



we think electronics.dependable

# High-Performance Data Processing Unit for Space Applications

Jochen Rust, Ulf Kulau, Ole Bischoff, Konstantin Geißinger, Lei Jia

DSI Aerospace Technologie GmbH • Otto-Lilienthal-Str. 1  
D-28199 Bremen • Germany

Phone +49 421 59696-951  
Fax +49 421 59696-959  
<http://www.dsi-as.de>



DSI Aerospace Technologie GmbH is an **SME located in Bremen, Germany**, which provides following electronic equipment:

**Platform &  
Instruments  
Computers**



**Payload Data  
Handling  
Units (incl.  
MMBs)**



**Test  
Systems  
(EGSE)**

**Data  
Processing  
Units**

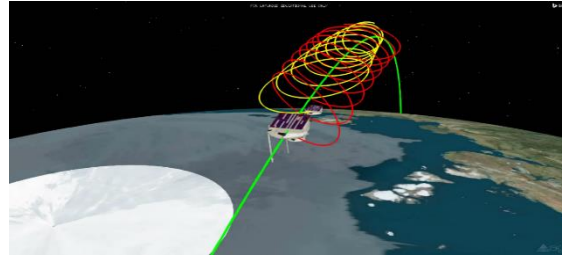
**Engineering  
Services**

**Aerospace Electronics**



## S3Net (H2020)

EO Satellite  
Constellation Study



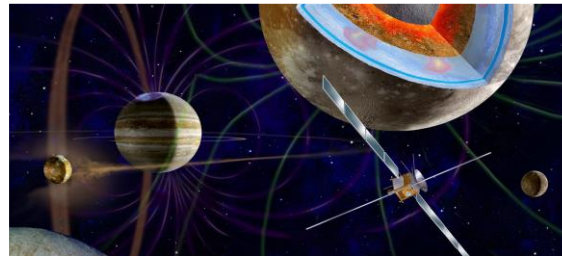
## EDRS-C Satellite

Ground crypto unit &  
key generation unit



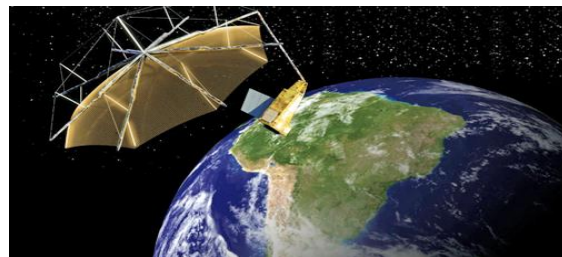
## JUICE CDMS SSMM

Solid state mass memory  
board



## Biomass

Payload data  
handling unit



## KACST Satellite Constellation

Satellite OBC with  
Mass Memory



## MetOp-SG ICI

Command & data  
processing unit of the  
Ice Cloud Imager  
instrument



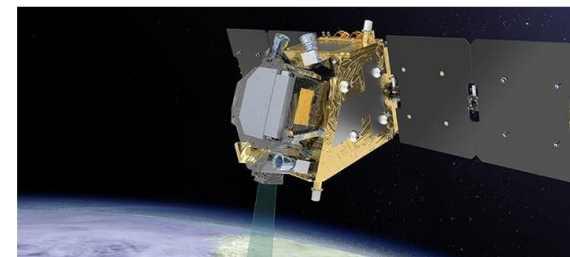
## Hayabusa-II MASCOT

On Board Computer



## FLEX

Payload data  
handling unit



Continuously rising demand for high-performance data processing in various space-applications

