

# The Systems Challenge of Quantum Technologies

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Since the beginning of the 21<sup>st</sup> century, physicists have made remarkable advances in the development of quantum technologies: these are technologies with functionality that relies on manipulation of the quantum state such that quantum superposition and entanglement are phenomena upon which devices and systems depend. Although quantum computing remains a long-term ambition, for other applications, such as navigation, sensing, timing, imaging, and communications are much nearer term. The transition from laboratory to real world applications is a challenge for engineers and there are many aspects that pose new problems for systems, and systems of systems engineering, particularly in the areas of modelling, verification, and architecting. This keynote will begin by describing the new physical effects that must be accommodated and briefly review the types of application being considered and the viability of quantum technologies for those applications. The main focus will be the challenges that these pose to the systems of systems engineering communities and the systems research that this inspires.

## Professor Michael Henshaw, Loughborough University, UK

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Professor Michael Henshaw, BSc (Hons), MBA, PhD, MRAeS, MIEEE, MINCOSE, MIEHF leads the Engineering Systems of Systems research group. He joined the University from industry in 2006 as Director of a major research initiative in complex systems. He graduated with 1<sup>st</sup> class honours in Applied Physics and his PhD research concerned modelling laser fusion for energy generation. Prof. Henshaw worked for 17 years for British Aerospace in Aeronautical Engineering and the development of Systems Engineering research. His current work concerns the integration of complex networked systems with contributions in Systems of Systems (SoS), Cyber-Physical Systems (CPS), and quantum systems engineering research. He has led two research agenda setting programmes for the European Union (T-AREA-SoS and TAMS4CPS) and contributed to a third (ROAD2CPS); all concerned with the challenges in complex systems. His work on Open Architectures to address commercial, technical, and operational agility has been influential in UK industry and Government. He is a co-chair of the IEEE SMC Society Technical Committee on Systems of Systems. He is an associate editor for the Aeronautical Journal, Problemy Mechatroniki (Polish), and the Systems Engineering Body of Knowledge (sponsored by INCOSE and IEEE) in which he has co-responsibility for the knowledge area of Systems of Systems Engineering.

At Loughborough University he is academic lead for the university-wide Secure & Resilient Societies Grand Challenge and Director of the Systems Engineering MSc. and Level 7 Apprenticeship programmes.