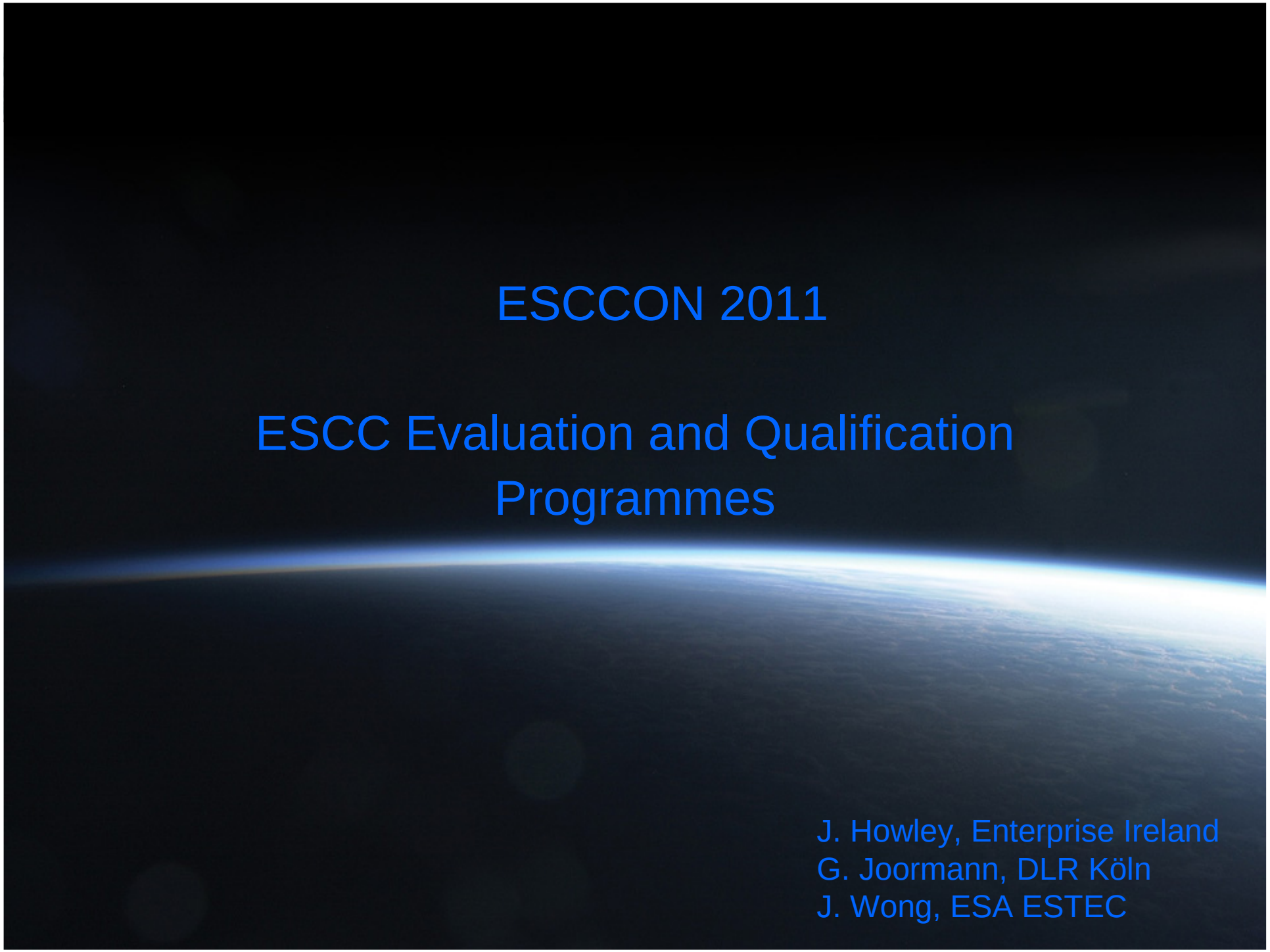


ESCCON 2011

ESCC Evaluation and Qualification Programmes

J. Howley, Enterprise Ireland
G. Joormann, DLR Köln
J. Wong, ESA ESTEC

ESCC Evaluation and Qualification Programmes- The ESCC System

European space programmes need stable sources and supply of components

- **The ESCC System is centrally positioned to address this need**
  an international system for the specification, qualification and procurement of EEE components for use in Space programs

- **ESCC Specification System**
  - **the technical specification of EEE components**
  - **methodologies for component evaluation and qualification**
  - **testing methods / quality assurance / operational provisions**

It offers a degree of autonomy for its component technology requirements and forms a basis for development and growth

All ESCC Specifications are freely available from the ESCIES web site. The web address is *https://escies.org*.

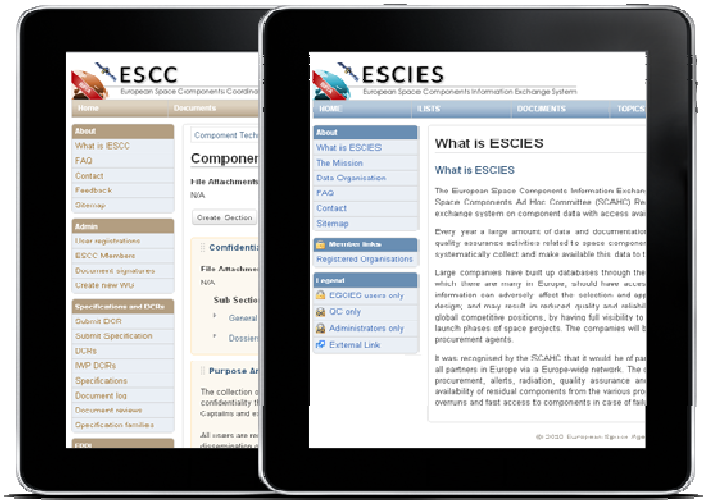
ESCC Evaluation and Qualification Programmes- The ESCC System

Sole purpose of the ESCC System is to provide components for space applications.

- A key objective is to improve the availability of strategically important EEE components

- It prefers European sources offering competitive performance and costs

- Key Products include:
  - ESCC specification system
  - Quality assurance infrastructure
  - Qualified Parts List
  - Qualified Manufacturers List
  - European Preferred Parts List
  - ESCIES and Spacecomponents.org

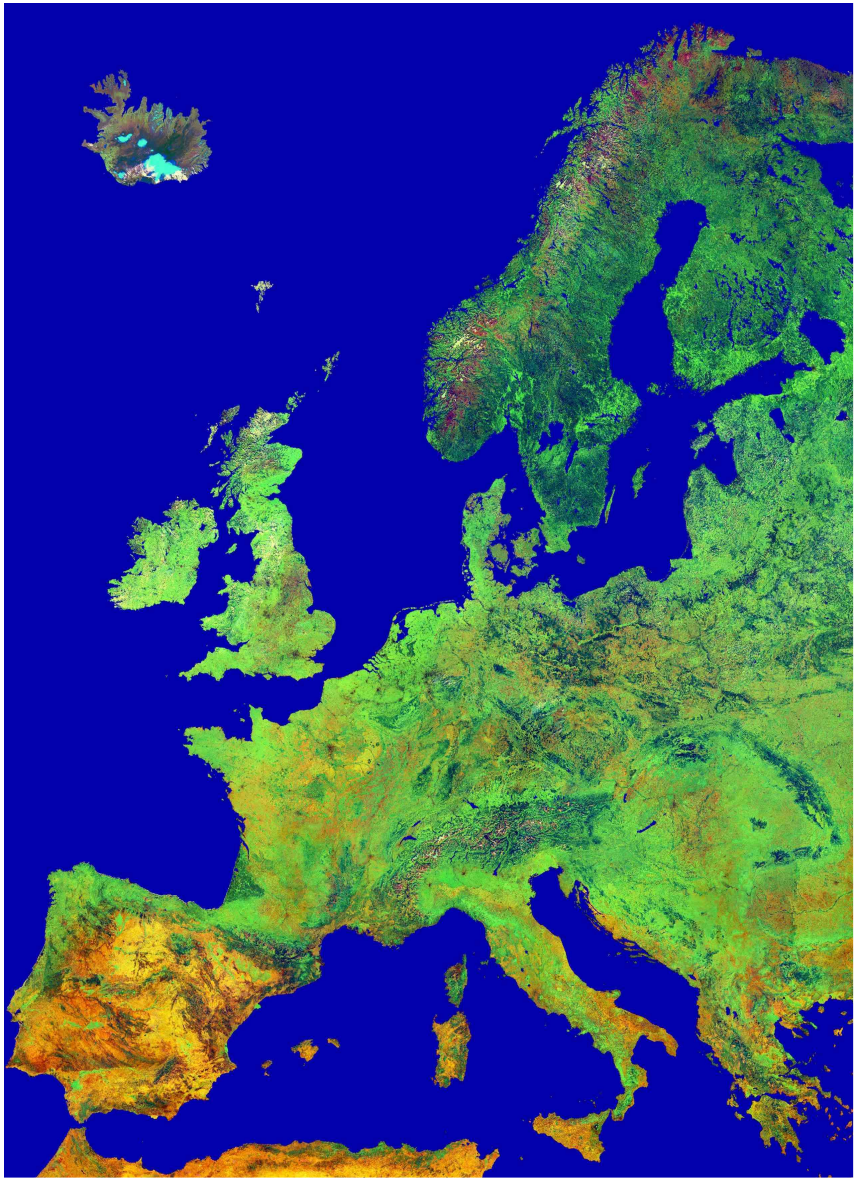


ESCC Evaluation and Qualification Programmes- The ESCC System

ESCC is a unified and single European system for space component specifications and the corresponding qualification and certification activities.

