PHOTONICS, COTS AND NEW SPACE: FUTURE CHALLENGES FOR RADIATION QUALIFICATION

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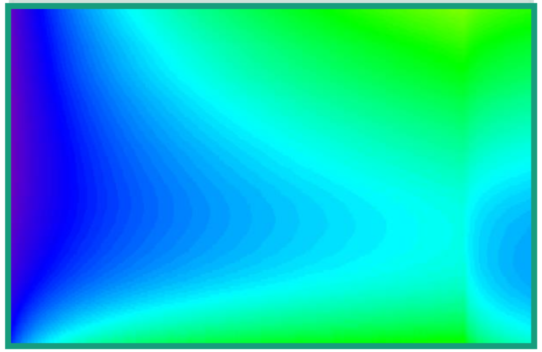
Business unit NEO

- Investigation and application of effects induced by ionising radiation in electronic and optic components and systems since early 1980ies

Experimental Work

- Planning, conduction and analysis of irradiation tests
- Characterising radiation sensitivities
- Wide range of test equipment



Consulting on radiation effects

- Design of standard-compliant tests
- Selection and qualification of components
- Mitigation and hardening concepts

QUALITY SYSTEM CERTIFICATION
DNV·GL
ISO 9001

Operation of irradiation facilities

- Three in-house Co-60 facilities for TID
- In-house Neutrons for DD
- Dedicated exclusive irradiation stations at external facilities

Simulations

- Radiation transport
- Environment modelling
- Shielding calculation
- Dose and fluence estimation

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Radiation testing of photonics – Part I

- Optical fibres (more than 200 tests completed)
  - All types: Single mode, Graded index, Step index, Polarization maintaining, Photonic Crystal Fibres, Amplifiers, Fibre lasers
  - Irradiations done with Gammas, Neutrons, Protons, X-Rays
  - Dose rate: 5 rad/h to 500 krad/h up to doses of 200 Mrad for Gamma
  - Wavelength: 300 nm to 1700 nm
  - Temperature: -263°C to 400°C
  - Measurements: Discrete and spectral attenuation, Bandwidth, Gain
  - All test steps done in house
    - Splicing, sample preparation, irradiation, analysis
    - Wide range of measurement equipment and setups available

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Radiation testing of photonics – Part II

- Fibre Bragg Gratings (more than 50 tests completed)
  - UV Type I/II, fs-Phasemask, fs-Point, LPG, Chiral gratings, Tilted
  - Measurement of Bragg-Wavelength-Shift and Amplitude
  - Dose rates and temperatures as above

- Passive components (more than 40 tests completed)
  - Filters, Substrates, Coatings, Prisms, Gratings, Couplers, Connectors
  - Gamma, Electrons (10 keV to 10 MeV), Protons (150 keV to 35 MeV)
  - Measurement of transmission: 500 nm to 2000 nm
  - Optimized experimental approaches for surface or volume effects

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Radiation testing of photonics – Part III

- Opto-Couplers (more than 30 tests completed)
  - Wide range of types and manufacturers covered
  - TID Tests with Gammas, TNID with Neutrons and Protons
- Light sources (more than 20 tests completed)
  - Laser diodes, fibre lasers, LEDs
  - Measurement of optical power, wavelength, bandwidth and all relevant electrical parameters
- Light detectors (more than 20 tests completed)
  - Photo diodes, APDs, Image sensors
  - Measurement of sensitivity, noise, optical and electrical parameters
- Additional: More than 300 tests of other electronics and components

What is the difference between …

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"New Space" characterization
What makes the difference?

- Orbit
  - Typical New Space projects are in low orbits → lower dose rate, well defined environment
- Duration
  - Satellites should survive 3-5 years → shorter time at lower dose rate = lower dose
- Swarms
  - Several satellites with system redundancy → Early failures are not mission critical
- Risk
  - Not aiming at 300% reliability → Success probability could be below 80%
- Purpose
  - The satellite does not matter at all → Is about solutions, not products

Use of COTS key factor in New Space projects
What are consequences with respect to radiation?

- Price
  - Buying COST components is cheaper
- Generation
  - COTS offers latest generation of technology
- Time
  - Delivery times are shorter
- Possibilities
  - Newer solutions available than High-Rel
- Volume
  - COTS produced in large quantities

- Price
  - Radiation testing might be more expensive
- Generation
  - Previous test results are obsolete
- Time
  - Qualification takes a lot of time
- Possibilities
  - Selection, which product should be tested
- Volume
  - Lot variation could be severe problem

Radiation qualification of COTS for Space
Possible process

Specification
- What is needed, what properties are desired and what is just nice to have

Pre-Selection
- Identify pre-qualified markets (e.g. automotive, aerospace) and list candidates

Pre-Screening
- Fast, cheap, smart pre-testing of candidates to reject clearly unusable components

Define test scenario
- Application specific, tailored and efficient tests with risk quantification approach

Qualification
- Parameter focussed method to provoke failures, alternative candidates considered

COTS and Photonics
What does that mean for us?

