Predicted Reliability

Voorspelde betrouwbaarheid

Jan Betten
Head Product Development & Test Engineering

VARIASS

Veendam

Electronic Manufacturing Services (EMS)

Design Support & Engineering
Innovation

High Tech System Supplier

Drachten

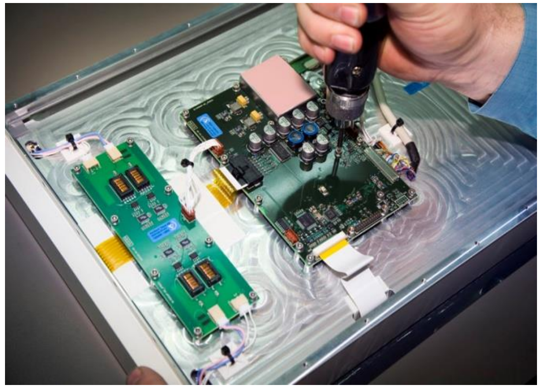
INNOVATION CLUSTER
HIGH TECH SYSTEMS • DRACHTEN

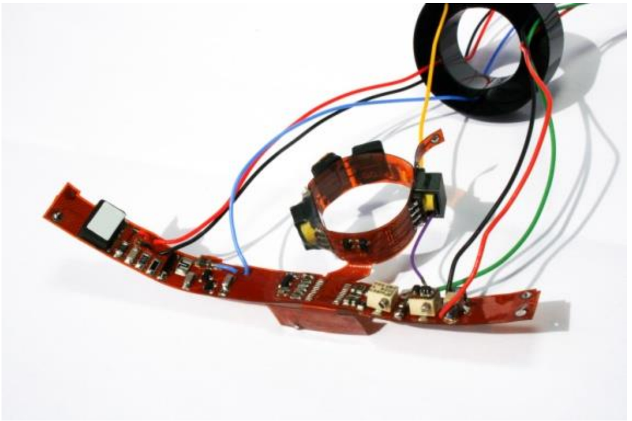
VARIASS

High Tech System Supplier and EMS specialist

- ✓ Industry
- ✓ Medical & Diagnose
- ✓ Defense & Security

- ✓ High quality standards:
  - ✓ ISO 9001
  - ✓ ISO 13485
  - ✓ AQAP 2110
  - ✓ IPC-A-610 / 620 / 630
  - ✓ ISO 26000 (MVO) & ISO 14001 (environment)
  - ✓ Work according OHSAS 18001





VARIASS

Competences

- ✓System supplier & EMS
- ✓Smart Custimization
- ✓Product Life Cycle Management (LCM)
- ✓Development & Engineering
- ✓Early Involvement
- ✓Design for eXcellence (DfX)
  Reliability & Robustness
- ✓Technical support of product certification

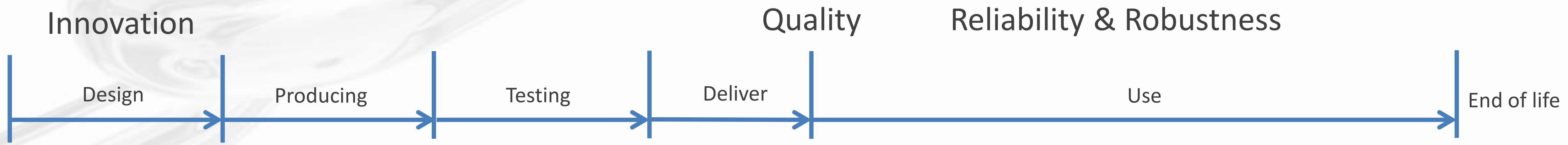
VARIASS

Contents Predicted Reliability

- ✓ Definitions
- ✓ Why?
- ✓ When?
- ✓ How?
- ✓ Summary

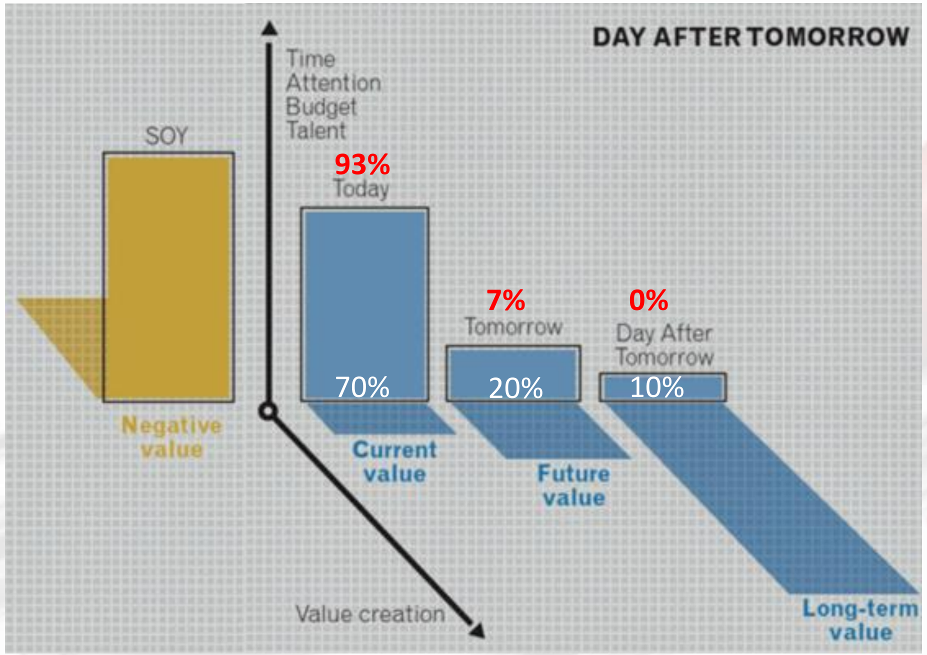
Definitions

- ✓ **Quality** (kwaliteit) = De productprestaties in relatie tot de functionele eisen direct na levering.
- ✓ **Reliability** (betrouwbaarheid) = Het vermogen van een systeem om consequent de bedoelde functie uit te voeren zonder verslechtering of uitval. Kwaliteit na verloop van tijd.
- ✓ **Robustness** (robuustheid) = Het vermogen van een systeem om te blijven functioneren onder de aanwezigheid van ongeldige inputs of stressvolle omgevingscondities.
- ✓ **Innovation** (Innovatie) = De ontwikkeling en succesvolle invoering van nieuwe of verbeterde goederen en diensten.

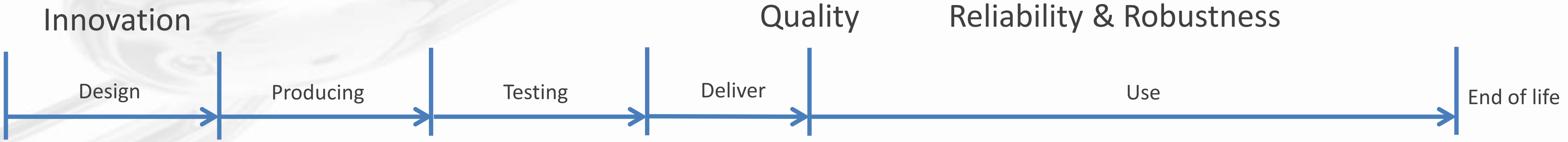


Definitions

Hoeveel tijd besteedt u aan waardecreatie (innovatie) voor de dag na morgen?