- The System is supported by the signatories to its Charter and its partners contribute resources with their own funding

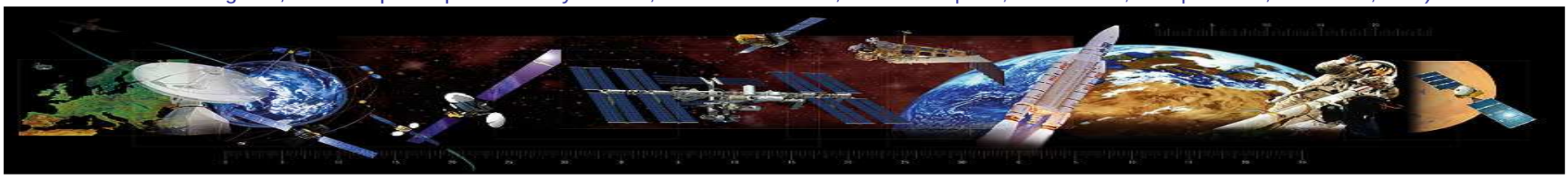
- The Space Components Steering Board (SCSB) is the penultimate body to contribute and supervise the resources to achieve its stated objectives



ESCC Evaluation and Qualification Programmes- The Perspective

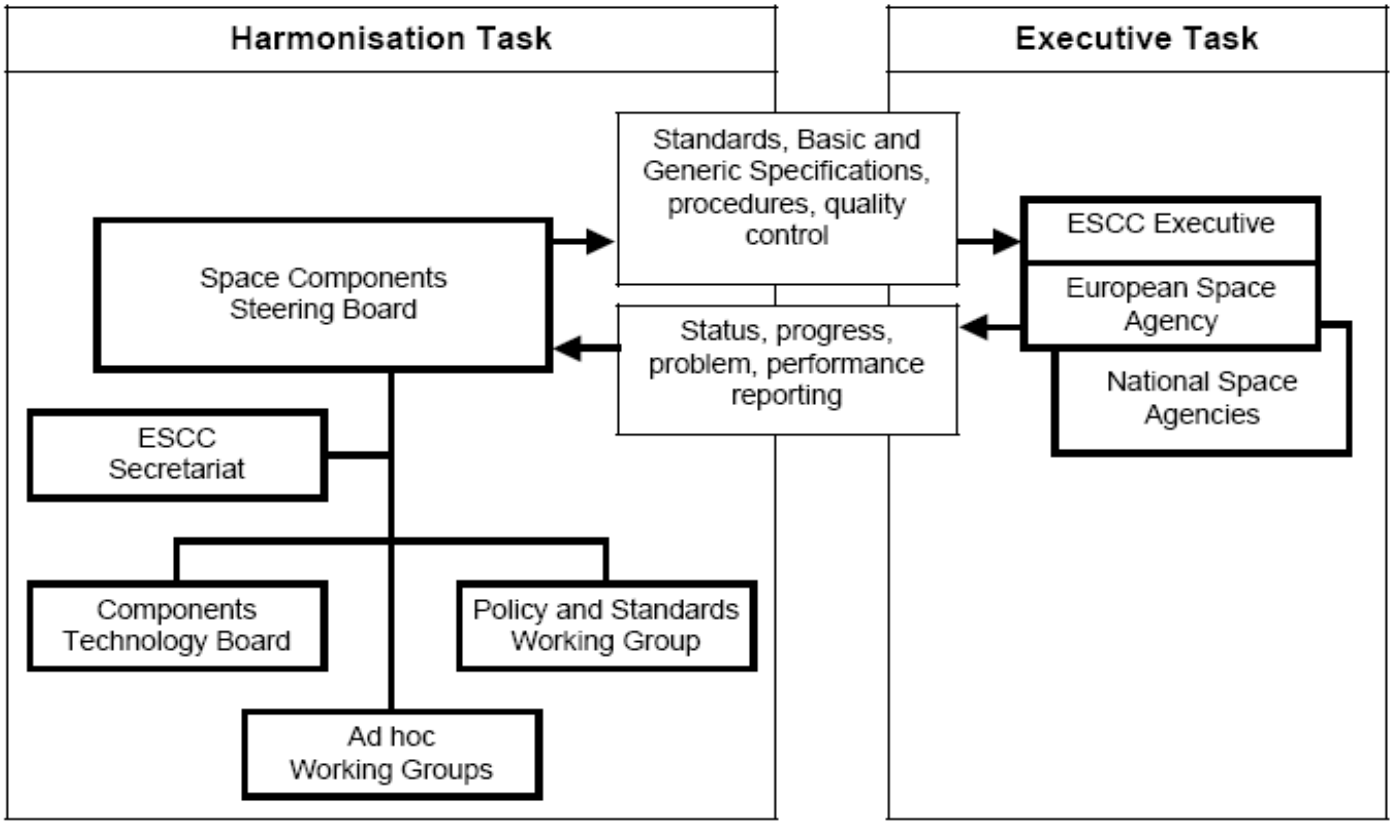
Segment	Programmes	No. of Companies	M€/year	Export, %	ESA %
Total			5,359	49.9[2]	
Satellite Applications		118	3,081	36.8	21.1
	Telecomm.		1,940	49.9	7.1
	Earth Obs.		938	16.9	36.8
	Navigation		204	-	82.9
Launchers		26	1,069	2.0	-
Science			821	6.5	81.4
	Science		443	-	70.4
	Human Space		342	-	93.6
	Microgravity		36	-	Mainly ESA
Ground Segment		48	387	9.8	-
	EGSE/MGSE		46	28.3	15.2
	Ground Stations		246	8.9	31.7
	Services		95	3.2	-
ESCC System					
	European Space Components	**45 (1180 employees)**	**Est. > 240**	N/A	N/A

Facts and Figures, The European space industry in 2009, Public Issue No. 1, ASD-Eurospace, 2010-06-18, except ESCC, L. Bonora, ESA)

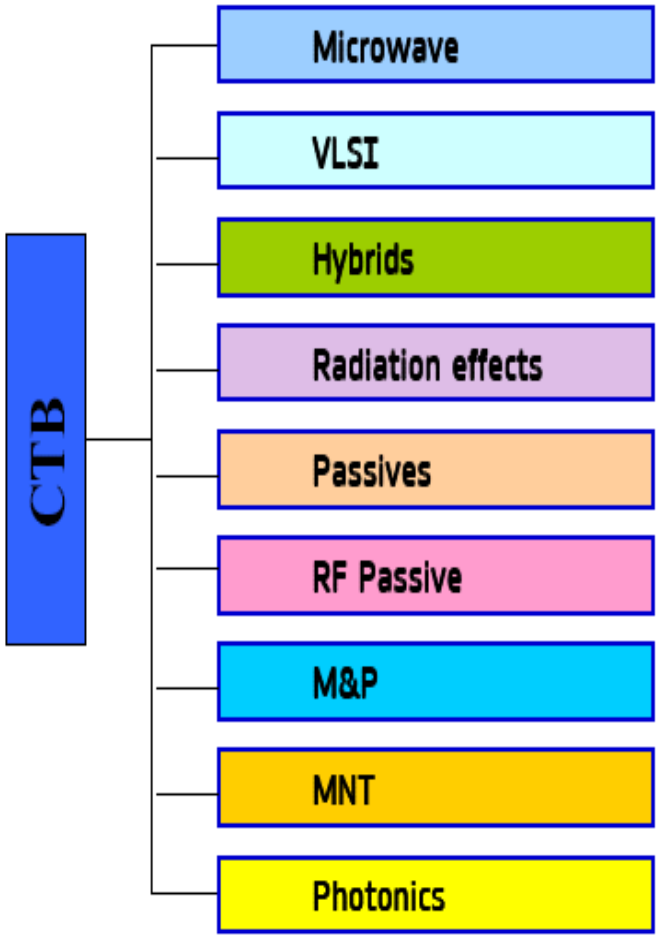


ESCC Evaluation and Qualification Programmes- The ESCC

Organisation of the European Space Components Coordination (ESCC)



ESCC Evaluation and Qualification Programmes- CTB



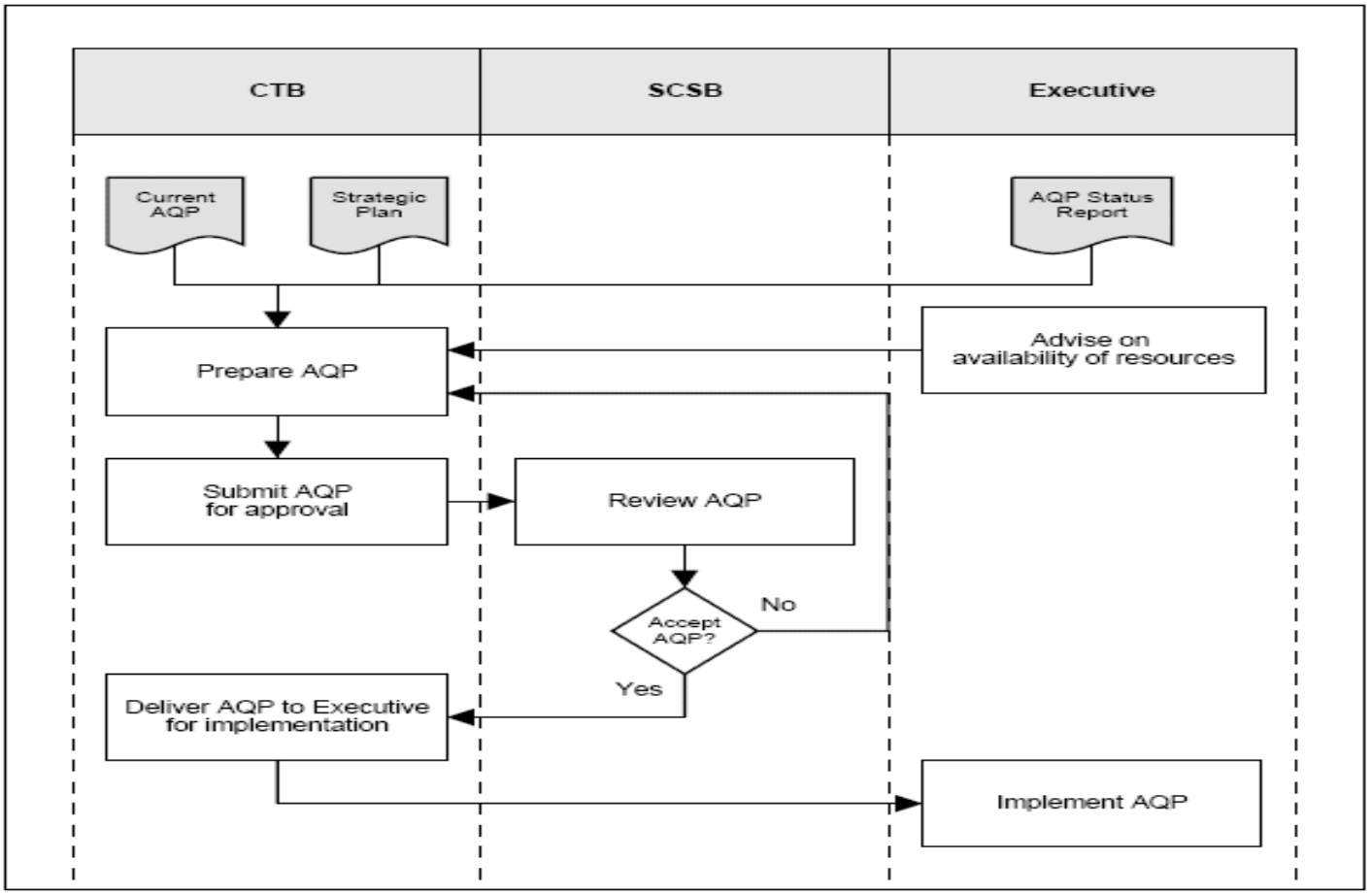
Formulates Programmes for Research and Development of EEE Components,
e.g., in the areas of:

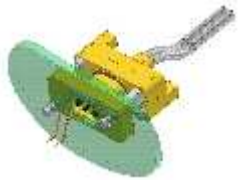
- o VLSI and Silicon Technologies
- o Hybrids and Packaging
- o Microwave Technologies
- o Micro-Nano Technologies
- o Materials and Processes
- o Photonics
- o Radiation Effects and Engineering Tools
- o Passive Technologies
- o RF Passive Technologies

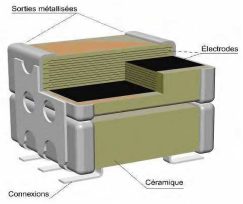
➢Leads to formulation of the Annual Qualification Programme (AQP)

