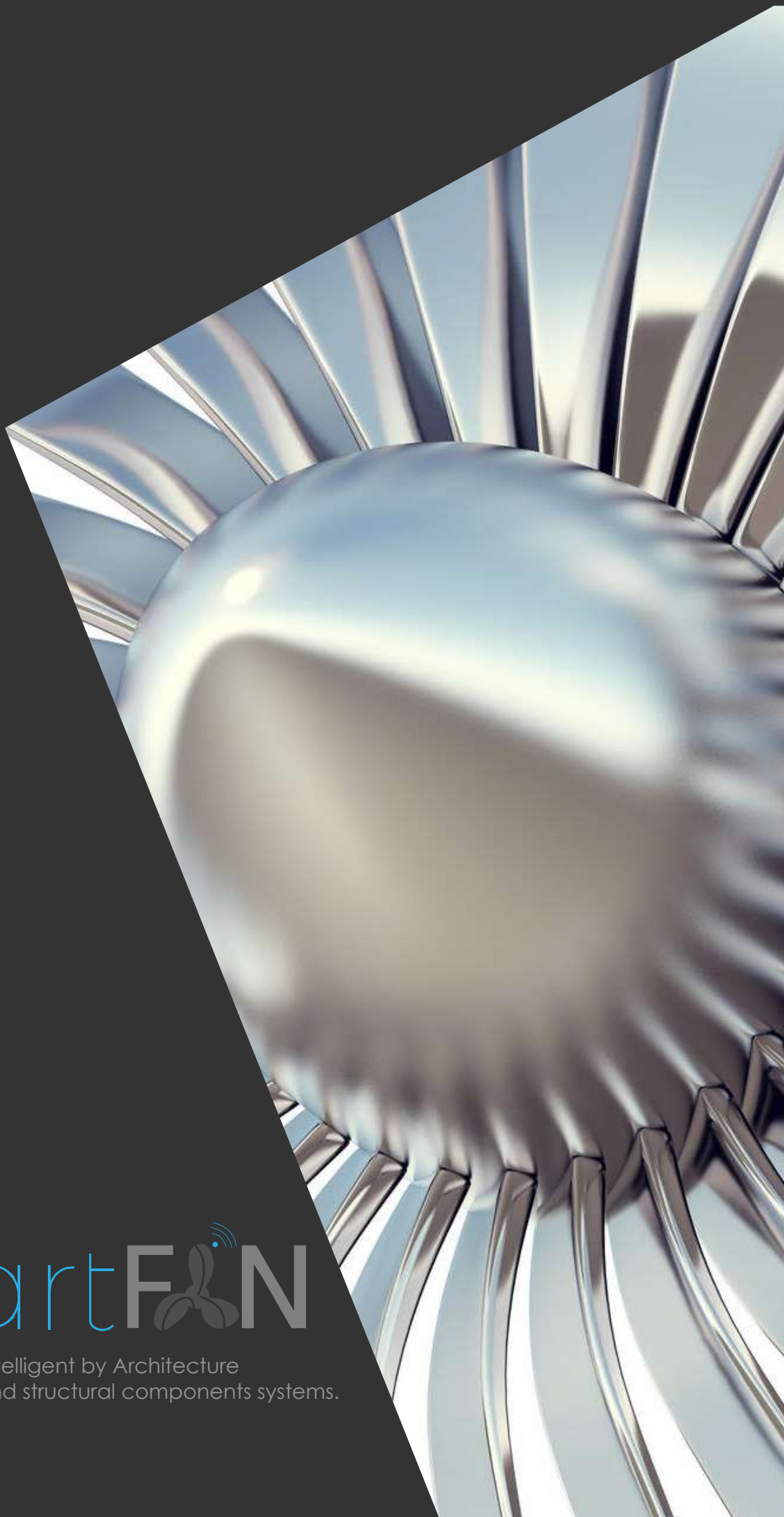
Volume 2



# SmartFAN

Smart by Design and Intelligent by Architecture
for turbine blade fan and structural components systems.

