

The structural monitoring provided by OSMOS entails the continuous measurement of deformations of a structure's most sensitive components, at very high acquisitions speeds (50 to 100 measurement points per second). In order for the measurements to make sense on the scale of the entire structure and so they can be relevantly compared to a theoretical value deduced from a model, the best sensors for this type of operation are long-base Optical Strand extensometers.

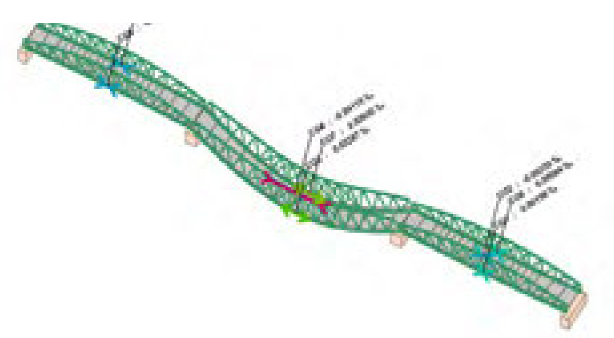
The gauge length is then 1 to 2 meters, so that it corresponds to a meaningful dimension on a structural scale. This eliminates uncertainties associated with localized effects that can upset the representativeness of classic measurements, taken by means of a strain gauge, for example, especially on bridges made of mixed materials, such as reinforced concrete and stone-masonry.

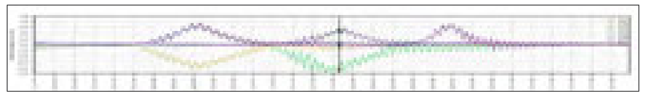
The continuous deformation measurement process, recorded at a high frequency, enables accurate reporting on the actual effects of all the loads that are borne by civil engineering structures over time.

During load testing, the measurements may, for example, refer to the longitudinal deformation between the farthest fibers of the deck at mid-span. This information is more relevant than the simple deflection that is usually measured, because it is directly linked to the strain that develops in the material during testing, in order to confirm the validity of the calculation models that were used to scale the deck and pass the tests.

Afterward, keeping the OSMOS system installed on the structure and in service can record convoys passing over it and causing stress, as well as their systematic comparison against the deformation levels recorded during the initial testing. There are many possible applications for these measurements: convoy weighing, general statistics used to determine the structure's actual rate of use, analysis of the structure's modes of oscillation under vibration from a passing vehicle, and the list goes on.

Example of bridge deformation monitoring





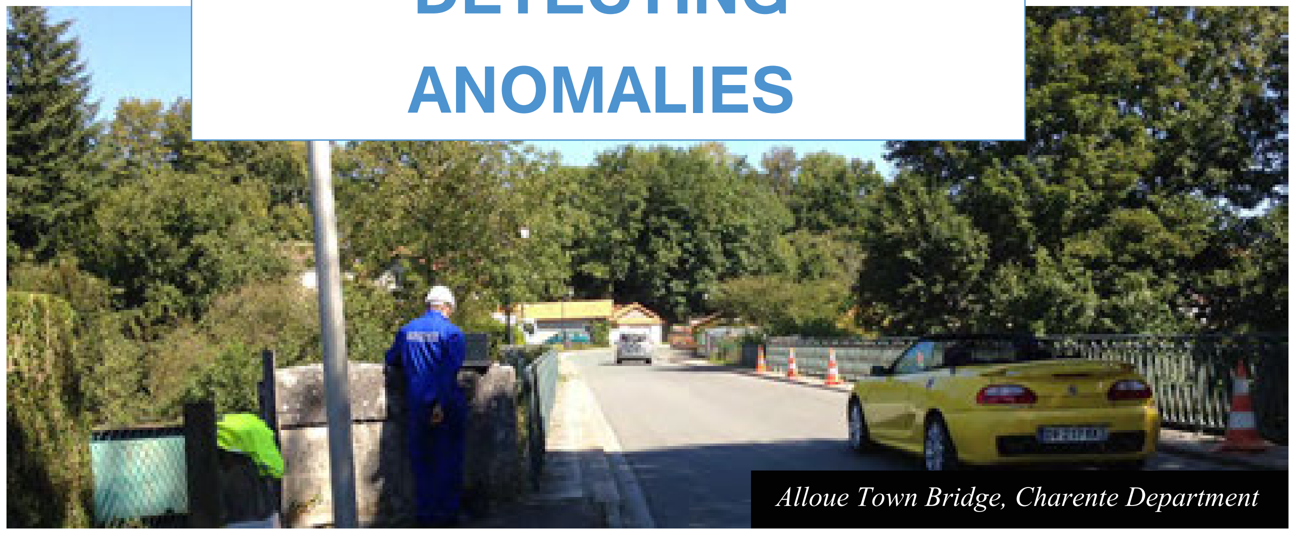
Passage of a vehicle and vibrations on an old metal truss girder bridge. View of overall deformation, based on measurements taken mid-span. Fleurville Bridge over the Saône, Ain Department.

