Method for Qualitative Evaluation of COTS Board Reliability

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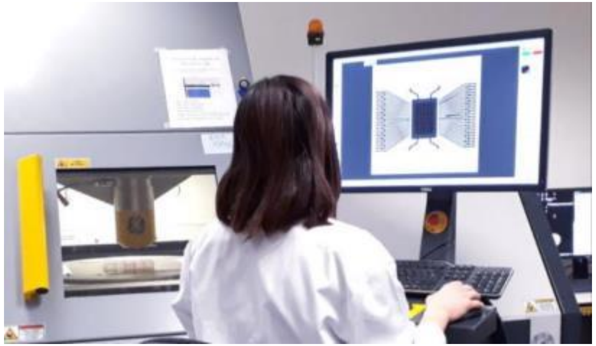
Vincent MARTINEZ

Who we are :



Expertise in electronics technologies, manufacturing processes, and materials characterisation laboratory in FRANCE (several sites)

- 5 laboratories: **75,000 ft²**
- **8,000** analyses per year
- Over **700** customers
- In-house R&D and collaborative projects

Chips | **Boards** | **Components** | **Materials** | **Power modules** | **RF**

Electrical systems and integrated testing

- **Electrical testing** of components, boards, systems
- **Qualification tests,** reliability tests, endurance tests, robustness tests, etc.
- **Electrical modelling**
- **Environmental testing**, T&H furnaces, HAST, Thermal shock/temperature cycle testing, HALT, vibration shakers, etc.

Physics and electrochemistry

- Batch **inspection,** counterfeit detection, broker checks
- **Failure analysis**
- **Construction analysis**, reverse engineering
- Si, SiC, GaN, MEB, TEM, FIB, etc. **chip analyses** and circuit edit for ASIC

Surface analysis

- **Physical-chemical analyses**
- **Surface characterisation**
- **All materials** for non-electronics sectors
- XPS, SSIMS, DSIMS, GD-OES, SEM-FEG, FTIR Microscopy, etc.

Consultancy and Training

- **Auditing** of assembly processes and industrialisation
- **Industrialization**
- **Obsolescence management**
- Board & System **reliability**
- Root cause **analysis** and **problem-solving** support
- **Training**

Context

- Strong push for cost reduction even for historical Hi-Rel sectors

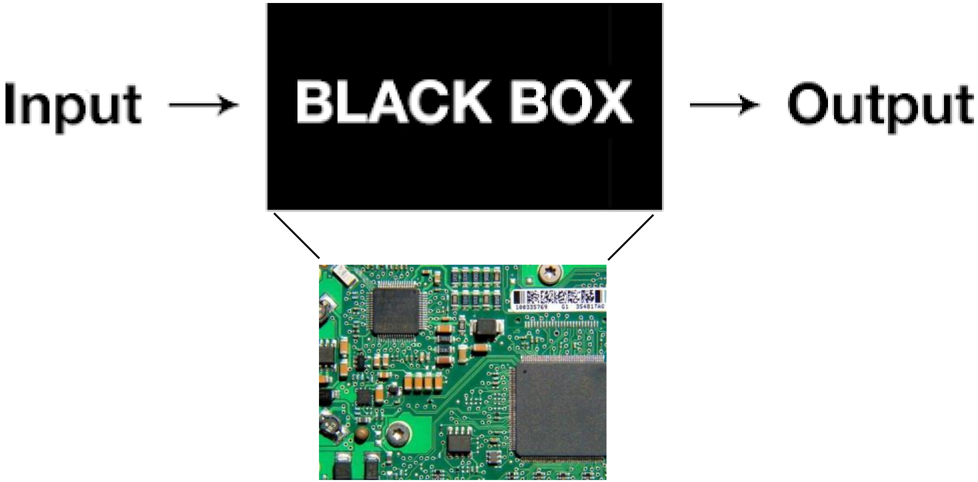
- COTS component gradual introduction for Hi-Rel already a reality

- COTS board introduction might be the next change…but…
  - Lack of technical data
  - Confidence in reliability data ?
  - Confidence in Design and Mfg quality ?
  - Product Change ”unNotification”

Note: COTS board a reality for spatial ground test bench.

Objectives

- Propose a method to technically assess the quality and reliability risks of the black box your purchasing department would love to buy !



