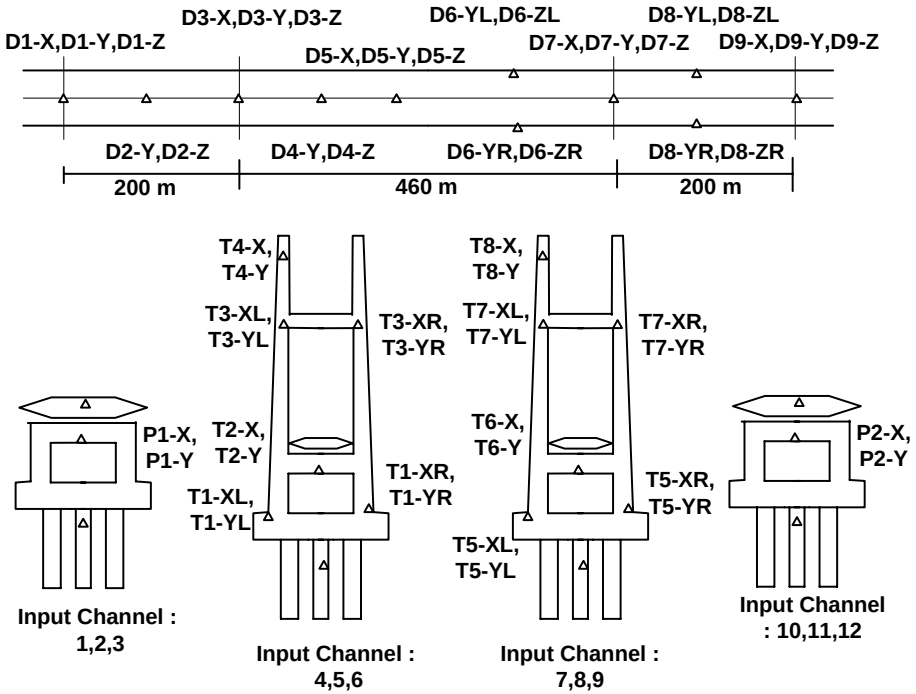
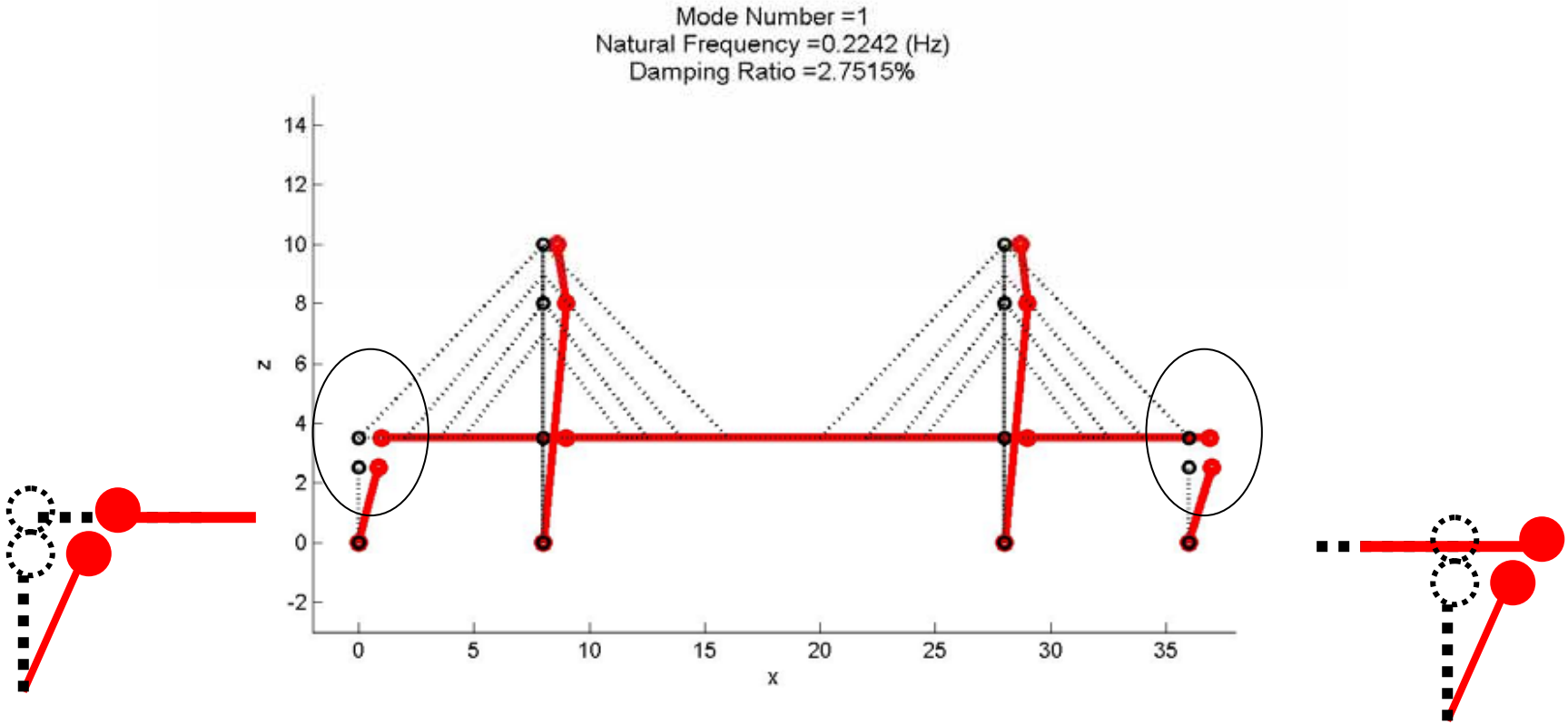
Case Study : Yokohama-Bay Bridge