François-Baptiste Cartiaux

OSMOS Group engineer and bridge specialist

For an engineer specialized in structural calculations, OSMOS's approach is both original and stimulating: rather than making calculation assumptions based on theory or on occasional testing, we improve our knowledge of the mechanical behavior of structures by measuring it in real-world scenarios, over an extended period of time. This introduces a continuous control loop into the recalculation process: each new stress recorded means an opportunity to further refine our models. It also encompasses the possibility of evolutions of the different parameters over time and the detection – or even prevention – of those evolutions, thanks to mathematical tools.

DETECTING ANOMALIES



Alloue Town Bridge, Charente Department

The monitoring system records every load that generates rapid variations in the bridge's deformation as a dynamic event: for example, whenever a heavy convoy passes or a strong wind blows, it is automatically timestamped, and the magnitude of its effects on the structure is accurately quantified.

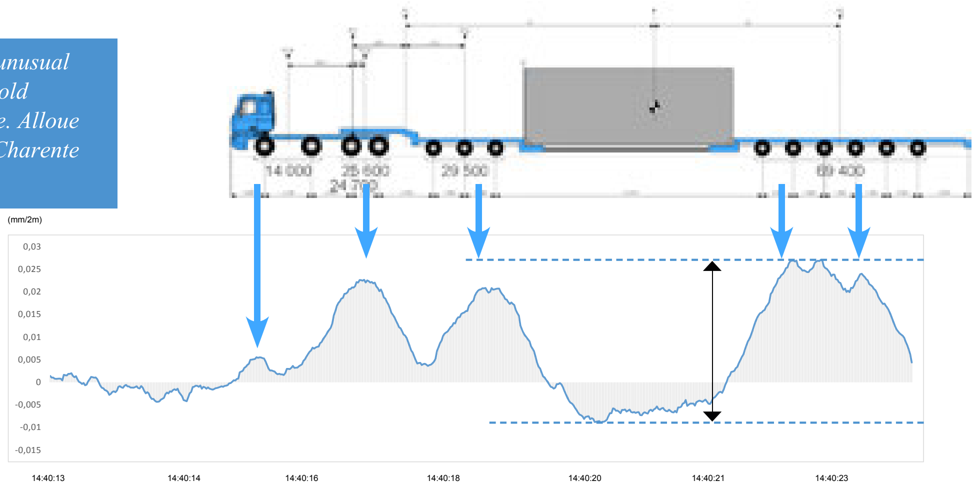
This automated recording has many applications, in terms of assistance with the operation of civil engineering structures. The first is monitoring unusual convoys passing over them and checking their actual effects on the structure, especially older or lesser-understood bridges for which a comparative approach using prior load testing is appropriate.

A second application is triggering automated alerts instantaneously, whenever any deformation exceeds a predefined critical threshold, enabling the real-time detection of overloaded convoys or any potentially critical stress on the structure. Finally, abnormal deformations can be detected in greater detail and very early on, from a standpoint of optimization of the overall organization of maintenance. To that end, OSMOS's Mathematics Department has developed stationarity tests to determine, based on a large number of events, whether or not drift is involved in the structure's response to stresses that may differ but that are statistically equivalent on a bigger scale.

This type of drift is a sign of a weakening deck, typically a relaxation caused by the spread of fissures in the concrete or corrosion of the steel.

Continuous monitoring can then help to qualify the pattern of that drift, in order to estimate the structure's stability in the long term.

Monitoring of unusual convoys on an old masonry bridge. Alloue Town Bridge, Charente Department.

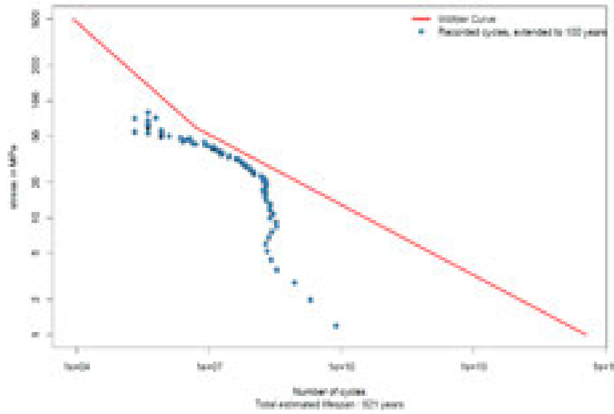


ESTIMATING LIFESPANS

Hagestein Bridge, Netherlands

Fatigue in a bridge's structural elements is a sensitive issue, especially in the case of metal structures. It is the result of an accumulation of many strain cycles in the bridge's materials during its operation: taken individually, each one is harmless, but their repetition over a long period of time can lead to the appearance and spread of fissures and, eventually, to collapse.

