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Opening address

On behalf of ESA I am very pleased to welcome you to this 9th European Conference on Spacecraft Structures, Materials, and Mechanical Testing. Continuing with good tradition, the conference is co-sponsored by CNES, DLR and ESA.

This series of conferences was initiated in 1985 and has stimulated at European and international level the exchange of information and joint sponsoring of developments in the area of structures, materials and testing methods. The extensive attendance here today manifests the continuing purpose of this event.

Structures, Materials and Mechanical Testing are disciplines with long histories going back to the industrial revolution. However, as far as space applications are concerned, significant and far-reaching advances have been witnessed in the last four decades, driven by the development of space systems with increasing complexity and dimensional constraints, and significantly higher service lifetimes. Such requirements necessitate ever-growing interaction between various disciplines, including structures, materials, thermal control, propulsion, and dynamic control. There is continuous progress in advanced problem simulation, and advanced manufacturing and testing techniques to address adequately the various issues.

Since the last conference at CNES Toulouse in 2002 many significant events have occurred.

The dramatic accident of the Columbia shuttle put in the spotlight that structural integrity cannot be taken for granted, and that multidisciplinary assessment of the system, including aerothermal, structures and operations, is essential.

The subsequent redefinition of the USA policy towards Exploration and CEV, and the setback to the ISS programme has, in the light of past experience, to be watched carefully, and some lessons should be learned. Indeed, regarding Europe's contribution to potential international joint projects, any element of such cooperation should allow Europe to progress in successfully completing the goals which might be set out, even if international partners drop out. On the other hand, it is through international cooperation that significant advances have been achieved, for example Huygens was taken to Titan by the US Cassini spacecraft.

The modified plan for the Ariane 5 ECA launch and other events in the domain of launchers have also highlighted that fundamental aspects such as load definition, structural stability, and manufacturing of composites also require attention. The recent successful AR5 launch is a much-welcomed sign of recovery in this area.

An overall policy frame for future launchers including reusables, aiming also at the post Ariane-5 era, is being established in the FLPP programme of activities. The valuable experience in hot structures and thermal protection systems that was acquired in Europe in the frame of the X-38 and CRV activities needs to be pursued further, bringing into fruition cooperative European demonstration flights.

In the area of Telecommunication and Navigation, the Galileo programme is now approaching launch of its two test-bed satellites (GSTB-V2), and the IOV satellites are being designed.

In the science area, Europe has been extremely successful. I am proud to mention some of the successes: Rosetta is on its path to comet Churyumov-Gerasimenko and transmitting pictures of the Earth and Moon; Huygens had a spectacular landing on Titan; SMART-1 is orbiting the Moon; and Mars Express is orbiting Mars, where it has detected ice and is returning amazing pictures. Issues affecting the MARSIS radar deployment indicate once more the importance of structural analysis in space systems.

In the antenna area, the development of a large, 12 metre, unfurlable antenna in cooperation with Russia is progressing well.

Advanced testing facilities such as Hydra have been employed efficiently for system verification. The ATV testing campaign on Hydra, which included classical sine and modal testing, was completed in a shorter period thanks to the capabilities provided by the shaker. More recently a luggage container of the Airbus 380 was successfully vibrated on Hydra.

The spacecraft business in general has now entered industrial maturity, forcing reductions in design, manufacturing, and testing costs of the space segment in order to succeed in the market. The predictions regarding decreasing size of spacecraft in all domains have not yet materialised. At present various large, medium, and small spacecraft units are being adapted for missions and cost objectives.

New classes of programmes are being established e.g. Aurora, targeted on long-term exploration goals, and scientific missions with very high precision and stability requirements. Structural concepts, technologies, and methods are being developed to meet special user requirements. These include:

- deployable and inflatable structures for large appendages, solar panels, thermal shields and antennas, capable of boosting performance of small spacecraft, and also for space habitats;
- advanced actively-controlled structures, either to control large flexible structures, or to ensure stability of optical structures;
- new advanced materials (e.g. fibres, resins, curing methods, smart materials) and manufacturing technologies applicable to these concepts;
- improved and specific design, development and verification methods e.g. virtual spacecraft, verification of inflatable structures and landing systems;
- reduction of conservatism, by designing against flight loads rather than against test.

Looking ahead, the ISS could be used as a test bench for technologies that are difficult to validate on the ground. This might be an area which needs to be explored closely with US colleagues.

To conclude, space structures, materials and testing are fundamental and specialised key elements for space missions, and as such they are recognised by ESA as a core technology within its research and development programme. R&D activities need to be pursued to keep abreast in this multi-mode and fast-changing field, in particular where such technologies constitute key enabling elements of the mission. The area of lessons learned requires special attention, to consolidate knowledge for future missions. I encourage you all to look for opportunities on how we can organise collaborative programmes, and consider partnership possibilities between public and private sector, in particular for flight and in-orbit demonstration.

I have seen the programme of the conference. It is impressive, and I would like to thank the Technical Committee for organising a very comprehensive programme covering all relevant aspects of space structures mechanical architecture, design, and verification. In addition, exhibition and poster sessions have also been organised to cover the underlying issues and challenges.

Structures and structural dynamics is my area of specialisation and I thank so many colleagues and friends for their highest professional dedication over the years, and for being here today. The Structures Section is the largest section in ESA, providing valuable support to all Agency satellite and launcher projects and Agency technology programmes. I am particularly pleased that Michel Klein and Torben Henriksen, both dear colleagues of the highest technical and personal integrity, have professionally continued efforts which I initiated in this domain some years back. I would like also to thank the Conference Bureau team for organising this series of events with the highest professional quality.

