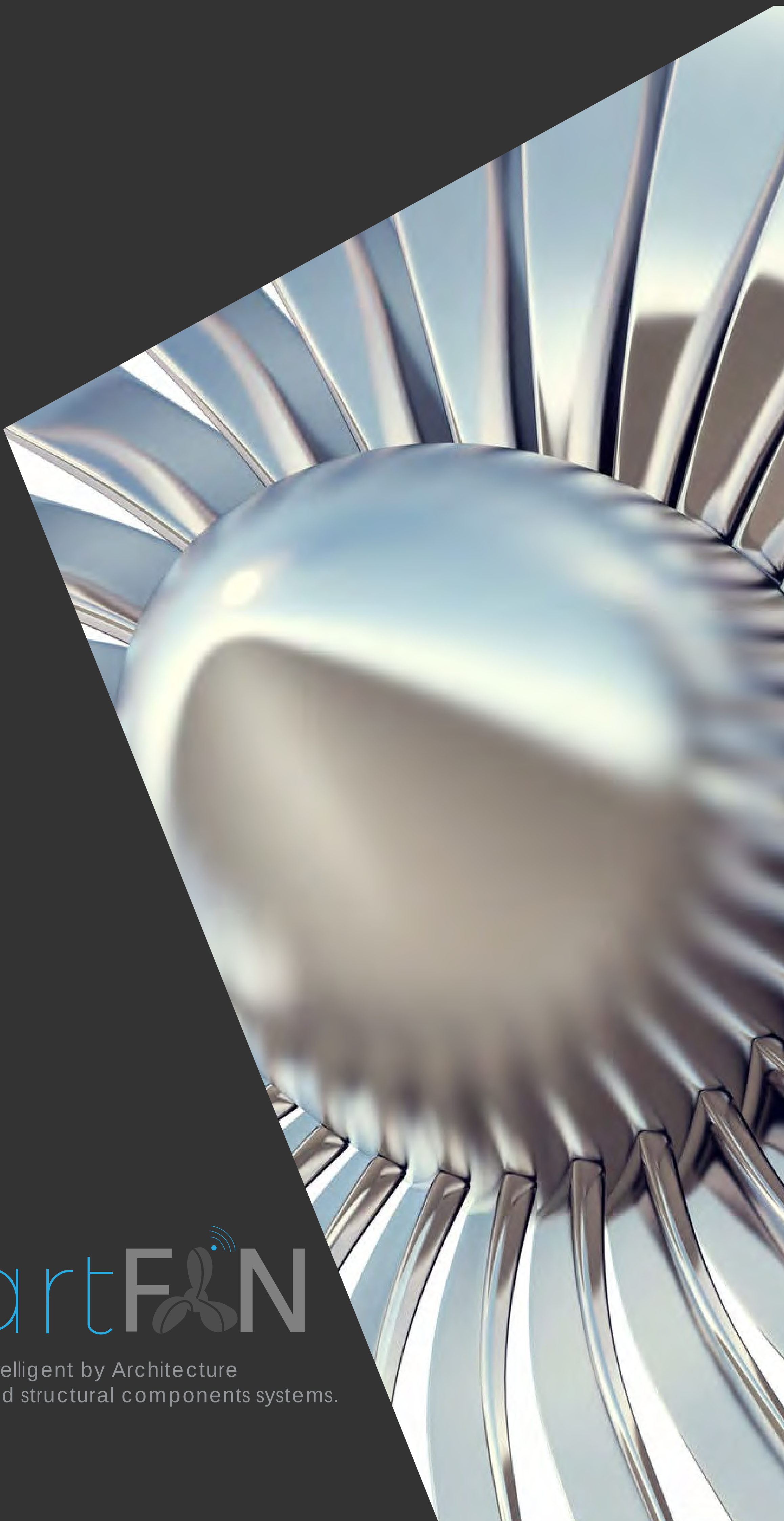
Volume 1



SmartFAN

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

Contents

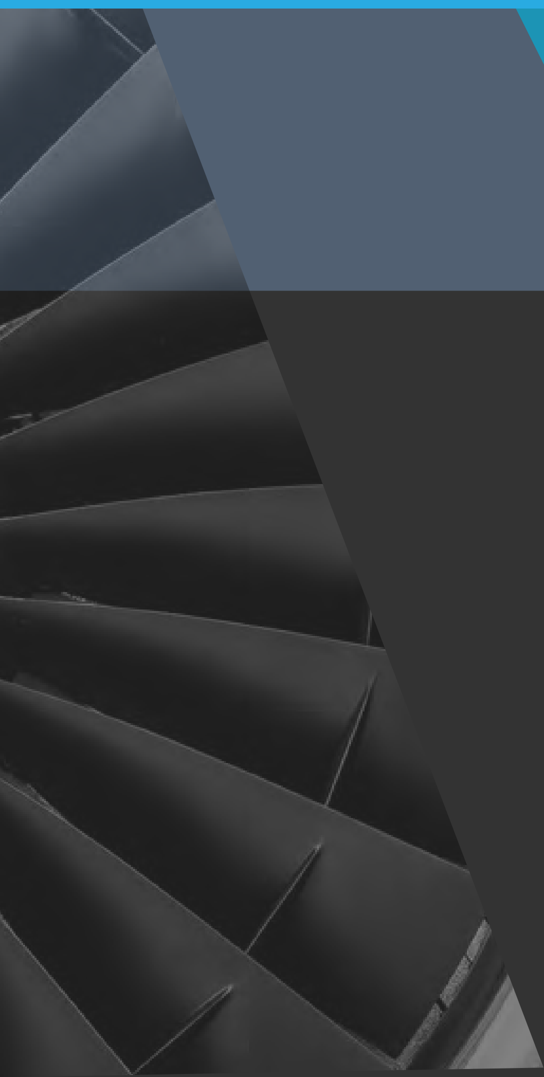
Partners

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 (**ADERA**)
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 (**THALES**)
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**)

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 variance, 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.

Project Overview

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

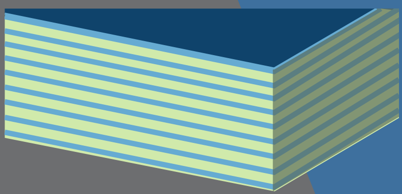
Intelligent communication through Internet of Things (IoT)

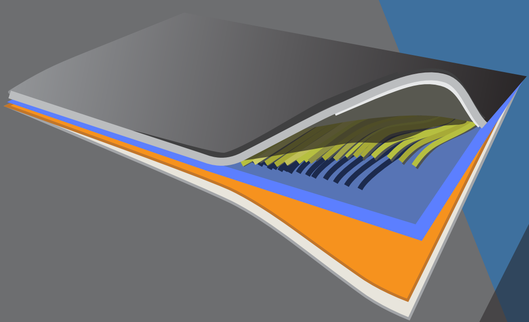
SmartFAN Framework

Smart by Design materials

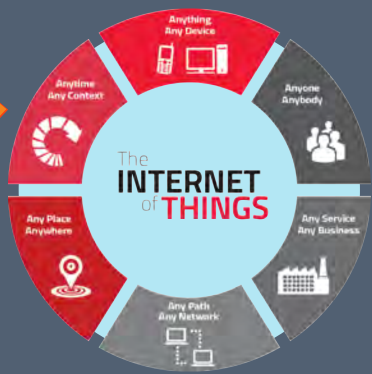
- Self-repair or self-healing materials
- Material for vibration suppression
- Lightweight composites
- Internal damage and process history
- Shape change
- Energy storage
- Functionally graded composite materials (FGCMs)

... now





SmartFAN L&G Concept



- 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

Intelligent by Architecture structures

Development of
“smart and green”
composites

Development of
new strategies
and processes for
pilot scale production

Development of
system design
strategies

SmartFAN

Project Goals

SmartFAN will approach intelligent structures through two different design concepts, the L concept and G concept. The L concept will be based on multilayer architectures of composite materials, while the G concept will focus on composite architectures including variable fibre grids.

Main Challenges

1.Novel concepts for intelligent components and structures with integrated functionalities that are able to communicate and interact with their environment, store data about their condition and react accordingly to external stimuli.

2.Development of materials that can alter their physical properties and shape.

3.Intelligent structures and components that provide information of their in-service conditions.

4.Self-repair, self-healing, lightweight composites that inform the user of any internal damage without the need of time consuming measurement techniques.

5.Non-destructive examination.

6.Materials or structures that can undergo shape change either passively or by activation. Functionally, Graded composite Materials (FGMs), energy storing components.

