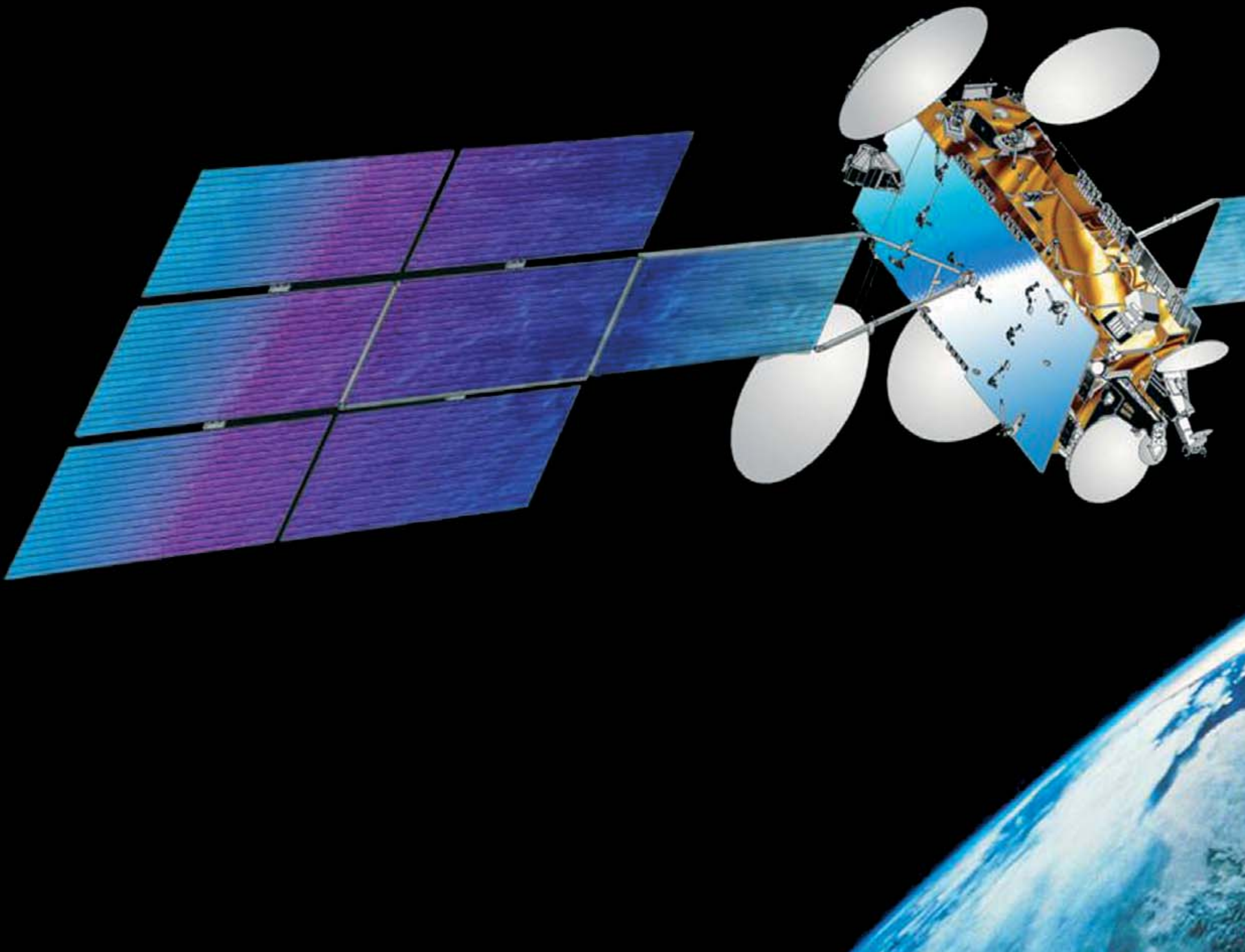
Powering the Future

A New Generation of High-Performance Solar Arrays



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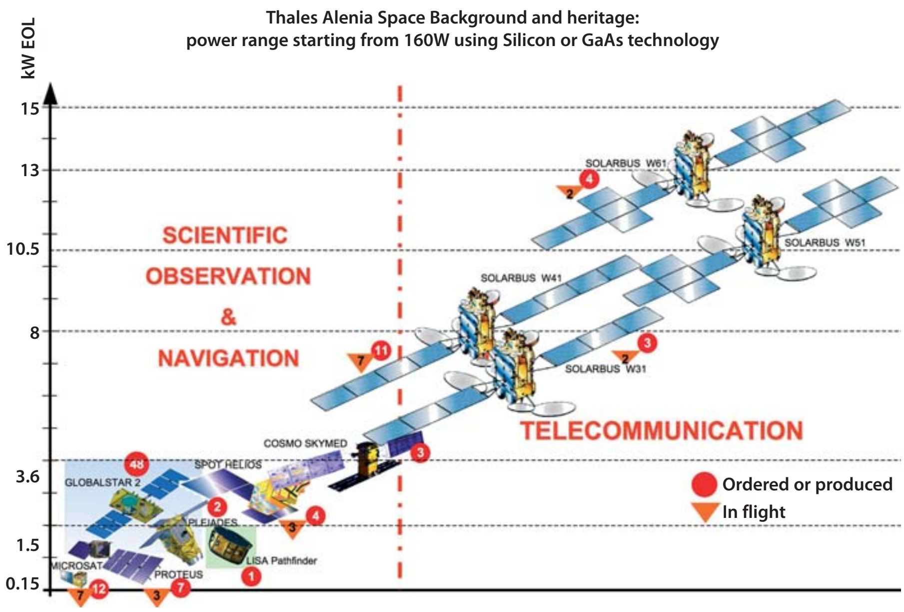
Funded by ESA's Advanced Research in Telecommunications (ARTES) programme, Thales Alenia Space has developed a new generation of high-power ultra-lightweight solar arrays for telecommunications satellites. Thanks to close cooperation with its industrial partners in Europe, the company has generically qualified a solar array io meet market needs. Indeed, three flight projects were already using the new design as qualification was completed. In addition, the excellent mechanical and thermal behaviour of the new panel structure are contributing to other missions such as Pleïades and LISA Pathfinder.

Introduction

The standard 'Solarbus' solar array of Thales Alenia Space for the Spacebus telecommunications satellite platform was designed in 1998. The flight-proven technology deploys modular panels, using patented frictionless hinges, to provide up to 13 kW end-of-life (EOL) power with an EOL power-to-mass ratio of 48–50 W/kg, the best now available.

Thanks to the close cooperation with the Spacebus satellite team, exactly the same design has been used for all of the



The new Solarbus array (top right) has been added to the range. The 'lateral' panels unfold from the central panels

solar array panels: more than 150 identical panels have been produced over the last 5 years.

