M1NIATURIZATION METHODS FOR DEEP SPACE MICROSPACECRAFT

Lilac Muller
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology
Cambridge, MA 02139

Abstract

Duc to the shi inking NASA budget, future scientific spacecraft programs will be di iven by their "life- cycle" cost. This cost figure, which includes development, integration, launch. and operation, can be reduced by making spacecr aft smaller and more autonomous. Such miniature spacecraft allow the launch of several microspacecraft on a single launch vehicle or the launch of a single microspacecl aft as a "piggy-back" rider on top a primary payload. Although each of these small spacecraft will not be capable of conducting the diversified science that is accomplished by such grand vehicles as Voyager and Cassini, a group of microspacecraft can conduct a composite of many different kinds of valuable science missions as well as enhance overall mission reliability.

The methodology used in the design of microspacecraft is different than that which is used for traditional planetary spacecr aft. This design approach involves the incorporation 01 advanced miniaturizing technologies as well as the modification of the system architecture so that it can supper t the desired small mass and sire. The progress in miniaturization is evolutionary: size can be reduced from one design to the next by further modifying the. system architecture and incorporating even more advanced technologies. 'l'Iris paper will cover the specific approaches used in the evolutionai y miniaturization process as well as the advanced technologies needed to build a miniature spacecraft designed to accomplish an asteroid flyby mission. A concept for a 3kg microspacecraft and an associated launch strategy are presented.

Introduction

Today's planetary spacecraft (Voyager, Galileo, Cassini) carry marry instruments on-board and conduct many scientific experiments al their destination. Because of this, they are considered today as heavy, power-demanding, and complex. <qualification tests for their parts arid subsystems were long and expensive, adding to an already long development time and high costs. The recent 10ss of the Mars Observer brought to attention (yet again) the risk of placing large resources into a single, complex spacecraft, This unfortunate setback has increased the support for smaller, more focused missions. With the shrinking NASA budget, scientists and engineers arc looking at ways of conducting valuable planetary science for less. Smaller spacecraft are expected to do just that. The vision is that of micro scale vehicles that will weigh orders of magnitude less than current spacecraft, consume far less power, evolve from concept to launch in less time and for less money, and still support focused world-class science investigations.

The main rationale. for designing and building smaller spacecraft is the need to lower total project costs. Smaller spacecraf t can be launched on smaller launch vehicles (LVs) which cost much less than heavy ones. Even smaller spacecraft can be launched as "piggy-back" riders cm LVs for other missions when mass margins are available, or as multiple. spacecraft launched on a single LV, thus reaching more than a single target or conducting science that can only be accomplished by multiple views of a single object. in addition, smaller spacecraft allow for greater upper stages within a given launch vehicle envelope, thus allowing higher launch energies and enabling shorter cruise phases for missions to far targets.

There are several other factors that make smaller spacecraft less expensive. Compact spacecraft require smaller integration and test facilities. Smaller spacecraft generally support simpler missions and allow for simpler system architectures which may lead to lower operations costs. On the other hand, these. vehicles require advanced technologies which incur high development costs. Many would requite more expensive manufacturing and qualification techniques. However, as the use of and demand for these technologies increase, these costs can be amortized over multiple uses.

Background and Approach

in the late 1980s, the Pegasus launch vehicle was introduced. Although it did not fty until 1990, it brought about an interest in smaller spacecraft that could be launched for lower cost. in 1990, a JPL study called the Pegasus-launched Near Earth Asteroid Flyby (PNEAF) [1] introduced a design for a spacecraft that could conduct deep