Minimizing operations and Spacecraft Development Costs in a Spat.ccraft Autonomy Paradigm.

Topic: **Operations** Automation
Alternative '1'epic: Cost Efficient Operations
Second alternative: Ground Segment Engineering and Architectures
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Abstract

An Outer Plane.t Orbital 1 exploration Systems study is king conducted at JPL, intended to develop mission concepts for highly efficient, cost constrained science missions. These studies arc , by design, unconstrained by current technology states and arc aggressive in performance goals. All mission aspects arc being addressed to lower total lifecycle cost. Operability and autonomy arc included in the study. This paper anal yzes the relationship between spacecraft complexity, operability and autonomy to meet this stud y's goal.

For a given level of autonomy, operations cost is a function of spacecraft complexity, science complexity and number of years in operation. Of these factors, spacecraft complexity tends to dominate and govern the science that is possible and the cost of the overal 1 mission. The spacecraft complexit y is driven by the avail abilit y or non-availability of margins and by physical limitations of the hardware. A given spacecraft constraint can bc dealt with at four different levels: at the hardware, flight software, ground software , and/or operations levels. At each IcvcI, the spacecraft constraint can bc encapsulated and simplified such that for the downstream "user'>, the complexity and cost is 1owcycc I. This paper will show that using flight rules to perform these kinds of trades across hard ware, Soft ware and operations boundaries will minimi zc the overall spacecraft complexit y and mission cost.

As autonomy increases the cost for hardware, software and operations development and maintenance will change. Some projections poi nt to reduced whi le other indications arc of i ncreased overall cost with i ncreased autonomy. For a very complex spacecraft, the autonom y i mplementation may not bc achievable. '1 'he challenge of this paper is to identify some necessary changes or paradigm shifts to ensure an overall downward trend of complexity and cost to enable increased autonomy.