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POSITION PAPER
**AVIATION SOFTWARE SYSTEMS FOR THE SECOND CENTURY OF FLIGHT:
DESIGN FOR CERTIFIABLY DEPENDABLE SYSTEMS**

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In this position paper, I will briefly outline some of the areas that I believe are important, and address the three questions requested in the call for papers. Obviously there are many other issues that need to be addressed as well.

What are the three most important challenges?

In order to ensure dependable aviation software systems, we need to address issues such as:

1. Software Engineering education
2. Verification and Validation (V&V) (especially for autonomous systems)
3. Software maintainability.

At the present time, the discipline of Software Engineering is not well defined and too few Software Engineers are familiar with aerospace systems. The IEEE has a Certified Software Development Professional (CSDP) certification program, but often the people that are certified are not engineers or scientists. On the other hand, few Aerospace Engineering educational programs include software engineering in their curricula. It can be argued that software engineering, systems engineering, and embedded computers are just as important (if not more so) than the traditional four areas (structures, aerodynamics, propulsion, and control) of aerospace engineering. While it is crucial to have electrical engineers, software engineers, computer engineers, and computer scientists involved in aerospace systems, we also need aerospace engineers who have an understanding of the entire system and rigorously-trained software engineers.

Verification and Validation (V&V) is always difficult for large complex networked systems, but many future aerospace systems will also be autonomous. This adds additional complications to developing reliable and maintainable software. V&V for these systems will be extremely difficult. There will also be semi-autonomous systems (which exist today), these will need careful human-computer interaction research. Also, many aerospace systems have extremely long lifetimes, which means that software maintainability is a crucial factor in developing successful systems. The life cycle models, requirements engineering, design, programming, V&V, and testing must be extremely well defined and rigorous.

What are the three most important information technology research needs?

Three of the most important research needs are:

1. Software engineering methods and tools for developing intelligent systems
2. Computer languages
3. Software for Network Centric systems

In order to develop autonomous unmanned air vehicles, it is essential to have more research in how to develop, test, and maintain software for intelligent systems. These systems may incorporate time-dependent neural networks, Bayesian networks, cognitive architectures, etc., which often lack the level of determinism that is desired in safety- and mission-critical software. The situation with computer languages could be better also. The current computer languages being used (C, C++, Java, Ada, etc.) all have their pros and cons. Some are better than others for safety-critical systems, some are better in real-time systems, and some have better performance than others. We also need to acknowledge that all future aerospace systems will be networked systems of systems, with all the additional complexities that that implies.

What is a possible roadmap for the next 5 to 10 years?

We need more visibility, more educational programs, and more federal funding for aviation software systems. We also need more educational programs to train the next generation of software engineers, and this should include the involvement of industry and government labs.

Short Biography of Lyle N. Long

Dr. Lyle Long is a Professor of Aerospace Engineering at The Pennsylvania State University (he also has a courtesy appointment in Computer Science and Engineering). He is also Director of the Institute for Computational Science (www.ics.psu.edu) and Administers the Graduate Minor Program in Computational Science. He was the founding Editor-in-Chief of the Journal of Aerospace Computing, Information, and Communication (published by AIAA: www.aiaa.org/jacic). Prof. Long has been at Penn State since 1989. He was a Senior Research Scientist at Lockheed Aircraft (Burbank, California) from 1983 to 1989. He has also been a visiting scientist at Thinking Machines Corporation and NASA Langley Research Center. He received a Doctor of Science degree from George Washington University's Joint Institute for the Advancement of Flight Sciences in 1983. He has a Master of Science degree in Aeronautics and Astronautics from Stanford University, and a Bachelor of Mechanical Engineering with Distinction from the University of Minnesota. His research interests are in software engineering, high performance computing, computational science, intelligent systems, and unmanned air vehicles. He will be teaching a new *required* course in Software Engineering in 2007, in the Department of Aerospace Engineering at Penn State. Dr. Long is an IEEE Certified Software Development Professional (www.computer.org/certification). He received the Penn State Engineering Society *Outstanding Research Award* for 1996. He received the 1993 IEEE Computer Society *Gordon Bell Prize* for achieving highest performance on a parallel computer. And he received the Lockheed Aeronautical Systems Company award for *excellence in research and development*, in 1987. He is a Fellow of the AIAA, and currently serves on the AIAA Computer Systems Technical Committee (TC) (which meets jointly with the Software Systems TC), the AIAA Intelligent Systems TC, and the IEEE Intelligent Systems Applications TC. He was also one of the Technical Co-Chairs of the 2005 AIAA InfoTech@Aerospace Conference. Prof. Long has written more than 130 technical papers.