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Most Common Failure Modes in Tests for COTS Components: Lessons Learned from ALTER

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Agenda

Introduction	Background and motivation
	Scope of the study and dataset
	Analysis methodology
Results	Global results on COTS failures
	Common failure modes and test efficiency
	Lessons Learned
Example	SAM Test Failure

Background and Motivation

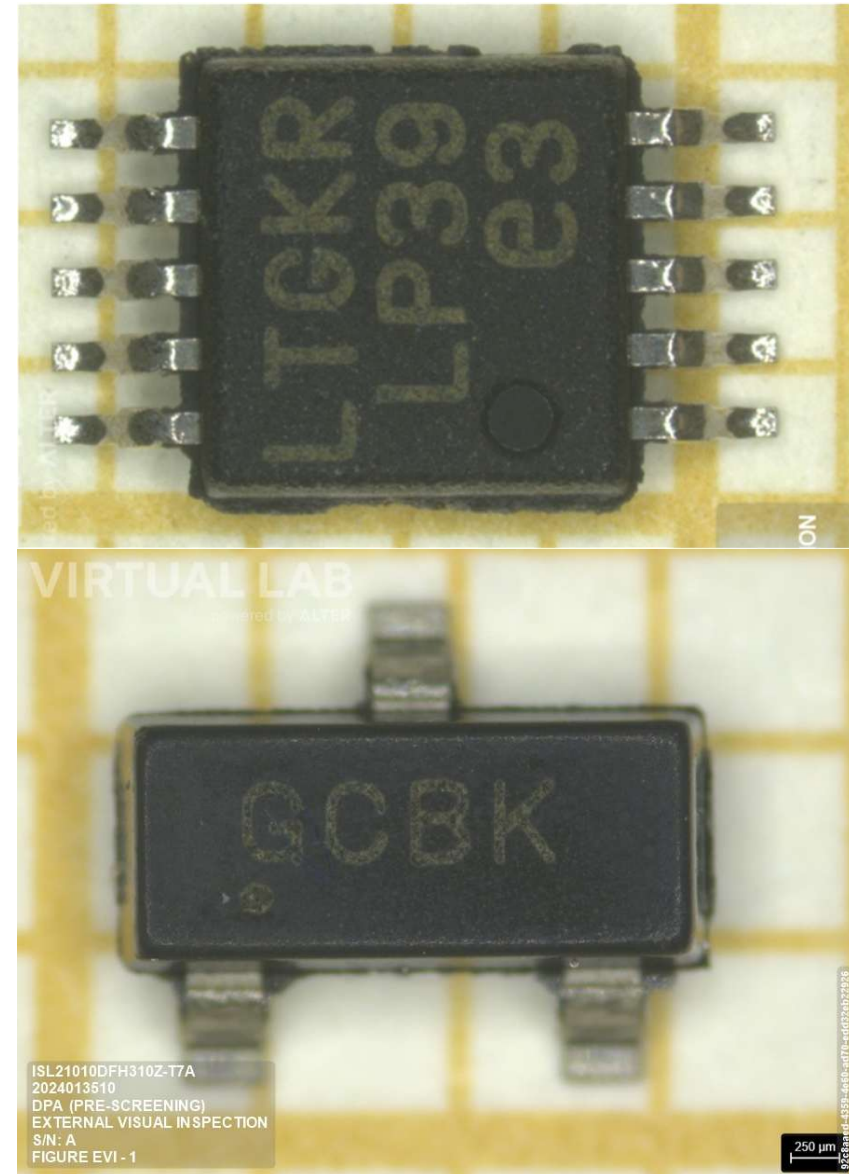
COTS adoption in space

The New Space approach has driven extensive use of Commercial Off-The-Shelf (COTS) **EEE components** in space hardware to reduce procurement cost and lead time.

Cost savings and risk

The apparent cost savings must be balanced against the increased risks related to screening, attrition and potential schedule impact.

This study supports data-driven decision making based on real laboratory test experience.



Objective of the Study

The objective of this work is to identify and quantify **most common types of failure in COTS components** based on ALTER's long-term testing experience.

Where Failures Occur

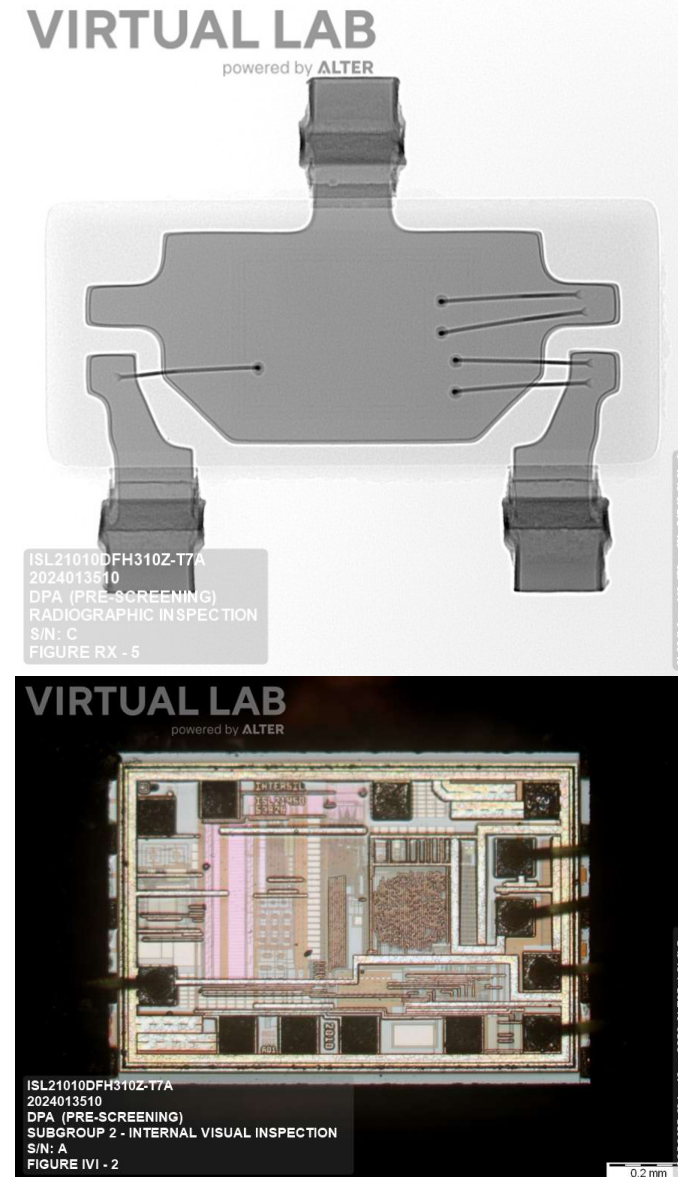
Comparison of Failures: COTS vs Non-COTS

Which Components and Quality Levels Drive Failures

Influence of quality level and component family.

Which Tests Really Detect Defects

Identification of the least effective laboratory tests using failure rate as a metric.



COTS Acceptance Model

TEST / ACTIVITY	PURPOSE	RECOMMENDED USE
Documentation and manufacturer evidence review	Confirm datasheet limits, quality system, process stability, PCN/obsolescence and available reliability data	All COTS candidates. Prior to procurement start.
Incoming inspection and identity verification	Detect transport, marking, packaging, traceability or counterfeit concerns	All flight lots
Constructional analysis / DPA	Identify package, die, material, workmanship or process concerns	New supplier, unknown lot, critical function, complex package or prior anomalies. DPA on all flight lots.
X-ray / SAM / cross-section	Detect internal defects, voids, delamination, die attach, bond and plating issues	Plastic packages, BGAs, connectors, high-risk lots, sampling basis. If DPA is not preformed.
Electrical characterization	Verify application-critical parameters across relevant temperature and voltage/frequency range	Critical electrical functions, tight margins, untested datasheet parameters
Screening	Remove infant mortality and workmanship escapes; avoid 100% screening unless justified	Sampling approach for lower-risk cases; 100% for high-criticality or high-uncertainty cases
Radiation TID/TNID/SEE	Establish survival, parametric drift, destructive /non-destructive SEE behavior and mitigation needs	Radiation-sensitive active parts and critical electronics
Thermal cycling / HAST / THB / life test	Address package, moisture, contamination, thermo-mechanical and wear-out mechanisms	Plastic packages, high lifetime, high duty cycle, high uncertainty
Board/unit/system validation	Verify “test like you fly,” monitor mitigations and close residual risk	Application-level or system-level acceptance cases

ALTER Testing Strategy

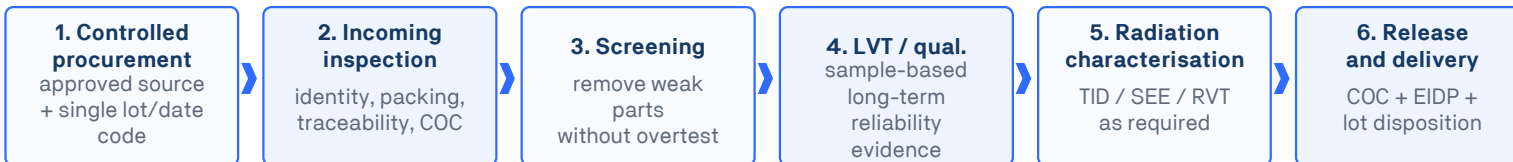
Dedicated QA plan: typical content

- Project-specific procurement, upsampling and test specifications approved before execution.
- Pre-procurement prioritization around long-lead items, special vendor constraints, obsolete/custom devices and single-date-code purchasing.
- Managed communication: real-time test execution through Virtual Lab, on-line status reporting through MyDoEEEt, monthly reviews, NCR follow-up and engineering support.
- Full release package with traceability, records, Certificate of Conformance, End Item Data Package, alert handling, ESD, storage and acceptance controls.

Reliability validation logic

- Screening screens out infant mortality but does not create intrinsic reliability.
- Qualification/LAT verify that screened parts and the procured lot remain suitable for long-term use.
- One-lot purchasing improves representativeness between evaluated parts and FM hardware.

Integrated assurance flow



Cost-reduction mechanisms



Dedicated QA Approach Vs Generic Cots Testing

Comparison matrix

Dimension	ALTER dedicated QA	Generic COTS-only path
Assurance basis	Mission/project-specific evidence, approved specs, lot control, documented release package.	Mainly vendor data, limited project tailoring, often fragmented evidence.
Screening depth	Can be 100% or tailored; aims to remove weak parts without inducing overtest.	Often basic incoming checks or ad-hoc customer testing only.
Traceability	Single lot/date-code preference, inspection lot controls, COC, NCR, data pack.	Traceability may weaken across distributors, repacking or multiple lots.
Reliability proof	Evaluation + screening + LAT/qualification + radiation + failure analysis where needed.	More reliance on vendor qualification; less lot-specific confidence.
Cost logic	More engineering upfront, but stronger reuse of data and fewer late surprises.	Lower entry cost can be offset by redesign, rework or repeated testing.
Best fit	Semi-critical to critical programmes needing COTS performance with managed assurance.	Lower-risk, shorter-life or experimental missions with higher residual uncertainty tolerance.

Case-style examples

Case A | one-lot campaign

Representative style case: evaluation, QM/FM and attrition are procured from one lot/date code; critical tests start early, then screening and LAT continue on that same lot. Benefit: stronger representativeness and less duplicated effort.

Case B | tailored LEO COTS path

Representative lower-cost case: sample-based upscreening plus DPA and selected radiation/life tests for approved commercial parts. Benefit: lower effort than full Class 1 treatment, while keeping traceability and documented lot decisions.

Key takeaways

- ALTER's model is not just "testing COTS"; it is controlled procurement + evidence generation + release discipline.
- Compared with generic COTS usage, it increases upfront engineering effort but lowers programme uncertainty.
- Compared with blanket full qualification, it can cut cost by tailoring depth, reusing data and planning by lot.

