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ROBOTICS FOR EFFICIENT PRODUCTION OF SATELLITE CONSTELLATIONS

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The planned mega-constellations in the telecommunication and Earth observation sector require significant changes in production methods for spacecraft. Traditional manufacturing methods need to be complemented by advanced automation methods. The “industry 4.0” approach uses in factories networked machines and robots in order to achieve efficient and flexible production of consumer goods. This contribution analyses specific technology transfer potential to production of larger quantities of satellites.

INTRODUCTION

The traditional way of satellite implementation is based on classical manufacturing with the use of significant manpower, as typical for small production quantities. Here the necessary investments in automation systems do not pay off. The currently envisaged mega-constellations in the telecommunication and in the Earth observation sector might change the situation, as here the requirement results to produce hundreds of satellites per year. For such an increased level of output, producing an amount of satellites per week similar to today’s output per year, the traditional approach for building satellites will not be feasible any more [5]. Therefore this contribution analyses the potential for transfer of advanced networked automation approaches developed as “industry 4.0” [1] for advanced production of consumer goods and for automotive industry to this satellite “mass” production environment.

The total logistics in implementing such production, launch, in orbit operations of the multi-satellite system, as well as collection and processing of related data streams pose very challenging problems requiring innovative solutions.

Currently the small satellite community moves from educational to commercial applications and in the last 3 year typically about 100 satellites per year were launched. The professional satellites among them contribute scientific observations, space weather measurements, and technology demonstrations [3], [4], [5]. Here also significant growth rates are predicted [2].

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INDUSTRY 4.0 APPROACHES

In terrestrial mass markets, current modern networked production systems enable flexible adaptation of the production process in the factory to the current product needs and status of machines. This approach takes advantage of the capabilities of modern telecommunication and computer systems for production environments, and is closely related to telematic systems, cyber-physical systems and Internet of Things (IoT), but is focusing especially on increase in efficiency in industrial production. To further advance and distribute these advanced automation methods, technology standardization efforts are addressed in Europe under the term “Industry 4.0” [1], in the USA by “Industrial Internet Consortium (IIC)” and in China by “Made in China 2025”. Of specific interest for satellite production are requirements related to

- high flexibility to variations of standard product,
- fast integration of modular components,
- respecting high quality requirements.

The product design needs already to reflect the subsequent production process to support the application of efficient automation approaches. Here in satellite integration in particular the modularization of the satellite bus and of the satellite subsystems is a key element.

Figure 1 displays all the satellite’s building blocks, like the subsystems for on-board data handling, communication, attitude determination and control, energy storage and distribution, which are plugged by connectors on the base plate. Here UNISEC Europe provided an advanced electrical interface definition [6] suitable for very small satellites including CubeSats. All data and power lines are physically placed in a backplane. The proposed bus supports robust and rapid development, integration and testing of the satellite as well as simple maintenance, extension and replacement of subsystems in the complete satellite lifecycle, from development (in a flat-sat configuration) to flight model integration.