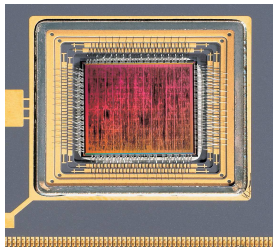
➢Based on technology specific dossiers

ESCC Evaluation and Qualification Programmes- Formulation









ESCC Evaluation and Qualification Programmes- Executive

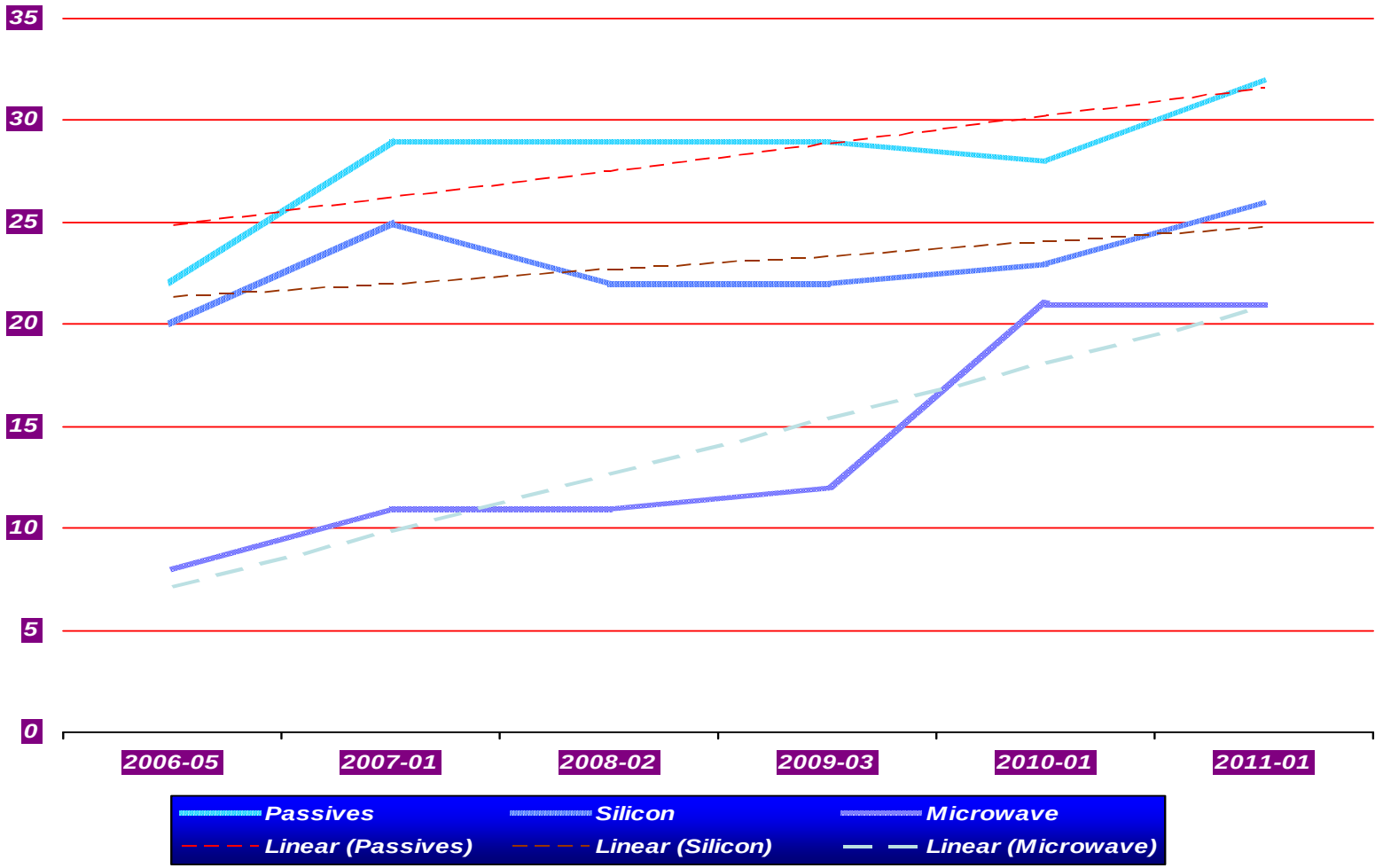
The CTB combines the collective participation and needs of European industry, manufacturers capabilities and space agencies for electrical, electronic and electromagnetic (EEE) components in one organization.

It establishes a coherent set of plans that aim to secure standard and strategic components through R & D programs, technology roadmaps and strategic dossiers, including

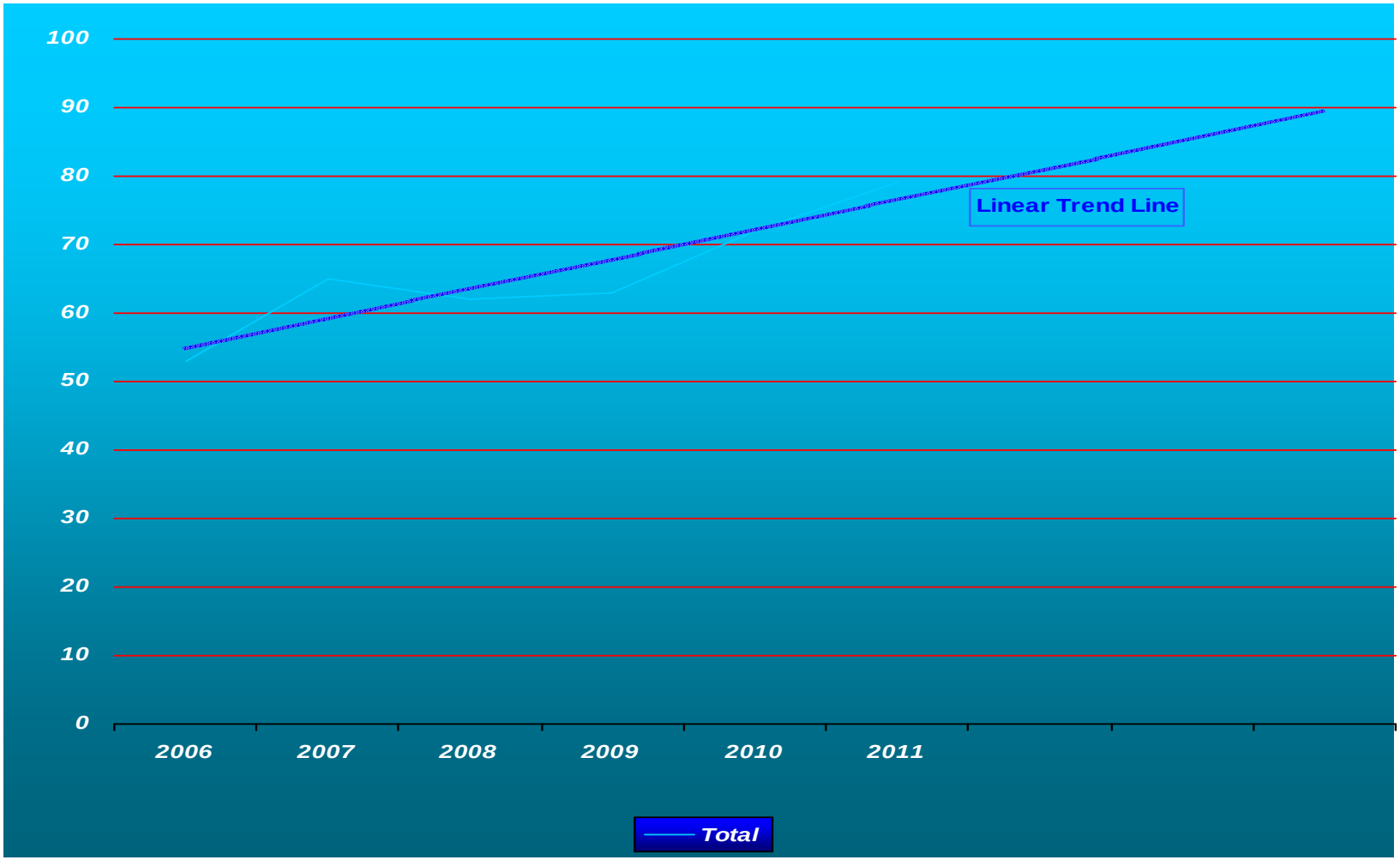
- an Annual Qualification Program (AQP)

The Executive provides the resources to implement the AQP.

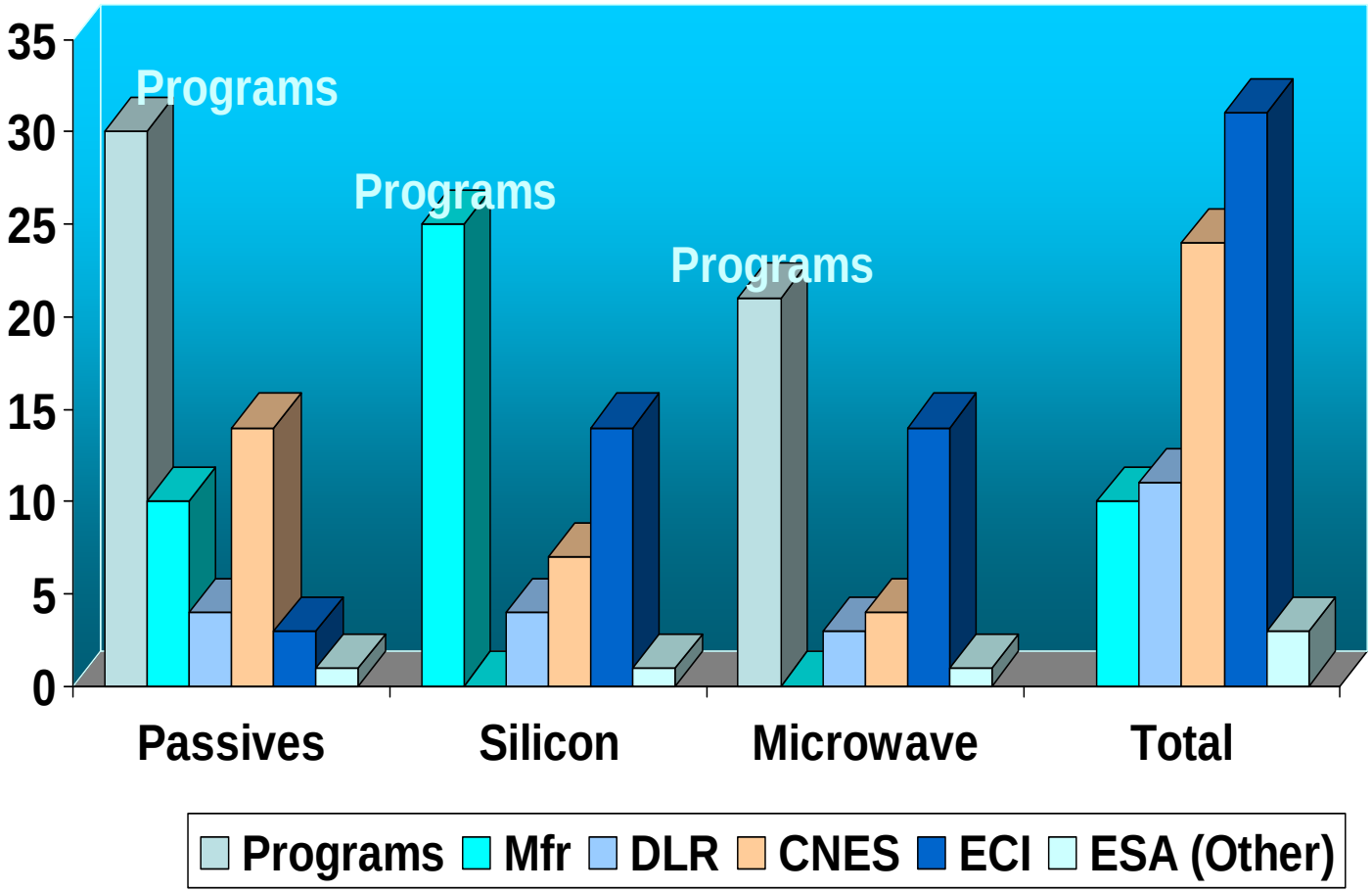
ESCC Evaluation and Qualification Programmes – Running Totals



ESCC Evaluation and Qualification Programme- 10 Year Trend Line



ESCC Evaluation and Qualification Programmes- Funding Profile



ESCC Qualification programme

– ESCC qualification is a general and long term authorisation for use in space.