The high-frequency, continuous recording of deformations in the bridge's most sensitive elements make it possible to accurately count the cycles actually undergone by the structure. For this purpose, OSMOS applies a rainflow algorithm to all of the measurements taken during a given window of time, in order to classify the measured deformation cycles by their magnitude. Structural modeling then allows those deformations to be converted into strain in the critical components, which may not be situated at the instrumented locations. For example, an Optical Strand arranged diagonally at one end of a deck girder will measure deformation proportional to the shear force on the supports.



Strain cycle count and estimated lifespan of a deck with metal girder sections.

Once the strain cycles have been determined and classified by magnitude, the rate of fatigue damage to the critical elements can be deduced by comparison with a number of limit cycles, according to magnitude. An extrapolation of the cycles measured to the entire life of the structure then enables an estimation of its actual lifespan, with regard to fatigue criteria, based not on risky load assumptions but rather on the actual stress observed during operation.

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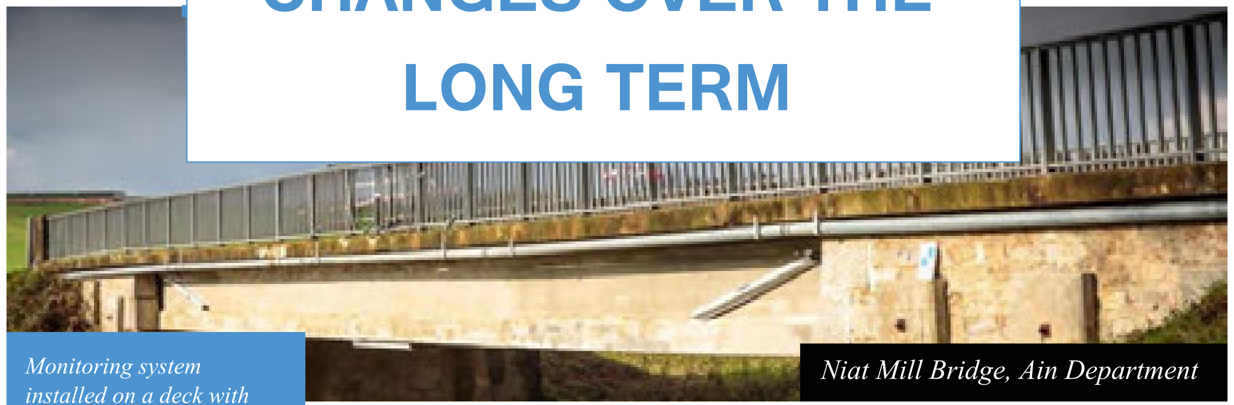
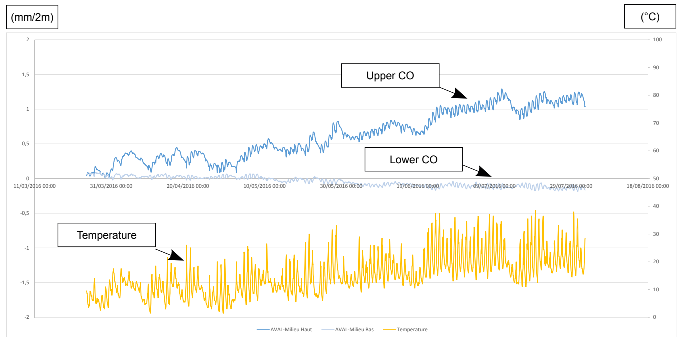
MONITORING CHANGES OVER THE LONG TERM



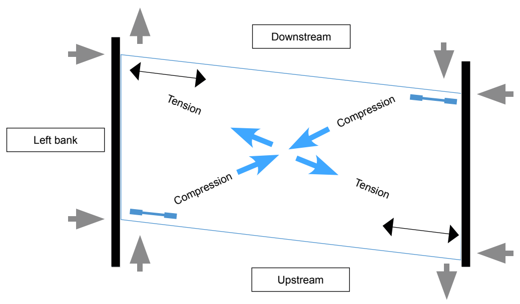
Monitoring system installed on a deck with reinforced concrete beams.

Niat Mill Bridge, Ain Department

Bridge over the Vière, Drôme Department



Evolution of the formation of a knuckle at the pin of a masonry bridge.



Other than dynamic events recorded at high frequencies, the OSMOS monitoring system also stores static measurements, corresponding to the structure's longer-term behavior: the interval of time between two measurements then varies between one minute and one hour.
Those static measurements are used to study the structure's behavior under the effects of temperature fluctuations and thermal gradients. In fact, temperature is systematically measured at the same frequency, at several different points when necessary.

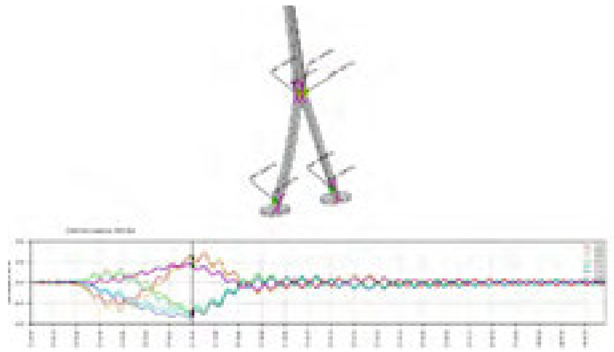
An analysis of the evolution of deformation, correlated with temperature variations, can then be used to identify the structure's apparent thermal expansion coefficients, for changes over different time scales, ranging from day to season. Expansion that is less than the norm is a sign of quantifiable clamping on the supports.