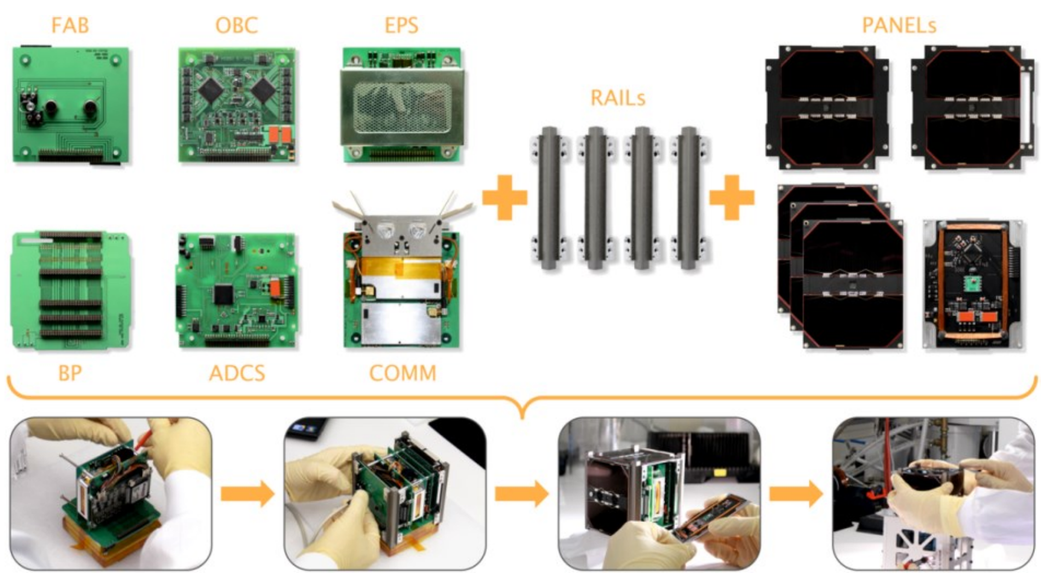

Figure 1. Modular building blocks of the satellite subsystems, supporting efficient integration on a backplane by standardized electrical interfaces.

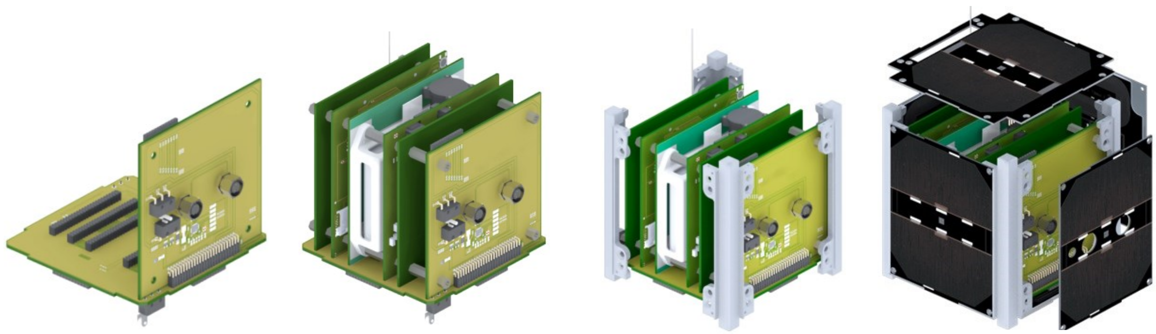

Figure 2. Modularization enables efficient satellite subsystem integration on a backplane and then adding structural items (guiderails and side panels)

The step-by-step integration process of the electrical subsystems on the baseplate is illustrated in Figure 2. This layout forms the basis for later use of automation systems and robotics to efficiently produce satellites in larger quantities.

ROBOTIC SUPPORT IN PICO-SATELLITE PRODUCTION

The evolution of robots enables today close human-robot collaboration in assembly, but also mobile robots for flexible transport tasks. In Figure 3 the role of such robots in satellite production is summarized.

