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Self-deployable Deorbiting Space Structure (SDSS)

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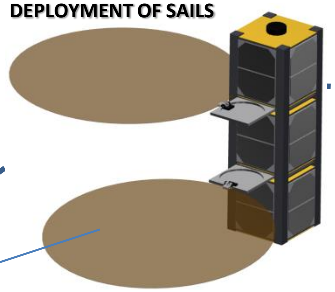
Deployment and unfolding:
Then the SDSS device will be activated as illustrated, i.e. the sail-like area will be deployed. The system being tested is a 10cm X 10cm X 20cm CubeSat. A deployed sail area of 1000cm² for one sail is achieved by folding one sail five times to a folded diameter of approximately 8cm allowing it to be packaged and fitted to the satellite with a maximum build height of 5mm.
The deployed area will increase the surface area by a factor 10 for each individual sail.

NB: The figure only shows two deployed sails – it should show four sails, however these are omitted for simplicity.

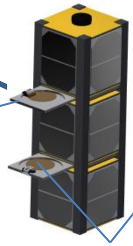
A small camera on the satellite will capture the SDSS deployment and should capture the SDSS sail area to verify successful deployment thus verifying the SDSS working principle.
Thereafter the orbital performance of the satellite will be monitored through daily interactions with the satellite and through 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.

DEPLOYMENT OF SAILS



DEPLOYMENT OF TRAYS

RELEASE TRAY



FOLDED SAIL

FOLDING OF SAIL

LAUNCH

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], [2].

The SDSS system:
The SDSS system is composed by a wire/frame based structure which supports a sail. The SDSS can be folded into a smaller diameter allowing for a compact storage on the satellite in either a porch or in a casing. During launch the SDSS is locked in a folded position with a wire based locking device.
The SDSS device is folded in a release tray mounted on the satellite. This release tray is spring activated and locked in the un-deployed position by a resistance/burn wire termed a locking wire. 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, i.e. releasing the elastic energy stored in the folded frame structure of the sail.

Objective:
A typical satellite if launched into an orbit with an altitude of about 300km will survive in orbit for about 60 days (the international space station is in such a orbit and needs to fire rocket motors every 30 days to maintain altitude). At 650 km 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. One way to accelerate the process is to increase the area of the satellite in relation to its mass (i.e. altering the ballistic coefficient). 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 such a device can ensure that the UN guideline of a maximum of 25 years in orbit after the useful life can be met [3]. Such a change of area vs. mass can be performed by deploying large areas from the satellite.

The SDSS device is targeted satellites orbiting in LEO where aero-dynamical effects can be utilized.

MISSION

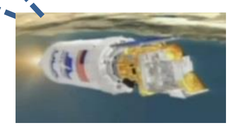
SDSS module

DEORBITING OF SATELLITE

Principle in SDSS:
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 600 or 1000km 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. 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 to the Earth.

Satellite system - CubeSat:
GomSpace Aps, Denmark, will assemble an up to 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 in 2014. 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. This research is supported by The Danish National Advanced Technology Foundation (Højteknologifonden www.hoejteknologifonden.dk).

SSDS - Essentials:
The unique structure of this flexible frame structure is gravitational neutral, i.e. self-supporting. This allows for testing of the SDSS device in any 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 footprint 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.



Low Earth Orbit (LEO)
Less than 2000km from earth.

ORBIT

References

[1] A. S. Kristensen and L. Damkilde, "Self deployable deorbiting space structure". Denmark Patent WO2012092933-A1, 12 7 2012.

[2] G. Tibert, "Deployable Tensegrity Structures for Space Applications," Technical Reports from Royal Institute of Technology, Stockholm, Sweden, 2002.

[3] "IADC Space Debris Mitigation Guideline".

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