Now, to satisfy growing market demands, a new-generation design has been developed to provide more then 15 kW power EOL in a 7-panel version. In addition, a new Lightweight Panel Structure (LPS) has been introduced to increase the solar array W/kg and thus maintain the competitiveness of Spacebus in the commercial market.

2004 was a particularly bad year in the telecommunications business: half of the insurance payouts stemmed from solar array problems in space (from other suppliers!). This confirmed that products as critical as solar arrays must be robustly developed to ensure high reliability.

Robust and exhaustive development is mandatory but not compatible with flight schedules. In fact, as the market becomes more aggressive, the manufacturing cycles are being more tightly squeezed. The conclusion is that development must be done outside of flight programmes. This requires 'generic' development to ensure the product is ready for the market before the first missions requires it.

Guidelines for Generic Developement

The development of Thales Alenia's generic new-generation high-power solar array began in 2002 under guidelines that came directly from customers. Customers are sensitive on two main requirements that are difficult to test on the ground: safe deployment in orbit, and production of the required power during the 15-year lifetime.

Safe deployment is ensured by detailed dynamic analysis correlated with the flight experience of numerous identical solar arrays, together with the use of 'lateral' panels with the frictionless Adele hinges flown in several programmes since 1998. Using only flight-proven solar cells satisfies the electrical aspects.

