Challenges in Software Aspects of Aerospace Systems

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The NASA and the Federal Aviation Administration (FAA) visions for modernizing the National Airspace System (NAS) can not be achieved without massive amounts of software. As David Hughes wrote in a commentary in *Aviation Week & Space Technology* "Information technology is becoming a key part of everything the aerospace and defense industry does for a living, and as the century closes it is computers and software that hold the keys to the future. The industry is being transformed from dependence on traditional manufacturing into something that looks more like IBM and Microsoft with wings." Software-based capabilities such as communications, navigation, and surveillance for air traffic management (CNS/ATM) are envisioned to be the backbone of the new airspace system. Developing complex software-based systems and verifying that these systems meet safety requirements and assurance standards will be essential. Recent history shows, however, that accomplishing this task will be quite hard.

Examples abound of large, complex aerospace systems that have failed or overrun planned costs and schedules. Recent examples from civil aviation include the multi-million dollar budget overruns and multi-year delays in fielding the Wide Area Augmentation System (WAAS), the Standard Terminal Automation Replacement System (STARS), and the Airport Movement Area Safety System (AMASS) program. NASA examples include substantial budget overruns on the International Space Station and failures in the Mars Climate Observer and Mars Polar Lander programs. In each of these cases, software problems contributed significantly to the failures and overruns. Acknowledging and addressing the causes of these software problems are critical to the success of modernization initiatives in the aerospace industry.

For many years, NASA has conducted and sponsored research in cooperation with the FAA to develop and improve software engineering methods for aerospace applications, concentrating on issues relevant to software aspects of the FAA's certification process. The purpose of this paper is to examine the results of one of those projects to provide insight into pressing problems in the aerospace industry in developing complex, software-based systems.

This paper will focus on results of the Streamlining Software Aspects of Certification (SSAC) program. Motivated by the cost and schedule overruns on major CNS/ATM programs, the FAA sponsored the SSAC program to gather and analyze data about cost and schedule drivers for software aspects of certification, and to recommend to the FAA ways to improve mandated software processes without sacrificing safety. As part of the SSAC program, four workshops were held with the aviation software industry and certification authorities to identify major issues affecting cost, schedules, and software approval. Based on those workshops, an extensive survey was conducted. The survey population included people with different levels of experience with FAA standards (namely, RTCA/DO-178B *Software Considerations in Airborne Systems and Equipment Certification*), experience with a variety of airborne and ground-based systems products, and experience with aviation projects of various size and criticality. The survey itself contained over two hundred questions about the FAA's software approval process and policy,

technical aspects of software development (including questions about verification, quality assurance, and tool qualification), and safety.

The SSAC survey results point to a number of technical challenges in software engineering, and challenges related to assuring software systems. Most notable among these challenges are difficulties with the definition and flow of requirements at all levels (system, high, low, and derived requirements) independent of certification, and the difficulties with keeping pace, from a certification perspective, with new technology. The paper will discuss how the survey results relate to the difficulties plaguing several of the current aviation modernization efforts, and provide suggestions for directions for future software engineering research.

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