

YAVUZ SULTAN SELIM BRIDGE STRUCTURAL HEALTH MONITORING SYSTEM

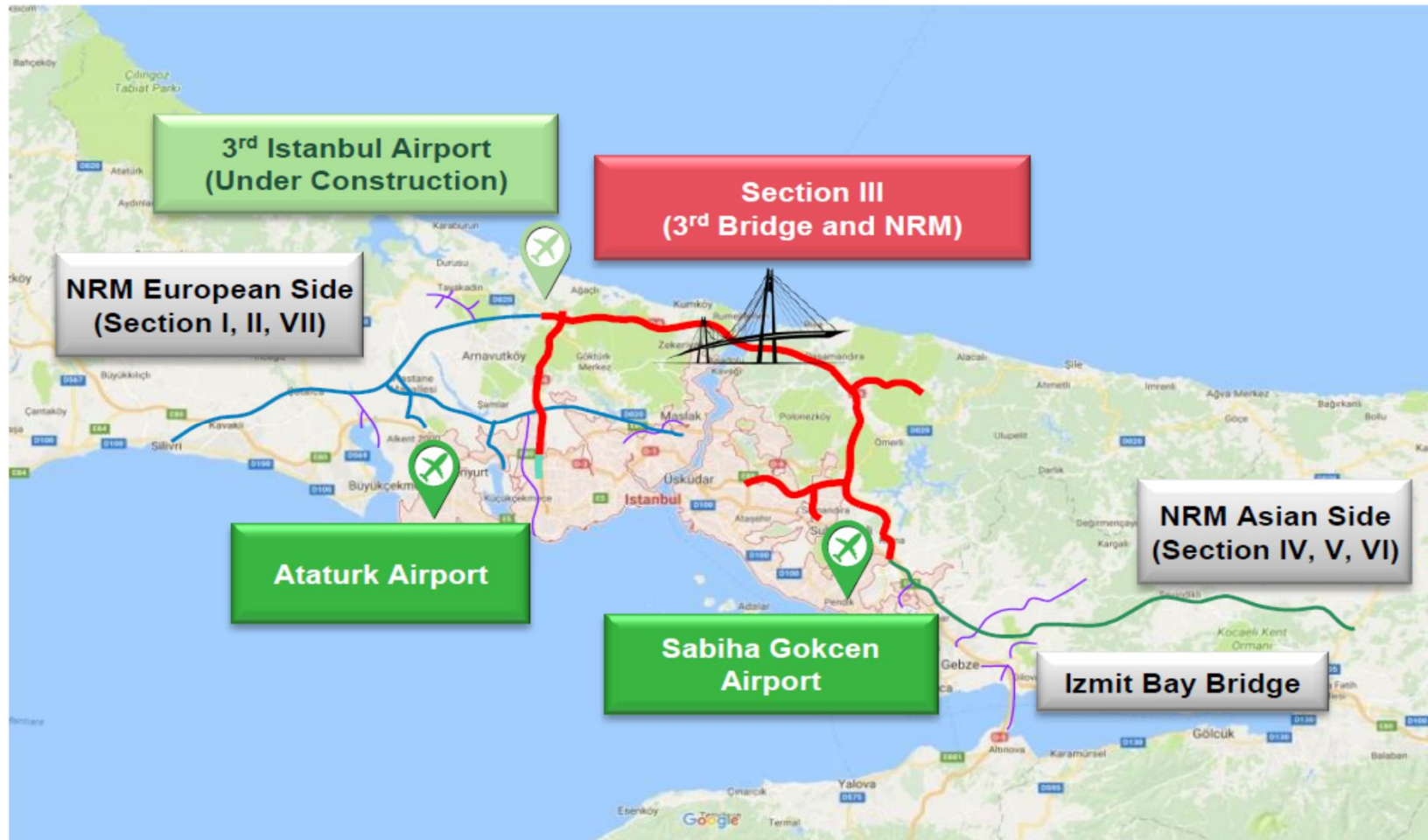
May 2018



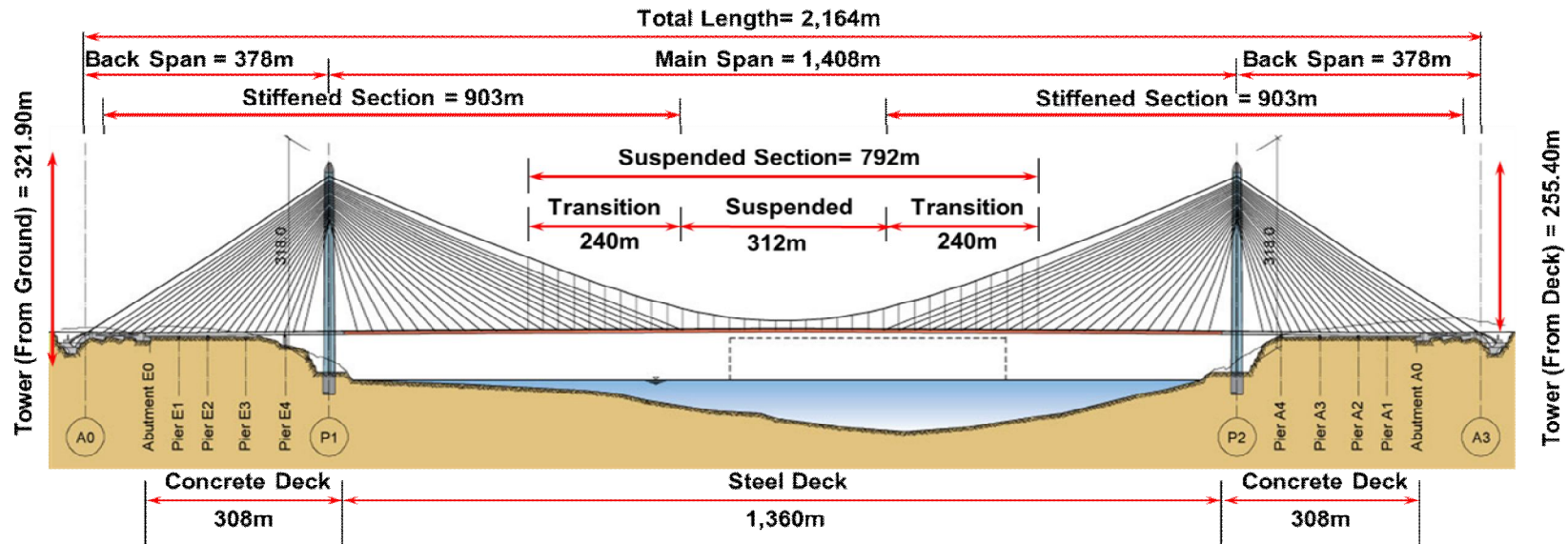
AGENDA

- *GENERAL OVERVIEW OF YAVUZ SULTAN SELIM BRIDGE*
- *MONITORING OF YAVUZ SULTAN SELIM BRIDGE*
 - *WHAT IS A STRUCTURAL HEALTH MONITORING SYSTEM (SHMS)*
 - *SHM SYSTEM OF YAVUZ SULTAN SELIM BRIDGE*

GENERAL OVERVIEW OF YAVUZ SULTAN SELIM BRIDGE



GENERAL OVERVIEW OF YAVUZ SULTAN SELIM BRIDGE



- Hybrid cable-stayed/suspended system
- Total length of **2.164 m**
- Main span of **1.408 m**
- Deck hosts a total of 8 road lanes and 2 railway lanes : total width of **59 m**
- Towers' height: Europe **322 m** – Asia: **318 m**
- Clearance height: **64 m**

MONITORING OF YAVUZ SULTAN SELIM BRIDGE



Yavuz Sultan Selim Bridge Main Control Room

WHAT IS A STRUCTURAL HEALTH MONITORING SYSTEM (SHMS)

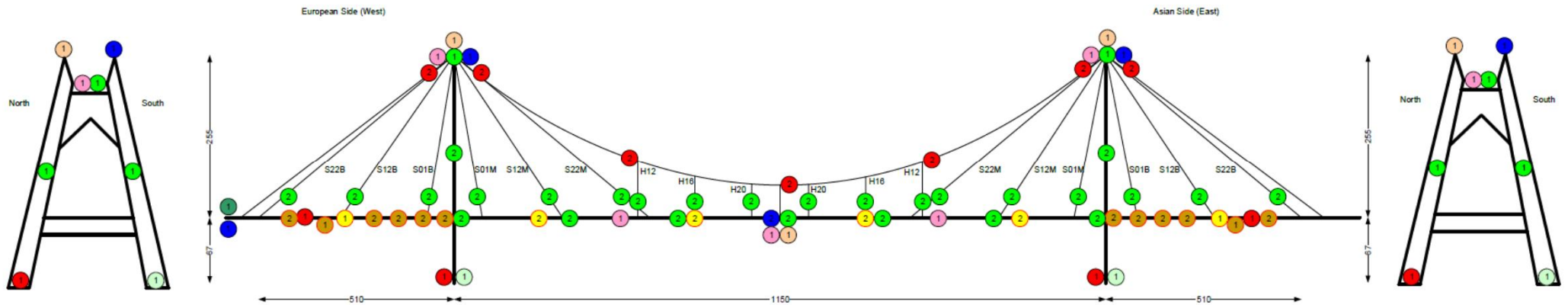
The term “Structural Health Monitoring (SHM)” refers to continuous inspection of a structure by analyzing real time records coming from various types of sensors that are strategically placed on the structure.

