Centre Français Fiabilité

NRTW 2025

National Reliability Technology Workshop

Mercredi 19 et Jeudi 20 mars 2025 | GANIL – Bd Henri Becquerel, 14000 Caen

Radiation and Reliability Qualification for New Space R2COTS Example

LIOUAEDDIN BOUKHANA - EEE COMPONENTS ACTIVITY MANAGER

TRAD a HEICO company

Organisé par :

OUTLINE

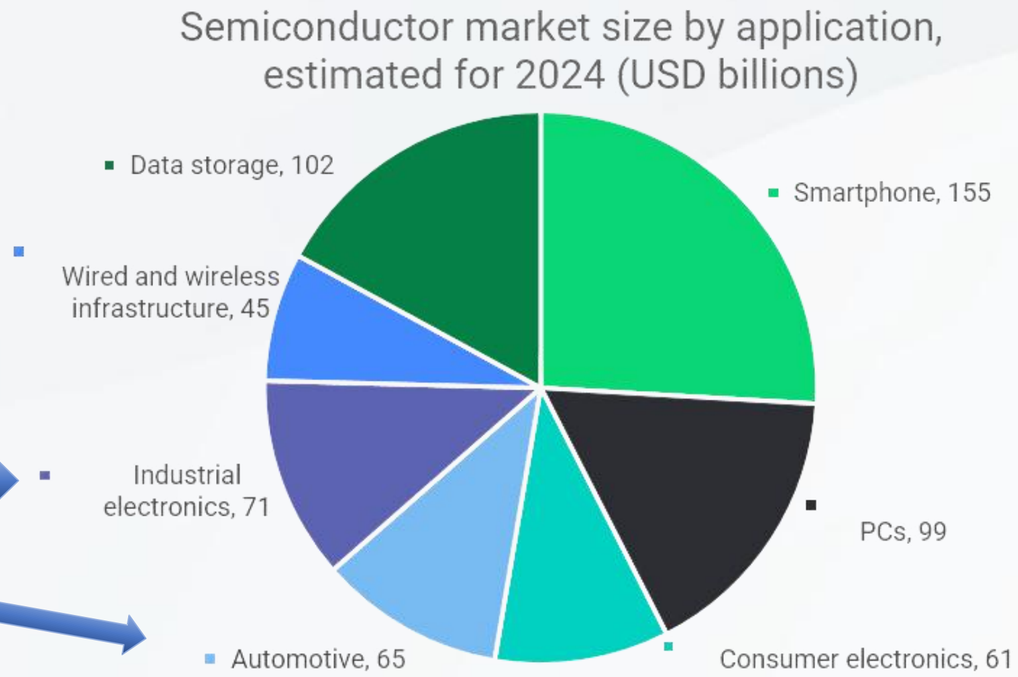
- **Why COTS in Space ?**
  - COTS Population
  - COTS Characteristics
- **Our R2COTS solution**
  - Class 3+ Space Ready COTS
  - R2COTS process flow
  - Summary
- **Conclusion**

WHY COTS IN SPACE ?

COTS Population

- **25 years** of **properly selected COTS** used across various military and space applications proves that **COTS are OK**
- The term **“COTS” (Commercial Off-The-Shelf)** refers to a huge EEE Components population
- **COTS dominate the global market (99.7% in $)**

COTS Candidates for Space applications

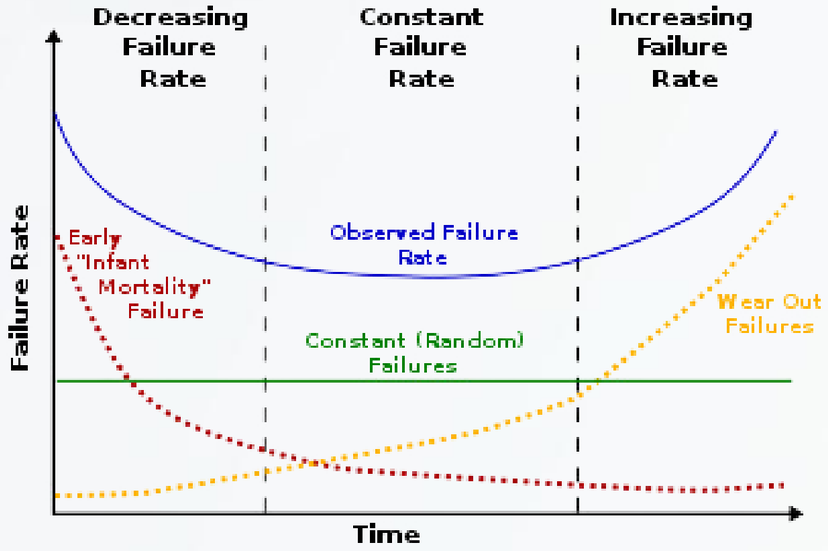


- Referring to COTS, there should be **no place for hasty generalization**

WHY COTS IN SPACE ?

