



Next-Generation Wireless Bridge Weigh-in-Motion (WIM) System Integrated with Nondestructive Evaluation (NDE) Capability for Transportation Infrastructure Safety

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Outline

- Participants
- Motivation and preliminary research
- Objective and progress
- Next-phase for the future

Participants

- Georgia Tech team: wireless sensing and ultrasonic nondestructive evaluation (NDE)
 - Dr. Yang Wang (PI)
 - Dr. Laurence J. Jacobs (Co-PI)
 - Dr. Jin-Yeon Kim (Co-PI)
 - Dapeng Zhu (Graduate Student)
 - Canny Fang (Graduate Student)
 - Kevin Arne (Graduate Student)
- UAB team: bridge weigh-in-motion (WIM)
 - Dr. Nasim Uddin (Co-PI)
 - Dr. Hua Zhao (Post-Doctor)
 - Dr. Zhisong Zhao (Previous Graduate Student)
 - Li Dong (Graduate Student)
 - Rahul R Kalyankar (Graduate Student)



ASCE 2009 Ratings on America's Infrastructure

Subject	GPA	Comments
Roads	D -	<ul style="list-style-type: none"> Poor road conditions cost each US motorist \$333 per year in repairs and operating costs
Bridges	C	<ul style="list-style-type: none"> 26% the nation's 600,000 bridges rated structurally deficient or functionally obsolete
Dams	D	<ul style="list-style-type: none"> 4,000 deficient dams, including 1,819 high hazard potential dams

Highway and bridges (per Year)

- Current spending: \$70.3B
- \$78.8B needed to maintain current conditions
- \$186B needed to improve to good conditions



I-35W Bridge Collapse
Minnesota, August 2007
13 Casualties



Teton Dam Collapse
Idaho, June 1976
Damage: \$2 billion

Current Practice for Bridge Inspection

- Inspection to a bridge is conducted **once every two years**, as required by Federal Highway Administration (FHWA)
- Current practice is **visual inspection using hammers and chisels**



Basket Lift



Extensive Climbing



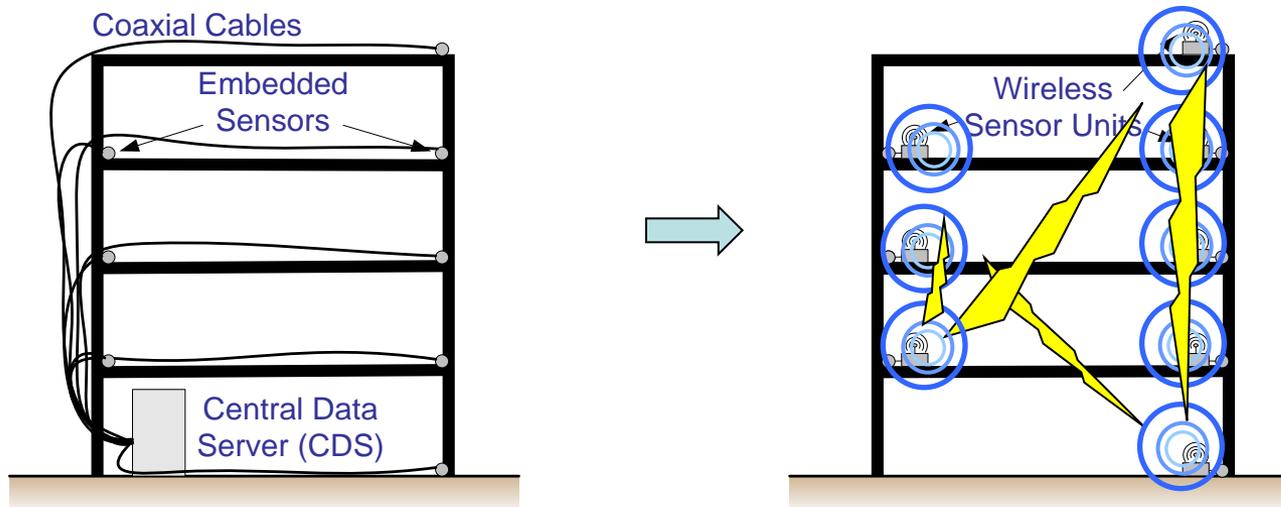
Rigging



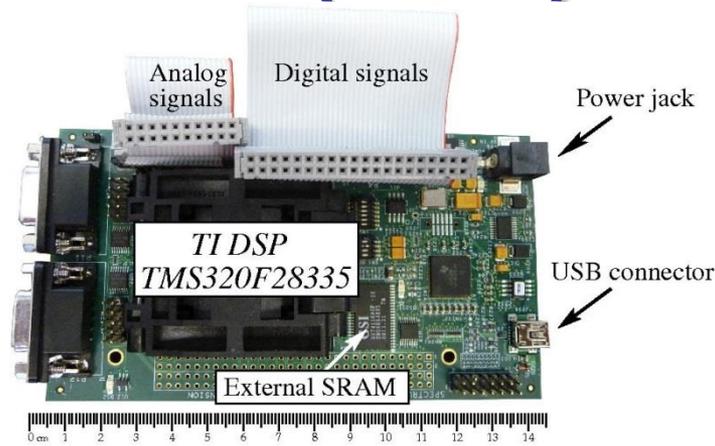
- Need for structural systems that can **autonomously monitor their conditions**