# Contents

# Partners

1.National Technical University of Athens (**NTUA**)

2.Warrant Group SRL (**WG**)

3.Association pour le Developpement de l'Enseignement et des Recherches Aupres des Universites, des Centres de Recherche et des Entreprises d'Aquitaine/CANOE Platform (**ADERA/CANOE**)

4.Dallara Automobili SPA (**DAL**)

5.Instituto Tecnologico De Aragon (**ITAINNOVA**)

6.Elica SPA (**ELICA**)

7.Foundation for Research and Technology Hellas (**FORTH**)

8.Innovation in Research & Engineering Solutions (**IRES**)

9.Techedge GMBH (**TECHEDGE**)

10.Inegi - Instituto de ciencia e Inovacao em Engenharia Mecanica e Engenharia Industrial (**INEGI**)

11.Politecnico di Torino (**POLITO**)

12.Thales SA (**TRT**)

13.Universita Degli Studi di Roma Tor Vergata (**UNITOV**)

14.The University of Birmingham (**UoB**)

15.3D NewTechnologies for medical and non-medical implementations (**BIOG3D**)

16.Open Source Management Limited (**OSM**)

17.Critical Materials SA (**CMT**)

18.Lavrion Technological and Cultural Park (**NTUA /AMDC**)

# Project Overview

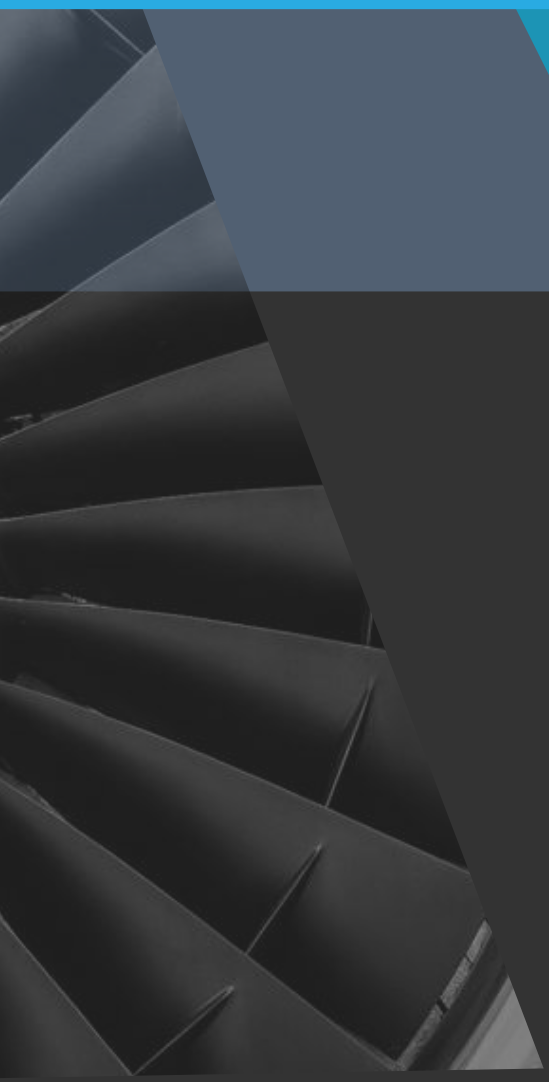
SmartFAN aims at the development of micro and nano componets, which will be used due to their special physico-chemical properties, in order to develop smart (bulk) materials for final application on intelligent structures.

CFs for reinforcement and conductivity varance, CNTs and CNFs for sensing, micro-containers for self-healing, electro-magnetic nanoparticles for fields detection and shielding, colouring agents for marking cracks and defects and piezoelectric materials can be the base for manufacturing new smart materials.

In order to develop lightweight composite materials and transfer the properties of smart components into bulk materials, polymer based matrices, such as Epoxy, PEEK, PVDF etc., will be used because of their compatibility with the above mentioned components, their low cost and their recyclability/reusability.

During synthesis of composite bulk materials several processes should take place in order to preserve the special physico-chemical properties of composites and to achieve the best dispersion in the bulk.

