SELF-DEPLOYABLE DEORBITING SPACE STRUCTURE (SDSS)

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ABSTRACT

The present research relates to the field of satellite deorbiting. In particular to research in space structures which facilitate deorbiting of satellites from Low Earth Orbit (LEO). A deorbiting subsystem for spacecraft in LEO is presented, i.e. a socalled Self-Deployable Deorbiting Space Structure (SDSS). When deployed, the SDSS increases the drag of the spacecraft by a factor 10-100, thereby slowing down the spacecraft, so deorbit is assured. A method is devised to pack/fold, stack/pack and unpack/unfold a Deorbiting Space Structure (SDSS) supported by a flexible frame so that gravitational issues are avoided, a correct unpacking/unfolding is assured, and the energy supply/propulsion for the unpacking/unfolding process is minimized.

1 INTRODUCTION

The present research relates to the field of satellite deorbiting. In particular to research in space structures which facilitate deorbiting of satellites from Low Earth Orbit (LEO). A deorbiting subsystem for a space structure, e.g. a satellite, in LEO is presented, i.e. a so-called Self-Deployable Deorbiting Space Structure (SDSS) [1].

Especially self-deployable concepts are addressed in this research in order to improve robustness [2].

GomSpace Aps, Denmark, will assemble a 2kg satellite CubeSat with a size of 10cm x 10cm x 20cm based on in-house standard products that have all already been tested in previously conducted missions. This satellite will be launched on a rocket approximately in 2014. The figure 1 left shows a similar sized satellite being finalized for shipment to one of GomSpace's customers. The satellite will be equipped with a SDSS module as illustrated in figure 1 right.

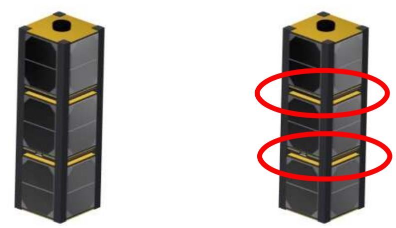

Figure 1. On the left is shown a CubeSat satellite from GomSpace. On the right is illustrated a similar satellite system fitted with two SDSS modules – in total 4 sails.

When the satellite has reached orbit it will be controlled from GomSpace's ground station in Aalborg, Denmark. The first two days all the systems on this satellite will be checked analyzing data and calibrated in order to confirm that all systems is working nominally. Then the SDSS device will be activated as shown in figure 3, i.e. the sail-like area will be deployed. A small camera on the satellite will capture the SDSS deployment and should capture the SDSS sail area to verify successful deployment thus verifying the SDSS working principle.

Thereafter the orbital performance of the satellite will be monitored through daily interactions with the satellite and through radar data from the US Air Force Space Command that are freely available for such purposes. These data will verify the "brake effect" of the SDSS device on the satellite and the performance will be compared to the chosen mathematical models.

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2 PRINCIPLE

One way to accelerate the deorbiting process is to increase the area of the satellite in relation to its mass, i.e. altering the ballistic coefficient due to aero-dynamical effects [3]. This will cause increased drag and result in a reduction of the orbital life-time of the satellite. For satellites launching to orbits with an altitude above 600km, and that is most satellites, such a device can ensure that the UN guideline [4] of a maximum of 25 years in orbit after the useful life can be met. Such a change of area vs. mass can be performed by deploying large areas from the satellite. Thus the SDSS device is targeted satellites orbiting in LEO where these aero-dynamical effects can be utilized. The basic idea utilizes the fact that the atmosphere of the Earth does not stop abruptly at some altitude but gradually thins out as the altitude increases. This means that even at 600km or 1000km, i.e. LEO, over the surface of the Earth there is a thin distribution of atmospheric molecules. When satellites collide with these molecules drag is introduced that very slowly reduces the speed of the satellite [3]. This means that the satellite will gradually loose altitude and eventually enter the denser region of the atmosphere. When the satellite is below approximately 250km of altitude the drag will be so severe that the satellite heats up and breaks apart, while falling towards the Earth.

A typical satellite, if launched into an orbit with an altitude of about 300km, will survive in orbit for about 60 days, e.g. the international space station is in such an orbit and needs to fire rocket motors every 30 days to maintain altitude. At 650km it takes 25-40 years before the satellite re-enters the atmosphere and in 950km it may take as long as up to 1000 years [3].

3 SYSTEM DESCRIPTION

The flexible frame is made without any mechanical or electronic parts. The SDSS include a locking device to lock the flexible frame in the packed/ folded configuration. The unpacking/unfolding process require no energy supply, i.e. no external energy is required for deployment of the flexible frame itself, as the required energy is stored in the folded frame.

Figure 2. On the left is shown a CubeSat satellite with the release trays deployed. On the right is illustrated the deployed sails.

The unique nature of this flexible frame structure is that it is gravity neutral and self-supporting. This allows for testing of the SDSS device in a gravitational field. It will be illustrated how a novel flexible structure, supporting a drag sail, will provide secure optimal storage, launch, deployment and operation economies of a deorbiting subsystem through

• Low weight and minimal foot print when packed, so the storage requirement in the spacecraft is minimized during spacecraft launch and operation,

• No external energy source is needed for deployment, as the frame itself automatically assures correct deployment, and

• Large foot print deployed, compared to the minimal foot print of the folded configuration.

Thus, SDSS provides a self-contained, simple, cost-effective and platform independent deorbiting subsystem suitable for all low earth orbit missions in the future.

4 DEPLOYMENT AND UNFOLDING

The SDSS device is folded in a release tray mounted on the satellite as shown in figure 1 and 3. This release tray is spring activated and locked in the un-deployed position by a resistance/burn wire termed a locking wire as illustrated in figure 3 left.

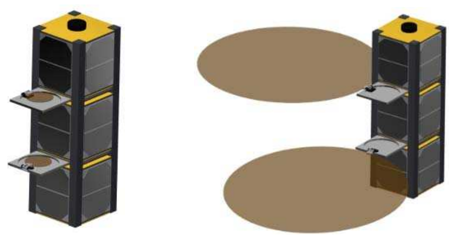

Figure 3. On the left is shown a CubeSat satellite with the release trays deployed. On the right is illustrated the deployed sails.

The unfolding of the SDSS device is initiated by a signal to a control unit on the satellite which burns the locking wire. The release tray is deployed thus disclosing the folded sail. This allows the SDSS sail to unfold and deploy see figure 3 right, i.e. releasing the elastic energy stored in the folded frame structure of the sail.

When deployed, the SDSS device increases the drag of the spacecraft by a factor 10-100, thereby slowing down the spacecraft, so deorbiting is assured.

The relative compact design allows for satellite designers to fit a SDSS module to a satellite system without compromising the structural and functional integrity. In this manner the SDSS system can function as a backup device to an Active Debris Removal (ADR) system, i.e. introducing redundancy to secure debris removal.

5 SUMMARY

A method is devised to pack/fold, stack/pack and unpack/unfold a Deorbiting Space Structure (SDSS) supported by a flexible frame. Th ereby gravitational issues are avoided, a correct unpacking/unfolding is assured, and the energy supply/propulsion for the unpacking/unfolding process is minimized. It is shown that this SDSS device can be fitted in a non-invasive way – not compromising the structural and functional integrity of the space structure. This allows designers to incorporate redundancy in relation to an ADR configuration on the satellite.

6 REFERENCES

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