Scope and Dataset

5,500+

procured EEE lots

3,300+

3,300 are COTS and +2,100
are non-COTS

580+

total detected
failures

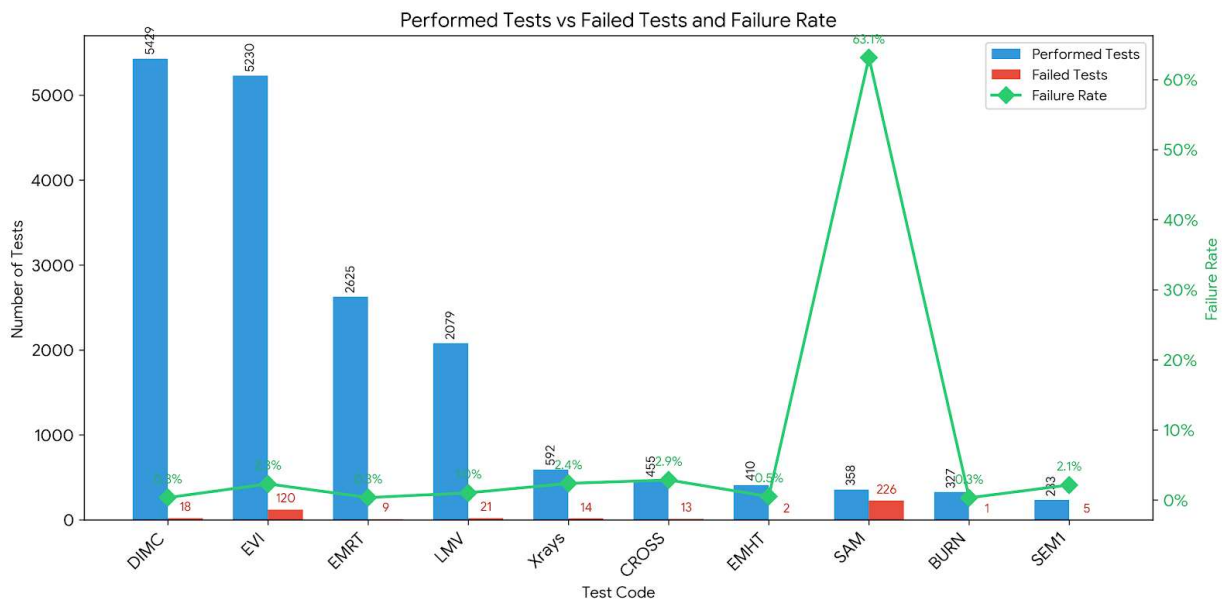
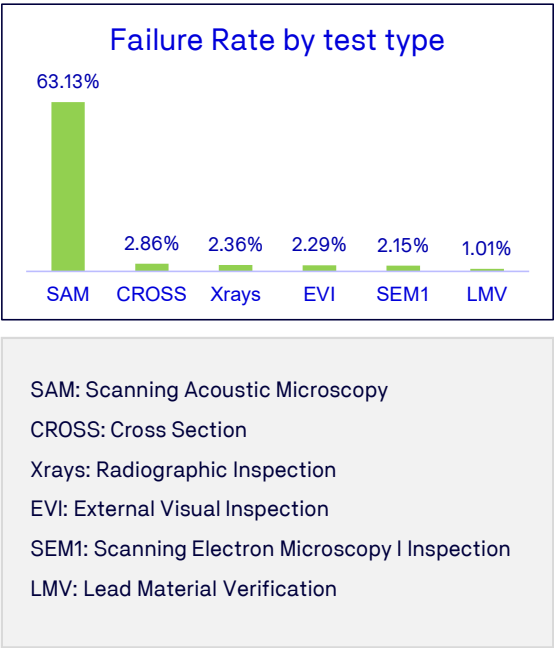
444+

failures associated with COTS
components (76.55% of the total
failures)

Failures indicate test failures or performance deviations, but **do not necessarily imply lot rejection**.
They support reliability assessment and identification of corrective actions to reduce risk.

Failure Analysis Dimensions of COTS

Laboratory Test Type	Quality Level	Family
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* Failure rate stands for number of test failed vs number of tests

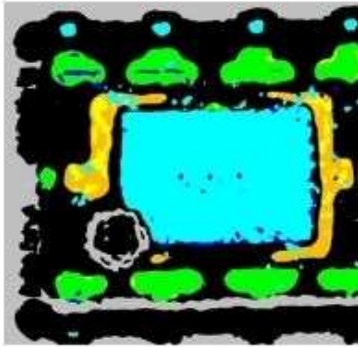
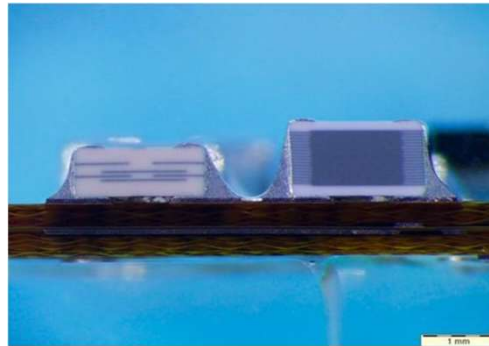
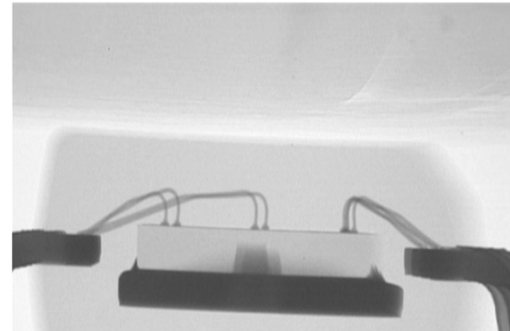
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Real Test Efficiency

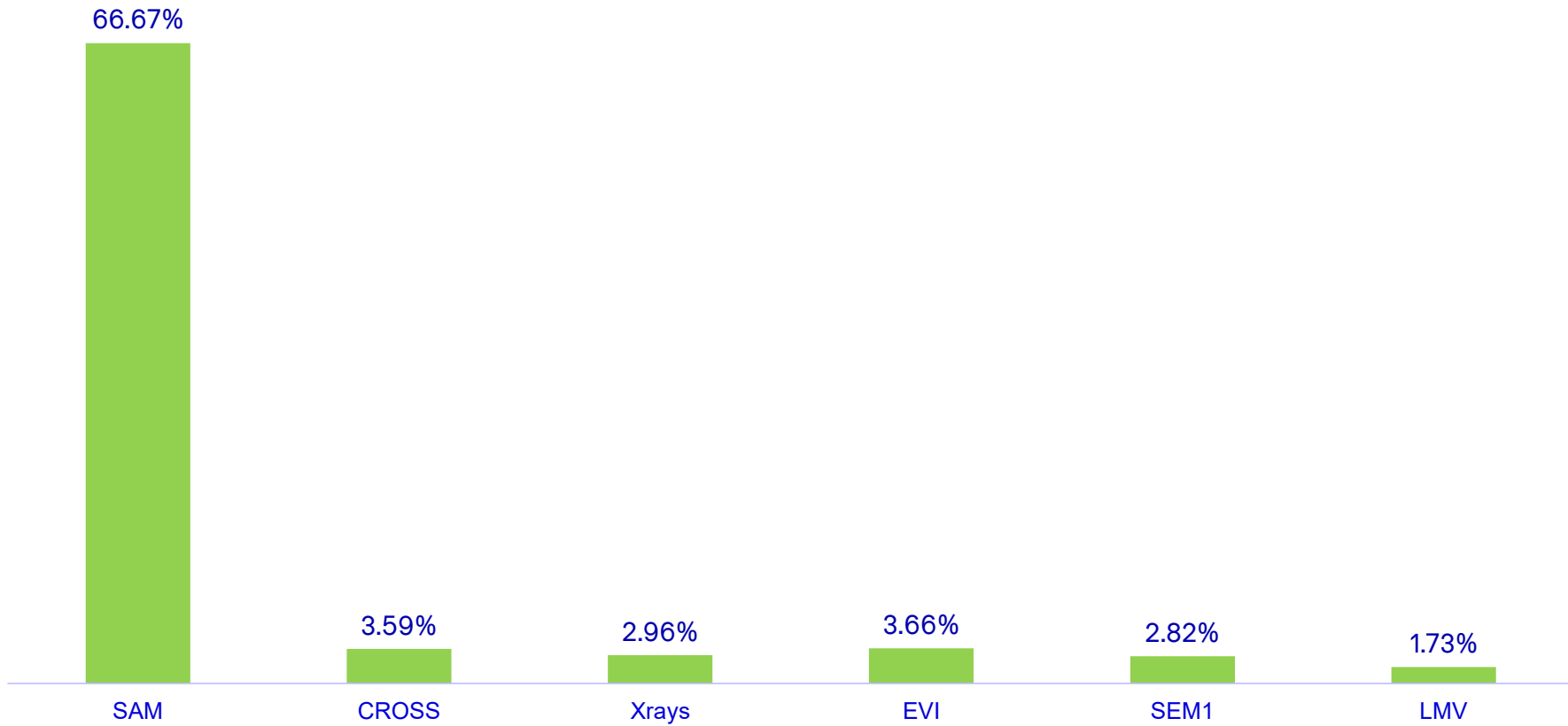
Although **EVI** is one of the most frequently performed tests, its failure rate remains **moderate**.

In contrast, **SAM** is applied less often but shows a **significantly higher** detection efficiency, revealing **internal defects** that cannot be identified by external visual inspection.

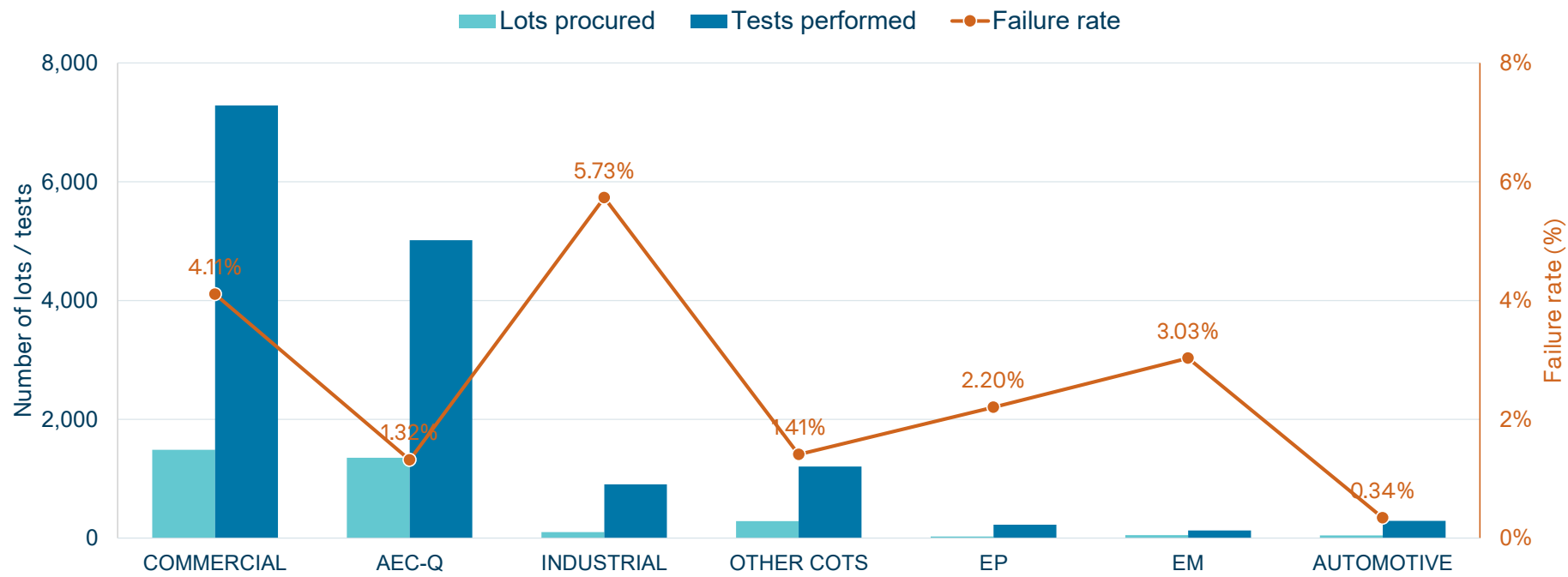
SAM inspection findings **rarely** lead to **lot rejection**. However, they can serve as **indicators** of potential defects that may cause future reliability degradation.



