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Distinguished Lecture

Aerospace Cyber-Physical and Autonomous Systems

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Abstract

Advances in aerospace Cyber-Physical Systems (CPS) are accelerating the introduction of automated decision making functionalities and the progressive transition to trusted autonomous operations both in civil and military applications. Major benefits of these capabilities include de-crewing of flight decks and ground control centres, as well as the safe and efficient operations of air and space platforms in a shared, unsegregated environment. In the commercial aviation context, CPS are supporting the development of single-pilot operated aircraft, with the co-pilot potentially replaced by a digital assistant and/or a remote pilot on the ground. A single remote pilot on the ground, on the other hand, will no longer be restricted to controlling a single aircraft and instead will be allowed to control multiple manned and unmanned vehicles, in line with the so-called One-to-Many (OTM) operational concept.

Important efforts are also being devoted to the integration of Unmanned Aircraft Systems (UAS) in all classes of airspace, eliciting the introduction of UAS Traffic Management (UTM) services seamlessly integrated with the existing (and evolving) ATM framework. In particular, UTM requires substantial advances in Communication, Navigation, Surveillance (CNS) for ATM (CNS/ATM) and Avionics (CNS+A) technologies and associated regulatory frameworks, especially to enable low-altitude and Beyond-Line-of-Sight (BLoS) operations. Recent advances in communications, navigation and Sense-and-Avoid (SAA) technology are therefore progressively supporting UTM operations in medium-to-high density operational environments, including urban environments. Research efforts are also necessary to demonstrate the feasibility of CNS+A technologies capable of contributing to the emission reduction targets set by the International Civil Aviation Organization (ICAO), national governments and various large-scale international research initiatives. Therefore, growing emphasis is now being placed on environmental performance enhancements, focusing on Air Traffic Flow Management (ATFM), dynamic airspace management, 4-dimensional (4D) trajectory optimization, airport automation and, in the near future, urban flight operations.

In addition to CNS+A technologies for air operations, space CPS are also being researched for a wide range of practical applications including commercial satellites, space transport/tourism, and interplanetary scientific missions. In this context, it is anticipated that economically viable and reliable cyber-physical systems will play a fundamental role in the successful development of the space sector and significant research efforts are needed in the field of reusable space transportation systems, Space Traffic Management (STM), and Intelligent Satellite Systems (SmartSats). In particular, the operation of space launch and re-entry platforms currently

requires considerable airspace segregation provisions, which if continued will become increasingly disruptive to civil air traffic. Moreover, the currently limited space situational awareness is posing significant challenges to the safety and sustainability of spaceflight due to the rapidly growing amount of resident space objects and particularly orbital debris. The deployment of network-centric CNS+A systems and their functional integration with ground-based ATM in a Space Traffic Management (STM) framework will support a much more flexible and efficient use of the airspace with higher levels of safety. These evolutions will support the transition to what the research community have started designating as Multi-Domain Traffic Management.

Bio-notes

Roberto Sabatini is a Professor of Aerospace Engineering and Aviation at RMIT University (Melbourne, Australia). He has 30 years of experience in aerospace, defence and transport systems design, testing an operations, acquired in progressively more responsible industrial and academic positions in Europe, United States and Australia. Currently, he serves as Chair of the Cyber-Physical and Autonomous Systems Group, Deputy Director (Aerospace) of the Sir Lawrence Wackett Centre, and Director of the Autonomous and Intelligent Systems Laboratory at RMIT University. Professor Sabatini is a Fellow and Executive Member of the Institution of Engineers Australia, a Fellow of the Royal Aeronautical Society, and a Fellow the Royal Institute of Navigation. Throughout his career, he led numerous industry and government-funded research programs on aerospace, defence and intelligent transport/mobility systems, and he has authored or co-authored over 300 publications. He is the recipient of prestigious international and national awards including the NATO-RTO Scientific Achievement Award (2008), the SAE Arch T. Colwell Merit Award (2015), the SARES Science Award (2016), the Northrop Grumman Professorial Scholarship (2017), and the Australian Defence Industry Scientist of the Year Award (2019). In addition to his primary duties at RMIT University and various adjunct/visiting appointments in the US, Europe, Asia and South Africa, Professor Sabatini is a Distinguished Lecturer of the IEEE Aerospace and Electronic Systems Society (AESS), Vice-Chair of the AESS Avionics Systems Panel (ASP), member of the NASA Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Collaborative Testing Initiative, and Australian National Representative at the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP), Impact and Science Group (ISG). Currently, he also serves as Editorial Board member for Progress in Aerospace Sciences, Technical Editor for the IEEE Transactions on Aerospace and Electronic Systems, Associate Editor for Aerospace Science and Technology, and Associate Editor for the Journal of Navigation.

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