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Lifecycle Verification of a System of Systems

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Abstract
System-level verification is intended to check that the system satisfies a set of requirements. The verification of a system of systems (SoS) is more difficult for a number of reasons. In a SoS, multiple organizations are involved, and there may be no overall project manager. It may be necessary to develop new systems that integrate with legacy systems that cannot be modified. Finally, the separate systems within a SoS can have separate development processes and schedules. New methods of system engineering (SE) processes are needed to deal with the verification of SoS. This presentation reviews how V-Models have been used to visualize the SE process for SoS. For the common situation of a SoS consisting of only two systems, an intersecting V-Model is suggested, followed by a discussion of important factors to consider when verifying a SoS, including configuration management, integrated master schedule development, lifecycle simulation, and test system design. These considerations are illuminated by describing the verification of a SoS consisting of an asset health monitoring system and data download software. The tradeoffs of using hardware versus software approaches to lifecycle simulation are presented. The presentation concludes with an overview of lessons learned for future SoS development.

Biographies
Brian Hatchell is a Senior Systems Engineer within the Health Monitoring and Radio Frequency Sensing Team of PNNL. Brian joined PNNL in 1991 and has been involved in a number of complementary areas involving optical-mechanical design, structural analysis, electrical/mechanical systems engineering, and robotics. In recent years he has been involved with several projects under the National Security Directorate involving the development of remote health monitor electronics for military assets. During the execution of these projects, he developed automated verification methods to accelerate environmental, shock, and vibration testing of asset health monitors. He has worked with graduate students to test vibration energy harvesting technologies for deployment on candidate transportation platforms, including the Apache Helicopter. Brian Hatchell holds a master of science degree in mechanical engineering from the Georgia Institute of Technology, is an INCOSE Certified Systems Engineering Professional, and has published several technical papers regarding the development of health monitors.

Fred Mauss is a Research and Development Engineer within the Health Monitoring and Radio Frequency Sensing Team of PNNL. He has experience in electronic system design and testing for long-life low-power sensor systems. He has a strong background in system testing and technical documentation. He also has experience in managing final system hardware and documentation deliverables. Recently he has been involved in the development of asset health monitors for missile containers. He performed extensive vibration and drop testing for algorithm development and verification. After leading the qualification program, he successfully transferred the designs to the private sector. Fred received a bachelor of science degree in electrical engineering from Washington State University.

Kurt Silvers is a Project Manager in the National Security Directorate, Electronics and Measurement Systems Group (EMSG) at PNNL. He has over 25 years of experience in project management, planning and execution of complex analytical, process and electronic systems projects. He is a certified Project Management Professional (PMP) and holds bachelor's degrees in chemistry and biology. He is an experienced system engineer and has developed a unique approach of implementing processes and procedures for electronics systems developed at PNNL. For the past 12 years he has lead an Asset Health Monitoring and Radio Frequency System development team producing and fielding multiple products for the U.S. Army and other government agencies. He has extensive experience in the design, development, qualification and deployment of new technologies involving integrated sensor systems supporting monitoring and reporting location and readiness status of high value assets using wired and wireless technologies. Mr. Silvers is responsible for managing the technology road map for EMSG, including development, maturation, and deployment of emerging and innovative technology solutions. Mr. Silvers' management portfolio for the past 5 years exceeds $30M in technology development.