German Aerospace Center (DLR) Report

ESCCON, 10.03.2021

Burak Gökgöz
German Aerospace Center (DLR)
Space Agency - Robotics, Digitalisation, and AI
EEE-Components

Agenda

- **German Aerospace Center (DLR) and EEE-Components Division**
- **National development and ESCC qualification projects**
- **Further Activities**
  - Digitalisation of Supply-Chain in Germany
  - DLR Stakeholder Workshop “Gallium Nitride”
- **COTS/New Space Working Group**

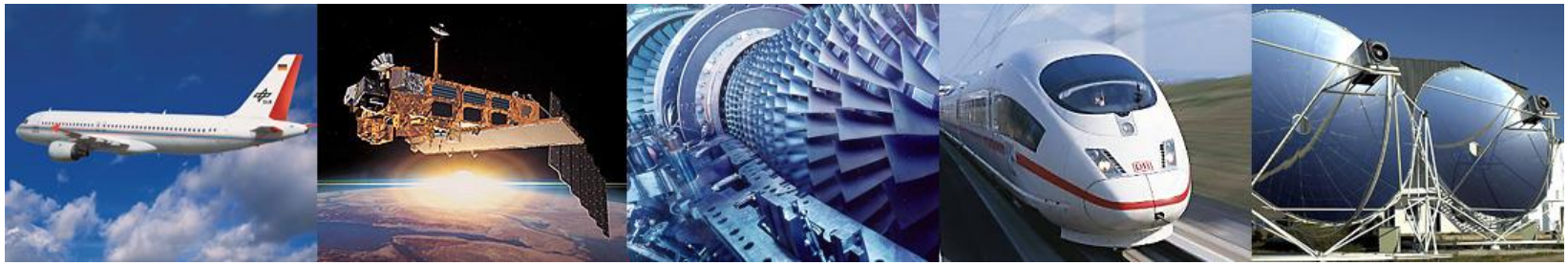
“Usage of automotive components in space applications”

German Aerospace Center (DLR)

DLR has approximately 9000 employees at 30 locations in Germany

- Research and Technology
- Space Agency
- Project Management Agencies

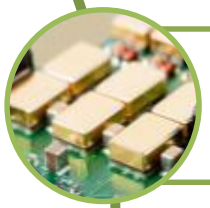
DLR also has offices in Brussels, Paris, Tokyo and Washington D.C.



Research Areas:
Aeronautics, Space Research and Technology, Transport, Energy, Defence and Security, Space Agency, Project Management Agency

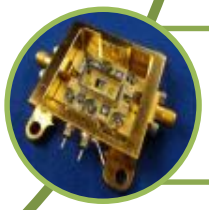
DLR EEE-Components Division Objectives

Ensuring German contributions on development and qualification



National coordination and information exchange

Provision of the necessary components for the German industry



Harmonization in Europe

EEE-Components Division / External Support

Burak Gökgöz
- General Coordination

Thilo Kaupisch
- Radiation Coordination

TESAT

- App. 30 Components experts as „Technical Advisor“
- ESCC CTB Working Groups
- ESCC PSWG Ad Hoc Working Groups
- Ongoing Projects
- MoQ, Audit
- Radiation

ALTER TECHNOLOGY GROUP

- App. 30 Components experts as „Technical Advisor“
- CTB Working Groups
- PSWG Ad Hoc Working Groups
- Ongoing Projects
- MoQ, Audit
- Radiation

Fraunhofer INT

- App. 10 experts as „Technical Advisor“
- CTB Radiation Working Group
- Ongoing Projects
- **Radiation effects in electronic components and optic**
  - ✓ Experimental Investigations
  - ✓ Radiation effects consulting
  - ✓ Operation of irradiation facilities
  - ✓ Simulation of radiation environment

EEE-Components national Experts Pool

- App. 20 experts as „Technical Advisor“ in many different fields, few examples:
  - ✓ GaN (Gallium nitride)
  - ✓ MMIC (Monolithic Microwave Integrated Circuits)
  - ✓ Different Active/Passive Components
  - ✓ Testing …

DLR

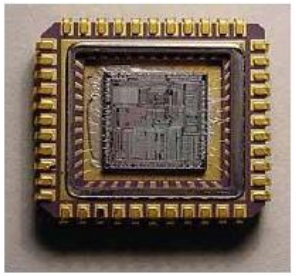
National development and ESCC qualification projects

SPAC: Capability Approval of a Commercial ASIC Technology

Activity	Status	Budget/k€	Remarks
Capability Approval Testing Phase of an IMST ASIC Technology based on 0.18 Micron CMOS Process by X-Fab Malaysia and Assembly	Running	2.075	**Completed:** Evaluation Testing, Design of Qualification Test Vehicle (QTV), Qualification Test Plan, P.I.D., Detail Specification, CA on pre-lot, assembly of qualification lot **Running:** Screening of qualification lot **Next steps:** Testing of Qualification Lot **Project duration:** October 2014 – December 2021

