DLR EEE-Components Activities
ESCCON, 8th March 2023

Thilo Kaupisch
German Aerospace Center (DLR)
German Space Agency
Robotics, Digitalisation and AI

Content

- Development and Qualification Programs
- ESCC Qualifications of German Manufacturers
- Maintenance of Qualification
- Consultancy of Companies
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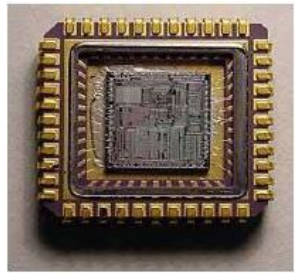
  - Space 2Motion
- Further COTS Activities
- International Cooperation

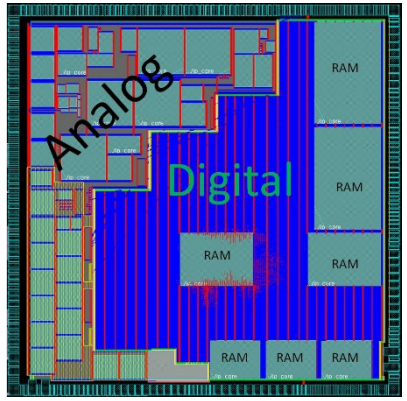
SPAC: Capability Approval of a Commercial ASIC Technology

Activity	Status	Budget/k€	Remarks
50PS1401 Capability Approval Testing Phase of an IMST ASIC Technology based on 0.18 Micron CMOS Process by X-Fab Malaysia and Assembly	**Completed**	2.075	**Completed:** Evaluation Phase Qualification Phase **Next steps:** ESA Review of Application Data Package **Project duration:** October 2014 – August 2022

SPAC: Capability Approval of a Commercial ASIC Technology



- **IMST** is responsible for the complete supply chain, part of the activities are subcontracted
- **Evaluation Phase – completed:**
  - Rad-hard library based on XH180 process developed
  - Evaluation Test vehicles tested acc. ESCC226900
  - Rad-hardness of all IP either 100krad or 300krad, no destructive SEE up to 88MeV/mg/cm²
- **Qualification Phase - completed**:
  - Minor modifications of rad-hard library implemented (improved performance)
  - P.I.D. and related documents, Capability Abstract, Detail Specification released
  - Completion of all qualification tests iaw. the test plan/ chart F4 of ESCC9000, finalization of qualification test reports
  - ESCC Audit dedicated to SPAC performed by DLR and ESA at IMST‘s premises on 19th +20th of July
  - Audit performed by DLR and ESA at RoodMicrotec (test house) in Stuttgart on 28th of July
  - DLR Review of Qualification Data Package, Application for ESCC capability approval submitted to ESA
- **Next Steps:**
  - Qualification Data Package and application for ESCC capability approval under ESA review



Layout / Floorplan of Qualification Test Vehicle

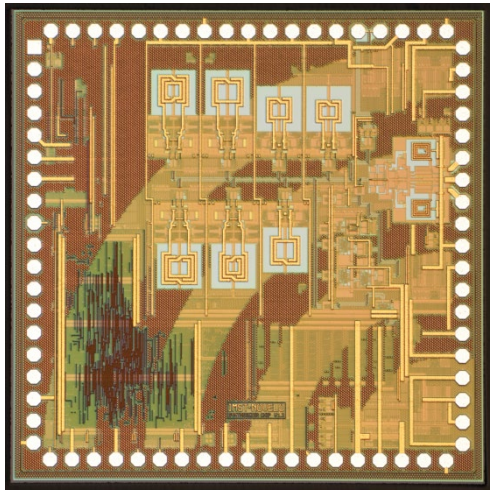
ESCC Evaluation and Qualification of a fractional N Synthesizer – “NOVELO”

Activity	Status	Budget/k€	Remarks
50PS1605 ESCC Evaluation and Qualification of a fractional N Synthesizer – “NOVELO”	**Completed**	1.800	**Completed:** Evaluation Phase Qualification Phase **Next steps:** NCCS closure **Project duration:** November 2016 – December 2021

