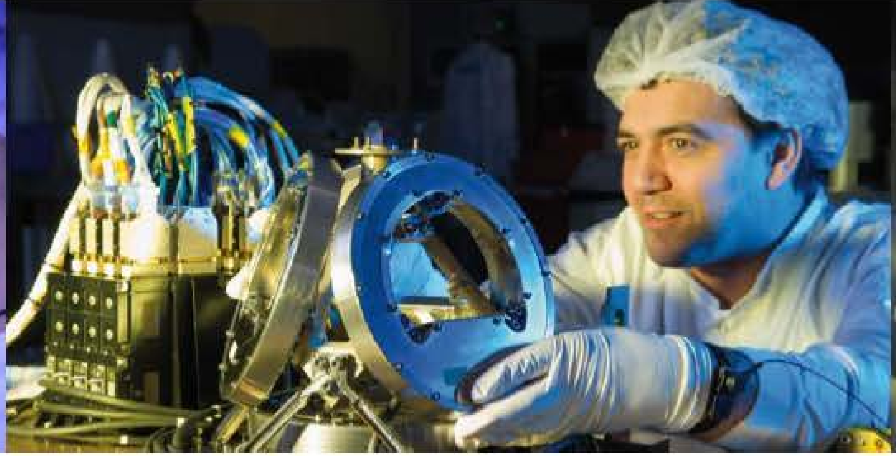
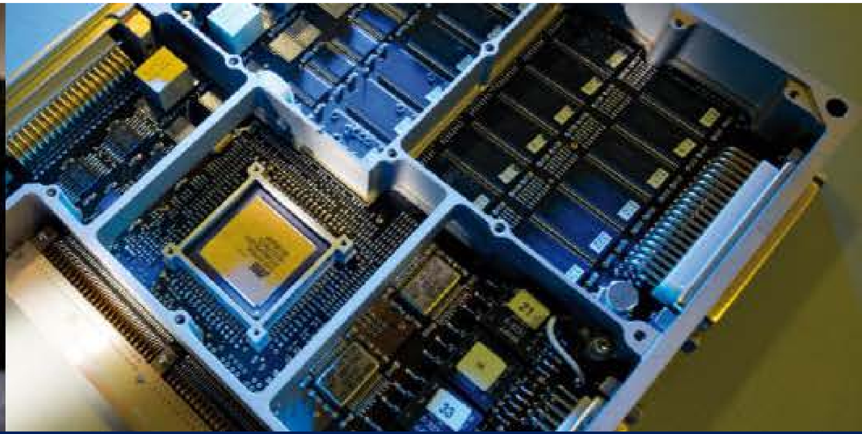




SPACE PASSIVE COMPONENTS DAYS 2018
AIRBUS DEFENCE AND SPACE ROAD-MAP





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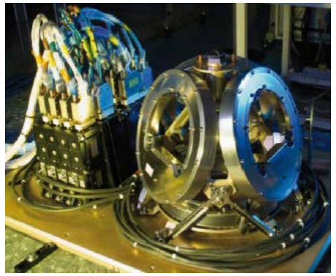
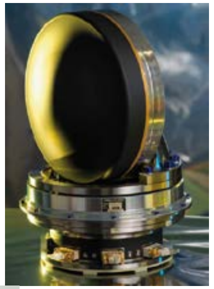
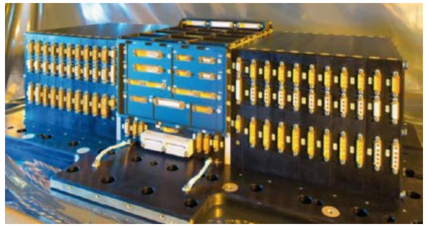
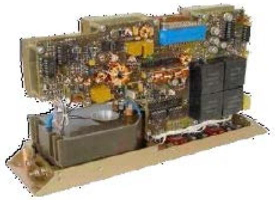
Space Equipment and TESAT within Airbus DS

Space Equipment and TESAT within Airbus DS

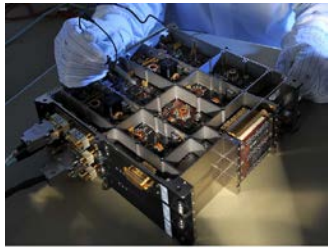
- Space Equipment
  - 1,600 persons in 5 countries, 8 sites
  - >50 types of products, 2000 boards per year
    - – Avionic: OBC, PLIU, FOG, CMG, GNSS
    - – Power: PCDU, PPU, EPC, Solar Arrays
    - – Pay-load: SSR, ICU
  - 29 countries customer base
  - 350M€ sales in 2017





