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# RESULTS OF A REQUIREMENTS STUDY FOR MOBILE AD-HOC NETWORKS OF SMALL SATELLITES

**Abstract**

When swarm or formation missions with a high number of satellites are realized, a vital aspect of the inter-satellite communication will be self-organization. This feature supports tolerance towards failures of single satellites and graceful degradation, reduces the problems of multiple channel access and introduces robustness towards altering relative positions within the multi-satellite system causing network topology changes. A very interesting approach in this scope is the research field of Mobile Ad-hoc Networks (MANETs). They provide autonomous reconfiguration of communication links and are therefore a good candidate for robust inter-satellite communications. The generality of MANETs enable for designing a multi-satellite system of heterogeneous satellites able to communicate with each other. The multi-hop property of a MANET can decrease the satellites' energy consumption and their interferences on the communication channels. Another positive side-effect is that they allow load balancing of the data traffic for the network nodes.

But while MANETs are successfully employed for research on terrestrial applications, none has been established in space yet, nor have any space borne experiments been performed. Before this can be realized, several problems have to be investigated and solved. This paper contributes with a requirement analysis of MANETs particularly realized with small satellites by excerpting the results of a feasibility study addressing communications and navigation technologies for small-satellite formations (NaKoFo).

The presented complex requirements study has been performed on an abstraction level which is independent from satellite-design specifics wherever possible but setting specific hardware requirements when necessary, e.g. when discussing and investigating aspects of medium access control and collision avoidance. While considering a high diversity of application scenarios, the exclusive focus is put on very small satellites in this study. This elicits high constraints like size and resource limitations, e.g. implying tight energy budgets. Furthermore this study uncovers essential characteristics of the routing protocols used in space which can narrow the search among a numerous amount of existing terrestrial protocols down to a selection of a few feasible protocols and give an indicator of necessary modifications for their adaptation to space. Also, the requirements for a secure communication between the nodes are analyzed. Feasible trade-offs with respect to those requirements and the restrictions imposed by very small satellites are

essential to allow operational MANETs in space. When designing a multi-satellite system, taking the requirements from this study into account will allow creating a flexible, robust, and scalable communication network for swarms or formations of satellites.