Communication Network: from Wired to Wireless

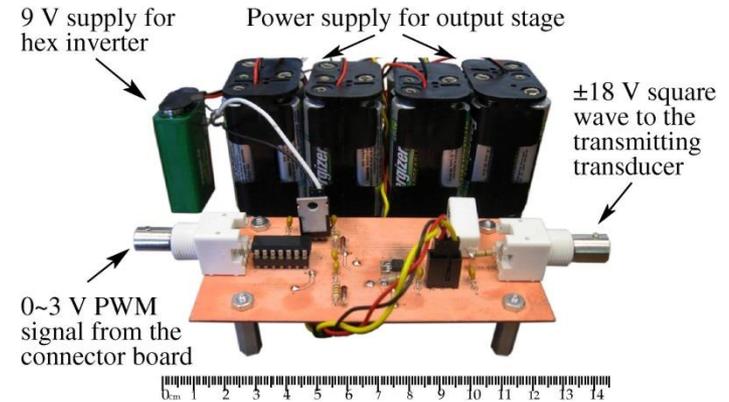
- Installation of wired system can take about **75% of total testing time** for large structures. (Straser and Kiremidjian, 1998)
- \$5,000 per sensor channel, **half of the cost** on cabling and labor. (Celebi, 2002)
- Over 1,000 sensors on Tsing Ma Bridge, Kap Shui Mun Bridge, and Ting Kau Bridge. **36 km of copper cable and 14 km of fiber optic cable. Over one year of installation.** (Solomon *et al.*, 2000)



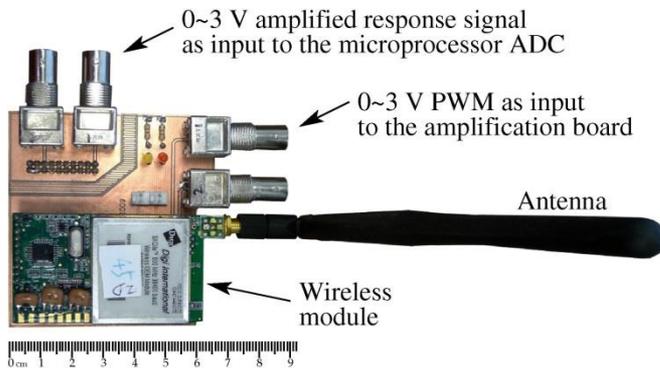
Wireless Ultrasonic NDE for Crack Detection (GT-1)