Backup

SPAC: Capability Approval of a Commercial ASIC Technology

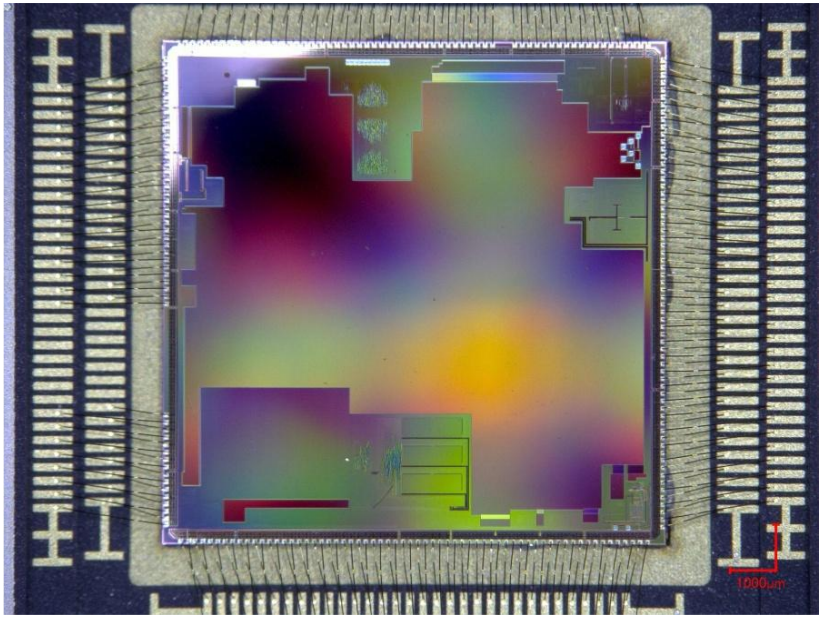


- **IMST** is responsible for the complete supply chain, part of the activities are subcontracted
- **Completed Activities**: **Evaluation Phase**
  - Rad-hard library based on XH180 process developed
  - Evaluation Test vehicles tested acc. ESCC226900
  - Rad-hardness of all IP either 100krad or 300krad, no destructive SEE up to 88MeV/mg/cm²
  - Audit close-out completed
- **Project status Qualification Phase**:
  - Minor modifications of rad-hard library implemented (improved performance)
  - Qualification Test Chip designed, Wafer processing at X-Fab done
  - P.I.D., Capability Abstract, Qualification Test Plan, Detail Specification released
  - CA on pre-lot successfully completed
  - Assembly of qualification completed
  - Screening of qualification lot ongoing
  - Next steps: testing iaw. Qualification Test Plan

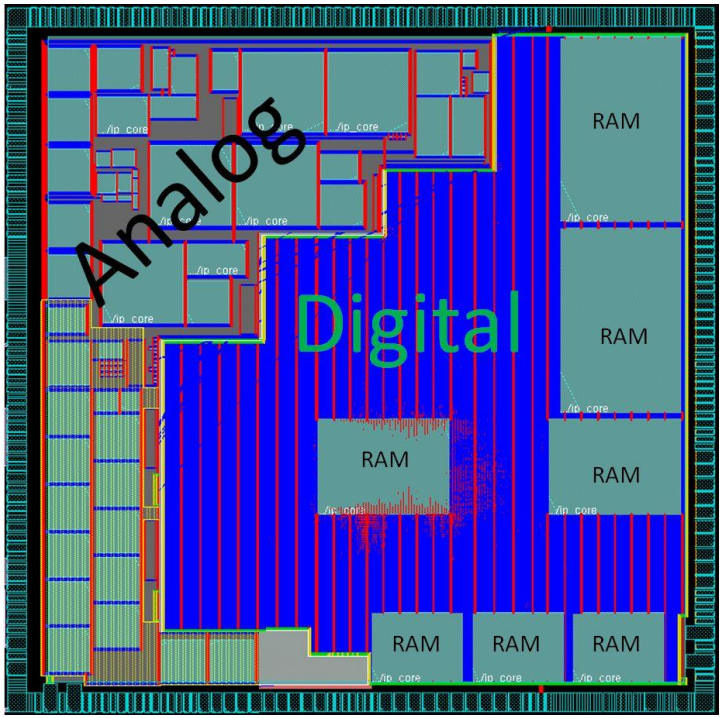
Backup

SPAC: Capability Approval of a Commercial ASIC Technology

- Evaluation Test Chip,
  (IVI, opened package CQFT256)



- Layout / Floorplan of
  Qualification Test Vehicle



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

Activity	Status	Budget/k€	Remarks
ESCC Evaluation and Qualification of a fractional N Synthesizer – “NOVELO”	Running	1.800	**Completed:** PID, Qualification Test Plan, Draft Detail Specification, all Evaluation tests completed with the exception of ESD and TID testing Assembly of qualification lot **Running:** Evaluation Tests: ESD Screening of Qualification lot **Next steps:** Completion of evaluation testing Qualification testing **Project duration:** November 2016 – July 2021 (project end under discussion with DLR)