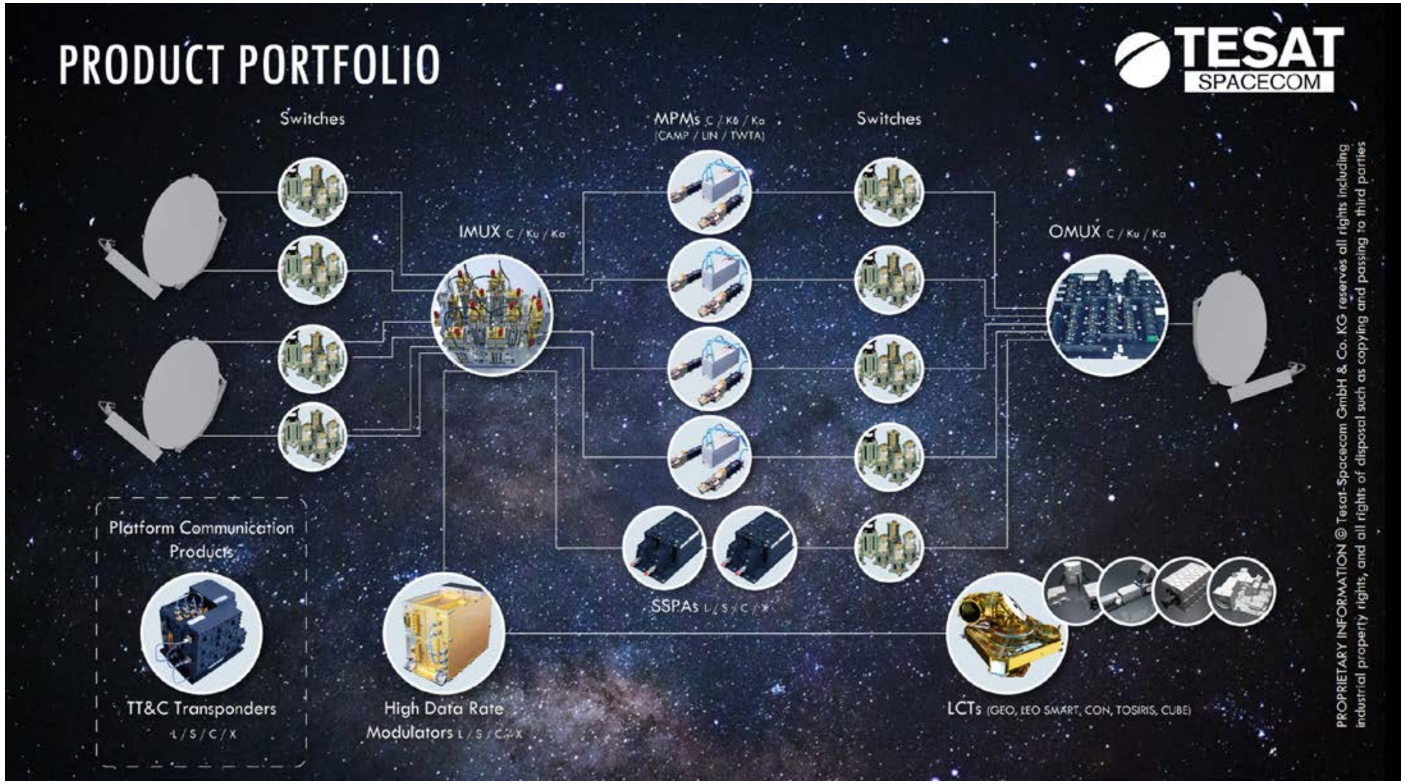





On-Board Computer, Pay-Load I/F Unit, Fiber Optical Gyro, Control Moment Gyro, Global Navigation Satellite System I/F
Power Control Distribution Unit, Power Processing Unit, Electronics Power Conditioner
Solid-State Recorder, Instrument Control Unit,