Failure Rate by test type



COTS Failures per Quality Level



Lots procured	1,488	1,352	100	285	27	51	45
Tests performed	7,283	5,017	907	1,207	227	132	290
Failure rate	4.11%	1.32%	5.73%	1.41%	2.20%	3.03%	0.34%

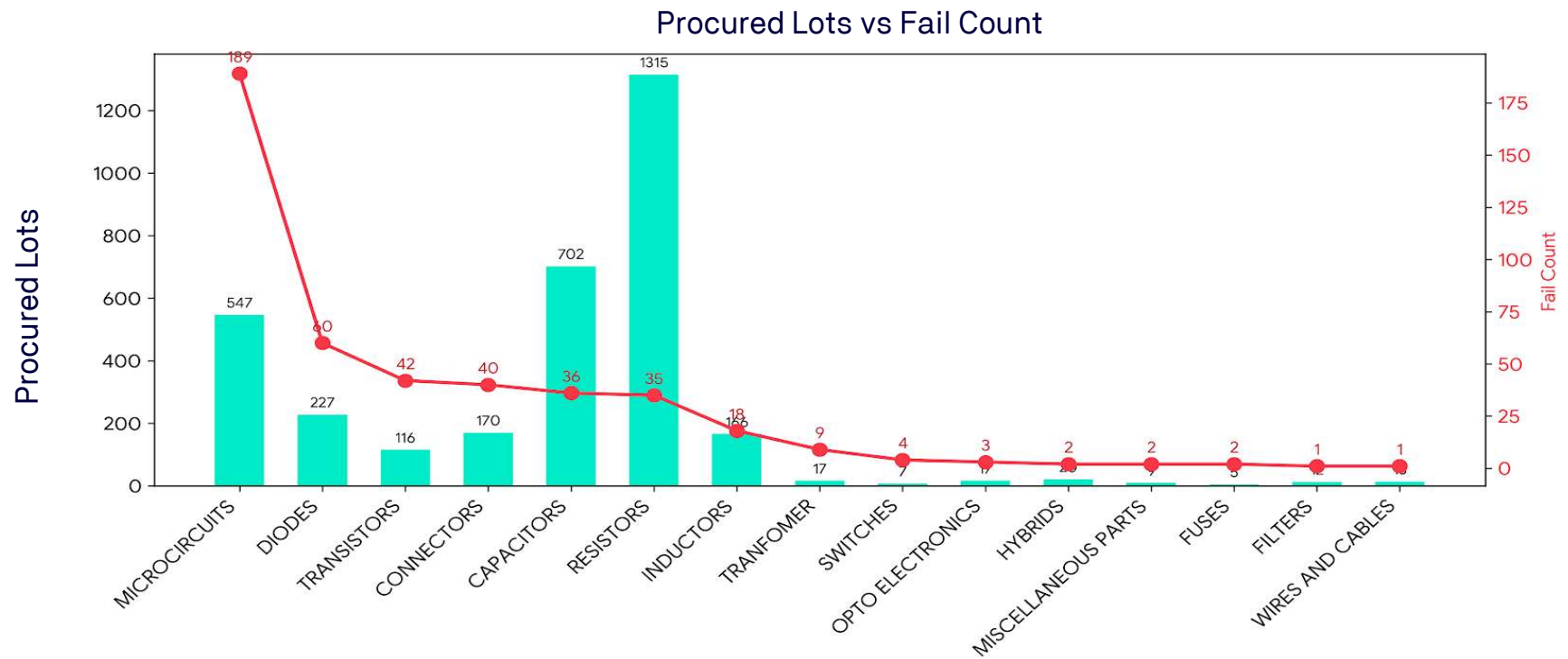
* Failure rate = number of failed tests / number of tests performed x 100.

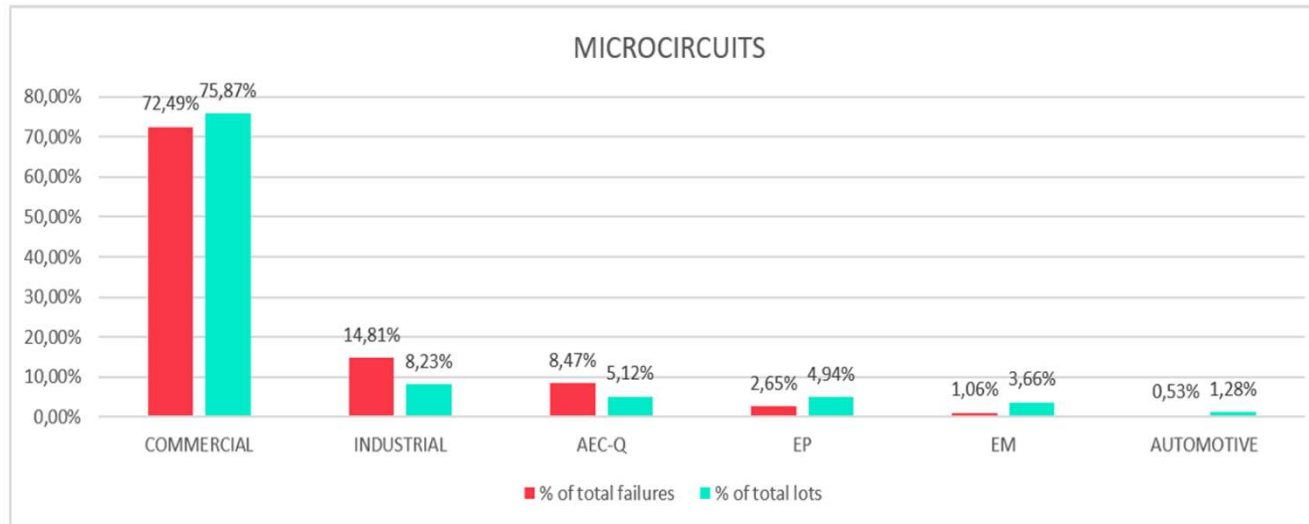
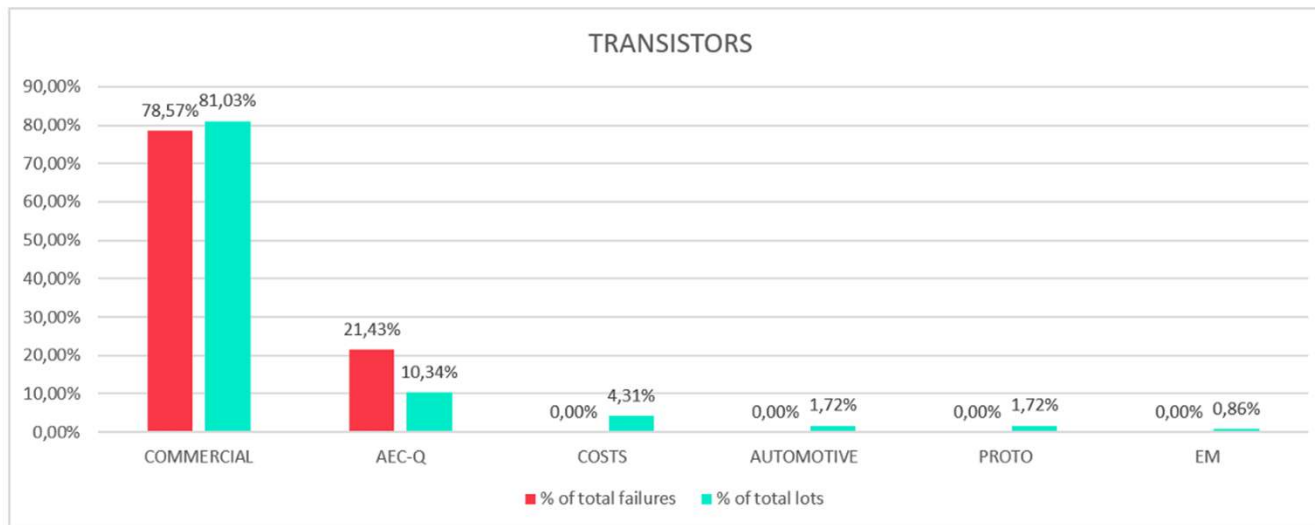
COTS Failures per Family

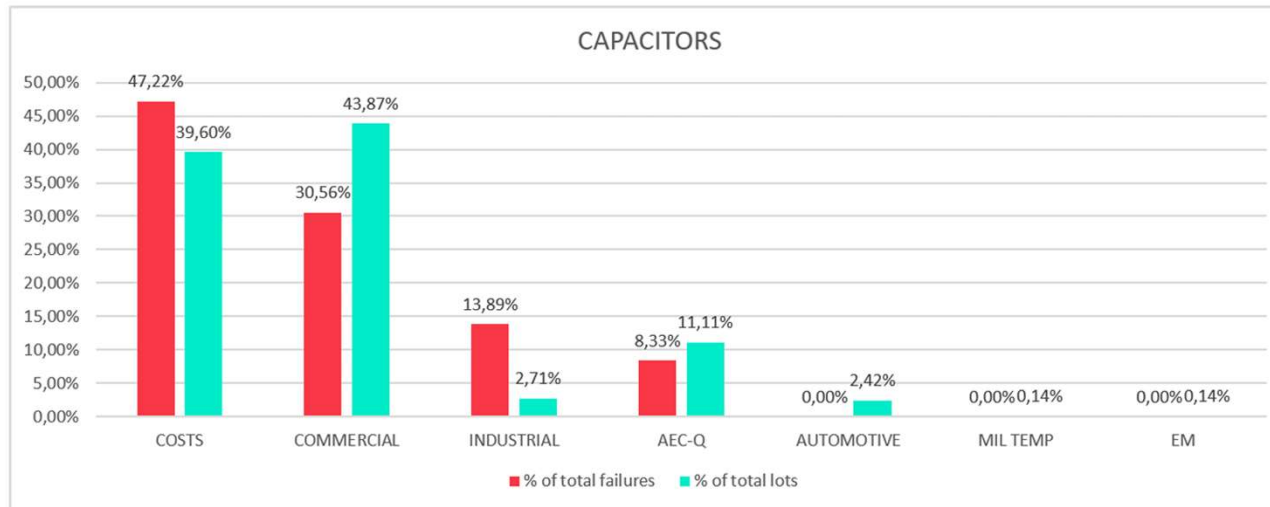
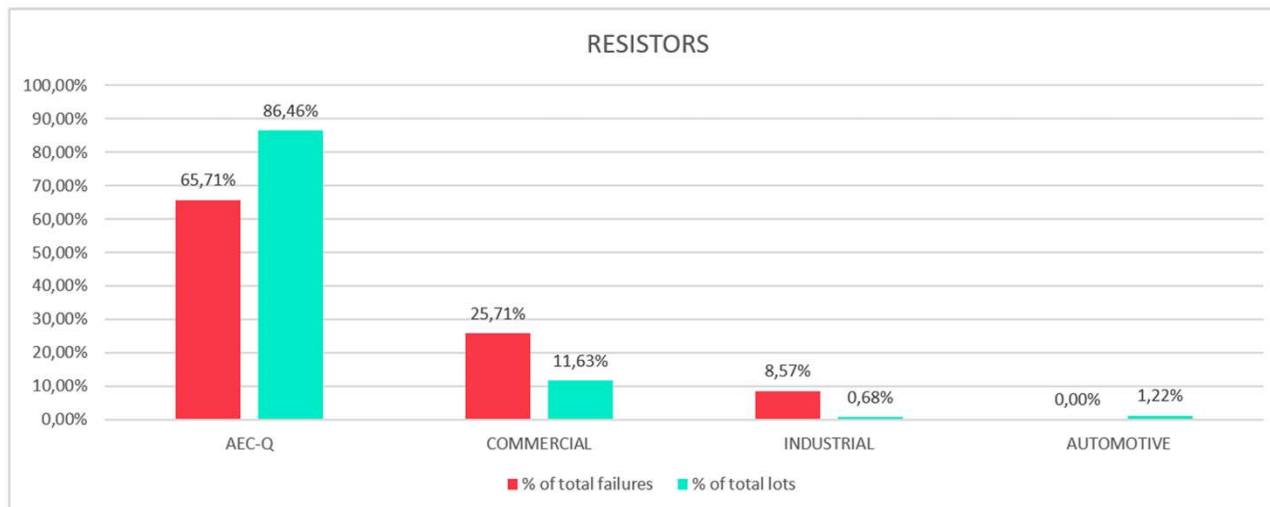
Laboratory Test Type