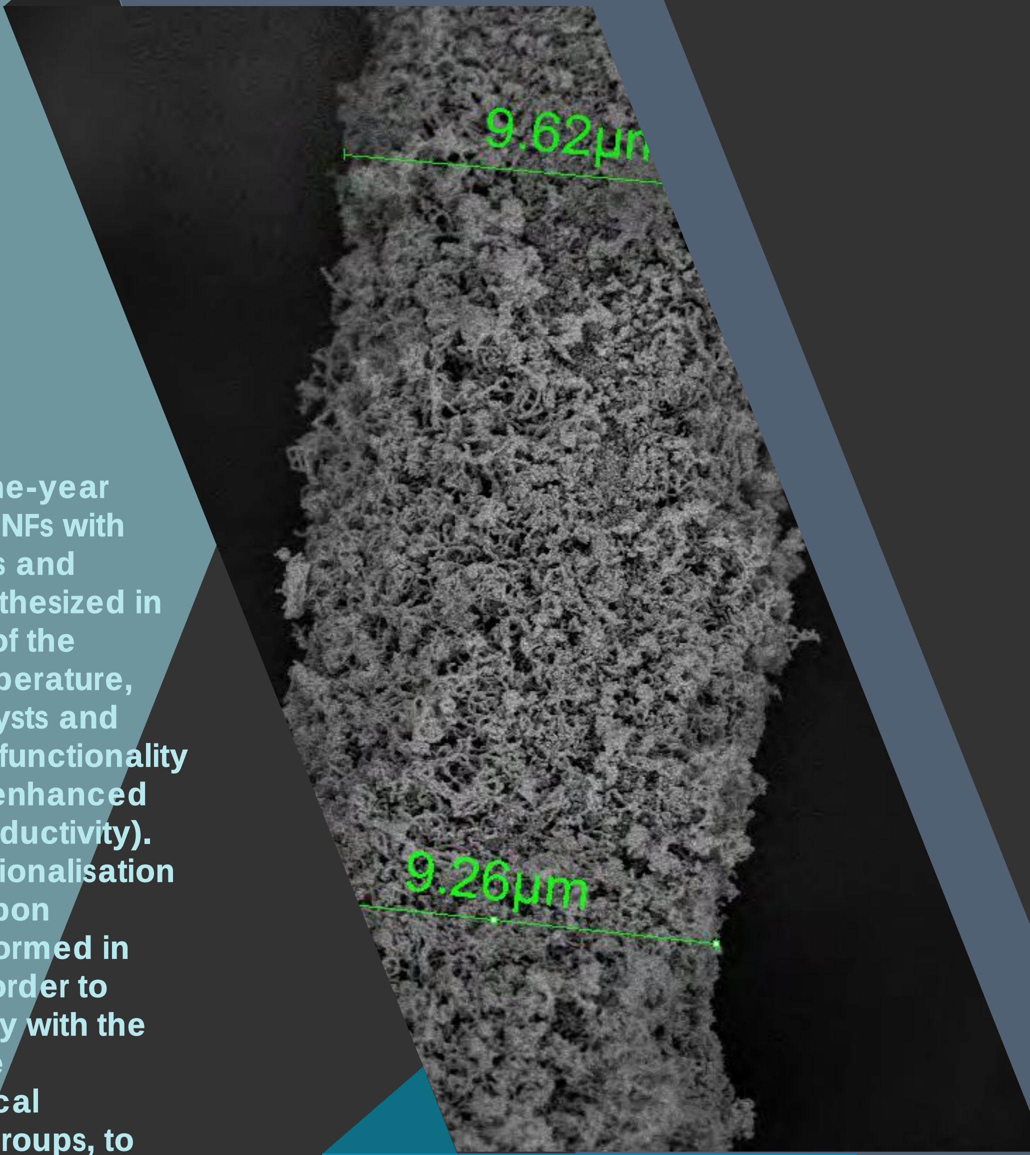
7.Predictive modelling of materials functionalities for those materials for which there are currently no accurate commercial or open-source codes available.

