Astro- und Feinwerktechnik Adlershof GmbH

Adaptable and Deployable Solar Array for Small Satellites

Overview

Astro- und Feinwerktechnik was commissioned by DLR (German Aerospace Centre) to develop an adaptable solar array for small satellites; this has now been produced and flown successfully. The outcome of the task is a three-part structure, consisting of a fixed center panel and two attached side panels that lie against the satellite during the start phase and are subsequently folded out with the aid of a release mechanism.
The development permits a variety of adaptations to the requirements of various missions with regard to attachment, dimensions and electrical parameters.

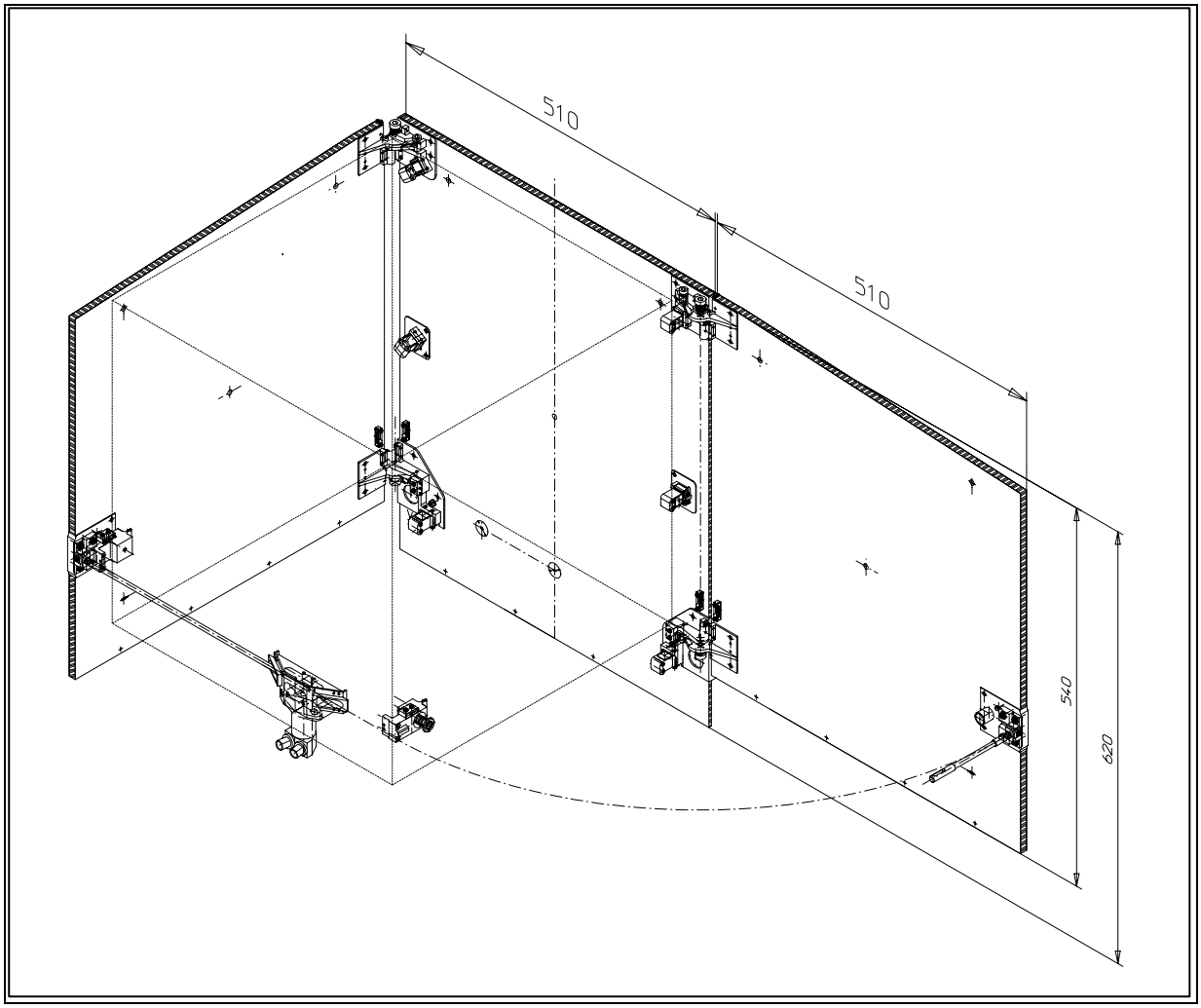

Figure 1 Solar Array – BIRD

Background of the development

In 1997, Astro- und Feinwerktechnik participated in a competition for development and manufacture of a solar array for the BIRD small satellite mission of the DLR - Institute for Space Sensor Technology and Planetary Exploration. The tender was accepted as a result of a convincing bid and proven competence.
To meet the requirements of the mission, adaptations to design changes had to be made repeatedly. These adaptations mainly related to the position of the attachment points and the size and shape of the free panel areas. This resulted in the development of a very flexible structure, enabling the design to be adapted to other projects as well.
The outlay for changes even during the production phase was kept within justifiable limits due to the fact that the design was manufactured entirely at Astro- und Feinwerktechnik Adlershof GmbH. A complete record of the manufacture was also advantageous in this regard.