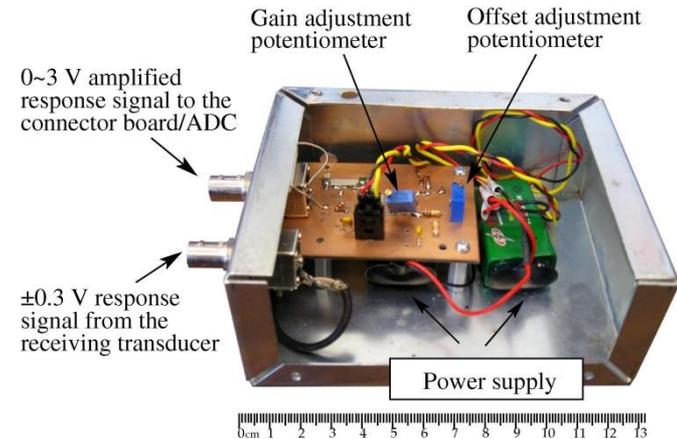
Microprocessor evaluation board



Excitation output amplification board

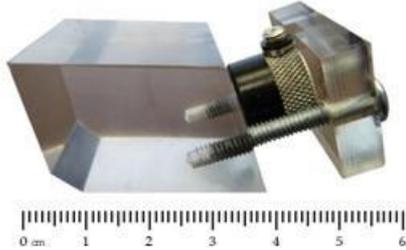


Wireless transceiver

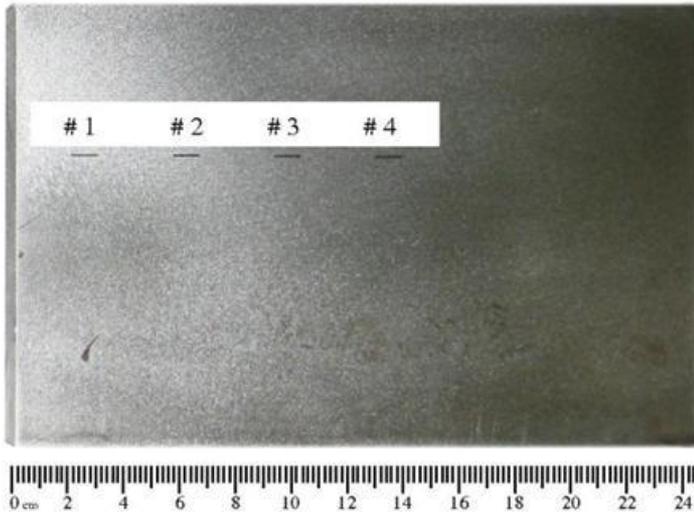


Receiving signal conditioning board

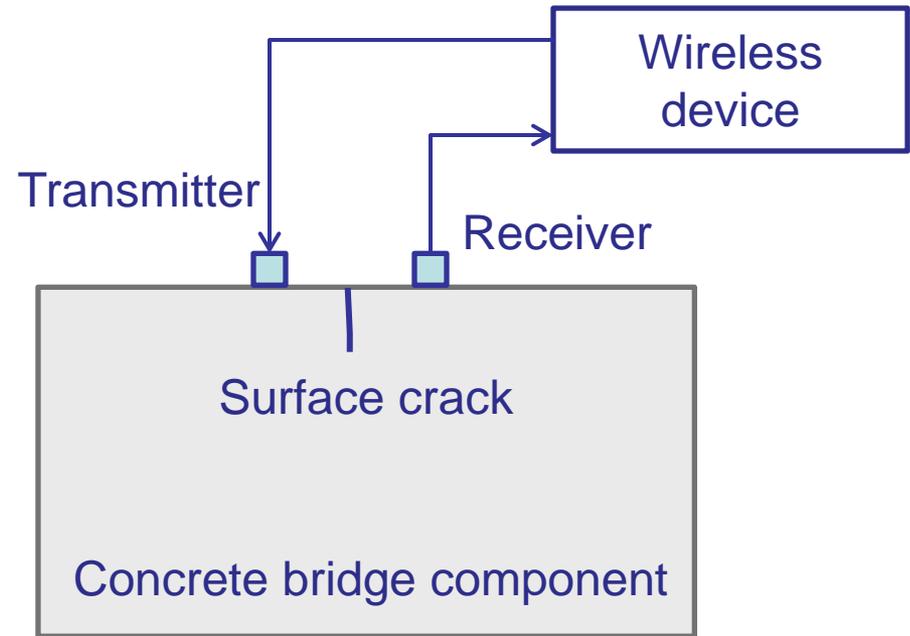
Testing with Steel and Concrete (GT-2)



