27th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Generic Technologies for Small/Micro Platforms (6A)

Author: Dr. Vladimir Zelentsov
Bauman Moscow State Technical University, Russian Federation, shcheglov_ga@bmstu.ru

Dr. Vera Mayorova
Bauman Moscow State Technical University, Russian Federation, victoria.mayorova@gmail.com
Dr. Georgy Shcheglov
Bauman Moscow State Technical University, Russian Federation, h15r@yandex.ru
Mr. Nikolai Tiutiunnik
Bauman Moscow State Technical University, Russian Federation, t_nik_nik@bk.ru
Mr. Evgeny Saliev
Bauman Moscow State Technical University, Russian Federation, salievjek@mail.ru

SERVICED SMALL SATELLITES CONSTELLATION BASED ON OPEN MODULAR ARCHITECTURE

Abstract

The increase in the size of near-Earth constellations up to several thousand satellites can lead to the "shortage of orbital resource", which will cause an increase in the value of orbital resources. As a result, the increased cost of the "orbital position" can make specialized missions for servicing spacecraft cost-effective. The experience in designing Earth-based technical systems shows that the most effective approach is to build them using open modular architecture. At the moment, this approach has been successfully utilized in manned space exploration on the International Space Station. Examples of small satellite projects based on modular architecture NowaWurks, iBOSS, MOSAR is well-known. This work considers a simplified example, that illustrates the concept of using open modular architecture to build a system of student-designed Earth observation mini-satellites (from 100 to 500 kg), serviced by a two-stage spacecraft of about 1900 kg. The advantage of this concept is that all the spacecraft of the system are built using a single standard of modules and interfaces, which makes them adapted for maintenance and repair. An analysis of the layout schemes showed that a limited nomenclature of seven Plug-and-Play modules performing various functions is required to build a system. For mini- and small satellites, it is rational to base the module housing dimensions on values divisible by 0.25 m. In this case, the mass of modules in the considered example is divisible by 4 kg. The hardware redundancy of the modules (in particular, a large number of "redundant" docking units) is both a drawback of the modular approach since it increases the vehicle mass and its advantage as it gives greater flexibility in operation and increases the total system reliability. The total project cost model is presented showing, that the use of modular architecture becomes effective when the number of small spacecraft exceeds 600. This corresponds to the typical estimated size of LEO constellations. The use of small-size serviced spacecraft is justified by the fact that the increase in the number of vehicles in orbit decreases the service cost per unit and for large groups servicing an individual satellite is more feasible than its complete replacement. In addition, it is shown, that the serviced modular architecture can be efficient in terms of profitability of the satellite group operation when individual modules built on cheaper COTS-components have relatively low reliability compared to devices built on a highly reliable component base.