Non-Terrestrial-Networks

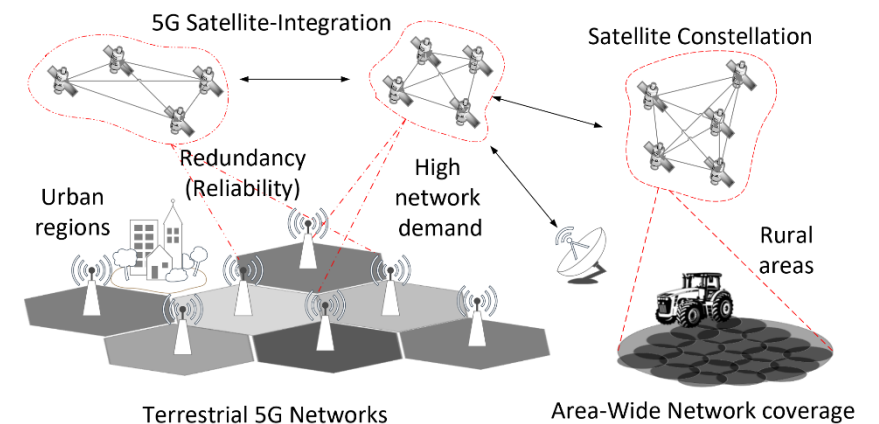
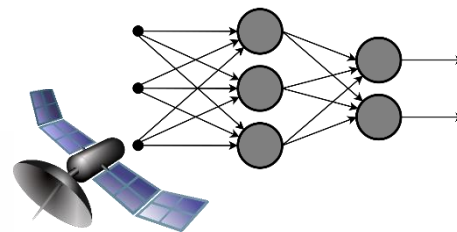
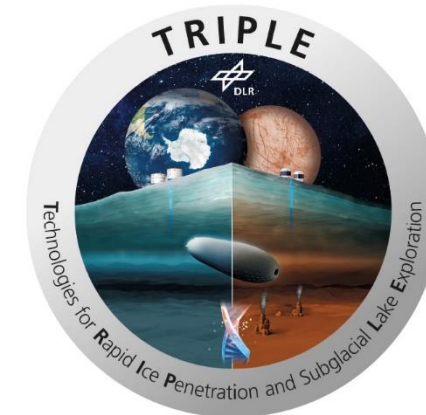
- Integration of satellite constellations

Explorer Missions

- Complex robotical tasks need to be carried out

Earth Observation

- Machine-Learning-based data processing



## Key features

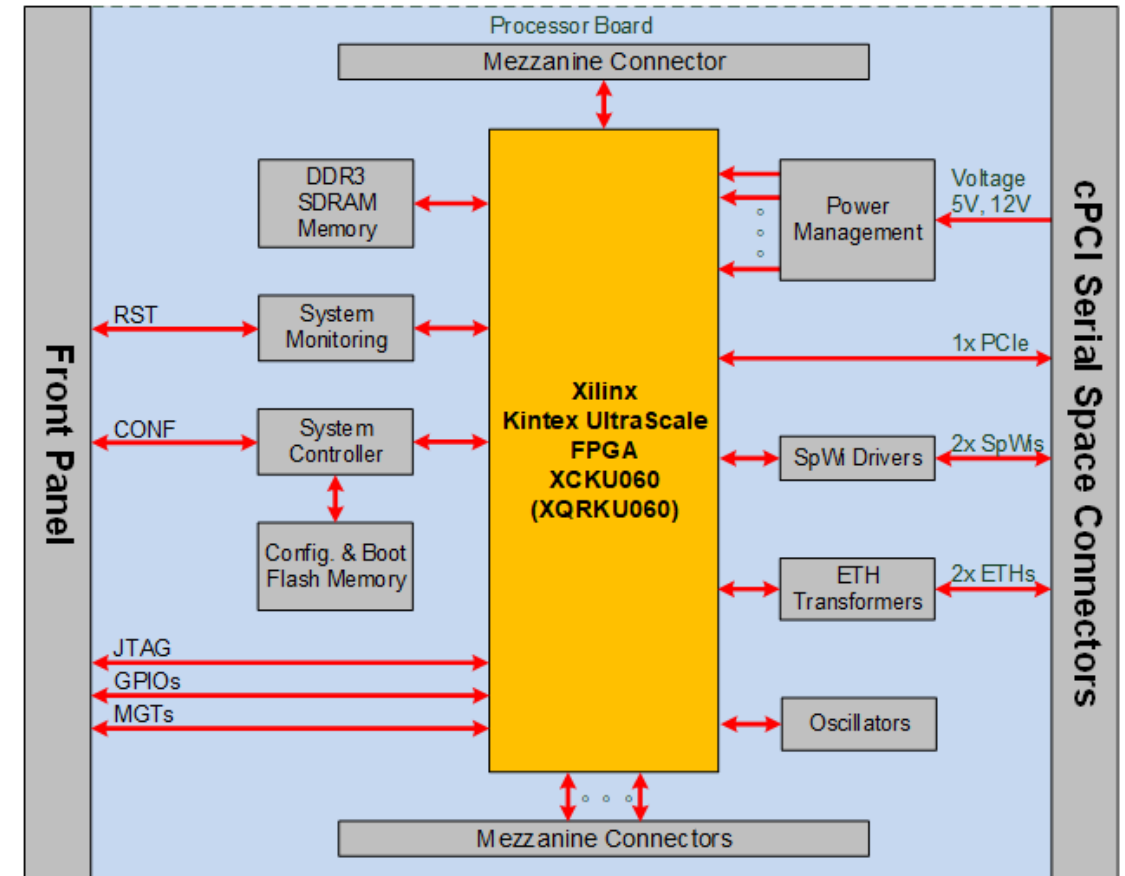
- Kintex UltraScale for Space Applications
- Various interfaces/communication protocols available