Space Equipment and TESAT within Airbus DS

- Tesat-Spacecom
  - 1,100 employees in Backnang, Germany
  - Telecom Satellite Payloads, Equipment, Subsystems & Laser Communication Terminals
    - Telecommunications:
      SSPAs, MPMs, TWTAs, Filters, Switches, Multiplexers, Assemblies like I/O-Networks, Multiport Amplifier, HDI-Equipment
    - Navigation:
      High Power Amplifiers and Passive Assemblies
    - Earth Observation:
      DL Subsystems (Hybrid), Laser Communication Terminals (GEO, LEO, CON, TOSIRIS, CUBE)
    - Science:
      Reference Laser for Gravity Measurements and LIDAR missions



700	12000	25000	47	1500	350000000
SPACE PROJECTS	CLEAN ROOM AREA [M²]	UNITS IN ORBIT	YEARS OF SPACE HERITAGE	DEVICES PER YEAR	HOURS OF OPERATION

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Key Ideas from the last SPCDs

Key Ideas from the Last SCPD 2013 and 2016

- SCPD-2013
  - Overview of passive components used in space:
    - ~80% of total components
  - Trend for the future
    - Miniaturisation
    - Lower supply voltage for IC, high frequency operation, high temperature operation, higher power for RF connectors
  - Need to be competitive for European manufacturers

Key Ideas from the Last SCPD 2013 and 2016

- SCPD-2016
  - Design for Manufacturing
    - Goal: 100% of part in automatic assembly
    - Passive part assembly qualification are critical
  - Major trends
    - VLSI like FPGA: lower supply voltage, higher operating frequency, many decoupling capacitors
    - Waiting for GaN FET for DC-DC converter
    - High data-rate interface
    - RF domain: 27-31 GHz parts are increasing, development for Q/V band running, rated power increase, connectors comes to their limits
  - Technology Status in Europe
    - The needs expressed by the space industry are almost covered with ESA qualified and/or evaluated components with the support of national agencies (CNES DLR)
    - Some missing components: chip ceramic BME in 0402, multi-anode polymer tantalum capacitors, high voltage relays, high efficient SMD magnetics
  - One word about constellation

Key Ideas from the Last SCPD 2013 and 2016

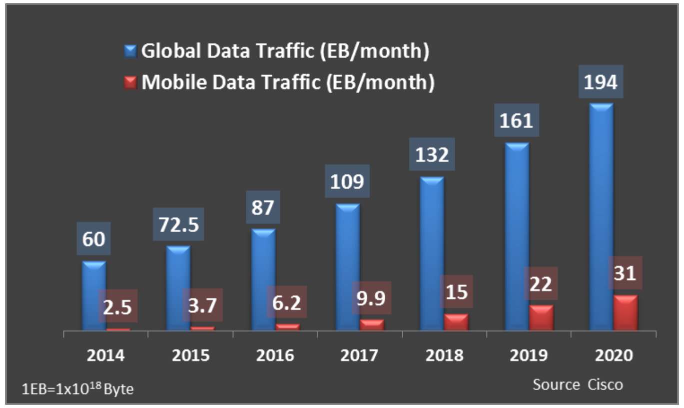
- All remarks from the two first SCPD are still valid
  - Lower size
  - Higher performance
  - Higher frequency
  - Higher power to be managed
  - Lower cost