Wedge ultrasonic transducer

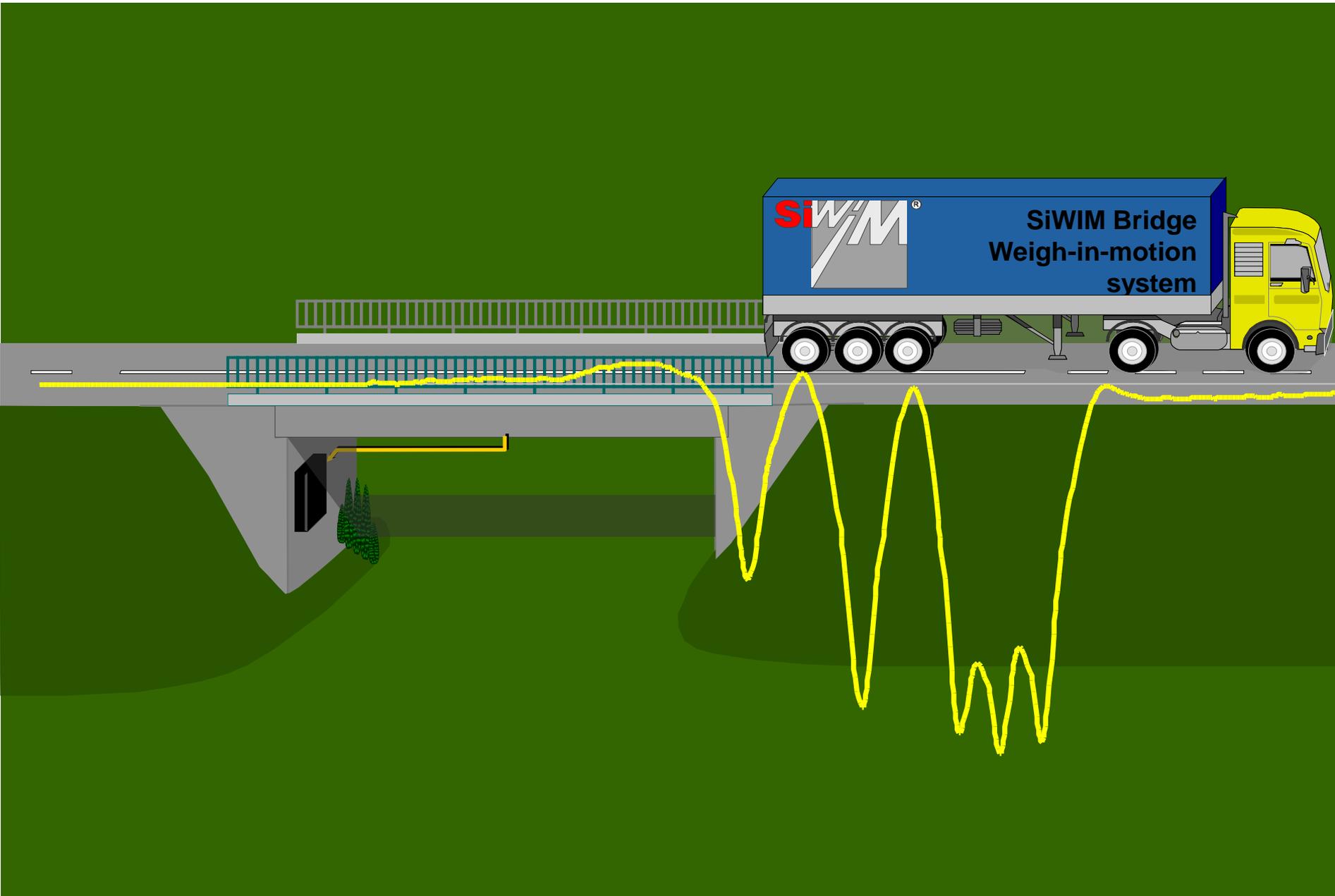


Steel specimen with various notches mimicking damage

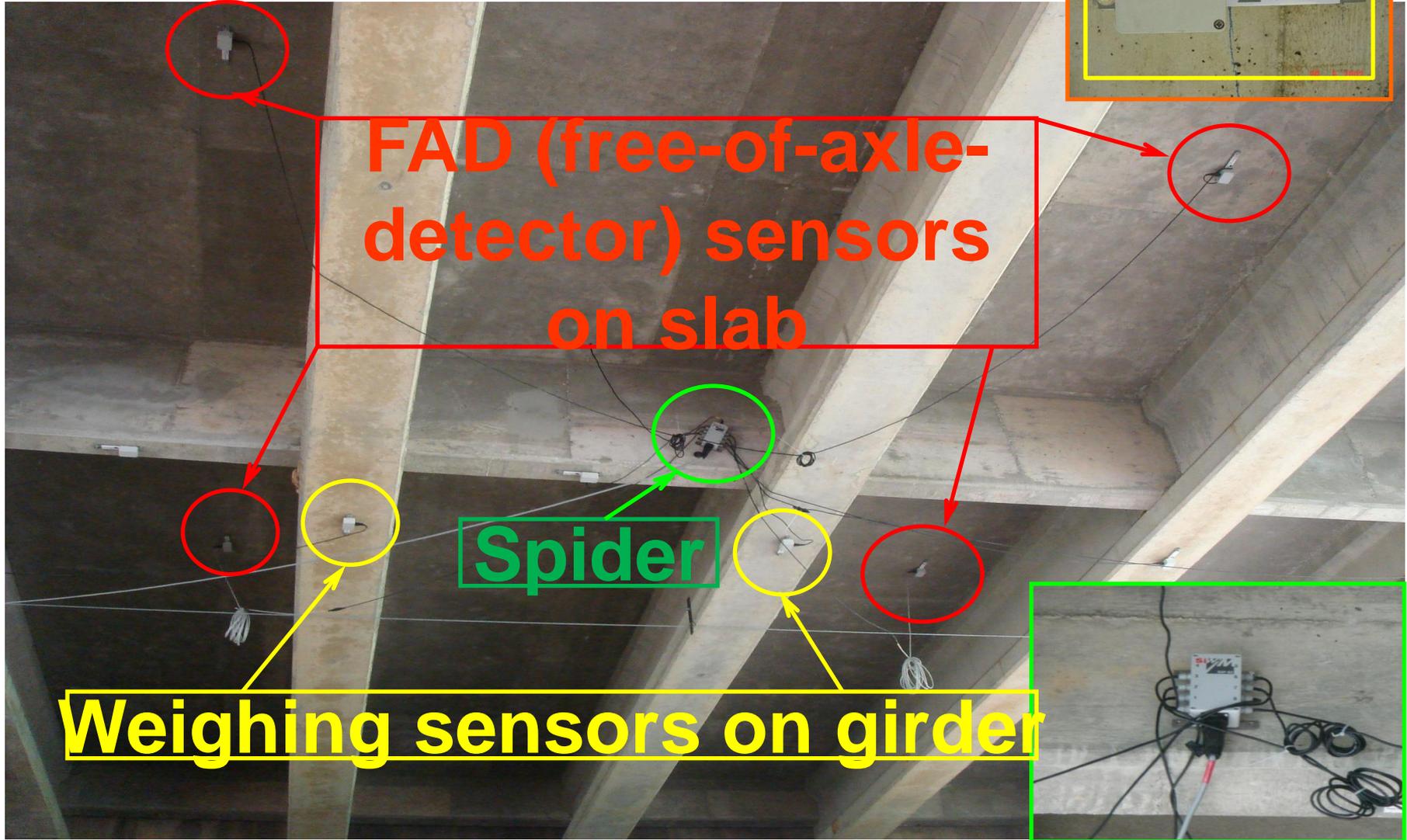


Diffuse ultrasonic NDE for concrete specimen

Project Background (UAB-1)



Project Background (UAB-2)

