GIM INTERVIEWS DR RAINER SANDAU, CHAIRMAN, INTERNATIONAL ACADEMYOF ASTRONAUTICS (IAA)

Potential of Small Satellites

Small satellites for earth observation are an important ongoing development in space research. How can mapping and disaster management benefit from small-satellite systems? What is the potential and what the challenges? Are small satellites an inferior alternative for developing countries that cannot afford large satellites? This monthâ€™s interviewee, Dr Rainer Sandau, provides answers to these and other questions.

What are mission, scope and organisational structure of IAA?

IAA encourages international scientific co-operation through scientific symposia and meetings and through the work of six commissions dedicated respectively to Space Physical Sciences, Space Life Sciences, Space Technology and System Development, Space System Operation and Utilisation, Space Policy Law and Economy, Space and Society Culture and Education. A major initiative is the development of a series of â€˜Cosmic Studiesâ€™ and â€˜Position Papersâ€™ dealing with science, engineering, social and policy aspects, including the Study on Cost-effective Earth Observation Missions. Here we use the outcomes of the symposia on Small Satellites for Earth Observation, a biannual conference that takes place in Berlin hosted by DLR. The 6th Symposium is scheduled to take place from 23rd to 26th April 2006.

Please elaborate upon your own role and involvement in IAA.

Elected as a member in 1997, I from the beginning promoted small satellites by initiating and organising IAA symposia in Berlin and the Small Satellite Session at the annual IACs. I chaired the study on Cost-effective Earth Observation Missions carried out by a group of 36 experts with various backgrounds and from differing disciplines such as science, engineering, application and management. These people originated from fifteen countries and five continents, ensuring unbiased results. I also organised the student prize paper competition and I co-chair the IAA symposium in Berlin, and the Small Satellite Symposium, with seven sessions at the annual IACs. As chairman of the IAA commission IV â€˜Space Operations and Utilisationâ€™ I am in charge of all academic activities dealing with (1) space activities and new concepts in space operations and utilisation, (2) communications, remote sensing, and navigation satellites, (3) small satellites for developing nations, countries emerging in space technology, and earth observation, (4) safety, rescue and quality, (5) EVA protocols and operations and (6) use of space facilities.

What markets do you expect for small-satellite missions?

Developing countries in particular use the possibilities of small satellites and restrict their requirements to the available technologies. But NASA and ESA are also increasingly considering the potential, which includes more frequent missions resulting in faster return of science and application data, and a wider variety of missions and thus more diverse use and more rapid expansion of the technical and/or scientific knowledge base. Smaller countries also want to involve local and small industry in the projects. Interest on the part of the military would lie in short assembly and launch times, while the private sector would step in whenever profit comes into view. For the latter I see two application areas: mapping and disaster management. Other potential areas of commercialisation include low-Earth orbit systems enabling low-energy communication covering populated areas, and medium-Earth orbit systems for navigation in traffic, and search and rescue. In the future all large systems such as ENVISAT with a development time of more than fifteen years will probably be replaced by small satellites. Large-satellite systems can be complemented by small satellites making specific measurements, such as the Normalized Difference Vegetation Index (NDVI), which could be corrected for aerosols and clouds using data from NASAâ€™s A-Train: a series of research satellites (Aqua, CloudSat, CALIPSO, PARASOL, Aura and OCO) that fly in formation.

What do you mean by small satellites complementing large ones?

A mission can be cost-effective and meet the needs without making all the measurements itself. NASAâ€™s â€˜A-Trainâ€™ makes individual measurements that support cross-platform science. Many sensors also use ancillary information, such as digital elevation models, to add context. One could readily envision a small-satellite mission that was intended to provide some niche product, such as crop-yield forecasting, in a particular region. Such a small satellite could produce a very specific measurement, such as NDVI, corrected using data from the A-Train. In such cases the spacecraft resource requirements could be quite small. Another approach is to decrease the ground-repeat delay by forming a co-operative that shares data produced by the elements of the constellation. Each member of the co-operative then gets the benefit of a much shorter revisit time, economies of scale being revealed as more members join the co-operative.

For such a future to become reality literally hundreds, or even thousands, of satellites would have to be rocketed beyond Earthâ€™s atmosphere. Wouldnâ€™t that be too costly?

Over the last ten years the availability of small launchers has increased and the prices are reasonable compared to the cost of small satellites; as a consequence small-satellite missions will no longer be constrained by launch costs. Most new launch systems are designed to serve an international commercial market. The entry of Russian and Ukrainian launch systems operated as joint ventures with US or European companies marks a major shift. Although some nations still insist on the use of a â€˜nationalâ€™ launch capability, the general trend is towards the use in new launch systems of major components built in other countries, blurring national divisions. The increasing availability of these low-cost launchers and the development of dispensers have opened up possibilities for single launches of a constellation and individual payloads. The launch of the NASA/DLR GRACE satellites used Eurockot Launch Services, the joint venture owned by Astrium and the Russian company Khrunichev, to place two satellites in a closely controlled formation via a dispenser. This launch was the first commercial use of the Russian SS-19 ICBM, which provides the two booster stages for the Rockot launch vehicle, with a heritage of 150 flights. At the other end of the spectrum, Ariane 5 has been used to launch six auxiliary payloads along with the primary Helios satellite. This included Nanosat, Spain's first small satellite, with a mass of less than 20kg. Development of small launchers is also stimulated by â€˜space tourismâ€™. On 4th October 2004 Burt Rutan and Paul Allen built and flew the worldâ€™s first private spacecraft to the edge of space to win the $10 million Ansari X Prize. Perhaps the early history of aviation foretells the next twenty years of space access. Initially air travel was risky and expensive, but with the growth of a commercial market costs and risks dropped. Now air transport is so cost-effective that bulky agricultural goods such as apples are shipped halfway around the globe at prices competitive with local transport and production.