What’s new in 2018

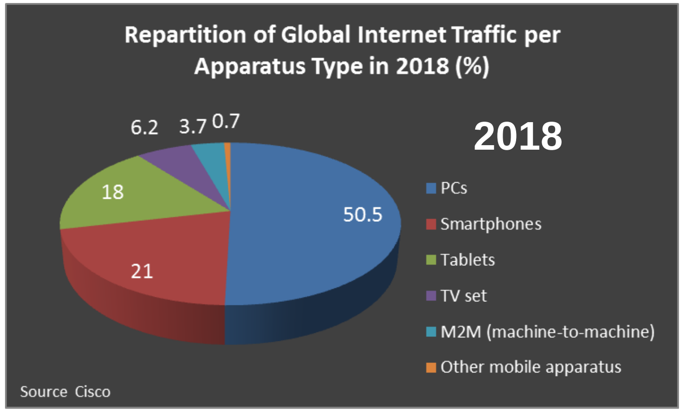
What's New in 2018

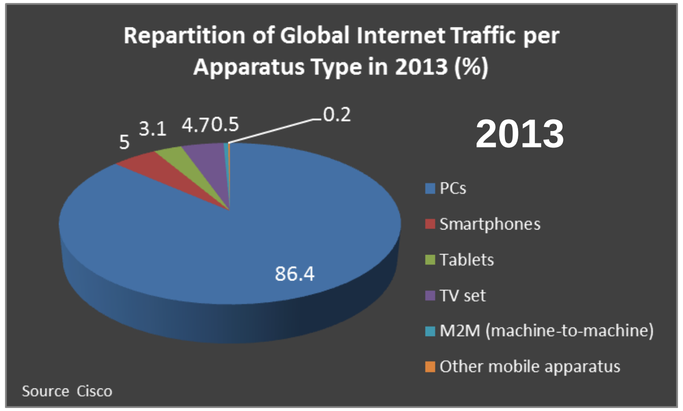
- We face a huge increase of data traffic