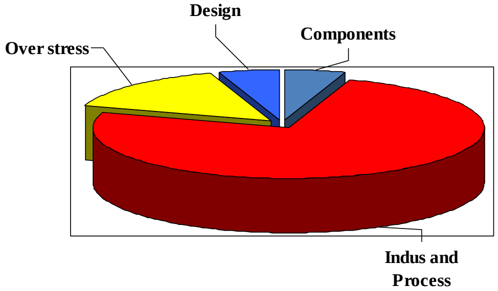
- Support Design/Reliability teams in charge of COTS introduction

Outline

- Introduction and lessons learned
- Reliability prediction and limits
- Presentation of the method (Process Diagram)
- Results
- Conclusion

Introduction and Lessons Learned

- Numerous COTS boards and suppliers available
- Partial technical data and limited communications possible with suppliers
- Lessons learned at SERMA about failure categories (multi-sectors)



➡ Development of a rapid approach based on first level inspection, component analysis and basic measurements (no long life test)

Goals:

- Risk identification and ranking vs mission profile and reliability targets
- COTS board suppliers comparison
- Limit testing only to identified risks

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Reliability Prediction and Limits

- Failure rate λ prediction based on theoretical formulas
- Several reliability handbooks can be used: MIL-HDBK, FIDES…

$$\lambda = \lambda_{\text{Physical}} \times \Pi_{\text{PM}} \times \Pi_{\text{Process}}$$

- λ predictions can be based on:
  - Complete models: need COTS BOM and schematics (de-rating)
  - Part Count method: need COTS board only

👍 Rapid failure rate prediction and comparison between COTS boards

Key assumption: constant λ (random failures)

👎 No assessment if end of life failure can occur during useful life

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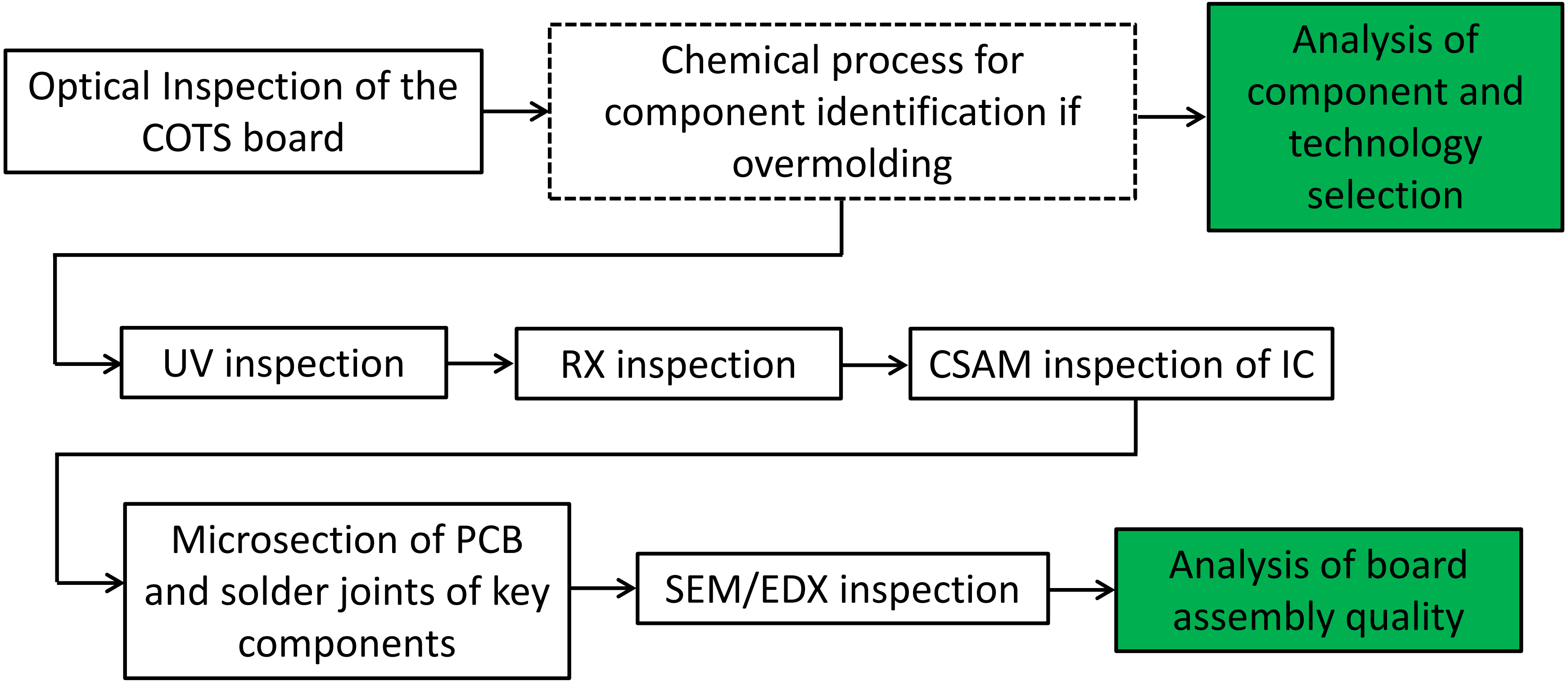
Process Diagram