The main objective in a general SHM system is to monitor the behaviour of the structure and its components continuously, and to identify its dynamic characteristics.

An integral part of the SHM system is the software that analyses and interprets the continuous data in real time, and issue warnings at several levels when there is a possibility of safety risk.

SHM SYSTEM OF THE YAVUZ SULTAN SELIM BRIDGE

COMPONENTS OF THE SHMS



- 3D ACC (Qty=18)
- 2D ACC (Qty=56)
- 1D ACC (Qty=2)
- GPS (Qty=5)
- 2D Tiltmeter (Qty=5)
- Wind sensor (speed, direction) (Qty=3)
- Weather station (speed, direction, T, P, RH) (Qty=1)
- Displacement (Qty=22)
- Temperature sensor (Qty=10)

Total Number of Sensors: 126

COMPONENTS OF THE SHMS

ACCELEROMETERS

18 Accelerometers 3D

56 Accelerometers 2D

2 Accelerometers 1D

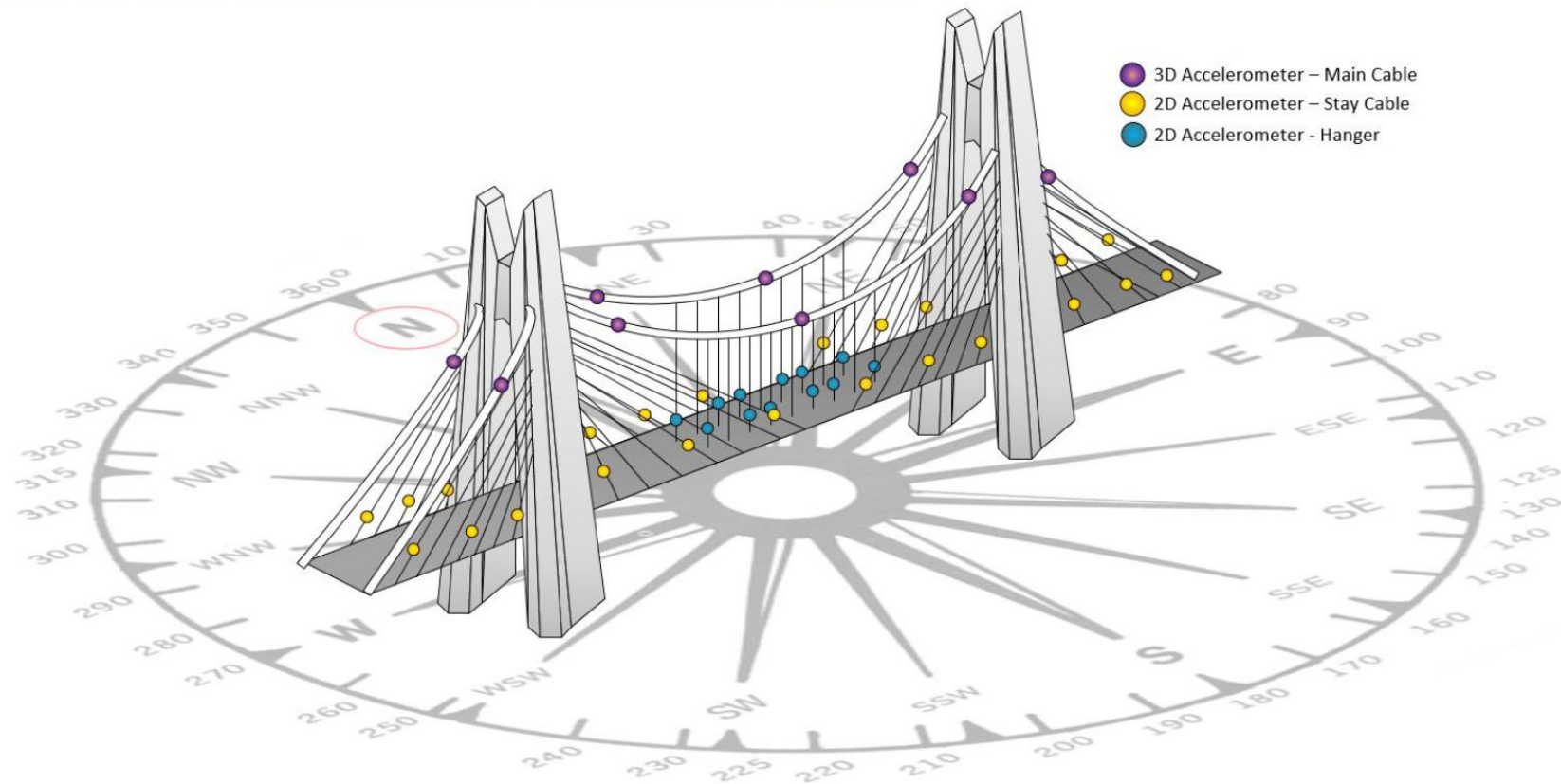


Accelerometers provide frequencies of the bridge elements which is useful for following the bridge behaviour over the years.

On cables, the frequencies can be used to measure the tension in cables.

