FIDES PRESENTATION

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DGA INFORMATION SUPERIORITY

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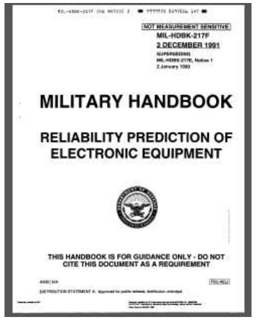
FIDES MEANS FAITH IN LATIN

"TO INCREASE CONFIDENCE IN RELIABILITY PREDICTION"

FIDES HISTORY

WHY DGA REQUIRED A NEW RELIABILITY EVALUATION GUIDE?

- **Electronic technologies, existing prediction guides are inadequate and now obsolete**
  - **Last IEC62380 issue is 2003 (RDF2000)**
    - Being merged with IEC61709
  - **Last MIL HDBK 217 issue is 1995**
  - **French Defense industry used MIL HDBK 217F with corrections factors but « tuning » was less and less effective**
  - **No COTS prediction**
  - **PRISM®/217Plus® not adapted to complex mission profiles and rugged environments**


NOT MEASUREMENT SENSITIVE
MIL-HDBK-217F
2 DECEMBER 1991

MILITARY HANDBOOK

RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT

THIS HANDBOOK IS FOR GUIDANCE ONLY - DO NOT CITE THIS DOCUMENT AS A REQUIREMENT


TECHNICAL REPORT

IEC TR 62380

Military equipment	MIL HDBK 217F (Pi Q=10)	MIL HDBK 217F with correction	PRISM (217plus)	Field return
MTBF (in hours)	3063	19036	59673	169895

WHAT IS FIDES ?

- Result of a study which began in 2001 on the aegis of the French MoD and developed by 8 companies
- Methodology for electronic systems reliability
- Based on Physics of Failure (PoF)
- Allows to take into account present processes from component selection to assembled board integration

- Answer to 2 strong needs
  - To make realistic reliability predictions
  - To build reliability without undergoing result

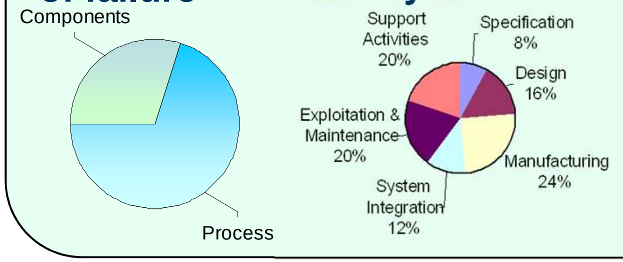
FIDES METHODOLOGY

FIDES GLOBAL MODELIZATION

Process impact

Origin cause of failure

Process failure distribution versus life Cycle



Components technologies

Technologies
- Electronic Component family Classification
- Detailed technologies
- =>Recent technologies covered

TECHNOLOGY

RELIABILITY

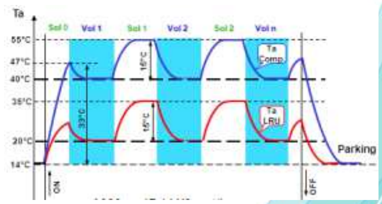
PROCESS

USE

Life cycle Audit 170 Questions

System Life Profile

Profile Description
- Phases breakdown
- Duration of each phase
- Functioning condition (on/off)
- Ambient temperature (constant)
- Thermal cycling (duration, frequency, amplitude)
- Relative Humidity
- Vibrations
- Chemical (pollution)



- Aims of FIDES
  - Realistic prediction
  - Usable for reliability assessment and building
  - Usable for all kind of items, including COTS sub-assemblies

GENERAL RELIABILITY MODEL

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

$$\lambda_{\text{Physical}} = \left[\sum_{\text{Physical\_Contributions}} \left(\lambda_0 \cdot \Pi_{\text{acceleration}} \right) \right] \cdot \Pi_{\text{induced}}$$

Processes management (quality & Control)