COTS Characteristics (1/2)

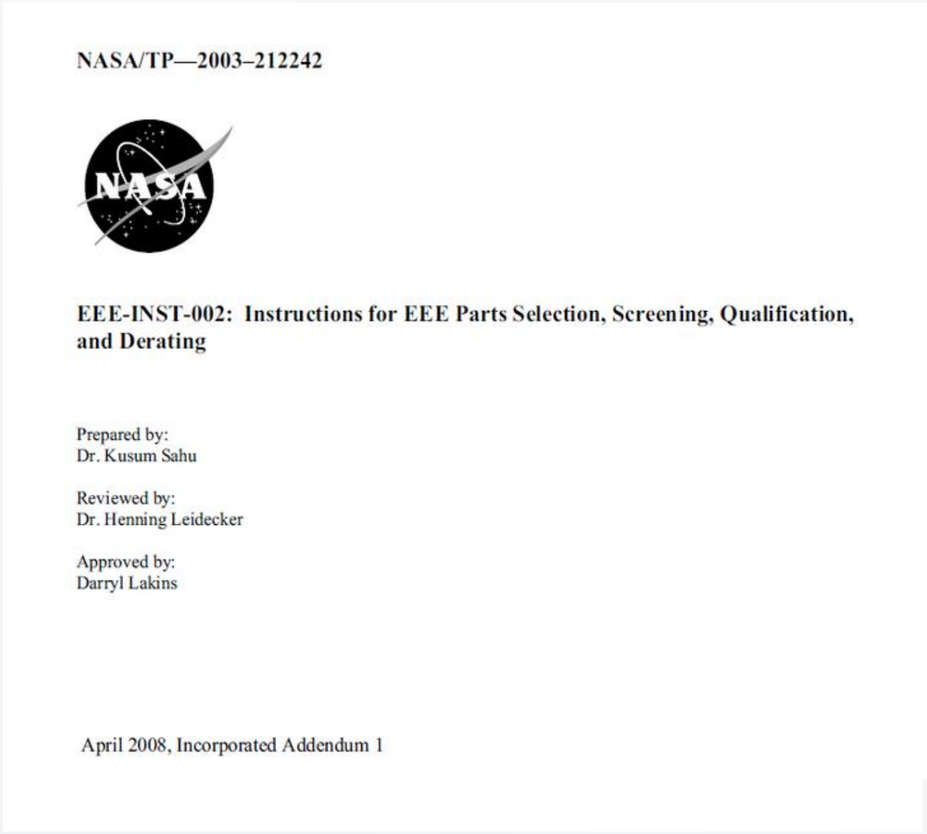
- The main drive:
  - **Performance advantage**
  - Cost savings are realized with COTS **used as is**, however for **space applications** COTS are **not used as is**
- High Volume Production ensures **efficiency of using statistical tools** in production line to **prevent defects**, translated into **reliability**
- Most failures are due to **component manufacturing defects (EIMF)**
- **VOLUME IS THE KEY**



Standards

COTS Characteristics (2/2)

- The main leading COTS in space policy documents:
  - NASA EEE-INST-002 (April 2008) and PEM-INST-001 (June 2003)
  - **ECSS-Q-ST-60-13C** (Rev.1 12 May 2022)