ESCC Evaluation and Qualification of a fractional N Synthesizer – “NOVELO”

- **IMST** is responsible for the complete supply chain, whereas some activities are subcontracted:
  IHP: wafer-manufacturing, SGB25RH technology
  MPD: wafer dicing
  RoodMicrotec: wafer testing, test support during evaluation/qual.
  Serma: hermetical sealing**,** leakage testing; Kyocera: package

  1.6…12 GHz, 1-chip fractional N synthesizer (2.6 x 2.6 mm²)



- **Completed:**
  - Package re-designed, based on castellations, Kyocera PB-CB 8187, CQFN-32
  - Detail Specification ESCC9202/085
  - All Evaluation Tests completed
  - All qualification tests acc. to the Qualification Test Plan based on ESCC9000 Chart F4 successfully completed
  - Final qualification data package acceptable to ESA, certificate is pending NCCS closure
- **Open:**
  - Close-out of NCCS related to mounting capability testing

Comparative Laser- and Heavy ion irradiation to characterize the SEE sensitivity of components – LUNT(E_2)

Activity	Status	Budget/k€	Remarks
50PS2105 Comparative Laser- and Heavy ion irradiation to characterize the SEE sensitivity of components – LUNT(E2)	Running	400	**Completed:** First irradiation at GSI Microbeam and presentation of first results at DLR EEE-Components Conference, adaptation of a laser micro drilling setup for transistor backside decapsulation 2nd Irradiation at GSI microbeam (29.05.-31.05.) **Next steps:** Data evaluation of GSI tests, evaluation of the laser micro drilling setup **Project duration:** April 2021-March 2024

Comparative Laser- and Heavy ion irradiation to characterize the SEE sensitivity of components – LUNT(E_2)

- **Partner**: Ernst Abbe University of Applied Sciences

- **Objective**: Comparative analysis of Single-Event-Effects with Lasers, Heavy ions (high and low LET) and which parameters have an impact on the assessment. Chosen components will be Super-junction power semiconductors (CoolMOS) and microcontrollers.
- Identify an inexpensive test methods, which is easy to carry out, for routine investigations. Contribute to a clearer understanding regarding the use of Lasers for SEE-Tests and a well founded assessment of the potential of this technology,

- **Project Status:**
  - 2 Irradiation campaigns at GSI microbeam,
  - preparation of samples for Laser tests
  - ongoing implementation of an upgrade of the laser system

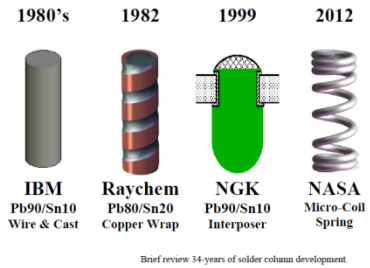
Development of a Soldering Process for Micro-Coil-Springs (MCS)

Activity	Status	Budget/k€	Remarks
Development of a Soldering Process for Micro-Coil-Springs (MCS)	Running	130	**Completed:** Micro-coil springs were assembled into three test vehicles. Visual inspection and X-Ray were performed with some observations: small tilted springs, small solder voids etc. Failure criteria for this construction type and result will be evaluated trough the testing campaign. MIP took place 20th Sep. TRR scheduled 21 Oct 2022. **Next steps:** Completion of the mechanical assembly and performing the environmental test: mechanical and thermal cycling test **Project duration:** January 2019 - February 2023

Development of a Soldering Process for Micro-Coil-Springs (MCS)

- **Responsible:** OHB

- **Initial situation:**
  Temperature stress induces into Packages with a high Number of Pins
  high mechanical stress. MCS avoid this by design.



Brief review 34-years of solder column development.