- Quality of manufacturer
- Quality of component
- Experience of supplier

Technology

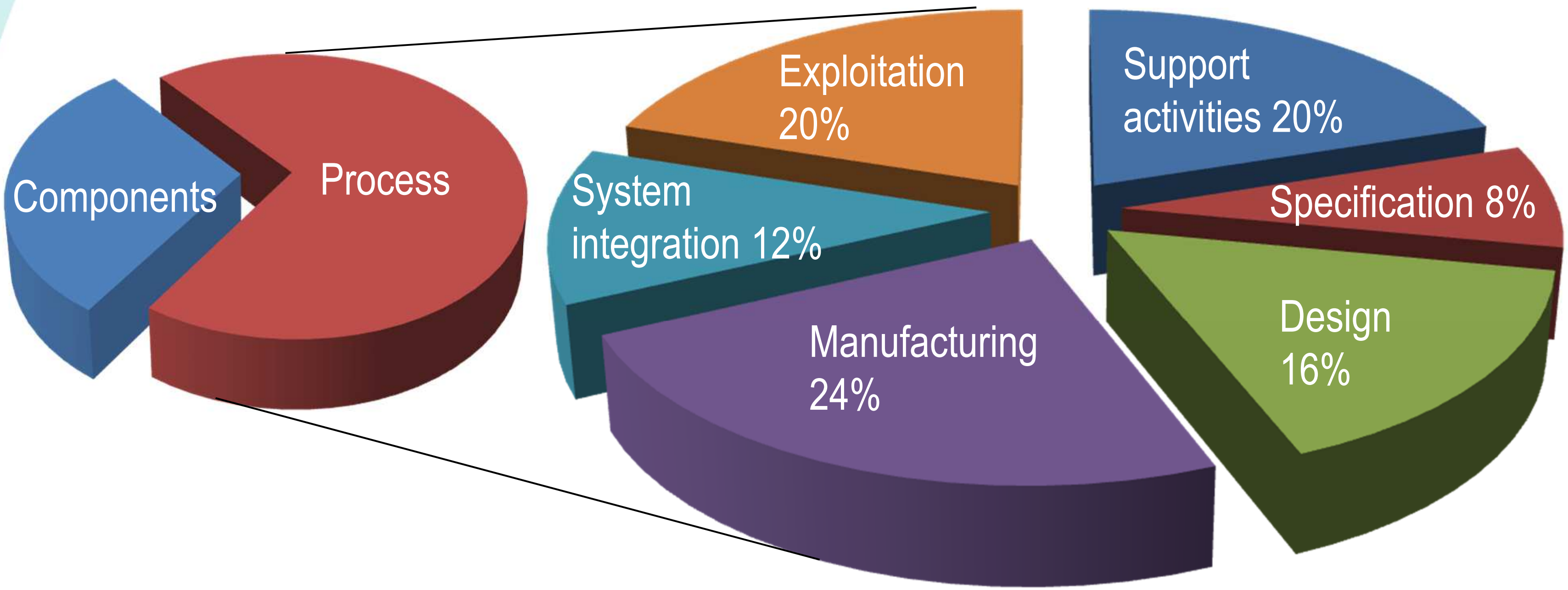
Acceleration (normal stress)

Π Thermal
Π Electrical
Π Tcy : Temperature cycling
Π Mechanical
Π RH : Humidity
Π Chemical

Induced (overstress)

Π Placement : influence of the placement in the product, interfaces for instance
Π Application : usage environment (vehicle, aircraft)
Π Ruggedizing : overstress consideration in design
Π Sensitivity : sensitivity to overstress of a technology

ROOT CAUSES OF SYSTEM FAILURES



We could not neglect about 70% of the failure root causes : process has to be taken into account = Πprocess audit check list (#250 questions)

FIDES BASICS

ΠPart Manufacturing 1/2

- Π_{PM} (from 0,5 to 2) component quality depending on
  - Quality assurance level
    - Manufacturer (QA_Manufacturer)

Manufacturer quality assurance level	Position relative to the state of the art	$QA_{manufacturer}$
Certified ISO/TS16949 V2002	Higher	3
Certified according to one of the following standards: QS9000, TL9000, ISO/TS 29001, EN9100, AS9100, JISQ 9100, AQAP 2110, AQAP 2120, AQAP 2130, IRIS, IEC TS 62239, ESA/ECSS QPL, MIL-PRF-38535 QML, MIL-PRF-19500	Equivalent	2
ISO 9000 version 2000 certified	Lower	1
No information	Very much lower	0

    - Component (QA_Component)

