Wireless sensor network and its application to structural health monitoring

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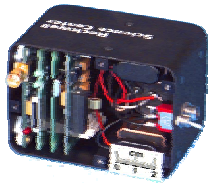
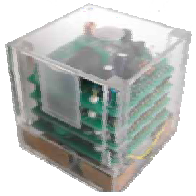
A historic decade of wireless smart sensor research



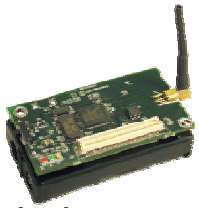
WINS 1 (1999)

EYES (2003)

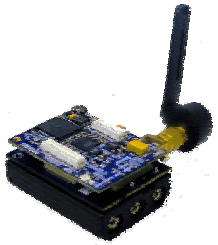
BTnode rev3 (2004)



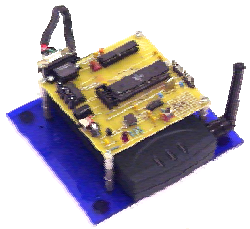
U3 (2002)



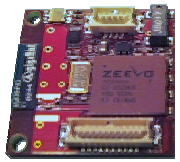
Berkeley Mote Mica2 (2004)



Imote2 (2006)



Prototype by Prof. Lynch (2002)

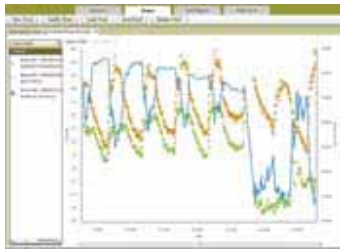


Intel Imote (2004)

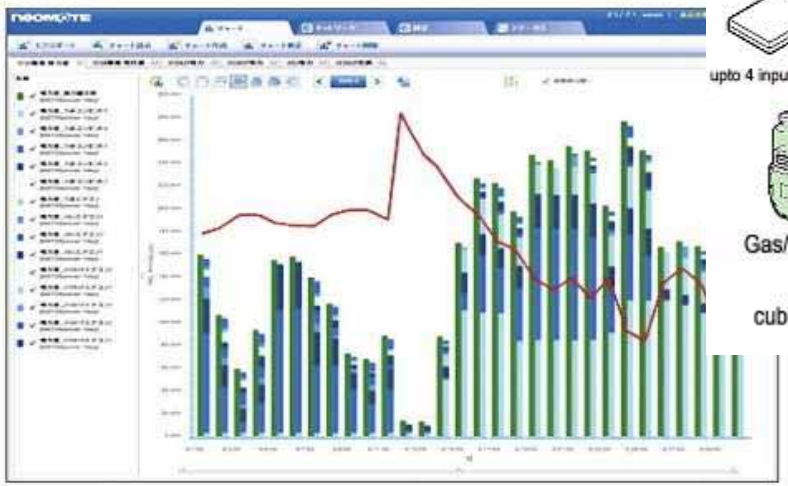
- ✓ In 2000, US Defense Advanced Research Projects Agency (DARPA)'s Networked Embedded Systems Technology (NEST) program funded projects aiming to build dependable, real-time, distributed, embedded applications comprising 100-100,000 simple computing nodes.
- ✓ Since then a variety of WS platforms have been developed

