



Structural Health Monitoring (SHM) today. The MEMSCON project approach



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SHM Applications

- Buildings (critical or even historical)
- Bridges
- Tunnels
- Wind Generators



>> Practically: any critical structure

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Outline

- Introduction to Structural Health Monitoring
- Structural Health Monitoring & Applications
- Structural Monitoring Challenges
- Technological Barriers & Solutions
- MEMSCON:
 - Challenge
 - S&T Solutions
 - Concept and vision
 - Strategic Impact
 - MEMSCON at European Level



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Structural Health Monitoring-SHM Applications

- Advanced health monitoring technologies
- Operational Evaluation
- Data Feature Extraction
- Statistical Models Development



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What is Structural Health Monitoring (SHM)

"The process of implementing a damage detection and characterization strategy for engineering structures"

SHM Involves:

- Health monitoring
- Operational Evaluation
- Data Feature Extraction
- Statistical Models Development



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Structural Monitoring Challenges (1/2)

- Infrastructure is expected to provide:
 - reliable service for long periods of time,
 - following major technology changes,
 - spanning several generations and experiencing dramatic evolutions
- Develop Wireless Sensor Networks
 - Reliable
 - Energy aware
 - Smart



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Structural Monitoring Challenges (2/2)

- Develop Design-to-service Solutions
 - Efficient Monitoring
 - DSP strategies
 - Evaluation Criteria
 - Knowledge bases
- Develop Smart Control Units
 - Real-time Feedback
 - Centralized (or not)



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Monitoring Metrics

Measure:

- Acceleration
- Strain
- Climatic Conditions
- Curvature
- Displacements
- Load
- Tilt/Slope
- Scour



Identify

- Corrosion
- Cracking
- Strength
- Tension
- Location of rebar/delaminations

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The Barriers up today

- Conventional cables
- High installation costs
- Vulnerable to ambient signal noise corruption
- Vulnerable to earthquake conditions
- Size and complexity of large structures require a large number of sensing points to be installed.



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MEMSCON Vision...

... vision for a new generation of **tiny, cheap, networked sensors** that can be 'sprayed' on structures to provide **detailed, quantitative information** on the structure's physical state while in service!



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Technological Solutions

- Wireless Sensors
 - Accelerometers/Inclinometers etc
- Laser Scanning
- RFIDs
- Acoustic Emissions
- MEMS (Micro-Electro-Mechanical Systems)
- Increase of Computation capabilities
- Fiber technologies



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MEMSCON aims in a nutshell...

“...to bring on board **RFID tags with integrated strain and acceleration sensing functionality AND make use of appropriate novel methodologies for structural assessment of buildings**”

A new approach to SHM monitoring system is pursued



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MEMSCON challenge (1/2)

- The device is targeted:
 - to have a **small size** compatible with the concrete cover,
 - to **operate independently** over at least **2 years** (even more for the strain sensors) powered by a primary **Li-battery** and
 - to communicate strain and acceleration sensing data measured to a base station **100-1000 m away**.



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Scientific and Technical Objectives (2/5)

- To develop a **Knowledge Base- KB**:
 - KB will contain domain and system knowledge, a History DB (building records such as geometrical and material characteristics) & an External Data DB with data on building structural condition & rehabilitation costs.



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MEMSCON challenge (2/2)

- **Wireless system architecture**
- **Integration technology for the sensors**
- **Software for the structural assessment**
 - Dramatically decrease the number of required strain sensors
 - To assess the structural condition of each and every one of the structural elements, as well as global stability



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Scientific and Technical Objectives (3/5)

- To develop a **methodology** based on which:
 - a. Input on **strain** will be processed to derive **internal forces and stresses** which will be compared to limit values to determine the structural adequacy of these critical cross-sections.
- possible need for **proactive maintenance** will be determined.



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Scientific and Technical Objectives (1/5)

- To integrate MEMS-based sensors and a RFID tag in a small sized package that will be attached to r.c. buildings to measure acceleration in 3-D or strain in 1-D that will be transmitted to a remote base station using a wireless interface.



