Editorial

Frank Dannemann*

Space information technology

<https://doi.org/10.1515/itit-2021-0038>

Received August 20, 2021; revised August 25, 2021; accepted August 27, 2021

Requirements on information technology (IT) in space has increased drastically over the last decade. Besides system-critical control tasks, cutting-edge space IT systems have to address the following societal challenges arising from current and future space missions:

The need for world-wide internet created the rapidly emerging *NewSpace* sector:

- large satellite constellations demand – at the same time – performant, reliable and cheap technologies
- in-orbit servicing demands highly agile, vision guided, autonomous rendezvous & docking maneuvers
- high demand for autonomous operating scenarios

Accelerating climate change created massive earth observation (EO) needs:

- highly-autonomous on-board (pre-)processing of payload data
- rapid space borne response to disasters

Deep Space Exploration to Moon, Mars & beyond demand

- highly autonomous missions, working in
- extremely resource constraint, mostly unknown & harsh environments

These are demanding tasks to be addressed by modern Space IT systems, but while the majority of terrestrial IT systems have changed radically over the last decades, the technologies in the space sector have remained more or less unchanged for a long time. Once being the major driving force for the technical evolution of IT systems, nowadays space technologies have the reputation to be completely outdated technology-wise in comparison to earth-bound systems. Recently however, space actors –

management and engineers – fundamentally change their perspective: driven by the *NewSpace* sector, private industrial players and their plans for implementing large satellite constellations are demanding appropriate technologies which are at the same time performant, reliable and cheap. As these three characteristics have so far been mutually exclusive in the space sector, there is a paradigm shift in sight: highly specialized, radiation hardened and expensive space hardware is replaced by commercial high-performance electronics that have proven their extreme reliability by undergoing various radiation testing campaigns and also by flight heritage, e.g. in the CubeSat domain. At the same time *artificial intelligence* (AI) technologies like *deep learning* (DL) algorithms have evolved tremendously in terms of energy-awareness, mainly driven-by and targeting on-device usage scenarios on cellphones and other mobile devices. Now the space community connects both of these developments and aggregate it under the term *NewSpace-Avionics*. This results in completely new application scenarios for future space systems and missions. Specifically computer science plays a major role in *NewSpace-Avionics*.

This special issue of *it – Information Technology* contains five articles which shed light on different aspects and challenges in Space IT. These contributions are grouped into two parts: the *Regular Papers* focusing on technologies and a *Special Section* containing a cross-domain contribution at the intersection of Computer Science and Psychology.

Regular papers

The first two articles in this section – “Towards Modular and Scalable On-Board Computer Architecture” and “Advanced Data Handling Architecture for EO Satellites” – concentrate on the “heart” of the spacecraft data handling system: the On-Board Computer (OBC). They shed light on the transition path from traditional federated embedded computing architectures to modular and centralized solutions based on commercial open standards, in order to address the demanding processing needs from e.g. EO missions.

As much as the embedded hardware changes within modern spacecraft, so does the embedded software. The

*Corresponding author: Frank Dannemann, German Aerospace Center (DLR), Institute of Space Systems, Department of Avionics Systems, Robert-Hooke-Str. 7, 28359 Bremen, Germany, e-mail: frank.dannemann@dlr.de, ORCID: <https://orcid.org/0000-0002-0636-5866>

article “spaceApps – A Modular Approach for On-Board Software” introduces a novel satellite software architecture based on a modular, App-like software concept as used on mobile phones in order to promote software modularity and partial qualification capabilities. The spaceApps concept was developed in the frame of the OPS-SAT mission, which provides an open experiment platform in space.

The section closes with a survey about the “Current State and Future Challenges in Deep Space Communication”. Here, not only an overview about the historical development in this field is given, but also the ongoing research as well as future challenges – arising from e. g. deep space mission or large satellite constellations – are described.

Special section

The *Qualitative Study of Machine Learning Practices and Engineering Challenges in Earth Observation* brings together the currently driving forces in the space sector: the research area *Machine Learning* (ML) and the application area EO. Within an empirical exploratory study using semi-structured interviews, the current practices and engineering-related challenges of applying ML to the enormous EO data sets are investigated from the perspective of EO domain experts.

I would like to thank the authors of the articles, who prepared and revised their contributions to this special issue, and the various reviewers for their helpful and constructive comments. I also would like to thank Stefan Conrad and the Host Editor of this issue, Görschwin Fey, for their support.

Bionotes

Dr. Frank Dannemann

German Aerospace Center (DLR), Institute of Space Systems, Department of Avionics Systems, Robert-Hooke-Str. 7, 28359 Bremen, Germany
frank.dannemann@dlr.de

Frank Dannemann is holding a diploma in Physics (University of Oldenburg) and has a doctoral degree in Computer Science (University of Würzburg). He joined the *German Aerospace Center* (DLR) in 2002, where he currently works as head of the Avionics Systems Department at the Institute of Space Systems in Bremen. He is DLR's representative in the advisory group of the *Space Avionics Open Interface Architecture* (SAVOIR) initiative of the *European Space Agency* (ESA). His research focus lies on model-based, scalable and autonomous avionics for future space systems.