Backup

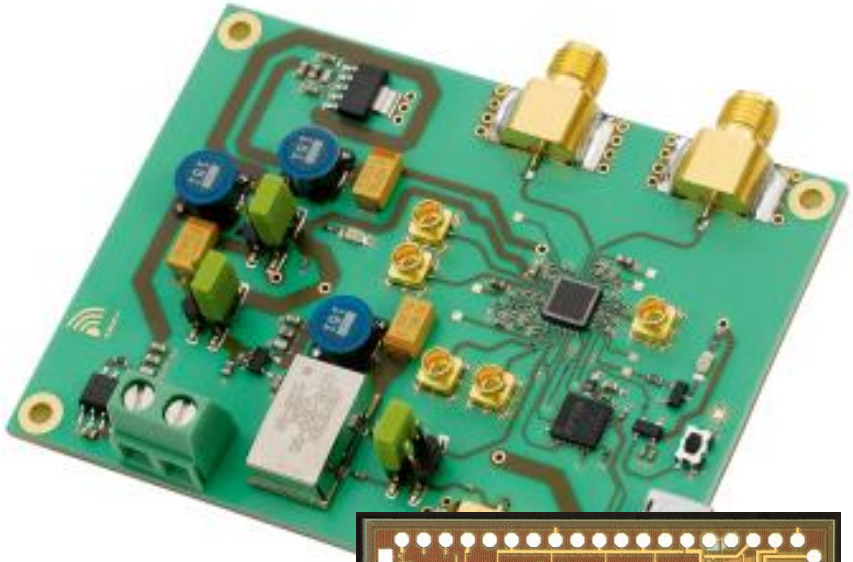
ESCC Evaluation and Qualification of a fractional N Synthesizer – “NOVELO”

- **IMST** is responsible for the complete supply chain, (PM, die-assembly, bonding, screening and qualification testing), whereas some activities are subcontracted:
  IHP: wafer-manufacturing, SGB25RH technology
  MPD: wafer dicing
  Rood Microtec: wafer testing, test support during evaluation/qualification
  Serma: hermetical sealing**,** leakage testing
  Kyocera: package
- **Completed:**
  - Package re-design (based on castellations, Kyocera PB-CB 8187)
  - Draft Detail Specification ESCC9202/085, PID, Qualification Test Plan
  - All Evaluation Tests completed with the exception of ESD and TID testing
  - Assembly of the Qualification lot
- **Next Steps**:
  - Completion of evaluation tests: ESD and TID test
  - Screening of qualification lot
  - Perform ESCC Qualification Tests

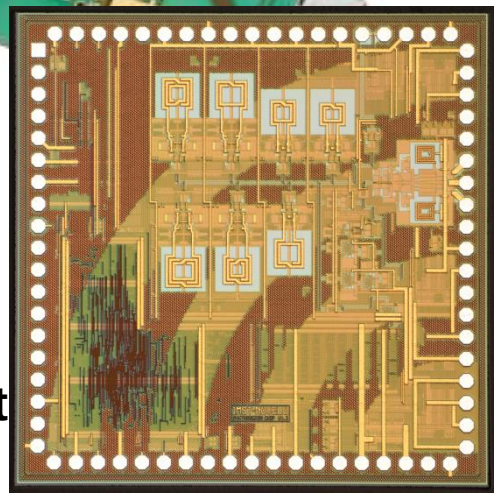
Backup

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

Project’s objective:



- **Space qualified NOVELO synthesizer**
  - Radiation hard SPI, registers and chip components
  - Qualified compact ceramic package for space applications
  - ESCC based qualification, handling and documentation
- **Superior performance**
  - 1-chip fractional-N synthesizer (2.6 x 2.6 mm²)
  - 1.6…12 GHz (1.5…14 GHz), 1 Hz resolution
  - -225 dBc/Hz normalized phase noise, 0.6° RPM @ 9.8 GHz
  - Long term life cycle component sizing and chip layout
- **European supply chain, EPPL/ ESCC QPL component**



ESCC Evaluation and Qualification of the SPPL12420RH Point-of-Load Converter

Activity	Status	Budget/k€	Remarks
ESCC Evaluation and Qualification of the SPPL12420RH Point-of-Load Converter	Running	370	**Completed:** Evaluation test report approved by ESCC Executive (pending Audit). **Running:** Screening/qualification iaw. ESCC9000 and 9102/014. **Next steps:** Completion of Qualification Sequence. Audit of Hitest/Space-IC/RHe premises **Project duration:** March 2017 - June 2021

Backup

ESCC Evaluation and Qualification of the SPPL12420RH Point-of-Load Converter

- **SPACE IC** and subcontractors DISCO, Hitest, SGS Fresenius, Cicor
- Radiation hardened Point-of-Load Converter microcircuit SPPL12420RH in ceramic flat pack 16 package
- **Status of Project – Evaluation Phase**:
  - Documents for Assembly, evaluation, screening, qualification and PID agreed
  - Evaluation and screening Reports approved by ESCC Executive (pending Audit).
  - New lot Screened with successful results. Qualification started.
- **Planned Activities:**
  - Formal audit of Space IC/Hitest/RHe facilities* (online&onsite).
  - Completion of qualification sequence in accordance to F4 ESCC 9000.
  - Qualification report to be submitted to Executive in May-June 2021.