## Interfaces

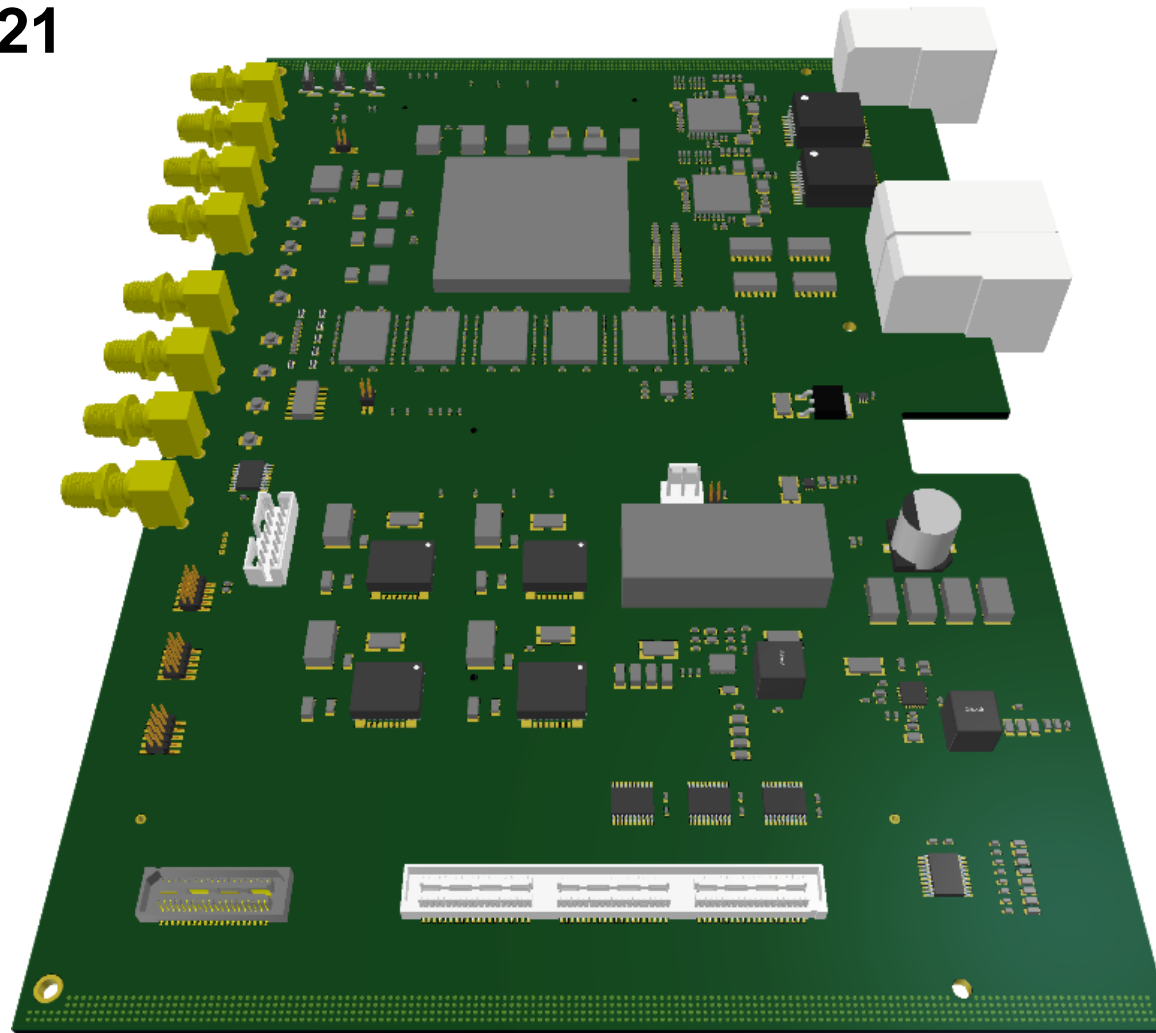
- Frontpanel: HSSL-based connectors
- Backplane: Compact PCI Serial Space (cPCI-SS)
- 2 Mezzanine connectors for expandability