National Technical University of Athens

Smart Properties by C-based nanostructures

Nanostructures based on carbon allotropes, with special emphasis on carbon nanotubes, graphene and their derivatives, have received worldwide attention due to their outstanding mechanical, thermal, and electrical properties. Potential applications include energy storage, chemical sensors, electric and optoelectronic devices, electromagnetic interference (EMI) shielding as well as the development of multifunctional and smart nanocomposites.
Within SmartFAN project, NTUA is working on the synthesis of raw materials able to provide smart functionalities. Specifically, the growth of carbon nanotubes (CNTs) and carbon nanofibers (CNFs) is achieved through the thermally assisted Chemical Vapour Deposition method (T-CVD), with the supported catalyst approach. The CNT anchorage to the carbon fibres (CFs) has been studied and it has been proved that enhances the adhesion with the polymer, which is in favor with a good transfer of electrical charge and heat between the nanotubes and CFs. Well aligned, long and dense CNTs can be grown on CFs with the CVD process. Carbon substrates, such as CFs, can be easily treated with this process, which takes place in the same reactor and does not need any handling between the two growth stages. Growing CNTs on the surface of high performance CFs provides the means to tailor the thermal, electrical and mechanical properties of the fiber-resin interface of a composite.

T-CVD system in NTUA
used for the growth of CNTs/CNFs.



CNTs grown on a single carbon fibre..

During the initial period (one-year timeframe), CNTs and/or CNFs with different lengths, diameters and number of walls will be synthesized in NTUA, through the control of the synthesis parameters (temperature, pressure, precursors, catalysts and substrates) to include multifunctionality (in particular, through the enhanced electrical and thermal conductivity). Also, the appropriate functionalisation of the surface of these carbon nanostructures will be performed in collaboration with UoB, in order to achieve good compatibility with the matrix in which they will be incorporated, and the critical percentage of functional groups, to obtain the desired electrical and thermal properties. Different functionalisations will be tested, such as the addition of carboxyl groups, amino groups, etc., as well as plasma treatment of the produced CNTs/CNFs. The developed C-based nanostructures will be used either directly in the polymer matrix of the composites to enhance the mechanical, electrical and thermal properties or as sizing approach for the CFs, to enable sensing properties for the G-Concept of SmartFAN (functionalization of specific CFs within a grid to achieve sensing, self-morphing and tailored properties). Moreover, CNTs/CNFs will be used in THALES demonstrators (supercapacitors and electromagnetic shields), as well as in other intelligent structures developed within SmartFAN project during the initial period.