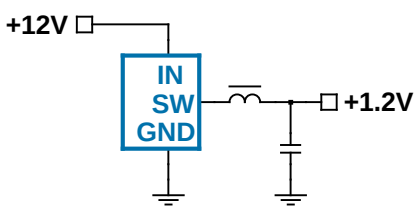
*Impact of Covid-19 TBC

Backup

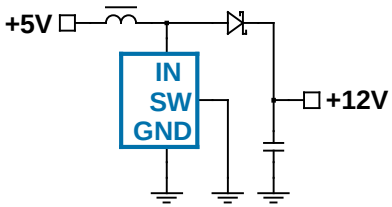
ESCC Evaluation and Qualification of the SPPL12420RH Point-of-Load Converter

- **Component Application:**

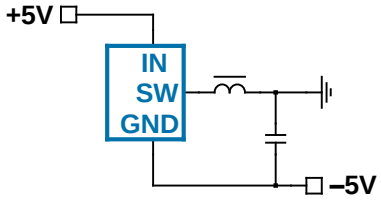
Buck operation:

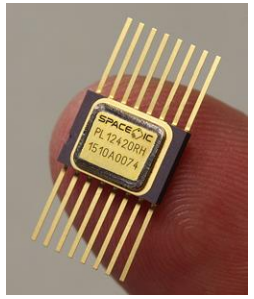


Boost operation:



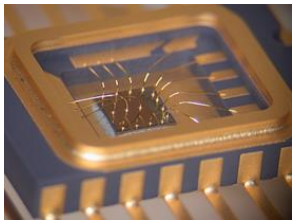
Buck-Boost operation:



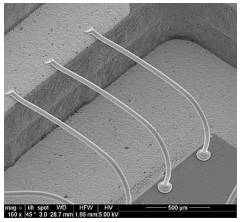


- **Evaluation Activities - Examples:**

Precap:



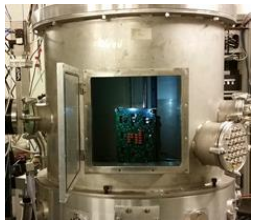
CA:



Endurance:

TID:

SEE:



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DLR

Latchup Investigations of Electronic Components - LUNTE

Activity	Status	Budget/k€	Remarks
Latchup Investigations of Electronic Components - LUNTE	finished	150	**Completed:** Hardware of automatable pulse laser set-up finished, second identical set-up built Latchup investigations performed Development and testing of latchup protection circuits Determine critical latchup switch-off time Further Latchup investigations with additional components **Project duration:** August 2017 - December 2020

Backup

Latchup Investigations of Electronic Components - LUNTE

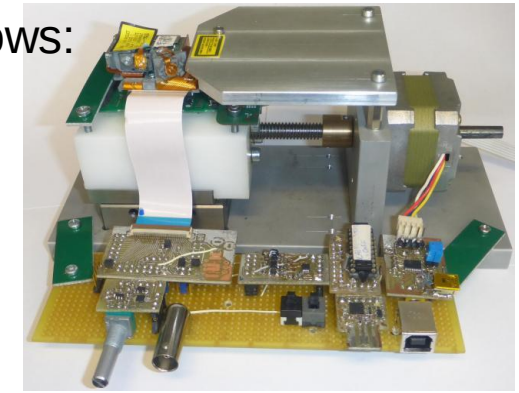
Partner: Ernst Abbe University of Applied Sciences

Objective: Conduct a scientific study to raise data of sensitivity of COTS microcontrollers towards Single-Event-Latchup (SEL).
The main focus is to build an educational setup to simulate the heavy ion impact in components and to determine the critical latchup switch-off-time.

Project Status:

Hardware of pulse laser set-up finished with features as follows:

- Positioning in X- and Y- direction on DUT
- Laser pulse width of 2-20 ns applicable
- Positioning with step width of about 250 nm
- Surface scan with subsequent SEL scan
- Latch-up protection & detection circuitry implemented



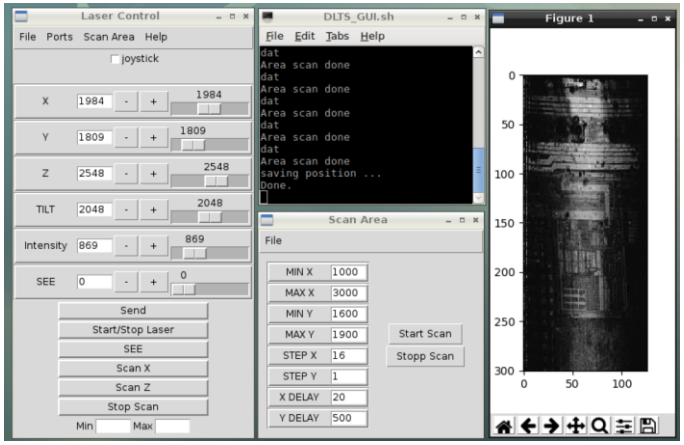
- second identical hardware has been built to perform parallel investigations

Backup

Latchup Investigations of Electronic Components - LUNTE

Project Status (continued):

