



LYRA

THE MOST ADVANCED SMART SOLUTION TO ASSESS THE STRUCTURAL INTEGRITY OF BRIDGE STAYS AND SUSPENSIONS

Cable tension is one of the most important parameters for any cable-stayed bridge, as it conditions its structural integrity. However, more often than not, the tension in the cable is monitored at very long time intervals (several years) - if it is monitored at all - leaving infrastructure managers in the dark between measurements. Without regular monitoring, cable tension drifts can go completely unnoticed, eventually leading to catastrophic structural failures and their consequences.

V2i specializes in the design, manufacture, and servicing of industrial measurement systems, with regards to the need for structural dynamic analysis. It combines extensive industry experience with the latest technology. V2i products can be used in various applications where quality control is required to improve the reliability and increase the life span of industrial and structural equipment.

For additional information, please visit our website www.v2i.be

Vibration-based monitoring of cables is a common way of estimating their tension, but it can be inaccurate without adequate post-processing of the raw vibration data. The flexibility of anchorage points, as well as the inertia of the cable, need to be considered for a spot-on vibration-based estimation of the tension, especially on shorter cables.

The V2i **LYRA** solution provides clear, continuous and more accurate monitoring of the cable tension for infrastructures. It is a complete end-to-end solution, which automatically acquires vibration measurements from the cables, converts them into tension and makes these values available remotely on a user-friendly web interface. The solution is designed with the infrastructures' managers in mind, making sure they receive a warning alert message whenever tension exceeds acceptable thresholds, while still allowing for a deeper analysis of the data when necessary.

LYRA empowers maintenance managers by providing them with clear and continuous knowledge about how healthy cables are. Based on this accurate information, critical assets maintenance and repair operations can be optimally scheduled, improving safety for people and decreasing maintenance costs.

The **LYRA** solution comprises high-quality vibration and temperature sensors, paired with a powerful and autonomous data-acquisition system. This data-acquisition system boasts an advanced computation algorithm, which yields tension values for cables of any length (even the shortest ones) and anchor-

age type. The solution is completed by a web interface which allows alarms to be defined and the health status of critical assets to be checked rapidly and reliably.

The **LYRA** solution dramatically improves the health-status management and safety of cable-stayed bridges: infrastructure managers are now able to monitor cable tension evolution remotely, allowing them to plan in-time maintenance operations based on objective, reliable and more accurate measurements, by avoiding unnecessary and time-consuming visual inspection in the field. Human safety and maintenance costs, therefore, are completely under control!

The **LYRA** solution has been designed to provide a complete remote-monitoring solution dedicated to civil-engineering structures. The standard configuration includes:

- high-quality wireless sensors, which are easily deployed and ensure a ten-year life span;
- an autonomous and rugged central system for data acquisition and processing;
- advanced and flexible Cloud-based data storage;
- a **LYRA** web interface for remote control of the central system, easy cable-tension monitoring and the management of alarm messages.



LYRA DESIGN & ARCHITECTURE

The **LYRA** solution relies on a high-performing architecture that offers a complete end-to-end remote-monitoring solution dedicated to civil-engineering structures. LYRA architecture has been designed to ensure the following data-related tasks:

- acquisition and processing with high-quality hardware (wireless sensors and rugged acquisition electronics) operating continuously and autonomously (up to ten years), thanks to an optimised power supply management strategy;
- logging and structuring in the Cloud: this subsystem provides a reliable solution to the need for long-term archiving and being able to retrieve data quickly for comparison and deep-analysis purposes;
- visualisation on a web-based user interface, allowing the administrator and his/her team to remotely monitor all the assets whenever and wherever they want via their connected device.

LYRA CONFIGURATION

The **LYRA** solution is dedicated to cable-stayed bridges. It is mainly based on:

- an autonomous acquisition and processing system;
- a Cloud-based data-storage tool with alarm services;
- a user-friendly web-based user interface for data visualisation and analysis.

The acquisition and processing system comprises a set of wireless, three-axis vibration and temperature sensors, which communicate with a computer driven by a real-time, multi-user and multi-tasking operating system (Linux RT). As the monitoring of a cable-stayed bridge may require the measurement of a large number of cables, the system allows several dozen sensors to be handled via the interface. The Cloud-based server compares the tension values with thresholds and sends alarms (via SMS or email) when required. Structural damage is anticipated and any catastrophic failure or hazardous event is avoided.

The Cloud-based data-storage tool allows the user to archive measurements in a pre-defined

data structure, in order to facilitate further analysis of any abnormal event. This is achieved by recording two kinds of information: raw signals with related pre-defined KPI's and their unique metadata. Proceeding in this manner permits the administrator and his/her team to store all information and retrieve it quickly when needed.