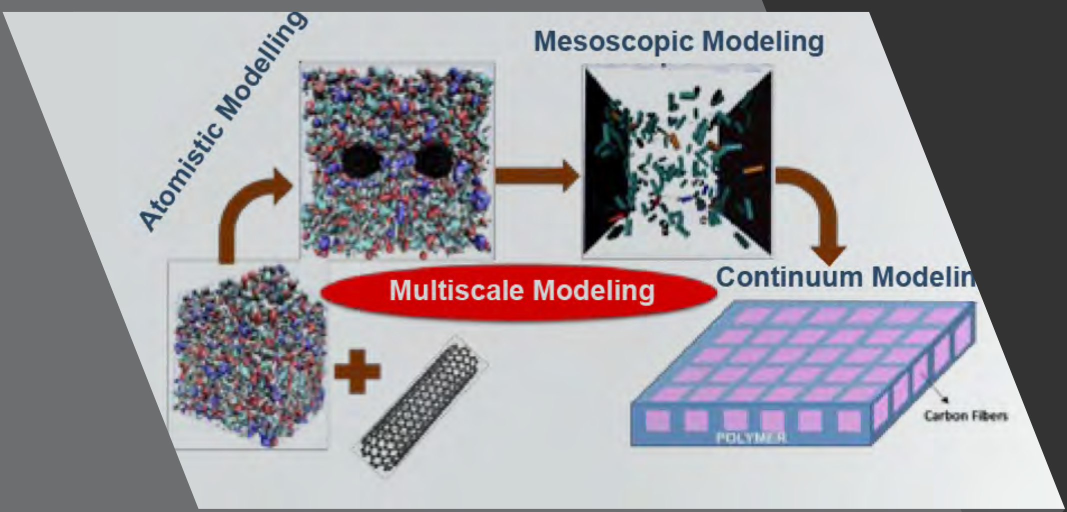
Politecnico di Torino

MULTISCALE MODELLING

Another objective of the SmartFan project is to develop the materials with improved properties and specific multi-functionalities. Polymer nanocomposites (PNCs) seem promising materials for numerous industrial applications (aerospace, automobile, home appliances, and energy storage). However, it is challenging to enhance their capabilities and performance relevant to the smart applications considered in this project. The advancement in computational technology facilitates the modelling and simulation of the materials on different space and time scales. Modelling tools have the ability to track and reveal function-structure relations of the material in-situ. Therefore, one of the work packages in this project is focused on modelling smart materials based on design-specific internal architectures. During this work package, multiscale modelling will be used that offer possibility to analyze components, component distributions and different geometric parameters of the constituting phases (thicknesses, reinforcements, lengths, and more) and their effects on material properties/performance. In particular, atomistic modelling will provide a better understanding of materials/interfacial properties at the nanoscale. The mesoscopic models upscale the reference responses at the molecular level and compute the effective mechanical and thermal properties of polymer nanocomposites.

Finally, the continuum models will be used to perform sensitivity analysis on effective material properties against different geometrical parameters that allow the optimization of materials architectures for the best performance. The application of multiscale modelling will minimize expenses and accelerates the development of smart-by-design engineering materials and transforms the optimally designed composite material to the manufacturing stage.

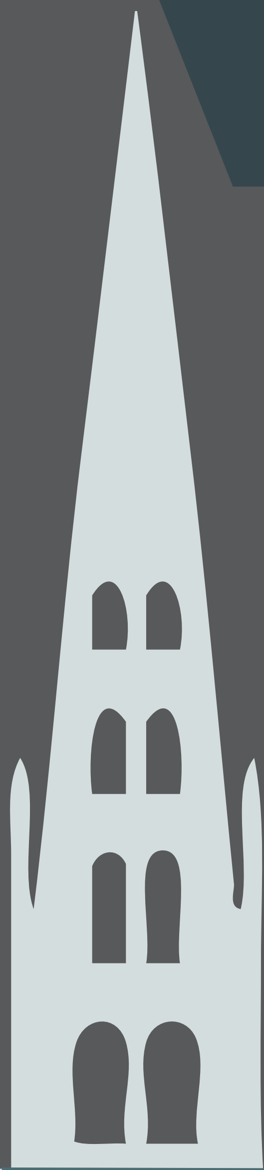
These techniques also set the benchmark for the development of new functional and marketable products. The time period of 40 months will be required for modelling smart polymer nanocomposites to achieve the current objective of the SmartFan project and the partners involved in these modelling activities are ITAINNOVA, NTUA, POLITO, and FORTH. Currently, POLITO is working in close collaboration with other work package partners on defining models that resembles materials required in the project. The models defined and developed will be described according to the MODA (MOdellingDAta) approach as recommended by European Materials Modelling Council (EMMC, http://emmc.info/).



Multiscale Modeling graphic

SmartFAN
kick off meeting

16 January 2018 Brussels,Belgium



After months of email exchanges and only virtual communications, on 18th January 2018 SmartFAN partners had finally the opportunity to meet in person at the project Kick-Off Meeting held at EC premises and attended also by the Project Officer, Dr. Achilleas Stalios (Research Programme Officer – Advanced Materials and Nanotechnologies). During the KOM, project contents were examined in detail, and next technical activities were scheduled.

SmartFAN partners
during Kick off meeting

SmartFAN booth in JEC

6-8 March 2018 Paris, France

JEC World 2018 is the biggest and most important world show dedicated to composites market.
From raw material to processors and end-users, JEC World attracts each year in Paris, over 40,000 professionals looking for innovation, new partners and insight on their industry's future.
Featuring ground-breaking solutions, unique manufacturing and business opportunities, JEC World is a networking hub of creativity, vision and action. It shows you how composites materials push the limits of your projects and ambitions.
Environment, sustainability, Smart Industry, Mobility: JEC World explores how composites can respond to our century challenges.
SmartFAN participated to this important event and, for the first time, they had the opportunity to present the project.