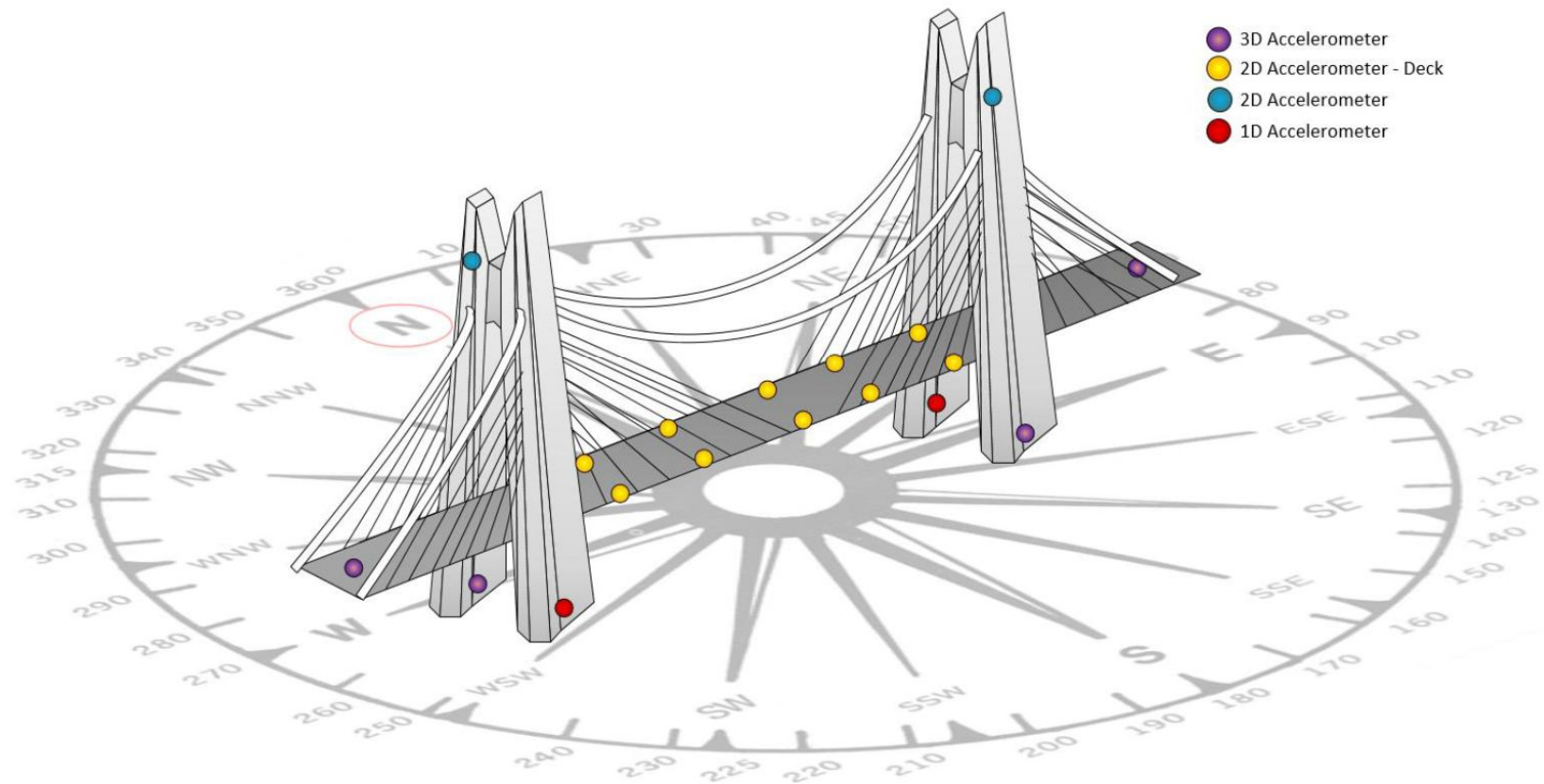
COMPONENTS OF THE SHMS

CABLE ACCELEROMETERS



COMPONENTS OF THE SHMS

STRUCTURE ACCELEROMETERS

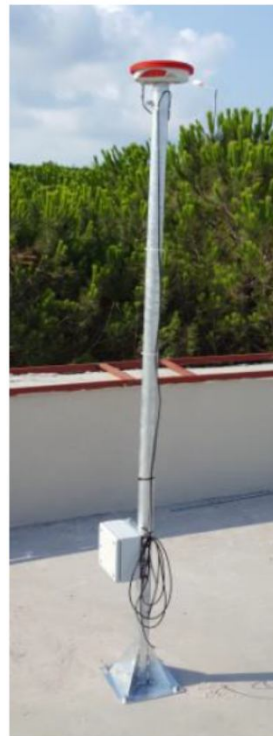
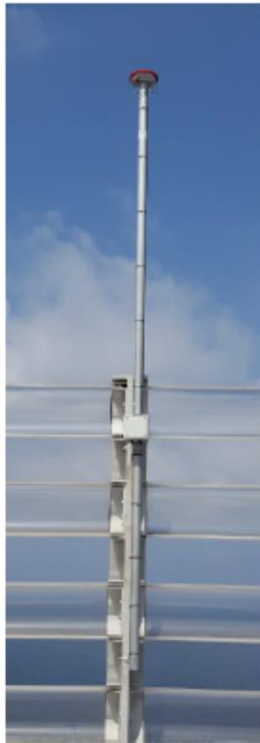


COMPONENTS OF THE SHMS

GPS LOCATION

1 Reference GPS

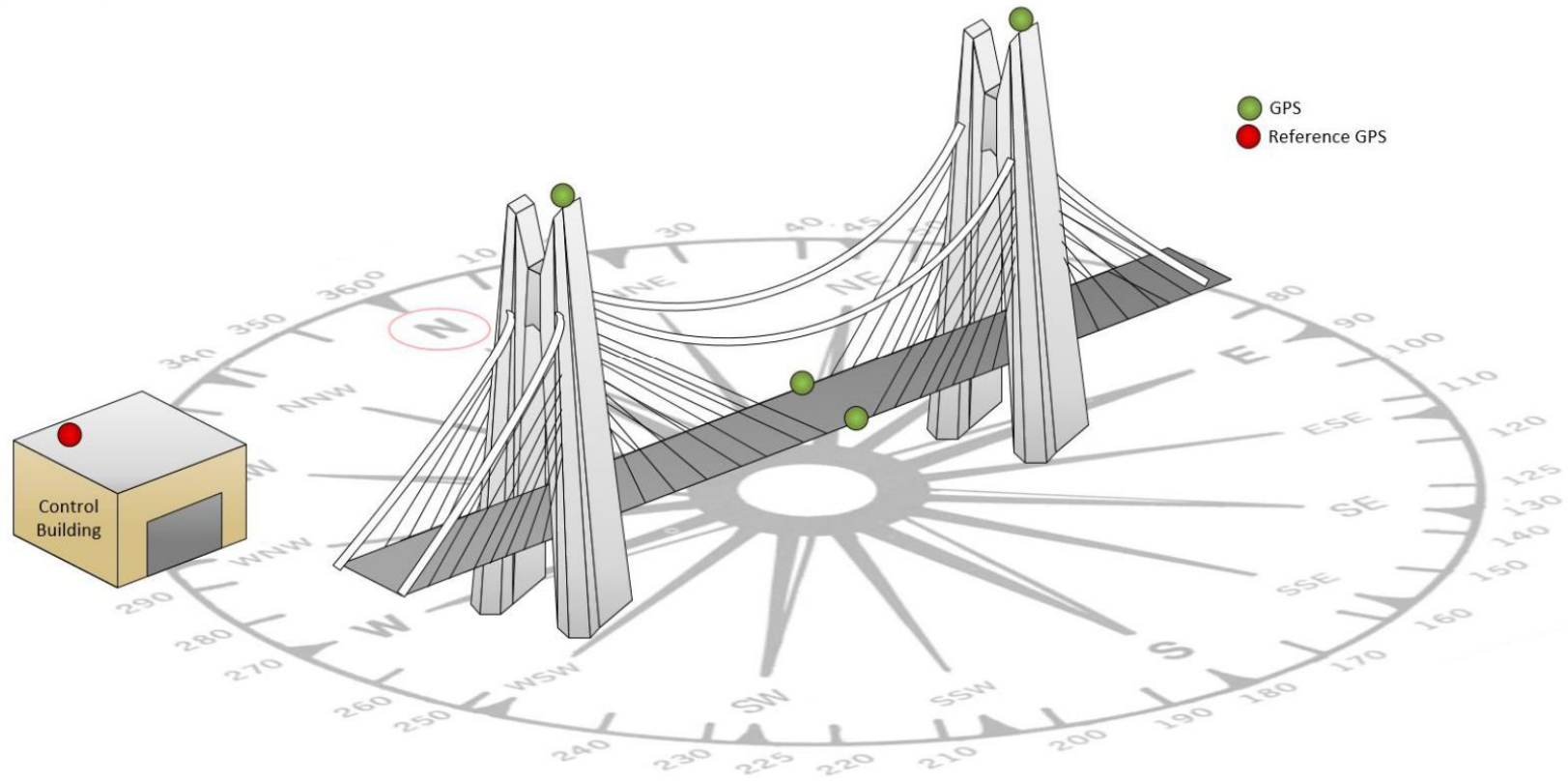
4 GPS sensors



GPS sensors installed at the top of each tower and center of the deck will enable measurements of deck deflection and tower movement.