- Truss-box girder, double-deck cable-stayed bridge
- Completed in 1988
- Span length: 200-460-200 m, Tower : 172 m x 29 m
- Permanently instrumented with 85 channels of accelerometers

Observed Longitudinal Mode from Sys. Id

Three observed typical first longitudinal modes :



(c) Typical Fixed-Fixed Mode
(Earthquake 1992-02-02 Frame-2)

Advantages of WSN for SHM applications

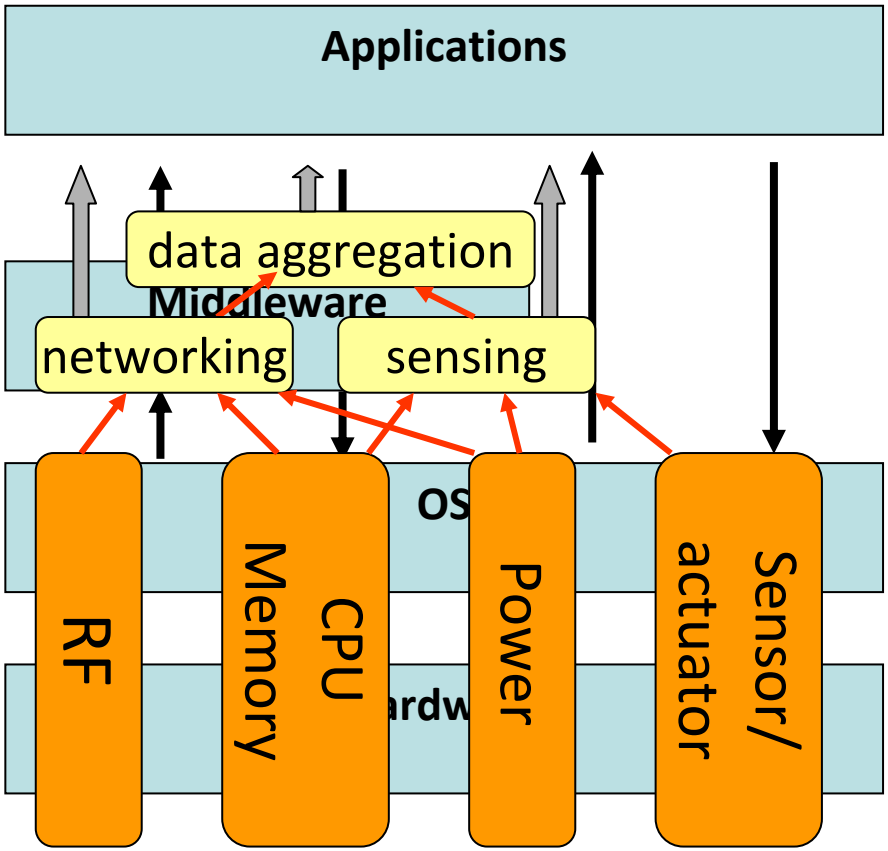
Wireless sensors potentially provides:

Inexpensive & Dense measurement; Easy installation

Autonomous measurement & judgment

Key to comprehend structural performance

WSN system development

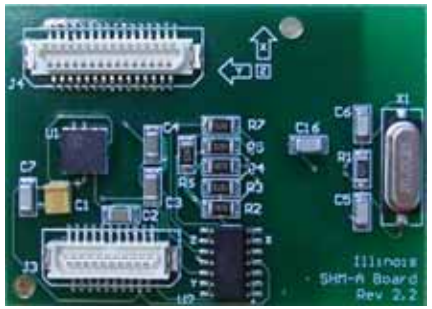


Synchronized sensing (Multihop)
Ack-based efficient data transfer

TinyOS

Imote2 (MEMSIC)+
customized sensor boards

Imote2:
CPU 400MHz
RAM 32MB
RF: 802.15.4



MEMS Accelerometer
+
ADC

Full-scale bridge vibration measurements: Jindo Bridge, Korea

(September 2008 – present)

2nd Jindo Bridge

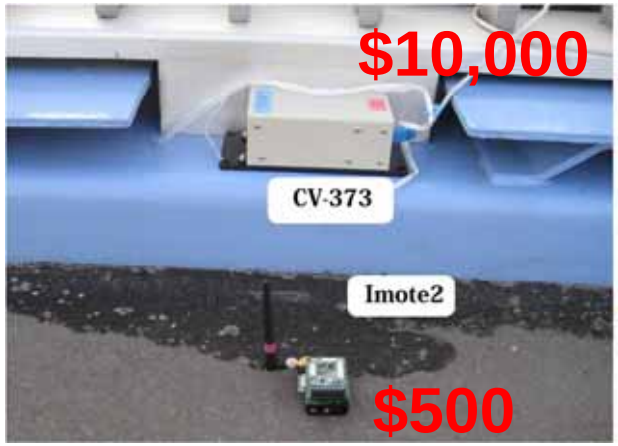
Haenam (Inland)

