Report on the First Canada-Europe-US-Japan Workshop on Micro/Nano-Technologies (MNT) for Aerospace Applications

By Dr. Jan SUSKI
President of the Aerospace and Geophysics Club, Nexus, Europe

Presented to Nexus and EC.

Hosted and organized by CLS3 (Centre for Large Space Structures and Systems) of Montreal, Canada, in cooperation with the CSA (Canadian Space Agency), this 1st historic meeting on Micro/Nano-Technologies (MNT) for Aerospace attracted over 200 delegates from across the world.

The delegates represented researchers and practitioners of microsystems and nano-technologies with interests which were not necessarily restricted to space applications. This, perhaps, emphasises the generic nature of micro/nano-technologies with regards to applications as well as the interest of the MNT community in identifying and exploiting new opportunities for this technology.

The workshop spanned a period of five days from the 25th till the 30th of August 2002. Over these five days, the conference addressed the following topics:

1. Missions benefiting from MNT
2. Mid to Long-term Nano-Technologies
3. Support and Tools
4. Communications
5. Scientific Payloads
6. Attitude Determination and Propulsion Equipment
7. Power and Data Handling
8. Instruments (Electrical)
9. Instruments (Mechanical)
10. MNT programmes

The opening remarks by the ESA/ESTEC Technology Programme Managers, explained the specific interest of the space programme in MNT. This interest was summarised by Antonio Martinez de Aragon as ESA's desire *"to be in space and not just get to space"*. To achieve this, technologies, which will reduce costs, time of launch, increase performance and capabilities as well as reduce mass, volume and power consumption, are essential. MNT, he maintained, offered a great promise to satisfy some of these objectives.

The objectives of this 3rd Round Table was to help set-up pan-European collaborations aimed at developing fully functional demonstrators, which integrate MNT within space equipment.
Antonio Martinez de Aragon explained that, over the last five years, the potential of MNT has been accepted for this, highly dynamic, sector of the market where both institutional support and industrial R&D have been driving developments in this field. He did, however, outline some of the important issues that require further investigation. These issues relate to reliability, component variability, impact of commercial-off-the-shelf (COTS) products and interface technologies as well as the,

current, general lack in understanding of failure mechanisms of MNT-based components.
Presentations made during the sessions attempted to address some of these issues. Further details and information may be found on the ESA/ESTEC Website address: http://www.estec.esa.nl/CONFANNOUN/00c02/index.html.

SUMMARY OF SELECTED PRESENTATIONS

11. John Stocky (Thrust Area Manager for Micro/nano Science-craft at NASA) reviewed some of the current activities undertaken by NASA as part of their "Cross Enterprise Technology Development Programme". The goal set by NASA is to reduce the mass (of satellites) by a factor of 10 compared to the 1995 state-of-the-art. This is to be achieved through miniaturisation, improved packaging and thermal performance and by reducing overall power requirements. In this context, The focus on development is, primarily, on Systems-on-a-Chip (SOAC), micro-gyros and accelerometers as well as on-chip liquid cooling. Activities on nano-technology, in particular, are directed towards atomic-scale operations and self-assembly of molecular devices.

12. Jacque Blamont (CNES) described the concept of "virtual" satellites formed by a network of co-orbiting, small (few 100 gm up to 10-20Kg), satellites, each with a different functionality. Applications include SAR and, possibly, the future basis of a "solar"-system wide area network.

13. The development of propulsion systems and micro-thrusters was described by speakers from the University of Munich and CNRS, respectively. The former outlined a modular design approach for low-cost missions. The latter described some of the microsystems including the propellant-filled, single-shot, micro-thrusters. Each of the 100 or 1000 array thrusters has a fuel reservoir, a membrane-covered nozzle and micro-resistive heaters to ignite the fuel.

14. Another micro-propulsion system was described by a representative from a European Collaborative study between Matra-Marconi-Space/Astrium, Alenia Aerospazio and Daimler-Chrysler. The cold-gas propulsion system is predicted to achieve a capability of 8m/s (0.02N).

15. Arnaud Lecuyot (MMS/Astrium) presented a concept where the tether cables of satellites may, with engineering, provide some functionality such as sensing, positioning and maintenance.

16. Stephen Ransom (Astrium) listed the challenges facing aerial vehicles for planetary-surface exploration. Mars, for example, has an atmospheric density 1/100th that of Earth, a temperature that spans -1200°C up to a maximum of -400°C, a non-combustible atmosphere (95% CO_2) and a windy, gusty and dusty atmosphere. Designs are currently progressing, including the nano-helicopters being developed by NASA.

17. The exploitation of the spin electrons phenomena (Spintronics) for the development of high density memory arrays was introduced by J de Boeck (IMEC). Companies such as Honeywell and Motorola are already testing MRAM-based storage devices with the aim of commercialisation by the year 2003. Other applications include sensors, inductive components and magnetic semiconductors.

18. Equally novel was the concept of nano-composites prepared by chemical nano-technology. Gerhard Jonschker (Nanogate) described some of the novel of for processing at the molecular level to develop materials with very specific properties (e.g. hard coatings).

19. Patric Salomon (MEMSCAP) introduced the newly formed NEXUS User-Supplier-Club focused on CAD Tools for microsystems design. He also outlined the design tools offered by MEMSCAP.

