<u>Atoms to Airplanes: Designer/Engineered Aerospace Material</u>: *The revolution of nano-materials and 3D printing in the world of airplanes, including multi-scale aspects.*

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Ever since the Wright brothers built and flew the first successful airplane more than 100 years ago, aerospace engineers have been striving to find the right materials and manufacturing processes for airplanes to make them lighter, stronger, more durable and easy to manufacture.

In the earlier days, materials used in aerospace were nothing more than what was available, such as wood, fabric, steel and rubber. The Wright brothers' design, for example, featured an engine with a lightweight aluminum engine block, a spruce and steel wire airframe structure and fabric skins. As the industry matured, more materials made their way onto airplanes, including plastics, stainless steel, advanced alloys, titanium, different composite materials and ceramics. Indeed today, more and more materials are being specifically engineered for aerospace applications.

So far, improvements in materials have been driven primarily by weight, strength and performance considerations. Future materials development is likely to focus more on multi-functionality, such as intelligent materials with imbedded sensors for structural health monitoring and nano-enhanced composites with improved electrical and thermal properties for lightning strike protection and anti-icing capability. Engineering such materials has becoming one of the most challenging tasks requiring a multidisciplinary approach.

Along with advancements in materials, manufacturing technology has assumed greater prominence within the engineering development cycle. Today's advanced manufacturing technology, involving composite materials and 3D printing, is enabling engineers to design complex and integrated aerospace structures to meet ever increasing performance and safety requirements. As the materials and structures become more complicated, multi-scale simulation spanning from material nanoscales to structural macroscales will provide another powerful tool which will further revolutionize the way airplanes are engineered.

With global air traffic doubling every fifteen years and a projected requirement of 30,000 new passenger and cargo aircraft between now and 2033, worth nearly US$5 trillion, the need for renewed innovation in the sector has never been greater. Within Europe this projected demand will need to be delivered within the EU's vision for aviation which aspires to a 75% reduction in CO_2 emissions a 90% reduction in NO_x, by 2050, over the 2000 baseline. Moreover, this vision aims to significantly reduce development and certification costs. Meeting these targets will require disruptive technologies in a number of research areas related to aerospace engineering and science.

With the excitement of a new era in aerospace materials, manufacturing technologies and modelling, it gives us great pleasure in introducing our speakers who are each contributing to these new frontiers. Professor Ian Kinloch, from the University of Manchester will report on harnessing the unique and tremendous properties of nano-scale graphene structures to develop multifunctional composite structures. Dr Tobias Schaedler, from HRL Labs, will show how use of cellular architectures across scales is leading to the development of a new class of lightweight materials with unprecedented structural properties. Professor Stephane Bordas, who has a joint appointment at the University of Luxembourg and Cardiff University will present recent progress and challenges in the modelling of fracture of composite materials across scales. This theme is further explored by William Grosse from The Boeing Company who will describe how the emergence of an integrated multiscale modelling methodology for aircraft, incorporated at all stages of the development cycle has the potential to lead to highly novel and efficient design configurations.