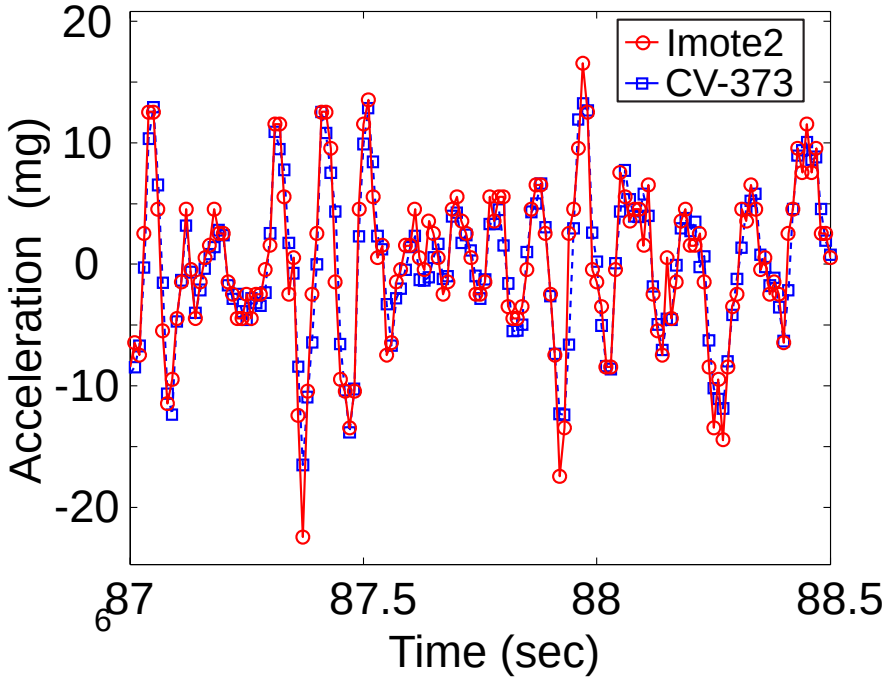
Jindo Island

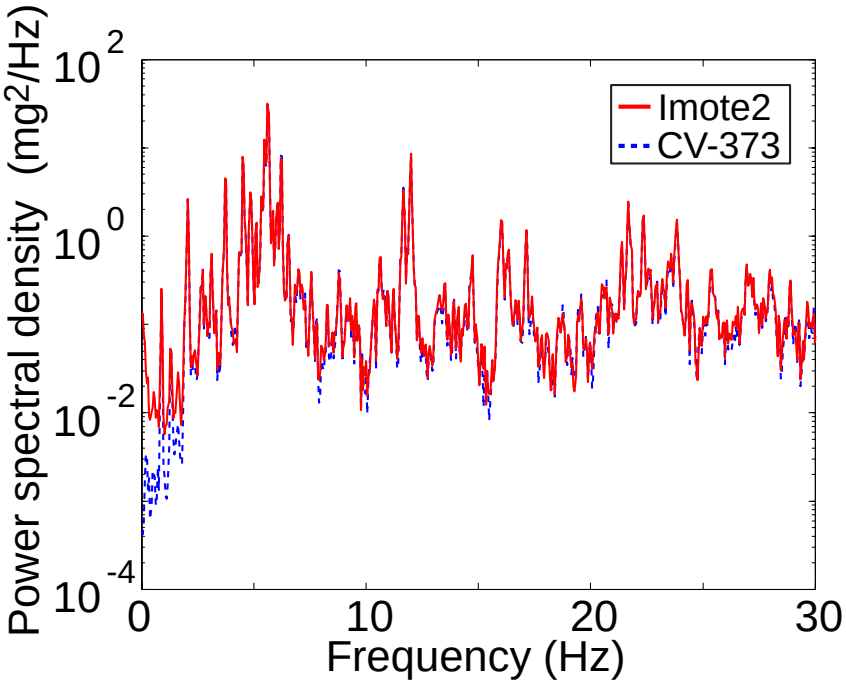
The 2nd Jindo Bridge	
Type	Cable-stayed bridge
Spans	70+344+70 = 484m
Girder	Steel box (12.55m width)
Design velocity	70 km/hr
Designed by	Yooshin cooperation (2000, Korea)
Constructed by	Hyundai construction (2006, Korea)
Owner	Iksan Regional Construction and Management Administration
Special feature	Twin bridge

Sensor validation preliminary test

- Wired and wireless sensors agree well in time and frequency domain







Sensor Deployment

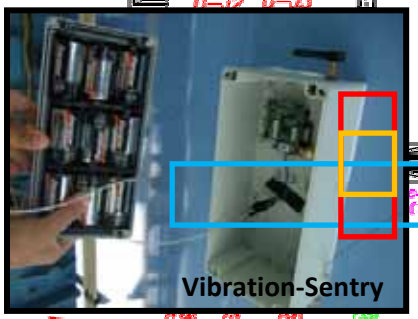
Cable : 8
Deck : 22
Pylon : 3
Total : 33

Jindo side (ch25)

Haenam side (ch20)

Cable : 8
Deck : 26
Pylon : 3
Total : 37

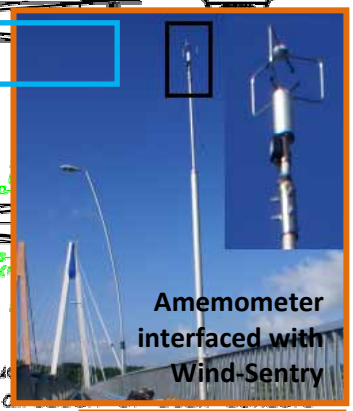
In total, 420 channels of sensors



Vibration-Sentry

Sensor location for Pylons & Cables

Sensor location for Deck



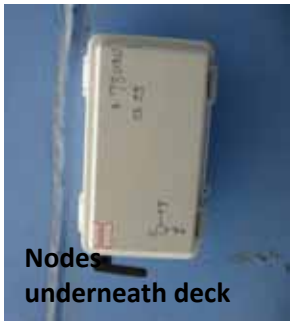
Amemometer interfaced with Wind-Sentry

⊕ Sensor location for Cables
⊕ Sensor location for Deck

⊕ Sensor location for Pylons
⊕ Sensor location for Deck

⊕ Sensor location for Deck

Note:
1. ( ) valu
2. z-axis



Nodes underneath deck

Nodes on pylons

Nodes on pylon top (powered by solar cell)