Characteristics of the solar array – BIRD

The solar array developed by Astro- und Feinwerktechnik for the BIRD small satellite has a capacity of approximately 120 W and a mass of 4187 g. The height of the center panel amounts to 620 mm. The width of the individual panels is 510 mm, resulting in a span of 1536 mm. When assembled (incl. release mechanism) and in the startup configuration, it requires a space of (546 x 548 x 620) mm^3.
The panels fold out when triggered by a retaining pin, which retains both side panels and is released by pyrotechnical means.

Mechanical features

The material of the structure is a specially produced sandwich-composite material made of slit aluminum honeycombs with 0.5 mm covering layers made of carbon-fiber plastic. The total thickness is 10 mm. The inserts and fittings cemented into this are produced from a high-strength aluminum alloy. Two bars of carbon-fiber plastic piping are used to hold the side panel in the start configuration.
These are attached at the front of the satellite in a release mechanism, which can be triggered redundantly using two pyro-initiators. The core element is a system made by the French company PyroAlliance (Separation Nut). The retaining bars are movably secured to the ends of the side panel and pivot open, together with these panels, when released.
The side panels are mounted directly on the center panel in the classic fixed / floating bearing configuration, in which the bearing bushings of modified PEEK move on polished stainless steel pins. At each bearing location there is a tangentially loaded helical spring for folding out the panels; these springs release approximately 50% of their pretension by the end of the movement. In addition, the two side panels are each accelerated by a push-up spring to ensure a reliable start to the movement. The stop is damped with a special plastic element and is locked by a latch.
The complete solar array is secured to the satellite structure at the center panel by six feet. The feet are designed in such a way that they can compensate thermal contractions. To increase the space available for integration, the solar array can be folded down at the lower two feet.

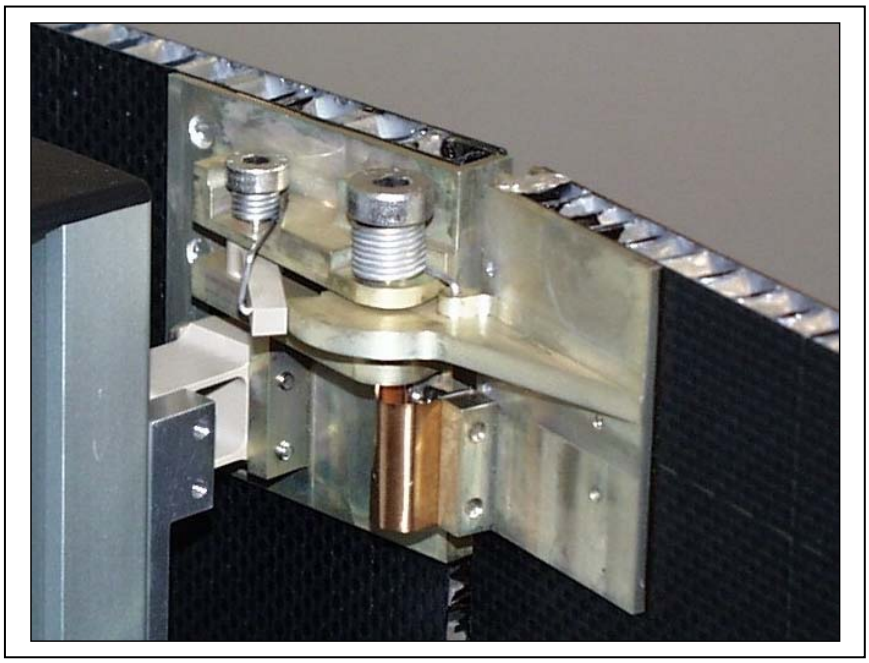

Figure 2 Joint with drive spring, locking latch and grounding plate

Thermal features

The material for the panel structure has a honeycomb core made of aluminum. This effectively dissipates the absorption heat, produced at the front, to the rear of the panel where it can be radiated again. Overheating of the solar cells is prevented in this way, thus improving efficiency. To optimize their radiation properties, the rear sides of the panels are coated with zinc oxide paint, which has selective absorption and emission properties. Temperature sensors are embedded in each panel so that the temperature can constantly be monitored.