Meeting Power Growth Needs

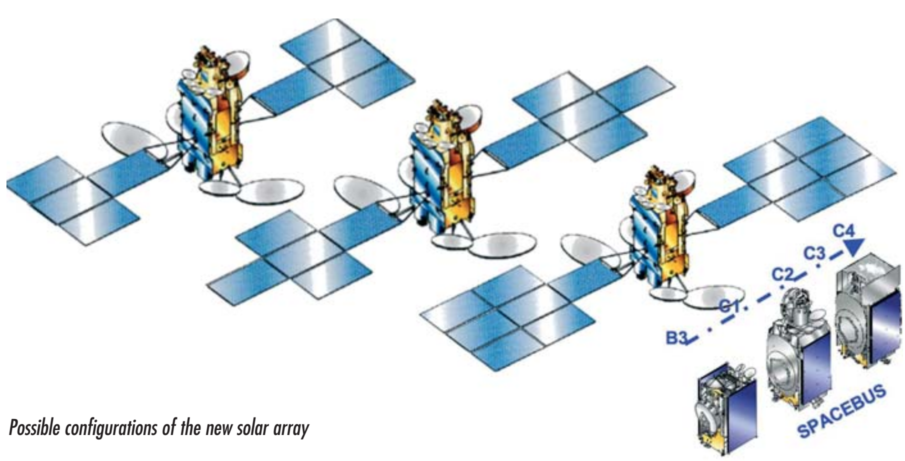
Usually, power growth is achieved by increasing the efficiency of the solar cells. This is how the 13% efficiency of standard silicon cells has grown to today's 28% for triple-junction gallium arsenide (GaAs) cells. More then 30% efficiency is expected in the near future for GaAs.

However, improving the power-to-mass ratio also calls for redesigning the mechanical and electrical architectures.

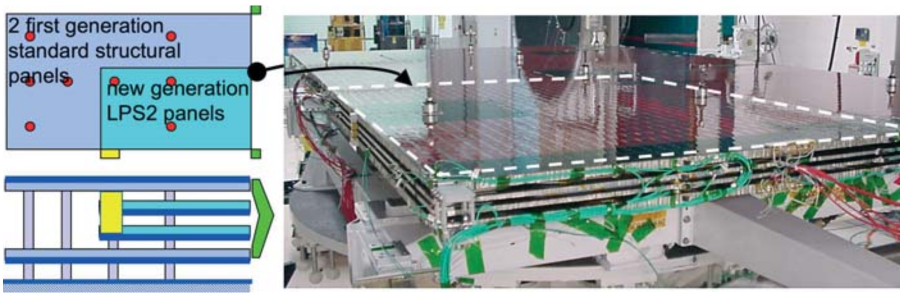
The mechanical improvement is in line with the logic of 1998: a standard modular panel multiplied to provide the desired area. The new array has seven panels per wing as the baseline, but offers a growth potential to a 10-panel version. Thanks to the novel way the array is stowed, non-structural ultra-thin lateral panels can be used. No other solar array does this.

Different cell technologies will cope with the power demand:

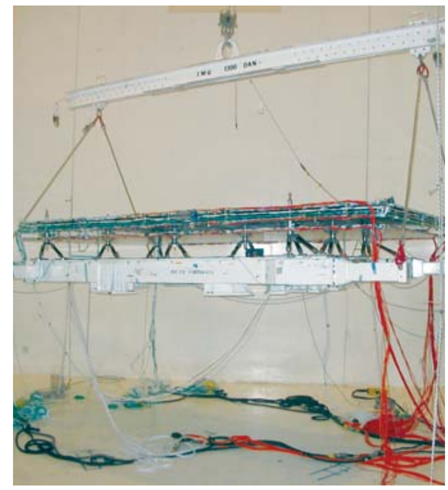
- for the near-term 15 kW EOL, thin high-efficiency silicon cells will be used for the first missions;
- GaAs cells will be called on in a second step if more power is needed;
- design novelties already under development will make the design more attractive.