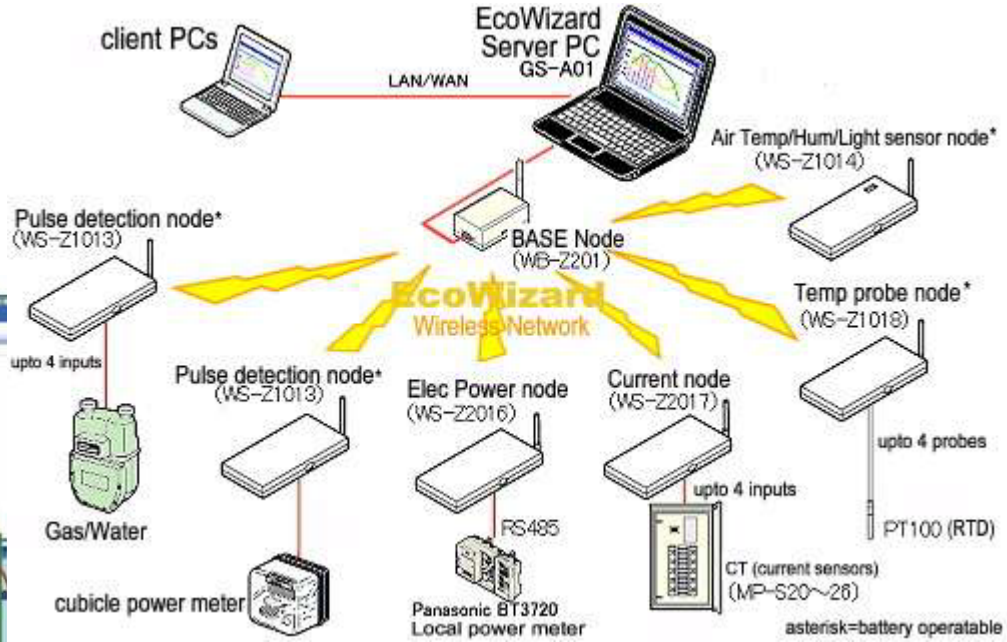
Application examples:
-Agricultural application-

- Soil moisture & temperature
- Ambient temperature & humidity



Application examples:
Energy monitoring solution





Ecowizard, Crossbow Japan

Application examples:
-Landslide monitoring-

MEMS inclinometer

Volumetric water content meter

No wiring work →
Low cost, easy instlation

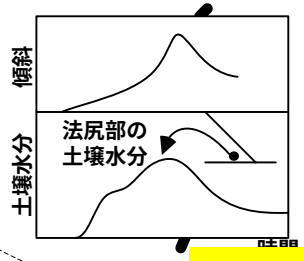
(4) Data is transferred via cell phone network to Internet. (every 10 mins.)

(3) Data is collected at the gateway unit.

Data can be accessed through internet

programs

(1) Sensor units with inclinometer and water content sensor.



Data link by Cell Phone Network (KDDI)

(5) Central server receives data and issue warning if abnormal data is found.