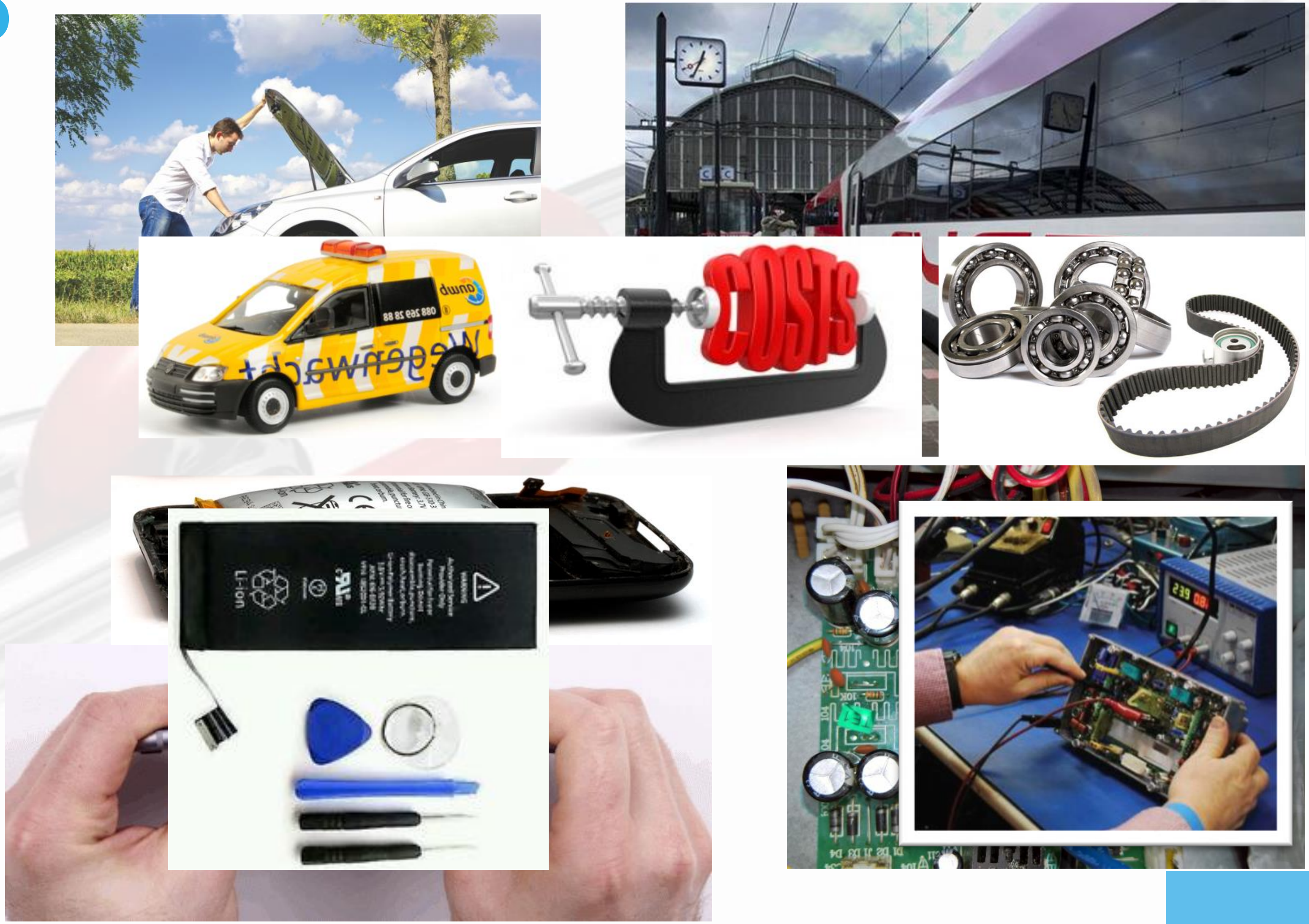


Bron: bnox.be & P. Hinsen, 2017, The day after tomorrow

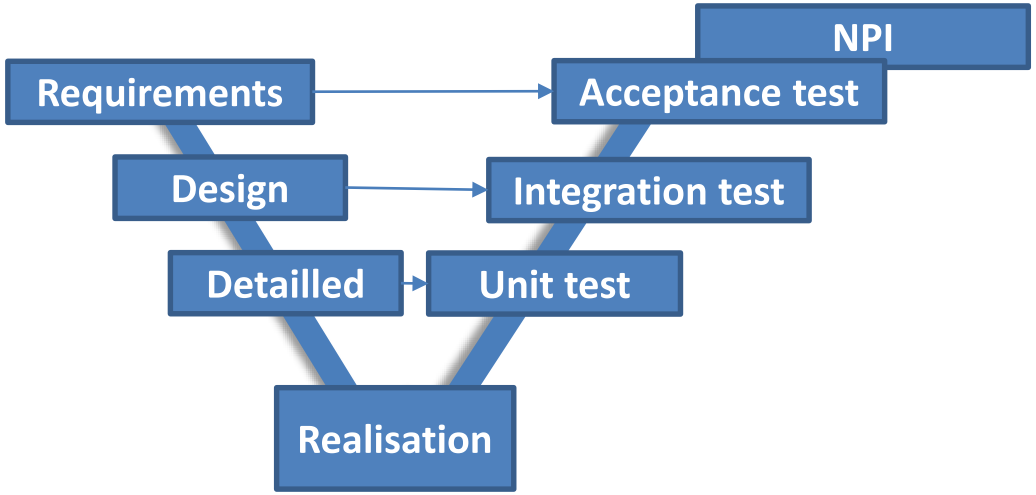


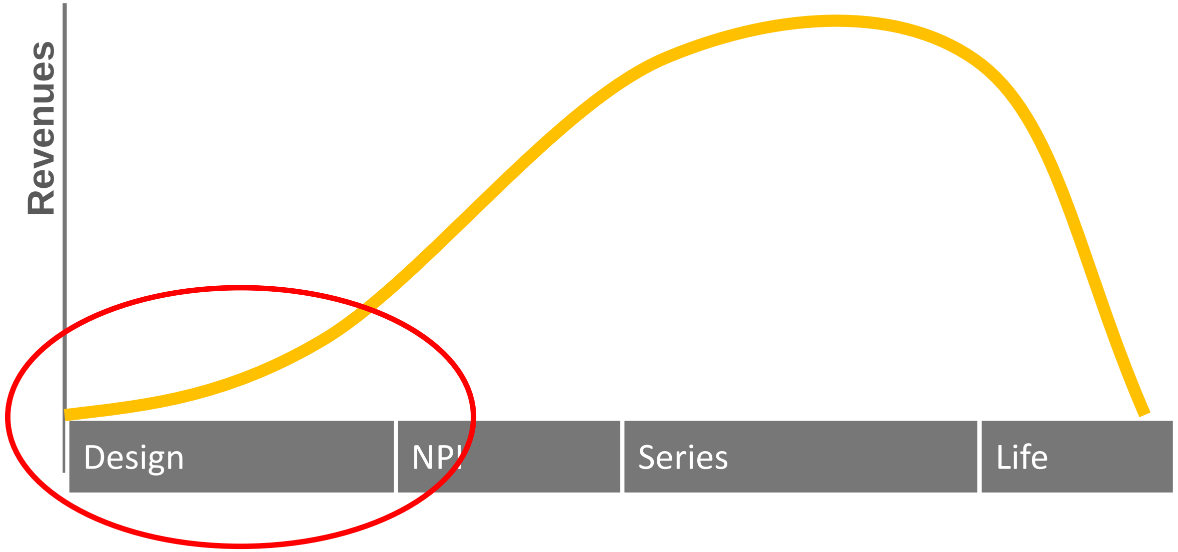
Why reliability?

- ✓ Avoid “Shit of Yesterday”
  - ✓ Failure in the field
  - ✓ Damaged image, claims
  - ✓ High costs for service and repair
  - ✓ The customer will find it!
- ✓ Keep you focussed at innovation
  - ✓ Opportunity for new business models
  - ✓ Service & repair
  - ✓ Product upgrade
  - ✓ Spare parts
  - ✓ Product costs reduction



When?



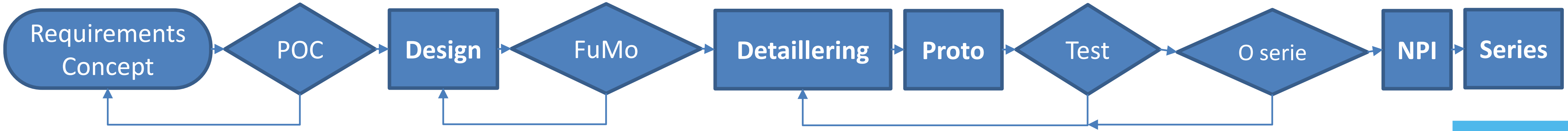


temp. vibration
pollution etc.

architecture, housing
interconnection, etc.

component selection,
tolerances, overdimensioning

HALT, ALT



How?