Component quality assurance level	Position relative to the state of the art	$QA_{component}$
Qualification according to one of the following standards: AEC Q100, MIL-PRF-38535 class V, ESA ESCC 90xx, NASDA-QTS-xxxx class I, NPSL NASA level 1	Higher	3
Manufacturer qualification including tests conforming with standards JESD22, EIAJ-ED-4701, MIL-STD-883, IEC 68 with identification of "front-end" and "back-end" manufacturing sites; Qualification according to one of the following standards: MIL-PRF-38535 class Q, MIL-PRF-38535 class M, MIL-PRF-38535 class N, MIL-PRF-38535 class T, NASDA-QTS-xxxx class II, NPSL NASA level 2 & 3, STACK-S0001	Equivalent	2
Qualification program internal to the manufacturer and unidentified manufacturing sites	Lower	1
No information	Much lower	0

FIDES BASICS
ΠPart Manufacturing 2/2

- **Component Reliability assurance level**
  - RA_Component

Title of accelerated aging test	High Temperature Operating Life (HTOL)	Pre-conditioning before TC, THB or HAST	Temperature Cycling (TC)	Pressure Cooker Test (PCT)	Highly Accelerated Stressed Tests (HAST)	Temperature Humidity Biased (THB)	
Reference standards	EIA JESD-22-A108 A or equivalent	EIA JESD-22-A113A or equivalent	EIA JESD-22-A104 or equivalent	EIA JESD-22-A102 or equivalent	EIA JESD-22-A110 or equivalent	EIA JESD-22-A101 or equivalent	
	Test results						Risk $RA_{component}$
Very reliable level A	1000h, 125°C, Vmax, 231/0 [1] 1500/0*	done	1000 cycles -55°C /+150°C or 500 cycles -65°C/+150°C 231/0 or 1000 cycles -55°C/125°C 385/0	168 h at 121°C / 100%RH 231/0	168 h at 130°C/ 85%RH 231/0	168 h at130°C/ 85%RH 231/0	**3**
Very reliable level B	1000h, 125°C, Vmax, 154/0 [1] 900/0*	done	1000 cycles -55°C /+125°C, 154/0	96 h at 121°C / 100%RH, 154/0	96 h at 130°C/ 85%RH, 154/0	96 h at 130°C/ 85%RH, 154/0	**2**
Reliable	1000h, 125°C, Vmax, 77/0[1] 231/0*	done	500 cycles -55°C /+125°C 154/0	96 h at 121°C / 100%RH, 77/0	96 h at 130°C 85%HR, 77/0	1000 h at 85°C/85%RH, 154/0	**1**
Not reliable	Design below the reliable level	Not done	Design below the reliable level				**0**

TECHNOLOGY

Physical contributors (IC model example)

$$\lambda_{Physical} = \sum_{i}^{Phases} \left(\frac{t_{annual}}{8760}\right)_i . \left(\lambda_{0_{TH}} . \Pi_{Therm} + \lambda_{0_{TCy_{Casing}}} . \Pi_{TCy_{Casing}} + \lambda_{0_{TCy_{Solder\_joints}}} . \Pi_{TCy_{Solder\_joints}} + \lambda_{0_{RH}} . \Pi_{RH} + \lambda_{0_{mech}} . \Pi_{mech}\right)_i . \Pi_{Induced-i}$$

- **λ_0 : basic failure rate for each stress**
- **$\Pi_{acceleration}$: acceleration factor, sensivity to rated physical contributors**

$\Pi_{Thermal\_}$	In an operating phase : $e^{11604 \times 0.7 \times \left[\frac{1}{293} - \frac{1}{(T_{j-component} + 273)}\right]_i}$ In a non-operating phase : $\Pi_{Thermal} = 0$	**Arrhenius**
Π_{TCy} Case	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^4 \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$	**Norris-Landsberg**
Π_{TCy} Solder joints	$\left(\frac{12.N_{annual\_cy}}{t_{annual}}\right)_i \times \left(\frac{\min(\theta_{cy}, 2)}{2}\right)_i^{\frac{1}{3}} \times \left(\frac{\Delta T_{cycling}}{20}\right)_i^{1.9} \times e^{1414 \times \left[\frac{1}{313} - \frac{1}{(T_{max-cycling} + 273)}\right]_i}$	
Π_{Mech}	$\left(\frac{G_{RMS}}{0.5}\right)_i^{1.5}$	**Basquin**
Π_{RH}	$\left(\frac{RH_{ambient}}{70}\right)_i^{4.4} \times e^{11604 \times 0.9 \times \left[\frac{1}{293} - \frac{1}{(T_{board\_ambient} + 273)}\right]_i}$ In an operating phase : $\Pi_{RH} = 0$	**Peck**