Quality Level

Family





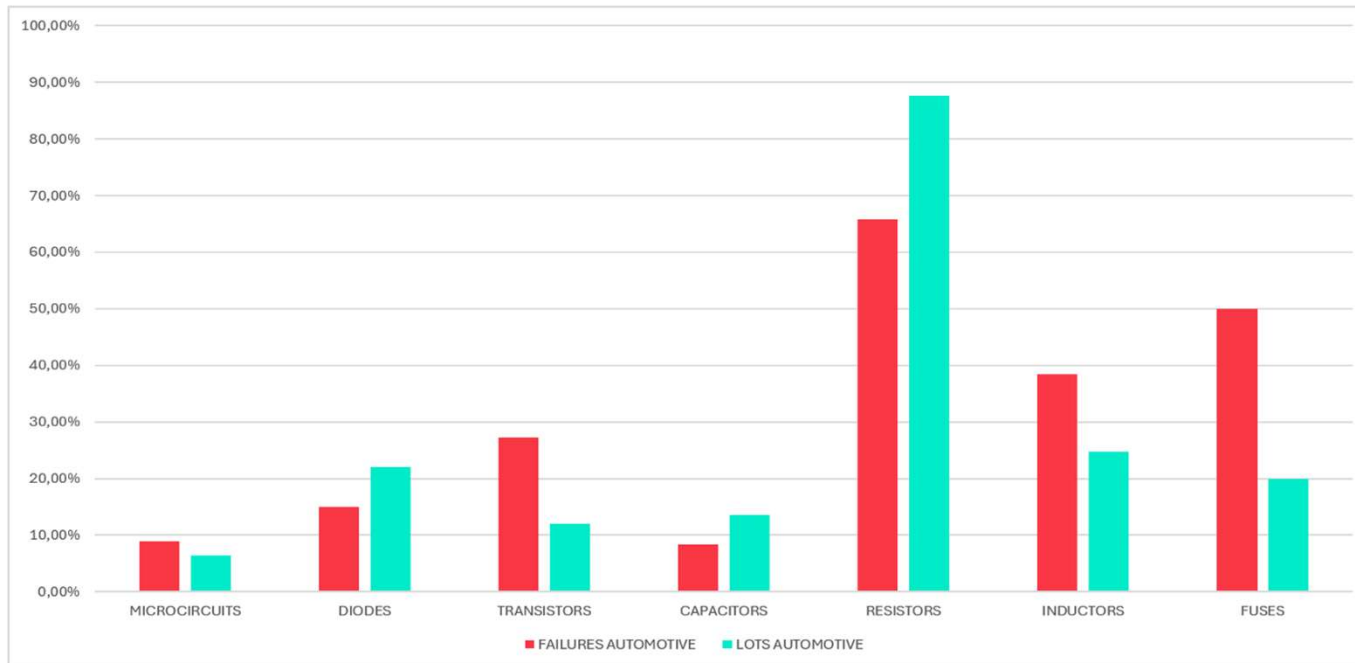


Distribution Of Automotive Failures By Family

Laboratory Test Type

Quality Level

Family



Failures detected in lots declared by manufacturers as “Automotive” or “AEC-Q” are basically proportional to the number of lots within each particular family. They do not show an intrinsic better reliability performance.

Lessons Learned

Analysis of historical test results, statistical trends, manufacturer quality controls, product quality consistency over time, supply chain robustness and other factors are the key lessons learned to support future activities and improving the approach.

Best practices and recommendations for improving procurement strategies and reducing sourcing risks and lead times requires a specialized approach, a consistent strategy and a centralized knowledge management to maximize return on the lessons learnt.

Example of Test failure

SAM failure

SAM failure

Problem

Analysis

Lessons Learned

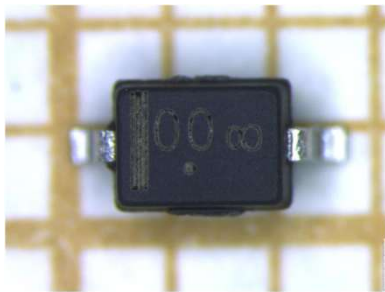


FIGURE 1: External View
Photograph showing the top side marking and orientation of the non-circuit side.

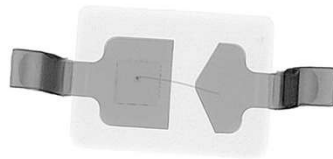


FIGURE 3: X-Ray normal view.
Photograph showing the internal structure of the system.

Zener Diode Regulator

Initial Scanning Acoustic Microscopy (SAM) as part of screening (ESCC 25200 Issue 4)

Scanning acoustic microscopy reveals major deviations in the inspected parts. These are rejectable as per the used inspection methods.

33 out of 80 parts showed rejectable package delamination.

Classified as non-compliant with ESCC 25200 §7.1

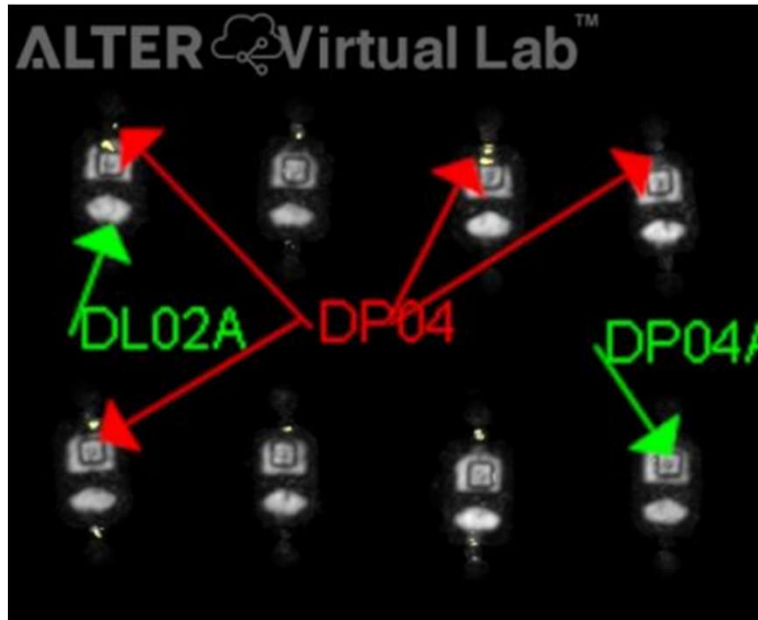
DPA with thermal cycling was performed on 3 samples (2 rejected + 1 compliant) to assess delamination evolution.

SAM failure

Problem

Analysis

Lessons Learned



DL02A: Acceptable partial delamination of the lead finger.

DP04A: Acceptable delamination of a surface-breaking part (paddle).

DP04: Rejectable delamination of a surface-breaking part (paddle) across the entire length towards the active area.

SAM failure

Problem

Analysis

Lessons Learned

Parts did not show function degradation nor evolution of the delamination after thermal cycling.

As the parts showed no functional degradation, the lot was considered acceptable. The customer was given the option to request additional testing and revise the disposition accordingly. The customer accepted the lot “as is” and requested no further action.



ESCC Basic Specification

No. 25200

7.1 DELAMINATION (See [Figure IB](#))

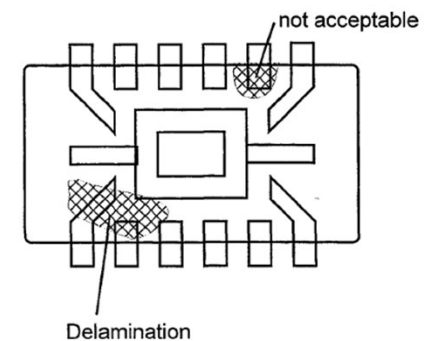
Delaminations found at the front side of the die, at the paddle area, at embedded films, or at the bonding area may have an impact on the reliability of the parts. If there is a significant relation to known failure mode (e.g. open circuit to delaminations in the bonding areas) the appearance of the delamination shall be observed as rejection criteria.

All delaminations that extend over the entire length of any surface-breaking feature are not acceptable. A surface-breaking feature includes lead fingers, tie bars, heat-spreader alignment features, heat slugs, heat sinks, laminate, laminate metallization, PTH, etc.

Complete delamination of die or die paddle is not acceptable.

Relative changes of the delamination area of more than 10% at stress tests are not acceptable.

FIGURE IB - DELAMINATION OF THE LEADFRAME



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Thank you for your attention!



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TUVIT

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Business Field Semiconductor

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TÜV NORD GROUP

Inspired by Knowledge

The TÜV NORD GROUP

Taken together, this is our expertise for your success.

Below ground



On ground



In space



Our Structure



ALTER

Figures, data, facts

The TÜV NORD GROUP at a glance (2025's figures)



1,795M

Sales



+15,500

Employees worldwide

TÜVNORDGROUP
TÜVNORD · DMT · ALTER · TÜVIT

4

Core Brands
in the Industrial Services, Mobility, Training,
Engineering and Natural Resources, Aerospace
and IT business units



+500

Locations worldwide



+150

Years experience
in the market

TÜVNORDALTER

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ALTER

Inspired by Knowledge

The Company

ALTER is a leading engineering company which provides reliable and agile solutions in engineering, procurement, assembly, and test to many of the world's most innovative technologies, such as semiconductors, electronic equipment and geospatial intelligence.