Predicted Reliability:

1. Physics of Failure (PoF, “How stuff fails”)
    - Voorgaande producten, QA database, Weibull-verdeling
2. Data sheets
    - MTBF, FIT, calculating , simulation and measure
3. Reliability Standards (empirical models)
    - IPC-A 6x0, MIL, SR-332
4. Testing
    - HALT, ALT, MEOST

How? Physics of Failure

✓ Register failure data

when, show time, interval, serial number, environment, conditions, …

1. Effect, Expected function not available

   No output, No connection, No coffee, …

2. Mode, Type of failure

   shutting down, degraded functionality, …

3. Mechanism, Physical explanation

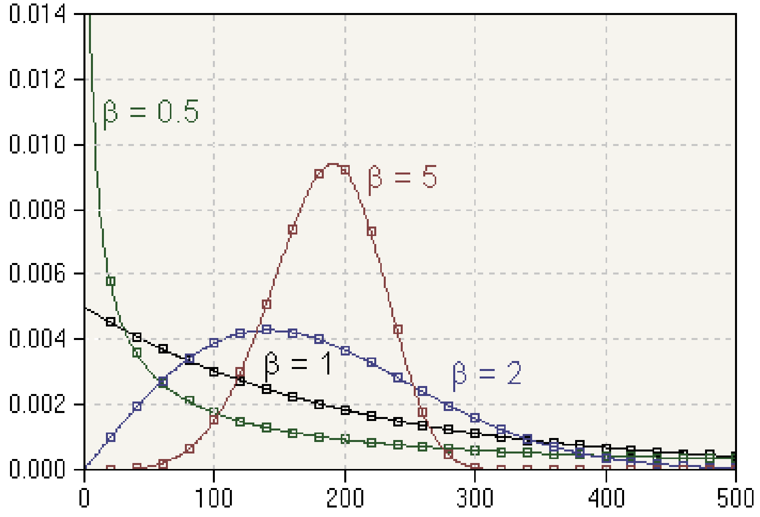
   corrosion, fracture, fatigue, …

4. Initiator, Physical root cause

   Temperature, Moisture, Vibration, Voltage, Salt, ..

How? Physics of Failure

✓ Analyze the data; Weibull Distribution



Beta <1: Infant Mortality

Beta=1: random failure

Beta 1…4: Early Wear out

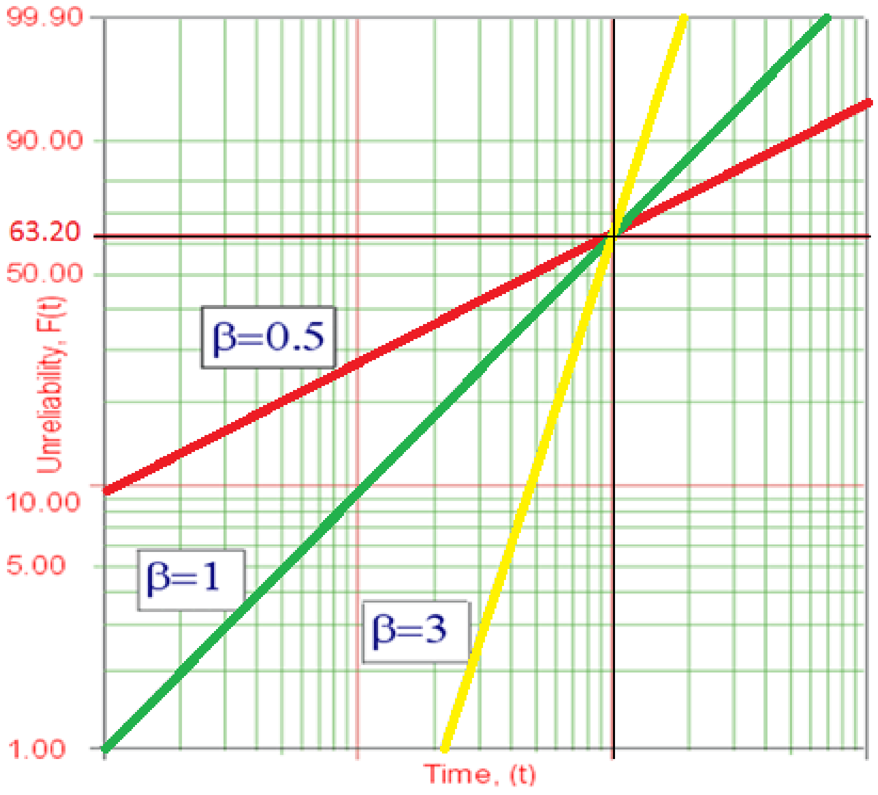
Beta>4: age rapid wear out

Statistical distribution (CDF)

$$F(t) = 1 - e^{-\left[t/\eta\right]^{\beta}}$$

F(t) = Failure Percentage
β = Shape Parameter
η = Characteristic Live

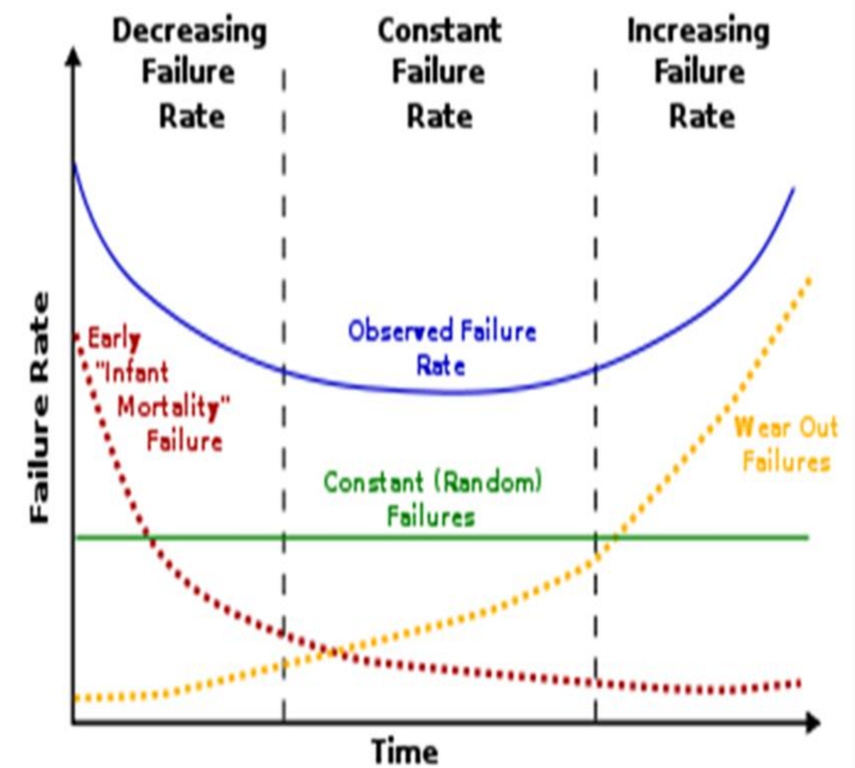
@ β=1, η=t
F = 1 – 0,368
Failure = 63,2%
R = 1 - F
Reliability = 36,8%