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COMPONENT MODELS

- **Model based on**
  - **Manufacturer reliability tests exploitation**

Test		IC	Discrete	λ_0
HTOL	High Temperature Operating Life	X		$\Rightarrow \lambda_{0TH}$
HTGB	High Temperature Gate Bias		X	$\Rightarrow \lambda_{0TH}$
PCT ou AC	Pressure Cooker Test / Autoclave	X		$\Rightarrow \lambda_{0RH}$
TC / TS	Temperature Cycle / Thermal Shock	X	X	$\Rightarrow \lambda_{0TC\_case}$

  - **Report on PCB qualification tests and simulation**
    - $\lambda_{0TCy\_solder\ joints}$
  - **Using standard acceleration laws**
    - Arrhenius (Π_{th}), modified Peck (Π_{RH}), Coffin-Manson (Π_{TCy_case}), Engelmayer&Norriz-Landzberg ($\Pi_{TCy\_solder\ joints}$), modified IPC-SM785 (Π_{meca})

COMPONENT MODELS IN 2009 FIDES GUIDE

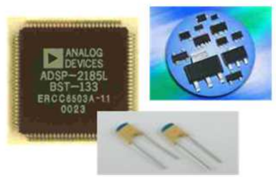
- Integrated circuits
- ASIC
- Discrete semiconductors
- LED
- Optocouplers
- Resistors
- Fuses
- Ceramic capacitors
- Aluminum capacitors
- Tantalum capacitors

- Magnetic components
- Piezoelectric components
- Monostable electromechanical relays
- Switches
- Printed circuit board
- Connectors
- Hybrids and Multi Chip Modules
- Hyper frequency (HF) and radiofrequency (RF) components

- Sub-assemblies :
- LCD screens
- CRT screens
- Hard disks
- AC/DC and DC/DC
- Lithium and nickel batteries
- Fans
- Keyboards

COTS boards
Part count
Family count
Lead free process

Parts



Boards

Sub-assemblies

LIFE PROFILE

Example – Personal car

Personal car - used daily

			Temperature	Thermal cycling				Hymidity	Mechanical	Chemical				Induced
Phase title	Calendar time (hours)	On/Off	Ambient temperature (°C)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum temperature during cycling (°C)	Relative humidity (%)	Random vibrations (Grms)	Saline pollution	Environmental pollution	Application pollution	Protection level	Πapplication
Parking off	8212,5	Off	15	10	365	22,5	20	70	0	Low	Moderate	High	Non hermetically sealed	3.1
Driving on road	365	On	35	20	730	0,5	35	22	1.4	Low	Moderate	High	Non hermetically sealed	5.1
Traffic jam	182,5	On	50	15	730	0,25	50	10	1.6	Low	Moderate	High	Non hermetically sealed	5.1
	8 760													