# Objectives



SmartFAN proposes the development of "smart" material and product architectures, with integrated functionalities, that will interact with their environment and react to stimuli by employing biomimetic, self-sensing, actuating and damage-repairing technologies. Their smartness is based on bio-inspired engineering and the use of:

- low and high grade carbon fibres (CF)
- CF reinforced polymers (CFRPs)
- nano-/micro-composites with special physicochemical properties, in order to develop smart (bulk) materials, applied on intelligent structures

Special functions of the smart materials involve:

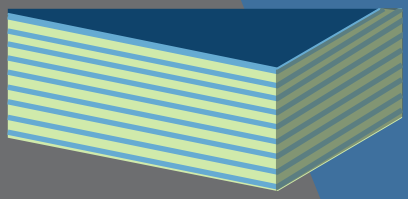
- CFs for reinforcement of the structure and creation of conductivity gradients
- Carbon Nano Tubes (CNTs) and Carbon Nano Fibres (CNFs) for sensing
- Micro-hollow particles for self-healing
- Electro-magnetic nanoparticles that enable field detection and shielding
- Coloring agents for marking cracks and defects
- Intelligent communication through Internet of Things (IoT)

# SmartFAN Framework

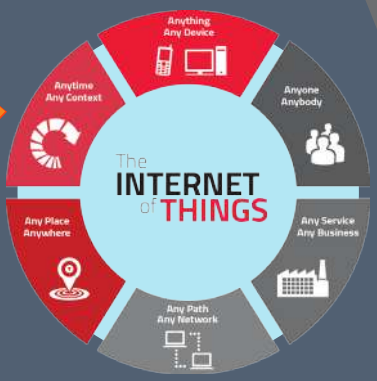
## Smart by Design materials

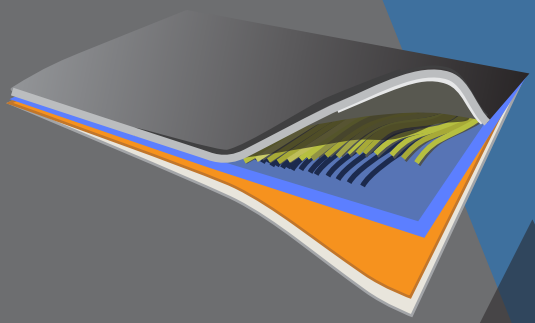
- Self-repair or self-healing materials
- Material for vibration suppression
- Lightweight composites
- Internal damage and process history
- Shape change
- Energy storage
- Functionally graded composite materials (FGCMs)

... now



SmartFAN L&G Concept



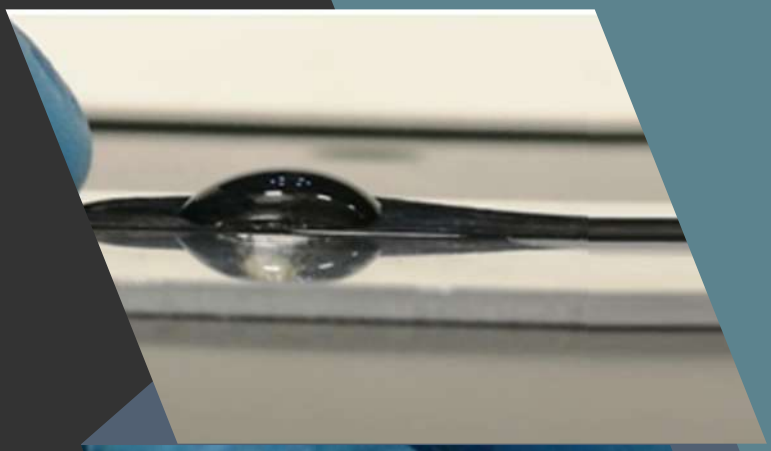
## Intelligent by Architecture structures

- Advanced sensors (nanosensor technology)
- Damage detection
- Self-repair, Self-actuation
- Self-sensing, Self-morphing
- Magnetic functionality (for non-magnetic materials)
- Optical functionality
- Sound and vibration damping
- Thermal management in ICT

# National Technical University of Athens

## Wettability assessment of SmartFAN's sized CFs

In WP2 which deals with the characterisation of the novel smart materials, NTUA is responsible for the wettability assessment of carbon fibres. For this period, NTUA received sized CFs from CANOE, which were coated with novel sizing formulations, including carbon nanotubes. NTUA proceeded with the wettability assessment of those fibers, trying to quantify the spreading rate of epoxy resin on the fibres. A prototype contact angle apparatus was used and video capturing took place to determine the rate of spreading. It was evident that the sized CFs, have stronger interaction with the epoxy resin, increasing the time needed for the spreading.



