AEROSPACE ENGINEERING

MUR DM 117/FEV - Application of nanotechnologies in the field of future sustainable mobility: The challenges related to simulation and experimentation

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Context of the research activity	This PhD program has the objective of investigating the applicability of nanotechnologies in both terrestrial and aeronautical transport engineering Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23001970004
	The first studies on nanotechnologies date back to 1959 [1] and, today, these technologies are widespread in all sectors. The strong growth in interest and diffusion of these technologies can be well represented by the analysis of the number of scientific articles on the subject in the 3 major world scientific journals (Nature, Science, PNAS) which from 1991 to 2016 reached 120% [3], or from the analysis of the growth of the "impact factor" of the scientific journal "Nanotechnology" which from 2000 to 2020 rose from the value of 1.6 to 3.6 [2]. This strong research footprint entered the industrial field with a strong impact, exceeding 9,000 patents in 2008 [3]. Nanotechnologies have been applied to the transportation sector to increase the performance of components on land, air, and sea vehicles. Some examples, in the automotive field [4]: use of nanotechnologies in automotive paints in order to ensure greater resistance and corrosion prevention; the use of nanotechnologies in order to improve the resistance of surfaces to UV rays; application of carbon nanotubes as substitutes for metal parts in order to reduce vehicle weight; applications of nanotechnological coatings in the cylinders of heat engines in order to reduce friction with the relative gains in terms of fuel consumption and reduction of pollution. In the aeronautical sector [4] at the moment the number of applications of nano-technologies is still very low and limited to the coatings sector. As

Objectives	regards the development of new "light" materials and/or made with innovative technologies, the most promising candidates are polymeric nanocomposites reinforced with carbon nanotubes and boron nitride and epoxy resins reinforced with nano clays (nanoclays). These materials offer a high ratio between toughness and weight, impact resistance and radiation protection and the prospect is to develop multifunctional composites. In perspective, integrated nanosensors for health monitoring of the state of health of the structure itself are also under investigation. Nanostructured metals, on the other hand, find applications in the parts most subject to corrosion and wear (landing gears, brakes, etc.). Finally coatings (in the form of thin films) including nano powders can be used as self-cleaning or anti-glare layers for windows. This PhD program has the objective of investigating the applicability of nanotechnologies in both terrestrial (automotive, railway) and aeronautical transport engineering in to develop new high-profile skills in the field of sustainable mobility in agreement with the lines of the PNRR M4C2. The doctorate will develop the study of nanotechnologies in collaboration with leading companies in the sector of production of nanotechnological formulations (4WardAerospace) and leading companies in engineering solutions related to mobility (FEV-Italia). In particular, FEV-Italia will co-finance the scholarship while 4Ward360, even if not direct co-financer of the scholarship, has made itself available to support the research work with the materials and treatments for the applications that will be conceived during the three-year PhD. The studies will start from the analysis of how these nanoparticles adhere to different surfaces and how these bonds can be estimated analytically or numerically. The study will than investigate of how the physical and mechanical properties of the various materials used in industry are conditioned by nanotechnologies, both with analytical approaches (rule of mixtures or homogenization methods adapted according to the chemical-physical characteristics of the material), and with numerical simulations (macro-microscopic models and simulations with meshless techniques) [5]. These results will be correlated by experimental activities carried out in collaboration with the FEV Italia at the laboratories of the Polytechnic of Turin and not only, in order to produce an experimental validation database of the theoretical and numerical results. Finally, the numerical study of complex components subjected to mechanical, thermal, fatigue load, in the fluid-structure interaction (FSI) field or in combination with electromagnetic fields will be investigated in order to establish how the application of nanotechnologies can influence performance. Bibliography [1] Drexler, K. E., Engines of Creation: The Coming Era of Nanotechnology, Anchor Books, 1986. ISBN 978-0-385-19973-5 [2] Zhu, Hongyi & Jiang, Shan & Chen, Hsinchun & Roco, Mihail. (2017). International perspective on nanotechnology papers, patents, and NSF awards (2000–2016). Journal of Nanoparticle Research. 19. 10.1007/s11051-017-4056-7. [3] https://academic-accelerator.com/5-Year-Impact-of-Journal/Nanotechnology [4] Jinu Mathew, Josny Joy, Soney C. George, Potential applications of nanotechnology in transportation: A review, Journal of King Saud University - Science, Volume 31, Issue 4, 2019, Pages 586-594, ISSN 1018-3647, https://doi.org/10.1016/j.jksus.2018.03.015. [5] Sumaiya Islam, Raafat Ibrahim, Raj Das, Tim Fagan. Novel approach for modelling of nanomachining using a mesh-less method. Applied

	Mathematical Modelling 36 (2012) 5589–5602 doi:10.1016/j.apm.2012.01.005.

Skills and competencies for the development of the activity	Master in Aerospace Eng. with experience in structural simulation and design. Experience with implicit-explicit commercial FEM codes (NASTRAN/LSDYNA other codes) . Autonomy in solving complex problems. Ability to work in teams with different backgrounds. Ability to adapt to program variations.