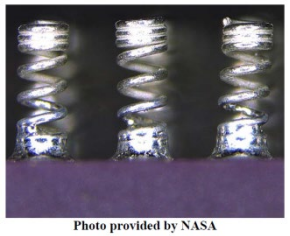


Photo provided by NASA

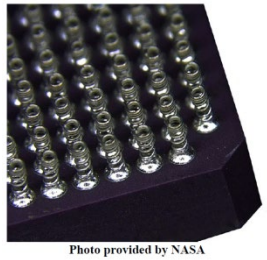


Photo provided by NASA

- **Target:**
  Use of Micro-Coil Springs to replace the standard CCGA solder columns by more reliable interconnects – Excellent performance regarding thermal cycling. This enables the use of certain standard PCB substrates like FR4 or Polyimide with large ceramic devices.

CMOS-TDI detector – Phase 1a Architecture

Objectives:

- Development of a CMOS based Time-Delay-Integration sensor architecture
- No Pixel: 2k … 20k
- Pixel pitch: 7µm // staggered by mask 3.5 µm
- FW: 200 ke-
- TDI steps: 256
- 12 Bit Dynamic Range
- RMS-Noise: < 2 LSB
- MTF[NY]: > 50%
- On chip: ADC[12 Bit], CDS[on/off], PRNU,DSNU, offset correction
- On package: Flash RAM, fiber transmitter, TM/TC&PPS-IF

Players:

- DLR Institute of Optical Sensor Systems
- Jena-Optronik GmbH
- IHP GmbH Leibniz Institute of innovated Microelectronics
- Fraunhofer Institute for Microelectronic Circuits and Systems (IMS)

Timeline:

- Phase 1a: 01.03.2021 bis 30.09.2021 (closes with PDR)

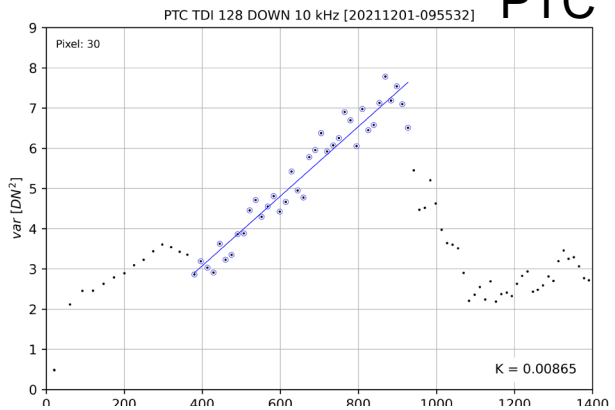
Funding:

- 1,385,243.- € federal grant

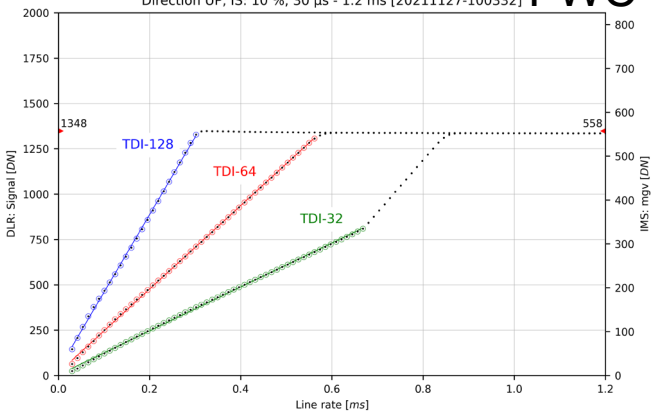
Results: Kick-Off, MTR1, MTR2, MTR3, PDR