20. The use of Proton beams for direct writing onto substrates was described by Meg Abraham (Oxford University) as a process for the rapid prototyping of micro-components. The beams, with typical energies of 2-3 MeV, were said to be capable of producing high aspect ratio (100:1) 3D microstructures in glass, epoxy resin and PMMA.

21. The Dutch company Xensor Integration reported the development of two micro-devices for space applications: an IR detector focal plane array for satellite navigation and a smart instrumentation point with sensors and associated signal processing. Both devices are radiation hard.

22. A consortium, headed by Alcatel Space, has devised a new concept of semiconductor chip-stacking. Thinned-down chips (5-10 microns) are stacked onto a passive silicon substrate and interconnected by means of vertical metalised vias.

23. Emma Taylor (MMS/Astrium) presented results of a study on the likely effects of space debris on components (such as microsystems) used for spacecraft.

24. A perspective on the drive of the mobile communications industry towards the development of microtechnologies and the impact this industry will have on space applications was presented by Dr Huomo from Nokia. In essence, this market's need for RF micro-components such as switches, filters and novel energy sources will push technology in general, thereby, benefiting the space application. The main issue of concern is that of fast-ramping from low to high volume as demanded by the mobile communications industry and whether microsystem developers will be able to satisfy this stringent requirement.

25. A Spanish consortium described the use of an optical wireless link for intra-satellite communication. Inter-satellite optical links using micromechanical mirrors were, on the other hand, proposed by representative from VTT, Finland.

26. Harrie Tilmans (IMEC) outlined developments of RF microsystems for space telecommunications. These included a description of a single pole double throw switch operating in the 5-6 GHz band. Passive microwave micro-components (waveguides and resonators) were also described by Tony Ewert from the Angstrom Laboratory in Sweden.

27. A number of presentations described various sensors and instruments aimed for space research. An overview by Nico de Rooij (University of Neuchatel), outlined the developments at the university's SAMLAB relating to chemical and physical sensors and actuators. Atomic Force Microscope cantilevers and micro-tips, spectrometers and micro-fabricated field emission arrays were

also described during the session on Scientific Payloads.

28. Markus Melf (Dornier) described an experimental attitude and orbit measurement system comprising an active pixel sensor from IMEC, a magnetic field sensor from IMS-FhG and an angular rate sensor from Bosch. The system is scheduled to form part of the MITA platform planned for a launch in July 2000.

29. A UK consortium, headed by Martyn Snelling of MMS/Astrium, described the initial results of a study aimed at developing an attitude sensor comprising a microsystem gyro and star tracker. The results included a comparison between the performance of a number of commercially publicised MST gyros such as Systron Donner's QRS11, Gyrochip, S1RRS01, ENC-03J and Samsung's gyro.

30. John Buckley presented the capability at DERA (UK) in the fields of microsystems and nano-technologies. The goal of developing a Micro/nanotechnology Attitude Control System (MACS) by the year 2003 was mentioned.

31. A Swedish consortium, primarily from the University of Uppsala, described the design of a "de Laval" type of micro-nozzle (with 11 microns throat dimensions) for propulsion. Thrusts in the range of 0.1 - 10 mN were achieved.

32. A number of presentations on energy generation devices and control subsystems formed part of the Power and Data Handling Session. High Temperature Superconducting magnets for energy storage (NASA), millimetre-sized transformers (Institute of Technology, Lausanne) and RF techniques for energy transfer (K U Leuven) are examples of the technologies described.

33. The sessions on "Instruments" attracted a large number of presentations describing a variety of approaches for sensing and monitoring in space. IMEC described a CMOS-based 512x512 CCD array sensor with >58 dB SNR. A miniaturised Fabry-Perot interferometer for monitoring CO_2, C_2H_4 and H_2O was presented by VTT (Finland). A micro-TAS (Total Analysis System) was described by 3T BV (Holland) and miniaturised pressure sensors with built-in actuators were described by Robert Puers (K U Leuven).

34. The final session of the RoundTable meeting was dedicated to a review of national programmes on microtechnologies. Tekes in Finland has initiated a new programme (PRESTO) aimed at promoting MEMS and micro/precision fabrication and assembly. The programme, which started in 1999, is both product and business oriented. Thomas Sommer outlined the European IST programme and the MST initiatives within this programme. S Manhart presented the initial results from the NEXUS Aerospace and Geophysics User-Supplier-Club. His focus was on the technology Roadmaps produced by this group. Martyn Snelling (MMS/Astrium) outlined the main aims of the UK's Aerospace MST Applications Partnership initiative, which include stimulating the development and application of MST through partnerships between academia, research and industry. Finally, Lars Stenmark (Angstrom

Laboratory, University of Uppsala), presented an overview of the MST and MNT activities at the Space Technology Centre of this Laboratory.

Findings

The application and exploitation of micro/nano-techniques for future space systems and payloads is, without doubt, an obvious step towards achieving the reduction in costs and weight demanded by the operators. This meeting has successfully demonstrated that both technologists (MST suppliers) and System developers (MST Users) have a mutual interest in achieving these goals. This mutual interest was manifest by the large presence of system developers who appear to have embraced the technology. Equally impressive were the number of collaborative projects involving research and industrial teams which are currently underway. Overall, the Round Table is succeeding in creating the right balance of technology-push and technology-pull.

Where do we go here?

CANEUS has agreed to work together and support the 4th ESA round table on MNT for Space to be held at the ESA during May 2003.

Milind Pimprikar
CANEUS – Initiator and Organizer
CLS3 (Centre for Large Space Structures and Systems)