

Smart & Resilient Infrastructures

Smart Composites & Nanocomposites, Durability

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IFSTTAR

Outline ...

- ❑ *Very High Performance Composites & Smart Composites for Extreme Applications*
 - ✓ *Movable, Lightweight & Smart Mechanically-Oriented Platforms*
 - ✓ *Offshore Wind-Blades*
 - ✓ *High-Speed Train*
 - ✓ *...*
- ❑ *Sensors of Various Types*
- ❑ *Applications*
 - ✓ *Roads*
 - ✓ *Smart Cities*

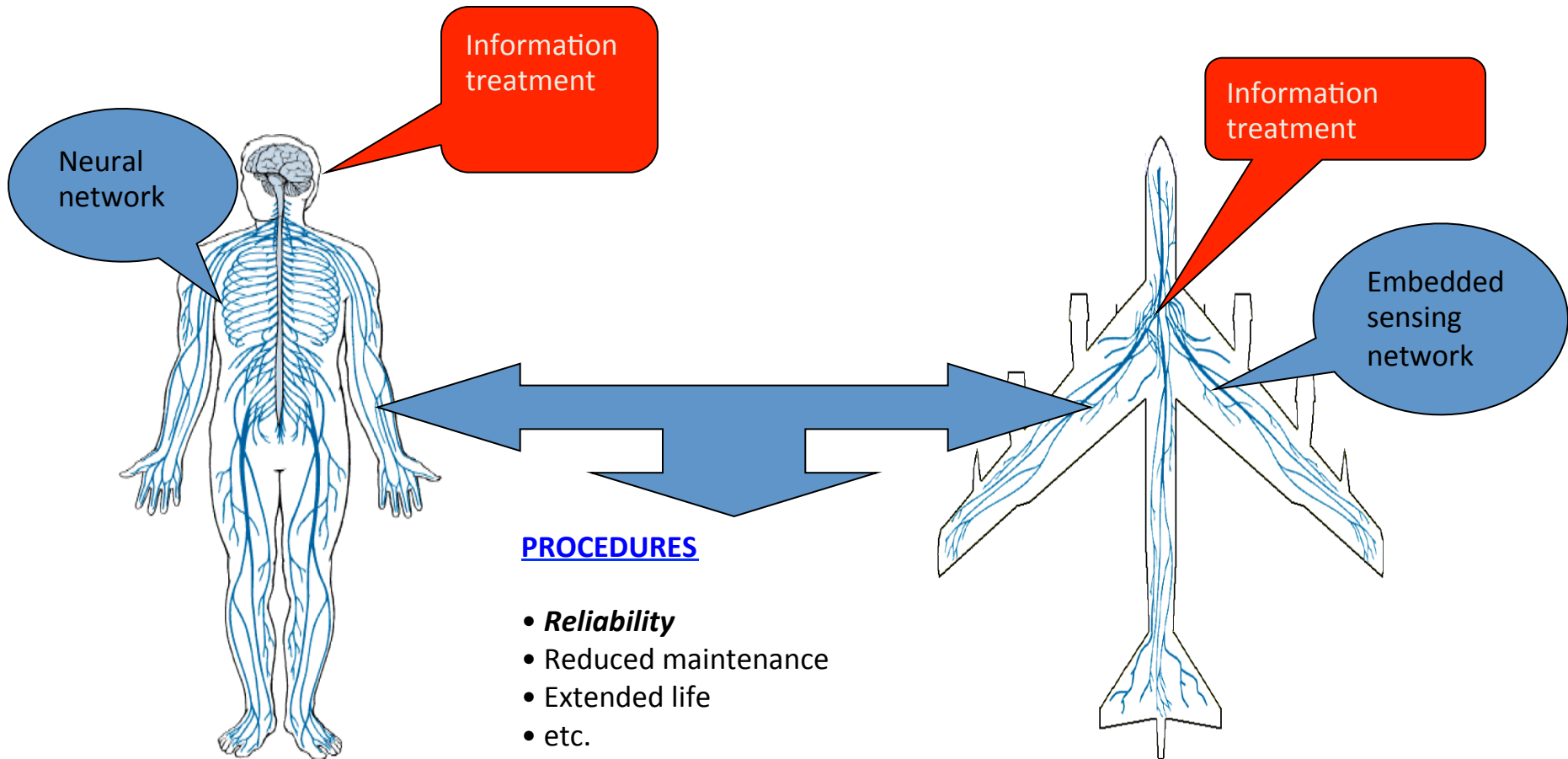
Smart Composite Materials for Extreme Structural Applications