CMOS-TDI first Test Chip results

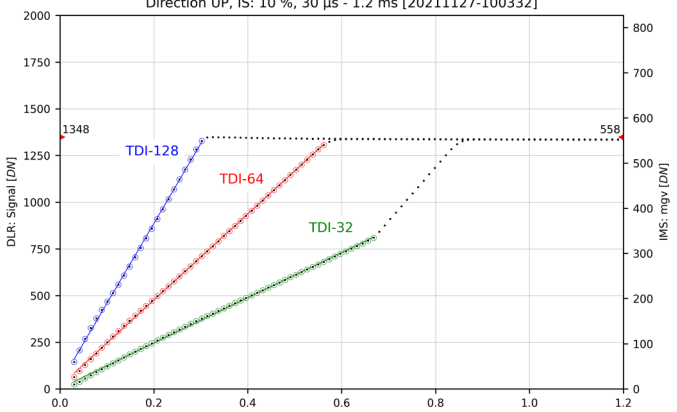
PTC



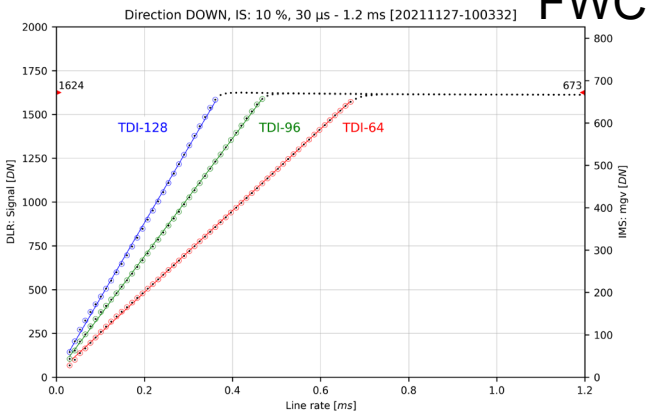
FWC



Linearity



FWC



PTC: Photon Transfer Curve
FWC: Full Well Capacity

	UP	DOWN
Saturation Level	1348 DN	1624 DN
K_1 = 0.00595 DN/e-	**FWC: 227 ke-**	**FWC: 273 ke-**
K_2 = 0.00865 DN/e-	**FWC: 156 ke-**	**FWC: 188 ke-**

GSTP Projects (1)

DLR EEE Component Division is involved as Technical Advisor and Observer in five EEE parts related GSTP projects with German actors

ATCOS (alternative test method for COTS)
Contractor(s): OHB, DSI, HTV, Berns Engineers, DLR Institute of Space Systems, Alter
Objective(s):
1) Gain further insight into reliability of commercial (automotive) parts.
2) Investigate the effectiveness and suitability of board/unit compared to EEE Component level testing.
3) Address new highly accelerated test methods (HASS, HALT)

ESCC Space Evaluation of 0.13um SiGe BiCMOS Technology
Contractor: IHP

Manufacturing, test development and evaluation of a monolithic, rad-hard ECM LVDS component family
Contractor: Space IC

GSTP Projects (2)

Definition and validation of a European source of bump services for 28nm and lower nodes flip-chip mounting
Contractor: Aemtec

Objective: To enable a validated European source for flip-chip wafer bumping for microelectronics packaging for VLSI technology (ASIC, FPGA, Memories, etc)using a technology node of 28 nm or smaller

RACOCO: Radiation characterization and functional verification of COTS components for space applications
Contractor: Fraunhofer

Objectives:
Characterize and assess COTS components and subsystems for radiation performances.
Critically survey components candidates and test methods.
Propose COTS guidelines to the CTB Radiation working group

Further DLR Activities – ESCC Qualifications of German Manufacturers

new qualifications

Qualification of Diodes and Transistors iaw. ESCC 5000 and ESCC 5010 - **Infineon**	ESCC 3901 Qualification of Type LEW Cables – **GORE**	ESCC Qualification of Resistors – **Isabellenhütte**
BAS70-04 and BAS40-05 per ESCC5512/020, Variant 04 and 05 BXY42-03 per ESCC5513/017, Variant 03 BXY43-09 and BXY44-10 per ESCC5513/030, Variant 09 and 10 BFY193F per ESCC5611/006, variant 09 BFY650B-12 per ESCC5611/010, variant 05 MOSFETS – 650 V Rad-hard BUY65CS MOSFETS – 60V Rad-hard BUY06CS → completed, listed on ESCC QPL in 2021	Lightweight, extra thin, fluorthermoplastic insulated wires and cables, low frequency, 600V, temperature range -200°C to +200°C Optimized for use in LEO orbit 21 variants of the cables of type LEW iaw. the Detail Specification ESCC3901/026 → completed Listed on ESCC QPL/ EPPL 2021, Certificate No. 373	SMD resistors of type BVR iaw. with anew ESCC-detail specification ESCC4001/0XX Extension of the resistor range of ESCC4001/027, Series SMT, size 2817, Resistance range 2.2 – 4.7 Ohms, rated dissipation 2 W → ongoing