Wettability assessment of SmartFAN's sized CFs

# Elica

## Material specification

ELC is currently working on deep investigation of material specification related to domestic appliance application. It is an important work that will help companies and research centres involved in new material development, to supply the most suitable material for appliances use case.

The material shall be suitable for mass production (injection molding) and shall comply all CE and IEC regulation for user safety and hazardous substances use. In detail: EN 60335-1, EN 60335-2-31 and UL 94 standards, as well as RoHS and REACH regulations.

During next months tests will be executed in Elica Lab (EPL) to verify the fulfillment of all requirements. First tests will be performed on small samples.

## The first smart grabbing device prototype

# University of Rome Tor Vergata

The Department of Industrial Engineering of the University of Rome Tor Vergata, has produced several prototypes of smart grabbing devices in lab-scale. These devices are made of shape memory polymer composite (SMPC) laminates and are able to freeze the open-shape at the end of a thermo-mechanical cycle.


Subsequently, the closed shape can be obtained again by heating with the possibility of grabbing objects. The idea is using this kind of structures on small satellites for Space cleaning. By increasing their size, it is also possible to design on-Earth applications. For the first time, these prototypes have been manufactured by using thin SMC films previously molded in a separate process.

Next steps will be integrating sensors and heating systems, and scaling up the size of the grabbing devices. Up today, SMPCs have been never used for grabbing systems even if their use has been evaluated for self-deployable structures in Space applications. These new achievements enlarge the technological possibilities of this new class of smart materials.

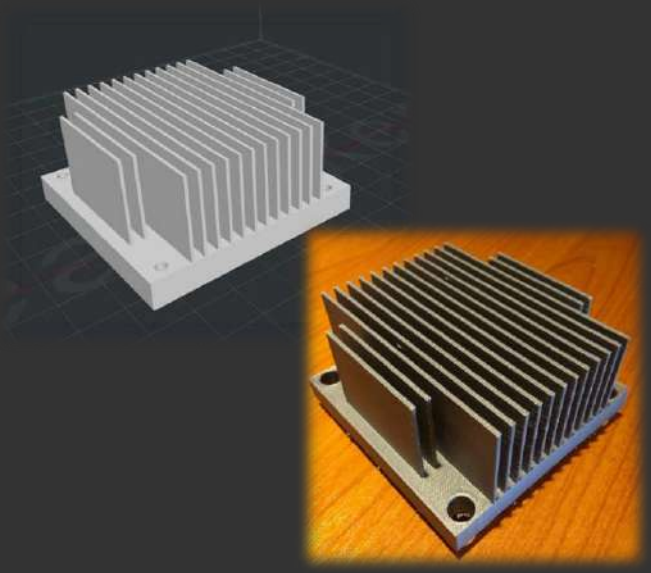
At present, SMPC grabbing devices are made of carbon fiber plies with the addition of a SMP interlayer made of epoxy resin. The SMP interlayer is located only in the folding zones during manufacturing. Thanks to the good compatibility between the SMP resin and the matrix of the composite plies, perfect adhesion is achieved between layers after composite consolidation. In the end, the SMPC structure combines the high structural properties of carbon fiber composites with the functional behavior of shape memory material.