Nodes on cables

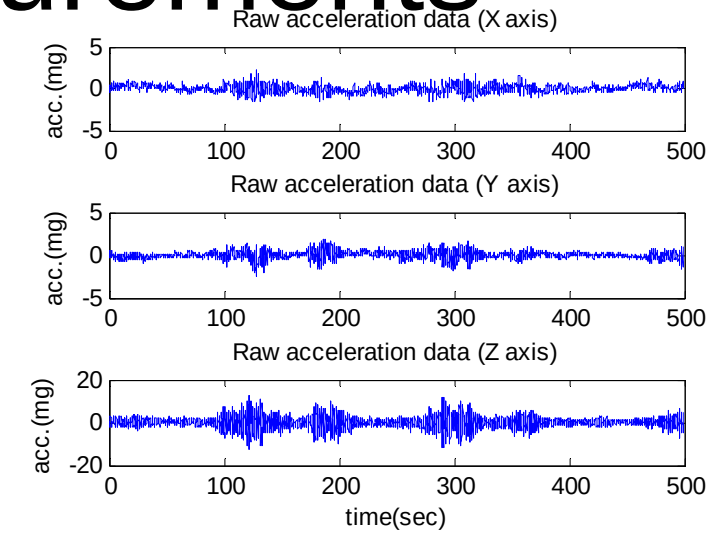
Nodes on cables (powered by solar cell)

Reference Nodes

Wind-Sentry

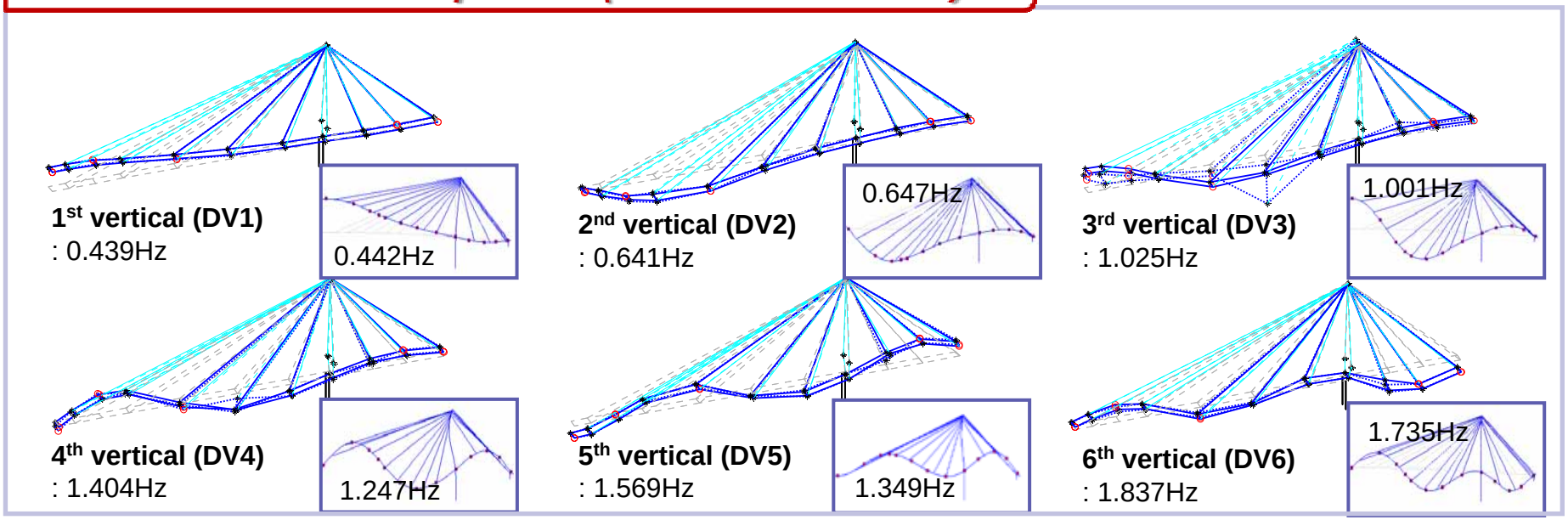
Vibration measurements

- Vibrations of the bridge deck, pylons, and cables are captured.
- Identified modal properties agrees well with FEM analysis



Deck vibration

- ***Extracted Modal Properties (Jindo-side WSSN)***



Full-scale bridge vibration measurements:

- Main span 570 m
- 49 nodes along the side walk.
- Prompt installation

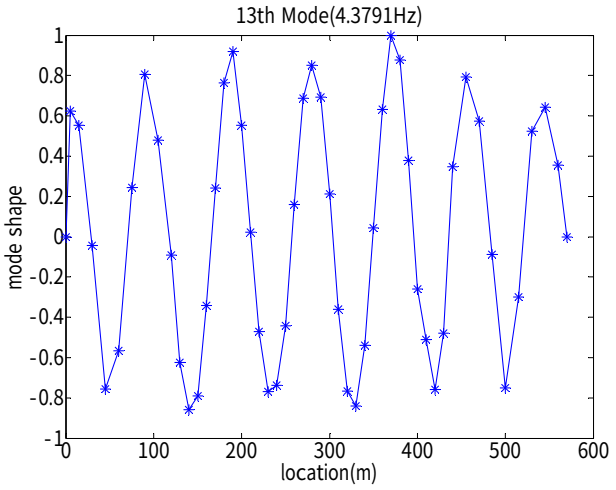
Installation：90min, Removal：45min
by 3 persons