- ❑ **Structural Civil & Military Applications at Ambient Temperatures (Bridges, Sensitive Buildings, Soldier's Protections), Ease of fabrication, corrosion-resistant, transportability, High Stiffness/Weight ratio ...**
 - ✓ Thermoplastic & Thermosetting Matrix Composites / Glass, Carbon ... Fibers
- ❑ **Structural Applications for Intermediate Temperatures / 500°C - 700°C**
 - “Polymer-Matrix Composites (Polyimide Matrix) / Carbon ... Fibers
 - ✓ **Metallic-Matrix Composites**
- ❑ **High Temperature Structural Applications / 900°C – 2000°C (Nuclear Applications, Anti-Blast, Bomb-confinement ...)**
 - ❑ Ceramic-Matrix Composites & Graphite Composites

Appropriate Embedded and/or Bonded Structural Health Monitoring !
Optical-Fiber Sensors, Ultrasonic Sensors, Thermography, Shape Memory Alloys,
Phase-Transforming Materials, Nanomaterials & Nanotechnologies ...

BIG CHALLENGE !

SMART MATERIALS ?





National Project DECID2

Budget 4M€ (2008 – 2012)

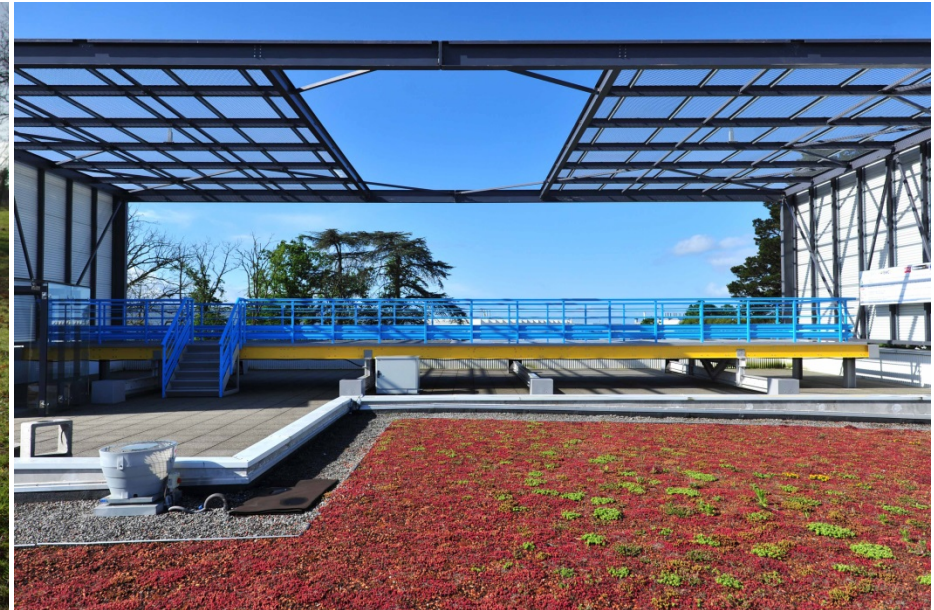


Figure . Smart Composite Platforms - DECID2 Project at IRT Jules Verne and Ifsttar Locations

EVEREST PROJECT ...
GIS DURSI, Alstom, Europe Technologies & IRT Jules Verne
Wind Turbine Blade / Bi-Reinforced Smart Composites
Budget : 1.5M€ (2014 – 2017)

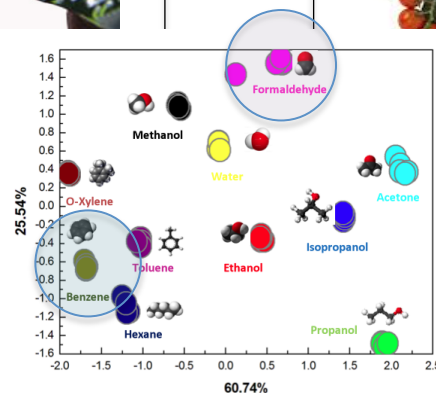
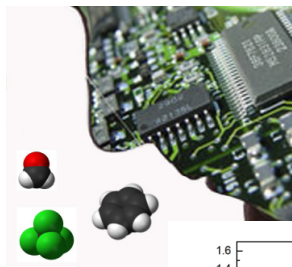