Weibull plot

How? Physics of Failure

- ✓ Analyze the data; Weibull Distribution



Bathtub curve

Statistical distribution (CDF)

$$F(t) = 1 - e^{-[t/\eta]^{\beta}}$$

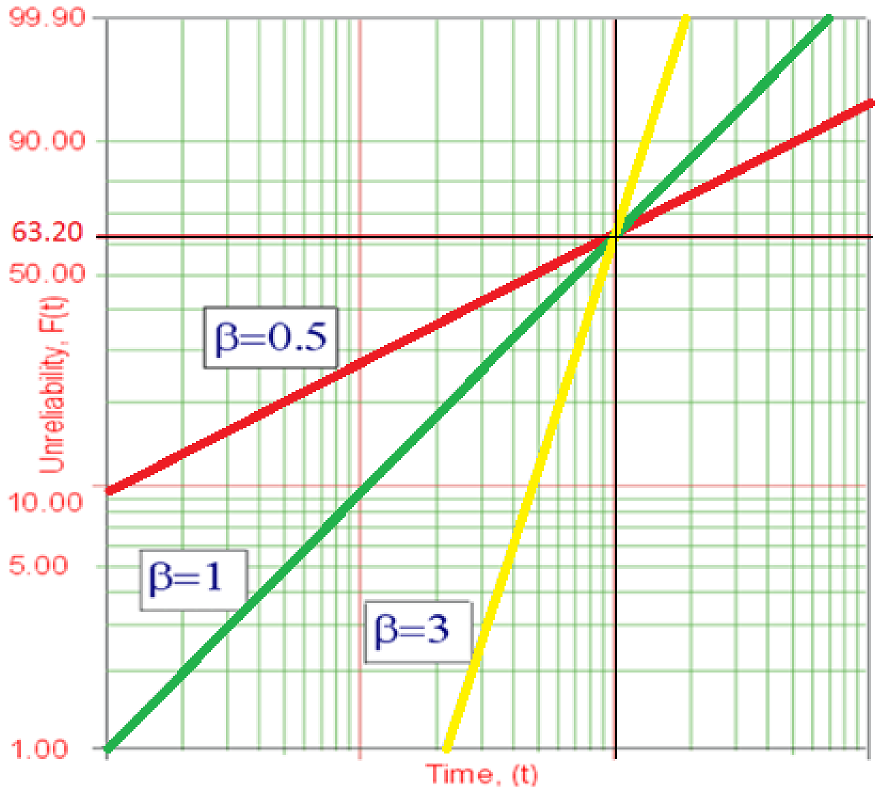
F(t) = Failure Percentage
β = Shape Parameter
η = Characteristic Live

Beta <1: Infant Mortality

Beta=1: random failure

Beta 1…4: Early Wear out

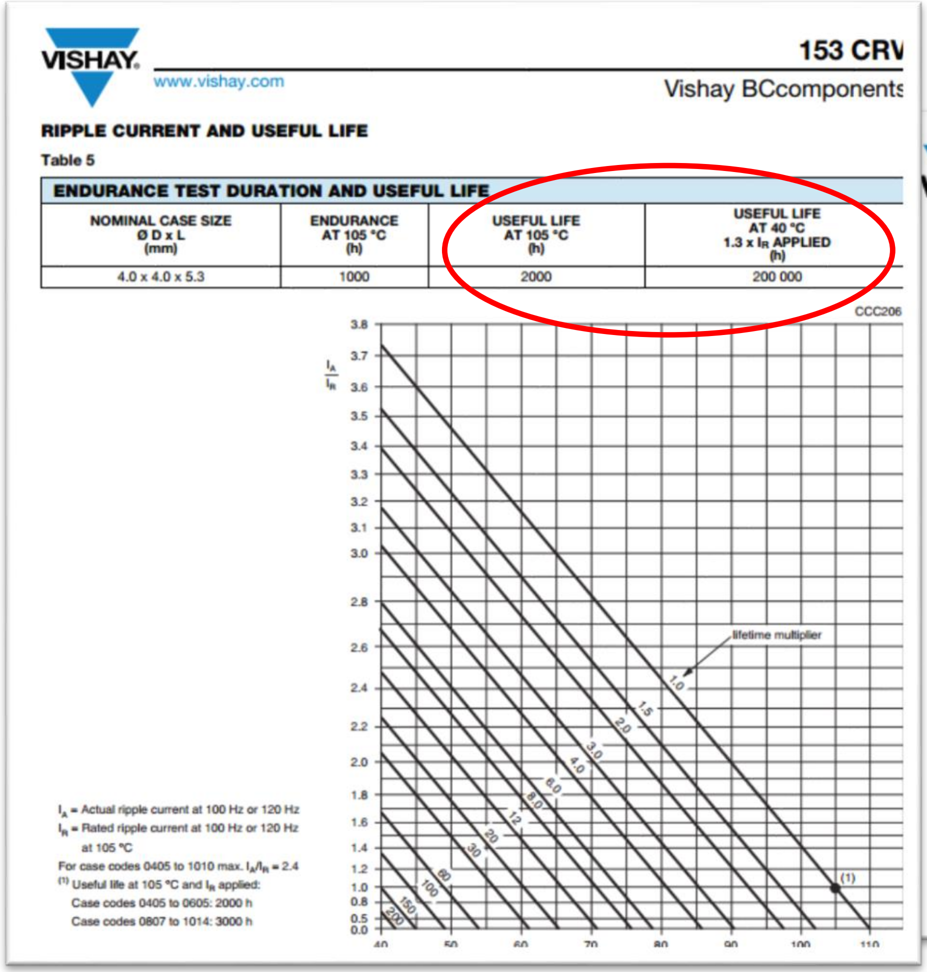
Beta>4: age rapid wear out



Weibull plot

VARIASS

How? Data sheets



153 CRV

www.vishay.com

Vishay BCcomponents

RIPPLE CURRENT AND USEFUL LIFE

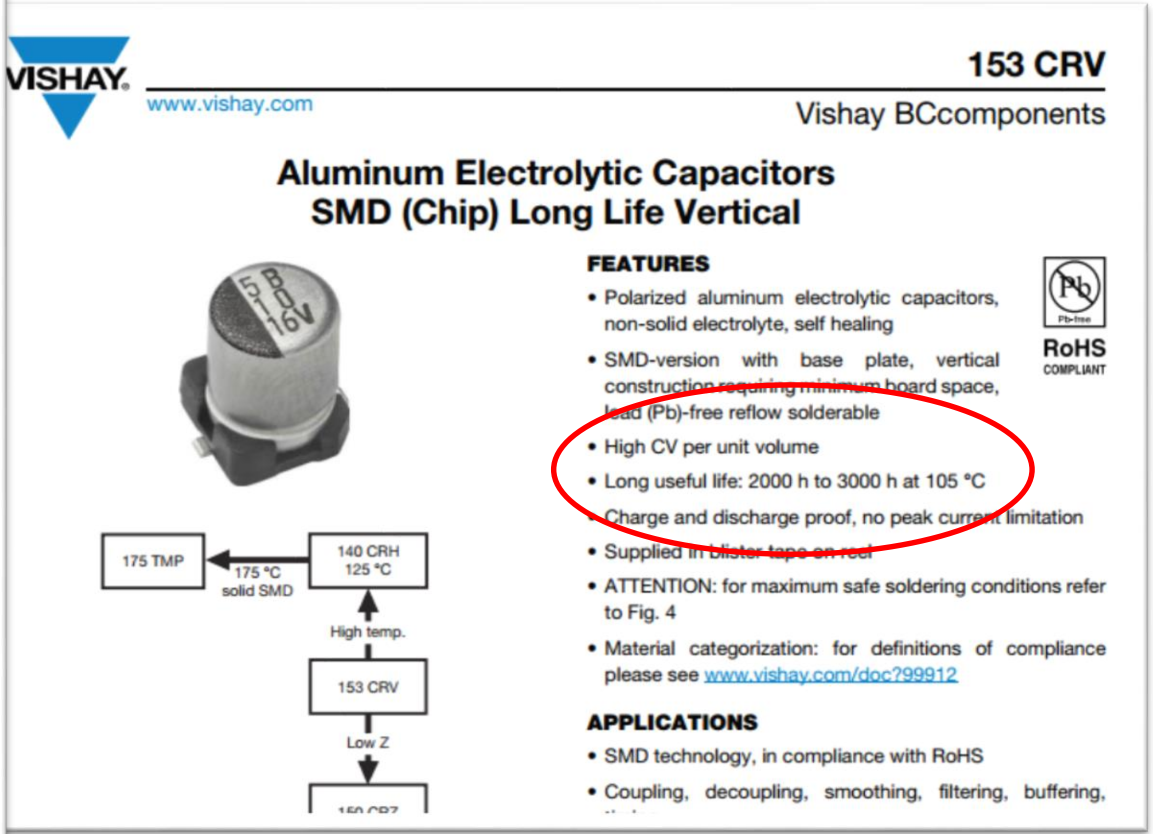
Table 5

ENDURANCE TEST DURATION AND USEFUL LIFE			
NOMINAL CASE SIZE Ø D x L (mm)	ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)	USEFUL LIFE AT 40 °C 1.3 x I_R APPLIED (h)
4.0 x 4.0 x 5.3	1000	2000	200 000