Performance improvement

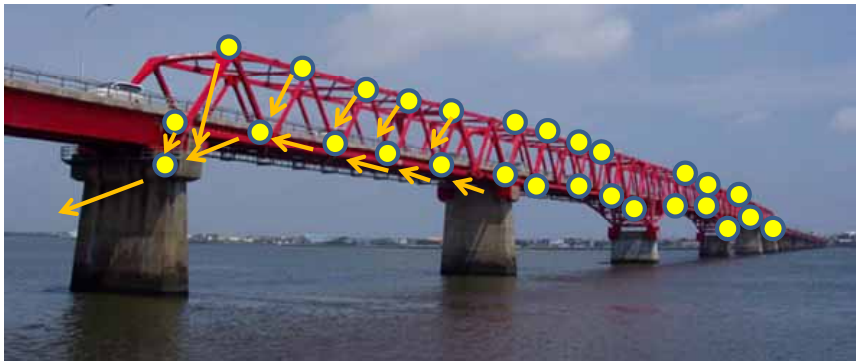
- Comparison with past measurements

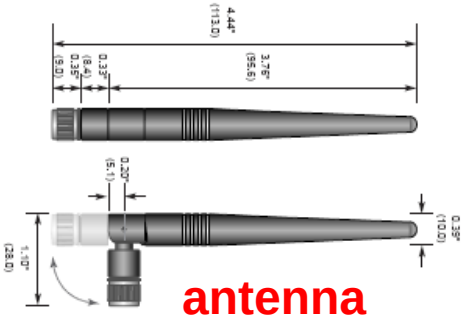
	Wirelelss	Excitation tests	Seismic records
1st bending	0.27Hz	0.26Hz	0.26Hz
2nd torsional	0.71Hz	0.68Hz	0.70Hz
5th bending	0.86Hz	0.84Hz	0.88Hz

- High order modes are identified(upto 17th mode)



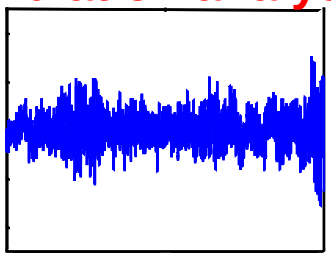
Interdisciplinary and international collaborations

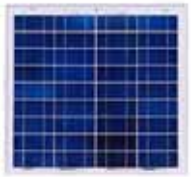


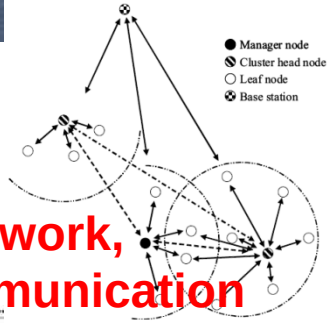


antenna

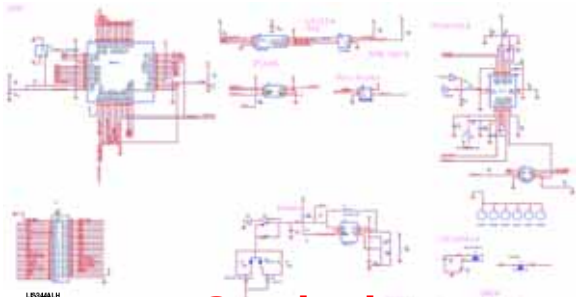
Vibration analysis

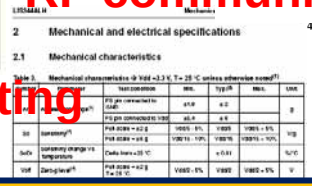


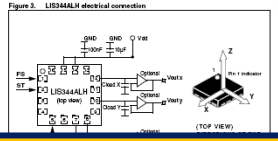




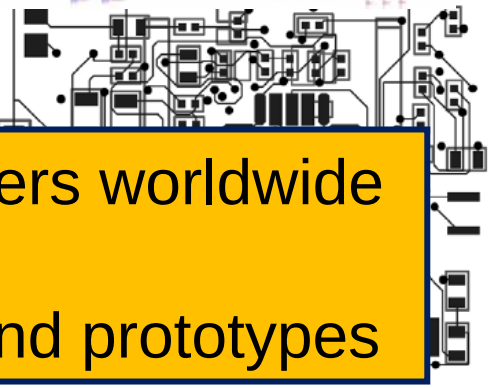
Network,
RF communication



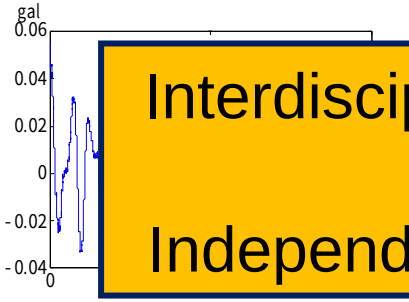




PCB design



Energy Harvesting



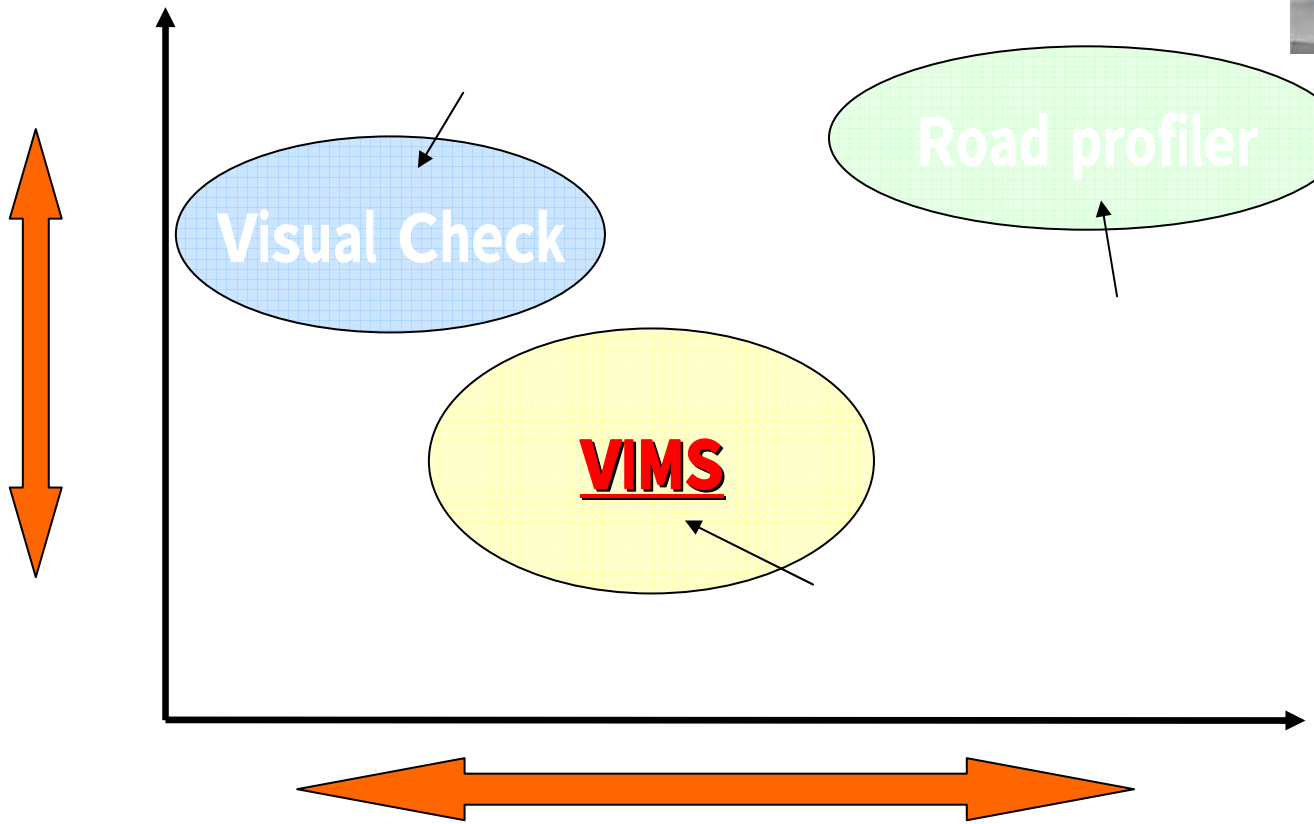
Interdisciplinary research involving researchers worldwide accelerate the advance
Independent research would take long beyond prototypes