Component Risk Matrix

Risk / Parameter				
Temperature	-55/+125°C	-40/+125°C	-40/+85°C	0/+70°C OR Unknown
Qualification	AEC MIL ESCC	Standard AND Well-known manufacturer	Standard AND Unknown manufacturer	Unknown
ESD	> 4kV (HBM)	3-4kV (HBM)	1-2kV (HBM)	< 1kV (HBM) OR Unknown
Obsolescence	Active	Not Recommended For New Design	End Of Life	Obsolete OR Unknown
Life Cycle	> 7 years	5-7 years	2-4 years	< 2 years OR Unknown
MSL	1-2	2a-3	4-5	5a-6 OR Unknown
RoHS	Yes	Whisker (e3)		No OR Unknown
REACH	Yes			No OR Unknown

Note: matrix can be adjusted for specific space (LEO, GEO…) or MIL missions.

Board Assembly Quality Matrix

Severity	+++	++	+	Remark (Rk)
Kind of observation	➢ Defect far from the state of the art	➢ OK relatively to usual criteria but not up to the state of the art. ➢ Will lead to +++ defect in case of process deviation	➢ OK relatively to usual criteria but not up to the state of the art. ➢ Will lead to ++ defect in case of process deviation	➢ OK but improvement is possible
Process	➢ Not under control	➢ Not completely under control	➢ Not completely under control	➢ -
Quality / Reliability objectives	➢ Major risk	➢ Risk in case of process deviation	➢ Risk in case of process deviation	➢ -

- Analysis based on IPC standards AND return of experience:
  - Component placement and packaging (pitch…)
  - Heavy component securing process
  - PCB technology and finish, coating/potting if any
  - Soldering technologies and alloy, repeatability, metallographic structure of solder joints
  - Component delamination, Board cleanliness
  - Board integration in the system
  - …

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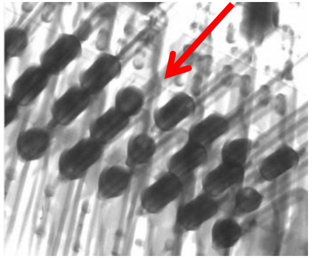
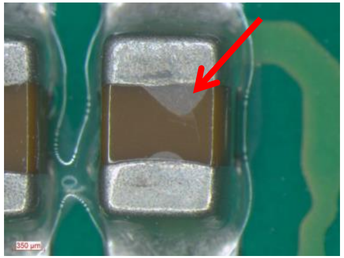
Component analysis results

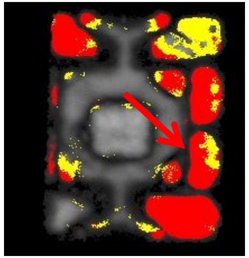
Item	Part Type	Part Category	Temperature	Qualification	ESD	Obsolescence	Life Cycle	MSL	RoHS	REACH
001	CAPACITOR	Ceramic								
002	CAPACITOR	Ceramic								
003	CAPACITOR	Ceramic								
004	CAPACITOR	Ceramic								
005	CAPACITOR	Ceramic								
006	CAPACITOR	Ceramic								
007	CAPACITOR	Array/Network								
008	RESISTOR	Film/Foil								
009	RESISTOR	Film/Foil								
010	RESISTOR	Film/Foil								
011	RESISTOR	Film/Foil								
012	RESISTOR	Film/Foil								
013	RESISTOR	Film/Foil								
014	RESISTOR	Film/Foil								
015	RESISTOR	Film/Foil								
016	TRANSISTOR	FET								
017	ANALOG	Regulator								
018	ANALOG	Amplifier								
019	ANALOG	Switch								
020	DIODE	Zener								