CCC206

lifetime multiplier

I_A = Actual ripple current at 100 Hz or 120 Hz
I_R = Rated ripple current at 100 Hz or 120 Hz at 105 °C
For case codes 0405 to 1010 max. I_A/I_R = 2.4
(1) Useful life at 105 °C and I_R applied:
Case codes 0405 to 0605: 2000 h
Case codes 0807 to 1014: 3000 h



153 CRV

www.vishay.com

Vishay BCcomponents

Aluminum Electrolytic Capacitors SMD (Chip) Long Life Vertical

FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte, self healing
- SMD-version with base plate, vertical construction requiring minimum board space, lead (Pb)-free reflow solderable
- High CV per unit volume
- Long useful life: 2000 h to 3000 h at 105 °C
- Charge and discharge proof, no peak current limitation
- Supplied in blister tape on reel
- ATTENTION: for maximum safe soldering conditions refer to Fig. 4
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

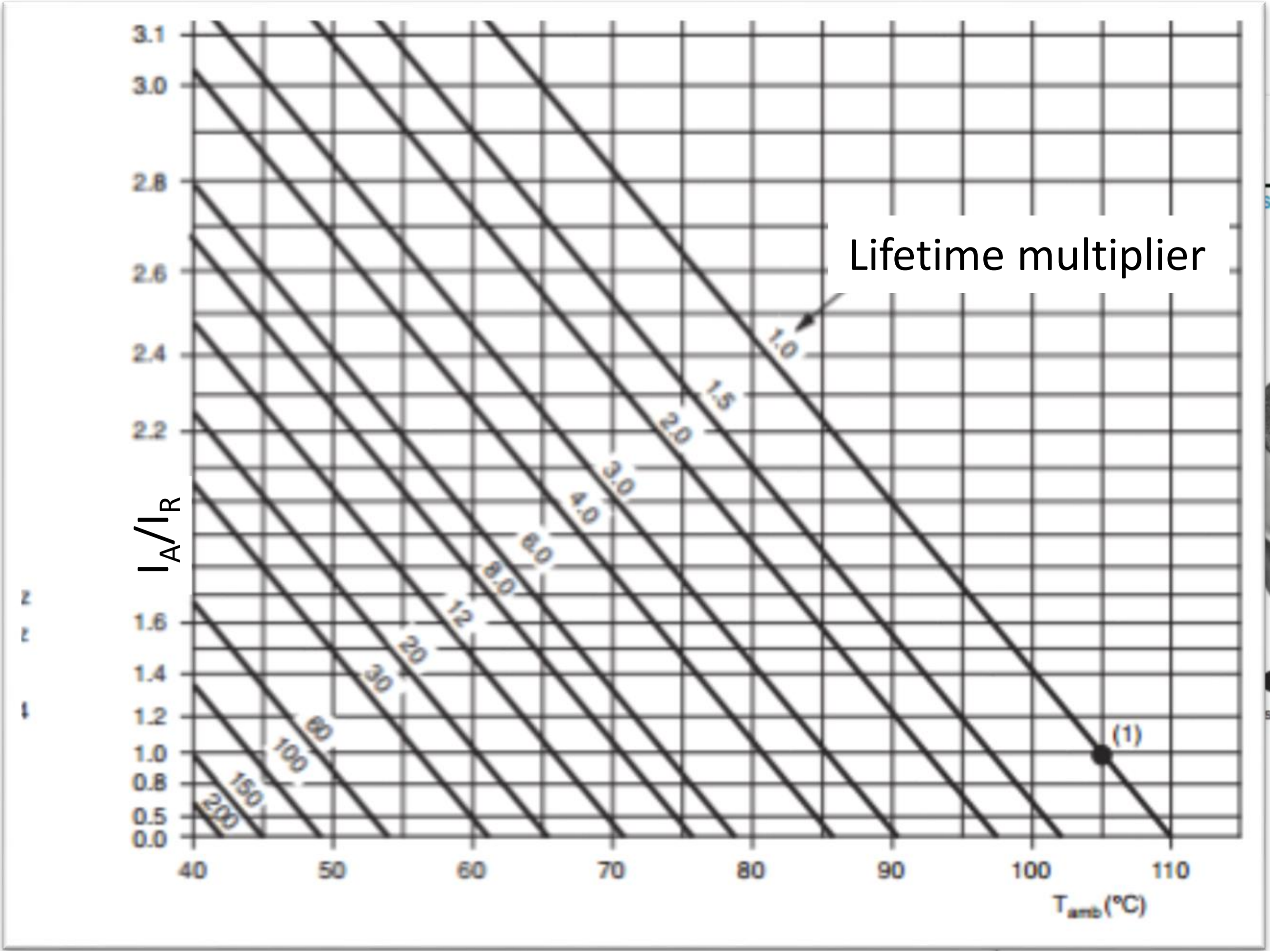
RoHS COMPLIANT

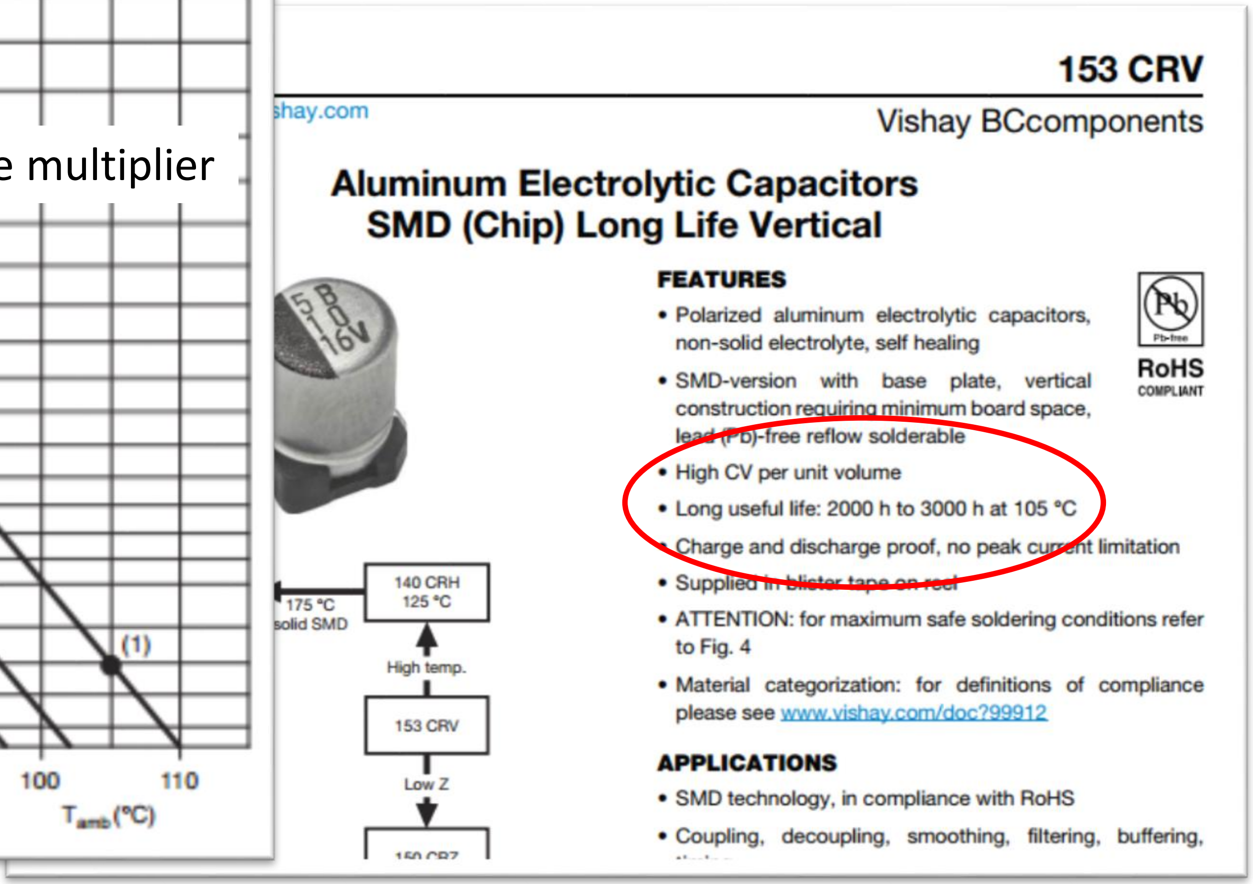
APPLICATIONS

- SMD technology, in compliance with RoHS
- Coupling, decoupling, smoothing, filtering, buffering,