Collaboration participants

Conclusion

- WSN is considered to allow dense instrumentation on large structures. Key to comprehend their complex behaviors and performances.
- SW/HW developments on a WSN platform resulted in full-scale bridge vibration monitorings, indicating the merit of WSN dense instrumentation.
- International/interdisciplinary collaborations are in progress to enhance the technology.

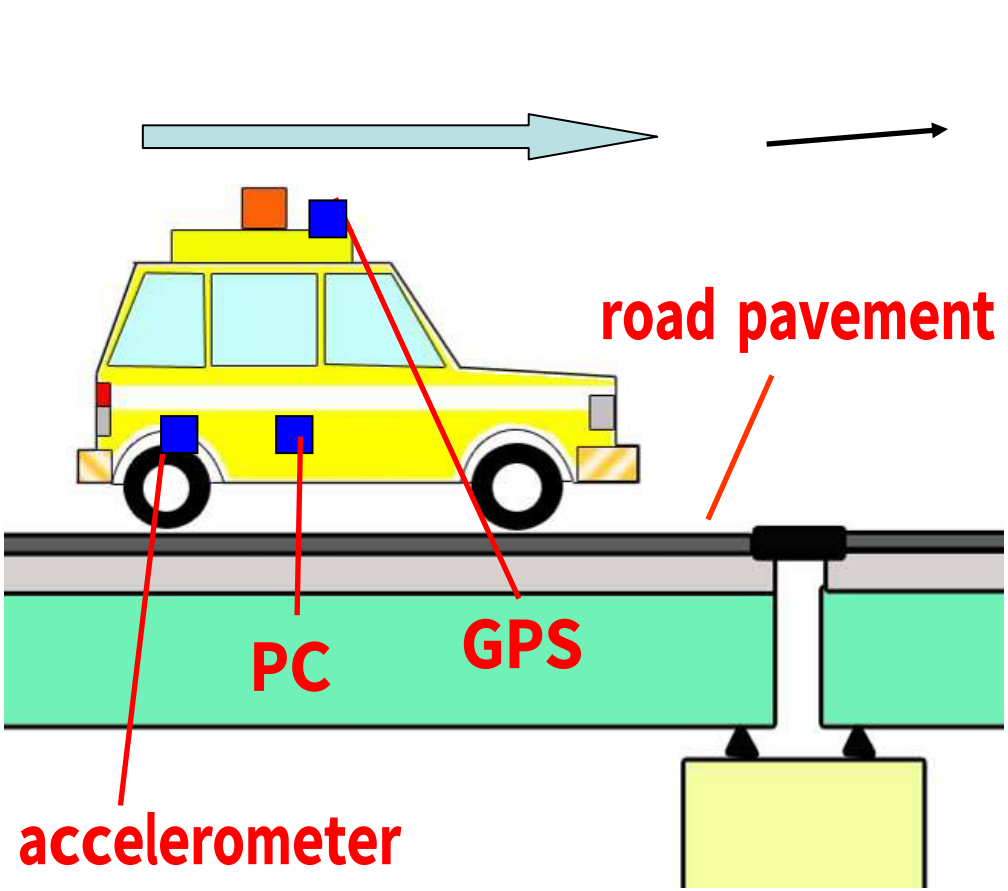
Vehicle Intelligent Monitoring System (VIMS)

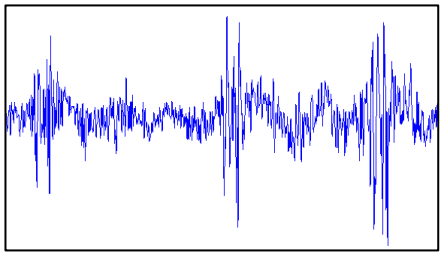


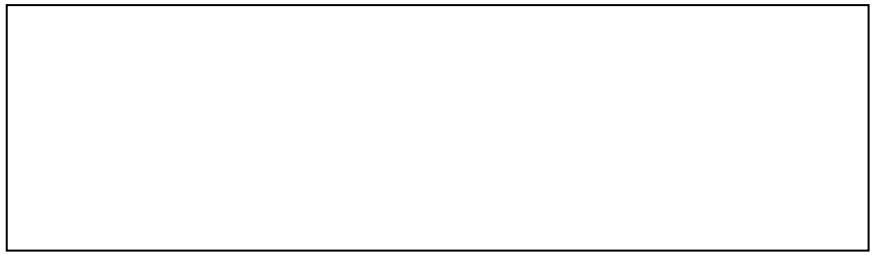
Vehicle Intelligent Monitoring System (VIMS)