This knowledge of a bridge's behavior at different temperatures is then used to identify long-term trends, by deducing the portion attributable to thermal effects from the measurements. This thermal correction is done using statistical methods that automatically learn the laws relating temperature to deformation. Once the measurements have been corrected for the effects of temperature variations, gradual phenomena can be clearly seen, such as contraction in the supports, development of creep, and loss of pre-stressing.

MODELING ACTUAL BEHAVIOR

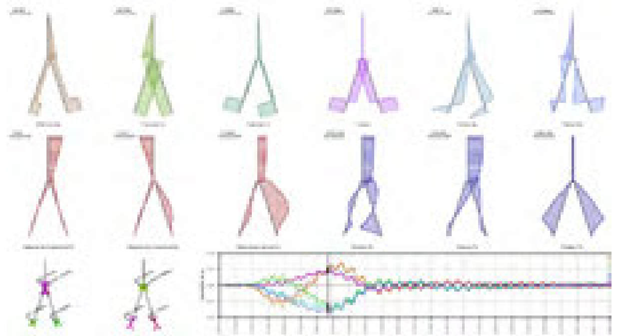
Seyssel Bridge over the Rhône, Ain and Haute-Savoie Departments

Beyond reporting on measurements, OSMOS can also provide in-depth exploitation of the data collected from civil engineering structures, to paint a complete picture of the actual behavior of the structures. OSMOS's engineering office has software solutions that use measurements as model input data, to deduce deformations and stresses anywhere in the structure, at any given point in time.



For example, deflection at any point of a bridge's deck can be accurately estimated based on curve measurements taken mid-span and correlated to diagonal deformation measurements at the ends and/or curve measurements at other points. Likewise, bending and shear force along the deck can be deduced by means of a series of assumptions about its geometry, its rigidity and the mechanical properties of its materials.

Used based on known loads, this type of model can also identify the mechanical characteristics of the structure itself: actual flexural rigidity, for example, where a value lower than the theoretical



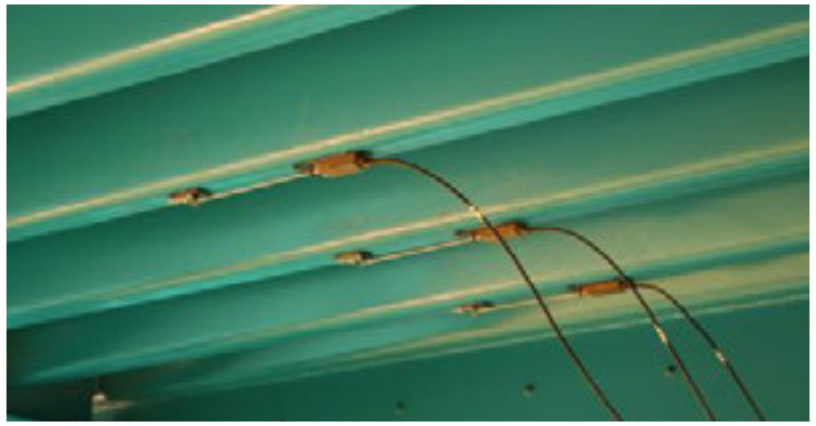
Model of a cable-stayed bridge's reinforced concrete pylon: displacement and stress along the pylon's elements, deduced from eight synchronized measurements, and graph of the overall deformation.

value deduced from the section's geometry is a sign of fissuring or loss of material. The same applies to the qualification of actual support conditions and the verification of the existence of clamping.

By exploiting all of the possibilities afforded by continuous measurements of a bridge's deformation, OSMOS is able to offer comprehensive structural monitoring solutions that can determine the actual rate of use of a structure, detect unusual loads and abnormal behavior, estimate lifespan in relation to fatigue, and analyze the structure's long-term behavior, among other uses. Combined with dedicated calculation models, this structural monitoring provides complete knowledge of the actual behavior of structures, which can help to verify their operations and optimize their maintenance.

HAGESTEIN BRIDGE, NETHERLANDS

Hagestein Bridge is one of the busiest in the Netherlands. The client wanted to understand its structural behavior and then set up a weighing/counting module to track the number and the magnitude of deformations as vehicles pass over the bridge, at several points along its span.
OSMOS was asked to provide a solution to continuously measure deformation with great accuracy, over a long period of time.
OSMOS's data enriched the existing database, so that the structure could be recalculated and its remaining lifespan could be evaluated based on objective data.