ESCC Qualification of Circular Connectors Range - Amphenol Air LB GmbH

Manufacturer

Amphenol Air LB GmbH (self funded)

new qualification

Description

ESCC Evaluation and qualification sequence for their circular connectors range manufactured in accordance with existing ESCC specifications 3401/056, /057, /058, /062, and /070.

Status

Analysis between test required in ESCC evaluation/qualification stage versus periodical MIL-38999 test required for qualification has been released, identifying potential redundancy.

After DLR visit to Amphenol Air LB in March 2022 to have a deeper overview of manufacturing process and link to other Amphenol plants, the process is ongoing. Coordination with CNES on qualifying French and German parts of manufacturing is initiated and ongoing.

Process Capability Approvals (PCA) in Germany

Manufacturers:

- **Tesat-Spacecom**, Backnang:
  - Process Capablility Approval iaw. ESCC2566000
  - Category 1, Option 2 Manufacturer, in accordance with ECSS-Q-ST-60-05C Rev.1
  - Microwave **Hybrid** Integrated Circuits (MHIC) and High Density Integrated (HDI) RF Systems in Package (RF-SiP) using LTCC multilayer technology
    Certificate No. 341C valid until Oct 2023

- **First Sensor Lewicki GmbH**, Oberdischingen:

NEW

  - ESCC Process Capability Approval Certificate for Assembly and Test House (**ATH**) Services iaw. ESCC25600 and ESCC2567000
  - Domain: Hermetically Encapsulated Discrete Semiconductor Components in SMD and TO Packages
  - Certificate No. 379 valid until March 2024
  - Intention to extend the domain, work in progress

Maintenance of Qualification in Germany (1)