# BioG3D

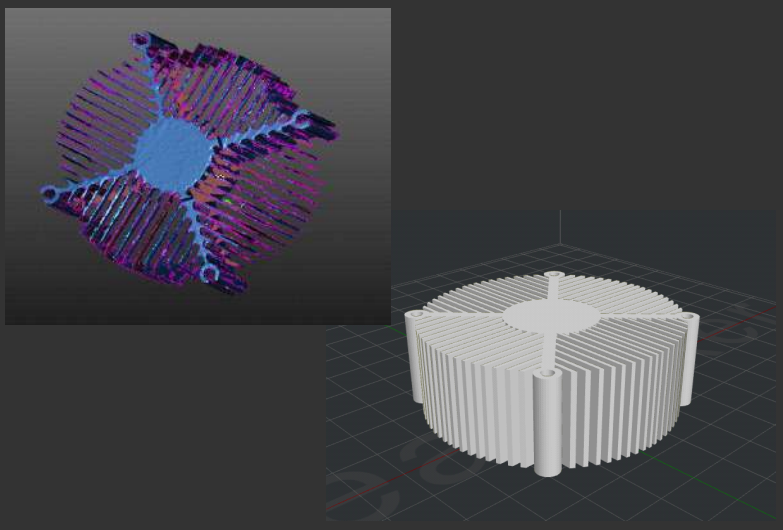
## Development of bio-inspired 3D printed processor cooling system

Within WP6, BioG3D is responsible for the development of one of the demonstrators of the project. Specifically, BIOG has undertaken the development of a bio-inspired processor cooling system through 3D printing technologies. During this period, BIOG focused on the creation of 3D models from the Heat sink of the cooling system and the 3D printing of these models with a common PLA filament. Two different 3D models were created, the first one by employing Reverse Engineering principles through 3D scanning of a commercial available unit and the second one by designing from the scratch the exact geometry of the object.

In the upcoming period, the developed 3D models will be employed to construct the mechanical parts of the processor cooling system, using the advanced composite filaments that will be produced within the project, thus demonstrating smart properties such as self-morphing and increased thermal capacitance. The ultimate goal is to develop lighter and smaller processor cooling systems with smart functionalities (increased heat flux and self-morphing abilities upon temperature increase) therefore improving their overall performance while decreasing operating noise.



*Heat Sink 3D model and 3D printed object.*



*Heat Sink 3D model through 3D scanning of commercial product.*

# IRES

## Data Management Plan

In the framework of Data Management Plan within SmartFAN project, research data will be easily discoverable, accessible, assessable and intelligible, usable beyond the original purpose for which they were collected, interoperable to specific quality standards, whenever relevant.

After the collection of the initial SmartFAN's partners description, regarding their Data & Metadata (DM), IRES in collaboration with OSM proceeded with planning of Database's next steps. From the beginning of the project, the appropriate database design has been achieved. Detailed Data & Metadata description resulted in the creation of DM Platform's demo version, to be updated frequently during the lifetime of the project, including collection of SmartFAN's Experimental Data. For the efficient collection and storage, Data Mapping & Data Integration techniques will be applied, in order to successfully combine and harmonise data from different sources.

The Platform will ensure the ease of communication across all Consortium partners as well as will offer shared access to project documents. This powerful tool will be incorporated in the project's intranet with specifically created software by OSM to allow data mining and classification. The software will enhance knowledge management capabilities for all 18 partners, ease of accessibility to results and monitoring of tests.

# SmartFan's Events

# Athens Science Festival

**April 2018, Athens, Greece**

The Athens Science Festival, the festival devoted to Science and Innovation since 2014, is an established cultural landmark in the field of Science, Technology, Innovation and Art in Greece!
For over 5 days every spring, residents and schools in and around Attica have the opportunity to explore scientific and technological advancements in an entertaining, innovative and interactive manner. At the same time, researchers, distinguished scientists, educators and artists give their best to communicate science and indulge the visitors to participate in their experience with it.
Since its introduction to the people of Athens in 2014, Athens Science Festival has collaborated with more than 3,600 scientific associates, 470 speakers, 240 artists and 1,100 volunteers. The Festival is repeatedly justifying its social impact having exceeded initial expectations and having reached out to more than 90,000 visitors over the past 4 years. In this framework, NTUA attended presenting SmartFAN achievements and demonstrating samples of CFs and composites.