INSURANCE, A DEVELOPMENT UNDER CONSTRUCTION

Our expansion into the world of insurance continues. OSMOS is consolidating its success while forging new partnerships.

The SMACL-OSMOS partnership was successfully tested with local governments in the Ile-de-France Region, before being rolled out in the rest of the country.

For all of the players, both public and private, the advantages of an insurance-based approach to structural monitoring for worksites and claims have been confirmed.

39% of proposals relying on smart objects and launched by insurance companies are associated with the home or construction (Accenture 2016 Report)

56% of insurance companies use data to improve their claims management and another 50% to prevent risks
(Source: Digital Insurance White Paper, Docapost & PAC, 2016)

SMACL-OSMOS, the winning partnership for local governments

A few months after a partnership agreement was signed between OSMOS and the leader in insurance for local governments, SMACL Assurances, the time had come for an initial assessment.

The first test phase in Ile-de-France yielded very encouraging results: 65% of the local governments contacted by SMACL went on to meet with OSMOS; all of them expressed a real interest and nearly 30% of those governments requested a quote for monitoring one or more structures; and the trial is expected to be converted in the vast majority of cases.

Backed by this real interest on the part of SMACL's members, the decision was made to extend the partnership to the rest of France. With that in mind, Philippe Lesage (Inspection Division Manager at SMACL Assurances) came to present SMACL to OSMOS's regional managers. He was accompanied by Pamela Christiny, Regional Manager for Picardy Ile-de-France, who explained how she had worked with OSMOS in Ile-de-France. The meeting allowed OSMOS's business engineers to grasp the weight that SMACL wields with local governments and to gain a better understanding of the insurance sector and, therefore, the value added by OSMOS's services in this domain.

Another noteworthy advance: SMACL decided to incorporate a presentation of OSMOS into all of its RFP proposals submitted to local governments, as part of its risk prevention plan. When a local government selects SMACL for its insurance, it is then given direct, preferential access to SMACL's partner, OSMOS.

Additionally, OSMOS met with all of the claims adjusters certified by SMACL, to introduce the partnership to them and raise their awareness of the advantages of structural monitoring in the case of major claims. The first adjuster requests have been sent to OSMOS and are currently being examined. The companies' initial objective has been validated: to propose an approach to local governments based on risk prevention, continuous monitoring of their assets, and cost control.

Pamela Christiny
Regional Manager, Picardy – Ile-de-France
SMACL ASSURANCES

Our partnership with OSMOS kicked off in early 2016, first covering a selection of local governments, and then obvious bridges appeared over the months and during meetings with our members, with regard to the need to offer them "smart" heritage monitoring services.
Since then, SMACL Assurances has been increasing our emphasis on the associated services, some of which will be rolled out in 2017. As a preferred partner, OSMOS is perfectly aligned with this objective. And so we have incorporated it fully into our approach, namely in our presentations of the satellite solutions and services offered by SMACL Assurances.

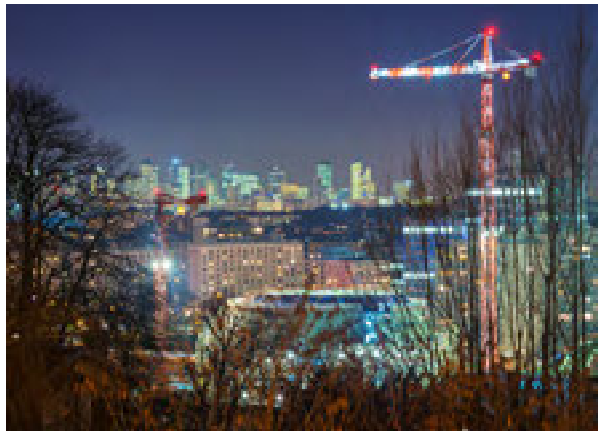
Project: the foundations of prevention

For construction foremen, construction sites in built-up areas pose proven risks to the surrounding buildings and roads. This has become a regular theme for OSMOS, which has proven itself, for example, during an earthworks phase conducted with Eiffage Habitat and at the Ricciotti block demolition site in Béziers, to name but a few.

Specifically with regard to construction foremen, earthworks phases are particularly tricky. As a result, precautions are taken to prevent landslides. However, in the event of a dispute linked to damage to neighbors, it can be difficult to determine the stage of the construction that is at fault and who is liable. To that end, the data that are continually collected by OSMOS solutions make it possible to prove to experts the real impact of the earthworks phase on neighboring structures.

"The strength of OSMOS's technology is that it can provide a report with data and graphs that experts cannot challenge, because they're factual. Without OSMOS, it's clear that we would have been held liable."

Bertrand Guigue
Construction foreman for Eiffage Habitat



Managing neighbors is a major concern for public and private clients. That is why a church in the Greater Paris Region was instrumented six months before construction started on a nearby underground public parking lot. The City of La Garenne-Colombes (a SMACL member) decided to assume its responsibility and establish real visibility of the health of the church at the start of the work.