What is the feasibility of small-satellite missions for topographic mapping purposes?

Small-satellite missions are suited for topographic mapping, but the main question is how far the ground resolution can be increased. High ground resolution is connected to large focal length and often also large aperture, and satellite stability needs to support this. The high data volume generated at high rates needs to be transmitted to the ground within mass, volume and energy budget, which requires careful design of small satellites. Resolutions better than 10m can be achieved, as proven by TOPSAT (UK) with its 2.5m, and EROS-A1 (Israel) with its 1.8m. RapidEye, with 6.5m resolution, also belongs to this high-resolution category.

In addition to mapping you have also mentioned disaster-management as an important application area. What are the crucial developments for this application?

In disaster-management we find application fields such as cyclone and storm, El Nino, flood, fire, volcanic activity, earthquake, landslide, oil slick, environmental pollution, industrial and power-plant disaster. The technology developments in the space segment from which disaster management would benefit result first of all from higher performance of the satellites themselves and secondly from the on-board sensors. Better performance of satellites can be achieved by ongoing improvements in subsystems such as board computers, data-handling systems, transmitters, solar arrays, batteries and GPS receivers. On-board sensors will grow in resolution both geometrically and radiometrically and will have more spectral channels. The feasibility of passive radar (SAR) micro-satellites flying in formation with an active radar satellite is being investigated. Furthermore, the costs of launching and operating small satellites will drop, making them affordable for dedicated constellations. Data stemming from different satellites and constellations will increasingly be used in an integrated fashion, increasing revisit time and information content. There will be increasing onboard processing of acquired data, resulting in high-level data products suited for direct use as soon as data reaches ground stations.

What do you see as the biggest long-term challenges?

The increasing world population will demand new or better methods to provide food and water in sufficient quantity and quality, despite higher risks of pollution and shrinking agricultural areas. This will demand global observation and control of resources using specialised satellite systems. Small-satellite missions can contribute to disaster management, agriculture, forestry, ocean and coastal zones, atmosphere, weather and climate, ice and snow, land-use and land-cover change and mapping. In this context, the biggest long-term challenge is developing a robust commercial market that supports the manufacture of small satellites. Small satellites appeal to the pride of some nations and provide a means for enforcing the industrial base and attracting students into high-tech industry. After the first few satellites, however, investments may no longer be justified by the nation eager to gain space-faring status; manufacture should remain relevant and cost-effective. In many markets space technology has entered the era of diminishing returns; for example, are there market gains in imaging at one centimetre when imagery of 1m is available? This â€˜plateau effectâ€™ means that more vendors can aspire to provide the same product. How many suppliers can the market support? It may be that the market can support more suppliers of imagery if revisit time is a key driver. The user draws products from several independent sources and understands enough about each to produce the product. Raw data products, though, are not likely to capture many more users; small satellites can supply tailored products that address specific needs. Vertical integration of the industry to provide instruments, data and integrated data products is likely to spur significant growth.

If there is a topic we have not already covered and upon which you would like to elaborate, please feel free to do so now.

Most of the key points elaborated here are based on the results of the IAA study group on Low-cost Earth Observation Missions, published by A. A. Balkema Publishers, a member of Taylor & Francis Group plc, Leiden, The Netherlands, 2006. ISBN 10: 0-415-39136-9, ISBN 13: 9-78-0-415-39136-8, 160 p.

International Academy of Astronautics (IAA)

IAA, with its current approximately 1,100 full and corresponding members in 65 countries, was founded on 16th August 1960 in Stockholm, Sweden, during the eleventh International Astronautical Congress (IAC). Since then IAA has regularly brought together the worldâ€™s foremost experts in astronautics to explore and discuss cutting-edge issues and provide guidance on the non-military use of space and exploration of the solar system. IAA is an independent non-governmental organisation recognised by the United Nations in 1996. Current president is Prof. Edward C. Stone, USA. IAA aims to foster the development of astronautics for peaceful purposes, to recognise individuals for their good work in the field, and to enable contribution to international endeavours and co-operation. IAA disseminates a diverse list of publications including Acta Astronautica, a monthly journal in English, a Newsletter, Proceedings of Symposia, and a Yearbook. It also releases electronic dictionaries in sixteen languages, Weekly News, Position Papers and Cosmic Studies and a scientific-paper database on the IAA website.