- Spatially resolved laser test results
  - Laser position detected to reproducibly delete the memory
  - Position for destructive SEL discovered (circuit protection to be optimized)
  - additional components investigated



Graphical User Interface (GUI)

Limitations:

- Metallization on DUT limits penetrable area
- Limited pulse energy avoids generatable effects in components with larger feature sizes
- Conversion to injected energy (LET) probably not possible

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

Activity	Status	Budget/k€	Remarks
Comparative Laser- and Heavy ion irradiation to characterize the SEE sensitivity of components – LUNT(E2)	Start 01.04.2021	400	**Next steps:** Kick off, theoretical preparation and test setup preparation **Project duration:** April 2021-March 2024

Backup

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.
- 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,
- Chosen components will be Super-junction power semiconductors (CoolMOS) and microcontrollers.

Project Status: Not yet started

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

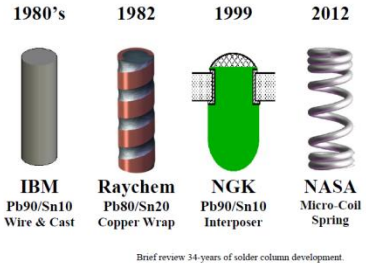
Activity	Status	Budget/k€	Remarks
Development of a Soldering Process for Micro-Coil-Springs (MCS)	Running	130	**Completed:** Computer simulation already performed (report under issue) and procurement of daisy – chain components & set-up/tools already performed. Pretests and design PCB verification, final soldering parameter definition and design review to be performed. Definition of soldering parameters nearly finished. **Next steps:** Soldering of Test Samples Testing and Verification **Project duration:** January 2019 - Project end under discussion

Backup

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.

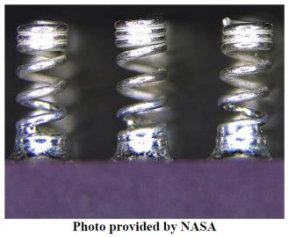


Photo provided by NASA

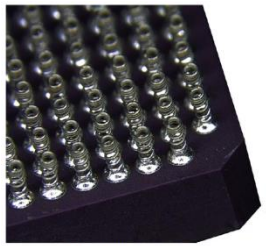


Photo provided by NASA

- **Target:**
  Using CCGA – Chips on Standard PCB's (Polyimide / HTG-FR4)

Consultancy of new companies 1/2

Company	Product Types	Status	Remarks
Amphenol - Air LB GmbH	Circular Connectors	ESCC eval. & qual. process is introduced. Manufacturer Application to Initiate ESCC Qualification is currently under preparation	MIL qualified part manufacturer.
Amphenol AAOP Berlin (FCI Deutschland GmbH)	Photonics on-board transceiver for Space	Project Idea pass Assessment Phase, currently Project Plan under development.	Heritage in Aviation
CIS electronic GmBH	Cable assembly / harnesses. MID (Mechatronic Integrated Devices).	ECSS, ESCC eval. & qual. process is introduced. Business plan currently ongoing at the manufacturer.	MID devices not available in ESCC system
ILFA	PCBs, flex, rigid-flex, several terminations,...	ECSS eval. & qual. process is introduced. Manufacturer visit held in Feb. 2020. ILFA provided the company presentation to the SMT-PCB working group.	Space and defense experience (> 25% volume).
Susumu GmbH	Thin film resistors, choke coils and high frequency devices	Susumu is studying options on how their automotive products could be considered for space activities.	Large automotive experience. Main manufacturing sites in China/Japan.
db-electronic	PCBs, flex, rigid-flex,..	ECSS eval. & qual. process is introduced. Manufacturer evaluation ongoing.	
Via Electronic/Koa	Low temp Co-fired ceramics	Introduction to ESCC qual. process is under planning. Via-Electronics provided presentation of products and manufacturing capabilities in the last H&P WG meeting, January 2021.	
Fb-photonics	Optical Fibre Components, laser systems	Introduction to ESCC qual. process already provided to the company.	

Consultancy of new companies 2/2

Company	Product Types	Status	Remarks
Bosch	Several incl. connectors	Pending arrange initial meeting 1st Quarter 2021	
ASP Equipment	Magnetics	ECSS, ESCC eval. & qual. process is introduced.	At present no intention to provide standard magnetics.
Axtal	Oscillators	Project Idea on High Stability Miniature OCXO is under evaluation.	
Fraunhofer IMS	Customized semiconductors incl. Sensors.	ECSS, ESCC eval. & qual. process is introduced.	Expected Follo-up meeting 1st Quarter 2021
Würth Elektronik eiSos	ferrite beads, inductors, transformers and other passive components	ECSS, ESCC evaluation and qualification process has been introduced in a first consultancy meeting	Follow up in May 2021

Further Activities
Digitalisation of Supply-Chain in Germany
DLR Stakeholder Workshop “Gallium Nitride”

EEE-Components Supply Chain in Germany Identification

Content of the Database

Company Name
City
Address
Contact person/s
Web Site
Entity Type
Entity Size
Entity Description
Entity Scope
Entity Market/Application
Key Products
Source