Exponential trend for global data traffic and mobile data



More and more Machine-to-Machine exchange (x8 in 5 years) and mobile service





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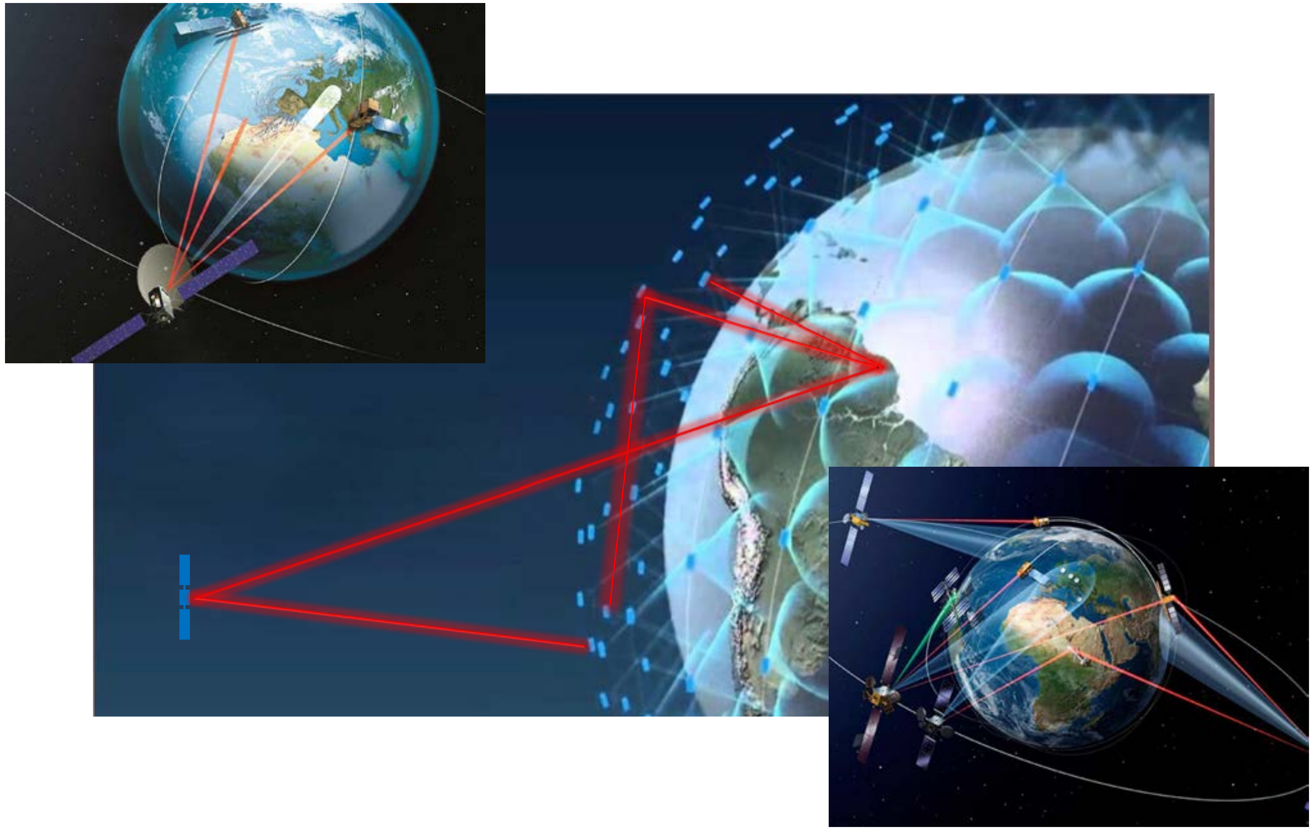
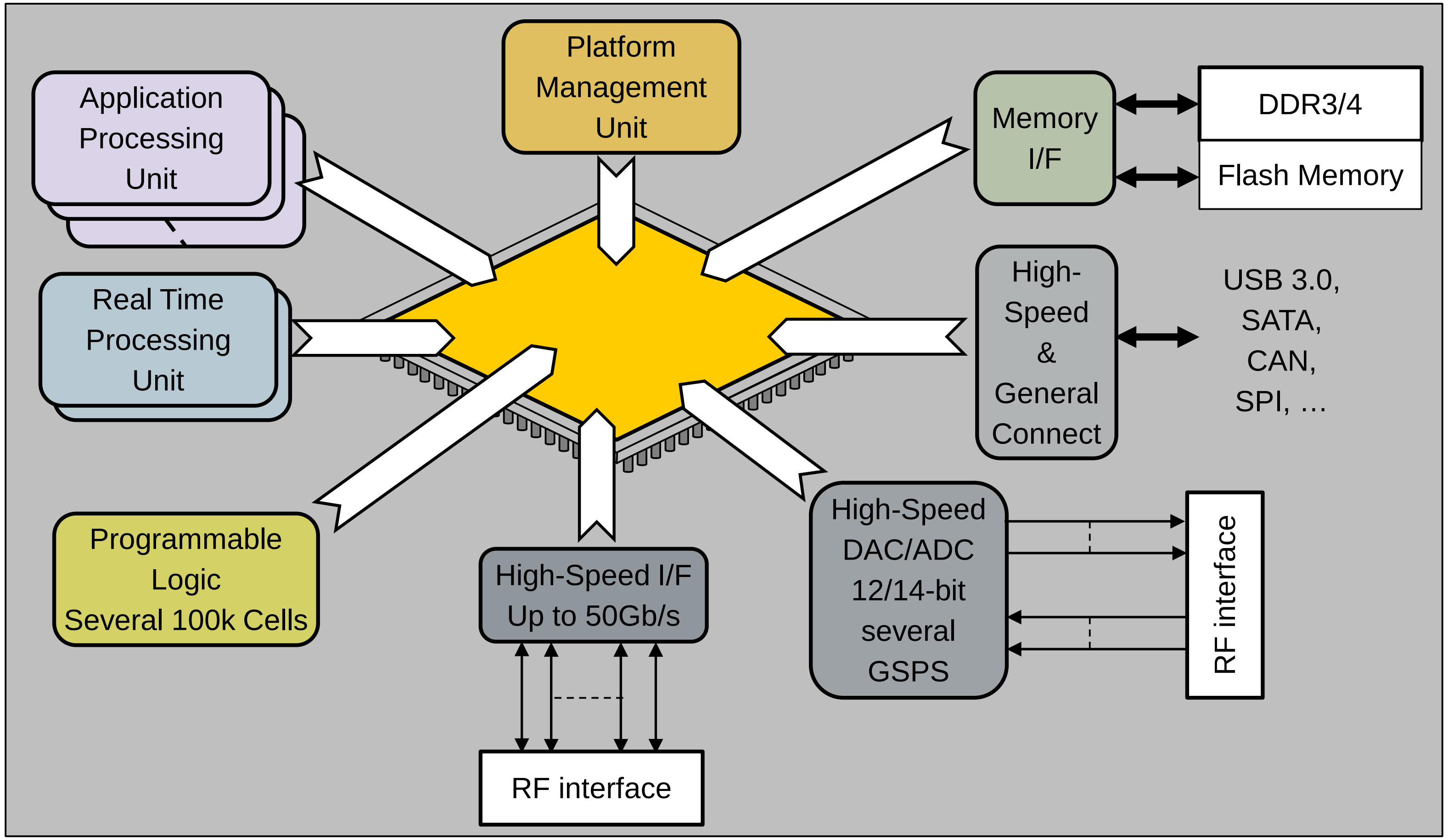
What's New in 2018

- Consequences for Data Exchange in Space
  - Move from RF to Optical Link between ground and satellites, between satellites LEO-to-GEO, LEO-to-LEO
  - Wide increase of data to be processed on board