Space



Telecom



Medical



Railway



Defence



Aeronautical



Automotive



Figures, data, facts

ALTER at a glance (2025's figures)



91

Million Euros Revenues



505

Employees



40

Years in the market



8

sites

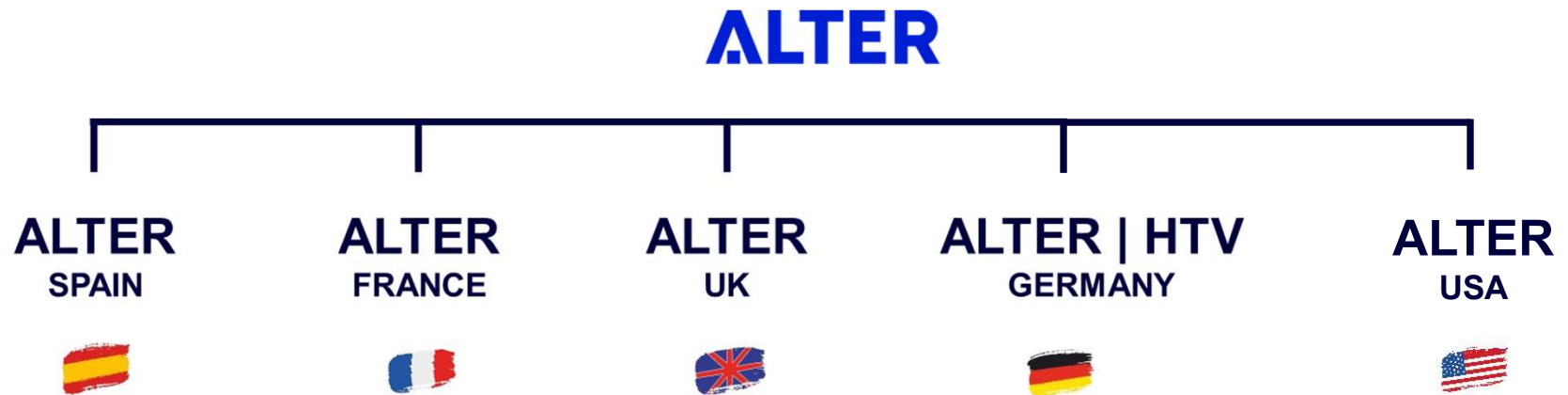


10,000

M2 laboratories

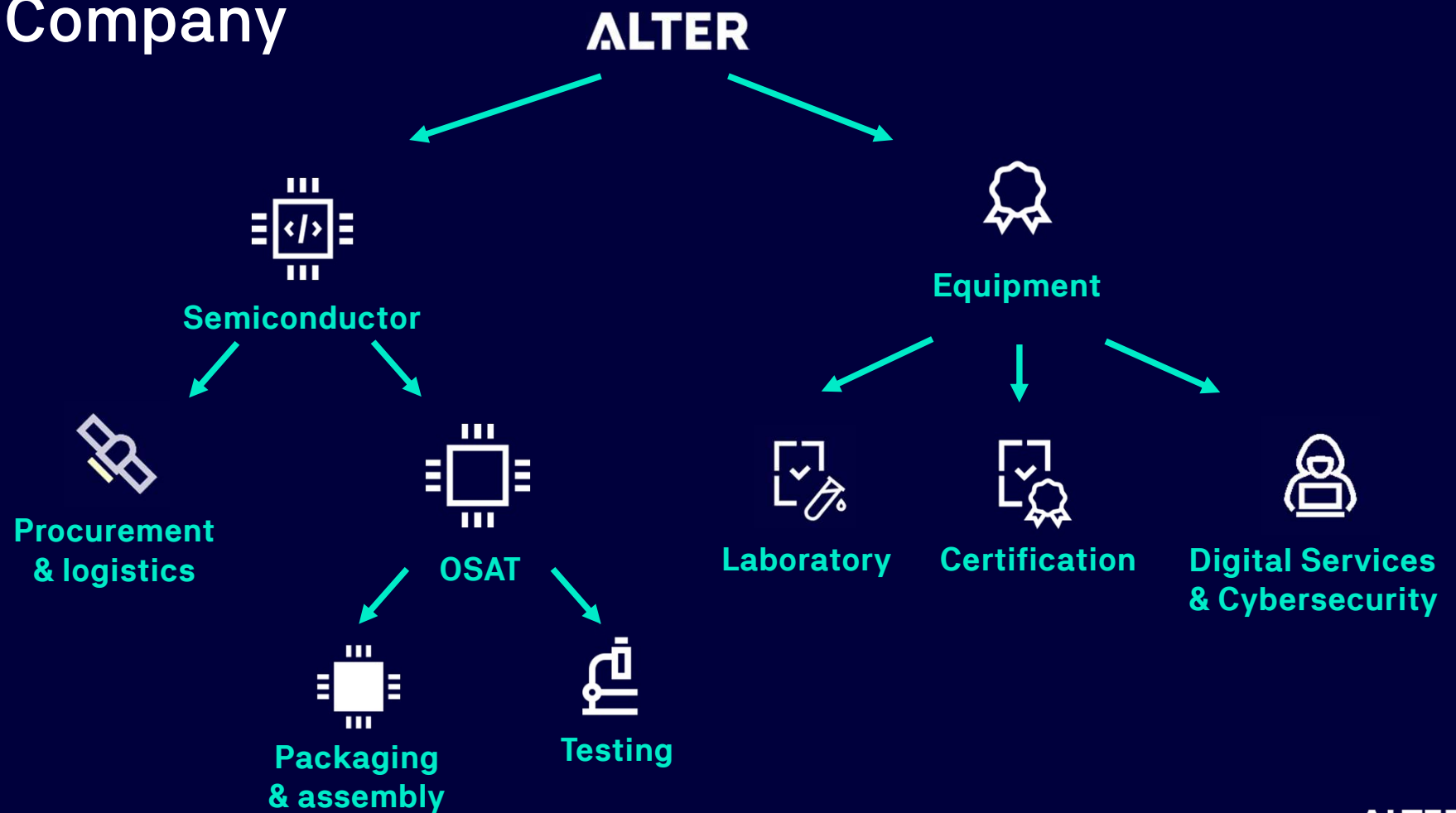
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Our Companies



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The Company



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PROCUREMENT & LOGISTIC SERVICES

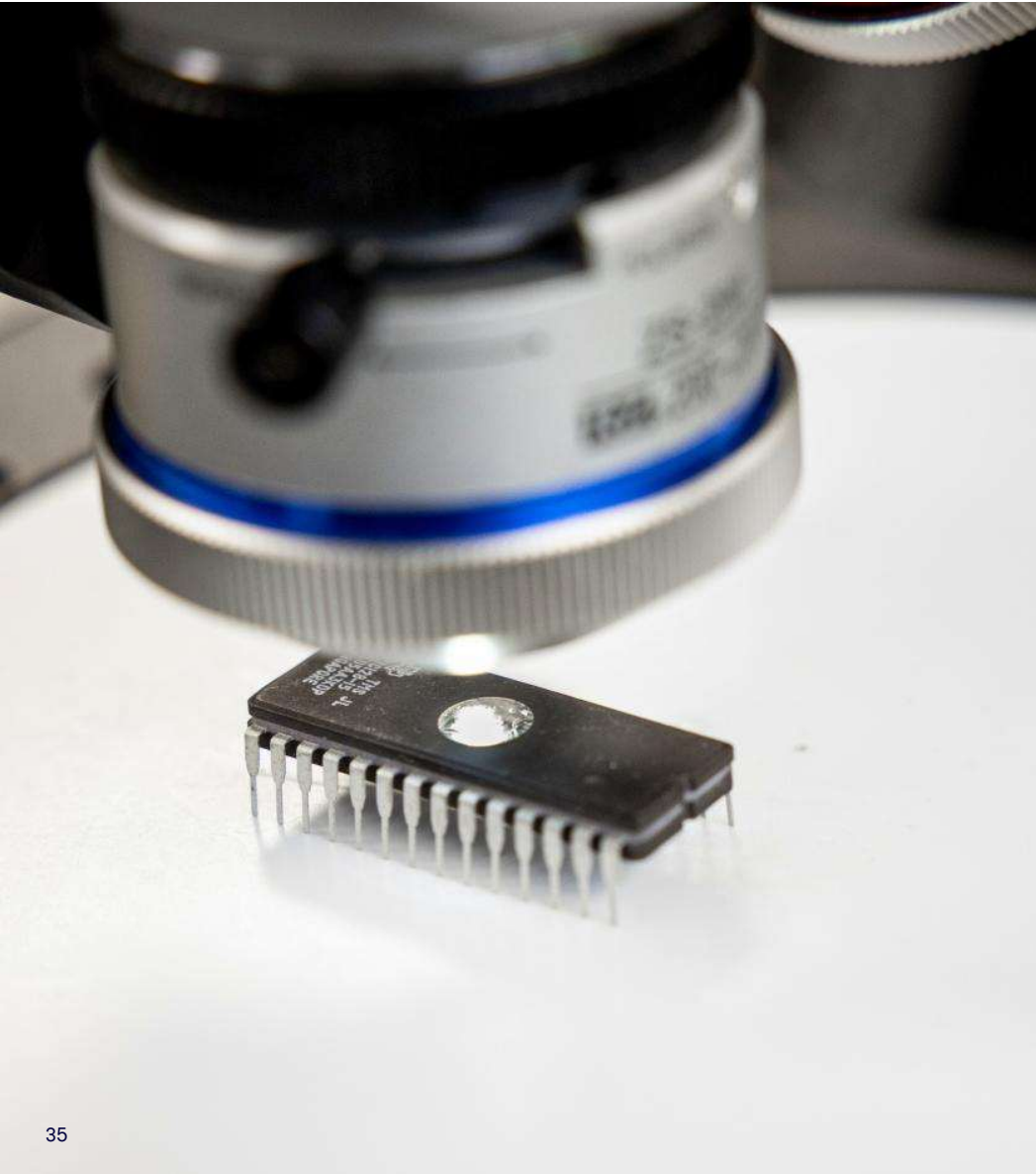
- Parts Engineering
- Procurement
- Long-term storage
- Counterfeit analysis



Parts Engineering

- Technical support to designers and system engineers
- Risk analysis and recovery plan
- Component technology assessment
- Radiation engineering and test plan
- Definition of validation and qualification testing plans
- Assessment on COTS parts for space application
- Obsolescence management
- Parts engineering and selection tool (doEEEt)

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Parts Procurement

- Specification preparation and integration
- Evaluation and screening plans
- Export license management
- Radiation data analysis
- Manufacturer audits
- Capability assessments
- Reliability analysis of test results
- Component database management

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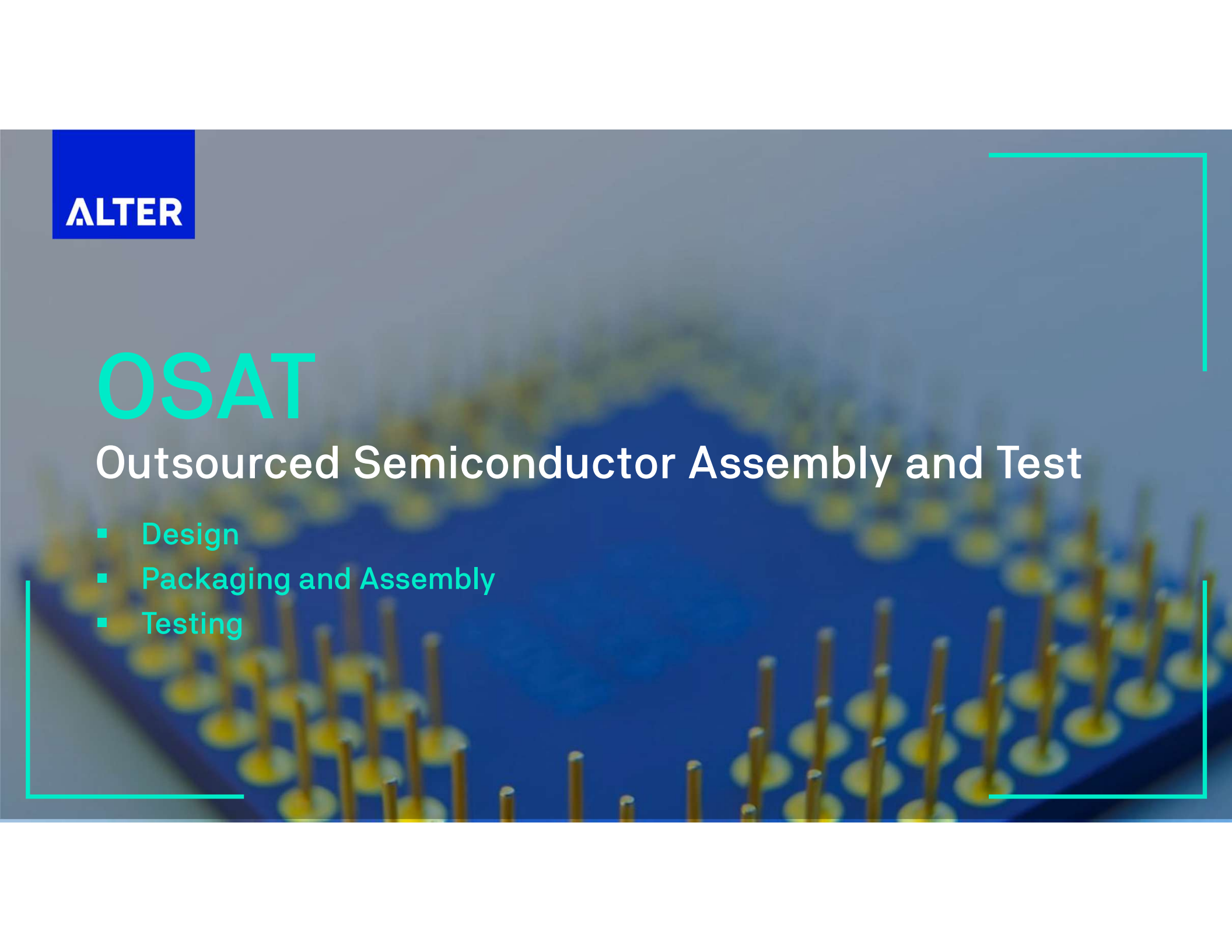