How? Data sheets

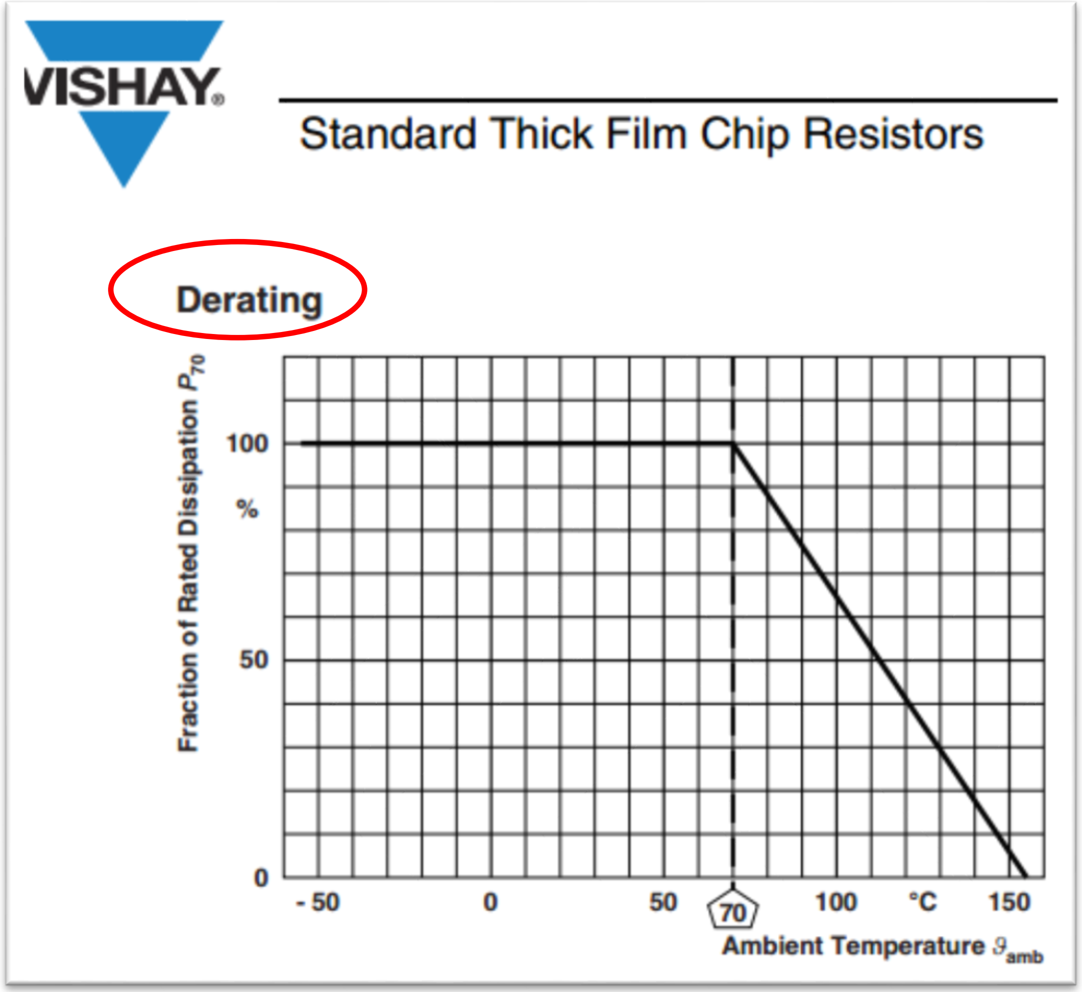
✓calculating , simulation and measure



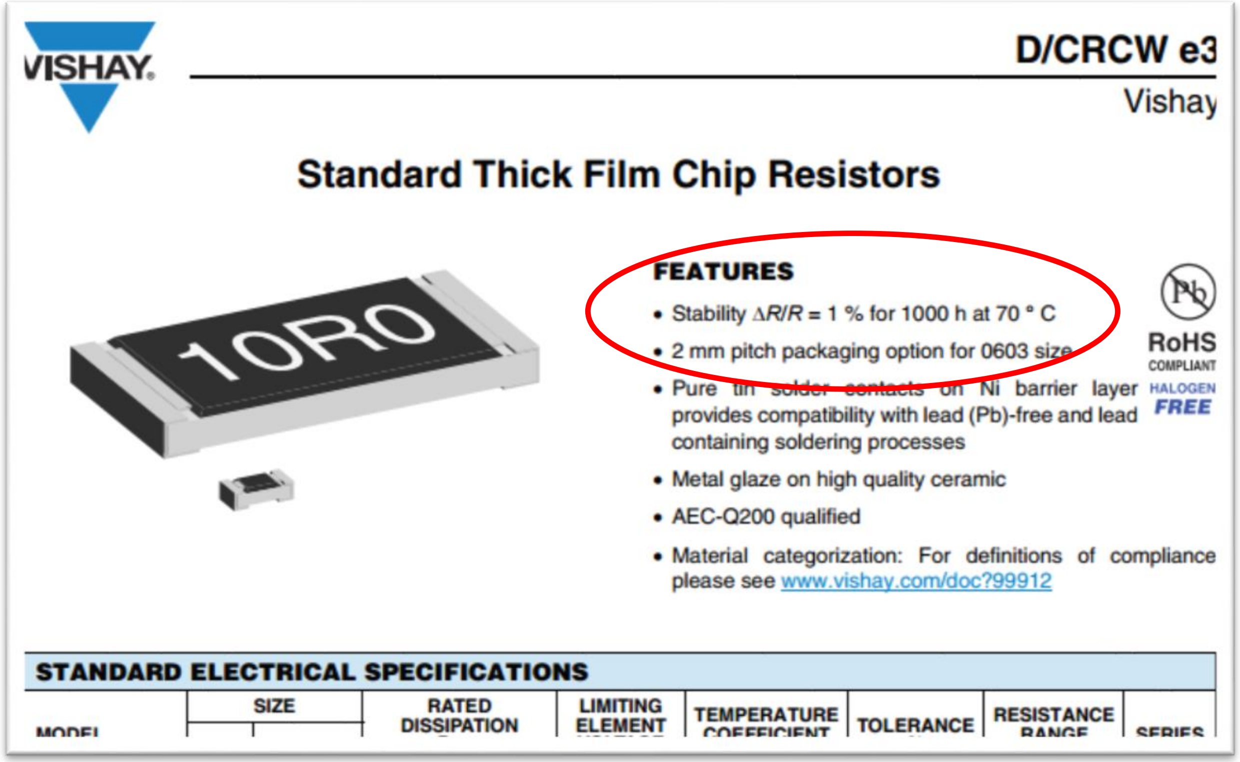


VARIASS

How? Data sheets

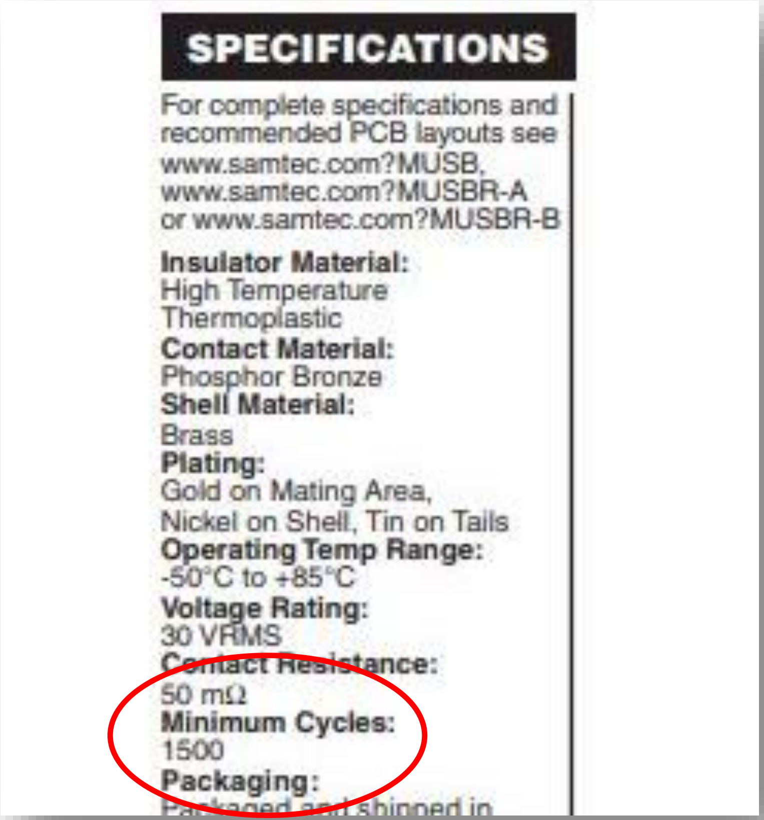


✓calculating , simulation and measure



VARIASS

How? Data sheets



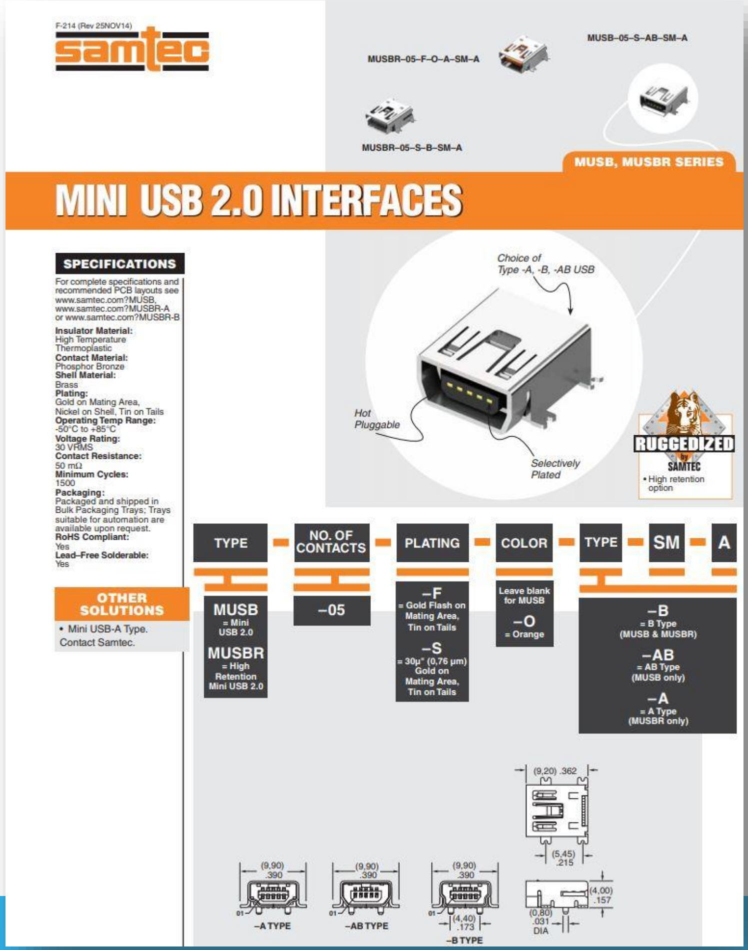
SPECIFICATIONS

For complete specifications and recommended PCB layouts see www.samtec.com?MUSB, www.samtec.com?MUSBR-A or www.samtec.com?MUSBR-B

Insulator Material:
High Temperature Thermoplastic
Contact Material:
Phosphor Bronze
Shell Material:
Brass
Plating:
Gold on Mating Area, Nickel on Shell, Tin on Tails
Operating Temp Range:
-50°C to +85°C
Voltage Rating:
30 VRMS
Contact Resistance:
50 mΩ
Minimum Cycles:
1500
Packaging:
Packaged and shipped in

Durability = 1500

✓calculating , simulation and measure



F-214 (Rev 25NOV14)

samtec

MUSBR–05–F–O–A–SM–A

MUSB–05–S–AB–SM–A

MUSBR–05–S–B–SM–A

MUSB, MUSBR SERIES

MINI USB 2.0 INTERFACES

SPECIFICATIONS