COMPONENT	MANUFACTURER	*2022*												*2023*												*2024*												NB	VALIDITY (YM)	CERTIF.
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D			
Connector. TNC. SMA, SMA2,9 SMP - ESCC3402/001, 3402/002, 3402/003, 3402/008, 3402/009, 3402/010, 3402/021, 3402/022, 3402/023, 3402/024, 3402/025, 3402/026	Rosenberger	L8	A	L8, L9											L1		L2	L2	L2	L4	L8		L9																	2401	329 D
Resistor: SM*-PW - ESCC4001/027	Isabellenhütte				L5	L7					L8	L9							L7	L8						L5	L7				L8	L9							2407	285 G
Resistor: SMV-PW - ESCC4001/028					L5	L7					L8	L9							L7	L8						L5	L7				L8	L9							2407	285 G
Resistor: MS1 - ESCC4001/022	Vishay				L1		L7	L7	L7				L8, L9				L1		L7	L7	L7	L8	L9						L1		L7	L7	L7	L8					2310	256 L
Resistor: TNPS - ESCC4001/029		L8							L1		L7	L7	L7	L8	L9						L1		L7	L7	L7	L8							L1		L7	L7	L7			2302	289 F
WIRE / CABLES Type SPC - ESCC3901/009	Gore											L1	L2	L4	L8	L9																			L1	L2			2305	138 P
WIRE / CABLES Type SPP - ESCC3901/017			L1	L2	L4	L8	L9																					L1	L2	L4	L8	L9							2409	215 P
WIRE / CABLES Type SPM - ESCC3901/018		L8, L9																			L1	L2	L4	L8	L9														2403	216 N
WIRE / CABLES Type SPL - ESCC3901/019																						L1	L2	L4	L8	L9													2404	380
WIRE / CABLES Type SPLD - ESCC3901/021		L8		L9																																		2404	380
WIRE / CABLES RF/Flex/Coax - ESCC3902/002		L4	L8	L9																		L1	L2	L4	L8	L9	L8	L9										2405	255 M
WIRE / CABLES SPACEWIRE - ESCC3902/003							L1	L2		L4	L8	L9																		L1	L2	L4	L8	L9				2501	304 F
WIRE / CABLES Type CSWL - ESCC3901/024							L1	L2		L4	L8	L9																		L1	L2	L4	L8	L9				2501	305 F
WIRE/ CABLES Type LEW - ESCC3901/026										L1	L2	L4	L8	L9																		L1	L2	L4	L8			2303	373
WIRE / CABLES Type CSC - ESCC3901/025		L2	L4	L8	L9																				L1	L2	L4	L8	L9									2406	328 D
WIRE / CABLES Type SPM - ESCC3901/018	BizLink														L2, L3	L3, L4	L4	L8	L9																			2309	374
WIRE / CABLES Type SPL - ESCC3901/019																																						2309	374
WIRE / CABLES Type SPLD - ESCC3901/021															L2, L3	L3, L4	L4	L8	L9																			2309	374
BAS40 and BAS70 - ESCC 5512/020 BXY42 - ESCC5513/017 BXY43C and BXY44 - 5513/030	INFINEON										L2			**L1**	**L4**	**L5**					**L8**		L3, A	**L9**															2311	227J
BFY193 - ESCC5611/006											L2			L1	L4	L5				L7	L8		L3, A	L9															2311	230K
BFY450 - ESCC5611/008											L2			**L1**	**L4**	**L5**				**L7**	**L8**		L3, A	**L9**															2311	245K
BFY640, 640B, 650B, and 740B - ESCC5611/009, 5611/010, 5611/011											L2			L1	L4	L5				L7	L8		L3, A	L9															2311	322E
BUY**CS** - ESCC5205/026, 5205/027, 5205/028, 5205/030			**L2**		**L4**	**L5**			**L7**	**L8**				**L1**	**L2**	**L4**	**L5**			**L7**	**L8**		**L3, A**	**L9**			L2		L4	L5			L7	L8					2311	319E
BUY15CS - ESCC5205/031			L2		L4	L5			L7	L8				L1	L2	L4	L5			L7	L8		L3, A	L9			L2		L4	L5			L7	L8					2311	339C
BUY06CS35J 01, BUY06CS80A 01, BUY06SC23K 01 and BUY06CS45B 01 - ESCC5205/032			L2		L4	L5			L7	L8				L1	L2	L4	L5			L7	L8		L3, A	L9			L2		L4	L5			L7	L8					2401	363A
BUY65CS08J-01, BUY65CS28A-01 - 5205/033			L2		L4	L5			L7	L8				L1	L2	L4	L5			L7	L8		L3, A	L9			L2		L4	L5			L7	L8					2405	360A
SPPL12420RH - 9102/014	SPACE IC													L1	L2	L3		L4	L5		A	L78	L9															2310	376

Maintenance of Qualification in Germany (2)

LEGEND :	L1	Kick off maintenance activity (option)	>>	postponed
	L2	Manufacture LAT lot	**X**	stopped
	L3	Precap in-process inspection	##	caution
	L4	Final production tests	Mx	Level x MRB
	L5	End of burn-in	Q	Q numbers indicate re-qualification programmes
	L7	End of life test / storage	**Y9**	ESCC QML Yearly status report
	L8	LAT report	**L9**	Action completed on DLR side
	L9	Application for extension of qualification	▒	Certificate granted
	A	Audit		

Vishay, Isabellenhütte:
Maintenance of Qualification activities combined with Delta Qualification activities to cover the planned material changes

Consultancy of Companies

- Companies/institutes interested in space activities and with high potential/ promising abilities
- DLR offers consultancy, provides introduction to ESCC in general:
  ESCC system
  ESCC evaluation and qualification options
  ESCC/CTB Working Groups, national stakeholder workshops etc.
- Company presentation, product and service portfolio, space projects and experience
- In-depth consultancy process started in 2020
- Consultancy meetings held with (among others):
  - ILFA, db-electronics
  - Via Electronic, Fb-photonics
  - ASP Equipment
  - Axtal, Würth Elektronik eiSos, AFT, WIMA, Comtronic
  - Fraunhofer IZM, Fraunhofer Space Allianz, FMD, FBH
  - Impulssys, EESY IC, Extoll, PTS, DFKI