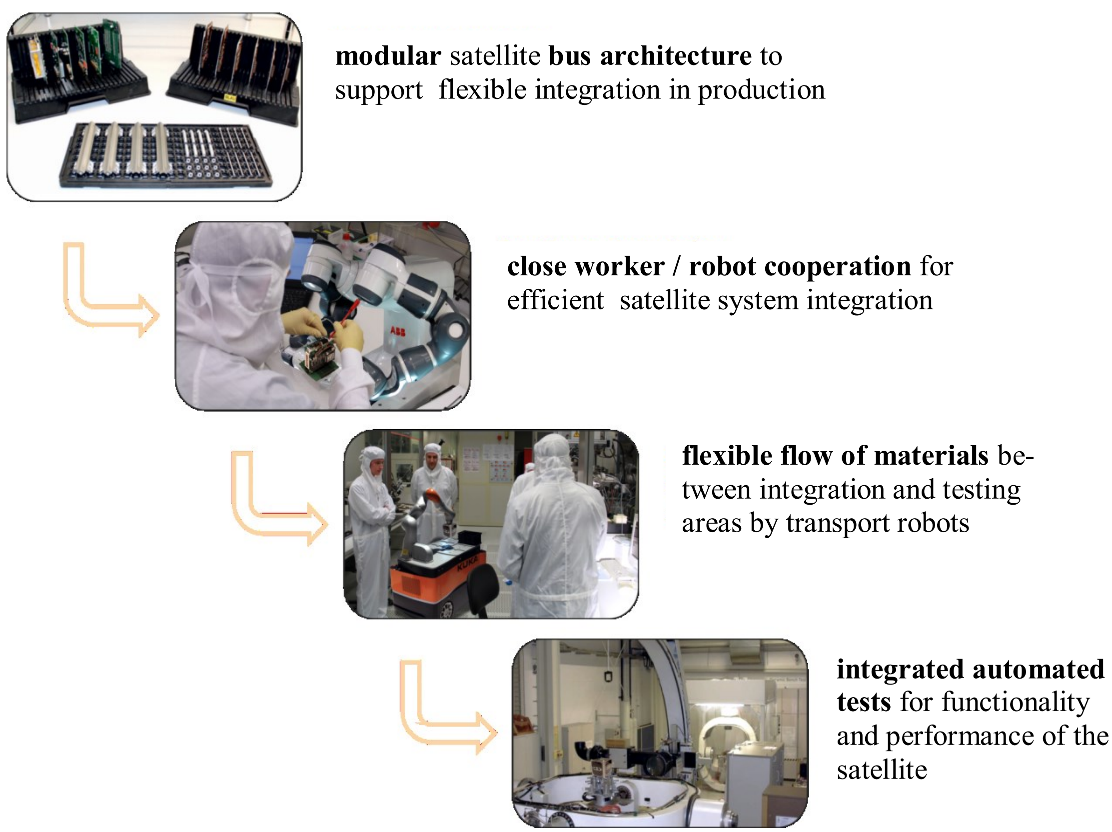

Figure 3. The industry 4.0 demonstrator in Würzburg with combined integration and test facilities, applied here to the example of a flexible small satellite assembly line.

The Zentrum für Telematik (ZfT) realized a technology demonstrator for industry 4.0 in order to illustrate capabilities of modern networked automation at a concrete example. It application focus was on consumer goods and automotive suppliers. But the flexibility of this demonstrator was used to adapt it also to small satellite production. Progress in key design steps for efficient satellite realization were related to

- replacement of typical traditional harness in order to provide a modular satellite bus architecture supporting flexible integration in production systems and robots,
- automated tests for functionality and performance of the satellite,
- use of mobile transport robots for a flexible flow of materials between assembly and testing areas to take account of extreme quality assurance requirements.

This way a much higher automation level supports the workers in satellite assembly and increases efficiency to provide the demanded higher quantity of satellite outputs, while maintaining the high quality and test standards. Specific advantages include a high flexibility to provide variations of the standard satellite product as well as fast integration of modular components. This approach was realized at the example of pico-satellites, but offers excellent transfer potential also to production of larger satellites in larger quantities.

CONCLUSION

Traditional satellite manufacturing will not be able to produce larger quantities of satellites in short timeframes as demanded by the planned mega-constellations. Therefore transfer and adaptation of modern consumer mass production technologies, like industry 4.0, to satellite production are investigated. Modularization and standardization of satellite subsystems and components offers the potential to apply also in this context modern automation and robotics technologies in order to increase efficiency in satellite assembly. In the technology demonstrator of ZfT, the integrated assembly and test facility provided evidence and experiences for efficient production of larger quantities of small satellites.

ACKNOWLEDGMENTS

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