Long-Term Conservation

The Long-Term Conservation Method is of decisive importance for wafers and bare DIES to ensure long-term processability and functionality as well.

It is possible to store wafers and DIES **for up to 50 years** without significant quality losses.

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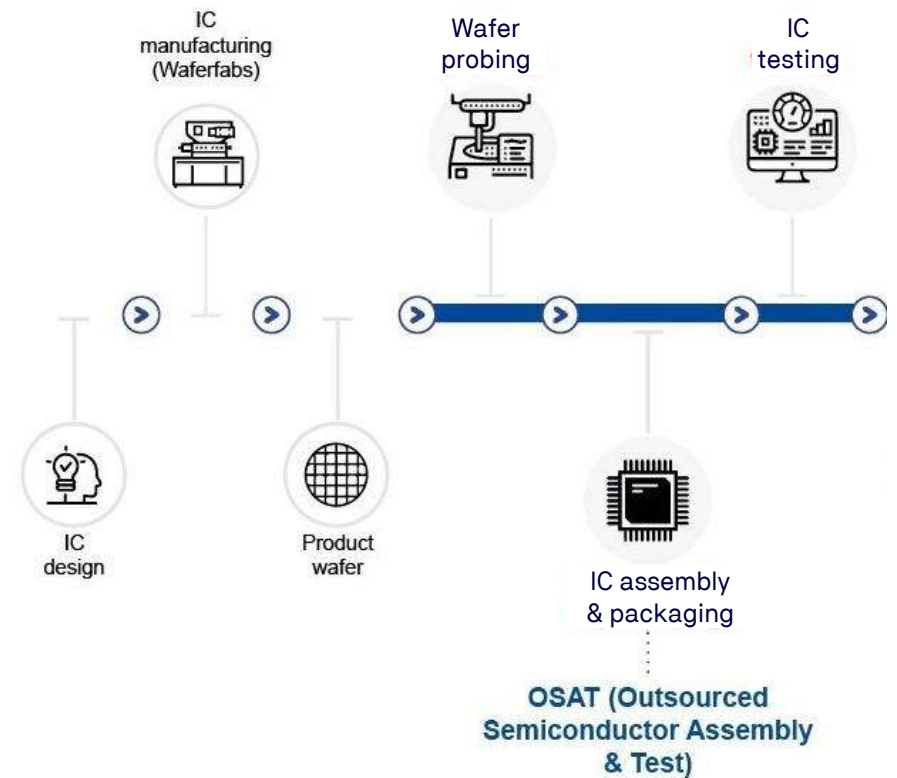
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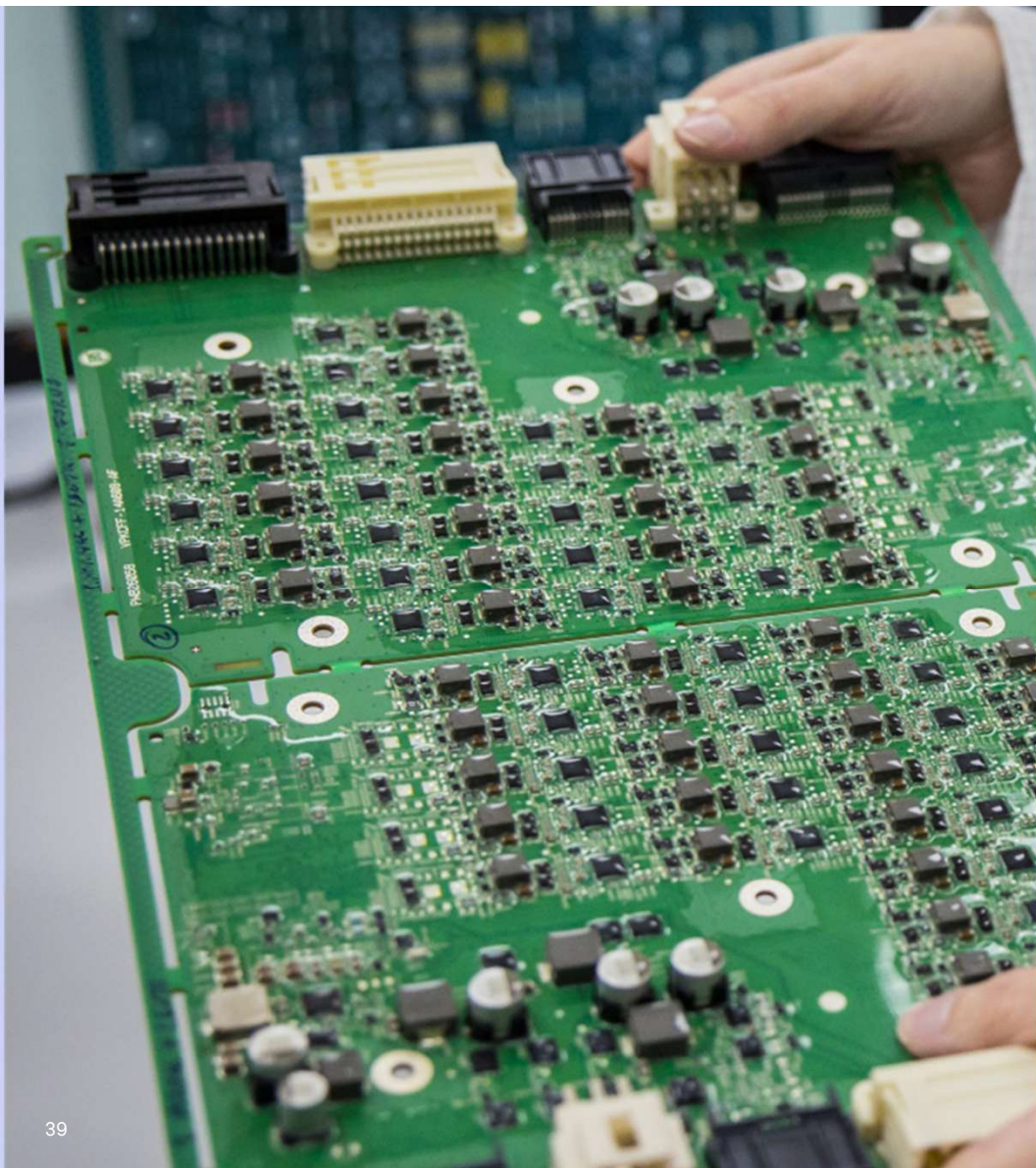
Outsourced Semiconductor Assembly and Test

- Design
- Packaging and Assembly
- Testing

ALTER position in the Semiconductor value chain



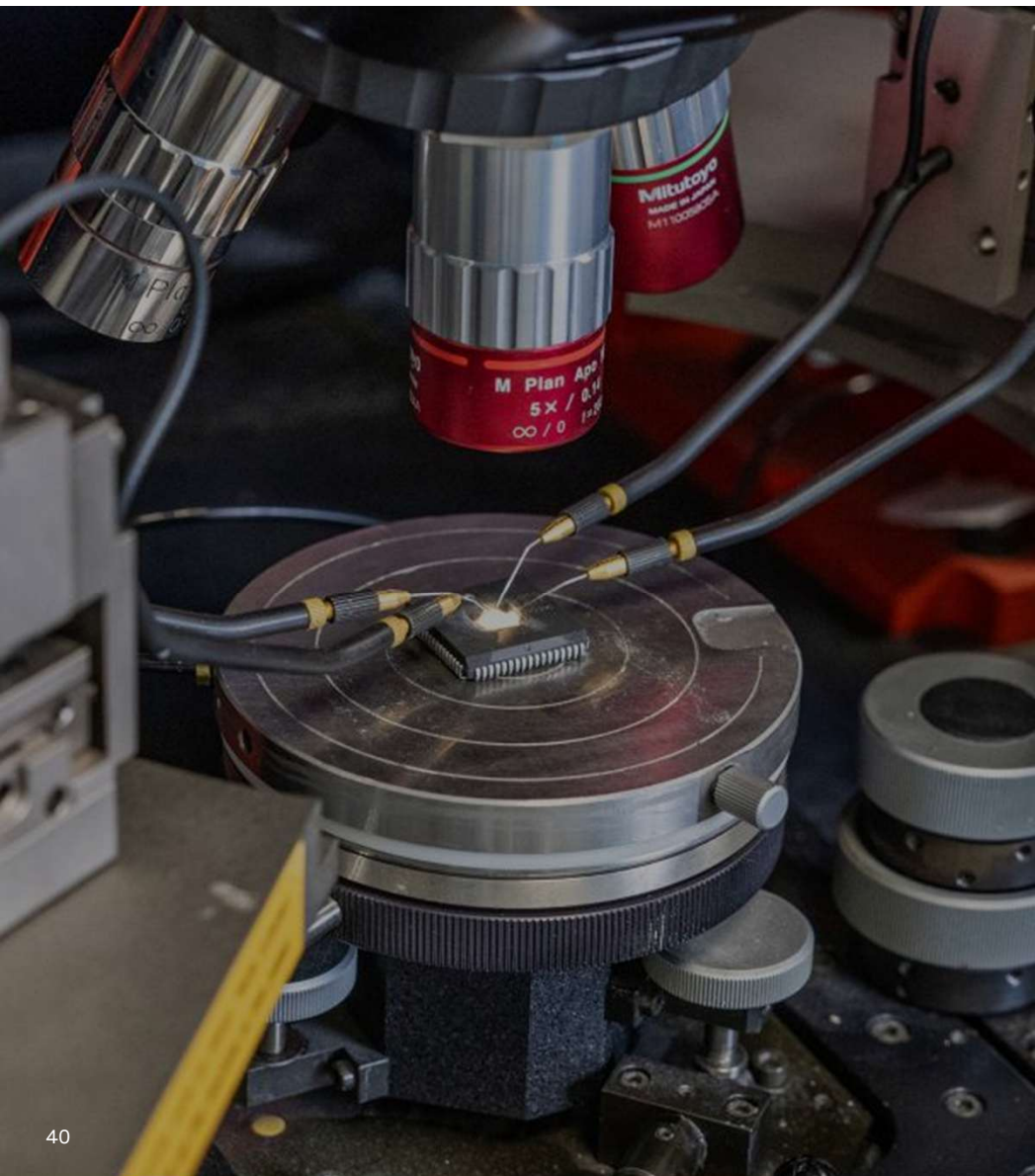
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Electronics Design