With the web-based user interface, the entire maintenance team is able to monitor any bridge, at any time, from any position in the world via a connected device (smartphone, laptop or tablet). This interface provides alarm messages and insight information related to the bridge structure itself, but also related to the hardware, like battery status and connection quality.

Thanks to LYRA, the number of on-site inspections is dramatically decreased to simply necessary operations, thus affording inspectors a huge amount of time to focus on necessary maintenance operations. Overall, this ensures the safety of the infrastructure by preventing any catastrophic failure, and reduces maintenance costs by regaining significant time via remote inspection.

Data acquisition and processing

Sensors



Station



Historicalisation, data structuring

Signal treatment



Secure cloud storage



Visualization on the web

Remote monitoring



Alarms



DATA PROCESSING & MANAGEMENT

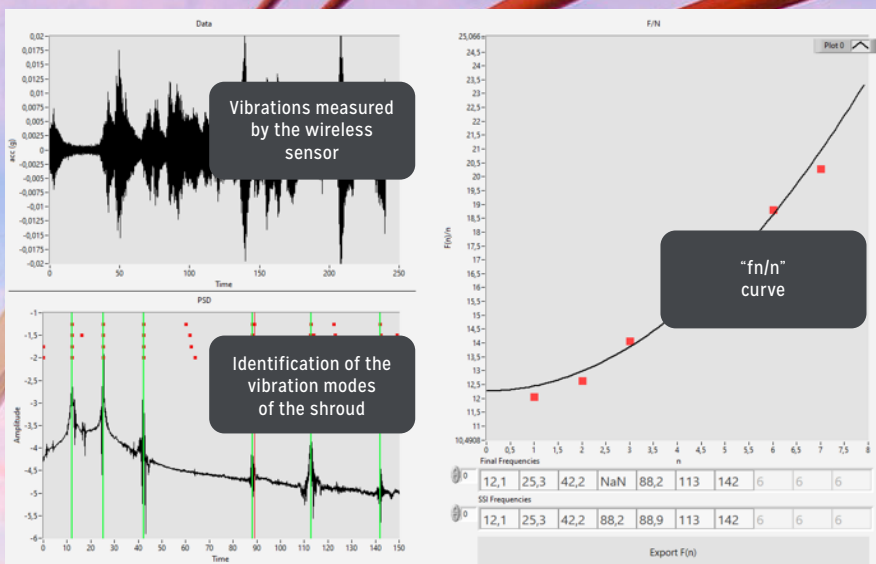
From cable vibrations measured on the field to cable tension on your screen... this is what data-processing tools and algorithms developed within the LYRA solution do. The main steps can be described as follows :

- high-quality wireless sensors deliver data to the autonomous acquisition systems: sensors integrated into LYRA have a wide bandwidth and have been programmed to transfer data without any loss. Transferred information is composed of vibrations on the three axes, temperature, battery status and the quality of the wireless connection;
- vibration signals are processed by the autonomous acquisition system, in order to automatically identify cable vibration modes via the Stochastic Subspace Identification method;
- cable vibration modes are then used to compute the cable tension via an advanced and powerful algorithm: an accurate tension value is computed by taking cable geometry into account and by estimating an error value on the final result. All kinds of cable lengths and clamping geometries can be considered;
- tension values and their corresponding raw data are recorded in a Cloud database via a 4G network and can be consulted by an inspector at any time using a connected device;
- if computed values exceed a pre-defined threshold, an alarm message is immediately sent to the maintenance manager.

MAIN ADVANTAGES

Non-invasive and easy to deploy, thanks to wireless sensors and an autonomous central acquisition system;

- reliable measurement and results: there is no loss of data and the result error is estimated;
- range of applications: rods and all cable lengths, from the longest to the shortest.
- reduced maintenance costs: continuous monitoring makes it possible to optimise maintenance operations by scheduling them and avoiding unnecessary activities;
- the infrastructure manager is the first person to receive alarm messages;
- peace of mind and savings on time: alarm messages are sent automatically - no need to systematically verify the structural health status;
- advanced analysis: raw data and KPI's are available for further processing;
- human safety;
- the LYRA solution can be interfaced with any existing user interface.



The system is smart because it is not only able to assess the relevant vibration level, but also to process its frequency, and it is capable of communicating data via the Internet in order to make choices or decisions. LYRA is an Internet-of-Things (IoT) implementation."

"The LYRA solution is dedicated to tracking the structural integrity parameters of bridges."

"The sensor data is combined with the mathematical models to determine the safety of the structure"