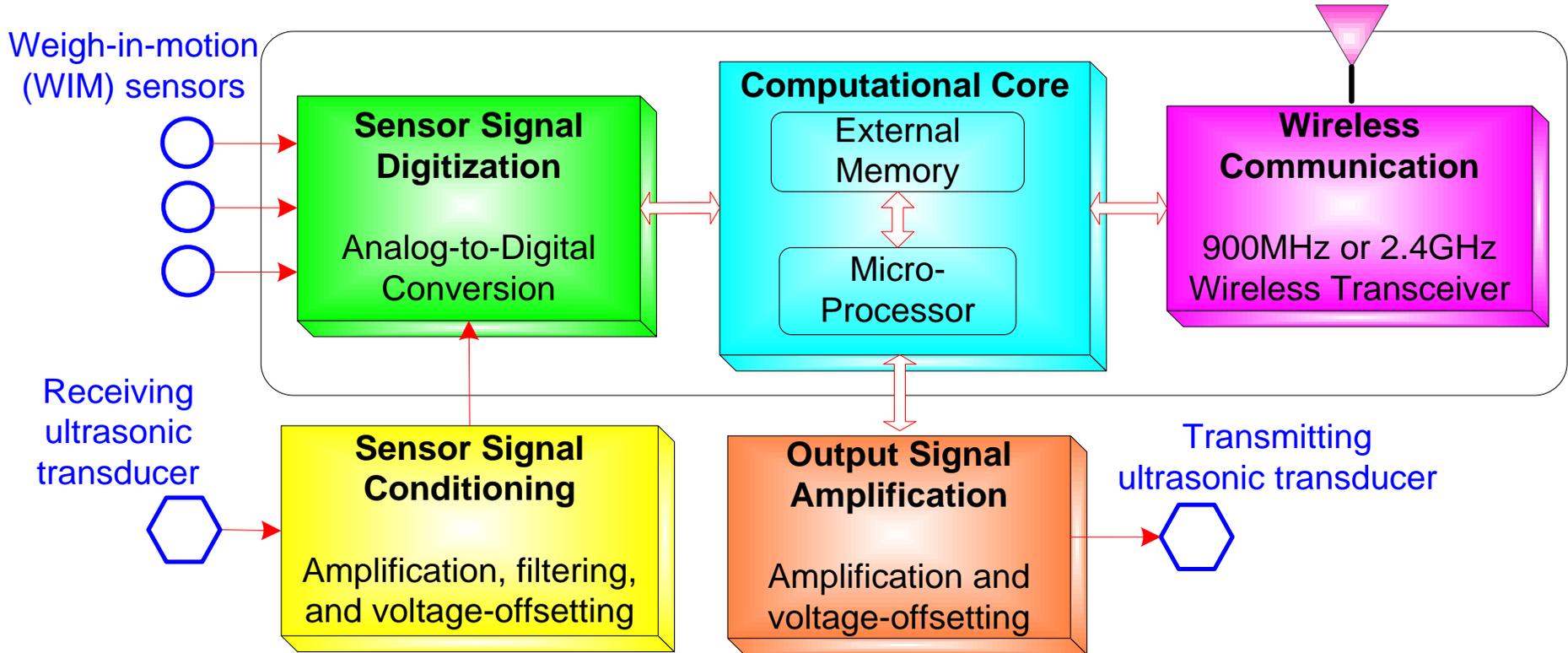


FAD (free-of-axle-detector) sensors on slab

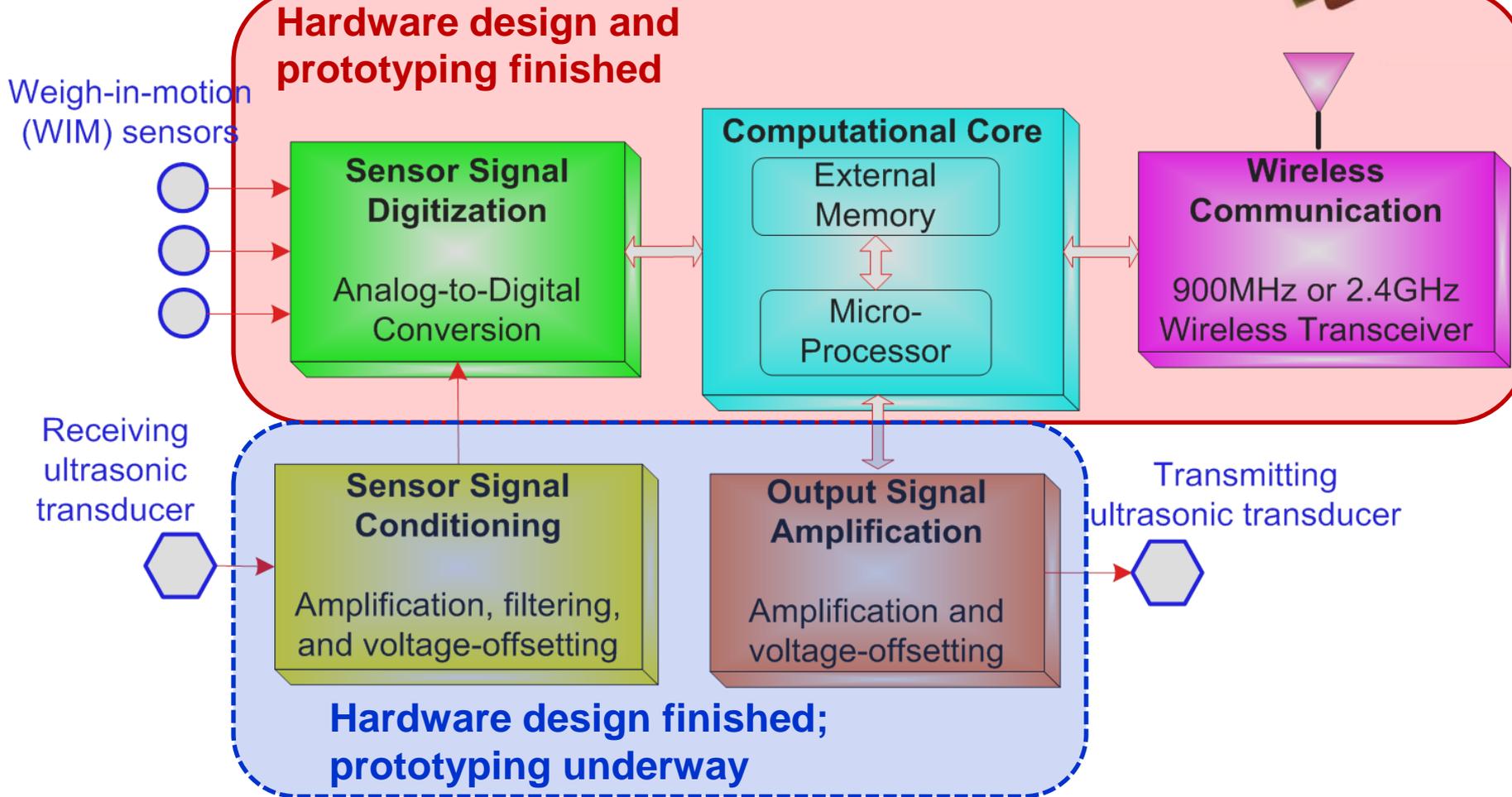
Spider

Weighing sensors on girder