Electrical features

The two side panels are each provided with 2 strings of 56 cells. Each string of the center panel has 68 cells to compensate the loss in capacity caused by increased level of heating. In total, the 6 strings have a capacity of approximately 120 W.

Signal sensors are located at the counter bearing and the lower joint of each side panel in order to monitor the status of the panel. In this way, both the start and the end of the opening procedure and the locking into the end position can be signaled.
The pyro-initiators of the release mechanism have an internal resistance of 1 Ω and can be triggered with a current impulse of 5 A/10 ms.

The panels are connected to each other in an electrically conductive manner over a grounding plate to prevent differences in potential caused by a static charge between the panels. The cable is routed from the side panel to the center panel by twisting the cable in the longitudinal direction. A main socket on the center panel is used to connect electrically the entire solar array to the service section of the satellite.

Qualifying tests

The first operational tests of the mechanical components were performed on a dummy that has a similar structure to the BIRD. The side panels were repeatedly pre-tensioned to a nominal force and the release mechanism was triggered using compressed air in order to examine and optimize the movement.
The vibration and shock test was performed in the in-house, ESA-certified simulation laboratory and completed successfully in accordance with the specifications of the BIRD mission.
The final operational test took place in a vacuum in a space-simulator at the DLR in Berlin-Adlershof on 04 August 1999 and was also completed successfully. Here, the entire system was exposed to a temperature change load from worst-case hot to worst-case cold. The side panels were then folded open at –120°C by triggering a pyro-initiator.

The solar array developed by Astro- und Feinwerktechnik Adlershof GmbH has proved its ability with the start of BIRD on 22 October 2001.

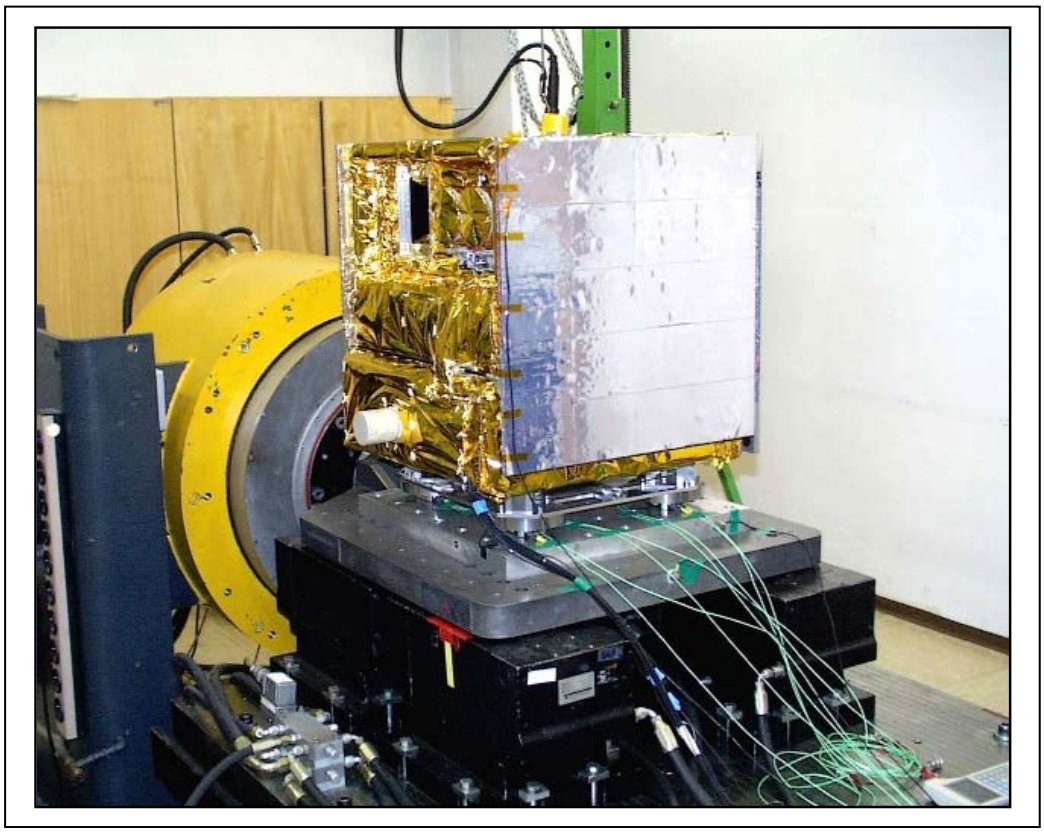

Figure 3 BIRD with solar array on vibration test bench

Prospects

The modular structures of the solar array as well as the technical competence of the developers in the implementation of the design form the basis for the adaptability of the existing development in terms of other projects. An adaptation is possible for a satellite that weighs approximately 200 kg.

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