– is based on a 2 step qualification approach:

Evaluation phase + Qualification Testing phase.

- is supervised by the ESCC Executive.

ESCC Evaluation Phase

Elements necessary at the beginning of / early in the Evaluation phase:

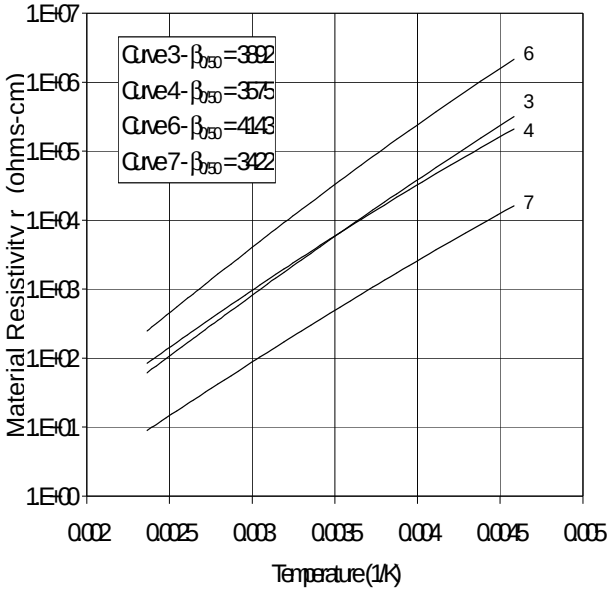
- Existing relevant test results and standard reliability data.
- Draft Detail Specification, if not already existing.
- Construction Analysis results.
- Draft Process Identification Document (PID).
- Domain and Test Vehicles description for Capability Approval/Technology Flow.

ESCC Evaluation Phase

Existing relevant characterization results, test results and standard reliability data:

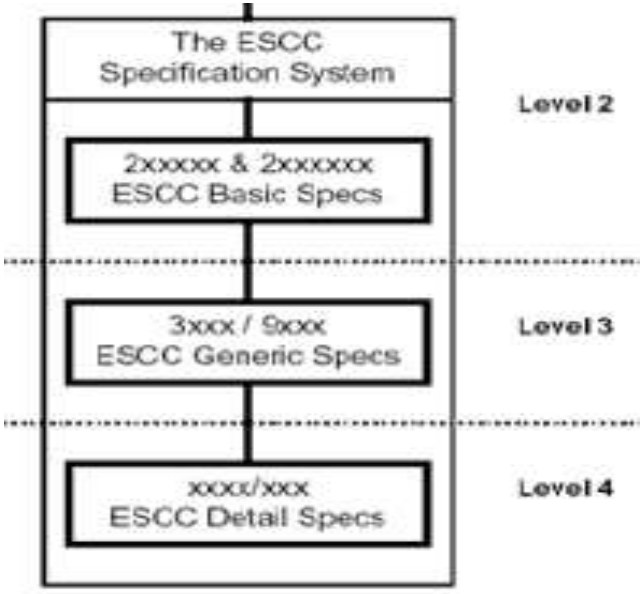
1 Very few EEE parts are specifically designed for space applications due to the low volume and sporadic purchasing/manufacturing requirements.

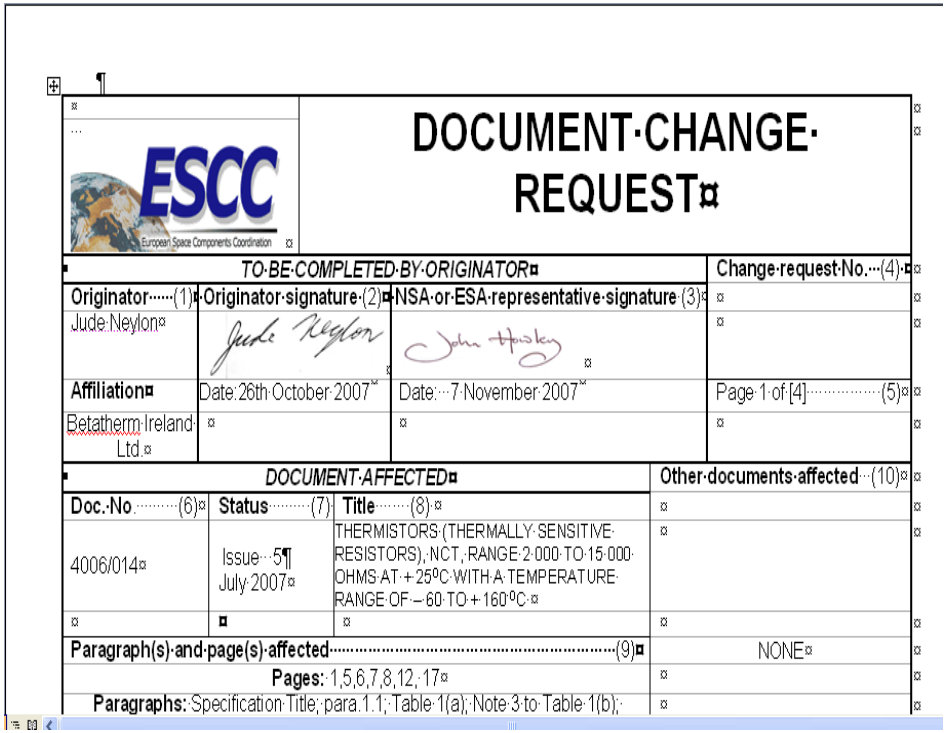
2 It is critical that all aspects of reliability and relevant known failure modes and mechanisms be addressed.



ESCC Evaluation Phase

Draft Detail Specification, if not already existing :





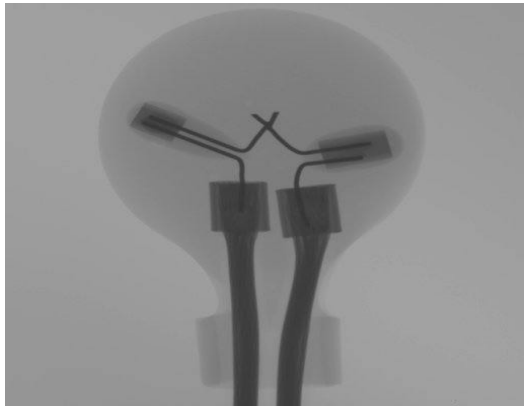
DOCUMENT CHANGE REQUEST

TO BE COMPLETED BY ORIGINATOR			Change request No. (4)
Originator (1)	Originator signature (2)	NSA or ESA representative signature (3)	
Jude Neylon			
Affiliation	Date: 26th October 2007	Date: 7 November 2007	Page 1 of [4] (5)
Betatherm Ireland Ltd			

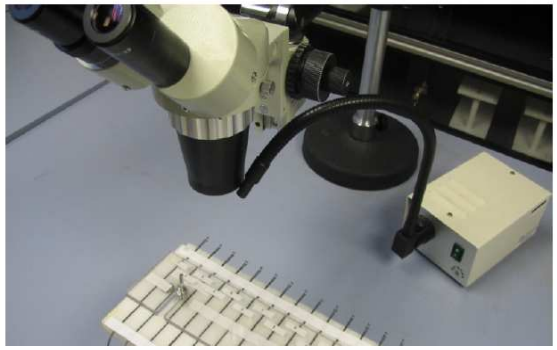
DOCUMENT AFFECTED			Other documents affected (10)
Doc. No (6)	Status (7)	Title (8)	
4006/014	Issue 5 July 2007	THERMISTORS (THERMALLY SENSITIVE RESISTORS), NCT, RANGE 2 000 TO 15 000 OHMS AT + 25°C WITH A TEMPERATURE RANGE OF – 60 TO + 160 °C	
Paragraph(s) and page(s) affected (9)			NONE
Pages: 1,5,6,7,8,12, 17			
Paragraphs: Specification Title; para.1.1; Table 1(a); Note 3 to Table 1(b);			

ESCC Evaluation Phase

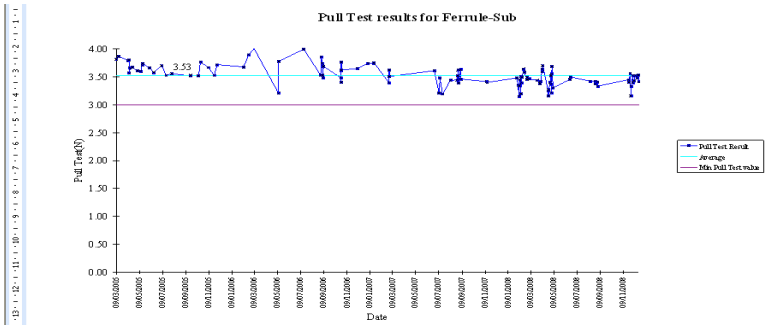
Construction Analysis results, for example:



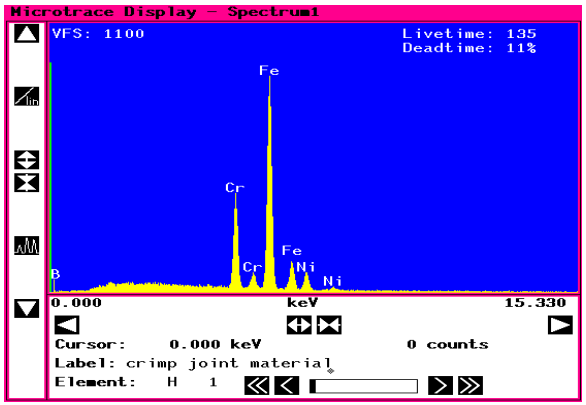
Radiography Analysis



Visual Analysis Results



Mechanical Analysis Results



SEM/EDX Element Analysis

ESCC Evaluation Phase

Draft Process Identification Document (PID)

The PID is an instantaneous and accurate picture of the actual manufacturing flow and practices.

