



## OFFICE OF THE DEPUTY ASSISTANT SECRETARY OF DEFENSE SYSTEMS ENGINEERING

### System of Systems Engineering Collaborators Information Exchange (SoSECIE)

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#### Traceable Engineering of Fault-Tolerant System of Systems

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#### **Abstract**

Systems of systems (SoSs) are characterised by a challenging combination of continuous evolution, emergent behaviour and distributed, autonomous and independent constituents. The development of SoSs that can tolerate faults and harmful events is hampered by these and other complexities. Currently there is little in the way of methods or tools to help SoS developers to design fault-tolerant SoSs. We present a structured approach for capturing requirements for a fault-tolerant SoS and a fault modelling architectural framework (FMAF) that supports disciplined and reusable development of fault-tolerant architectures. We also provide a traceable mapping of the fault-tolerant requirements into SoS architectural designs. Finally we apply our techniques to a real-world SoS case study.

#### **Biography**

Dr. Zoe Andrews is a Research Associate at Newcastle University with interests in dependability, architectural modelling, formal methods, probability, systems of systems and cyber-physical systems. She currently works on: modelling and analysis of dependability attributes, primarily at the architectural level (UK EPSRC TrAmS-2 project); and producing roadmaps and strategic agendas for the development of dependable cyber-physical systems (EU H2020 Road2CPS and TAMS4CPS projects). Prior to this Zoe worked on the COMPASS project, where she developed extensions to SysML in order to support modelling and analysis of faults in systems of systems. Zoe was awarded her PhD on “Continuous Probability Distributions in Model-Based Specification Languages” in 2012, investigating ways in which stochastic reasoning could be combined with logical reasoning for the specification and analysis of fault-tolerant systems. Zoe also contributed to the ReSIST network of excellence and worked on developing metadata-based descriptions of resilience mechanisms and providing formal support for decision-making over such mechanisms.

Prof. Jon Holt is an internationally-recognised expert in the field of Model-based Systems Engineering (MBSE). He is an international award-winning author and public speaker and has authored nine books on MBSE and its applications, including UML and SysML for systems engineering, process modelling, enterprise architectures, model-based requirements and competency assessment. Jon was the founder-director of Brass Bullet Ltd, a systems engineering consultancy and training company for over 12 years, until it was acquired in 2009 by Atego where he was the Global Head of Systems Engineering. He is currently a Director and consultant for Scarecrow Consultants, who are ‘outstanding in the field of MBSE. Jon is also a Professor of Systems Engineering at the UK Defence Academy, where he is involved with teaching of and research into MBSE. He is a Fellow of both the IET and the BCS and is a Chartered Engineer and Chartered IT Professional. He is



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currently the Technical Director of INCOSE UK where he is responsible for all technical activities. Jon is also actively involved in the promotion of Science technology Engineering and Mathematics (STEM) where he uses magic, mind-reading and occasional escapology to promote Systems Engineering at Science Festivals, the IET Pythagorean Cabaret, radio shows and other STEM events.

Dr. Claire Ingram earned her PhD at Newcastle University in 2011 with a thesis that involved developing new metrics to investigate whether early project data can be used to predict later change-proneness. She has worked on DESTTECS, a project funded by the European Union which produced new tools and techniques to support collaborative, cross-disciplinary development of fault-tolerant embedded systems. She spent several years working on COMPASS, an international EU-funded project which examined the use of model-based techniques for developing and maintaining SoSs, where she contributed towards SoS modeling techniques and roadmapping for future research efforts in modeling and simulation for SoSs. Currently she works on projects in SoS and in cyber-physical systems (CPS), including the EU cascade funding project CPSE Labs that provides support for CPS innovators around Europe. Her research interests span empirical software engineering, software metrics, architectural modeling and systems of systems engineering as well as cross-disciplinary development methods.

Dr. Richard Payne obtained his PhD in 2012 at Newcastle University, with a thesis examining formal verification of policies defined using a reconfiguration policy language (RPL) for the governance of resilient component-based systems. Richard worked on the UK Ministry of Defence funded SSEI project, investigating the use of contract-based interface specification in system of systems architectural models. He worked on the EU-funded COMPASS project, specifically studying architectural modelling, fault modelling and tool development for SoSs. Richard is currently working on several SoS and cyber-physical system projects, including the EU H2020 INTO-CPS project which is aiming to produce a model-based tool chain for CPS design and development. His research interests include system architectural modelling, architectural reconfiguration, the pragmatic application of formal modelling, and systems of systems engineering.

Mr. Simon Perry holds Bachelor degrees from the University of Leeds and the Open University and has spent over 25 years working in software and systems engineering. He is the co-author of five books on systems engineering and related topics. Simon is a founding Director and Consultant for Scarecrow Consultants, providing consultancy and training and conducting research in the application of systems engineering, including UML and SysML for systems engineering, process modelling, enterprise architectures, model-based requirements and competency assessment. He works in industry, government and academia and has applied his work across many disciplines and in a wide range of industries. He is a Member of the IET and INCOSE.

Prof. Alexander Romanovsky is a Professor at Newcastle University where he leads the Secure and Resilient Systems Group (School of Computing Science). His main areas of research are dependability engineering, system modelling/verification and fault tolerance. He has been involved in various UK, EU and industrial projects on these topics. He led the EU project on the development of a Rigorous Open Development Environment for Complex Systems (RODIN) and was the coordinator of the Industrial Deployment of System Engineering Methods Providing High Dependability and Productivity (DEPLOY) integrated project. He is a member of UKCRC.