For complete specifications and recommended PCB layouts see www.samtec.com?MUSB, www.samtec.com?MUSBR-A or www.samtec.com?MUSBR-B

Insulator Material:
High Temperature Thermoplastic
Contact Material:
Phosphor Bronze
Shell Material:
Brass
Plating:
Gold on Mating Area, Nickel on Shell, Tin on Tails
Operating Temp Range:
-50°C to +85°C
Voltage Rating:
30 VRMS
Contact Resistance:
50 mΩ
Minimum Cycles:
1500
Packaging:
Packaged and shipped in Bulk Packaging Trays; Trays suitable for automation are available upon request.
RoHS Compliant:
Yes
Lead–Free Solderable:
Yes

OTHER SOLUTIONS

- Mini USB-A Type. Contact Samtec.

Choice of Type -A, -B, -AB USB

Hot Pluggable

Selectively Plated

RUGGEDIZED by SAMTEC

- High retention option

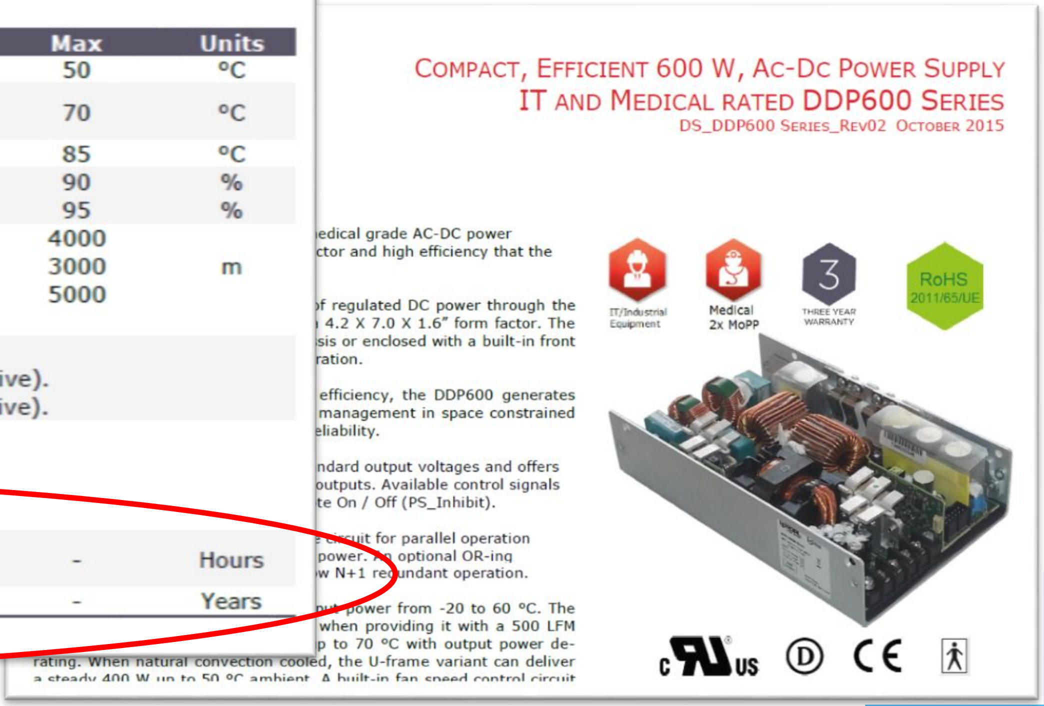
TYPE	NO. OF CONTACTS	PLATING	COLOR	TYPE	SM	A
MUSB = Mini USB 2.0 MUSBR = High Retention Mini USB 2.0	–05	–F = Gold Flash on Mating Area, Tin on Tails –S = 30µ" (0,76 µm) Gold on Mating Area, Tin on Tails	Leave blank for MUSB –O = Orange	–B = B Type (MUSB & MUSBR) –AB = AB Type (MUSB only) –A = A Type (MUSBR only)		

