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FROM COMPLEX TO COMPLICATED: DEVELOPMENT OF A MODEL BASED SYSTEMS ENGINEERING AND CYBER SECURITY APPROACH FOR A QUANTUM KEY DISTRIBUTION NANOSATELLITE.

Abstract

Current global security systems are built on the premise that mathematical complexity and limitations of processing power are sufficient to protect data. With the emergence of quantum computing these assumptions are now being challenged. Space based Quantum Key Distribution (QKD) is a method of encryption key delivery offering significant benefits over ground-based counterparts in terms of range and coverage. Additionally, the emergence of Artificial Intelligence (AI) offers increases in efficiency through cloud avoidance. For an AI enabled nanosatellite for QKD, design engineers must trade the often-conflicting requirements of space, cybersecurity, AI and quantum to progress the design from the complex to the merely complicated.

The Responsive Operations for Key Services (ROKS) mission aims to provide QKD services which augment larger scale QKD efforts. The onboarding of AI to detect and avoid cloud has a significant impact on the concept of operations, moving to significant levels of autonomy. In systems engineering terms, added to the design burden of implementing an emerging technology such as QKD, the established principles of operation are also being challenged. Additionally, as nanosatellites have rarely been deployed as nodes in a secure network to date, the project requires the synthesising of different security standards and approaches into a coherent framework.

For the programme significant consideration is given to project lifecycle. In the initial phases agile principles are employed, allowing for experimentation in design. With increasing knowledge of the problem space, there is a reduction in the uncertainty in design elements, leading to a transition from an agile based lifecycle to the waterfall-based methods more suitable for Flight Model implementation.

Underpinning the project is a Model Based Systems Engineering approach. Enterprise Architect was selected as the MBSE tool of choice during blue sky design stages, allowing a smooth transition from capability level considerations to systems and subsystems design. The Zachman framework offers a consistent, but potentially over flexible, approach to model development. MBSE offers a clear methodology for integrating the model with external simulation tools to provide on ground verification of platform behaviours and porting design effort to support new mission concepts.

The application of flexibility in lifecycle management, sound security principles and a model-based approach to technical development has proven to be a highly effective approach in increasing our understanding of complex systems allowing for complicated, but mature, designs to be defined.