- ❑ Scalability issues for "self monitoring" approaches : prefabrication, satellite-based..., high performance computing : hardware issues (dedicated GPGPU...), software issues (Reduced order models, fast geometric model creation, fast algorithms ...)
- ❑ Robustness w.r.t. environmental conditions : comprehensive holistic monitoring and elimination of envelop perturbations
- ❑ Monitoring of Construction processes as a productivity and safety enhancer. Reduce CAPEX
- ❑ Monitoring as a maintenance enabler over large scales (replace fleets of vehicles) : reduce opex

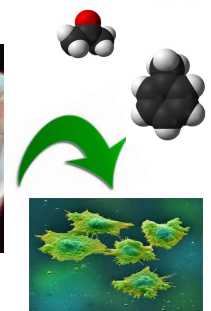
Analytical Topics ...

- ☐ **Low cost : multi-functional materials, remote electromagnetic sensing, sensor sharing (satellite ...), prefabrication**
- ☐ **Real-time Monitoring (get answers in a timely way : exceptionally heavy trucks, scour ...)**
- ☐ **Data fusion and optimal design of a monitoring system as a whole.**

Monitoring of toxic VOC in atmosphere



Monitoring of VOC biomarkers produced by living organisms



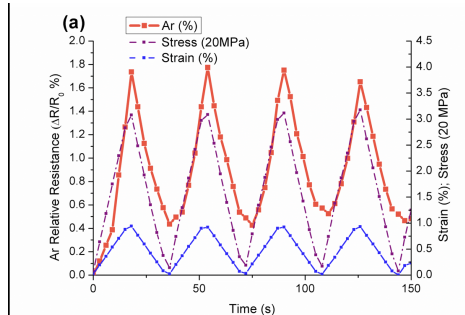
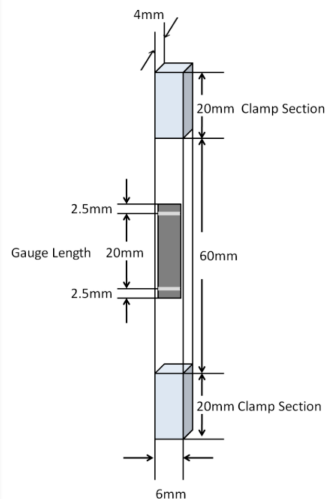
Air pollution kills due to fine particles ($f < 2.5 \mu\text{m}$) and Volatile Organic Compounds (VOC), in France 5000 per/year (VOC, benzene, formaldehyde, or carbon tetrachloride are identified as the most potentially dangerous due to their abundance and carcinogen character]

Bacteria responsible for food degradation and cancerous cells in lung are producing hundreds of VOC.

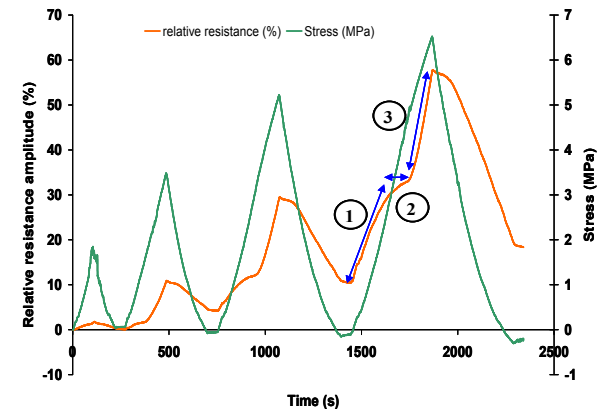
T. T. Tung, M. Castro, T. Y. Kim, K. S. Suh, J. F. Feller,,
Journal of Materials Chemistry, 22, 2012, 21754-21766.

M. Castro, B. Kumar, J. F. Feller, Z. Haddi, A. Amari, B. Bouchikhi,
Sensors & Actuators B: Chemical, 2011, 159, 213-219

It is also possible to envisage the anticipation of structural composite fracture and make health monitoring with CPC



CPC sensors can monitor the sail deformation and monitor its load to optimize its design



C. Robert, J. F. Feller, M. Castro, **ACS Applied Materials & Interfaces**, 4, 2012, 3508–3516.