Laser Communication Requirements Drive Cost-Effective Solutions

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The use of laser communications for interconnecting space-based assets has been investigated for some three decades. A wide variety of applications have been proposed that use low earth orbit (LEO) and geostationary earth orbit (GEO) satellites, and the many applications often stress different aspects of the design. Some applications are extremely limited in swept volume and real estate available for mounting thermal radiators, others demand low power consumption consistent with acceptable solar array area, and most applications desire lightweight hardware to reduce launch cost. Achieving these goals is normally traded off against the system performance, development and operational risks, and overall program cost. For example, laser power and aperture are often traded in the design, since they have a direct impact on laser terminal performance, swept volume, radiator size, mass, prime power, and subsystem cost, but they also influence such items as handling, integration and test.

This paper uses design examples to show how the system requirements in three types of space-to-space applications influence optimum laser communications hardware solutions. The applications discussed are short-range LEO-to-LEO links, medium-range LEO-to-LEO links, and longer range LEO-to-GEO and GEO-to-GEO links. Representative design trades are briefly described that achieve a balance between the many program goals defined above for each application. Examples designs are then described that meet the three classes of system requirements, differing in their transceiver approach, laser power, telescope aperture, and coarse pointing gimbal configuration.

Besides differences realized in optimizing the design for the various classes of requirements, there are many components common to each system. Modular design concepts allow an efficient and cost-effective integration of the application-specific and common hardware elements. This also reduces the overall program risk, so that production of flight hardware requires the completion of general engineering tasks needed to produce any electro-optic instrument.