The PID includes; amongst others:
- specimen of the travellers/route sheets used
- detailed flow chart with related manufacturing specifications
- list of piece parts and materials used
- a list of test equipment and test/inspection procedures
- a list of subcontractors and suppliers

ESCC Evaluation Phase

Domain and Test Vehicles description for Capability Approval / Technology Flow

The Capability Approval problem - Some components have design features that are tailored to a particular customer requirement, and may be required for a short time and often in small quantities.

Capability Approval solution – Define and evaluate a capability domain, and its boundaries, that will enable both the provision of standard devices and the ability to satisfy specialised needs.

Technology Flow (ESCC QML) issues – require to instil Quality Management (QM) within the manufacturing environment, using Statistical Process Control (SPC) and Process Technology Certification to accelerate the insertion cycle of high quality and reliable component types with emphasis on continuous improvement led by the manufacturer.

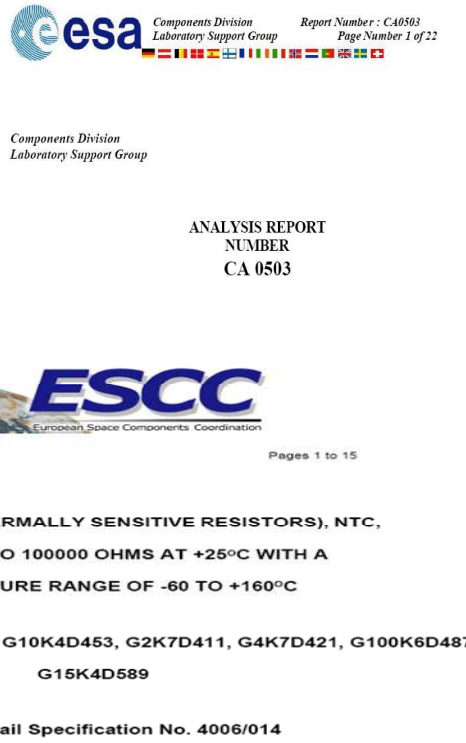
ESCC Evaluation Phase

Component Selection

ESCC Executive will review existing data and verify that the proposed component is appropriate for evaluation.

If the results are promising, random samples, taken from current production, shall be subjected to a Construction Analysis (CA).

After Construction Analysis, if the decision is to proceed, a Detail Specification will be required at this point.



esa Components Division Laboratory Support Group — Report Number : CA0503 Page Number 1 of 22

Components Division
Laboratory Support Group

ANALYSIS REPORT
NUMBER
CA 0503

ESCC European Space Components Coordination

Pages 1 to 15

THERMISTORS (THERMALLY SENSITIVE RESISTORS), NTC,
RANGE 2000 TO 100000 OHMS AT +25°C WITH A
TEMPERATURE RANGE OF -60 TO +160°C

BASED ON TYPE G15K4D489, G10K4D453, G2K7D411, G4K7D421, G100K6D487, G15K4D589

ESCC Detail Specification No. 4006/014

ESCC Evaluation Phase

Component Selection

- EVALUATION TEST PROGRAMME (ETP):

- Components and technologies are extensively characterized and tested; to destruction wherever possible!

- Tests are designed to:
  - Gauge reliability and lifetime
  - Provide stresses that simulate thermal, mechanical, electrical, vacuum and radiation environments
  - Address intrinsic and extrinsic failure modes
  - Determine the margins for these failure mechanisms (these are used in the ECSS-Q-ST-30 derating standard as well as for ESCC Detail Specification parameter derating).

ESCC Evaluation Phase

Component Selection

- EVALUATION TEST PROGRAMME (ETP):

• Established in conjunction with the Manufacturer / ESCC Executive
• On a sample representative of the component family – unscreened parts (no Burn-In)
• In order to determine failure modes and margins, it includes:
- A review of existing reliability data
- Endurance tests (HTRB, Extended Burn-in, Life Test)
- Destructive tests (Step-stress, radiation, Environmental/Mechanical/Assembly…)

• Ancillary specifications ESCC 226xxxx describe the procedure and requirements to create and perform an ETP

ESCC Evaluation Phase

EVALUATION OF A MANUFACTURER

- A survey of the Manufacturer's production, inspection and testing facilities is carried out under control of the ESCC Executive, particular attention being given to the existence and adequacy of formal updated documentation and control procedures relating to the component to be evaluated.

- this survey is performed as a formal audit in accordance with the requirements of ESCC Basic Specification No. 20200.

5 DEFINITIONS

In this report, the following definitions are employed:

FINDING - Objective evidence that a control feature of the quality programme or manufacturing process is not implemented in accordance with the requirements.

OBSERVATION - An observed control feature of the quality programme or manufacturing process, which is a cause for concern. A condition that may become a Finding.

COMMENT - A comment to an observed control feature of the quality programme or manufacturing process, which is neither a Finding nor Observation.

A Finding requires a corrective action and an Observation requires consideration by the manufacturer.

ESCC Evaluation Phase

EVALUATION OF A MANUFACTURER

Outputs of the Evaluation Phase are:

- Evaluation report
- Applicable Detail Specification(s)
- Final PID
- Final definition of the Domain (if applicable)
- A Generic Specification, if not existing
- Audit report + evidence of completed Corrective Actions

Resulting in:

Certification of the Evaluation by ESCC Executive

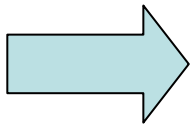
ESCC Qualification Phase

- Components required for qualification testing must be produced strictly in accordance with the PID.
- Qualification testing of the component must be in accordance with the requirements of the relevant ESCC Generic & Detail Specification.
- Successful completion of the testing phase results in listing on ESCC-QPL.
- A Qualification, once established, is valid up to 2 years.

ESCC Qualification Phase

Requirement for Qualification Approval

Chart II/F2:	Final Production Tests
Chart III/F3:	Burn-in & electrical measurements
Chart IV/F4:	Qualification tests