"With the total redevelopment of the city's main square and the creation of a parking lot, we are undertaking one of the largest, most complex projects in La Garenne. So it was vital for us to be able to rely on OSMOS's expertise throughout the project, to ensure that it will be a complete success."

Philippe Juvin
Mayor of La Garenne-Colombes – SMACL member

For insurance companies, monitoring construction sites that are technically complex, or whose financial stakes are high, is a major challenge. Whether from a perspective of contractor's guarantee or property damage insurance, collaboration between OSMOS and the insurer can prove to be a saving grace for all of the parties, including the project manager and the end client.

Backed by its experience monitoring construction sites, OSMOS is currently engaging in a multitude of discussions and test phases, with the aim of creating a specific support service for insurance companies, to the benefit of all of the stakeholders.

IoT in the Service of Construction

Installation of OSMOS Optical Strands

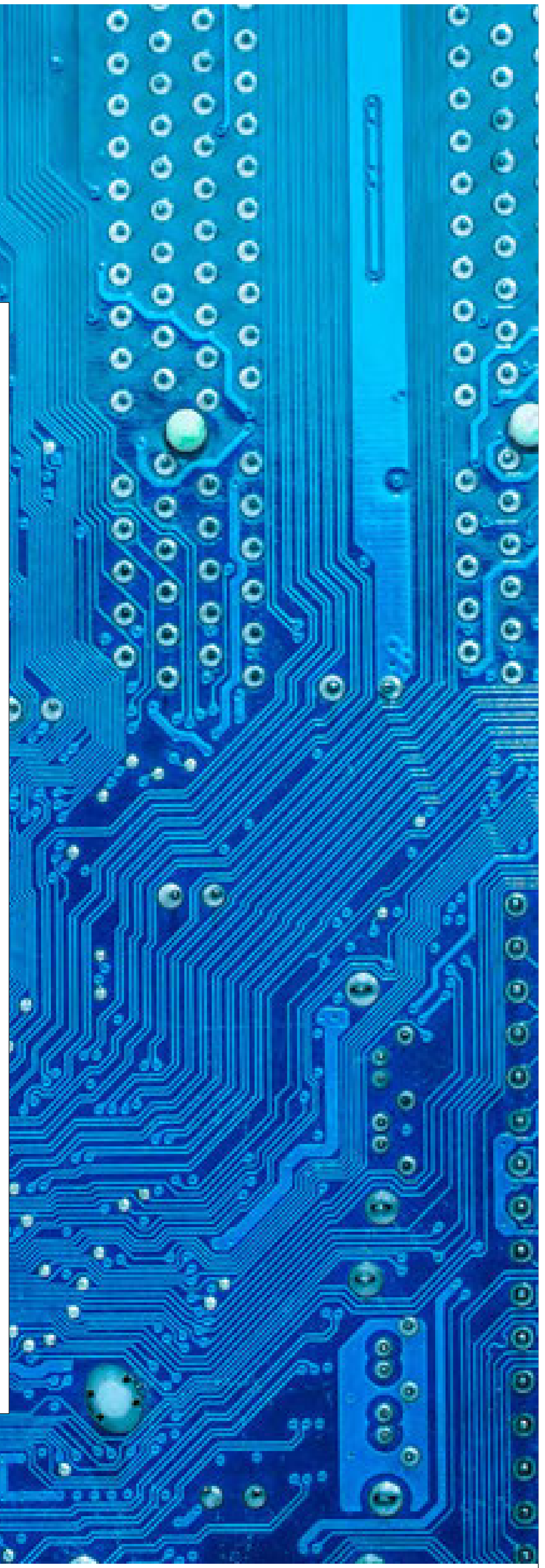
Continuous structural monitoring

Making the right decisions at the right time

Ongoing structural monitoring

- **Anticipating risks and damage**
- **Accelerating dispute resolution**
- **Extending the lifespans of constructions**

OSMOS LAB



CONTINUOUS ENHANCEMENTS PERFORMANCE

Ever since the company was founded, R&D has occupied a central role. The department is in charge of developing and improving our sensors, real added value that enables OSMOS to offer solutions that are unique on the monitoring market.

For example, the fiber-optics-based process can perform long-base measurements of deformation in real time, which eliminate localized effects and provide relevant information on the entire structure. This unique, innovative use of fiber optics has been the focus of the company's development since its early days.

The mission of the Research & Development Department today is to continue to enhance existing technologies, so as to optimize their performance, but also to think about the possible development of new sensors that can meet the market's rising demands.

11 people work in the R&D Department, developing new solutions and enhancing existing technologies

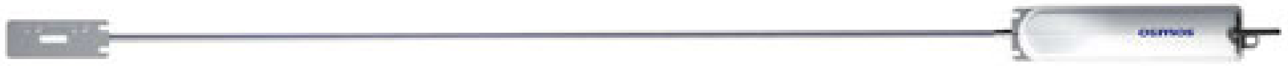
20% of OSMOS's total spending in 2016 was invested in research and development

Optical Strands™, Light as a Vehicle for Information

The development of OSMOS's sensor ranges relies on the unique, original use of fiber optics to measure structural strain. The OSMOS process is based on the principle of light intensity modulation according to the strain applied to the Optical Strand, producing an instant response from the sensors.

