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SMART STRUCTURES AND MATERIAL: VISIONS, PROMISES AND CHALLENGES IN AERONAUTICS

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Summary: Technological developments in materials and computer science have evolved to the point where their synergistic combination has culminated in a new field of multi-disciplinary research in adaptation. The advances in material sciences have provided a comprehensive and theoretical framework for implementing multi-functionality into materials, and the development of high-speed digital computers has permitted the transformation of that framework into methodologies for practical design and production. Adaptive structures represent a new approach or design philosophy that integrates the actions of sensors, actuators and controls into a system that can respond adaptively to environmental changes. This integrated system exhibits a functionality that adds significant value to materials, technologies or end-products, which in turn enables system performance enhancements that are not possible with traditional conventional approaches. Electro-magneto-thermo-mechano-rheological materials such as shape memory alloys, magnetostrictive materials and piezoelectrics have been key enablers of adaptive structures in terms of actuation simplicity and compactness.

Air transportation is increasingly becoming more accessible to a greater number of people who can afford travelling by air, both inside and outside Europe, for leisure and business purposes. This is evidenced by the fact that last year the EU air transport system moved more than 1 billion passengers and 14 million metric tonnes of freight through its airports, whilst handling more than 12 million movements over the same period. The sector forecasts that over the next decade, both passenger and freight traffic is expected to increase at an average of 4 to 5% p.a., with freight being expected to increase slightly more - both significantly above global GDP growth. In air transport terms, this implies a doubling of traffic about every 16 years [1]. It is evident that environmental requirements, such as noise impact and emissions, will play a dominant role in future transport aircraft development, becoming a driving force for aircraft design. This is the main reason for which ACARE, in the Strategic Research Agenda [2], established the so-called greening aircraft as the first objective of future research activities related to Aeronautics. The adoption of this kind of global requirement has two main consequences: firstly, the greening level becomes one of the criteria for which a new aircraft has to be judged or selected; and secondly, the aircraft configuration itself must be defined to fulfil the greening requirements. Since other design targets, such as economic and technical factors, must be satisfied, new design criteria arising from the greening requirements must be taken into account right from the beginning of the design cycle.

The direct greening design criteria, as formulated into Vision 2020 ACARE Agenda, are represented by: 80% cut in NOx emissions, halving perceived aircraft noise and CO2 emissions per passenger-Km, and green design, manufacturing and maintenance. Other indirect greening requirements must also be considered, for instance, drag reduction and weight savings. It is obvious that by reducing a small amount of fuel burn and multiplying this by the total number of transport aircraft leads to a remarkable reduction of emissions into the atmosphere. Looking at the medium and long term period it is evident that significant steps forward to more efficient aircraft, able to meet direct and indirect greening requirements, will be achievable only by enhancing the aircraft capability to adapt its configuration to different flight conditions so as to be always in the optimal configuration.

There has been a great deal of recent activity in this area in USA through the Active Flexible Wing Wind Tunnel Test Program [3], the US Air Force/NASA Active Aeroelastic Wing Flight Test Program [4], and a few EU collaborative research projects such as 3AS [5], SADE [6], SARISTU [7] and NOVEMOR [8].

The invited lecture will provide an overview of a EU Project recently completed in the 7th Framework Program. The aim of the NOVEMOR (NOvel Air VEhicle Configurations: From Fluttering Wings to MORphing Flight) research project is to investigate morphing wing solutions to enable "Leaner, Greener and Safer" Transportation. The design and development of the proposed solutions have been performed as an integral part of the aircraft conceptual design, rather than just as an add-on later in the design cycle, thus enabling innovative aircraft designs to be made through the use of morphing and adaptive structures technologies.

References:

[1] Canadian Airports Council, "Canadian Air Transportation Industry: A $34.9 Billion Economic Footprint", http://www.newswire.ca/en/story/1144391/canadian-air-transportation-industry-a-34-9-billion-economic-footprint, 2013.

[2] Advisory Council for Aeronautics Research in Europe (ACARE), "A Vision for 2020", ISBN 92-894-0559-7, 2001.

[3] Pendleton E., Griffin K.E., Kehoe M.W., and Perry B., "A Flight Test Programme for Active Aeroelastic Wing Technology" AIAA-96-1574-CP, 1996.

[4] Noll T.E., and Eastep F.E., "Active Flexible Wing Program", Journal of Aircraft, Vol. 32, No.1, 1995, pp. 9.

[5] Active Aeroelastic Aircraft Structures (3AS), EU 6th Framework Program, G4RD-CT-2002-00679, 2002-2005.

[6] Smart High Lift Devices for next Generation Wings (SADE), EU 7th Framework Program, FP7-AAT-2011-RTD-1, Grant no. 213442, 2008-2012.

[7] Smart Intelligent Aircraft Structures (SARISTU), EU 7th Framework Program, FP7-AAT-2011-RTD-1, Grant no. 284562, 2011-2015.

[8] Novel Air Vehicles Configurations: From Fluttering Wings to Morphing Flight (NOVEMOR), EU 7th Framework Program, ACP1-GA-2011-285395, 2011-2014.