## Mechanical properties

- Form factor: 6U
- Mass: < 800g (without mezzanine extension)



**EM available in Q3 2021**



### Xilinx Kintex Ultrascale device technology (20nm)

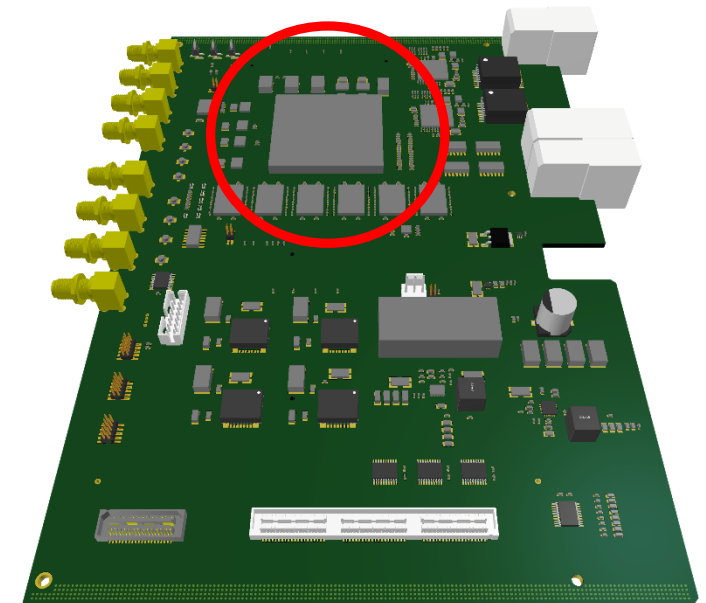
- 726k logic cells
- 2760 DSP slices
- 1080 BRAM Blocks
- High-speed transceivers (GTH)
- Full Xilinx design suite support



[www.xilinx.com](http://www.xilinx.com)

### Variants

- Radiation Tolerant (XQRCU060)
- Commercial/NewSpace (XCKU060)
- (Almost) full footprint compatibility