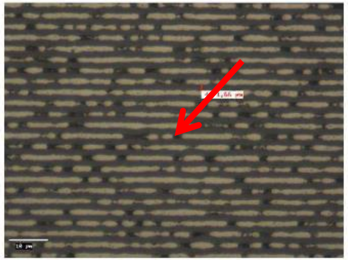
- Notes:
  - Evaluation of “Qualification” can be adjusted for specific space (LEO, GEO…) or MIL missions.
  - Instantaneous screenshot of component status (need further supplier management strategy for COTS)

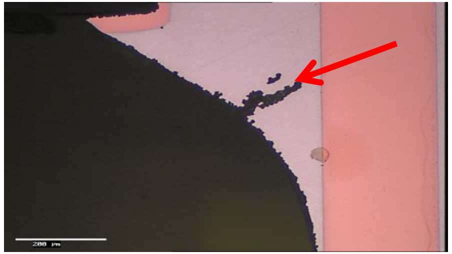
Board assembly analysis results



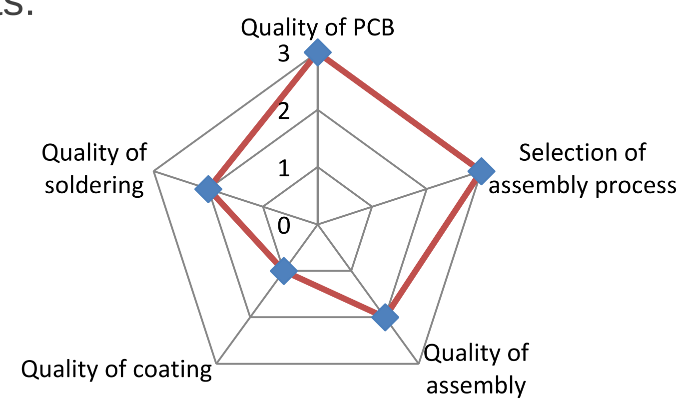








- Findings and risk level ranking have to be adjusted vs mission profile
- High level board assembly results:



Synthesis of the evaluation (example of 2 COTS Power Supplies)

		Risk			
		+++	++	+	-
Component and technology selection	Critical components	Supplier B			Supplier A
	Placement			Supplier A/B	
	PCB			Supplier B	Supplier A
	Assembly process			Supplier A/B	
	Coating/Potting		Supplier A/B		
	Component Securing	Supplier B		Supplier A	
	Integration		Supplier B		Supplier A
Assembly quality	Cleanliness			Supplier A/B	
	Wiring		Supplier A	Supplier B	
	Repeatability of solder joints		Supplier B		Supplier A
	Metallographic structure of solder joints			Supplier A/B	
	Delamination			Supplier A/B	
	Voids			Supplier A/B	

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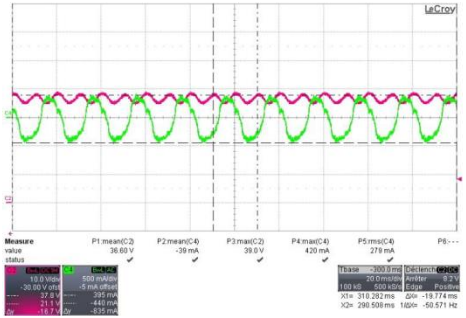
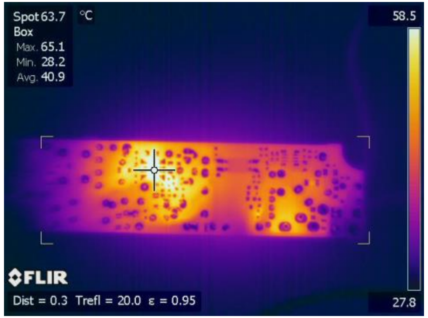
Conclusion

- Rapid comparison of COTS products
- Rapid identification of reliability risks
- Rapid identification of targeted test (component, process…)

- Method is only a first level qualitative evaluation for critical applications (no quantitative assessment of λ or TTF)

- Method can be pursued with targeted tests: performances, IR camera, robustness tests, reverse eng…depending on the level of criticity and need for quantitative data





Thank you very much for your attention, questions ?