NASA/TP—2003–212242

EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification, and Derating

Prepared by:
Dr. Kusum Sahu

Reviewed by:
Dr. Henning Leidecker

Approved by:
Darryl Lakins

April 2008, Incorporated Addendum 1

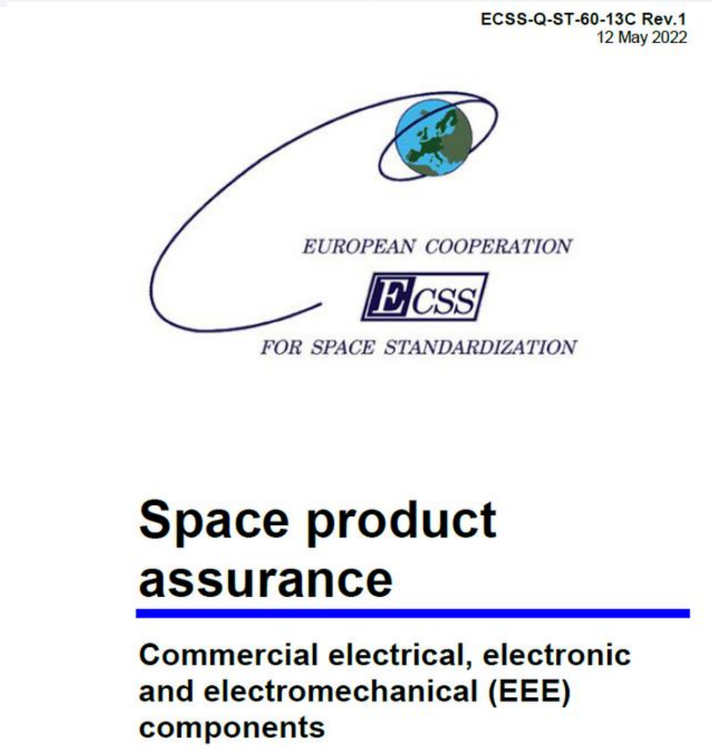
NASA/TP—2003–212244

PEM-INST-001: Instructions for Plastic Encapsulated Microcircuit (PEM) Selection, Screening, and Qualification

Prepared by:
Dr. Alexander Teverovsky and Dr. Kusum Sahu

Reviewed by:
Dr. Henning Leidecker

Approved by:
Darryl Lakins



ECSS-Q-ST-60-13C Rev.1
12 May 2022

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

Commercial electrical, electronic and electromechanical (EEE) components

Standards

COTS Characteristics (2/2)

- The main leading COTS in space policy documents:
  - NASA EEE-INST-002 (April 2008) and PEM-INST-001 (June 2003)
  - **ECSS-Q-ST-60-13C** (Rev.1 12 May 2022)
    - Class 1 : Hi-Rel and Rad-Hard technologies and processes, cavity & hermetic package, full screening + LAT
    - Class 2 : JD , partial screening & reduced LAT
    - **Class 3** : Organic package, JD , no screening & LAT limited to radiation and construction analysis :
      - AEC-Q100, Q101 or Q200
      - Enhanced product _ EP
      - Catalog /& industrial product