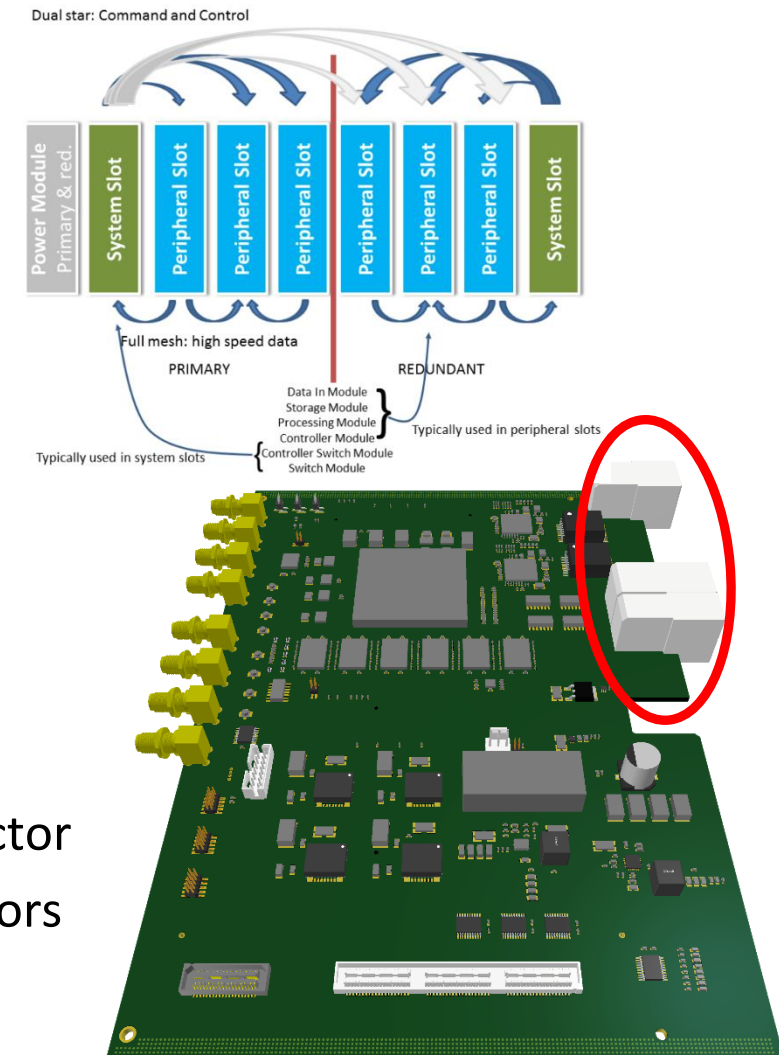


### cPCI-SS backplane standard

- Robust and reliable standard
- Enables modular assembly of space electronics
- Fixed slot profiles/pin assignments
- Supports various interfaces,
  - *2 PCIe, 2 SpW, 2 Ethernet*

### FMC-based Mezzanine connectors

- 2 LPC connectors are used for the HPDPU
- 68 user-defined signals (34 differential pairs) per connector
- Enables integration of application-specific HW accelerators





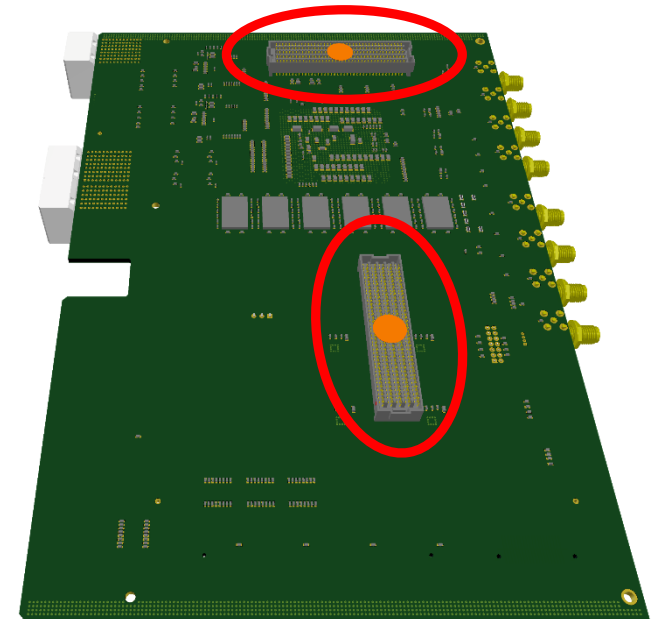
## cPCI-SS backplane standard

- Robust and reliable standard
- Enables modular assembly of space electronics
- Fixed slot profiles/pin assignments
- Supports various interfaces,
  - *2 PCIe, 2 SpW, 2 Ethernet*



## FMC-based Mezzanine connectors

- 2 LPC connectors are used for the HPDPU
- 68 user-defined signals (34 differential pairs) per connector
- Enables integration of application-specific HW accelerators