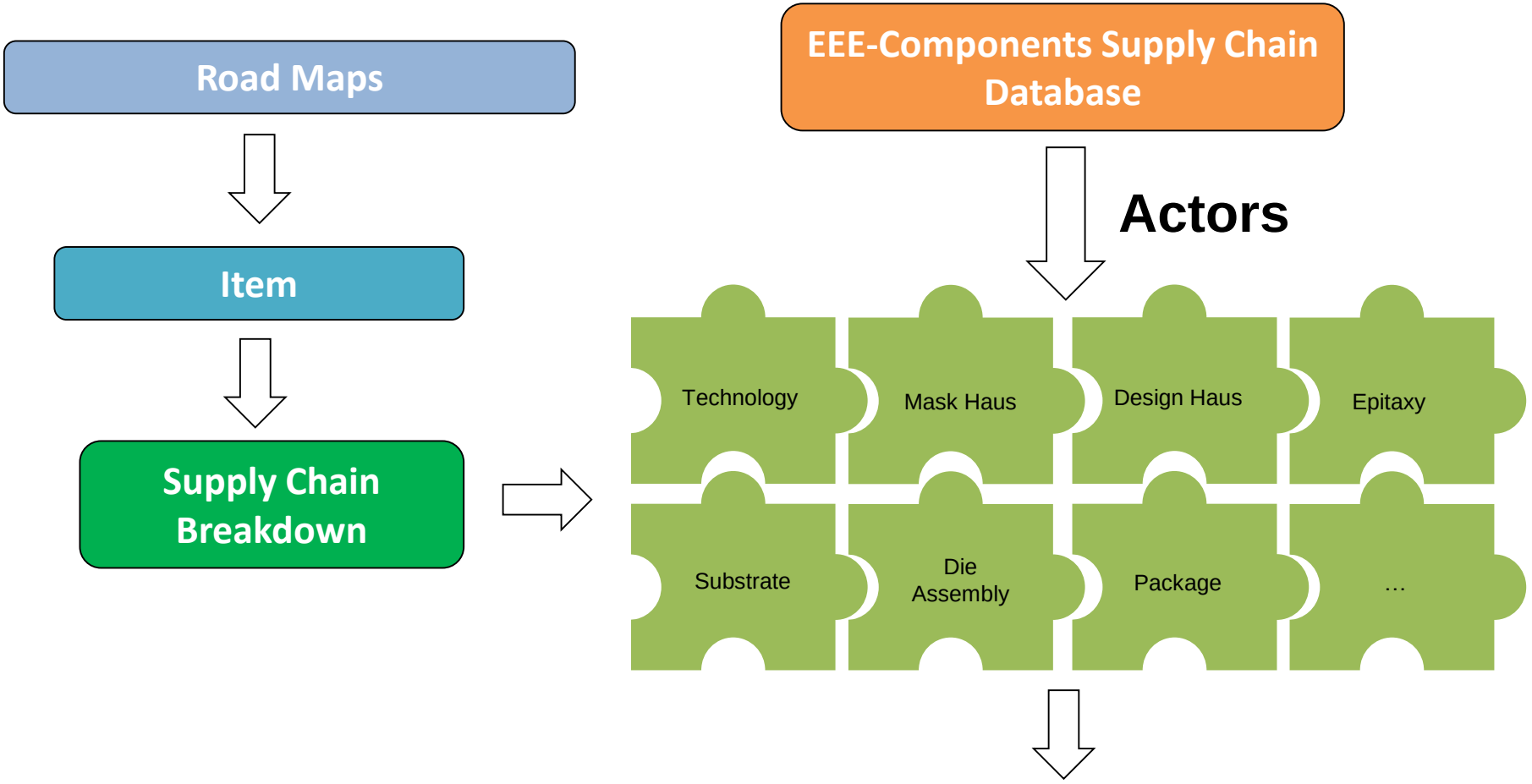
	Entity Type in Supply Chain Database
1.	substrate provider
2.	epitaxy
3.	Design House
4.	Mask House
5.	3a - Wafer Manufacturer - front-end
6.	3b - Wafer Manufacturer - back-end
7.	EEE-Parts Assembly House
8.	EEE-Parts Test House
9.	EEE-Parts Manufacturer
10.	EEE-Parts & Components User
11.	EEE-Parts & Components Distributor
12.	R&D Institutes (research organisations)
13.	Raw material (not wafer related)
14.	Software
15.	University
16.	Consultant
17.	Engineering company
18.	Equipment Supplier
19.	Test Equiment Manufacturer
20.	EEE-Parts Package supplier
21.	Equipment Test House
22.	non EEE-Parts components manufacturer
23.	Primes
24.	others

- **Early development phase, first step for a Database and EEE-Components Map**
- **2470 Entities (all companies/institution/universities/… in space) are identified**
  Breakdown of the EEE-Components related entities ongoing