OUR R2COTS SOLUTION

Class 3+ Space Ready COTS

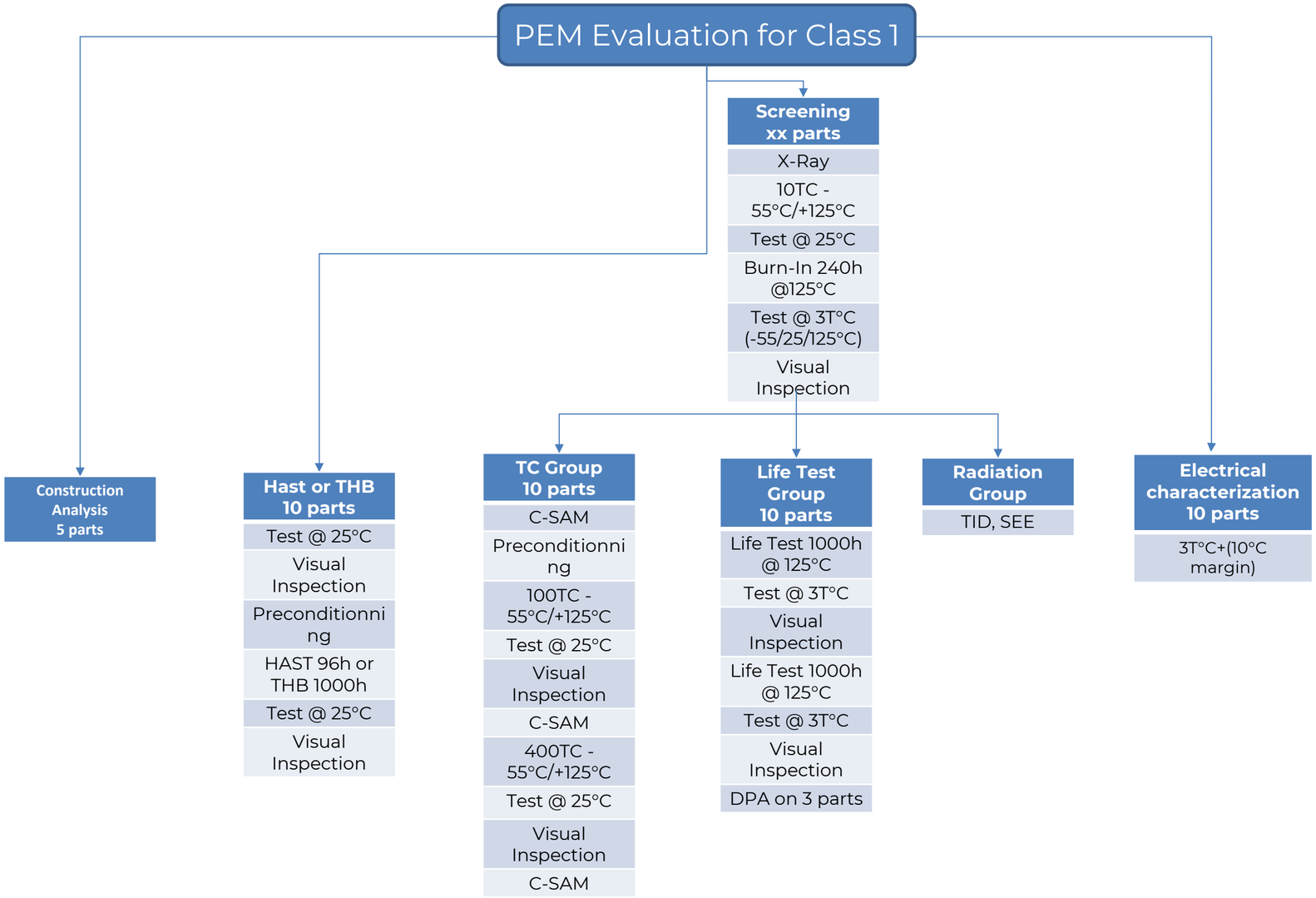
Our R2COTS(Radiation & Reliability on Commercial-Off-The-Shelf) parts includes:

- www.R2COTS.com
- Provision of more than 100 COTS parts /& functions
- A target of 150 references by the end of 2025
- Full traceability and JD (EEE Data)
- SEE testing with heavy ions – destructives
- Simplified TID – Co60
- Light screening
- Quick availability

- How are these components selected, evaluated and qualified?

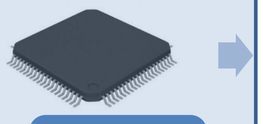
OUR R2COTS SOLUTION

Traditional Qualification methods



OUR R2COTS SOLUTION

Traditional Radiation methods

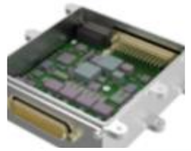


Design

Define the schematic and the function of the equipment

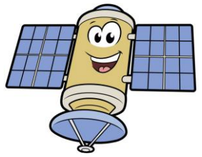
Engineering model

Validation of performance and functionality test



Flight model

I'm ready to go !



AT COMPONENT LEVEL ONLY

TID testing

- 10 samples per lot minimum
- Dose rate
- Samples biased ON and OFF
- Maximum number parameters tested
- Worst case biased

Co60 source

Heavy Ions

Protons or calculation If LETth ≤ 15

SEE testing

- 3 parts minimum for destructive event
- Maximum operating voltage and temperature SEL, minimum operating voltage and room temperature for other events
- 5 LETs to plot a cross section
- Plot the cross section for all types of events

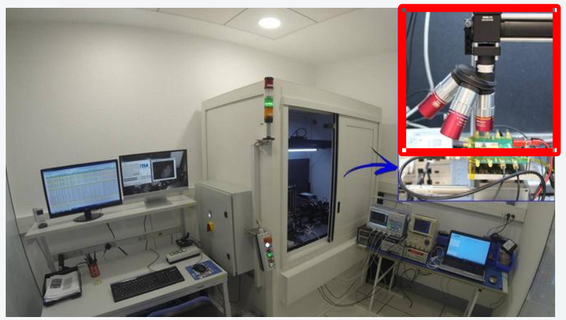
OUR R2COTS SOLUTION

Radiation flow

Function definition

- EP /& AEC Q
- Several MPNs :
  - Key Manufacturers
    - Data accessibility (JD)
    - High volume
    - Reliability test program (SPC)
  - Different wafer Fab process , if possible