- HW electronics design
 - Analog, Mixed Signal and Analog Design
 - Power Electronics
 - Design for EMC
 - Microcontroller programming (C, Python)
 - CAE / Simulation
 - RF PCB layout
 - Prototypes build
- FPGA design
 - VHDL, Verilog
- Industrialization
 - Design for Manufacturing
 - EBOM optimization for costs and timing
- System In Package Design

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Photonic Design

Photonic Products for Quantum and Space

- The role of the PDC is to accelerate commercialisation of photonic products into quantum technology and space markets
- We do this by,
 - Actively engaging in relevant funded grant projects
 - Maintaining close ties and collaborating with our partners, customers and suppliers
 - Developing Alter brand platform products
 - Working closely with the manufacturing site to deliver manufacturable, qualifiable, robust products and processes
 - Investigating and pursuing new technologies and developments to keep the business innovative



Atomic
clocks

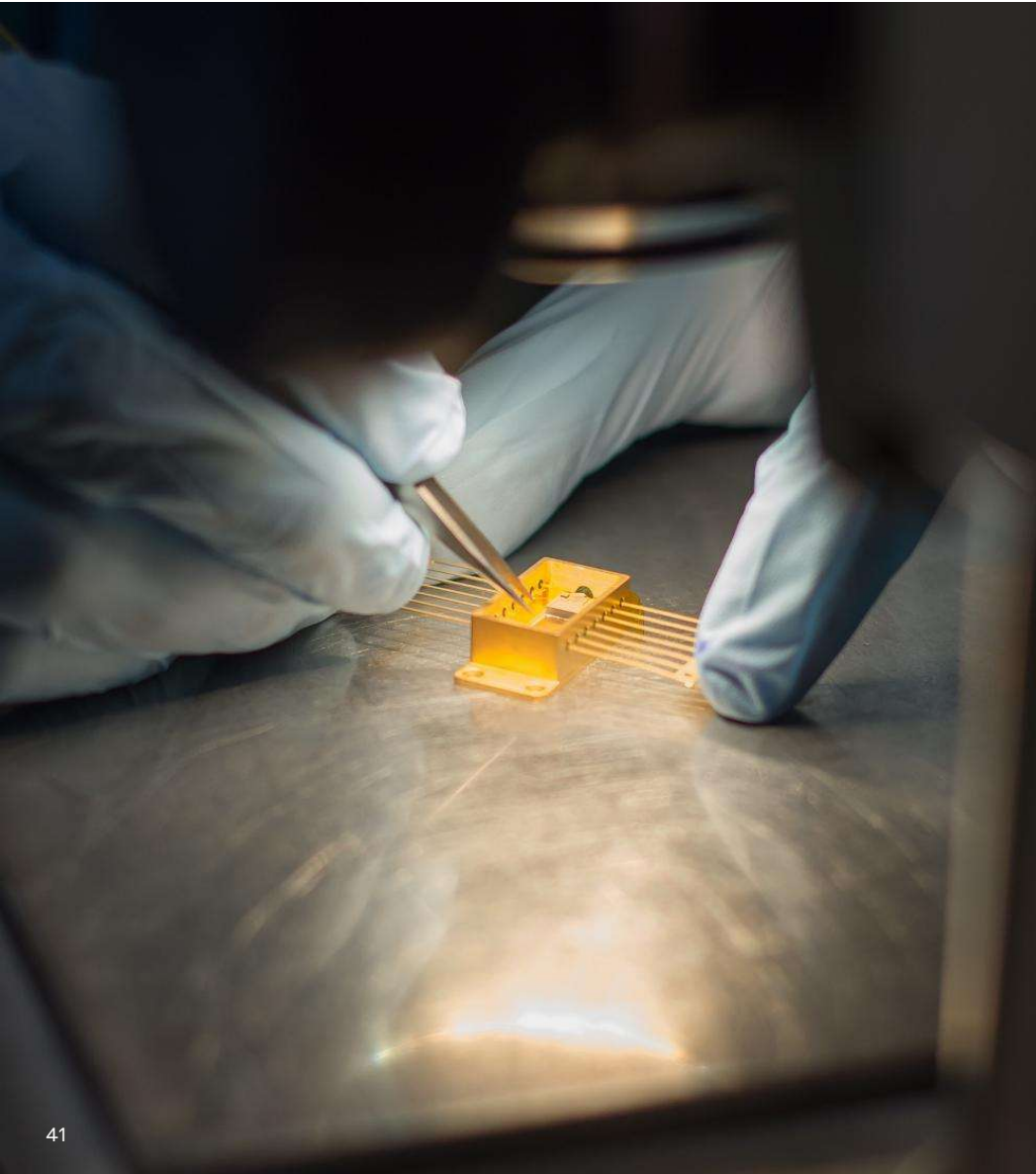


Position,
Navigation
and Timing



Sensing

ALTER

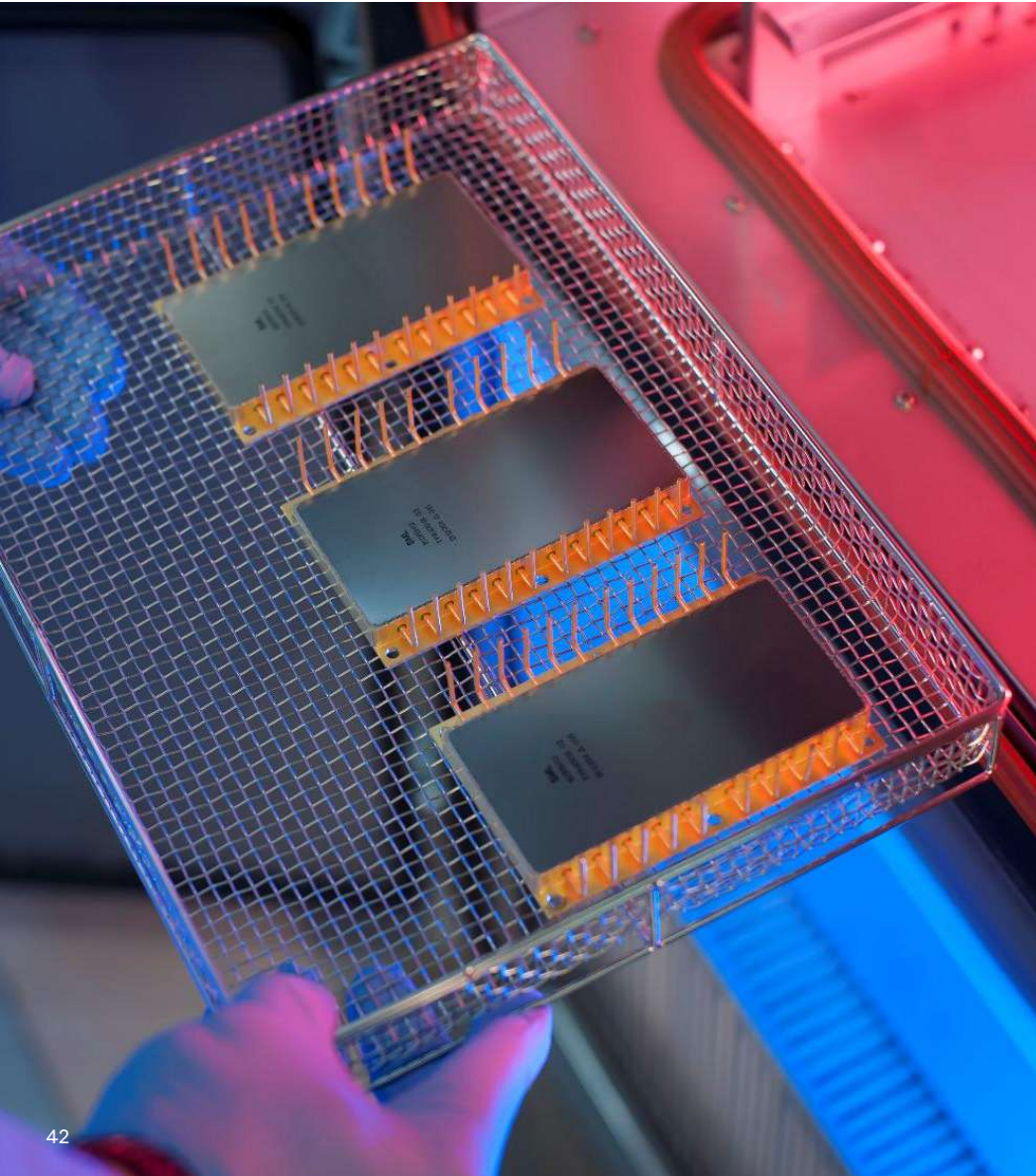


Packaging & Assembly

Our expertise in semiconductor packaging solutions spans the full product life-cycle: from design through prototyping, process optimization, product qualification, failure analysis and volume manufacturing.

- Full end to end semiconductor package design and assembly processes
- Plastic, chip on board and hermetic packages
- Photonic packaging platforms

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Parts Testing

- Technology analysis
- Functional testing on parts
- Physical and mechanical testing
- Materials analysis
- Detection of counterfeit components
- Failure analysis on components and on PCB-level
- Reliability testing
 - Environmental testing
 - Mechanical testing
- Radiation testing (TID, DD, SEE)
- Parts programming / flashing also in high volume
- Testing monitoring and reporting tool (Virtual Lab)

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PROPRIETARY PRODUCT



FLAME

Frequency stabilised,
< 1MHz source



REMOTE

ECDL source for repump



FISH

Dual frequency-locked
source in a single package



TAPERED AMPLIFIER

Amplification up to 2W



ENTANGLED PHOTON SOURCE

Suitable for SmallSats



OPTICAL TRANSCEIVER

For VHTS satellites up
to 56 GB/s per channel



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DOEET

Your place for EEE parts in space

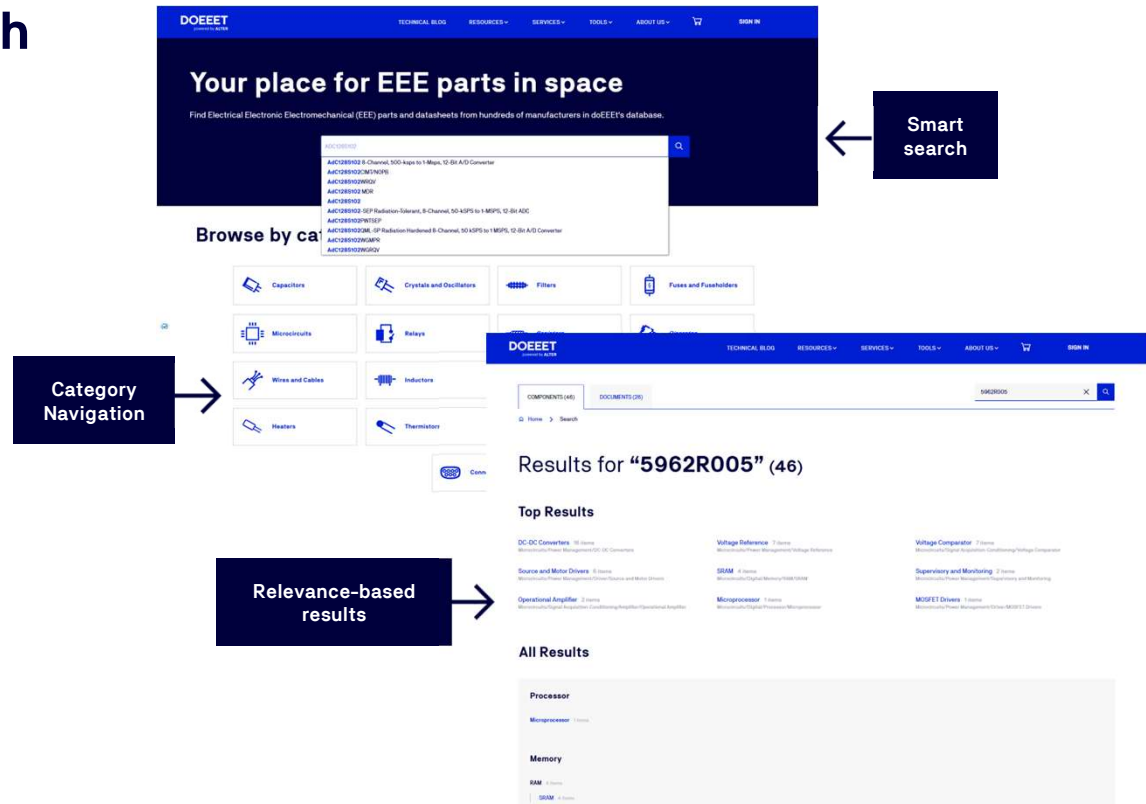
Digital Marketing and Business Data Analytics Department

doEEEt

Smarter Component Search & Project Management

A redesigned platform that simplifies how engineers find, evaluate, and manage components. Faster and with less effort.