EEE-Components Supply Chain Break Down Example

Name of Projekt	**ESCC Evaluation and Qualification o**				
Funding					
Part type / part family					
Technology					
substrate provider	xxx				
epitaxy	xxx				
Design Haus	**Digital design**	**Analog design**	**Layout**		
	xxx	xxx	xxx		
Mask Haus	xxx				
3a - Wafer Manufacturer - front-er	xxx				
3b - Wafer Manufacturer - back-er	xxx				
EEE-Parts Assembly House	**Wafer processing (sawing, backgrinding, etc.)**	**Die assembly (die attach, bonding, etc.)**	**Sealing (lidding)**	**Terminals (like BGA, CGA, etc.)**	**Others (provide details - e.g. technology specific steps)**
	xxx	xxx	xxx	xxx	xxx
EEE-Parts Test House	**SEE**	**TID**	**ESD level**	**Others (please specify)**	
	xxx	xxx	xxx	xxx	
EEE-Parts Manufacturer	xxx				
Technology Qualification	xxx				
EEE Parts Qualifications	ESCC				
Possible Intrument/s user/s	xxx				
Application	xxx				

EEE-Components Supply Chain digitalization Target



DLR Stakeholder Workshop “Gallium Nitride”

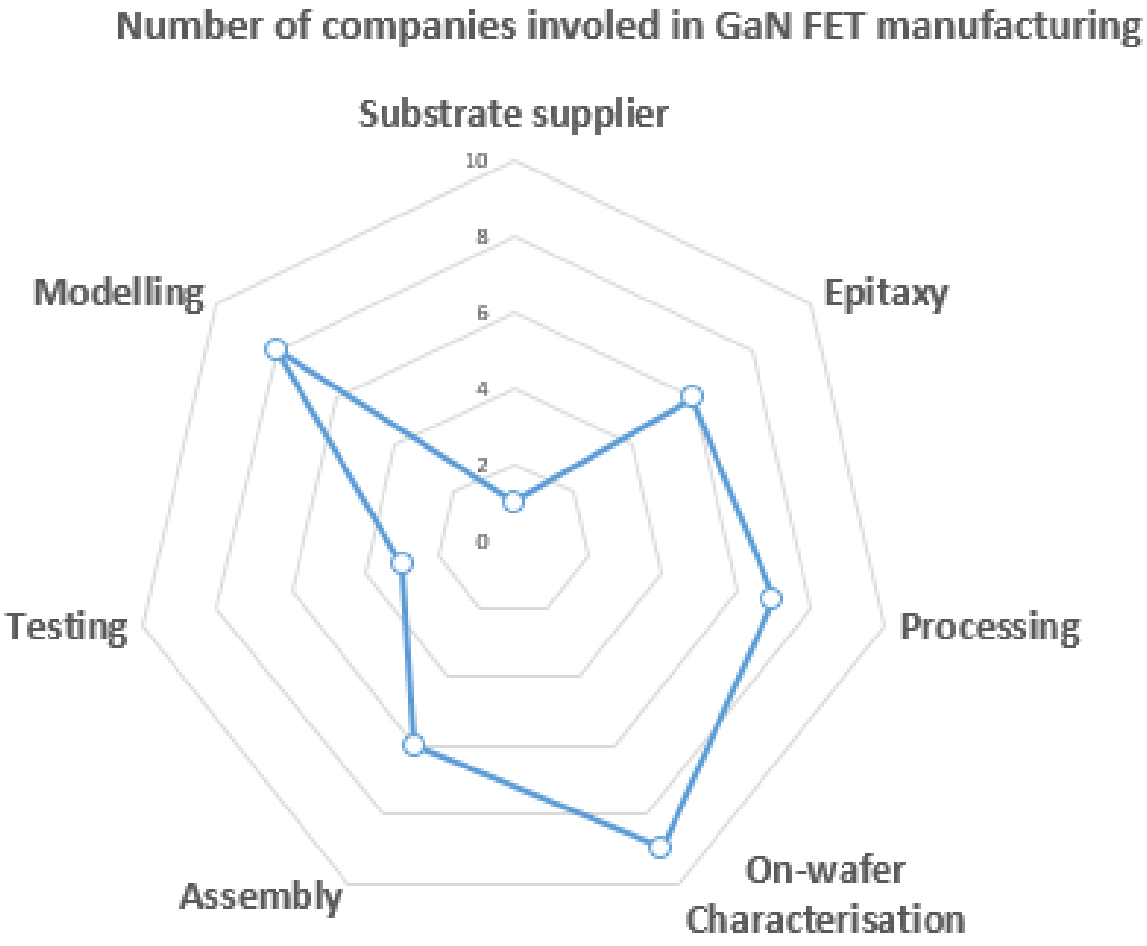
Focus: normally-off GaN FETs

Goal: to establish German supply chain for normally-off GaN FETs

- Already completed:
  - identification of the companies/institutions working on GaN FETs development
  - identification of the users’ need on GaN FETs
  - organisation of the 1st GaN Workshop on 4th of March 2021

- Next steps:
  - definition of working groups for dedicated supply chain elements
  - definition of the “ideal” transistor to be manufactured
  - support networking between partners

DLR Stakeholder Workshop “Gallium Nitride” German Supply chain landscape



COTS/New Space Working Group

“Usage of automotive components in space applications”