Selection Cycle



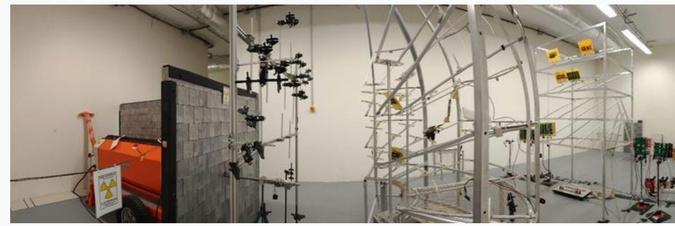
Destructive SEE

- Laser Nd:YAG, Cf-252
- LET ≥ 40 MeV.cm²/mg on 2 parts (Space Agencies recommendations)
- Typical operating conditions (ESCC 25100: Vcc , T° ...)
- Typical application for specific & complex functions
- DSEE, SEFI, simplified SET @ DSEE configuration

Evaluation Cycle

TID

- 6 samples per lot minimum
- Representative dose rate (Co60), limited n# of steps (ESCC 22900)
- Reduced number of parameters tested (Eval board can be used for complex functions)
- Simplified biasing



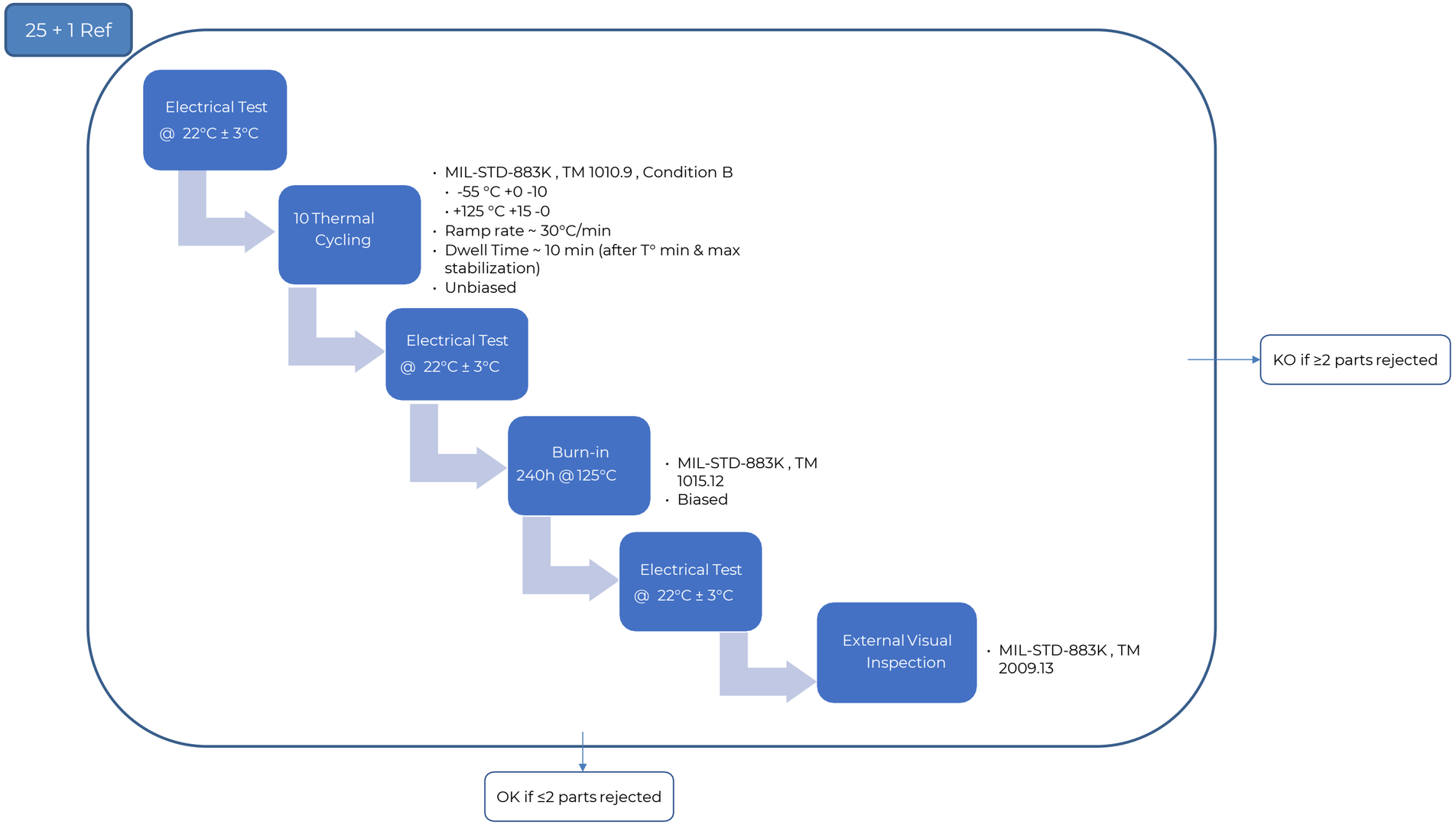
Implementation in R2COTS catalogue

- 2.5k to 10k PCEs stored in house
- DSEE data relevancy (Nok , Retest)
- Light screening (25 parts)