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Scientific and Technical Objectives (4/5)

- To develop a methodology based on which:
 - Input from the acceleration sensors during an earthquake will be processed to estimate:

- Damage and possible need for rehabilitation
- whether the building is safe



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Scientific and Technical Objectives (5/5)

- To provide an integrated package for structural assessment and rehabilitation planning under routine operation and seismic forces. It will include:

- The sensors, data collection hardware and communication modules
- The KB, the History DB and the External DB.
- A DSS for proactive rehabilitation and rehabilitation after earthquake damage.



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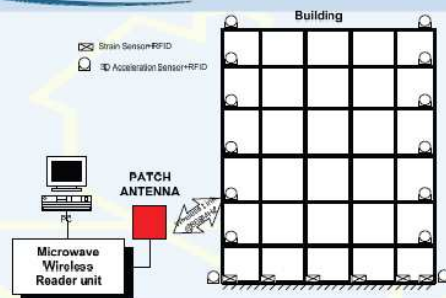
MEMSCON Strategic Impact 1/2

- Transforming building rehabilitation sector dominated by SMEs into an advanced knowledge sector
- Enhance the competitiveness of European SMEs in building design, construction, inspection and rehabilitation
- Promote the 'Proactive Condition-Based Maintenance' of buildings based on measurements



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Technical Approach - Concept



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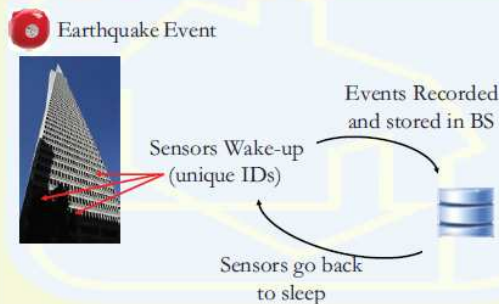
MEMSCON Strategic Impact 2/2

- Promote a new concept of civil engineered smart structures conceived and designed as high performance systems
- Enable the MEMS European SMEs to enter the large building market
- Offer an integrating solution towards sustainability
- Act as a catalyst for new high-tech sensing systems



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MEMSCON concept



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MEMSCON at European Level 1/4

- Shifting from construction costs to life cycle costs:
 - Non-destructive evaluation technologies incorporated into buildings throughout Europe



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MEMSCON at European Level 2/4

❖ Interest to ALL EU countries:

- ❖ Knowledge of the structural condition and safety of in-service structures on a continuous time basis
- ❖ Insufficient funds to maintain the existing building infrastructure
- ❖ Increasing demand for structural engineers to deal with the issues of life extension of existing structures



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MEMSCON Facts...

- MEMSCON is funded under the 7th FW /Theme 4 - NMP-Nanosciences, Nanotechnologies, Materials and new Production Technologies
- Project full title: Radio Frequency Identification Tags Linked to on Board Micro-Electro-Mechanical Systems in a Wireless, Remote and Intelligent Monitoring and Assessment System for the Maintenance of CONstructed Facilities



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MEMSCON at European Level 3/4

- ❖ Of interest to ALL earthquake prone countries in the southern part of the Union
- ❖ High demand on buildings under operating conditions and seismic disturbances, examining structures' behaviour in the nonlinear realm



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The consortium

No	Beneficiary name	Short name	Country
1	Institute of Communication and Computer Systems	ICCS	Greece
2	Interuniversitair Micro-Electronica Centrum VZW Microsystems, Components and Packaging	IMEC	Belgium
3	Stichting IMEC-NL	IMEC-NL	Netherlands
4	MEMSCAP S.A.	MEMSCAP	France
5	Concept to Volume BV (C2V)	C2V	Netherlands
6	University of Trento-Department of Mechanical and structural Engineering	UNITN	Italy
7	TECNIC S.p.A.	TECNIC	Italy
8	D. Bairaktaris and Associates Ltd.	DBA	Greece
9	RISA Sicherheitsanalysen GmbH	RISA	Germany
10	Advanced Microwave Systems Ltd.	AMS	Greece
11	Acropole Charagionis S.A.	ACH	Greece
12	SITEX 45 SRL	SITEX	Romania

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MEMSCON at European Level 4/4

- ❖ Supporting the recognition of the strategic importance of the MEMS market for the EU
- ❖ New markets for MEMS technology growing rapidly



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MEMSCON Partnership



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Thank you for your attention

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THE END!

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