Cost-Effective Earth Observation Missions: Outcomes and Visions from the International IAA Study

Rainer Sandau (DLR), Larry Paxton (JHU/APL), and Jaime Esper (NASA/GSFC)

An IAA Study of Small Cost-Effective Satellites Has Been Produced.

- International Academy of Astronautics (IAA) Commission 4 (Space Utilization) developed a Subcommittee to address the needs of potential users of small satellites.
- The goal of that Subcommittee was to develop a study that presents a summary of the state of the industry and some of the issues associated with developing small satellites.
- This paper summarizes the results of that study.
- The intent is to address a broad high-level audience as well as those interested in the next level of detail.

The focus is on the status quo and prospects of applications in the field of Earth observation.

- The results of the study were published as:

Sandau, R. (ed.), *International study on "Cost-Effective Earth Observation Missions"*. Taylor & Francis, London/Leiden/New York/Philadelphia/Singapore, 2006.

- The IAA website has a copy of the study available.

http://iaaweb.org/iaa/Other%20Publications/earthobservation.pdf

The conclusions and recommendations of the study are the focus of this paper.

- The study provides a definition of cost-effective Earth observation missions, information about background material and organizational support, shows the cost drivers and how to achieve cost-effective missions, and provides a chapter dedicated to training and education.
- They are summarized in terms of
  - more general facts that drive the small satellite mission activities,
  - outcomes from the background material used in the study which show that good work has been done before and the lessons-learned process started soon after beginning of the small satellite activities,
  - additional outcomes of the study which go beyond the information of the background material, and
  - some ideas concerning the future of cost-effective Earth observation missions.

- We propose a simplified nomenclature for subsets of small satellites:
- mini satellites < 1000 kg
- micro satellites <100 kg
- nano satellites <10 kg
- pico satellites <1 kg

Small sat programs meet many needs

- Commercial – requiring a profit to be made from satellite data or services
- Scientific/Military – requiring that new scientific/military data to be obtained
- New technology – developing or demonstrating a new level of technology
- Competency demonstration – developing and demonstrating a space systems competency
- Space technology transfer/training – development of an organic capability
- Engineering competency growth – developing engineering competence using space as a motivation
- Education - personal growth of students via course projects or project team participation

Cost-effective small satellite missions are supported by contemporary trends

- advances in electronic miniaturization and associated performance capability
- the recent appearance on the market of new small launchers
  - e.g. through the use of modified military missiles to launch small satellites
- the possibility of ‘independence’ in space
  - small satellites can provide an affordable way for many countries to achieve Earth Observation and/or defense capability, without relying on inputs from the major space-faring nations

Small satellite missions have major advantages

- more frequent mission opportunities and therefore faster return of science and application data
- larger variety of missions and therefore also greater diversification of potential users
- faster expansion of the technical and/or scientific knowledge base
- greater involvement of local and small industry.
- smaller investment enable a small sat program to be more risk tolerant

New developments enhance the capabilities of small satellite missions

- The convergence of data acquisition and data visualization technologies
- The ready availability of new small launchers and the rise of “space tourism”
- The development of smaller, lighter, lower power satellites that can act as a constellation or independently
- The development of a collective sensor web of ground- and space-based instruments.

Disaster response missions illustrate some of the broadly applicable issues

- Improve the operations of satellites by building a flexible ground segment,
- building of networks of ground stations for increasing the satellite operational performance and data access without time delay,
- improving response time in imaging according to user requirements,
- data policy is in many cases to restrictive for fast disaster response and must be addressed beforehand,
- distribution of data and algorithms for support of disaster management using COTS products running on personal computers will enable better use of the data,
- very small ground stations for in-situ measurements with data transmission facilities via satellites are available and they are independent of existing infrastructure,
- tailoring of information for particular users and disseminating the informaton
- improving and disseminating knowledge of the utility of space-based sensor information

Disaster-assistance missions illustrate other small-sat issues

- tele-medicine applications and medical weather maps should be integrated into public health applications,
- national disaster preparedness should integrate the space segment,
- integration of space-based sensors into the spectrum of sensors that includes ground- and aircraft-based systems ie UAVs, airships and sensor webs,
- integration and fusion of data from all available sources
  - For example, GPS information and imagery
- expert systems need to be developed to rapidly classify data and to enhance the utility of the data for untutored users

Who pays to certify these new technologies for spaceflight?

- We all have experienced the “tyranny of the TRL”.
- How does one incorporate new technologies into a mission?
  - A technology demonstration mission is costly and slows the process of incorporating new technologies by putting them on a “roadmap”.
- Cost-sharing between a larger, richer, risk-averse partner and a smaller, poorer, more risk-tolerant partner may prove beneficial to both parties.

What makes a mission cost-effective?

- An acceptable price for performance…
- Sharing the risk may make this easier to achieve.
  - "Failure" may be effective if other objectives are met.
- Small missions must be able to incorporate new technologies that reduce costs and improve performance.
  - Small satellite missions face growing competition in regional markets from GPS-based solutions, UAVs, balloons, and sensor webs, for example.
- The chief advantage of satellites is their global access. Exploiting that, and successfully marketing that advantage, will hold the long-term key to keeping small satellites cost-effective.

Many challenges face national space agencies

- Building or maintaining an infrastructure
- Developing public support
- Improving performance in a risk-averse environment
- Developing the marketplace
- Promoting diversity and competition
- Small satellites can meet these challenges and lead the way.