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## System of Systems – From Definition to Architecture to Simulation to Space Applications

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### *Abstract*

One of the main challenges of any related paradigms in systems engineering is being able to handle complex systems under unforeseen uncertainties. A system may be called complex if its dimension (order) is too high and its model (if available) is nonlinear, interconnected, and information on the system is so uncertain that classical techniques cannot easily handle the problem. A system of systems (SoS) is a “super system,” or an integration of complex systems coordinated together in such a way as to achieve a wider set of goals with possible higher significance such as global warming, Mars missions, air traffic control, global earth observation system, etc. Computational Intelligence or Soft Computing, a consortium of fuzzy logic (approximate reasoning), neuro-computing (learning), genetic algorithms and genetic programming (optimization), has proven to be a powerful set of tools for adding autonomy and semi-autonomy to many complex systems. For such systems the size of soft computing control architecture will be nearly infinite. In this presentation, paradigms using soft computing approaches are utilized to design autonomous controller with controller reuse for a number of space applications. The notion of adaptation in autonomous controller reuse can be handled via intelligent tools to add on additional capabilities in real-time scenarios. Learning from past experience is but one such scenario for the reuse of autonomous controllers. These applications include satellite array formations, robotic agents and the Virtual Laboratory (V-LAB®) for multi-physics modeling and simulation. A view of the future activities of the NASA JPL for space exploration will also be given. SoS concepts will be described and a few testbed cases will be introduced, including a robotic swarm with dynamic sensor networks for homeland security at UTSA ACE Center. Some animated and experimental implementation movies will be shown.

**Biography:** Mo M. Jamshidi (Fellow IEEE, Fellow ASME, Fellow AAAS, Fellow TWAS, Fellow NYAS, Fellow HAE) received the Ph.D. degree in electrical engineering from the University of Illinois at Urbana-Champaign in February 1971. He holds three honorary doctorate degrees from Azerbaijan National University, Baku, Azerbaijan, 1999, University of Waterloo, Canada, 2004 and Technical University of Crete, Greece, 2004. Currently, he is the Lutcher Brown Endowed Chaired Professor at the University of Texas, San Antonio, TX, USA. He has also been the founding Director of Center for Autonomous Control Engineering (ACE) at the University of New Mexico, and has moved the Center to University of Texas, San Antonio in 2006. He is also the Regents Professor Emeritus of Electrical and Computer Engineering, and the AT&T Professor Emeritus of Manufacturing Engineering at UNM. He was a Senior Research Advisor at US Air Force Research Laboratory, KAFB, NM from 2002-2005. He

was also a consultant with US Department of Energy Office of Industrial Technologies on robotic automation effects on energy efficiency in 10 industries of the future from 2001-2004. He was also been an advisor for the NASA Headquarters Minority and Women-owned Business Utilization from 1998-2004. He was on the advisory board of the NASA JPL's Pathfinder Project mission, which landed on Mars on July 4, 1997 and a member of the NASA JPL Surface Systems Track Review Board. He was on the USA National Academy of Sciences NRC's Integrated Manufacturing and Ford Foundation Review Boards. Previously he spent 6 years at US Air Force Phillips (formerly Weapons) Laboratory working on large-scale systems, control of optical systems and adaptive optics. He has been a consultant with Department of Energy's Los Alamos National Laboratory and Oak Ridge National Laboratory. He has worked in various academic and industrial positions at various national and international locations including with IBM and GM Corporations. In 1999, he was a NATO Distinguished Professor in Portugal conducting lectures on intelligent systems and control. He has over 550 technical publications including 54 books and edited volumes. Six of his books have been translated into at least one foreign language. He is the Founding Editor or co-founding editor or Editor-in-Chief of 5 journals (including Elsevier's International Journal of Computers and Electrical Engineering Elsevier, UK, Intelligent Automation and Soft Computing, TSI Press, USA) and one magazine (IEEE Control Systems Magazine). He is editor-in-chief of the new IEEE Systems Journal (to be inaugurated in 2007) and co-editor-in-Chief of the International Journal on Control and Automation. He has been or still is on the executive editorial boards of a number of journals and two encyclopedias. He was the series editor for ASME Press Series on Robotics and Manufacturing from 1988 to 1996 and Prentice Hall Series on Environmental and Intelligent Manufacturing Systems from 1991 to 1998. In 1986 he helped launch a specialized Symposium on robotics which was expanded to International Symposium on Robotics and Manufacturing (ISRAM) in 1988, and since 1994 it was expanded into World Automation Congress (WAC) where it now encompasses five main symposia and forum on Robotics, Manufacturing, Automation, Control, Soft Computing, Multimedia and Image Processing. He has been the General Chairman of WAC from its inception. Dr. Jamshidi is a Fellow of the IEEE for contributions to "Large-scale systems theory and applications and engineering education", a Fellow of the ASME for contributions to "Control of robotic and manufacturing systems," Fellow of the AAAS - the American Association for the Advancement of Science for contributions to "Complex large-scale systems and their applications to controls and optimization," a Fellow of Third World Academy of Sciences (Trieste, Italy), Member of Russian Academy of Nonlinear Sciences, Associate Fellow, Hungarian Academy of Engineering, a member of the New York Academy of Sciences and recipient of the IEEE Centennial Medal and IEEE Control Systems Society Distinguished Member Award and the IEEE CSS Millennium Award. He is currently on the Board of Governors of the IEEE Society on Systems, Man and Cybernetics. He is an Honorary Professor at three Chinese and one Australian Universities. In October 23005 he was awarded the IEEE SMC Society's Norbert Weiner Research Achievement Award. He is on the Board of Nobel Laureate Glenn T. Seaborg Hall of Science for Native American Navajo Nation. He is listed in a number of biographical (Who's Who) volumes.