Project Objective



Hardware Development (GT)

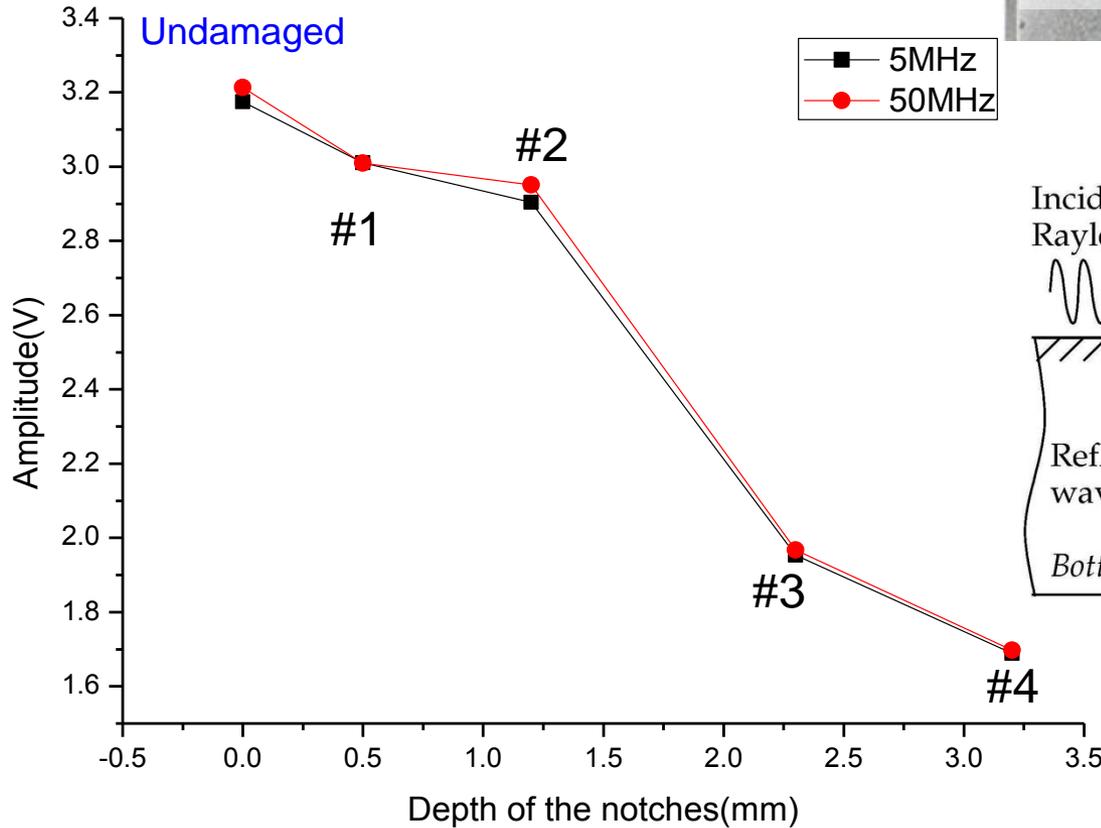
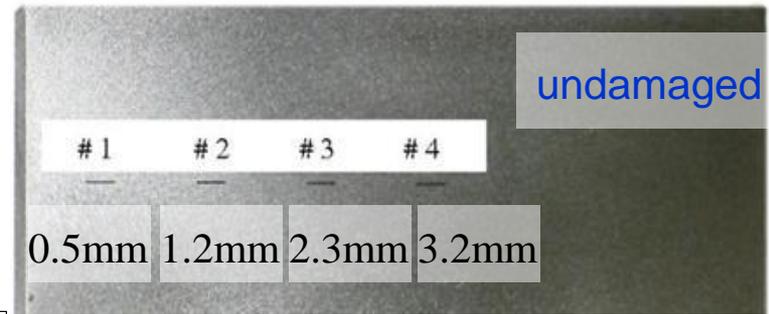


Identified Strain Transducer (GT+UAB)