-  **Smart full-text search** with instant suggestions
-  **Structured navigation** by component categories
-  **Optimized engine** highlights most relevant component families



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From Search to Technical Decision

1 Results page



Parametric filters
to quickly narrow your search



Stock availability



Instant access to key part info
(hover preview)

The screenshot shows the DOEEET search results page. At the top, there's a navigation bar with links like TECHNICAL BLOG, RESOURCES, SERVICES, TOOLS, ABOUT US, and SIGN IN. Below the navigation bar, there's a search bar and a filter section. The main content area displays a table of search results with columns for Manufacturer, Stock, Package, and Package. A 'Quick Search' section is also visible, showing a table of results with columns for Part reference, Stock, CAD Model, Quality level, Package, and various electrical parameters like V_{CE} , I_{CE} , $I_{CE(sat)}$, $V_{CE(sat)}$, $I_{CE(sat)}$, and $V_{CE(sat)}$.

2 Product Detail Experience

All critical data centralized for faster evaluation:



Technical specs
(parametric, mechanical, radiation)



Documentation & lifecycle notifications



CAD models
(3D, 2D, PCB symbols & footprints)



Direct access to lab services

The screenshot shows the product detail page for JANTXV2N5237S. It features a 3D model of the component, a table of technical specifications, and a section for documentation and lifecycle notifications. The table includes columns for Part number, Manufacturer part number, Manufacturer, Quality level, Package, and various electrical parameters like V_{CE} , I_{CE} , $I_{CE(sat)}$, $V_{CE(sat)}$, $I_{CE(sat)}$, and $V_{CE(sat)}$.

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From Selection to Procurement

3 Manage components

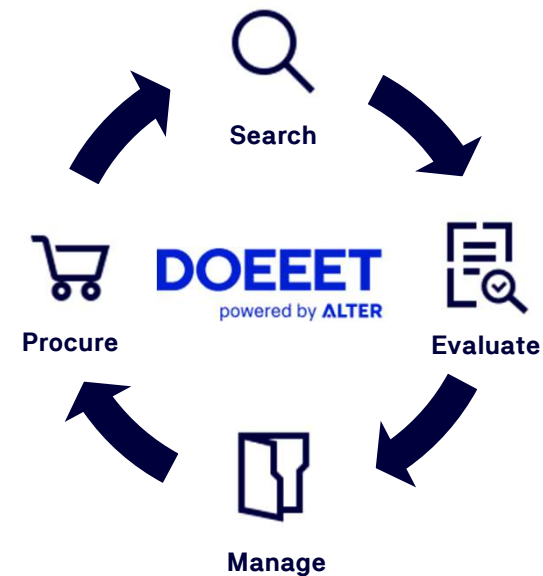
-  Add components to lists from any page
-  Standardized DCL/BOM management
-  Create, import, export, and share lists

4 Compare easily

-  **Reference-based**
Set one component as reference to compare to
-  **Parametric-based**
Compare by required parameters

5 Request & Quote Instantly

-  Add tests & inspection services
-  **Get ROM (estimated) quotations in minutes**



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Virtual Lab

All in one.

Virtual Lab

All in one

A comprehensive platform for real-time test tracking and document management.



Smart Realtime monitoring:

Monitor your testing progress live as it happens



On-demand interaction:

Seamlessly communicate with our engineering team whenever needed



Document Authenticity:

Instantly verify the validity and integrity of your test reports

PRODUCTION ORDER	2024901197	PACKAGE
PART TYPE	2N2222AUB LCC-4 (UB)	COMPONENT NUMBER
PLAN REFERENCE	N/A	MANUFACTURER
MARKING	JSR2222AUB#R1905#CDWR#S/N	DATE CODE
RECEPTION DATE	2024/06/19	COMMITMENT DATE

SHOW INDICATORS SHOW RELATED DOCUMENTS SHOW INVOICES SHOW CONTACT CALENDAR SHOW DEPENDENCE TREE



Smart search

FAILURE ANALYSIS

ORDER	TEST NAME	METHOD	START DATE	RESULT DATE	RESULT	ST
1	EXTERNAL VISUAL INSPECTION	MIL-STD-750, Method 2071.9 - 2A (w/Change 2)	2024/06/20	2024/06/20	●	
2	ELECTRICAL CHECK FOR CHARACTERIZE FAILURE	CUSTOMER REQUIREMENTS	2024/06/21	2024/06/21	●	
3	RADIOGRAPHIC INSPECTION	MIL-STD-750, Method 2076.6 - 2B (w/Change 1)	2024/06/21	2024/06/21	●	
4	SEAL TEST					
5	PIND					
6	INTERNAL VISUAL					



PRODUCT	MODEL
CUSTOMER	
PRODUCTION ORDER	CUSTOMER PO REF
RECEPTION DATE	COMMITMENT DATE

SHOW INDICATORS SHOW RELATED DOCUMENTS SHOW INVOICES SHOW CONTACT CALENDAR SHOW DEPENDENCE TREE SHOW USERS ACTIVITY



Relevance-based results



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Core Capabilities

1 Monitor



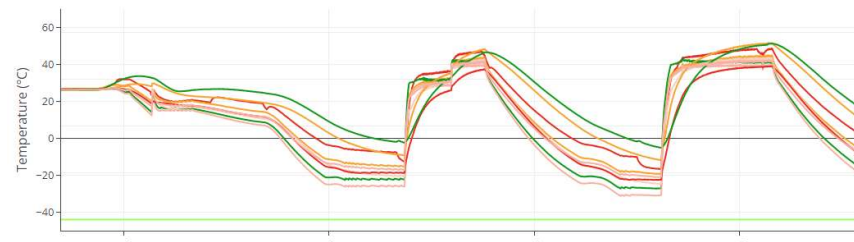
Smart filters
to quickly narrow your search



Instant access to any test execution

	PART TYPE	Ensayo FM	PACKAGE
	COMPONENT NUMBER	PN-1000	PLAN REF
	MANUFACTURER		MARKING
	DATE CODE	N/A	CUSTOMER
	PRODUCTION ORDER	2020901750	

MAXIMUM TEMPERATURE	51.6 °C	MAXIMUM PRESSURE	8.51e+002 mBar
MINIMUM TEMPERATURE	-31.2 °C	MINIMUM PRESSURE	7.09e-007 mBar
MAXIMUM TEMPERATURE VARIATION	82.9 °C	MAXIMUM PRESSURE VARIATION	8.51e+002 mBar



2 Interact

Direct contact with the key personnel for faster evaluation:



Technical assessment
(parametric, mechanical, reliability...)



Documentation & notifications

DIRECT CHAT

Hola! Y ese resto a qué puede deberse? A contaminación desde SMD? Qué raro!

2020-10-01 10:00:00 Dimas Morilla Mainén

Es difícil de determinar. Por lo que vemos en SEM parece que no se trata de una aleación de Ag y Sn. El Sn está presente en el finish de la vía, y la plata en el finish de los pines que van insertados en estas vías.

2020-10-01 10:00:00 Dimas Morilla Mainén

Select files... **BROWSE...**

Type Message ...

Send

CLOSED

ALTER

The #1 Differentiator Chosen by Customers

1 Our primary strength:

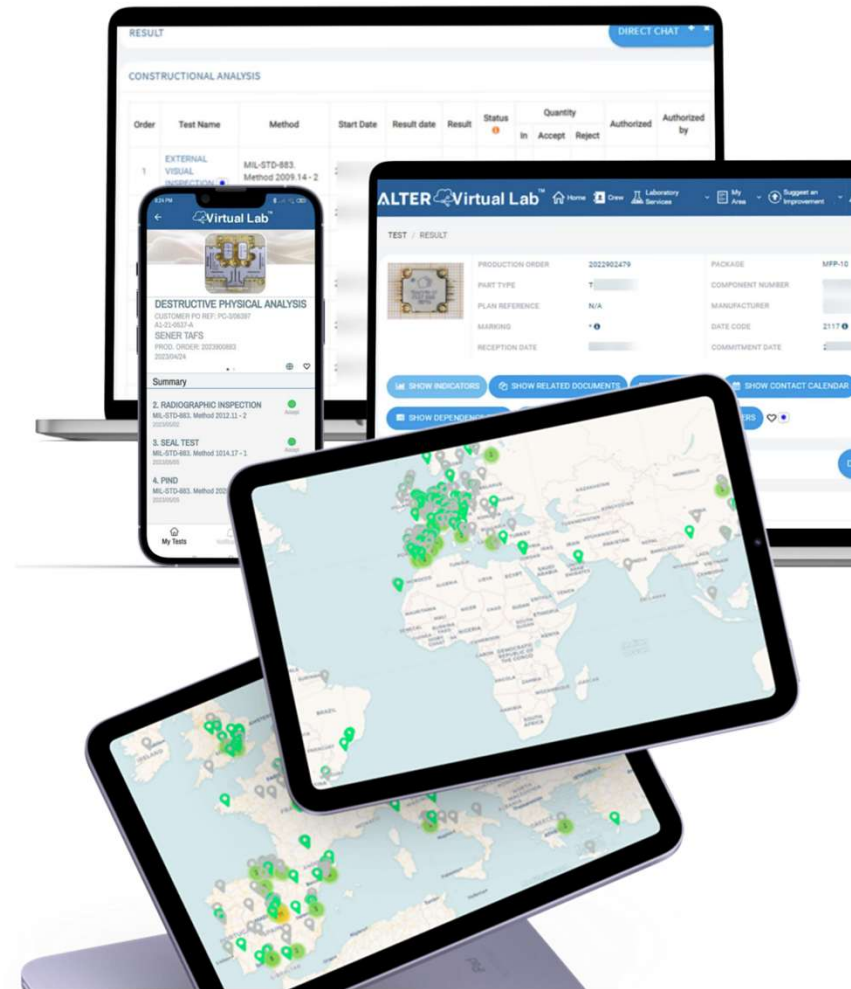
Customers rank Virtual Lab as the top factor that makes our services stand out from the competition

2 Multiplatform

Wherever you are:
Laptop, Tablet or SmartPhone

3 Solid growth:

An internationally recognized platform that already serves over 1,200 direct Virtual Lab users



ALTER

Our Sites



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Toulouse

ALTER
Edinburgh
& Glasgow

ALTER
Minnesota

ALTER
Seville

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Essen

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Berlin

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