

SPACE SYSTEMS SYMPOSIUM (D1)
Innovative and Visionary Space Systems Concepts (1)

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ON THE ORIGIN OF SATELLITE SWARMS

Abstract

For a species to develop in nature, two basically two things are needed: an enabling technology and a "niche". In spacecraft design the story is basically the same. Both a suitable technology and a niche application need to be there before a new generation of spacecraft can be developed. Last century two technologies have emerged that had and still have a huge impact on the development of technical systems: Micro-Electronics (ME) and Micro-Systems Technology (MST). Both are ruled by Moore's Law that indicates that considerable technology updates appear at the pace of years or even months instead of decades. Systems that need a development time of more than a few years will inevitably be based on "out-dated" and thereby difficult to maintain and repair technology unless during the development constant redesigns are made. This makes the development of the system at least very expensive. Although expenses do not seem to be a frequent show stopper in the design of spacecraft, it is still very interesting to investigate what system architectures might evolve when the specific properties of the new technologies ME and MST are fully exploited. ME presently offers more than 2 billion transistors on a chip and MST offers mechanical systems like resonators, mechanical switches, propulsion units, gyroscopes and many other sensors that fit in a volume of a few square millimeters to a few centimeters. So it is possible to fit a lot of signal processing power together with the necessary sensors and actuators in a volume that is really very small compared to any known space system. Of course state-of-the-art spacecraft will immediately outperform these units in all aspects apart from cost and quantity. For the first time it makes sense to envisage the operation of formations of tens to hundreds of satellites that are cheap because they are based on standard commercial COTS technology and system designs. These satellite swarms will not be the systems that replace all other space systems. But, like in nature, there is a niche where swarms are the optimal solution. It's time to start occupying this niche. Typical properties of a swarm in nature are robustness, redundancy, large area coverage, the lack of a hierarchical command structure, limited processing power per unit and self-organization ("swarm-intelligence"). This paper discusses the technological trends that lead to satellite swarms, where they can go and what new science they can create.