COMPONENTS OF THE SHMS

GPS

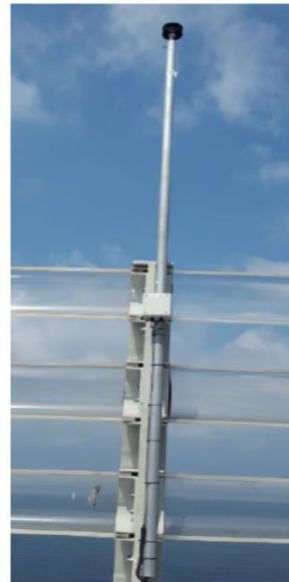


COMPONENTS OF THE SHMS

WEATHER SENSORS

1 Weather Station

5 Wind Sensor



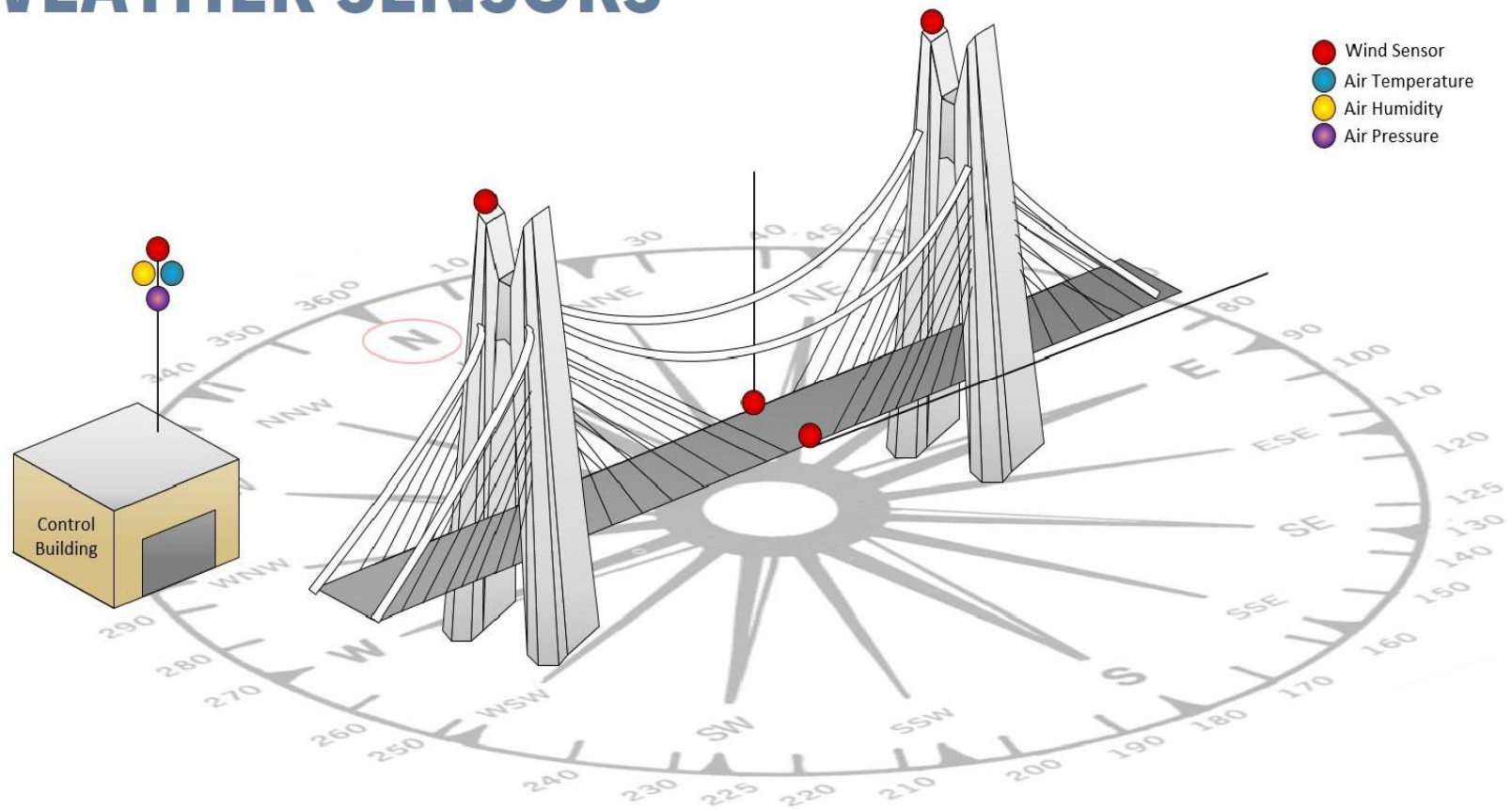
The Weather Station is equipped with 1 anemometer which measures:

- Air Temperature
- Air Humidity
- Air Pressure

Wind sensor (Anemometer) measures the speed and direction of the wind.

COMPONENTS OF THE SHMS

WEATHER SENSORS



COMPONENTS OF THE SHMS

INCLINOMETERS

2 at tower Top
3 inside Steel Deck

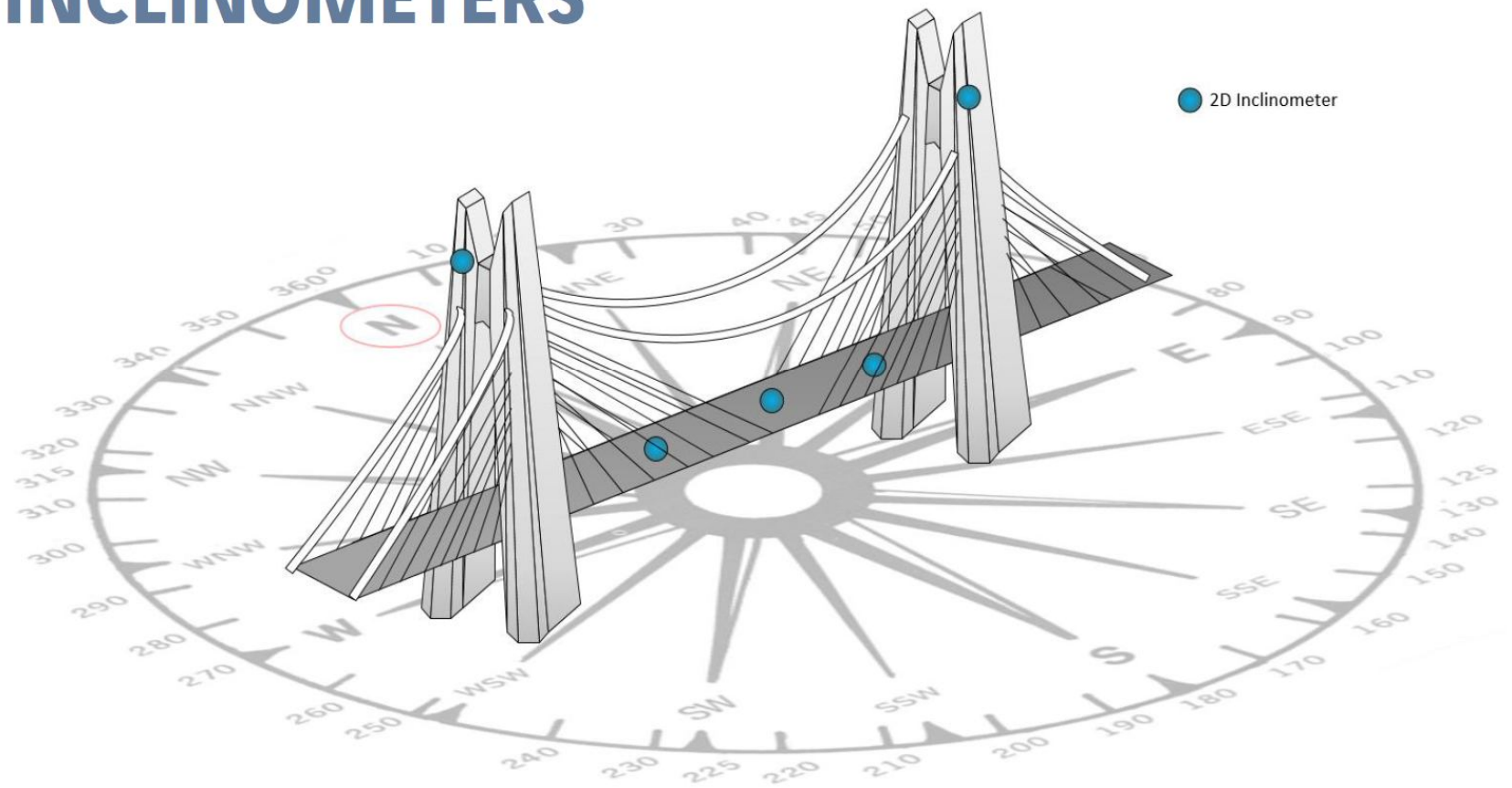
(Tiltmeter = Inclinator)



Inclinometers measure inclination of towers and deck on a +/- 3° scale.