→ Covering a broad spectrum of EEE part types, technologies, PCBs and EEE parts related services

National Exchange Platforms

- **DLR Annual EEE Components Conference** 2023 (*DLR Bauteilekonferenz*)
  16th and 17th of May in Backnang

- **Stakeholder Workshops:**
  - **Gallium Nitride Initiative** – Stakeholder Workshop on 04.03.2021 as exchange platform
    Project proposal under DLR evaluation
  - **Optoelectronic Initiative** – German Stakeholder Workshop on **28th and 29th of March 2023** as exchange platform, supported by ESA
    Match abilities and needs in Germany, define strategy and roadmap to establish supply chains

- DLR **New Space** Activities
  Space2Motion Working Group
  Space sector meets automotive sector
  Use of automotive EEE parts in space applications

INNO space 2motion

Space2Motion Working Group: Automotive EEE Components

- Title: Electronic, electrical and electromechanical automotive components for space applications
- **Objective**:
  Investigation of the suitability of AEC-Q qualified components (according to AEC-Q100, -Q101 and –Q200) for space applications
  - → Target: class 1 components
  - → Complete data packages for use as evidence in Justification Document
  - → Availability of screened parts
  - → Support of German users: use of synergies, cost and time saving, risk reduction
  - → Extension of range of components available for space applications

- Members of 41 organizations (58 persons)

- Terms of Reference finalized in July 2019
  - → Structured in 5 phases
  - → Break-down to work package level

INNO space 2motion

Procedure in Space2Motion Working Group on Automotive EEE-Components

Phase 1 – Identification

Target: Gain insights from previous projects and determine component needs

German-wide survey completed

Phase 2 – Analysis

Target: Perform a gap analysis between ESCC qualified and AEC-Q qualified components, differentiate between class 1, class 2 and class 3 requirements

Identify challenges (e.g. radiation sensitivity, pure tin, traceability etc.)

Phase 3 – Concept Development (3 Options)

Target: Development of concepts and verification methods to demonstrate the suitability of AEC-Q components in space applications: concept for testing on component level, concept for testing on board level (in laboratory), concept for In-Orbit Verfication

Phase 4 – Testing and Verification

Target: Implementation of the developed concepts, execution of the tests in the laboratory and launch of the IOV mission; Comparison of test results, lessons learnt for future optimization

Phase 5 – Development of an exchange platform/ database

Target: Development of a platform/database for the exchange of test results, transparency

Status of Space2Motion Working Group on Automotive EEE-Components

Pilot Phase – 8 Test candidates, Testing on component level				
Infineon	Nexperia	Bosch	Rosenberger	Isabellenhütte
TLE9180D-31QK TLF51801ELV TLS202A1MBV	74AUP2G57GU 74AUP1G17GW (Logic Ics)	BT1M1200025 die, 1200V, SiC	H-MTD	BVR Resistor Series, 5W 4026
Procurement phase, radiation test plans under preparation; CA on TLS202A1MBV completed	AEC-Q qualification completed; procurement phase, test plans under preparation	AEC-Q qualification completed; NDA	Procurement ongoing	CA completed, life test completed

Continuous selection process;
Selected test candidates, e.g.:
Infineon CoolSiC MOSFETs AIMW120;
MOSFET Gate Driver 2EDS8265H etc.