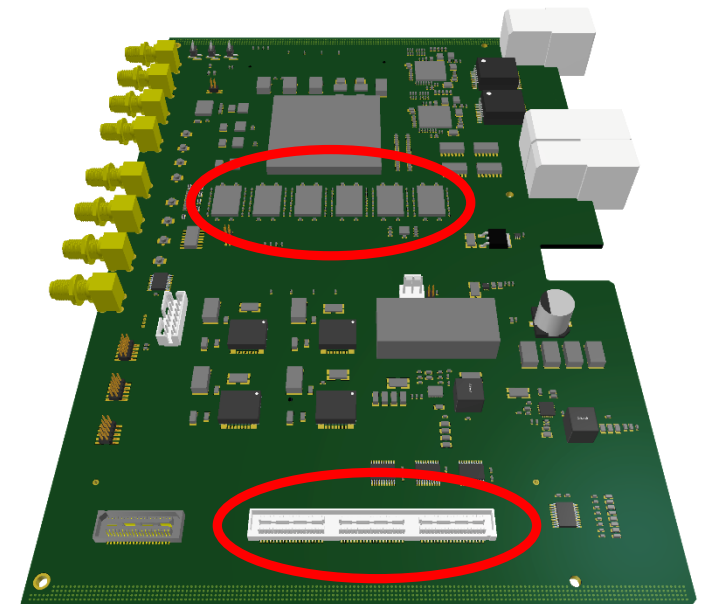


### System Control

- External programming device and scrubber
- 256 MiByte NOR-Flash

### Data Memory

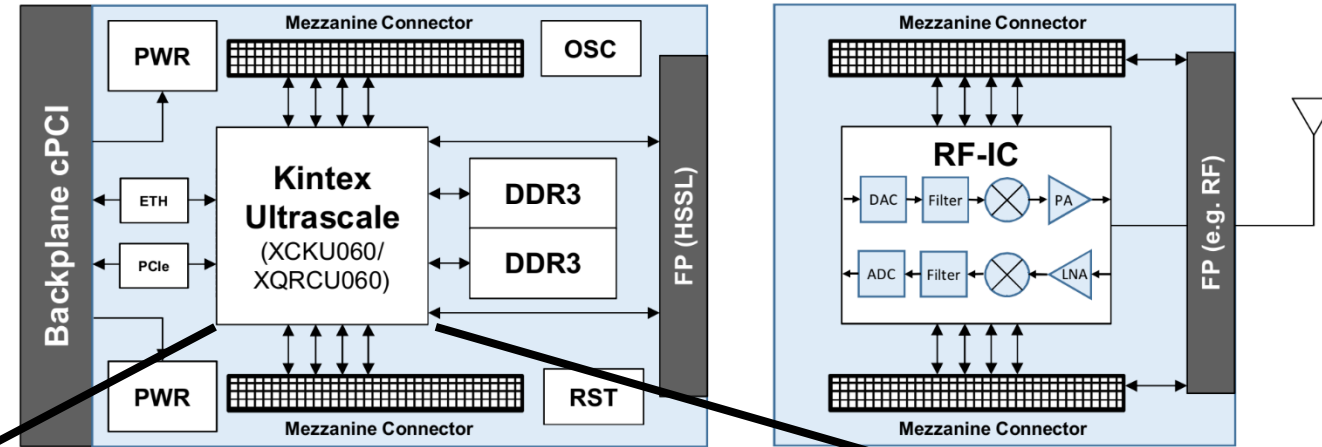
- 8 GiByte SDRAM
- Up to 16MBps throughput
- 16-bit databus
- Fault-tolerance
  - *Reed-Solomon-based error correcting codes: RS(12,8)*