- TID (10 parts, typical bias, extended list of parameters)
- Full JD (more than ~ 30 Items)

Flight Batch

OUR R2COTS SOLUTION

Light Screening flow



Experience Feedback

R2COTS lessons learned (1/2)

- **SCREENING**
  - Commercial components (including EP; AEC Q) have **no screening**

- **Technical support**
  - **Limited communication** with the EEE manufacturers

- **PDN & PCN (Product Change& Discontinuance Notification)**
  - **High turnover of commercial components (including automotive parts**)
    => **obsolescence to be managed**

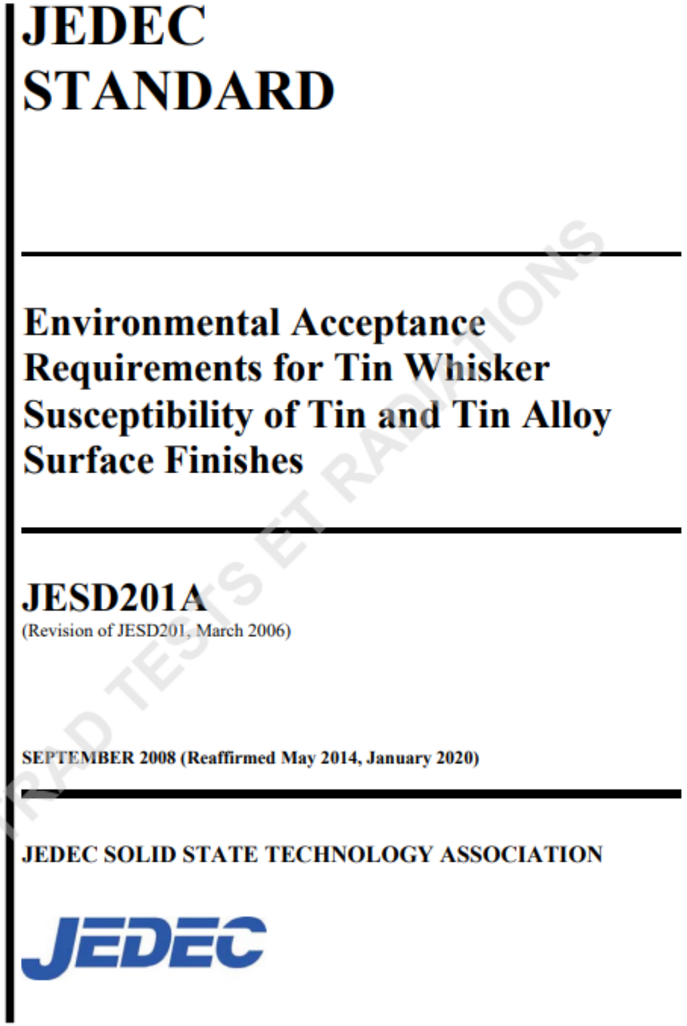
  - **Many PCNs** are generated => This requires to be followed
    => Efforts, skills , time and tools are necessary

Experience Feedback

R2COTS lessons learned (1/2)

