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COMMAND AND CONTROL OF SMALL SATELLITES USING TABLET COMPUTERS: INCREASING COLLABORATION AND INNOVATION IN SPACE OPERATIONS

Abstract

Small satellites have enabled new classes of innovative space applications and business models. A common product line approach to small satellites supports multiple mission areas, ranging from communications to earth science and technology demonstrations based on a shared hardware and software architecture that can be configured for different missions. Cost-effective mission operation of a small satellite product line must also take advantage of the benefits of tailoring for new mission configurations to minimize changes and new software development required for novel mission configurations and applications.

In this paper we describe a tablet computer implementation of a mission command and control capability for small satellites. The satellite control system is architected for ease of maintenance and modification, is evolvable to support multiple missions, and is designed for increased useability in an operational setting. To illustrate these features, we focus on fault and failover management of on-board avionics systems. This stressing case highlights the ability of the system to maintain system availability and performance even in the presence of anomalies. In particular, we detail a redundant satellite avionics system that uses a primary and backup Configurable Avionics Unit (CAU) for mission-critical processing. We describe the role of the primary CAU, which continuously monitors for failover fault conditions in software and reboots the primary CAU if a failover fault occurs. The backup CAU monitors the heartbeat of the primary CAU, and if both hardware and software detect loss of heartbeat, the backup CAU initiates transfer of control from the primary. The primary and backup CAU are configurable by either ground command or autonomous failover on-board the satellite (which subsequently requires a ground reset). This tiered failover concept implemented in software provides increased visibility into the state of health of on-board processes and gracefully manages mission degradation for a variety of failure modes.

In addition to the robust mission operations architecture, we describe the benefits of a tablet-based implementation. Tablet computers enable satellite operators to move from their workstations to collaborate, share data, and reason about anomalies in a more natural manner. We show the satellite subsystem abstractions and graphical interface that enable access to the right level of system detail in a way that speeds decisions and improves the operator's ability to discover, access, and use data about on-board faults and failures. This approach reduces operator workload and improves mission availability and anomaly resolution for processor failovers and software faults.