Usage of automotive components in space applications

Space sector meets automotive sector – members of **34 organizations**

Terms of Reference finalized in 2019

<u>Target:</u> Investigate suitability of AEC-Q qualified parts (iaw. AEC-Q100, -Q101 and -Q200) in space applications

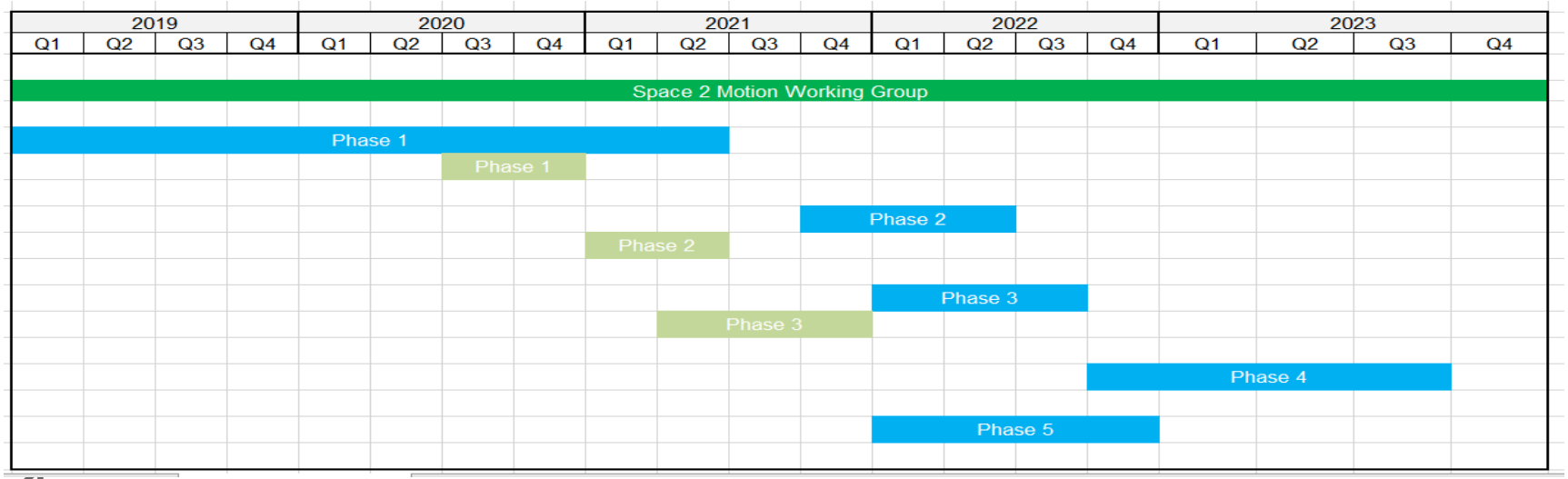
Objective of the Five Phases:

- Phase 1 – **Identification of the needs**
- Phase 2 – **Delta Analysis**:
  Perform a gap analysis between ESCC/MIL qualified and AEC-Q qualified parts, consider qualification philosophy, identify challenges like pure tin, traceability, radiation sensitivity etc.
- Phase 3 – **Concept development:**
  Development of concepts and verification methods to demonstrate the suitability of AEC-Q components in space applications

Usage of automotive components in space applications

- Phase 4: **Testing and Verification**
  - Implementation of the developed concepts
  - Performing of tests, OOV mission, evaluation of results
  - Comparison of test results of the different concepts
- Phase 5: Development of a **platform/database** for the exchange of test results

Schedule (preliminary):



green: „pilot“ phases

Usage of automotive components in space applications

Selection Criteria and Process applicable in pilot phase:

1. Manufacturer country of origin: **Germany and AEC-Q qualified**
2. **Complexity of components:** (due to limited ressources in pilot phases): **Efforts** (expenditure of work) and parts costs
3. **Risk Analysis** taking into consideration following aspects (e.g.):
   - Potential export restrictions
   - Obsolescence
   - Manufacturer‘s experience in space
   - Outgassing
   - Availability of (reliability) test data
   - …
4. Estimation of **potential need** (in addition to the need identified by individual users participating in the working group
5. Similar item with Priority 1 or 2 on **CTB Roadmap**

Usage of automotive components in space applications

Pilot Phase Result of the pre-selection:

9 potential **test candidates** (pilot phase)

Infineon	Nexperia	Bosch Semiconductor	Rosenberger	Isabellenhütte
TLE9180D-31QK TLF51801ELV TLE4935L TLS202A1MBV	74AUP2G57GU 74AUP1G17GW	BT1M1200025 die	H-MDT	BVR-Series, 5W, 4026

DLR Decision:

- green light for the green marked components: activities have been started
- others:
  - either ongoing technical discussions
  - or ongoing administrative decision process

Usage of automotive components in space applications

Future usage of selected automotive test candidates

User feedback about intended **fields of application**:

- Earth observation
- Navigation
- Science satellites
- Telecommunication satellites
- Orbital service
- Planetary exploration robotics

Questions & Answers

Thank you for your attention!