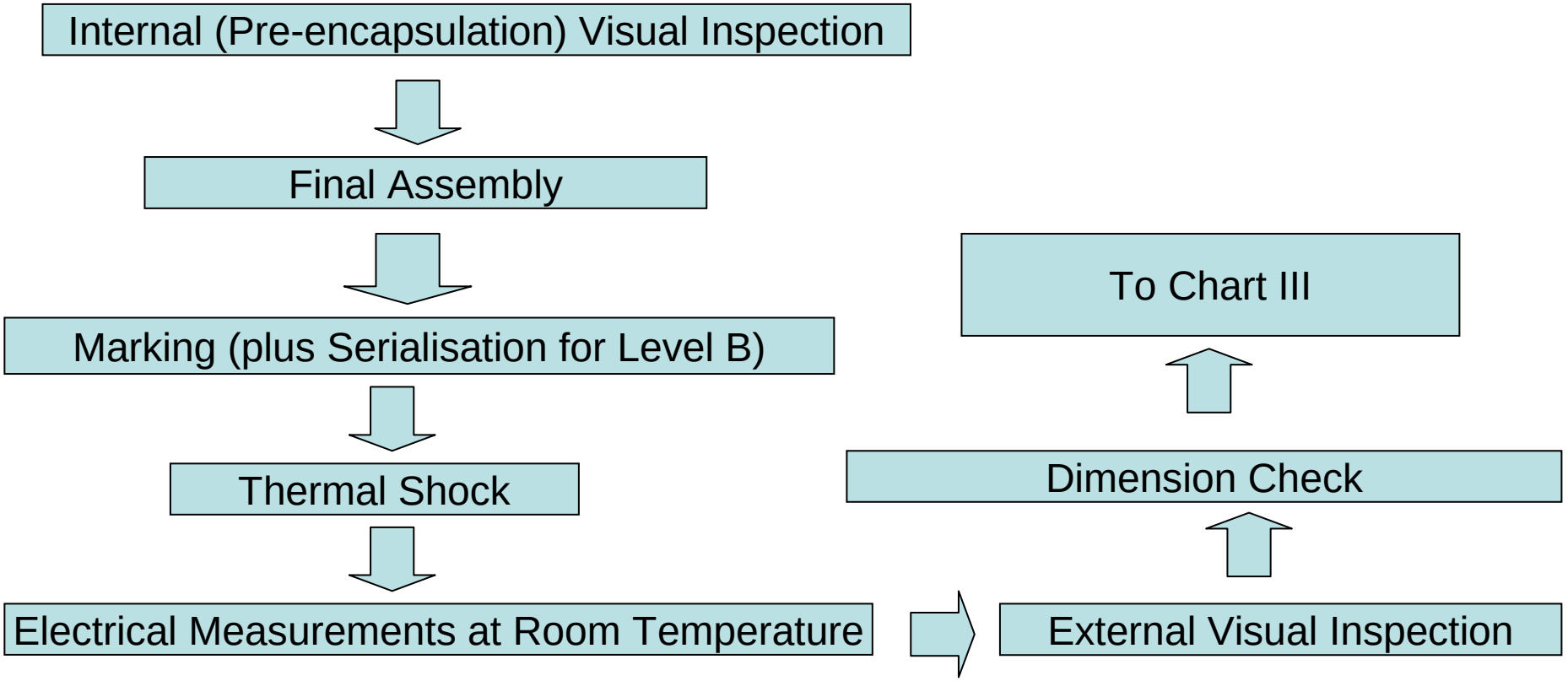


Test, Record and Report

ESCC Qualification Phase

ESCC Generic Specification No. 4006 - Thermistors

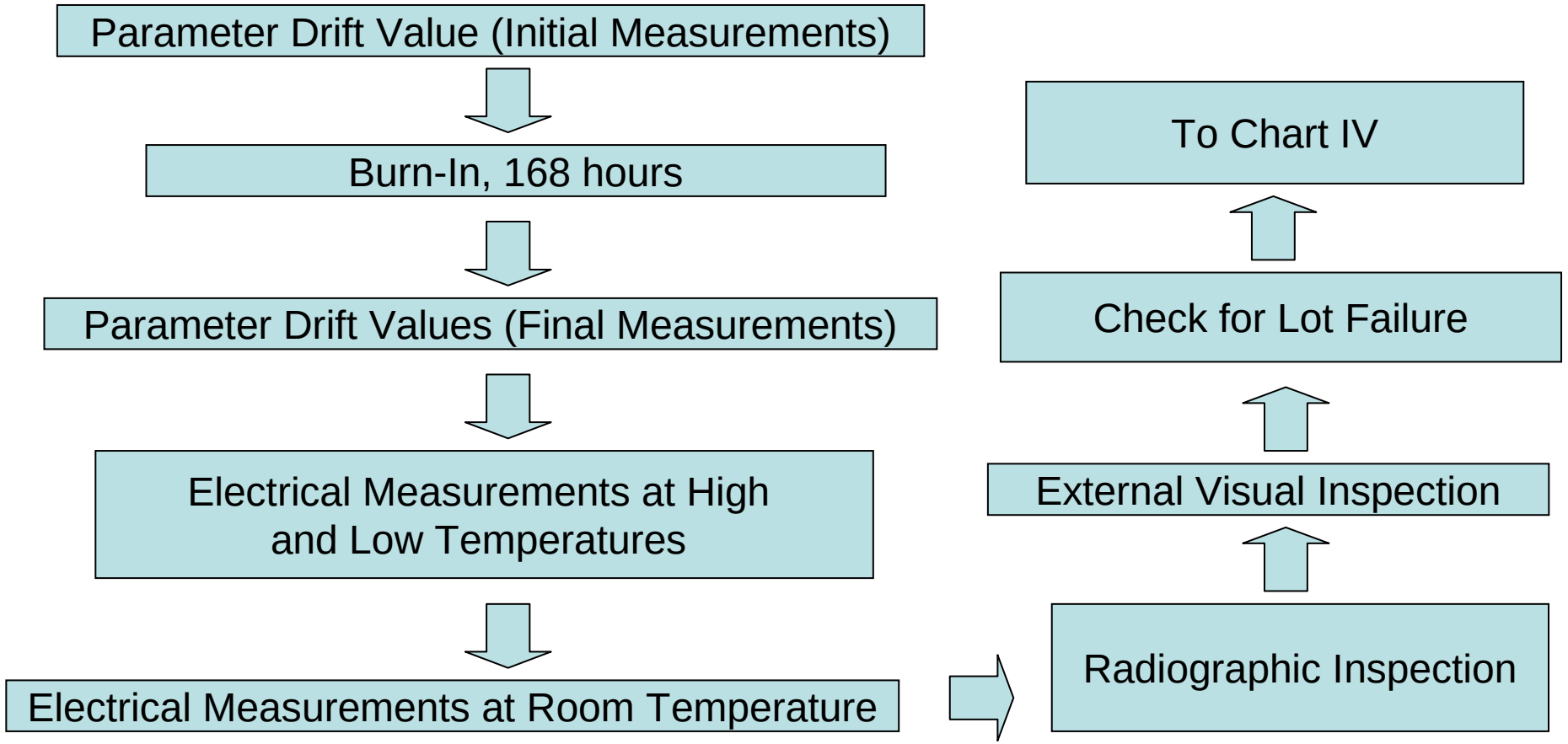
Chart II – Final Production Tests



ESCC Qualification Phase

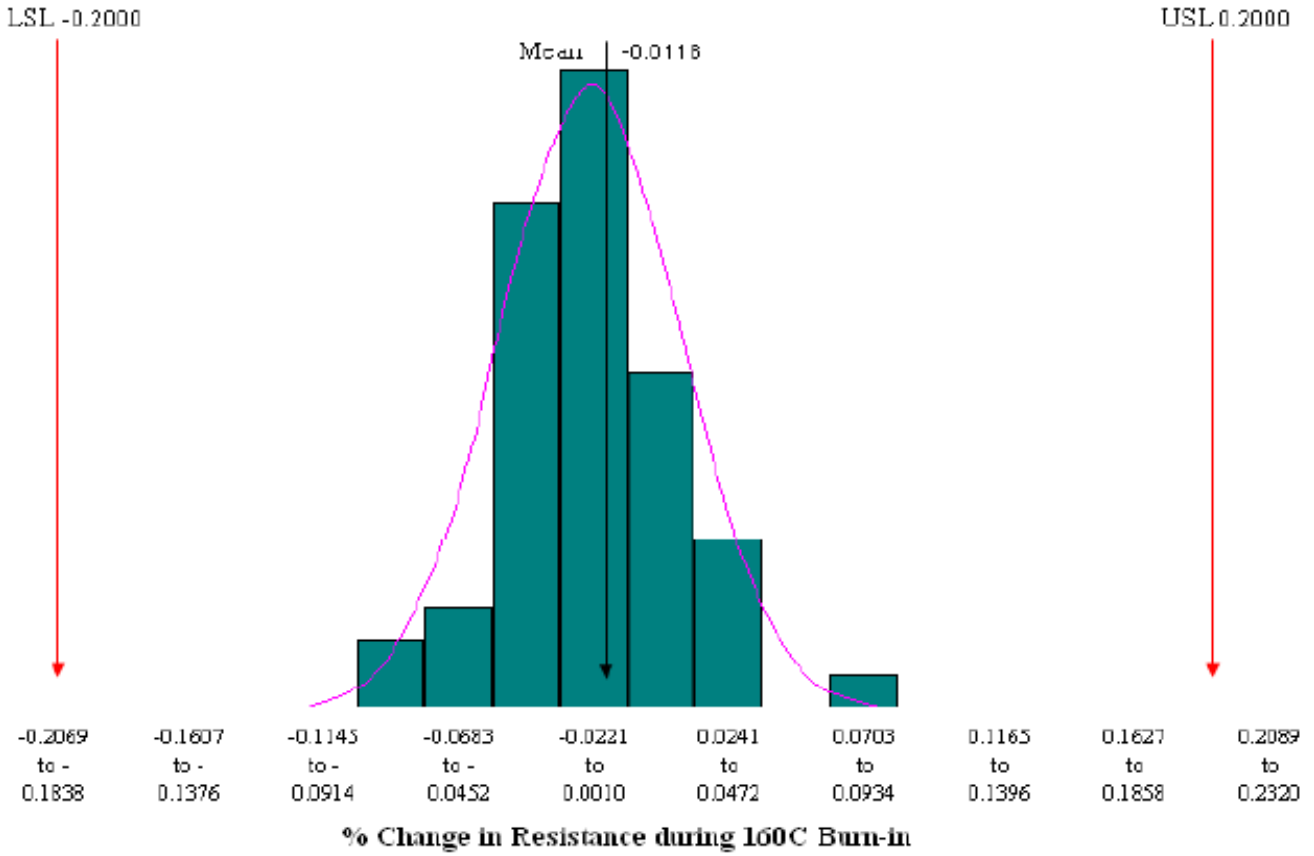
ESCC Generic Specification No. 4006 - Thermistors

Chart III – Burn-In and Electrical Measurements

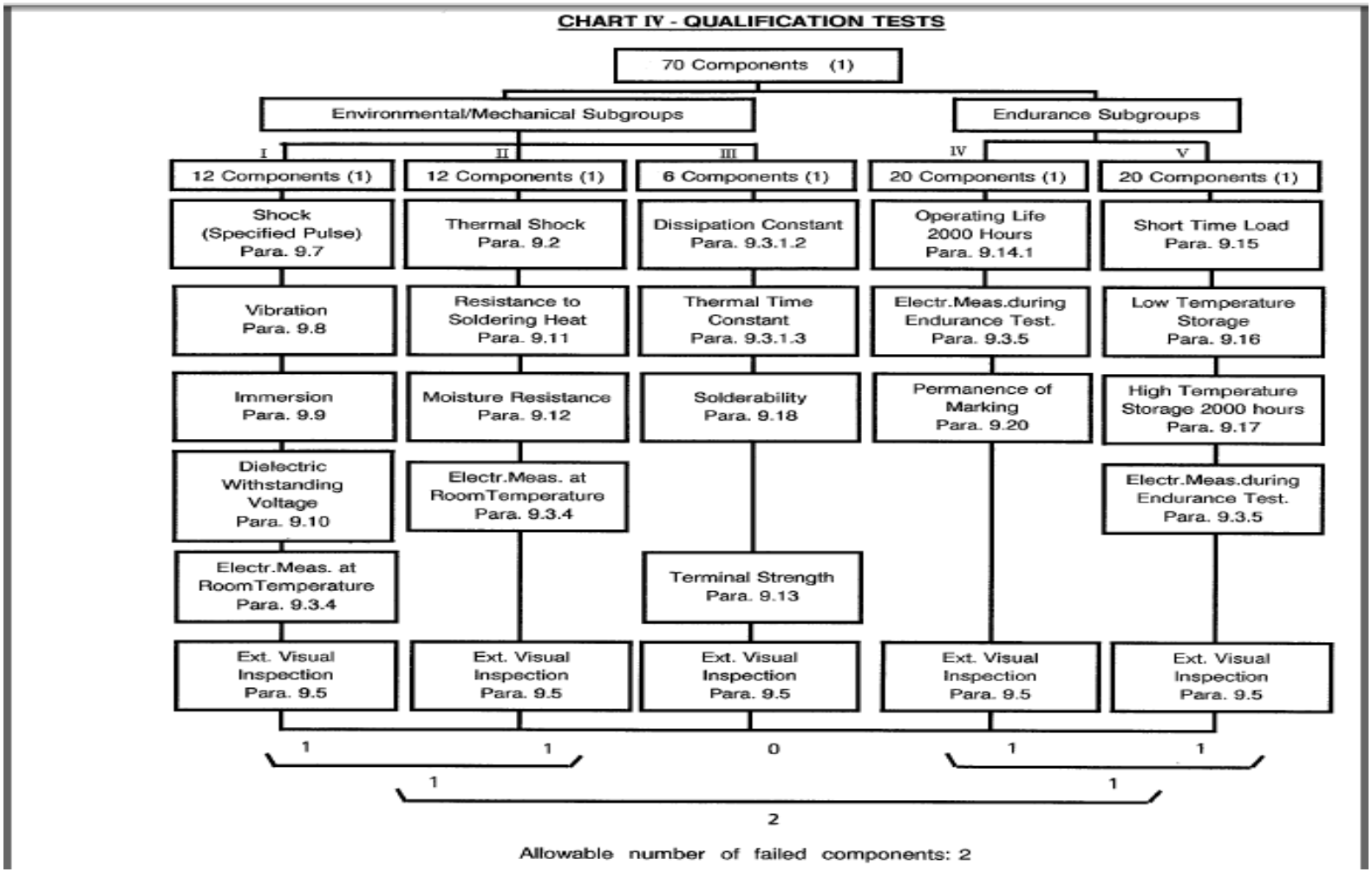


ESCC Qualification Phase

Parameter Drift Data - Results



ESCC Qualification Phase



ESCC Qualification Phase

- Qualification testing of the component is documented and certified by the manufacturer.
- Non-conformances, failure analysis and DPA results when applicable are closed.
- A Qualification Report is accepted by the ESCC Executive.
- Components meeting the qualification requirements are certified by ESA.
- An ESA logo is applied by the manufacturer to each component meeting all the inspection and test requirements!

ESCC Qualification Phase

The expected result!!