Rad hard components	COTS components	Photonic components
Available for space applications	Not specifically space aimed	No real space market
Universal products with wide use	Selected for specific application	Selected for specific application
Mature, slow technology	Cutting edge	Pretty high end
No conventional pressure	Challenging markets	Driven by terrestrial applications
Interest in space	Does not care about radiation	No primary design goal
Strictly regulated	Expect flexible space standards	Nearly no standards existing
Heritage counts	No heritage available	Some experience available

Photonics for New Space
Conclusions

- Photonics much closer to New Space than traditional electronic space components
- Users already know that they have to adapt and will not get Plug’n’Play
- Currently discussed processes for COTS electronic components might not be suited for photonics
- No standards in the way (but maybe there should be some)
- Development of efficient qualification methods is required
- New Space applications are ideal use cases for photonic technologies

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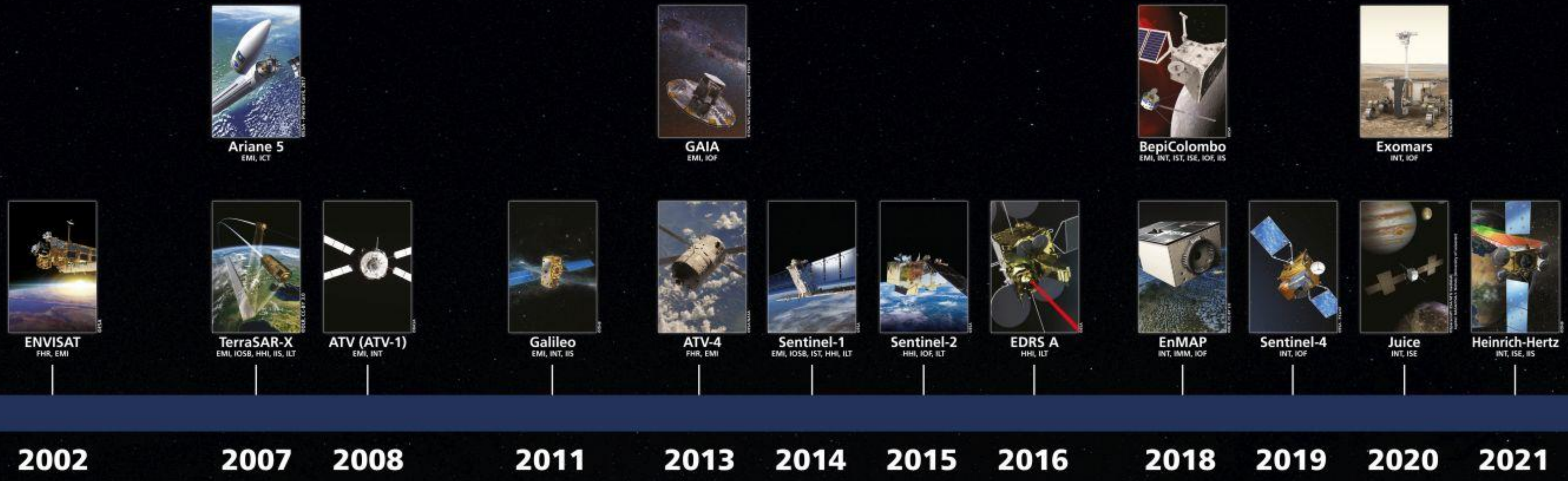

Thanks a lot for your attention!

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Other Missions

Mission	Date	Institute
LDEF	1984	EMI
GIOTTO	1985	EMI
Raumstation MIR	1986	FHR
Olympus	1989	EMI
ROSAT	1990	FHR
HUBBLE	1990	EMI
BeppoSAX	1996	EMI
ADEOS I und II	1996	FHR
COLUMBUS	1997	EMI
CODAG	1998	IOF
X-38	1999	EMI
Spot 5	2002	EMI
COLUMBUS II	2004	EMI
MSG Meteosat Second Generation	2004	INT
UWE	2005	INT
SAR-Lupe	2006	IOSB
Met Op	2006	EMI

COSMO-SkyMed	2007	IOSB
RADARSAT2	2007	EMI, IOSB
US-NFIRE	2007	HHI, ILT
Don Quijote	2007	EMI
RapidEye	2008	IOF
GOCE	2009	EMI
Herschel-Planck	2009	EMI
Tjangong	2011	FHR
Spektr-R	2011	EMI
Phobos-Grunt	2011	FHR
ARTES 5	2012	EMI
SARah	2013	IOSB
Phootprint	2014	EMI
LOFT	2014	EMI
DLR-Hayabusa 2/MASCOT	2014	IST
Eu: CROPIS	2014	EMI
Kent Ridge 1	2015	EMI
Lisa Path finder	2015	INT

ROSETTA	2016	EMI
SCDisrupt	2017	EMI
DESIS (ISS-MUSES)	2017	IOF
GRACE follow	2018	IOF
AEOLUS/aladin-TAO	2018	IOF
James Webb Weltraumteleskop	2018	IOF
Merlin	2019	INT
Biomass (ESA)	2020	INT
NASA Mars Rover 2020	2020	IST
Europa Clipper	2020	INT
EUCLID	2020	INT
Sentinel-5	2021	IOF
MetOP SG	2021	IST
ERNST	20XX	EMI, INT IOSB
FLEX/FIMAS	2022	IOF
CarbonSat	2023	IOF
Lisa	2034	INT

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