COMPONENTS OF THE SHMS

INCLINOMETERS

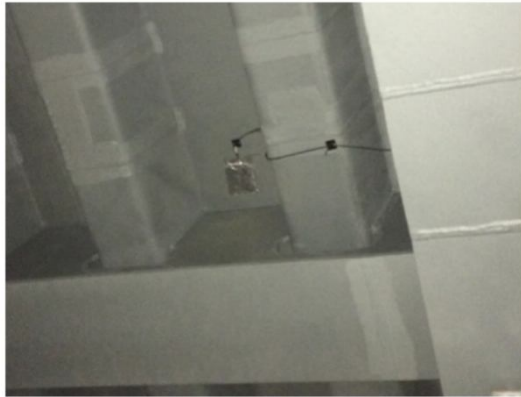


COMPONENTS OF THE SHMS

DECK TEMPERATURE

2 Temperature sensors in concrete deck

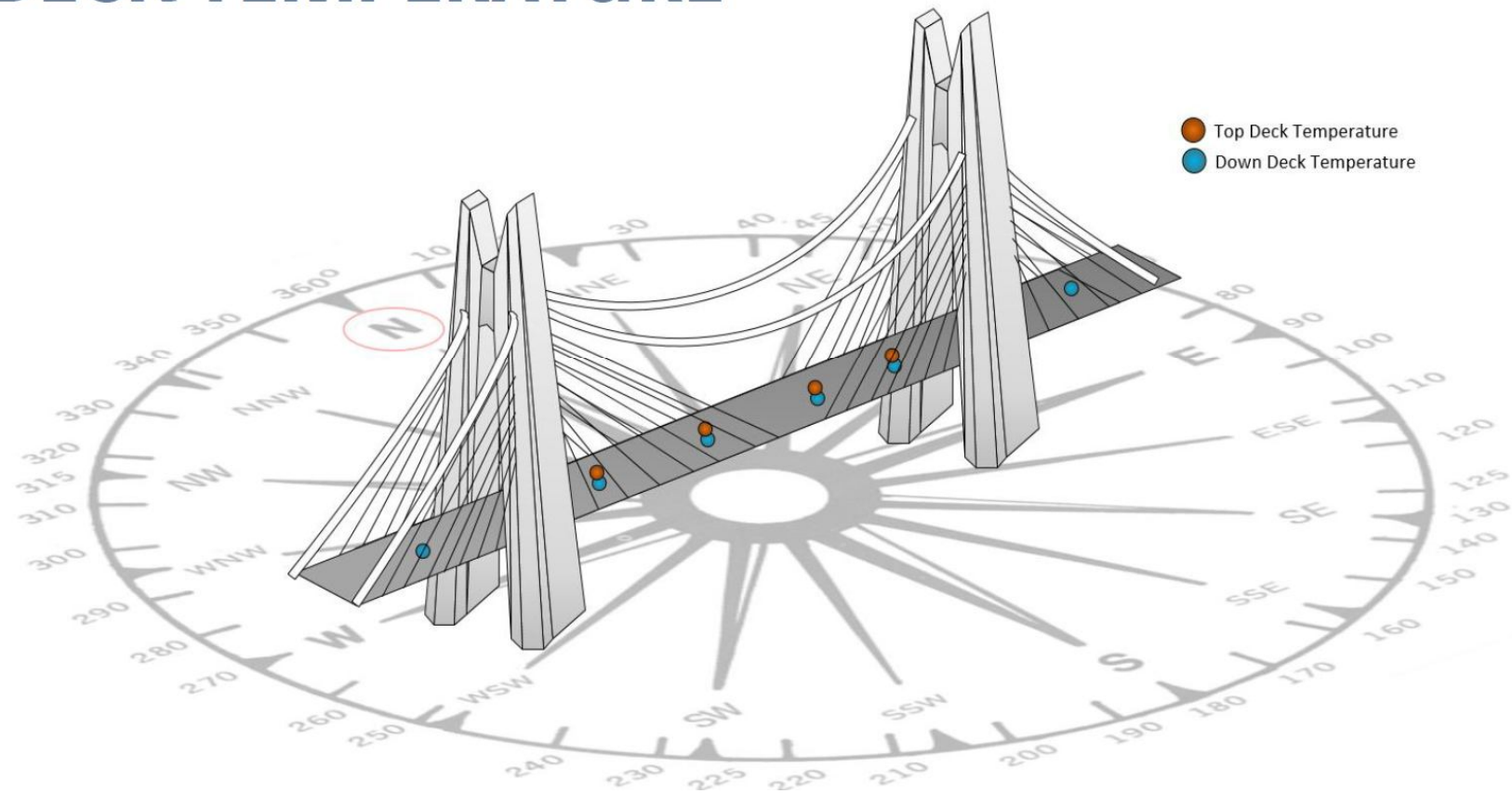
10 Temperature sensors in steel deck



Temperature sensors measure the surface temperature on the top and bottom of the concrete and steel decks.

COMPONENTS OF THE SHMS

DECK TEMPERATURE



COMPONENTS OF THE SHMS

DISPLACEMENT SENSORS

10 Vertical Displacements

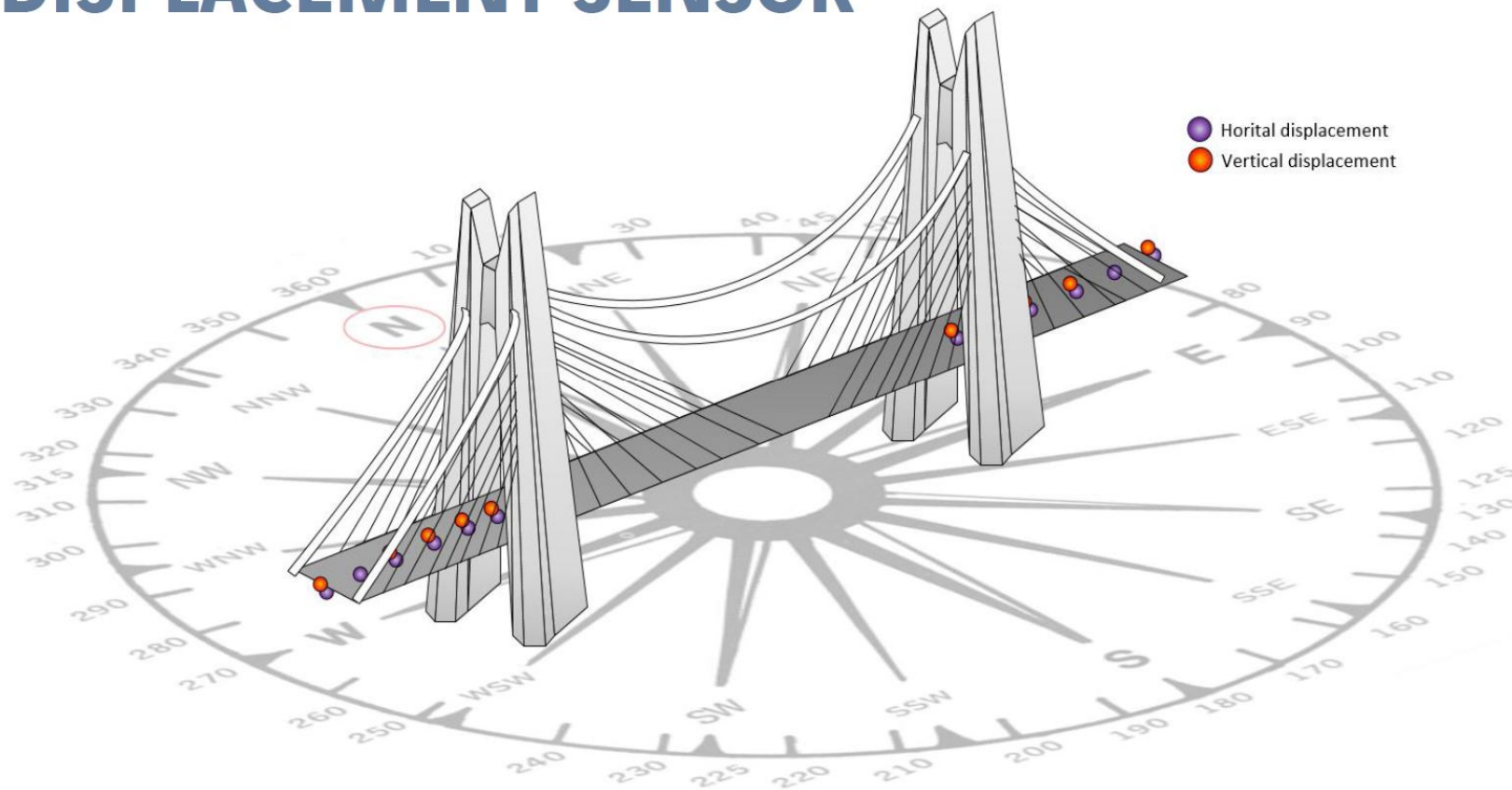
12 Horizontal Displacements



Displacement sensors measure the displacement of the bearing, vertically and horizontally.