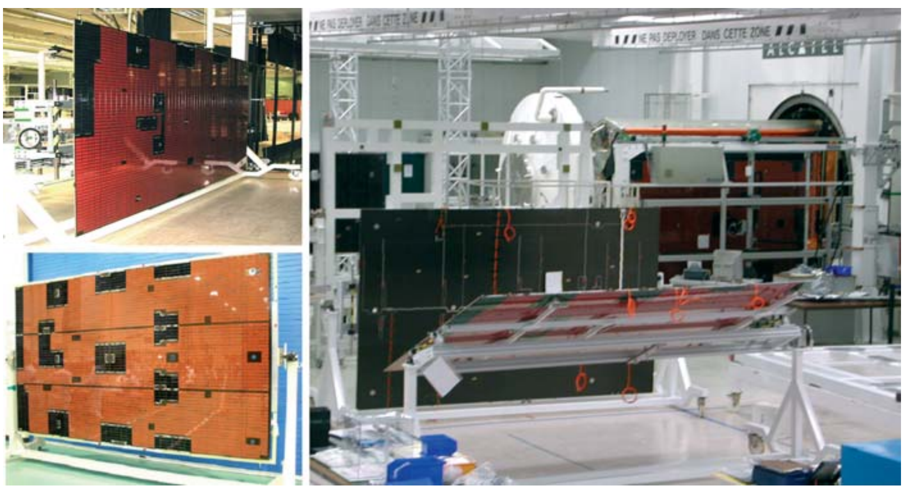
Possible configurations of the new solar array



Vibration test of a folded array, with two ultra-thin panels sandwiched between standard panels for protection



Preparing for the acoustic vibration test to simulate the rigours of launch



Preparing a full-scale panel for thermal-vacuum tests

Development Based on Design Heritage

The overall goal of this huge development effort is that the optimised mechanical structure will support continuous improvements in the electrical architecture over the next 10 years. After this robust generic development, protoflight qualification will be provided by the first flight project.

Design targets

The new design is based on the fact that, during the three major life phases of a solar array (launch, deployment and orbital life), the structural needs of the central panels are more important than for the lateral panels. The novelty of the LPS design rests on this difference, allowing the lateral panels to be half as thick as the central panels.

A central mast has a yoke plus two, three or four central panels. When more power is needed, lateral panels are added. The stowed configuration is the key to this innovative design. The panels are stacked at launch so that the ultra-thin lateral panels are protected between two 'structural' central panels. Shims keep the launch loads away from the lateral panels.

This approach allows several configurations, with two or three panels in line and zero to six lateral panels.

Step-by-Step validation

Qualification was achieved using a step-by-step approach that limited the risk during the programme. The first test campaign characterised the shims' dynamic behaviour during launch. A second text validated the load path through the shims, tuned the shims and validated the model's stiffness linearity.

Thanks to these two main tests at the start of the development process, it was possible to model the shim characteristics and to build a global mathematical model that represents the entire solar wing. Using this model, a detailed analysis was performed to size the new substrates and the mechanical architecture of the 4–10-panel wing configurations.

Additional intermediate tests were performed on half-scale panels to verify early on the integrity of the solar cells after the vibration tests.

In addition, new manufacturing processes were developed for the lightweight panels, together with a robust database for mechanical and thermal design. Compatibility with all cell and bonding processes were verified via lifecycle testing. Finally, full-scale panels equipped with GaAs, silicon cells and representative cell dummies were subjected to thermal vacuum cycling.

In addition, the full Assembly, Integration and Test sequence was validated.

Conclusion

The first two steps of this development programme are completed. Three commercial flight projects are already running using silicon high-efficiency cells for 15 kW EOL power. The use of GaAs cells is then foreseen to provide more power or reduce the number of panels. GaAs cells will allow the LPS architecture to satisfy future market needs easily. It will be possible to reach 23–29 kW BOL in a 7-panel configuration; more can be achieved because the LPS design offers 10 panels per wing.