What's New in 2018

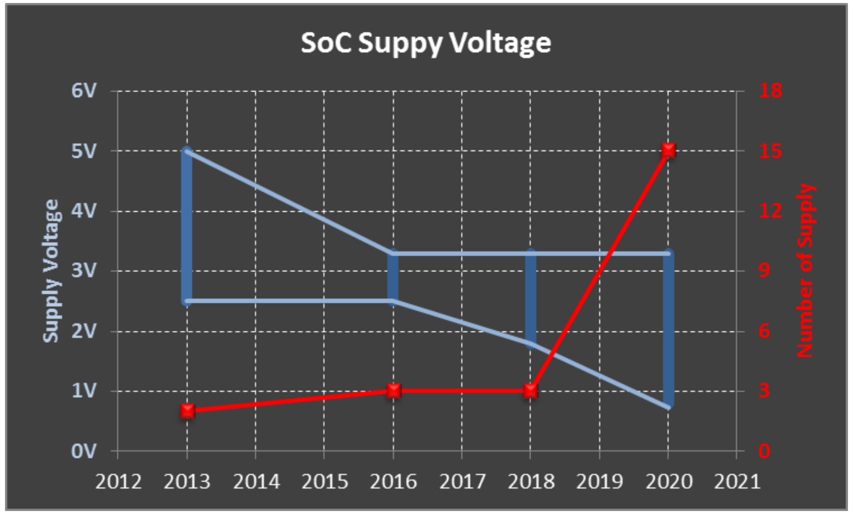
- In parallel, there are major evolutions in data processing
  - From system in box to system-on-chip
  - Mix of electronics: digital, power, RF signal interface to be managed in the same area
  - Applications:
    - Frequency Conversion, Signal Processing, Data Compression, Signal/ Data Security/Encryption, Data Storage, Telemetry and Control,



Consequences for Electronics

Consequences for Electronics

- Voltage Power Supplies for SoC
  - Number of power supplies
    - Due to the high number of different functions and interface types, more and more different supply voltages will have to be managed separately
    - Multiplication of Point-of-Load and Low-Drop-Out regulator



- Example with one SoC design

Source	Voltage (V)	Current (A)	Supplied with
VCCINT	0.720	10.40	*POL
VCCINT_IO	0.850	0.51	POL
VCCBRAM	0.850	0.05	**LDO
VCCAUX	1.800	0.40	POL
VCCAUX_IO	1.800	0.40	POL
VCCO 3.3V	3.300	0.00	LDO
VCCO 2.5V	2.500	0.00	LDO
VCCO 1.8V	1.800	0.16	POL
VCCO 1.5V	1.500	0.00	LDO
VCCO 1.35V	1.350	0.00	LDO
VCCO 1.2V	1.200	0.42	POL
VCCO 1.0V	1.000	0.00	LDO
MGTVCCAUX	1.800	0.04	LDO
MGTAVCC	0.900	0.36	POL
MGTAVTT	1.200	0.59	POL

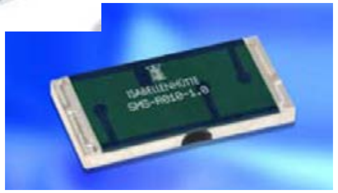
*Low Drop-Out voltage regulator, **Point-Of-Load

Consequences for Electronics

- Multifunction management
  - Increase of Electromagnetic Compatibility constraints
    - Low voltage and High current: down to 0.8V >10A, supplied by a DC-DC converter (several 100kHz)
    - High frequency interface: 25GHz, even more in a near future
    - DRR3/4 memories: high data-rate exchange
    - Low voltage data monitoring for the supply currents

Consequences for Electronics

- Consequences for passive parts
  - Decoupling capacitor for FPGA and SoC can have a major impact on surface
    - – Use of low voltage, high capacitance, low size, last generation of BME ceramic capacitors are mandatory
    - – In addition, large capacitance, low voltage and low ESR: tantalum, polymer multi-anode
  - Supply voltage functions: point-of-load and low drop-out voltage regulator
    - – Use of low voltage, high capacitance, low size, last generation of BME ceramic capacitors are mandatory
    - – In addition, large capacitance, low voltage, tantalum, polymer, multi-anode (but ESL could be a limit with high-frequency switching operations)
    - – High current inductors
    - – Shunts are mandatory for overload protection