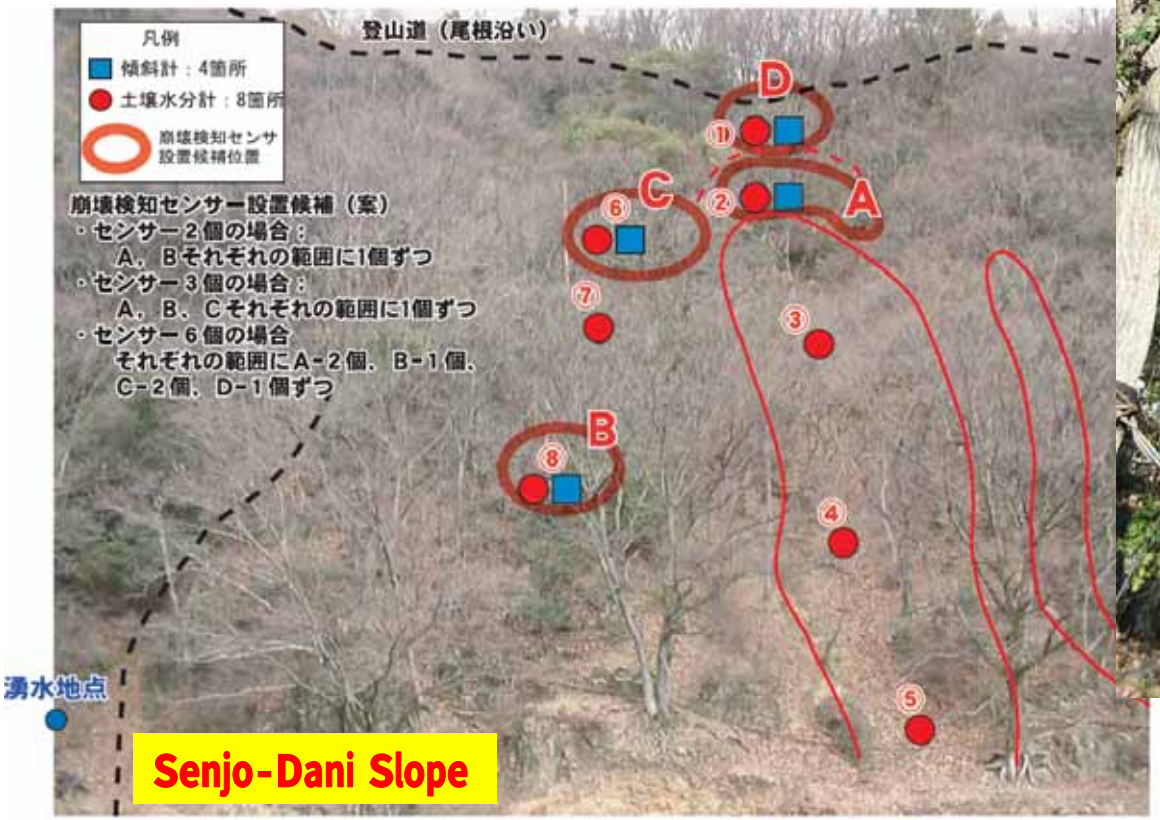
Low-cost, easy instllation

(2) Data is relayed by mult-hopping among sensor units.

-Landslide monitoring-

The prototype system is installed
on steep slopes in Kobe City, Japan.

Installation takes less than 30 min per unit



Ogawa-Dani Slope
(which failed due to 1995
Hyogoken-Numbu earthquake)

Application examples:

-seismic response monitoring-

Ubiquitous Structural Monitoring System

Application examples:
-Bridge vibration monitoring-

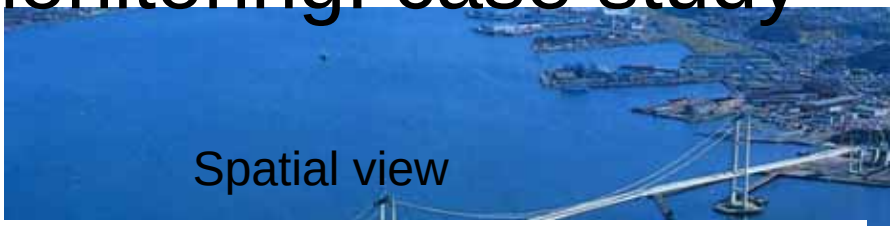
- What can we obtain from dense structural vibration measurements?
- How can WSN contribute to bridge engineers?