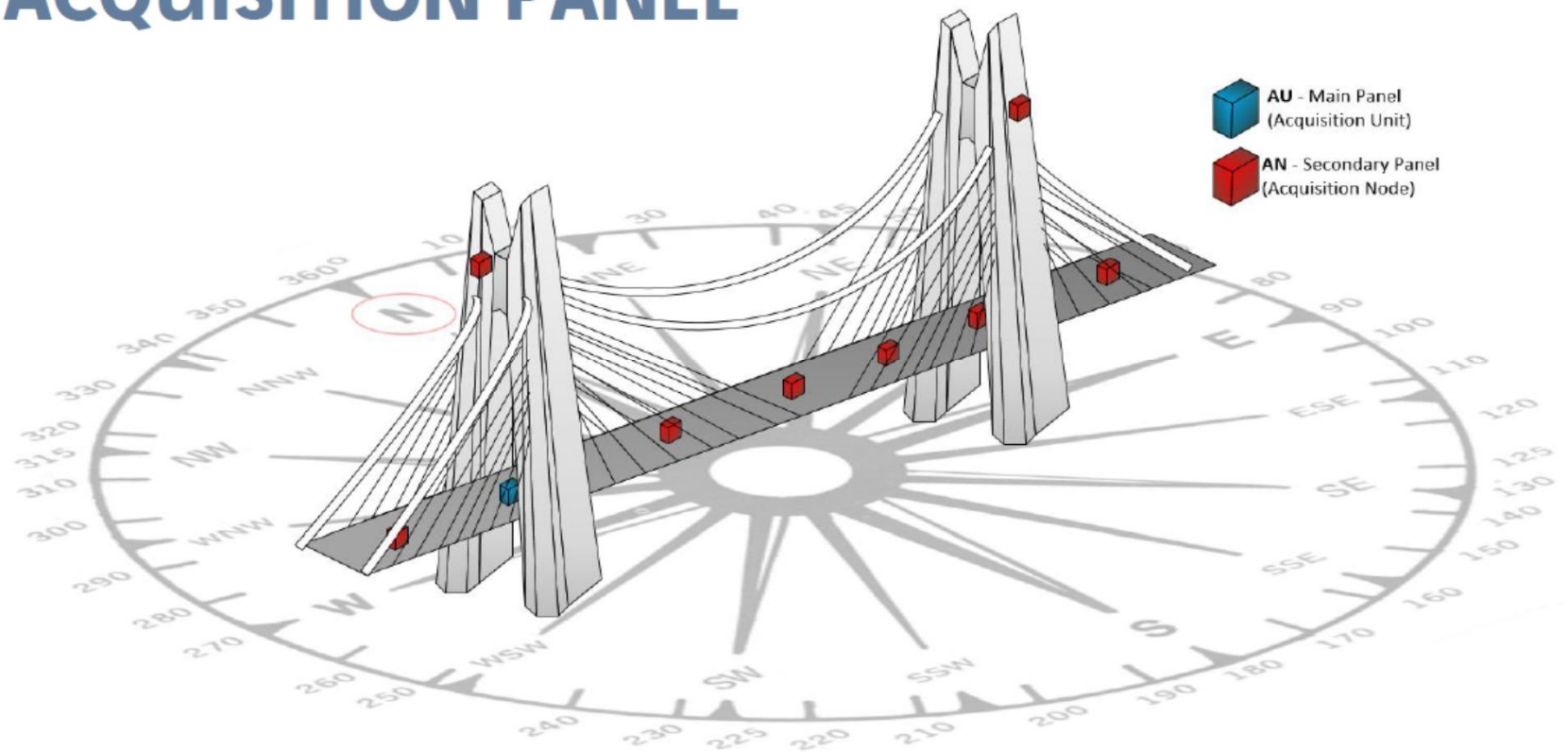
COMPONENTS OF THE SHMS

DISPLACEMENT SENSOR



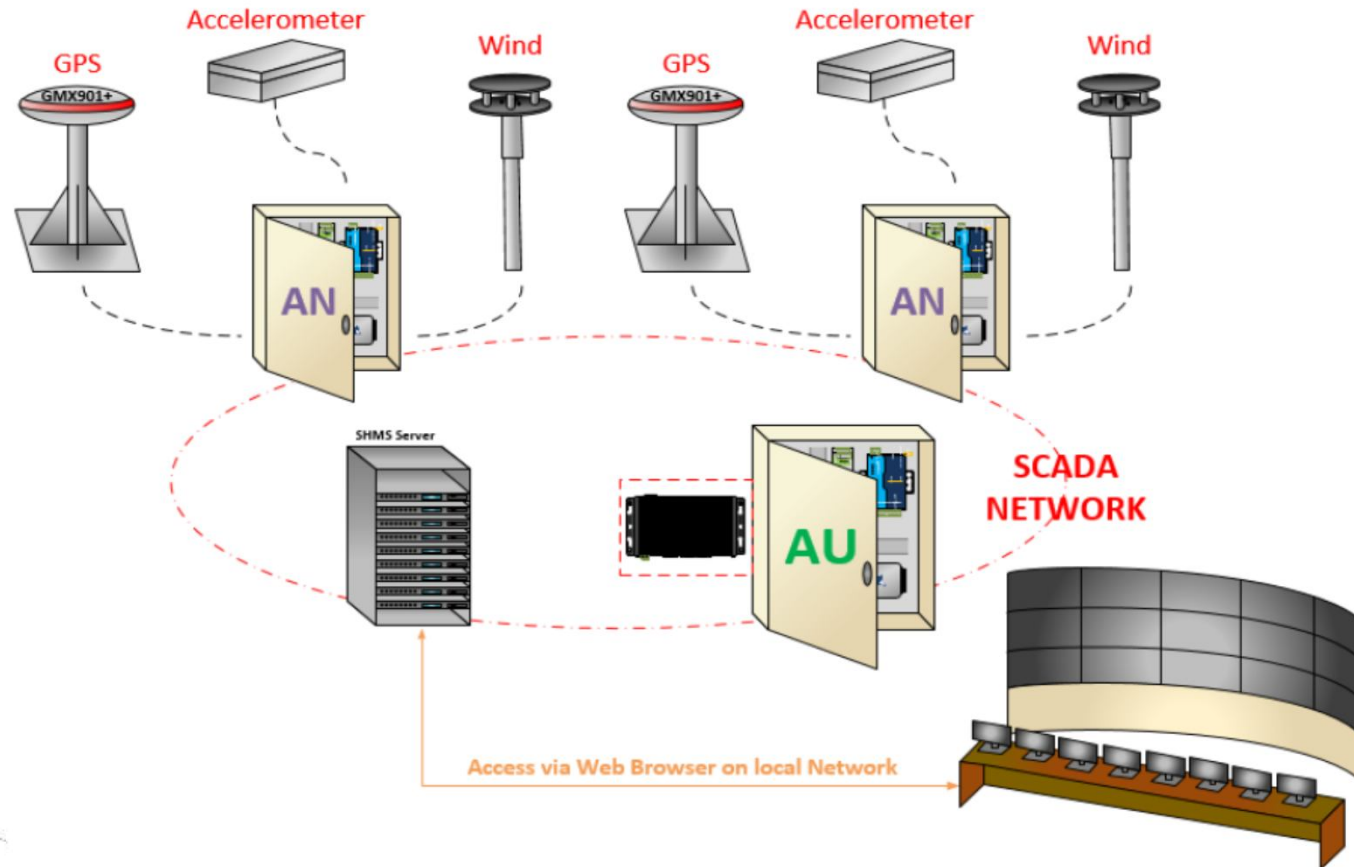
ACQUISITION OF DATA

ACQUISITION PANEL



Sensors are distributed along the YSS Bridge in order to measure structural attributes such as temperature, tilt, vibration, etc. The signals from these sensors are digitized in 9 acquisition nodes installed locally on the bridge as per above.

ACQUISITION OF DATA



The Acquisition nodes are connected together.