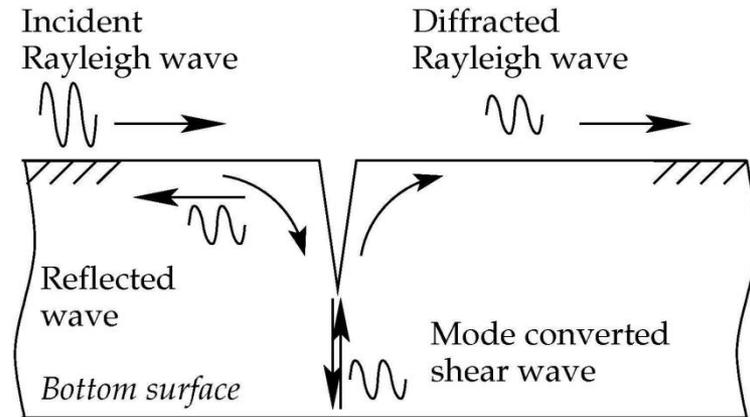


Specification	ST350
Gage length	3 in
Strain resolution	$\sim 1\mu\epsilon$
Strain range	$\pm 2000\mu\epsilon$
Circuit	Full Wheatstone bridge with 4 active 350 Ω foil gages
Supply voltage	1~10V
Full-range linearity error	1%
Sensitivity	2 ($\mu\text{V}/\text{V}$) / $\mu\epsilon$

Ultrasonic NDE (GT)

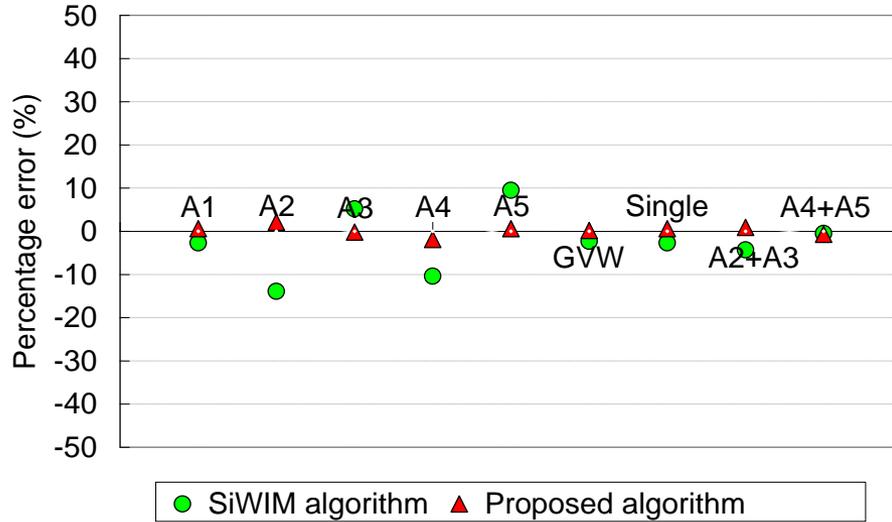


Steel specimen with different notch depth

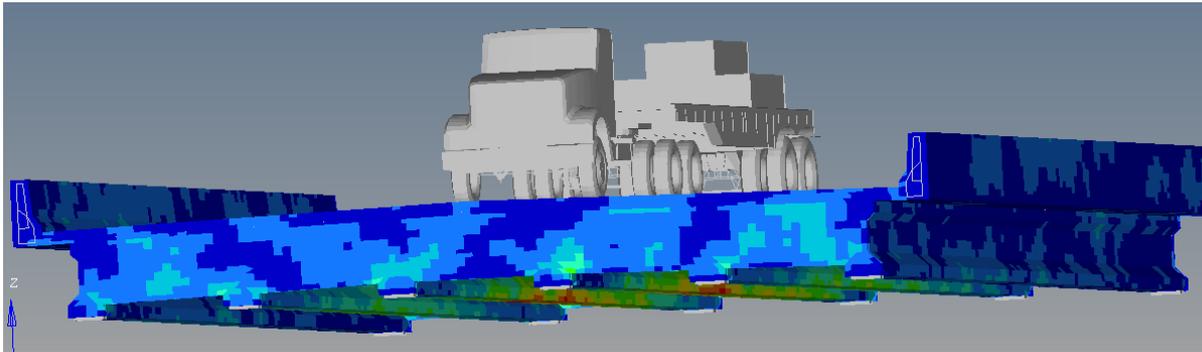
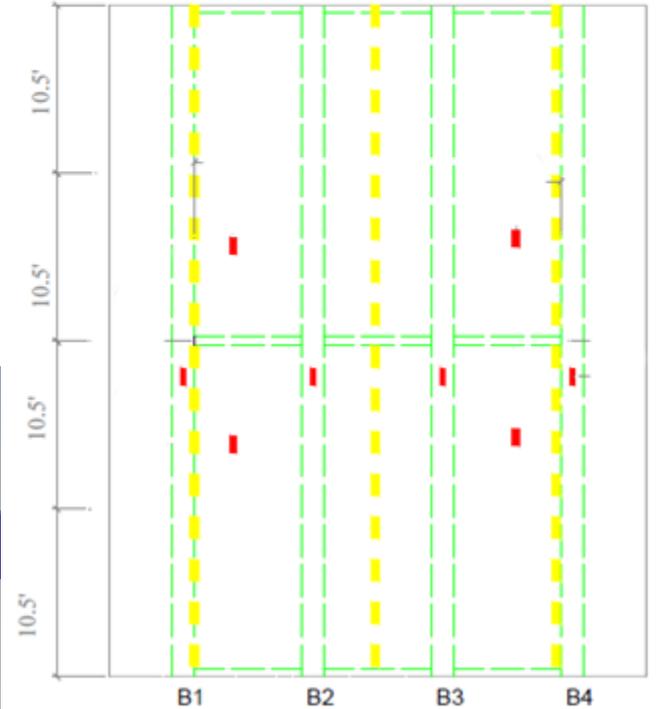
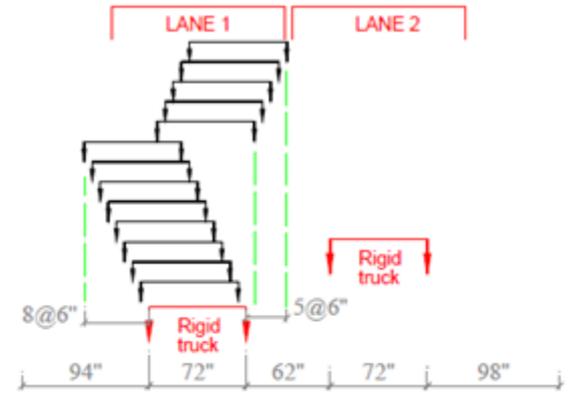