A simple and inexpensive road monitoring system

to check the condition of the road surface







System components & Presentation of results

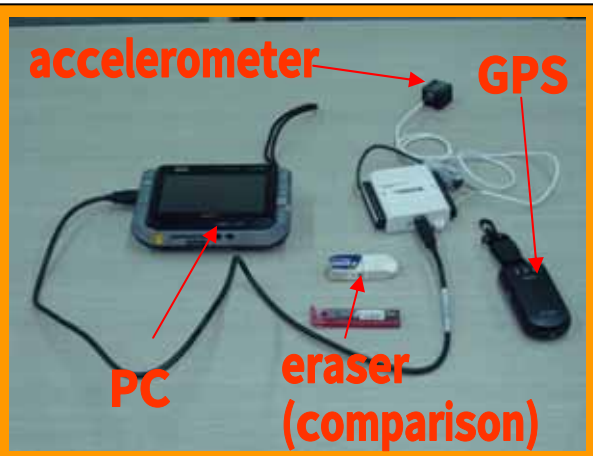
< System components >

Compact

Inexpensive

Battery-operated

Easy to install

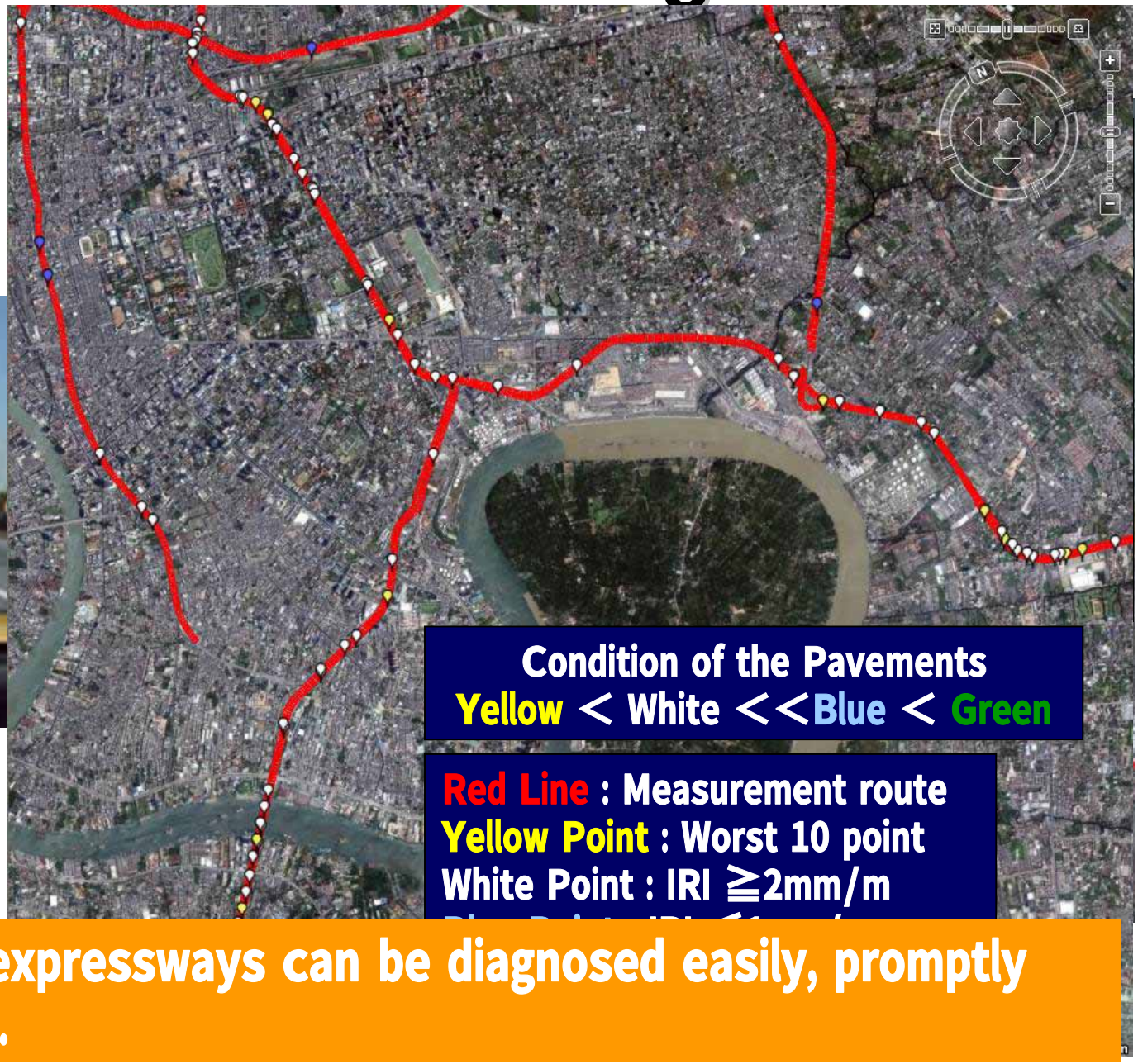


< Presentation of monitoring results >

Google Earth

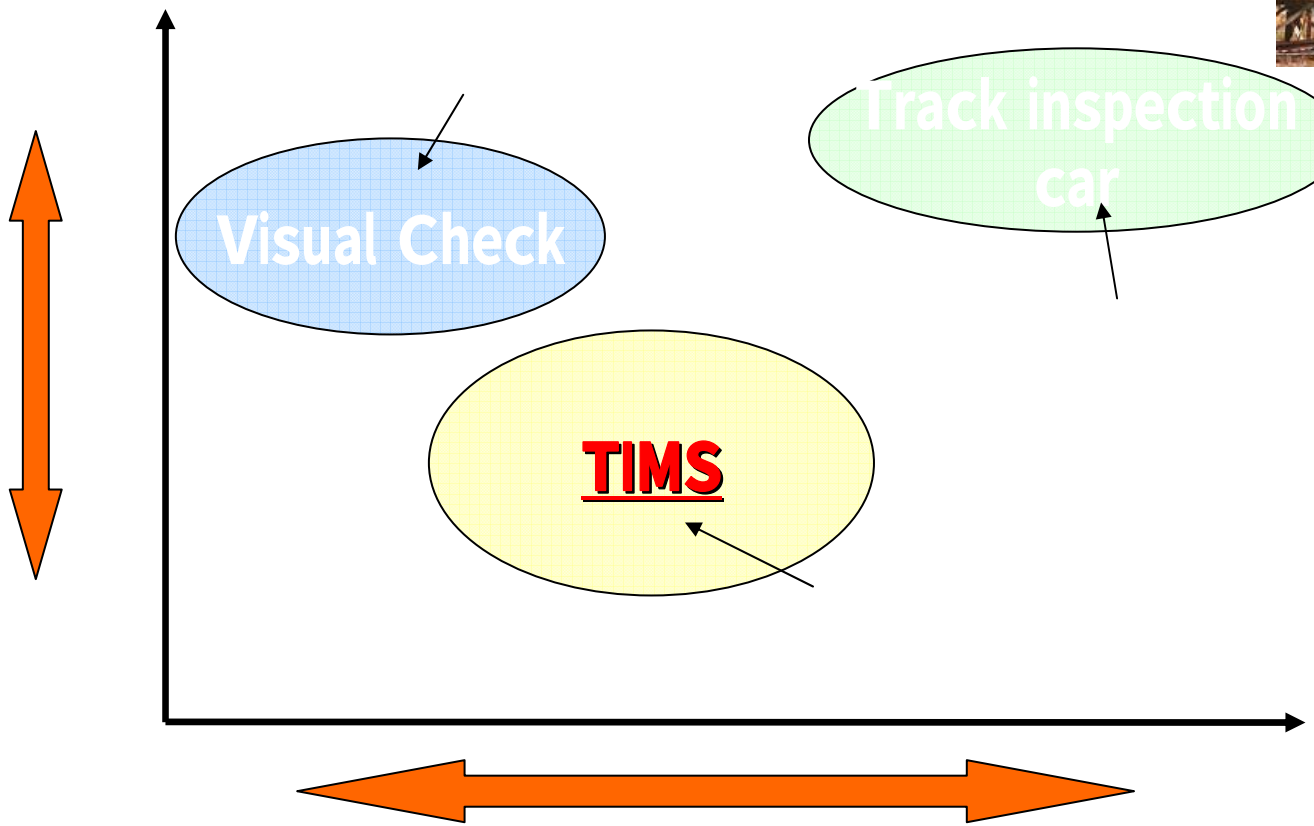
- Measurement route
- Bad section

Measurement **in Bangkok**