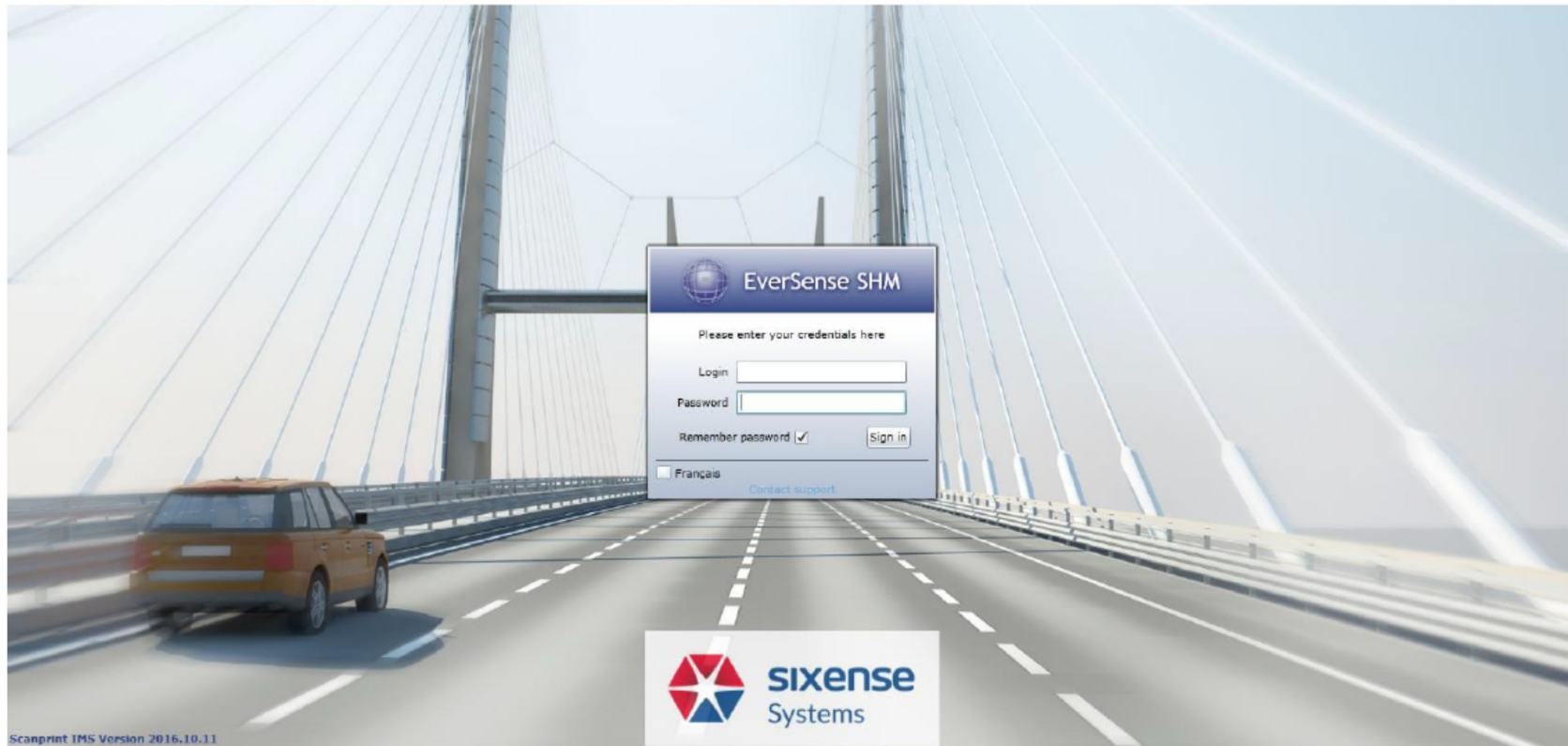
At the end of the chain, the Acquisition Unit collects the measurements and performs the signal processing and the recording of the data. The data are then transferred through the internet to our local servers.

MAIN OBJECTIVES OF THE SHMS DATA

The three main objectives of this interpretation and exploitation of SHMS data are:

- ✓ The first and the most important one is to control the operational conditions of the bridge to guarantee third party safety,
- ✓ The second one is to control if the actual bridge behavior is in line with design forecasts,
- ✓ The third and last one is to control through time the ageing of the bridge.

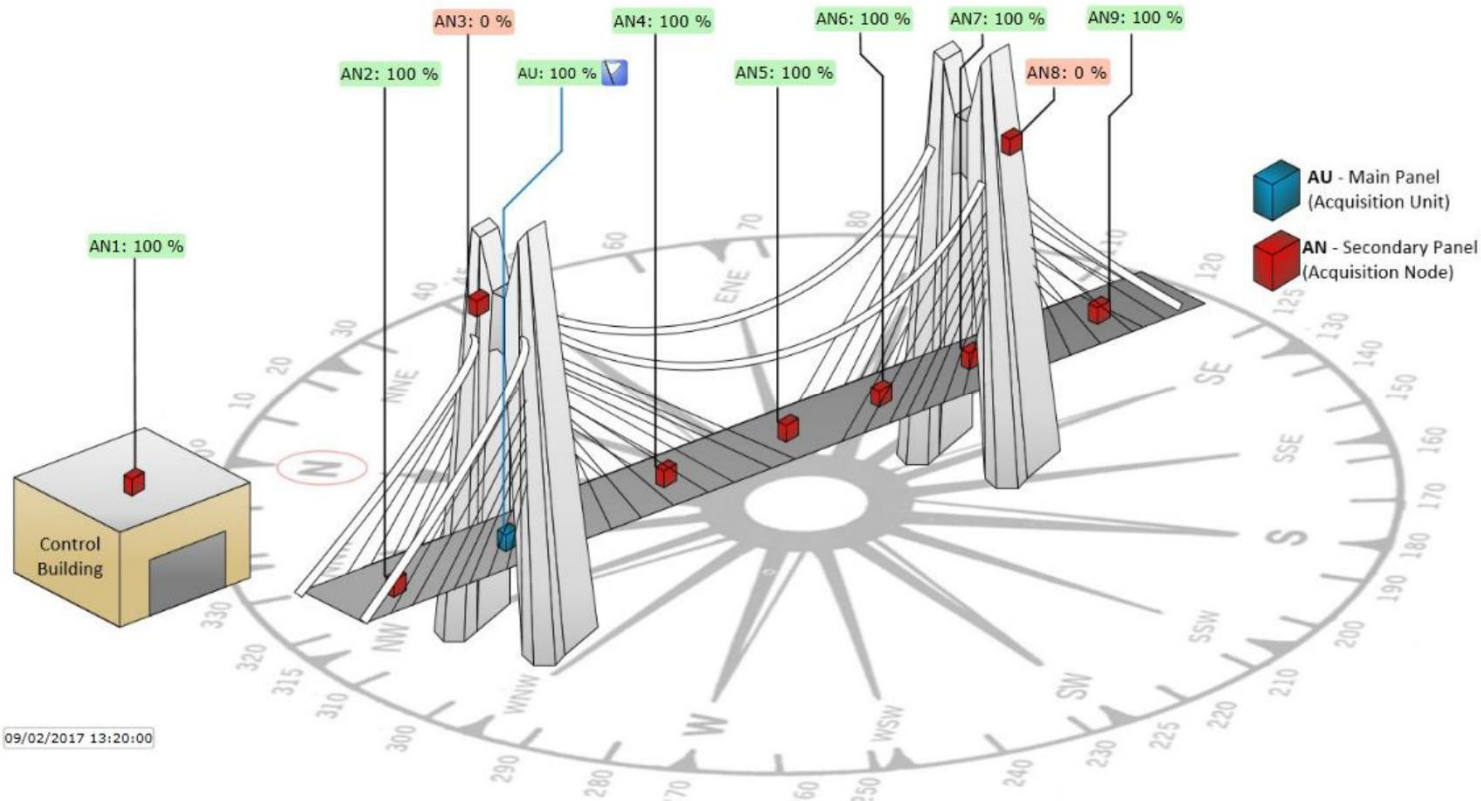
ABOUT THE SOFTWARE



ABOUT THE SOFTWARE

The image shows a screenshot of the EverSense SHM software interface. The interface has a dark blue header with the text "EverSense SHM - Welcome to EverSense SHM" and search/filter buttons. A sidebar on the left contains a navigation menu with items like Home, My routings, Inventory, Inspections, Management, Monitoring, Reports, and Administration. The main content area displays the date "21 Mayıs 2018 Pazartesi" and a grid of icons for various functions: Inventory, Inspections, Routings, Alerts, Activities, Map, History Database, and Synoptics. The background of the interface is a photograph of an aircraft wing with a sensor mounted on it. A black label at the bottom of the sensor reads "A2-11 - ACC2D-P1-Center-S-D". The Sixsense Systems logo is visible in the bottom left corner of the interface.

SYNOPTICS



The System Status view displays which panels are working and which are not. If a panel is not working, check power and network at its location.