Various purposes of structural vibration monitoring

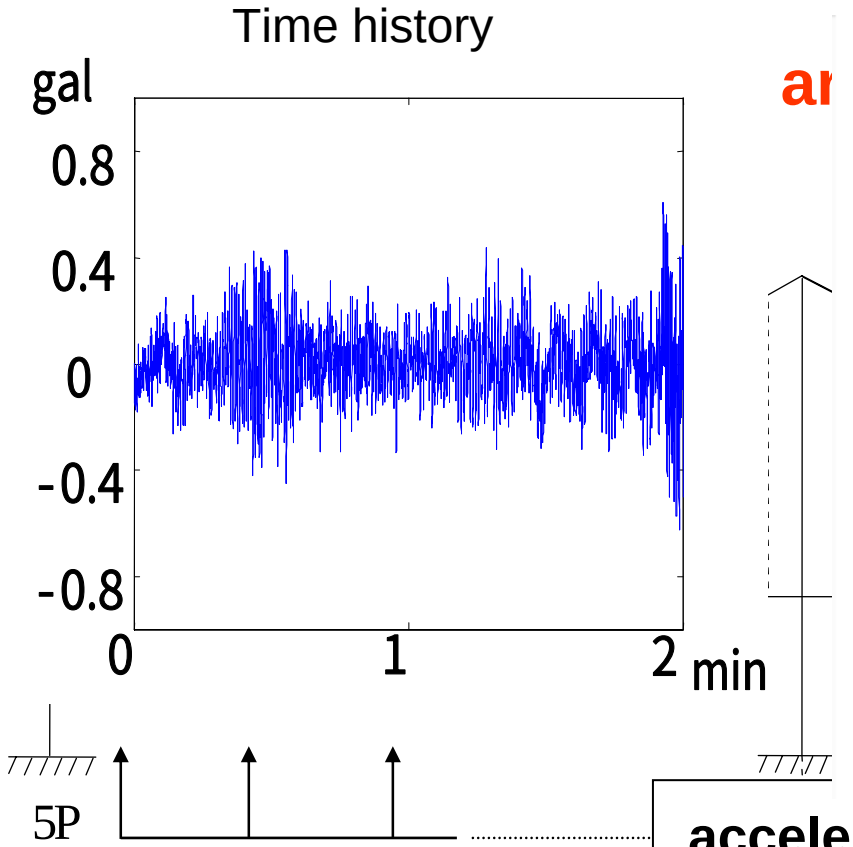
- **To monitor and control the construction process**
- **To validate the structural designs and characterize performance (e.g., develop database)**
- **To characterize loads in situ**
- **To assist with building/bridge maintenance**
- **To detect and localize damage before it reaches a critical level, thus increasing the safety to the public**
- **To reduce the costs and down-time associated with repair of damage**
- **To assist with emergency response efforts, including building evacuation and traffic control**

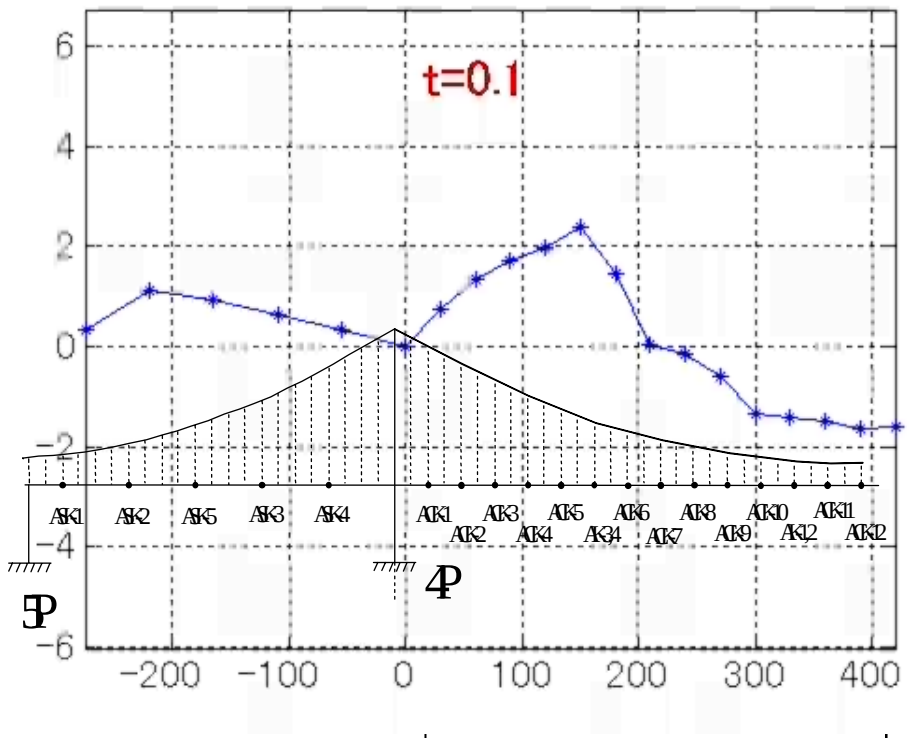
(Prof. B. F. Spencer, Jr. UIUC)

Structural vibration monitoring: case study



Measurement:



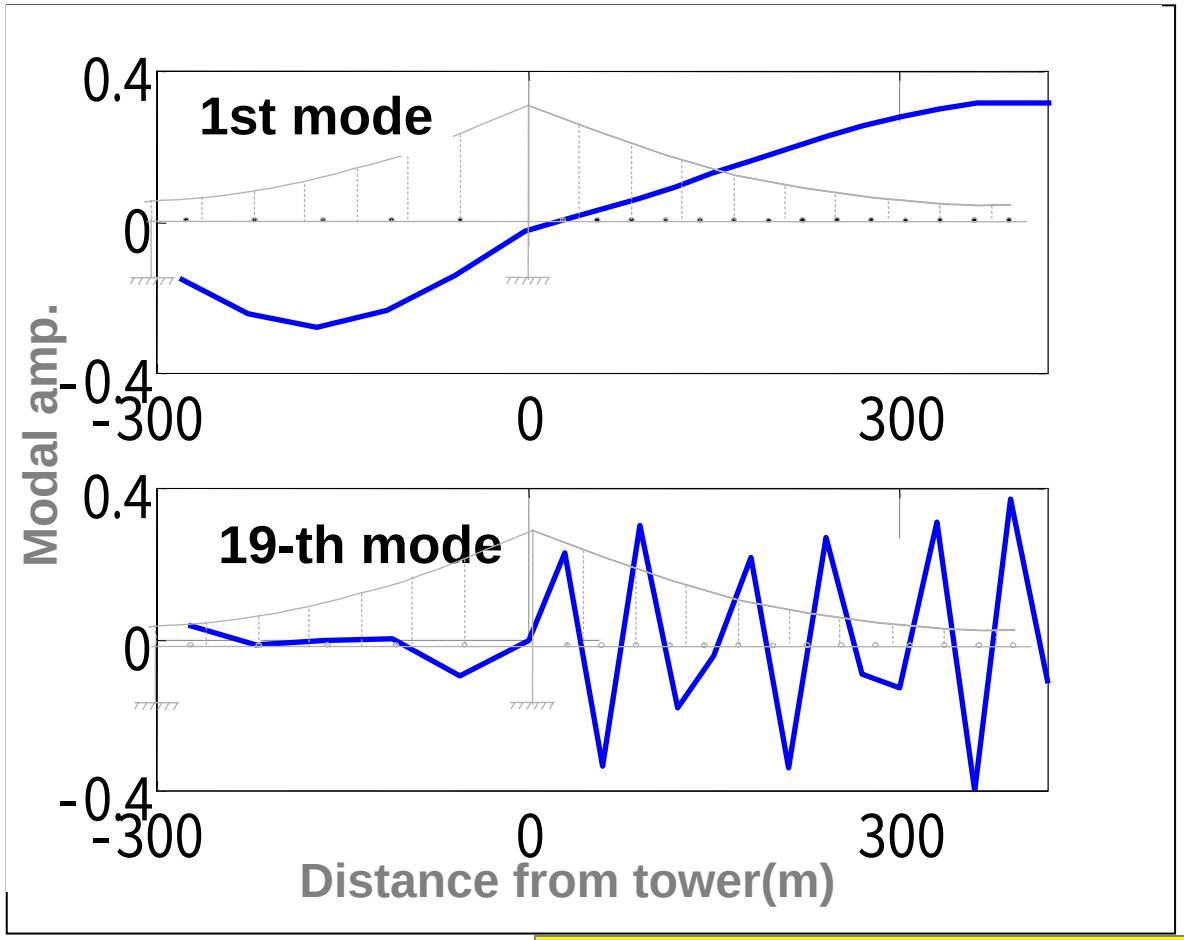


accelerometers (19pts)

How much can we know about the bridge from measurement by dense arrays of sensors?

