Meetings International SciTechnol

J Phys Res Appl 2018, Volume: 2

International Conference on
APPLIED PHYSICS AND MATHEMATICS

World Congress on
MATERIALS RESEARCH AND TECHNOLOGY

October 22-23, 2018
Tokyo, Japan

Battle-damage tolerant automatic controls

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In the 1950s and 1960s, the North American X-15 rocket powered aircraft was pioneering the concepts and principles that would come to define modern powered flight. Among the ground-breaking ideas proposed was a system of adaptive controls, or a controller that would take into consideration the changing operational environment to deliver appropriate control to the operator. Limitations of current technology abounded, leaving the X-15 with a successful, but severely limited adaptive control system. Since then, many limitations have fallen away, allowing for the first-time employment of adaptive controls on a large scale. The nature of adaptive controls, or controls for unpredictable systems, lends itself naturally to the concept of damage tolerant controls in high performing systems, such as aircraft and spacecraft. Recent technical demonstrations of damage tolerant aircraft prove the concept of adaptive controls in an operational environment. Research covered by this paper expands on the topic by discussing the application of adaptive controls to spacecraft and theory behind simulating damage tolerant control implementation. Simulation is then used to demonstrate the stability of adaptive controls when experiencing sudden mass loss and rapid changes in inertia. The development of adaptive controls and the enabling technology for them has reached a point where new and innovative uses are now becoming possible. The purpose of this research was to determine the plausibility of damage-tolerant control in satellites. By introducing a modified adaptive Proportional Integral Derivative (PID) controller with adaptive feed forward control to this simulated spacecraft, it is demonstrated that the controls have achieved significant damage tolerance. This comes at a time where the need for such tools has never been greater, and the dangers associated with space operations grow daily.

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