ABOUT THE SOFTWARE

The screenshot displays the 'Filters' application window. At the top, there are controls for 'Create new filter', 'Save changes', 'Delete', 'Set this filter as public', and 'Set as startup filter'. The main area is divided into two sections: 'Filter on generalities' and 'Filter on attributes'. The 'Filter on generalities' section includes input fields for 'Name Contains', 'Asset Id Contains', and 'Comments Contains', along with a 'Parent Equals' dropdown and an 'Archived' checkbox. The 'Project / Client' dropdown is currently set to '3rd Bosphorus Bridge'. The 'Filter on attributes' section has a 'Delete selected' and 'Clear all' button, and a table with columns for 'Logic', 'Operator', and 'Value'. To the right, the 'Types' section lists various sensor types with checkboxes, including 'Structure', 'Acquisition Unit', 'Acquisition Node', 'Junction Box', 'Cast In Box', 'Calculated channels', 'Accelerometer', 'Acoustic sensor', 'Anemometer' (which is checked and highlighted in yellow), 'Camera', 'Corrosion sensor', 'Displacement sensor', 'GPS Sensor', 'Humidity Sensor', 'Inclinometer', 'Load cell', 'Scour sensor', 'Strain gage', 'Survey point', 'Temperature sensor', 'Weather station', 'Alert groups', and 'Excel import'. A red box highlights the 'Types' list, and a red arrow points to the 'Anemometer' entry with the label 'Select Types of sensors'. Three other red arrows point from the 'Name Contains', 'Asset Id Contains', and 'Project / Client' fields to the text 'Use part or full name to filter'. Two more red arrows point from the 'Asset Id Contains' and 'Project / Client' fields to the text 'Use Asset code ID to filter'. A third red arrow points from the 'Project / Client' field to the text 'Select by project (if many)'. At the bottom right, there are 'Apply' and 'Cancel' buttons.

Custom filter allows us to select assets by type, group, name or project.

Filters can be saved to be easily accessible.

REAL TIME

Real time function allows:

- The most current data received to be viewed
- For values to be received every 10 minutes
- To view sensor by sensor
- To filter which sensor to display

EverSense SHM - Real Time

Hide filters

Component type Equals Not filtered

Name Contains Value >= <= Status Not filtered

Number Contains Comments Contains

Date : 09/02/2017 15 13:41

Apply Clear Filters

List Map Synoptics

Group by Don't group

Displaying 600 items

#	Asset	Component
A3-03	ACC3D-P1-EU-N-MCTop	Longitudinal acceleration_Min A3-03
A2-21	ACC2D-P1-AS-S-H16	Longitudinal acceleration_Min A2-21
A2-16	ACC2D-P1-AS-N-H12	Longitudinal acceleration_Min A2-16
A3-05	ACC3D-P1-AS-N-MCTop	Longitudinal acceleration_Min A3-05
A3-07	ACC3D-P1-AS-N-MC_Q	Longitudinal acceleration_Min A3-07

I-03 - INC2D-Midspan-C-DCenter Longitudinal inclination_Ave

1.91
1.41
0.91
0.41
-0.09

REAL TIME

EverSense SHM - Real Time

Home
Inventory
Inspections
Management
Monitoring
Synoptics
Real Time
History Database
Events
Day Files
Reports
Administration

Show filters
List Map Synoptics
Group by Don't group
Displaying 600 items

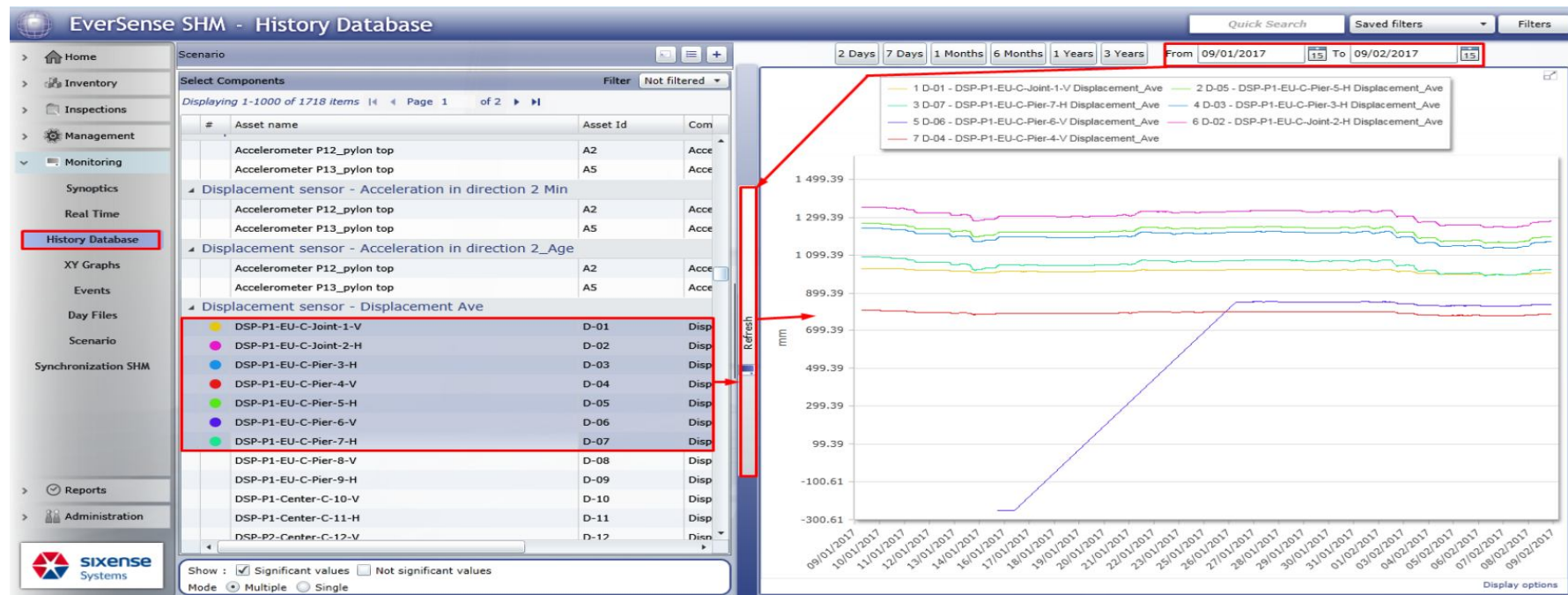
#	Asset	Component
I-03	INC2D-Midspan-C-DCenter	Longitudinal inclination_Ave I-03X
G-REF	GPS-Controlroom-EU	Nb of satellites_Ave G-REFNS_AVE
G-04	GPS-P2-AS-C-Top	Nb of satellites_Ave G-04NS_Ave
G-02	GPS-Midspan-N-Deck	Nb of satellites_Ave G-02NS_Ave
G-03	GPS-Midspan-S-Deck	Nb of satellites_Ave G-03NS_Ave
G-01	GPS-P1-EU-C-Top	Nb of satellites_Ave G-01NS_Ave
T-05	TMP-P1-AS-C-D-H7E-B	Temperature_Ave T-05_Ave
T-10	TMP-P2-AS-C-D-8	Temperature_Ave T-10_Ave
T-06	TMP-P2-EU-C-D-H7A-T	Temperature_Ave T-06_Ave
T-03	TMP-P1-AS-C-D-H22E-B	Temperature_Ave T-03_Ave
T-09	TMP-P2-EU-C-D-H22A-B	Temperature_Ave T-09_Ave
T-07	TMP-P2-EU-C-D-H7A-B	Temperature_Ave T-07_Ave
T-04	TMP-P1-AS-C-D-H7E-T	Temperature_Ave T-04_Ave
T-08	TMP-P2-EU-C-D-H22A-T	Temperature_Ave T-08_Ave
T-02	TMP-P1-AS-C-D-H22E-T	Temperature_Ave T-02_Ave
T-01	TMP-P1-EU-C-D-8	Temperature_Ave T-01_Ave
A2-21	ACC2D-P1-AS-S-H16	Transversal acceleration_Max A2-21
A2-25	ACC2D-P1-AS-S-H20	Transversal acceleration_Max A2-25
A2-27	ACC2D-P1-AS-S-S22M	Transversal acceleration_Max A2-27
A2-23	ACC2D-P1-AS-S-DH19E	Transversal acceleration_Max A2-23
A2-38	ACC2D-P2-EU-N-DH14A	Transversal acceleration_Max A2-38
A2-34	ACC2D-P2-EU-N-DH19A	Transversal acceleration_Max A2-34

T-06 - TMP-P2-EU-C-D-H7A-T Temperature_Ave

jeudi 9 février 2017 13:30:00

HISTORY DATABASE

- The History Database function allows us to go back to previous records for each sensor.
- For example, we are able to refer back to values from extreme events, such as strong earthquakes, wind storms, unusual extreme loadings etc to evaluate and compare values as required.



CONCLUSION

The ability to continuously monitor the integrity of our bridge offers the opportunity to reduce maintenance and inspection costs, and ensure a more reliable inspection than traditional methodologies.

The bridge may react in different ways while operational. It is very important that all of these changes are recorded and kept under control. It is for this reason that the bridge is inspected on a routine and extraordinary situation basis. During these inspections, the data collected from the sensors on the bridge are used. The structural health monitoring system needs to be continuously monitored for the interpretation and analysis of these data.

Thank You. Any Questions?

Meltem AKYÜZ