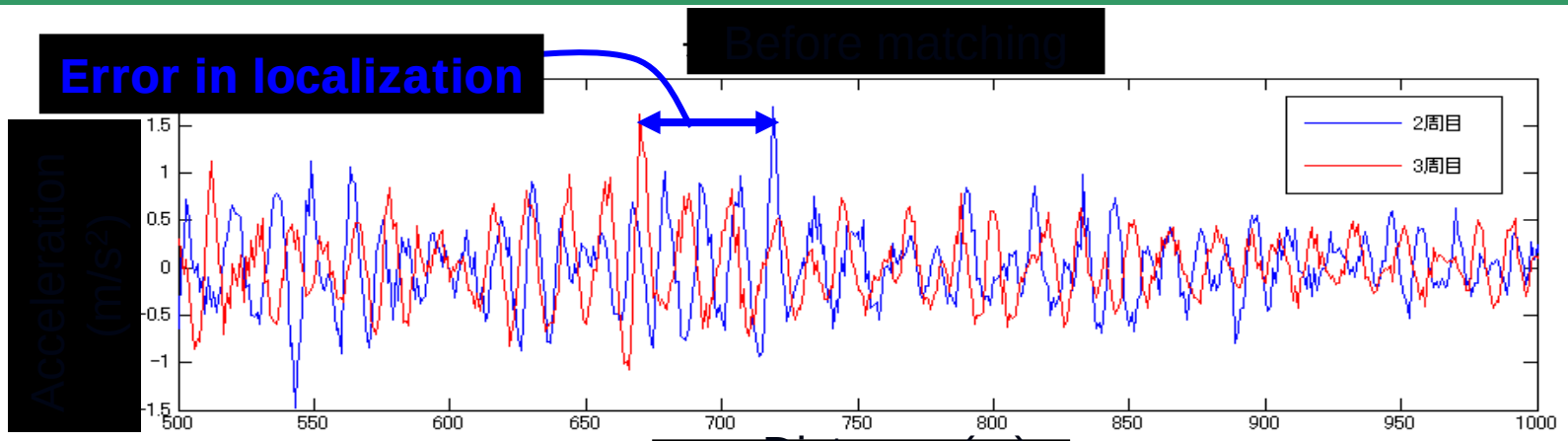
The condition of expressways can be diagnosed easily, promptly and quantitatively.

Train Intelligent Monitoring System (TIMS)



Train Intelligent Monitoring System (TIMS)

Data processing 2



- Localization has noticeable error.
- Repeated measurements on the same track are not directly comparable.
- Need for Matching

Change After Local Repair Services

5 out of 12 locations of repair services were detected

Change in rail condition can be detected.

Thank you