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Consequences for Electronics

- Consequences for passive parts (cont'd)
  - Module interconnection
    - Very high-frequency connector (from 6 to 25 Gb/s up to 50Gb/s) with many channels in parallel, press-fit or BGA technology
  - EMI management
    - Introduction of 0402 RF inductors
    - Introduction of Chip ferrite beads for power applications

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New Space

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New Space

- Behind these words there are many different interpretations
  - Use of commercial parts with the same reliability goal than space qualified parts
    - Already done since many year for extended range
    - COTS philosophy for passive parts: same techno and package, same screening and lot validation than space components
    - SnPb finish can be asked
    - But without major cost reduction vs qualified components
  - Use of commercial parts without any additional screening test
    - Considerable cost reduction (at least by 100)
    - ROHS finish compliant: Pb free
  - The next slides refer to the last definition

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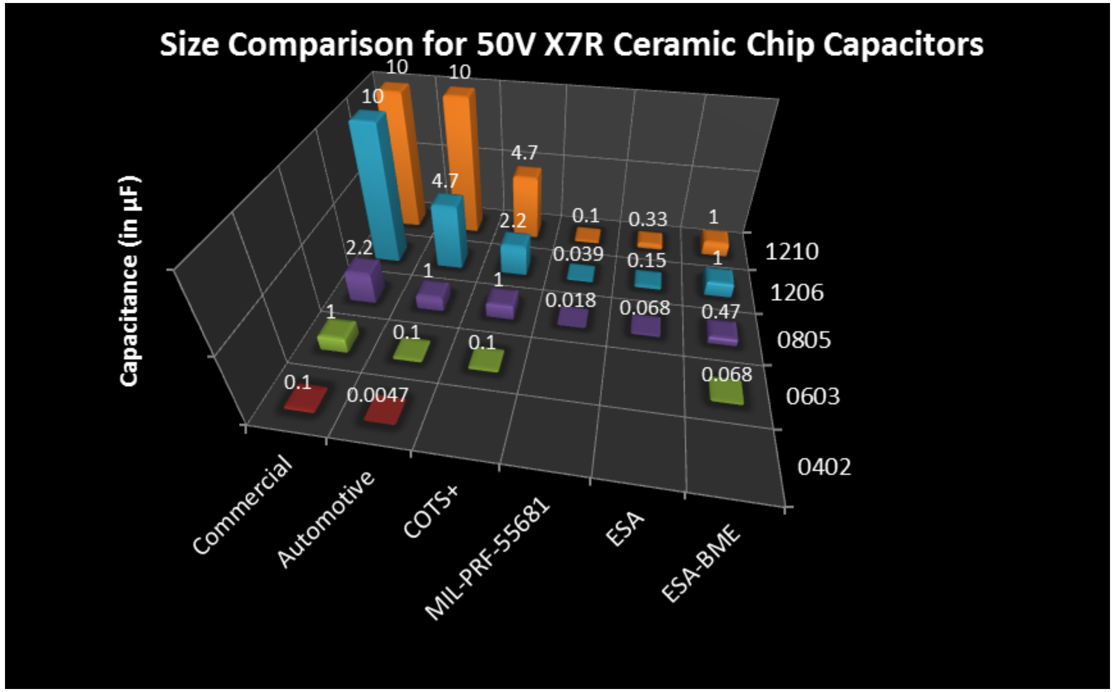
New Space

- Advantage of automotive components:
  - Example with chip ceramic capacitor
    - – Cost:
      - – Between ESA and Automotive: **x** 400
      - – Between COTS+ and Automotive: **x** 100
    - – Miniaturization
      - – Can be mandatory: due to radiation issue, replacement of IC by discrete solution requiring more space
      - – Example with ceramic chip capacitor:
        - – size Comparison from a manufacturer supplying capacitors from commercial to full qualified ESA and MIL, including BME techno:
        - – for 1210 size 50V, from 0.1µF in MIL qualified to 1µF in ESA BME, up to 10µF in automotive
    - – Continuous production quality survey and improvement



