24th AIAA International Communications Satellite Systems Conference (ICSSC) and 4t
11 - 14 June 2006, San Diego, California

AIAA 2006-5328

COST-BENEFIT ANALYSIS OF A NOTIONAL FRACTIONATED SATCOM ARCHITECTURE*

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INTRODUCTION

The basic functions of a typical satellite, distilled to their quintessence, include only the absorption, processing, and subsequent re-radiation of photons. To this end, spacecraft components need only be able to exchange energy – which tends to be dichotomized into power and information – and transmit the occasional force or torque. Perfectly adequate and efficient mechanisms for accomplishing both of these tasks without resorting to a connecting solid structure exist.[i] Perhaps the most philosophically satisfying consequent view of a spacecraft is as a cloud of microstructural components – "pixie dust" – which may or may not be molecularly bonded to each other, contingent only on consideration of some appropriate overall system measure of merit. It is the aim of this analysis to construct such a measure of merit, and to assess its implication for the optimality of various architectures.

Philosophical appeal notwithstanding, we must, by necessity, commence our inquiry by considering the status quo. Thus, consider a monolithic satellite designed to deliver some service to the user. We define the number of similar and dissimilar modules in which this spacecraft is fractionated as the homogeneous and heterogeneous degree of fractionation, respectively. A monolithic spacecraft has a homogeneous and heterogeneous degree of fractionation of unity. We define the measure of merit for a particular architecture in dollar terms as the value (benefit) delivered to the user minus the total cost expenditure over the entire life cycle of the system. The vast majority of the intellectual energy underlying this analysis is expended on exhaustively quantifying all sources of value delivered by the system that are likely to scale with fractionation.[ii]

Four such value sources are identified. They include the intrinsic value of the service or capability offered by the space system (e.g., value of a unit of bandwidth, value of a unit of area of coverage, or value of a certain number of pixels of resolution on a target); the value to the user derived from incremental deployment and graceful deterioration of capability due to on-orbit failures or hostile actions; the value to the user derived from the flexibility to increase service levels in response to increased demand throughout the

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