Component Level	Board Level	In-Orbit-Verification
Selection of additional test candidates follows *)	Selection of test candidates follows	Selection of test candidates follows

*) based on Phase 1 result (German-wide EEE-components survey)

Space2Motion Working Group on Automotive EEE-Components

Way forward over the next few years:

- Space2Motion working group members submit project proposals which fit the terms of reference and objectives of the working group
- Forming teams with Space2Motion working group members to carry out the project
- Parts selection:
  - is based on the parts need of German users
  - defined selection criteria will be applied
  - focus is put on AEC-Q qualified /automotive parts

Outlook:
Expansion of activities to

- COTS components in general
- Space2Health

INNO space 2motion

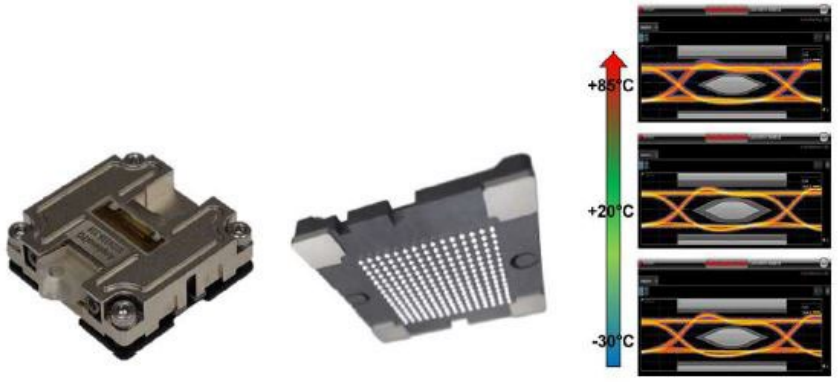
INNO space 2health

Further DLR COTS Activities - Commercial Optical Transceiver for Space Applications

- **Manufacturer**: Amphenol Active Optics Products, Berlin
- **Objective**: Assessment of a commercial optical transceiver for space applications
  - LEAP® On-Board Transceiver: 12-channel duplex optical transceiver with data-rates of up to 25Gbps per channel (300Gbps cumulative) on multi-mode fiber
  - ESA contract (carried out by ALTER): assessment of the reliability by evaluation with focus on the non-hermetic package aspect
  - **DLR contract**: fill the gap by focusing on the radiation characterization

- **Status**:
  - Samples on stock, test set-up preparation ongoing
  - TID test results expected by end of February 2023 (initial observed degradation at 65krads – pending assessment)

- Pilot project, analogous approach in future:
  „Pre-selection“ tests on commercial parts
  → Start of ESCC qualification project pending result of evaluation/ pre-selection tests



German-Japanese Cooperation in the Field of Automotive EEE-Components for Space Applications

- Initial step: **Workshop** on 24 March 2021 in virtual format:
  „**Open exchange between Japan and Germany: Usage of automotive components in space applications**”
  - **Result**:
    - Interesting overview of the automotive parts related activities and experiences
    - Strong interest in a German-Japanese cooperation in the field of automotive EEE-components
    - Ideas for shaping the cooperation, first project ideas
- Extended framework agreement signed by DLR and JAXA on 5 April:
  „**Inter Agency Agreement for Strategic Partnership**“
- DLR JAXA Agreement: Establish a German-Japanese Working Group dedicated to Automotive EEE-Components for space applications
  - Steering Board: DLR and JAXA
    Each project under the umbrella of this German-Japanese cooperation requires approval from both, space agencies
    JAXA and DLR jointly decide on the technical baseline and selection of test candidates (automotive EEE-Components)

DLR – JAXA Cooperation in the Field of Automotive EEE-Components (2)

Status and Result:

- Regular bilateral meetings between DLR (EEE-Components Division) and JAXA
- JAXA- DLR agreement on exchange of documents
- Mitsubishi Heavy Industries‘ proposal: a project idea as potential project under the umbrella of the German-Japanese cooperation in the field of automotive EEE-components
  - Development of a „Common (Standard) Board for Rad-hard Test“

  → Evaluation of the project idea by JAXA and DLR

  → Three-party meetings (JAXA, DLR, MHI), technical clarification meetings

Next Steps:

- Planning of the 2nd German-Japanese Workshop with participants from both countries - **March 22, 2023**:
  - presentation of legal framework, roles and responsibilities
  - presentation of the scope of the working group and the technical baseline
  - participants‘ contributions: feedback and project ideas
- Finalization of the Terms of Reference of the German-Japanese Working Group

Questions & Answers

Thank you very much for your attention!

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