Amplitude

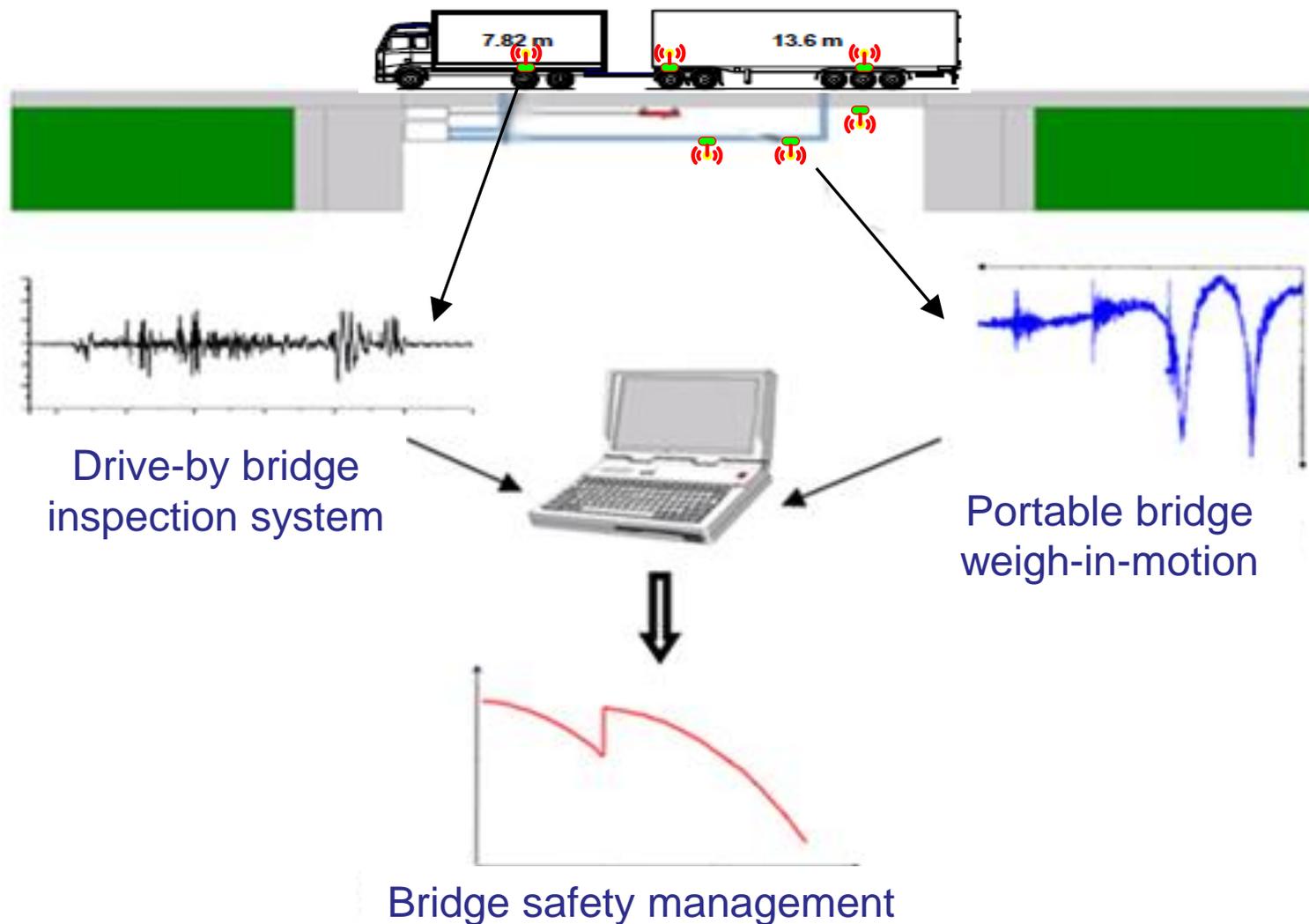
Bridge WIM (UAB)



78 East
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Future: Wireless Drive-By Inspection





NCTSPM



Thank You