Types covered by similarity:		Remarks: Refer to variants table 1(a) in the Detail Specifications for resistance to temperature characteristics		
Procurement Specifications	Manufacturer	Nature of Approval	Supervising Authority	Date
Generic ESCC 4006 Detail ESCC 4006/013 4006/014	MEAS Ireland (Betatherm) Galway Ireland	Qualification Extension Extension Extension Extension Extension	ESTEC ESTEC ESTEC ESTEC Enterprise Ireland Enterprise Ireland	Jul 2001 Jan 2002 Sep 2004 Nov 2006 Nov 2008 Nov 2009
Characteristics: 4006/013: Variants 01 to 05 and 07 are qualified. 4006/014: Variants 08, 09, 12 and 13 are qualified. Operating Temperature Range, (°C): ˉ55 to ⁺115 for 4006/013 variants 04, 05 and 06, ˉ60 to ⁺160 for 4006/014 variants 08, 09 and 13				
ESCC QPL	THERMISTORS, (THERMALLY SENSITIVE RESISTORS), NTC, BASED ON TYPES G15K4D489 AND *K3A35*	Current Validity of Qualification Certificate 266 E	 Valid Until November 2011	Page 11-01 001

Evaluation & Qualification Programs in Germany

Jürgen Tetzlaff (juergen.tetzlaff@dlr.de),
Guido Joormann (guido.joormann@dlr.de)
ESCCON, Noordwijk, 15. - 17. March 2011

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

DLR EEE Parts Projects

Activity	Term	Status
PPH15-Process Evaluation	2003 - 2006	finished
Evaluation and Qualification of Thin Film Chip Resistors	2004 - 2008	finished
Evaluation and Qualification of Cables	2005 - 2009	finished
Qualification of Quartzes and Oscillators	2005 - 2010	in progress
Qualification of Microwave Connectors	2005 - 2011	in progress
Certification of an Assembly and Test House	2006 - 2011	in progress
Qualification of MMIC Local Oscillator	2007 - 2011	in progress
Development and Qualification of PowerMOSFETs	2008 - 2011	in progress
Qualification of Diodes and RF-Transistors	2008 - 2011	in progress
Evaluation of the UMS PPH15x Process	2008 - 2011	in progress
Development of a GaN 1000V Switching Transistor	2007 - 2011	in progress
Capability Approval of L-Foundry	2010 - 2013	In progress
Qualification of RF-Circulators / Isolators	2011 - 2013	planned
Capability Approval of IHP‘s SG13 Technology	2011 - 2013	planned
Qualification of a fully automatic LTCC Line	2011 - 2013	planned
Feasibility Study of the SiC Diodes Technology	2011 - NN	planned

All projects under : www.dlr.de/qp/en/desktopdefault.aspx/tabid-3091/4699_read-6881/

Evaluation and Qualification of RF-Connectors

This project shall improve the components availability for the European space users in the area of high frequency connectors. The request for qualified RF-connectors arose from the German manufacturers for space equipment, since connectors are required in lot of space equipment.

Info : www.rosenberger.de/

Qualification of Diodes and RF-Transistors

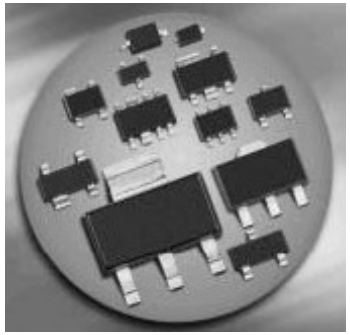
For automotive und wireless applications, Infineon provides high-quality diodes and microwave transistor chips. On request of German users they shall be packaged in suitable housings and an ESCC qualification of these parts is in progress.

Diodes: BAY6642 (1N6642)

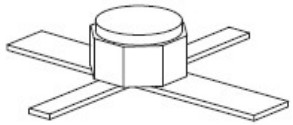
RF-Transistors: BFY640, BFY640B, BFY650B, BFY740B.

Info : www.infineon.com/cms/en/

=> discretes



Diodes

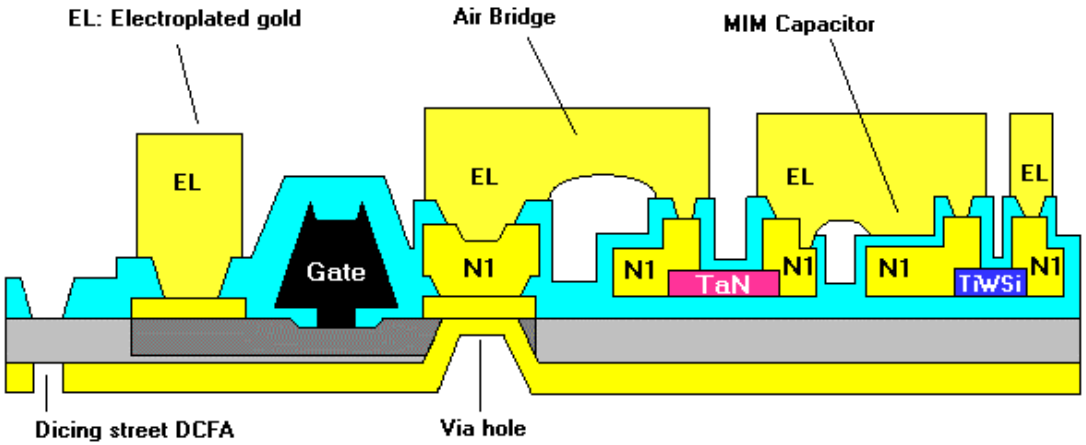


RF-Transistor, Micro-X Package

Evaluation of the UMS PPH15x Process

In this program, a delta evaluation of the PPH15x MMIC process will be performed. PPH15x stands for Power PHEMT (Pseudomorphic High Electron Mobility Transistor), a GaAs based technology with 0,15 Micron gate length, the x for a power enhancement of the PPH15 process, which was already evaluated. Life time and reliability tests have been performed. Space evaluation has started.

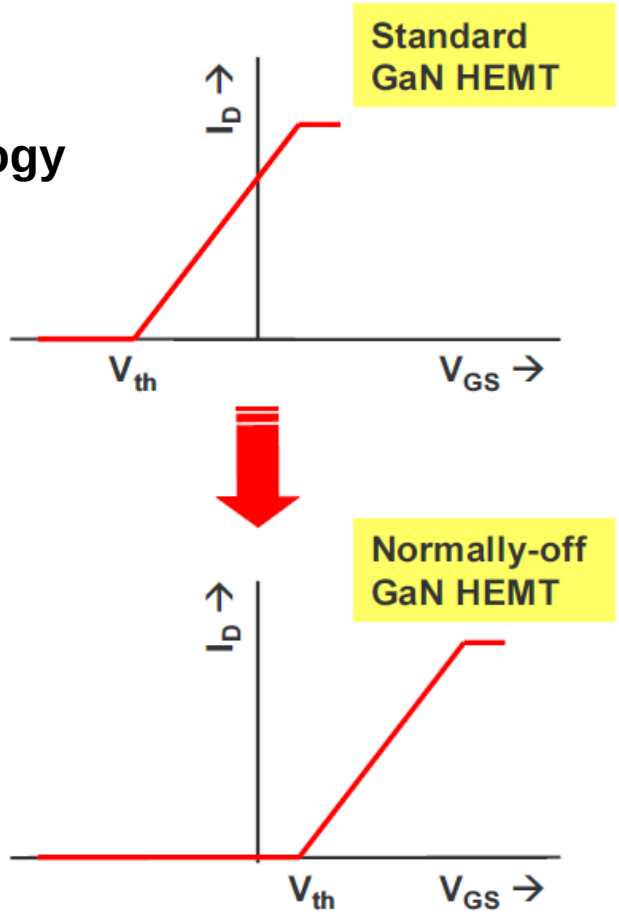
Info : www.ums-gaas.com/



Development of a GaN 1000V Switching Transistor (1)

Targets

- **Normally-off GaN transistor technology for space borne power conditioning**
- **Requirements**
  - low on-state resistance
  - high breakdown voltage (up to 1000 V)
  - Threshold voltage Vth > + 1 V
  - Large gate swing > 3 V
  - Low leakage currents
  - Reproducible process
  - Radiation hardness
  - High Reliability

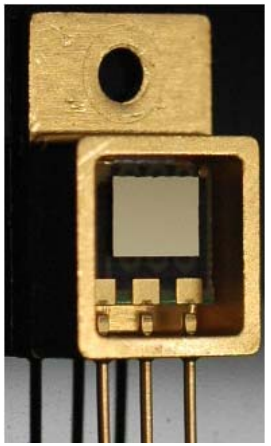


Development of a GaN 1000V Switching Transistor (2)

Actual Results

- Stable 3” GaN process
- Positive threshold voltage (+ 1.2 V)
- Large gate voltage swing (5 V)
- High IDS-max (0.5 A/mm) → good trade-off to normally-on devices)
- Low leakage:
  - off-state drain leakage 10 µA/mm @ VGS = 0 V
  - on-state gate leakage 10 µA/mm @ VGS = + 5 V
- Good saturation properties
- Transistor-channel conductive if operated in reverse direction
  - 3rd quadrant operation
  - May be used for “self protection” when switching inductive loads
- Safe transistor operation up to 200°C ambient
  - IDS decreases with T _ CT = -1.3 mA/(mm K)
  - RON increases with T _ CT = 43 mWmm/K
  - Vth constant with T _ CT = -0.24 mV/K

→ **No thermal run-away situation in p-GaN gate power transistors**



50 A device flip-chip mounted in TO 220 package

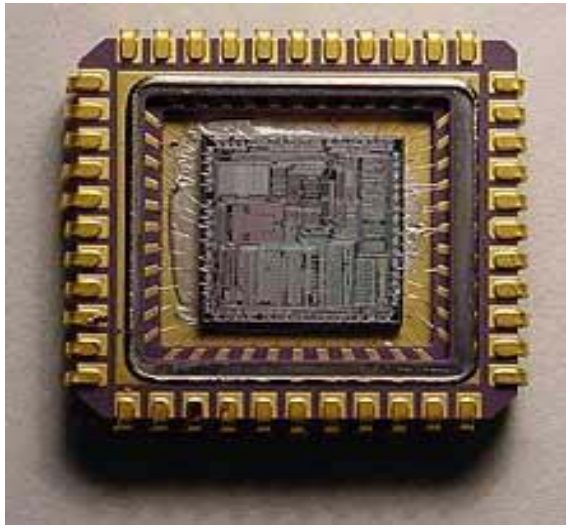
Capability Approval of L-Foundry

For space applications, less and less semiconductor foundries are available. Recently, the widely used MG2RTP CMOS process from Atmel became obsolete, too.

In preliminary investigations, L-Foundry (Landshut) was determined as suitable foundry. Meanwhile L-Foundry has bought Atmel's foundry at Rousset (F), too.

In a first test step, the suitability of commercial library elements for a radhard design will be verified.

In case of a positive result, an ESCC capability approval will be carried out.

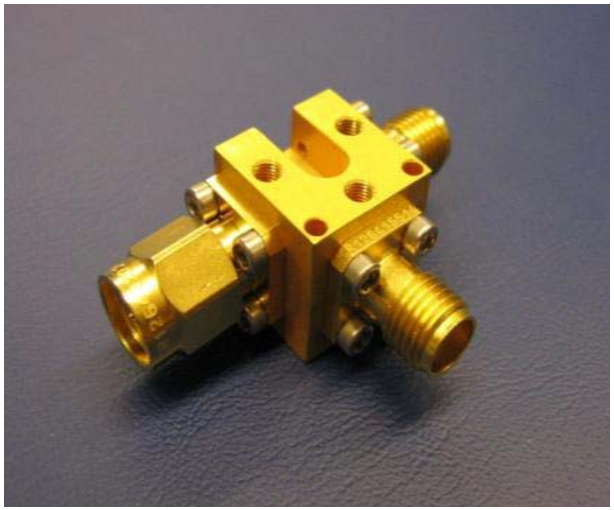


Info : www.lfoundry.com/

Qualification of RF-Circulators / Isolators

There are only two not qualified suppliers in Europe (Chelton [F] and Trak [GB]), who can deliver RF-Circulators / Isolators with required properties :

- High Reliability
- Low Insertion Loss
- High Isolation.