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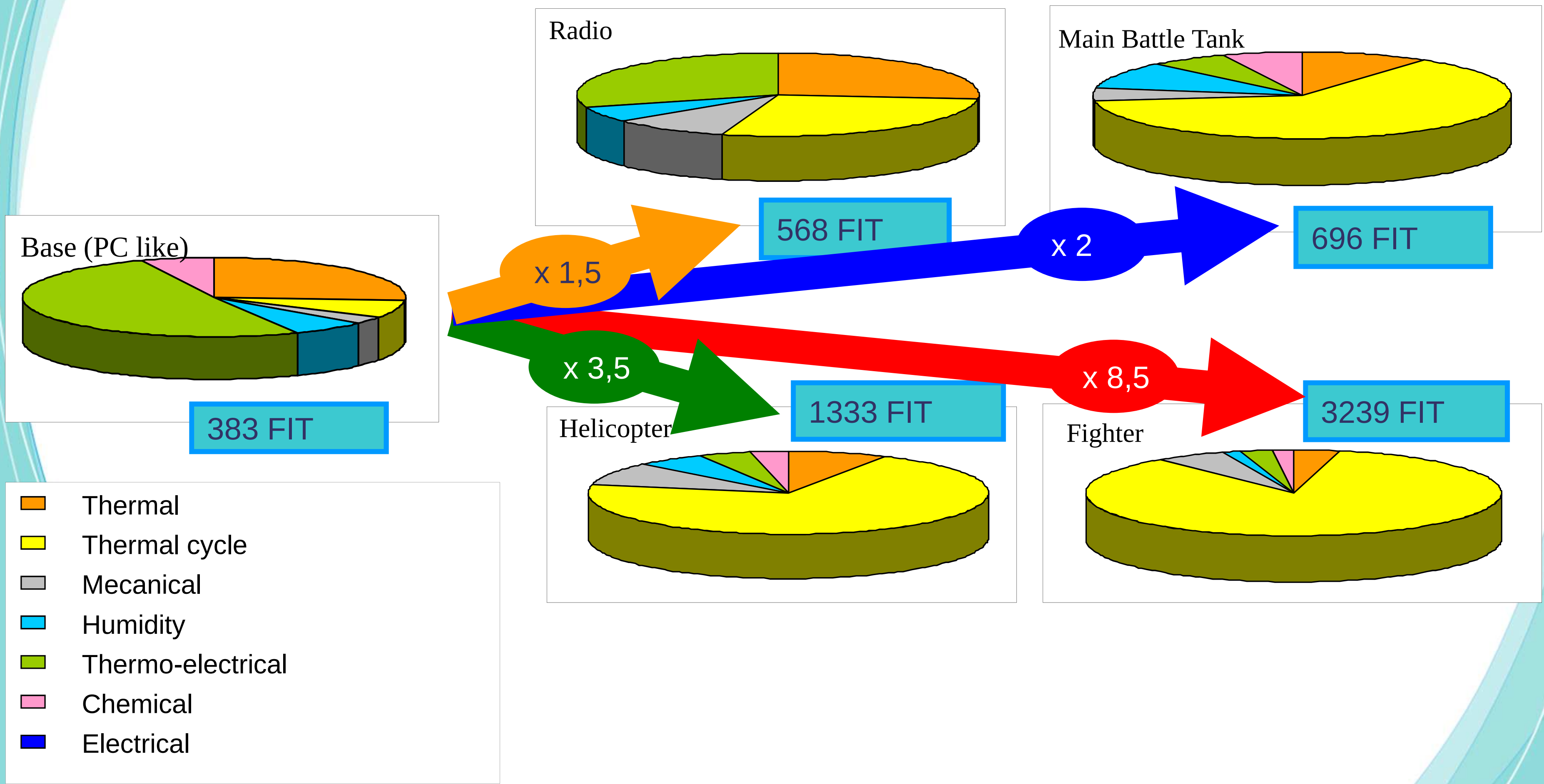
LIFE PROFILE INFLUENCE

Example – Recent electronic board assessment



COMPARISON BETWEEN FIDES AND MIL HDBK 217F

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ECSSQ-HB-30-08A EXTRACT
January 14th, 2011

- « MILHDBK217 should not be used (nor extrapolated) beyond limitations identified in the table above »
- « When a specific family is not covered by MILHDBK217, the methodology prepared in the present handbook should be used to choose the most appropriate alternative standard or handbook

Table B-1: EEE families applicability matrix for MIL-HDBK-217

Component class	Component category	Component sub–category	MIL-217 para	MIL-217 para and limits
Active	Integrated circuits	Logic devices	5.1	≤ 60 k gates ≥ 0,8 μm
		Linear devices	5.1	≤ 10 k trans
		Microprocessors	5.1	≤ 32 bits ≥0,8 μm
		Volatile memories	5.2	≤ 1 Mbit ≥0,8 μm
		Non–volatile memories	5.2	≤ 1 Mbit ≥0,8 μm

FIDES VERSUS MIL HDBK 217F

- News technology/component (µprocessor, memory, COTS board…) models in FIDES
- MIL HDBK 217 = operating failure rates

  FIDES = calendar failure rates (with detailed definition of dormant phases)
- Extrinsic failure rate considered in FIDES : $\Pi_{Process}$ and $\Pi_{induced}$ factors
- FIDES : sensitive to quality considerations, from design to usage (Π_{PM}, $\Pi_{Process}$)