Identification results

Modes

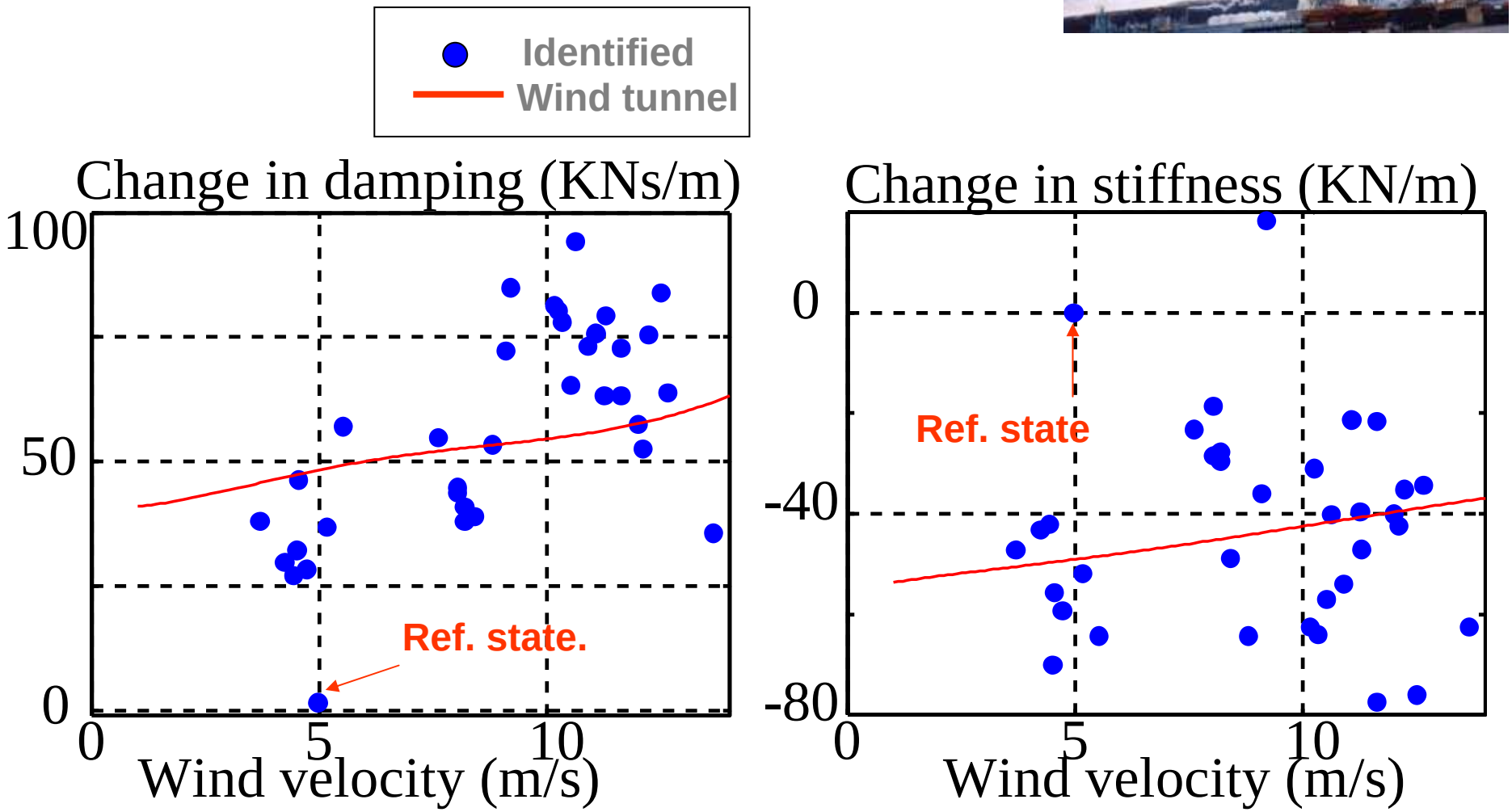


Damping & freq.

	ζ_r	f_r(Hz)
1st	0.0235	0.130
2nd	0.0122	0.152
3rd	0.0066	0.221
…		
10th	0.048	1.32
17th	0.031	3.20
19th	0.055	3.86

Obtained: up to 23rd mode

Result 1: Aerodynamic damping & stiffness



Result 2 Bearing damping & stiffness