Big Data – Big Testing?

Challenges and Novel Approaches for Testing Large Numbers of Small Satellites

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INTRODUCTION

New applications in the global Earth-observation and communication domain require more and more data, in order to constantly improve the understanding and interconnection of our world. The data needs to be collected, processed and transmitted in high-volume at high velocity and in high variety to enable these new services.

Distributed cooperating small satellites in constellations and formations offer an effective way of collecting so-called big data. These systems promise increased temporal and spatial resolutions at significantly reduced costs and development time compared to traditional single satellites and represent a rapidly emerging market. Already the scheduled and performed launches of 474 Nano Satellites in 2017 constitute approximately 32% of all 1495 operational satellites (end of 2016). The increasing number of small satellites involved in a single mission, such as Planet, OneWeb and NetSat, offers numerous opportunities while introducing new challenges to spacecraft design, integration, verification and operations.

CHALLENGES

Where previously only one big satellite was integrated, verified and operated as a single unit, hundreds of small satellites require the same tasks to be performed in the future with regard to planned mega constellations and formations – while being even more cost effective. The verification process of these satellites is affected by this trend in particular and faces certain challenges:

- Increasing test effort due to increasing mission requirements and miniaturization
- Difficult test sensor placement due to highly integrated systems
- New test equipment and methods are required to qualify distributed, cooperating systems for new applications such as autonomous feature tracking with cooperating satellites in a formation
- Conventional test equipment does not provide a sufficient measuring resolution for small forces such as those occurring in attitude and orbit control actuators of small satellites

I. Design for testability

The challenge of time and cost efficient verification of a high quantity of small satellites in a short period of time represents a further requirement to system design. Enabling easy access to each subsystem for programming, testing and diagnostic even in a completely integrated satellite is a key-factor to achieve robustness [3]. Therefore, the testability of the satellite must be considered as a keyrequirement already in the design phase in order to enable easy and effective verification.

The evaluation of the testing demand indicates numerous advantages small satellites offer to test equipment. The table shows in which way small satellites facilitate different test procedures due to their low mass, small size and low power consumption. However, the low actuator forces and the highly compact integration poses challenges to conventional test facilities and create the necessity for advanced test equipment.

II. Advanced test methods and equipment

Besides the need to measure smaller torques and forces, new applications require advanced verification processes and facilities to ensure reliability and robustness. With the paradigm shift towards small cooperating systems, the demand for functional testing of distributed, autonomous systems is rising. Test facilities for applications such as cooperative feature tracking barely exist and require simultaneous testing of multiple satellites. An integrated test environment for cooperative attitude control is currently being developed at ZfT.

III. Standardization

Standardization is the key to economical use of small satellites in large numbers. It enables fast and reliable development, integration and verification. A standardized interface facilitates access to the system and therefore increases testability. The UN/SCS electrical bus specification represents such a standardized interface that allows efficient and compact integration of the entire satellite in a plug and-play manner while offering access to each subsystem, even when the satellite is completely integrated.

The standardization of protocols combined with the interconnection of simulation, development and verification equipment leads to a powerful environment that enables rapid development and testing of small satellites.

IV. Automation

The automation of test procedures can contribute significantly to meet the needs of testing an increasing quantity of small satellites. Automation leads to time optimization and cost efficiency while enabling better utilization of test equipment and higher reliability.

Standardization and unified interfaces to the test hardware are required to enable automation. Especially the automation of time-consuming repetitive tasks, such as inertial sensor tests and calibration, can lead to cost reduction by a factor of 9 [4]. The table on the left classifies which tests offer potential for automation. In addition to automation of the test procedures itself, the evaluation of test results as well as the generation of test reports and documentation can easily be automated by appropriate software.

CONCLUSIONS

This contribution addresses challenges for the verification process of a large number of small satellites introduced by big data applications in the global Earth observation and communication domain. The efficient and economical verification of a high quantity of small satellites in a short period of time is not possible with conventional test facilities. Furthermore, the measuring resolution of conventional test equipment is often not sufficient for the small forces occurring on these systems. With the evaluation of test procedures, various benefits and challenges introduced by small satellites were found. The need for advanced test methods and equipment was illustrated. Several approaches to enable efficient verification have been presented and briefly discussed. The design for testability and the standardization of the electrical bus and protocols enable the implementation of an integrated simulation, development and verification environment which offers rapid development and testing. Automation finally leads to time optimization and cost reduction and allows the economical usage of a large number of small satellites to enable big data applications.

REFERENCES & ACKNOWLEDGEMENT

References


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