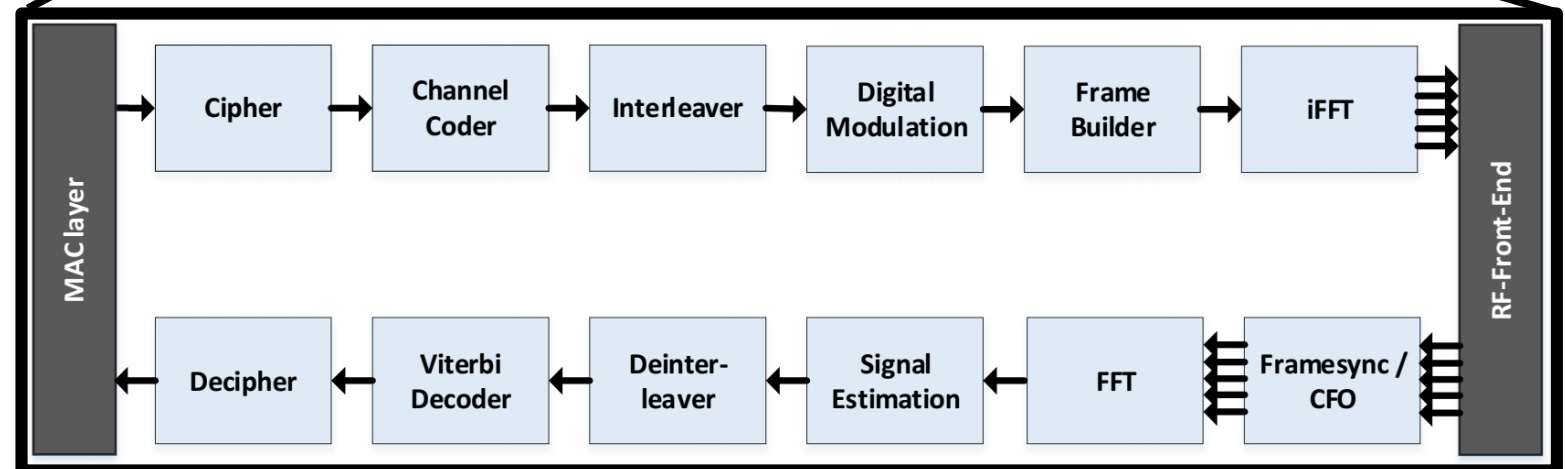
**URC-oriented BBSP**

- High-reliability, latency optimized
- OFDM-based transmission scheme
- QPSK-based modulation
- Convolutional coder
- VHDL-based design



**Implementation**

- Logic/physical synthesis
- Strategy: balanced



## Comparison to state-of-the-art FPGAs for space-applications

	Kintex Ultrascale	RTAX	RTG4	Artix-7	Zynq Ultrascale+
Device	<b>XQRKU060/ XCKU060</b>	4000D/DL	CG1657M	XC7A200	XCZU9EG
Technology [nm]	<b>20</b>	150	65	28	16
Logic Utilization [%]	<b>14.04</b>	320,59	52.00	38.41	16.98
DFF Utilization [%]	<b>7.95</b>	438.44	47,93	25.11	9.62
RAM Utilization [%]	<b>3.15</b>	11.67	28.88	12.74	3.73
DSP Utilization [%]	<b>24.49</b>	100.00	100.00	74.59	26.83
Power [W]	<b>1.15</b>	n/a	1.88	0.86	1.096
Radiation Tolerance	<b>SEL immune up to 40 MeV/mg/cm<sup>2</sup>, 100 Krad TID<sup>†</sup></b>	SEL immune up to 95 MeV/mg/cm <sup>2</sup> , 300 Krad TID	SEE immune up to LET 110 MeV/mg/cm <sup>2</sup> , 100 Krad TID	No	No

<sup>†</sup> *These values are only valid for the space-qualified XQRKU060 Kintex device*

⇒ **Very good results in terms of resource utilization and energy consumption**



- HPDPU is a novel high-performance data processing unit for various space-applications
- EM will be available in Q3 2021
- A high-end Kintex Ultrascale FPGA is used which is available as radiation tolerant and commercial device
- The cPCI-SS backplane standard provides high re-usability while offering significant cost savings for future DHS
- The FMC mezzanine connector enables an easy integration of application-specific extensions, e.g. RFIC boards

**The results highlight the HPDPU as a powerful working horse for next generation space applications**



**Thank you for your attention!**

**Questions?**

**<jochen.rust@dsi-as.de>**

**This work has been funded by**

- European Union's Horizon 2020 research and innovation programme in the project "S4Pro" under grant agreement no. 822014
- The European Regional Development Fund (ERDF) in the project "5GSATOPT"



DSI Aerospace Technologie GmbH • Otto-Lilienthal-Str. 1  
D-28199 Bremen • Germany

Phone +49 421 59696-951

Fax +49 421 59696-959

<http://www.dsi-as.de>