The physical principle employed consists of detecting changes in the transmission properties, caused by strain applied directly to the fibers and adjusting the quantity of light transiting along the cables.

By using light as the sole vector for capturing and transmitting information, OSMOS's sensors offer a multitude of benefits: for example, the sensors retain their stability over time and are not sensitive to electromagnetic effects. The power of OSMOS's technologies also offers a degree of data-capture precision that reflects any structural phenomena as closely as possible and records both static and dynamic data.



Static and dynamic measurements?

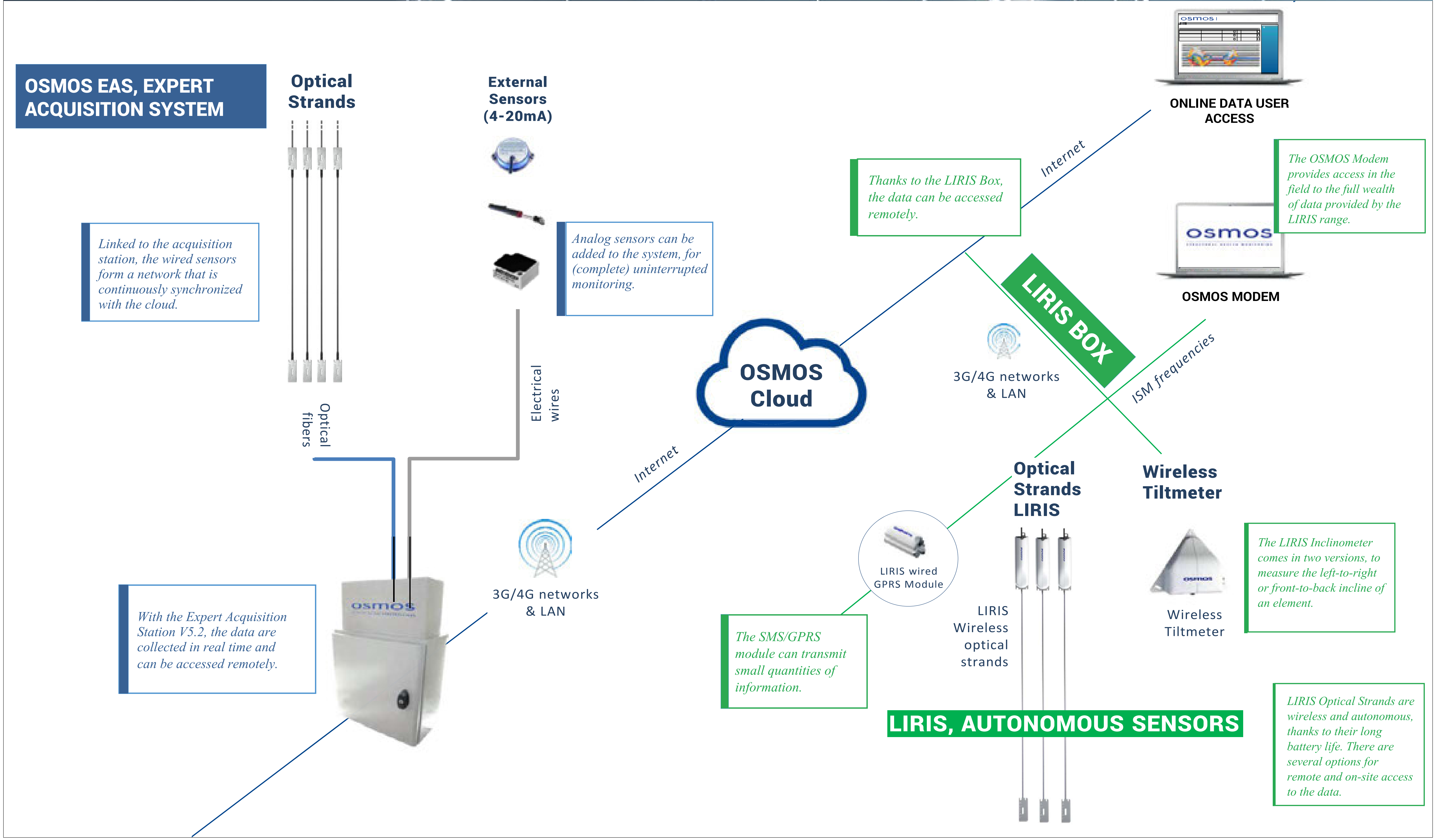
Static and dynamic measurements provide complementary information about the monitored structure's behavior.
Static data are recorded at a frequency of up to 1 Hz. Between each of the recorded static points, an average is calculated on a 100 Hz data-capture base.