# SmartFAN Technical meeting (M9)

**5 September 2018, Brussels, Belgium**

The one day SmartFAN Technical meeting was held on the 5th of September, in Brussels, Belgium, at UoB's premises. Focus was given to pending technical issues regarding materials development and characterization, demonstrator cases, correlation of materials to demonstrators, and integrating the main SmartFAN concepts (L & G).

The first half of the meeting was dedicated to the demo cases. Partners in charge of demo cases presented comprehensively their demonstrator including photos, designs, dimensions, smart functionalities, SmartFAN concept application, processing technology, required materials, sensors and testing.

The second half of the meeting was devoted to the work progress with emphasis on the pending deliverables until the end of this year. The goal was to achieve concrete decisions and action plans for the period from M9 until the submission of the deliverables at the end of M12 mitigating any delays.

*SmartFAN's Technical Partners in UoB premises in Brussels*

*Presentation of BIOG demo cases by Dr. D. Brasinika*

# SmartFAN Technical meeting (M9)

*UNITV representative, prof. Quadrini, in UoB premises in Brussels presenting smart grabbing device*

*Data management Plan presentation by IRES*

*SmartFAN's novel sizing of CF fabric by NTUA*

# SmartFAN at Nanoinnovation 2018

**11-14 September 2018, Rome, Italy**

Nanoinnovation is the reference event in Italy for the world of nanotechnology and its application. More than 1,200 researchers and professionals attended the event, entering in contact with leading exhibiting companies and research teams. Significant affluence has been recorded in the over 80 symposia, joint events, workshops, key note and special sessions which took place.


SmartFAN was presented during the "Nanocomposite materials applications" session chaired by Isella Vicini from Warrant Group (WG), where Dr. Tanja Kosanovic on behalf project coordination (NTUA) gave an overview of the project with the presentation: **"Smart by Design and Intelligent by Architecture Nanocomposites Materials: The SmartFAN project".** Dr. Mauro Castello from Elica S.P.A. (ELC) introduced **"smart fan"**, one of the SmartFAN demo cases through **"Industrial demo case based on smart nanocomposites materials: Fan for ventilation systems"** presentation. The session was closed with presentation **"Carbon Fibres & Advanced High Performance Composites Cluster"** where Massimo Rinaldi (WG) gave an overview of the CFPC cluster objectives, activities and member projects including the SmartFAN.


*SmartFAN partners WG, ELC and NTUA at Nanoinnovation*

# SmartFAN at Nanoinnovation 2018

*Introductory words to the "Nanocomposite materials applications" session by Isella Vicini (WG).*


*"Smart by Design and Intelligent by Architecture Nanocomposites Materials: The SmartFAN project" presentation by NTUA.*


*"Industrial demo case based on smart nanocomposites materials: Fan for ventilation systems" presentation by ELC*

*"Carbon Fibres & Advanced High Performance Composites Cluster" presentation by Massimo Rinaldi (WG)."*

# SmartFAN at the 5th Researchers' night

**28 September 2018, Athens, Greece**

National Technical University of Athens opened its gates on Friday September 28th 2018 from 5 o'clock in the afternoon until midnight for the 5th year to hold the Researchers' Night with aim to re-invent the connection between Academia and Society by inviting the public of Athens to meet hundreds of researchers and understand that research is serious but can also be fun. Dozens of cutting edge technologies have been presented through interactive experiments and games that introduced to the young audience.

At the R-NanoLab/NTUA booth, the SmartFAN brochures have been shared and "smart material" development highlights were given and explained, demonstrating composite materials, carbon nanotube dispersions and their "Smart" applications, together with videos and presentations. NTUA/LTCP attended also the event.

*National Technical University of Athens hosted 5th Researchers' Night event.*

# SmartFAN at the 5th Researchers' night

*Snapshoths from 5th Researchers' Night event: R-Nano booth demonstrating and promoting SmartFANs materials.*

# Cluster Activities

# Cluster Activities

## Carbon fibres & advanced high performance composites cluster (CFPC)

SmartFAN is one of the core projects in CFPC. In May 2018, the "CFPC Roadmap exercise" was organised in the European Commission, in Brussels, where core partners from the cluster met to set the main structure of the Composites Roadmap.

