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Spacecraft in the 21st Century: Taking Today's Design Drivers out of the Space Equation

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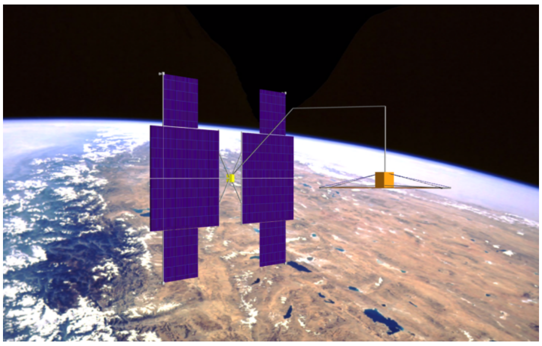
A Look into the Future

Space system design will see remarkable changes over the next several decades. These changes are driven by an abundance of revolutionary new technologies creating a dramatic shift in the way the world conceives of spacecraft. The traditional model of one spacecraft bus, launched on an expendable vehicle and supporting one or more payloads, will be superseded by a variety of new architectures including distributed systems, collaborating constellations, deployable spacecraft, inflatable spacecraft, and reusable launch vehicles. Spacecraft will see the most dramatic changes in design ever with a shift to both very small, highly capable micro/nanoSats and a trend toward huge monsterSats for large aperture applications. A class of highly maneuverable spacecraft will be developed as we start to routinely perform operations in space and remarkable breakthroughs in power technology will enable us to develop increasingly more powerful space vehicles. Structures will play a key, if not the key, role in making these new space architectures a reality.

Today, three concerns still dominate the space industry and drive all spacecraft design: aperture size, available power, and launch cost. Revolutionary spacecraft component technologies under development are the key to overcoming these design drivers.

Taking Power out of the Space Equation

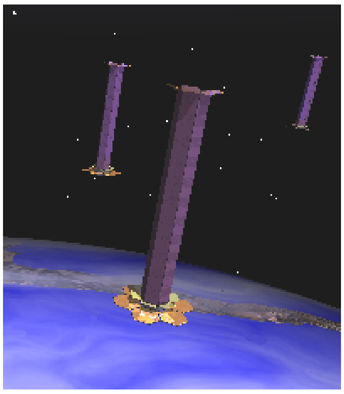
Modern spacecraft are power starved. For example, a standard GPS spacecraft uses about the same power as a household hairdryer. For many applications, spacecraft capability is directly related to available power. A host of new technologies, such as thin film photovoltaics and thermal to electric conversion, provide a window of opportunity for structures engineers to redesign the traditional solar cell 'wing' typical to most spacecraft.



Probably the most exciting concept is the PowerSail system. Marrying lightweight deployable structures technology with thin film photovoltaics, electric propulsion, and power beaming, this concept comprises a large photovoltaic "sail" free-flying from the spacecraft. Early incarnations will require the sail to be connected to a host spacecraft using a super conducting power tether. Efficient power beaming technology, when developed, will allow for power generation to be completely decoupled from the spacecraft architecture. Large power "stations" in orbit could provide power to multiple spacecraft much as the electric grid does down on earth, providing unheard of levels of power to future spacecraft.

Important Structures Technologies
Critical structures technology for these concepts are very lightweight structures that can be reliably deployed. Inflatable structures, elastic memory composites, and tension-compression structures will play key roles.

Taking Aperture out of the Space Equation



For many spacecraft, size does matter. Many of the most important space missions involve some type of sensing, either of the earth or of deep space. Whatever segment of the electromagnetic spectrum being collected (radar, optical, etc), the greater the aperture of the collecting surface, the better. Traditional platforms used large, precision structures to achieve this aperture size. For large radar platforms, advances in light, stiff, deployable structures will have the greatest impact. For optics, precision is the name of the game. The future will see the first application of deployable optics, which will revolutionize deep space exploration through a whole series of new space telescopes.

As long as a sensing platform comprises only one spacecraft, aperture size will be a concern for spacecraft designers. The advent of highly capable microsats (spacecraft under 100kg) is driving a paradigm shift in spacecraft design that will forever erase the aperture constraint limiting today's systems. Collaborating constellations of these highly capable microsats, working together, provide for an essentially unlimited and reconfigurable aperture size.

Important Structures Technologies
Critical structures technologies for these concepts include multifunctional structures (the embedding of capability such as electronics and processing into spacecraft structure), an enabling technology for highly capable microsats, and precision optical structures, deployable to optical tolerances (10nm).

Taking Launch out of the Space Equation

Launch cost is the one restriction on spacecraft that shows little promise of being removed in the near future. Still, some progress is inevitable. Expendable launchers will become increasingly cheaper, particularly due to increased global competition and the advent of truly private launch systems. Additionally, development of reusable systems must continue if space is to become commonly accessible. The development of an unmanned reusable system is critical to the goal of greatly decreased launch costs. Probably of most interest, several novel launch systems have been proposed in recent years including the use of rail guns, nanoSat launchers on high performance jet fighters, and pulsed lasers. While early in the development phase, these systems have great potential for virtually free launch of many smaller spacecraft.

Important Structures Technologies
The traditional structure development goals of lower cost manufacturing and lighter weight are obviously still important but with the advent of reusable systems, structural issues commonly found in the aircraft industry, such as durability and operability, will be even more important. Novel launch concepts will require structures that are able to withstand severe environments, particularly high heat and shock loading, while being very lightweight and stiff.