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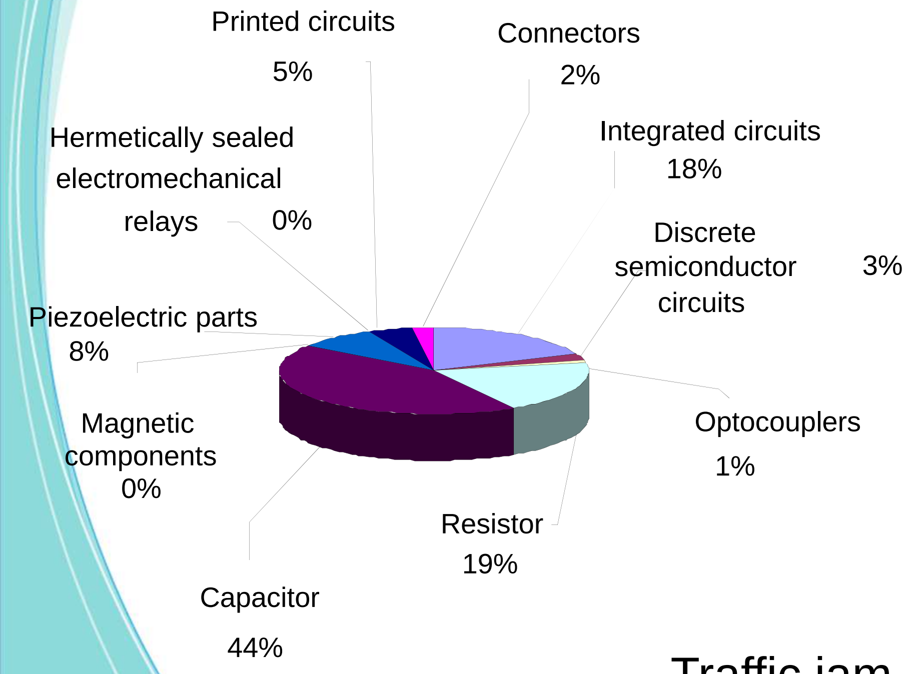
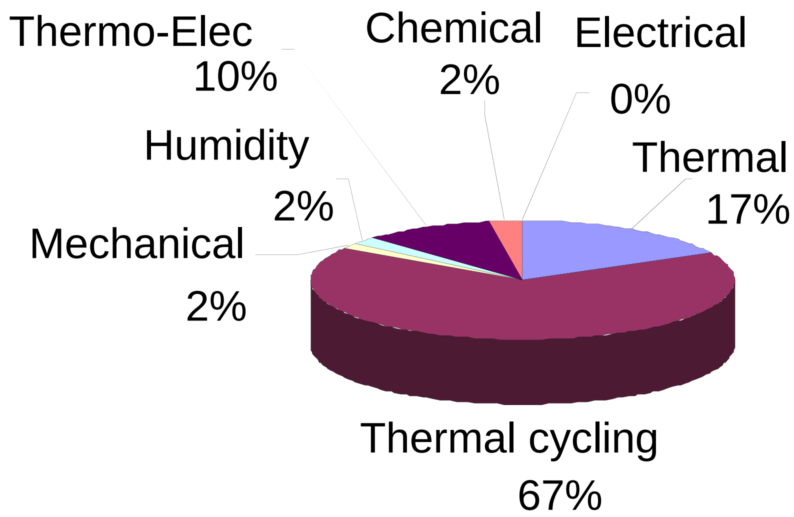
RELIABILITY ENGINEERING WITH FIDES RESULTS

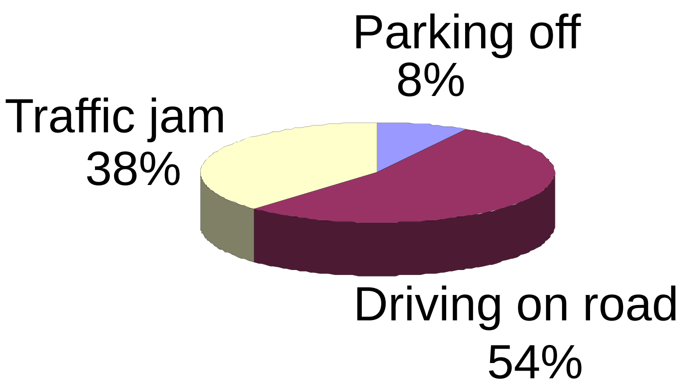
- **Failure distribution according to life profile**