The same month, experts on CFs and composites hold a meeting in Dresden, which resulted in the establishment of the Global Scientific Association of Carbon Fibres (GSAC).The 40 scientists from Europe, Asia and USA that participated hope that GSAC will give impetus to research and industry.

In June 2018, the 7th CFPC Cluster Workshop took place in Chios, Greece. During the meeting, an overview of what has been achieved till now was presented by NTUA. Dr. Elias Koumoulos presented the Roadmap Status and Perspectives. Four invited speakers attended the Workshop: Dr. Paolo Bondavalli, who presented THALES achievements in SmartFAN, Sylvia Rueda, who presented ACCIONA's achievements and MASTRO Project and Dr. Fabio Pegorin, who presented the recent advancements of Ghent University in composites. Finally, the EuMAT platform and its possible linkage with CFPC was presented by Amaya Igartua.

Finally, in October 2018, two events in collaboration with EuMaT were held. Prof. Costas Charitidis attended the Steering Committee meeting of EuMaT, which was held in Brussels, in the beginning of October, while at the end of October, the Industrial Technologies took place in Vienna, Austria.

*Roadmap Exercise, Brussels 2018*

*GSAC, Dresden 2018.*

*Dr. Elias Koumoulos presenting EC perspectives for re-finding industry*

# Cluster Activities

## Nanosafety Cluster (NSC)

SmartFAN project has been introduced to the Nanosafety community through NanoSafety Cluster Autumn 2018 newsletter. In the 'new projects' section, SmartFAN 'Smart by Design and Intelligent by Architecture for turbine blade fan and structural components systems' is introduced. Its development of "Smart and green" composites that will be recyclable and reusable is a hot topic in light of the recent UN announcement. The project details, partners and objective are given, with emphasis on the SmartFAN overall strategy in Nanosafety.

New Projects

Introducing SMARTFAN

Smart by Design and Intelligent by Architecture for turbine blade fan and structural components systems

http://www.smartfan-project.eu/
charitidis@chemeng.ntua.gr

The EU funded H2020 Research and Innovation action SMARTFAN started at the beginning of January 2018. SMARTFAN aims at the development of "smart" material and product architectures with integrated functionalities that will interact with their environment and react to stimuli by employing bio-mimetic, self-sensing, actuating and damage-repairing technologies. "Smart and green" composites that will be recyclable and reusable will be developed within the project, applying system design strategies, in order to develop Carbon Fibre Reinforced Polymers (CFRPs) as bulk materials with self-sensing characteristics.

Coordinated by the National Technical University of Athens, SMARTFAN has a runtime of 4 years, and its consortium consists of 18 partners, with a total budget of almost 8.000.000 €.

SMARTFAN Objectives

Development of smart materials, applied on intelligent structures, is based on bio-inspired engineering and the use of low- and high-grade carbon fibres (CF), CFRPs and nano-/micro- composites with special physico-chemical properties. Special functions of the smart materials include:

- CFs for reinforcement of the structure and creation of conductivity gradients,
- Carbon Nano Tubes (CNTs) and Carbon Nano Fibres (CNFs) for sensing,
- Micro-hollow particles for self-healing,
- Electro-magnetic nanoparticles that enable field detection and shielding,
- Colouring agents for marking cracks and defects,
- Intelligent communication through Internet of Things (IoT).

SMARTFAN overall strategy in Nanosafety

Since nanomaterials (carbon based, microcapsules, metal oxides, etc.) are being used in intelligent structure applications, their safety aspects are considered within SMARTFAN project, for a safe handling and operation. Thus, in all stages of the project, decisions influencing exposure and environmental impacts will be addressed, considering safe-by design approaches, based on European regulations and standards. Results from the identification of safety issues, hazard assessment and exposure measurements will be drawn together to identify common and bespoke findings from across individual partners' sites and activities, to promote the development of industry-focussed guidance on the safe production and handling of the nanoparticles, nano-containing intermediates and products developed, as well as any necessary control measures to minimise the risk to human health amongst workers, researchers, end-users and the environment.

/cntd...

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# SmartFAN

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