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New Space

- Drawbacks of Automotive components
  - Automotive vs Space Environment and Requirements
    - Traceability ✓ (But can be limited, difficult access to manufacturer data)
    - Assembly qualification ✗ (To be assessed like all components)
    - Space environment
      - Temperature range ✓
      - Mechanical vibrations ✗ (But qualified through the assembly qualification)
      - Mechanical shocks ✓ (checked through the assembly qualification)
      - Thermal cycling ✓
      - Radiation ✓ (No passive part are considered as radiation sensitive)
      - Out-gassing ✗ (To be assessed, especially for inductors, transformers, connectors)
    - Long term operation ✓(But not on the lot)
    - Early failure rate ✗ (No specified screening procedure)
  - Lack of lessons learned in space mission

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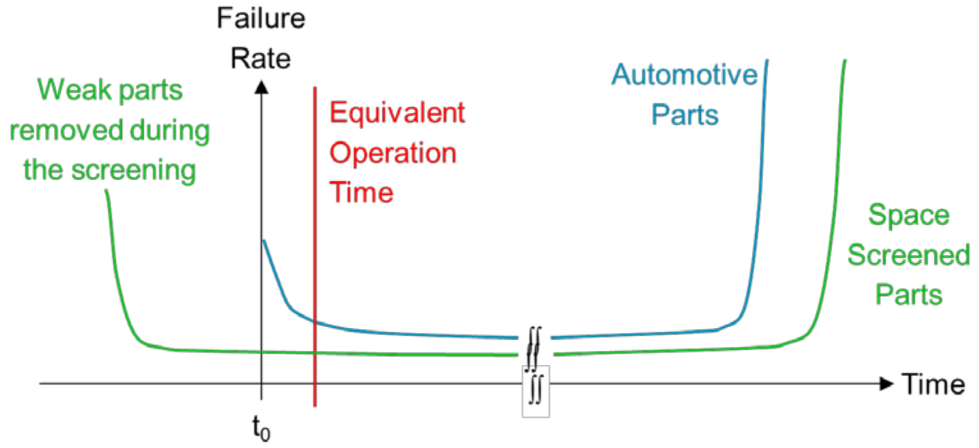
New Space

- Early failure rate
  - Example based on ceramic capacitor
    – According to Prokopowicz and Vaskas model: $\frac{t_1}{t_2} = \left(\frac{V_2}{V_1}\right)^n exp\left[\frac{E_a}{K}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right]$
    – MIL-PRF-55681 <u>voltage conditioning during the screening</u>:
    100 hours with 2 x Vrated at 125°C, are equivalent to
    111 years at 0.5 x Vrated at 75°C, with n=3 and Ea=1.2 e.V
    – AEC-Q200 <u>operational life conditions</u>:
    1000 hours with Vrated at 125°C, are equivalent to
    139 years at 0.5 x Vrated at 75°C, with n=3 and Ea=1.2 e.V



  - Therefore, the screening conditions for space qualified components are equivalent to the operational life conditions for AEC-Q200!

  - The failure rate will be higher for sure
  - But the redundancy management is done at the constellation level and not at the satellite level

New Space

- Current Space: Telecom Satellites
  - Since 1990, 66 have been launched:
    - 49 still in operation
    - 17 retired from services having exceeded their planned service life time
  - Representing 600 cumulated years
  - None have ever been lost in orbit

- New Space: Mega-constellation of ~1000 satellites
  - Will be launched in a 2 year period of time
  - 6 year operations
  - By the end of 2025 10 times more cumulated years in orbit

- We have to be patient
- See you the next SCPD

REACH - Pb Metal Included in *SVHC Candidate List

*Substance of Very High Concern

REACH - Pb Metal Included in *SVHC Candidate List

*Substance of Very High Concern

- The regulatory developments on Pb metal continue at fast speed:
  - In June, Pb metal has been included in the SVHC Candidate List
  - Immediate consequences about the substance identification when concentration >0,1% weight/weight
  - Estimated Annex XIV timeline to work with is

Milestone regarding Annex XIV	Reasonable worst-case date / timeline
Candidate List inclusion	27 June 2018
Priority setting: Public Consultation on Draft ECHA Annex XIV Recommendation including Pb metal	September – November 2019
Final ECHA Recommendation	2020 (first half)
REACH Committee vote	2020 (second half)
Inclusion in Annex XIV	2021
Latest application date	2023
Sunset Date	2024

  - 2024 is tomorrow!
  - Best case: same than RoHS, for which the equipment designed to be sent into space are excluded from the regulation without a time limit
  - Worst Case: no more lead, even for space

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Thank you