Parts family contribution



Environmental contribution



Phases contribution

FIDES VS FIELD RETURN

- ***REX*** **was French MoD study with 5 companies**
  - ***15 electronic systems***
  - ***24 millions electronic components***
  - ***>2 years of observation***

FIDES is generally closer to field return, more realistic and less pessimistic than MIL HDBK 217F

Equipementier	Equipement	MTBF REX/MIL	MTBF REX/FIDES
A	1	51,8	3,3
	2	10,1	1,1
	3	6,7	0,9
	4	-	4,2
	5	2,8	1,0
	6	0,6	0,5
	Total	**9,1**	**1,1**
B	7	4,8	1,2
	8	17,6	4,5
	total	**6,4**	**1,6**
C	9	**12,4**	**2,2**
D	10	3,1	0,7
	11	3,2	0,8
	total	**3,1**	**0,7**
E	12	2,5	1,3
	13	1,4	0,6
	14	1,3	0,3
	15	0,5	0,2
	total	**1,1**	**0,4**

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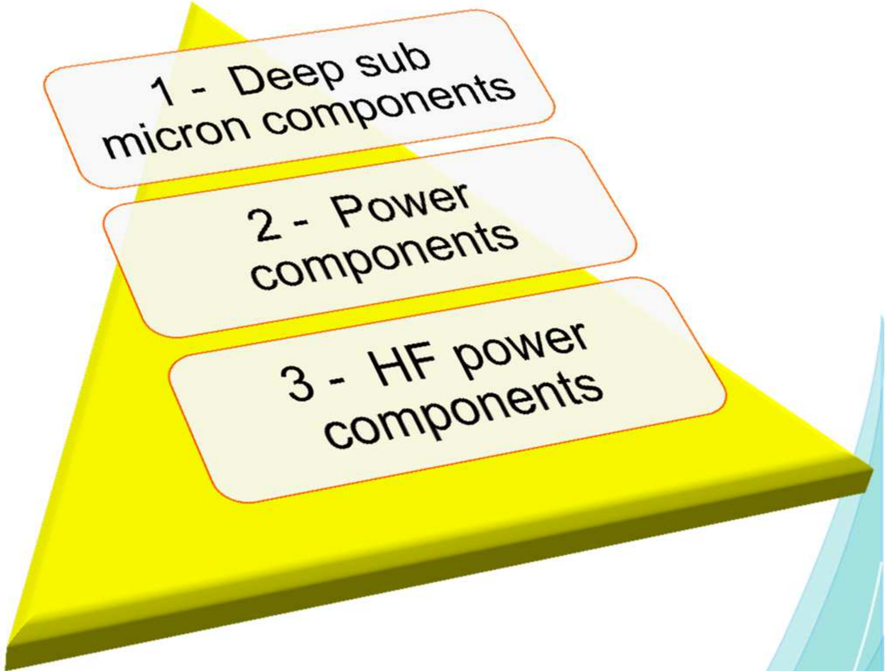
FIDES REVISION

- **New DGA R&T study *PISTIS* (2015-2019)**
  - **DSM, HF power (GaN) and power (IGBT) components reliability**
  - **Are existing FIDES models adapted to these new technologies?**
  - **What about lifetime (wearout) of these technologies?**
  - **Fides models or parameters revision**
    - λ_0 die and case
    - $\Pi_{process}$ audit
    - $\Pi_{induced}$ (EOS)



CONCLUSION 1/2

- Impossible to use and adapt obsolete MIL HDBK 217 for new designs
- FIDES takes into account overstresses, life profile (even for dormant applications)
- FIDES is able to improve reliability by contributors analysis and $\Pi_{Process}$ audit check list
- Maintenance structure created to update FIDES methodology
  - www.fides-reliability.org
- FIDES has potential for evolution

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CONCLUSION 2/2

- FIDES is a reference standard in DGA contracts since 2005 (missile, radio telecom, vehicle, fighter aircraft…)
- FIDES aims to cover all the industrial needs in matter of reliability, included space domain
- FIDES is used by several companies in Europe (Aeronautical, Defence, Automotive, Rail transportation, General purpose…)
- Need for an international reference

THANK YOU FOR YOUR ATTENTION

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