- **PURE TIN**
  - **No SnPb finish**
  - In case of pure tin, only **matte tin authorized**
  - **No risk to deal with pure tin if JESD-201 class 2 validated**
- **TRACEABILITY**
  - **Tracecode is enough to manage the quality aspects** but **insufficient t requirements**
- **RADIATIONS**
  - Radiation may require to be managed per **diffusion lot** or per **wafer fab**
  - A **tracecode** may include parts from **several wafer fabs** and **several diff**
  - To manage radiations, traceability is key : die revision, mask set, wafer fab lot …

    => **BIG TIME CONSUMING**


JEDEC
STANDARD

Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes

JESD201A
(Revision of JESD201, March 2006)

SEPTEMBER 2008 (Reaffirmed May 2014, January 2020)

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

JEDEC

OUR R2COTS SOLUTION

Summary

	Class 3			Class 3+	Class 1 / 2			
	Commercial	AEC-Q100	EP	R2COTS	QMLQ	Space EP	QMLV	QMLV-RHA
Packaging	Plastic	Plastic	Plastic	Plastic	Ceramic	Plastic	Ceramic	Ceramic
Bond Wires	Au/Cu	Au/Cu	Au	Au/Cu	Al	Au	Al	Al
Can be Pure Tin (Sn)	Yes	Yes	No	Yes	No	No	No	No
Production /& Screening Burn-in …	No	No	No	Light screening TC, HAST & LT on request	Yes	No	Yes	Yes
Radiation Tested	No	No	No	Yes	No	Yes	Yes	Yes
Radiation Assured	No	No	No	No	No	Yes	No	Yes
Typical Temperature Range	-40°C to +85°C	-40°C to+ 125°C	-55°C to +125°C	-40°C to +85°C -40°C to +125°C -55°C to +125°C	-55°C to +125°C	-55°C to +125°C	-55°C to +125°C	-55°C to + 125°C
Availability	immediately to several months			2 weeks	Several months			

OUR R2COTS SOLUTION

RCS-1/24-0100

- Mise en place d'une offre de service de COTS qualifiés en radiations, accompagnés de garanties de traçabilité, pour répondre aux besoins du tissu spatial français

		Livrables	T0=01/11/2024	T1 = 02/12/2024	T1 + 8 mois
Lot 1	Tache 1.1	Liste consolidée des partenaires intéressés par cette offre de service.		×	
	Tache 1.2	Liste brute des besoins de test.		×	
	Tache 1.3	Liste définitive des références, avec un soutien de références alternatives.		×	
	Tache 1.4	Plans de test complet (TID, SEE, ...) pour chaque référence. Document de définition technico-économique des essais et de la mise à disposition des références retenues.		×	
Rapport				×	
Réunion			×	×	
Lot 2	Tache 2.1	Rapport global commun à toutes les références testées dans cette phase de déverminage.			Déverminage DSEE en cours
	Tache 2.2	Liste des références qui sont qualifiées. Rapport des essais TID et SEE réalisés.			
	Tache 2.3	Rapport final.			
	Tache 2.4	Dossier de traçabilité des composants. Système de catalogage des composants évalués pour permettre leur mise à disposition.			
Rapport					
Réunion					
Catalogue					

BJT
- HIGH POWER (> 2WATTS)

GaNFET
- VDS > 100 V

AMPLIFIER
- Current sense amplifier
- OPA /& Instrumentation Amplifier

LOGIC GATES

TRANSCEIVER

POWER MANAGEMENT IC
- V REF
- LDO
- Gate driver
- Over Current Protector
- PoL

Data converters
- ADC(>50 MSPS)
- DAC(>50 MSPS)

Memory (MRAM, DDR3/4, NAND, EEPROM)

OUR R2COTS SOLUTION

Conclusion

The COTS selection must be carefully managed by technical experts from different domains (EEE, radiation, reliability, tests…) in order to evaluate risks and ensure equivalent (or better) reliability figures than standard space components

Our R2COTS solution is the good trade-off between radiation, reliability and costs

This approach is valid only if COTS parts are selected from major manufacturers, with high volume production and reliability data available , but primarily In whom you trust !!!

Centre Français Fiabilité

NRTW 2025

National Reliability Technology Workshop

Mercredi 19 et Jeudi 20 mars 2025 | GANIL – Bd Henri Becquerel, 14000 Caen

merci pour votre écoute !

Organisé par :