For dynamic measurements, on a sampling frequency of 100 Hz, instantaneous variations in magnitude (configurable detection window) can be detected. The sensors' data are recorded before, during and after the event, in order to study it from its beginnings through to any return to normal.

Robin Cohen-Selmon
R&D Manager, OSMOS Group

2017 has been a particularly busy year for the R&D Department. In 2016, we launched the development of the LIRIS Inclinometer, the LIRIS Box and new versions of the LIRIS Optical Strand and the Expert Acquisition Station. In parallel, we are developing software solutions to simplify access to the data. These projects are challenges that truly motivate the team, which we have recently expanded with a number of new hires.

OSMOS Ecosystem
Two Ranges of Sensors to Meet Needs in the Field



Safe Works

ALWAYS A MEASURE AHEAD

for optimized structural management

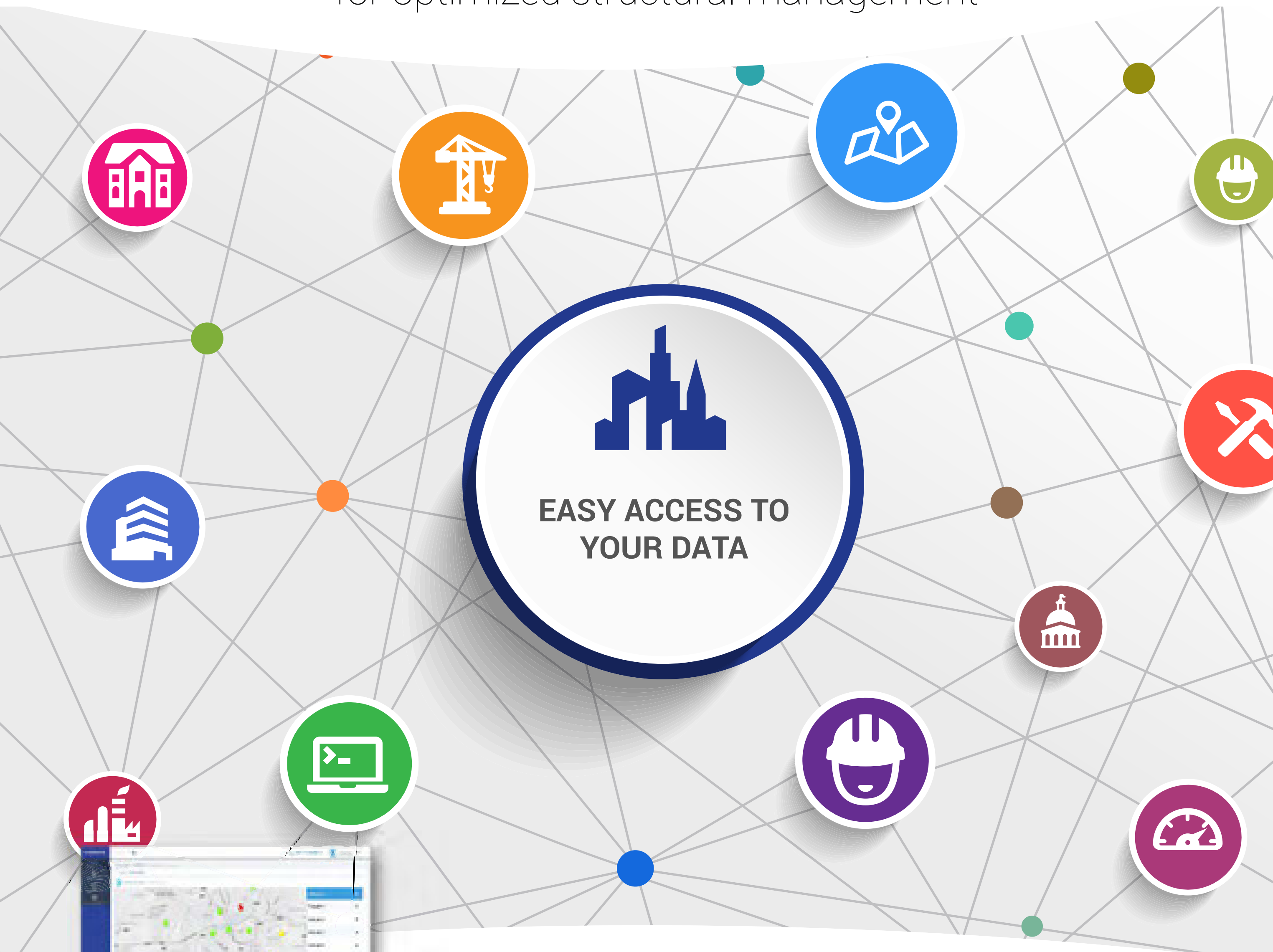


Photo credits: OSMOS Group SA – Publication: OSMOS Group SA

The **SAFE Works and SAFE Analyzer** software suite offers structure managers an overview of their buildings and infrastructure over time.

osmos

STRUCTURAL HEALTH MONITORING

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