SmartFan in JEC World

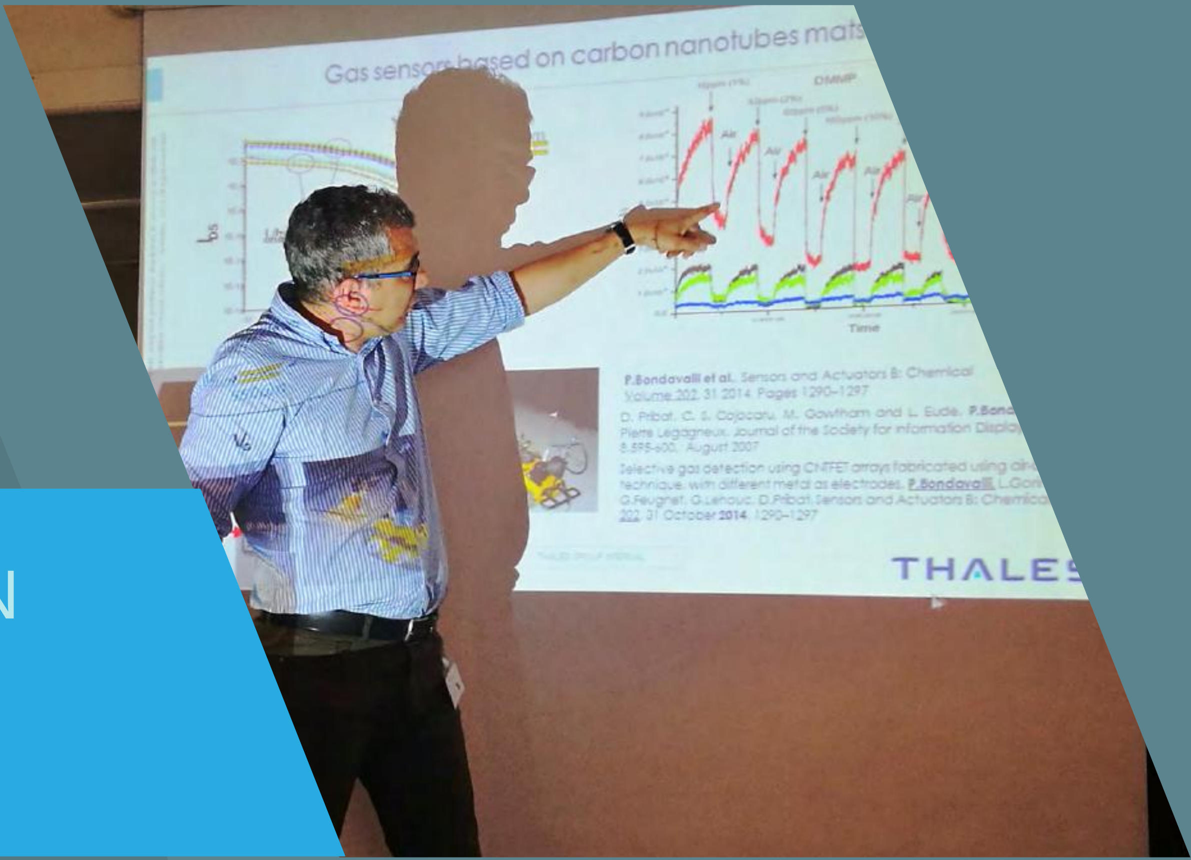
SmartFAN partners during
JEC world 2018, Paris.

SmartFAN 6M Meeting

19 June 2018 Chios, Greece

The 6M SmartFAN meeting was held on the 19th of June, at Chios Island in Greece. The Project Officer, Dr. Achilleas Stalios took part in the meeting. Partners presented their progress for the first six running months of the project and emphasis was given to the smart materials that have been synthesized. During the meeting a group discussion focused on the processes and demonstrators that will be developed within the project was held and the activities for the next months were planned.

SmartFAN partners during
6M meeting in Chios



SmartFAN 7th CFPC Meeting

7th CFPC Meeting

The 7th CFPC Meeting was held on the 18th of June, at Chios Island in 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 MODCOMP and FIBRALSPEC project that are involved in the CFPC, Sylvia Rueda, who presented ACCIONA's achievements and MASTRO Project and Dr. Fabio Pegorin, who presented the recent advancements of Ghent University in composites. The EuMAT platform and its possible linkage with CFPC was presented by Amaya Igartua. During the round table discussion, SMARTFAN's partners, discussed with the invited speakers about SMARTFAN objectives and how these can be oriented towards the Cluster needs.

SmartFAN's involvement in Clusters

CARBON FIBRES & ADVANCED HIGH PERFORMANCE COMPOSITES CLUSTER (CFPC)

THE EUROPEAN MATERIALS MODELLING COUNCIL (EMMC)

THE EUROPEAN MATERIALS CHARACTERISATION COUNCIL (EMCC)

NANOSAFETY CLUSTER

ECHOES CLUSTER

SmartFAN

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