I have no doubt you will be busy these two and a half days in pursuing advances in spacecraft engineering, design, materials and testing. I hope that the social programme which has been organised will contribute to strengthening existing relations and establishing new contacts.

On behalf of ESA, I now formally declare open this European Conference on Spacecraft Structures, Materials and Mechanical Testing. Best wishes to you all for a stimulating, productive and enjoyable conference.

C. Stavrinidis

DLR Welcome Address

On behalf of DLR, the German Aerospace Research Center and Germany's Space Agency, I would like to welcome the participants to the 9th International Conference on Spacecraft Structures, Materials and Mechanical Testing. It's an honour for me to open the conference on behalf of DLR. I have attended the conference series for more than a decade already. I am really pleased to meet again many scientists whom I cooperated with in several projects. This conference is always a good opportunity to meet the community of engineers involved in spacecraft structures development and mechanical testing. The programme selected by the programme committee offers a fantastic overview of recent developments, results and perspectives of spacecraft structures. My thanks to the committee for the selection work, structuring the contributions into interesting sessions over the next three days.

Materials, structures and mechanical testing are the backbone of the process chain of the development of high performance spacecraft. Sustainable effort to reduce weight, thus enabling new missions, is based on new materials, advanced structural design, new manufacturing technologies and finally on reliable and representative testing. I am really longing to learn about new materials, active materials, adaptive structures, realization of deployable and inflatable structures, and to hear reports on test campaigns.

The conference programme announces contributions on new **materials** and experiences from the application of advanced materials:

- nanotechnology
- introduction of new features into materials and structures through multifunctional materials
- the application of active structures for vibration control, control of structural deformations

We will have several sessions on **composite structures**:

- new tooling and processes
- design, manufacturing and testing
- fittings and joints
- hybrid titanium composite material
- modelling and robust design
- polymerisation in free space

Recent developments of **deployable and inflatable structures** will be presented:

- UV-curable inflatable structures
- polymerisation in free space
- modelling
- mechanical testing

Reports will be given about **test campaigns** including

- new sensors and actuators
- advanced test methods
- fundamental aspects of mechanical testing

Many thanks to the organisation committee, especially to Torben Henriksen, the ESTEC Conference Bureau, and thanks to ESTEC for hosting the conference.

I wish the conference fruitful discussions, new ideas, maybe new projects, extending the network. I'm sure the conference will contribute to pushing back the frontiers of science.

Finally I would like to announce that DLR will organize the 10th International Conference on Spacecraft Structures, Materials and Mechanical Testing in Berlin in 2007.

M. Sinapius

CNES Welcome Address

On behalf of CNES, the French Space Agency, I am pleased to welcome you to this new edition of the Conference on Spacecraft Structures, Materials and Mechanical Testing.

First of all, I would like to apologize for David Assemat, CNES Toulouse Deputy Director, who had planned to be here today to participate in the opening session of this conference but had to change his agenda at the last minute.

Then, I think we can thank our colleagues from ESTEC for the organisation of this edition of the Conference, we can be sure that it will be a success with all the presentations which are planned and the technical exchanges they will generate.

This Conference is a kind of 'birthday', as the first edition took place twenty years ago in Paris, and we can see the distance that has been covered: thirty papers were presented at that time, compared with more than a hundred and fifty this year.

The different conferences, organised in the Netherlands (Noordwijk), Germany (Braunschweig) and France (Toulouse and Paris), have always provided the opportunity of discussion at an international level about the state of the art and about the evolution of technology and practices in the field of spacecraft and launcher mechanical design, development and verification, including the advances in testing techniques. Each conference has pointed out a kind of focal point such as structural dynamics, new launcher mechanical environments, mechanical testing, micro-dynamics, shock environments… which were at that time the up-to-date leading subjects in our mechanical community.

Since the last Conference in Toulouse, we can emphasise the return to flight of Ariane 5 ECA which is a great success for European industry and for the Agencies which have led the work to solve the problems encountered during the first flight.

We can also have a quick look at the various recent satellite programmes and see that the developments performed for these different projects give us good examples to illustrate the main subjects that we had to face in the past few years and that we will have to cope with in the near future. Globally, the subjects that were taken into account by the Conference three years ago seem to be still up-to-date:

- Design, manufacture and qualification of large, very light appendages. Ultra-light reflectors and light panels for solar arrays are good illustrations of the current trends concerning mass reduction.
- The mechanical qualification of these light structures and of systems using local dampers has led to many analyses due to their non-linear behaviour. The combination of analysis and test to achieve qualification is one important point of interest and it includes all the questions concerning model correlation and updating.
- Stochastic analyses are another point of interest as they can allow a better management of the specification and dimensioning margins, and different projects have started to use them as an engineering tool.
- Qualification against the shock environment coming from the launcher or from internal pyrotechnic devices remains a heavy task for the project teams, with the recurring questions: how to define the environment for the equipment? how to qualify the units? what test installations to use? are we able to define the strength of the units through analysis? This shock environment is a source of costs for the launcher and satellite industries. Being able to cope with it with little effort will be great progress.

I expect that this conference, as all of its preceding editions, will give you the opportunity to have a precise description of the state of the art in the mechanical world of space programmes and will give to all of you the opportunity to have fruitful discussions with colleagues coming from the different industries and agencies. I am convinced that all participants will find the conference both useful and informative and I wish it great success.

G. Turzo

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