On the other side a German supplier fabricates excellent RF-Circulators / Isolators for their own use.

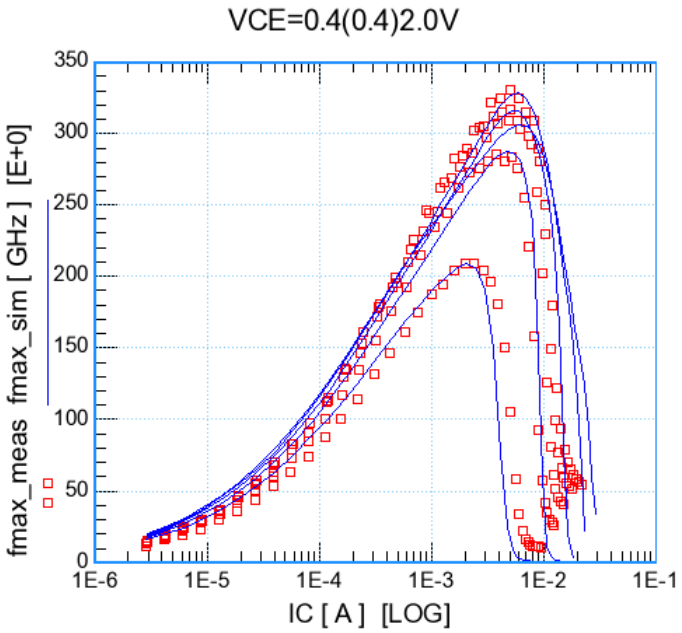
Therefore, German users asked for the ESCC qualification.

Capability Approval of a SG13 BiCMOS Technology

The SG13 BiCMOS technology is a mixed signal 0.13 µm technology with the focus on high frequencies (up to 140 GHz) and low power CMOS transistors.

In a first step several suitability tests will be performed, prior to developing a radhard library and test circuits for this technology.

Thus a further process for space use will be established in addition to an existing 0.25 µm technology, which is applicable for frequencies to 20 GHz and is already in the ESCC capability approval.



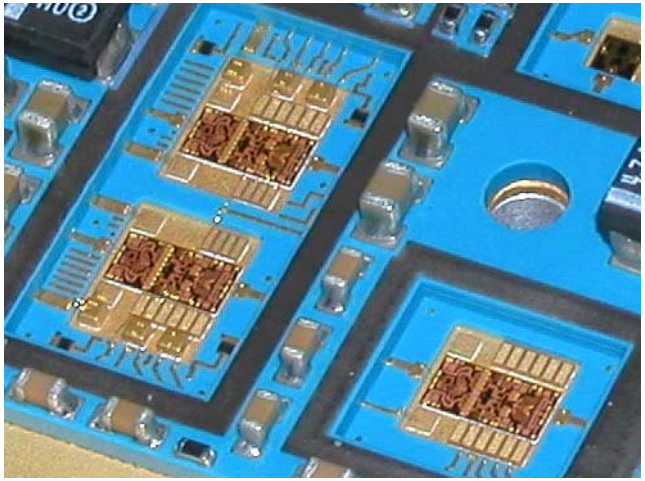
SiGe HBT f_{Max} versus $I_{collector}$ measured and modeled

Qualification of a fully automatic LTCC Line

A German supplier operates a fully automatic LTCC (Low Temperature Cofired Ceramics) line, which was used up to now for commercial applications.

This line shall be extended for space modules manufacturing and an ESCC capability approval shall be performed. By the extremely high degree of automation of this line, a very small error rate (First-pass yield > 95 %) will be achieved.

Due to the high process reliability of the line, a cost-effective fabrication of small and lightweight MMICs (e.g. up- and down converters or channel amplifiers) will be possible.



Feasibility Study of the SiC Diodes Technology (1)

Why Silicon carbide ?

- Space applications need robust and heat resistant components.
- Silicon power semi conductors are more and more reaching their physical limits (higher junction temperature, higher loss), which can lead to the damage of the parts.
- SiC offers excellent material properties and allows components with outstanding electrical characteristics and high junction temperatures.

➔ **A feasibility study shall examine the use for Space application.**

Feasibility Study of the SiC Diodes Technology (2)

Comparison Si ↔SiC

Characteristics	Si	SiC
Band Gap (eV)	1.1	3.2
Electron Mobility (cm^2/Vs)	1400	900
Disruptive Field Strength (kV/cm)	250	> 2000
Thermal Conductivity (W/cmK)	1,5	4.9

Advantages	Less Defects Higher Yield Lower Price	High Temperature Strength High Ampacity Chemical Resistance Radiation Hardness Material Hardness
Drawbacks	High Switching Loss at High Temperature At Performance Limit	High Increase of Crystal Defects Processes difficult to control Costly Bulk Material

Thank you for your attention!

Dr.-Ing. **Andreas K. Jain**
German Aerospace Center

Head - Standardization and EEE Components
Quality and Product Assurance

Porz-Wahnheide, Linder Höhe
51147 Köln, Germany

Telephone 02203 601-2954
Telefax 02203 601-3235
E-Mail andreas.jain@dlr.de

Dipl.-Ing. **Jürgen Tetzlaff**
German Aerospace Center

Standardization and EEE Components
Quality and Product Assurance

Porz-Wahnheide, Linder Höhe
51147 Köln, Germany

Telephone 02203 601-3862
Telefax 02203 601-3235
E-Mail juergen.tetzlaff@dlr.de

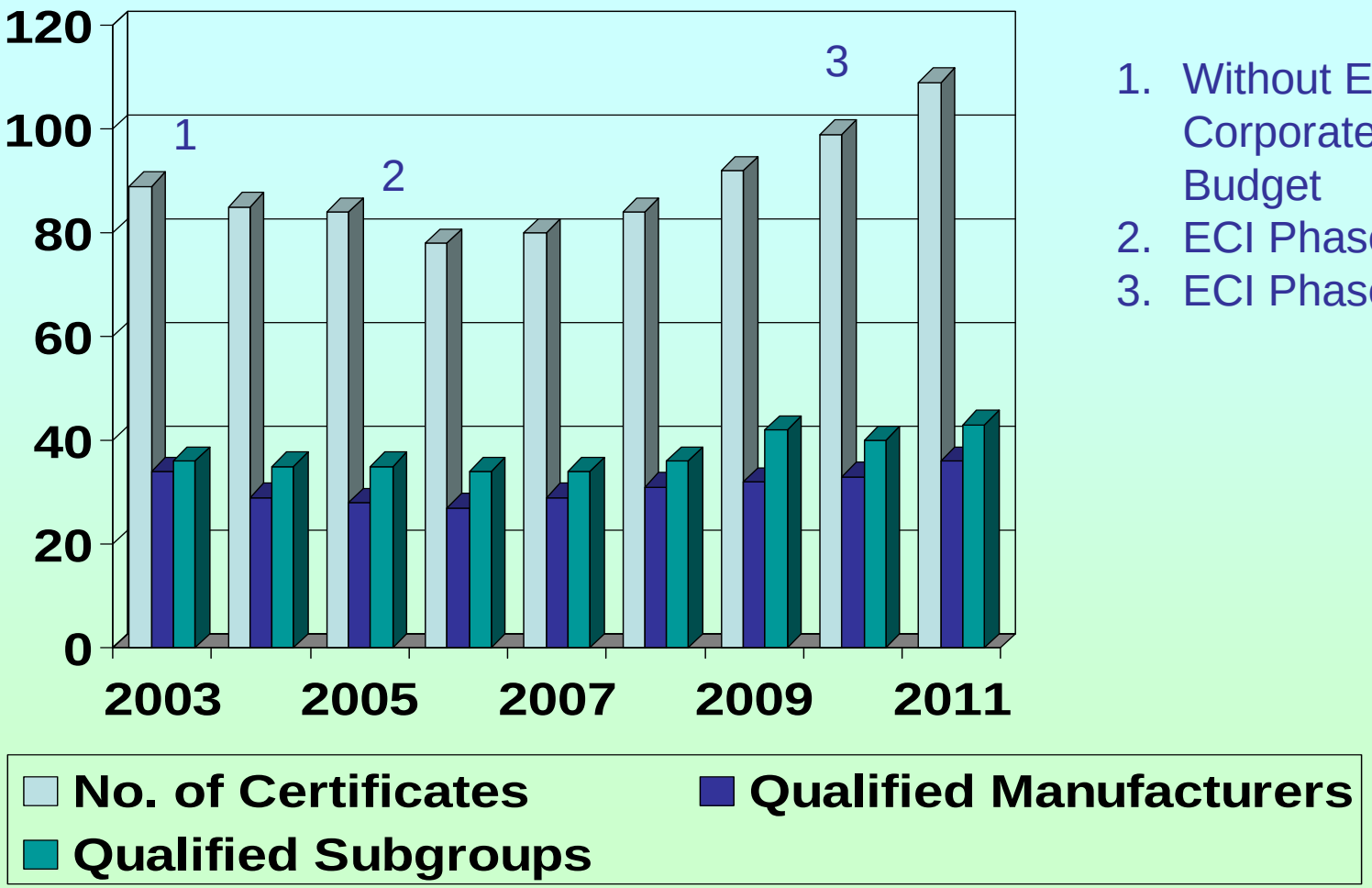
Dipl.-Ing. **Guido Joormann**
German Aerospace Center

Standardization and EEE Components
Quality and Product Assurance

Porz-Wahnheide, Linder Höhe
51147 Köln, Germany

Telephone 02203 601-3724
Telefax 02203 601-3235
E-Mail guido.joormann@dlr.de

ESCC Evaluation and Qualification Programmes: Certificates



1. Without ESA Corporate Budget
2. ECI Phase 1
3. ECI Phase 2

ESCC Evaluation and Qualification Programmes: Benefits

The ESCC products constitute a pillar of product assurance through standardization of EEE components in space programs.

By applying standardization and type reduction space programs benefit in a number of ways:

- Components used in designs are applied properly with margin supported by available test data
- Components are evaluated or qualified to established criteria prior to use
- Quality and reliability of each component is established
- Components are compatible with equipment manufacturing processes
- Evolution of component quality and significant parameters are under configuration control
- Provides for component obsolescence management
- Component data is collected and stored for retrieval and analysis.

ESCC Evaluation and Qualification Programmes: Benefits

Key Results:

ECI stimulus funding from CNES, DLR and ESA has reinitiated AQP investment

AQP Programs managed by the ESCC Executive since 2005 up by 50%

Number of ESCC qualification certificates since the low of 2006 up by 40%

12.7 % of AQP Programs are self funding

European space component manufacturers 2010 turnover > 240 M€

1200 employees of European manufacturers dedicated to space components


ESCCON 2011
Thank You for Your Attention
J. Howley, Enterprise Ireland
G. Joormann, DLR Köln
J. Wong, ESA ESTEC