VARIASS

How? Data sheets

ENVIRONMENTAL SPECIFICATIONS

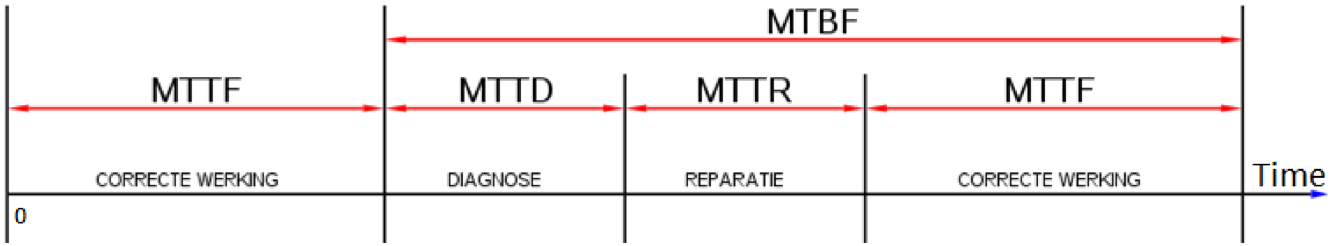
Specification	Test Conditions / Notes	Min	Nominal	Max	Units
Operating Temperature Range	No de-rating up to 50°C	-20	-	50	°C
Operating Temperature Range with De-rating	See de-rating curves and conditions in the Output Specifications section	-	-	70	°C
Storage Temperature		-40	-	85	°C
Humidity	RH, Non-condensing Operating. Non-operating	-	-	90 95	% %
Operating Altitude	MoPP (100 – 250 V_{AC}, 50/60 Hz) MoPP (100 – 277 V_{AC}, 50/60 Hz) MoOP, ITE grade Power de-rating above 1800 m	- - -	- - -	4000 3000 5000	m
Shock	**EN 60068-2-27** Operating: Half sine, 30 g, 18 ms, 3 axes, 6x each (3 positive and 3 negative). Non-Operating: Half sine, 50 g, 11 ms, 3 axes, 6x each (3 positive and 3 negative).				
Vibration	**EN 60068-2-64** Operating: Sine,10 – 500 Hz, 1 g, 3 axes, 1 oct/min., 60 min. Random, 5 – 500 Hz, 0.02 g^2/Hz, 1 g_{RMS}, 3 axes, 30 min. Non-Operating: 5 – 500 Hz, 2.46 g_{RMS} (0.0122 g^2/Hz), 3 axes, 30 min.				
MTBF	Full Load, 40 °C ambient 80% Duty cycle, Telcordia SR-332 Issue 2	300000	-	-	Hours
Useful Life	Worst nominal V_{IN}, 80% load, 40 °C ambient.	-	4	-	Years



MTBF = 300.000h -> 34 Years ?

VARIASS

How? MTBF



MTBF (mean operating time between failures)

$$R(t) = e^{-\lambda t} = e^{\frac{-t}{MTBF}}$$

@ t = MTBF -> Reliability R(t) = 36,8%

Power Unit: R(t) = 36.8% @ 300.000h (34 Years)

R(t) @ 3 Years: R(t) = 92%

Calculation of spare parts

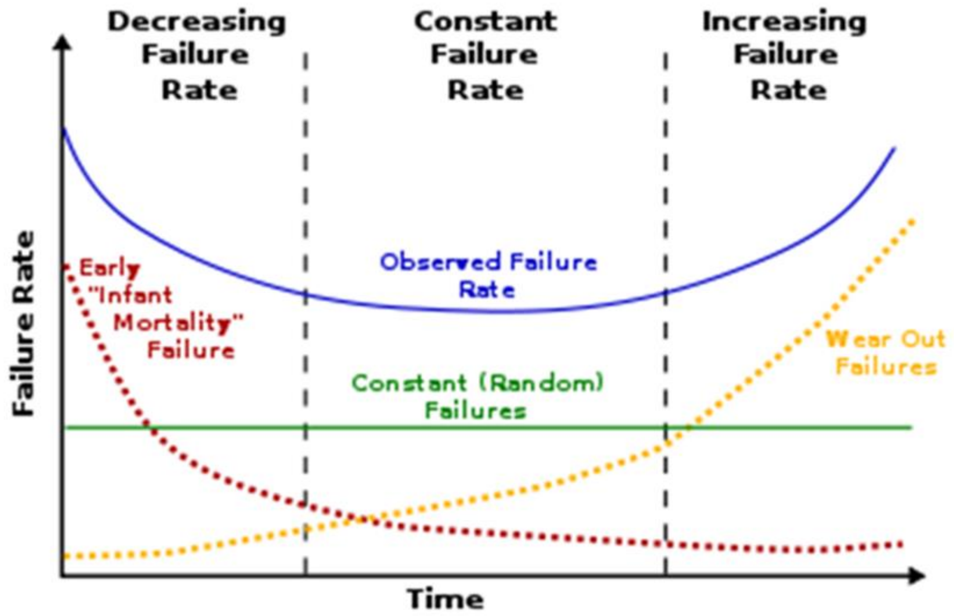
Q = N * (T / MTBF)

Q = # of spare units
N = # of operating units
T = expected live time

T = 3 Year, N = 100 units

Q = 100 * (26.280 / 300.000) = 9 units

10 degrees decrease in temperature makes the lifetime double

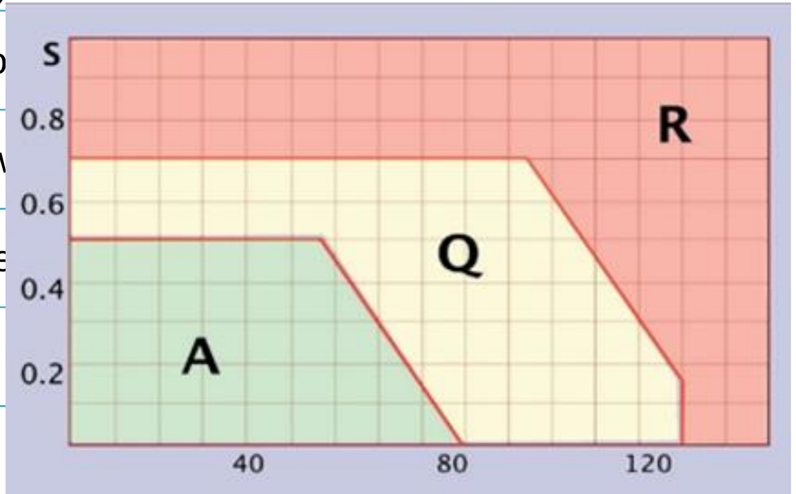


Bathtub curve

VARIASS

How? Reliability Standards

	MIL-HDBK-217	FIDES	SR-332
Origin	US Army	European tech industry	US telecom industry
Publisher	DoD, model is not supported anymore	Fides group (Thales, Eurocopter, Airbus, others)	Telcordia (subsidiary of Ericsson)
Modelling	Components only	Components and process	Components o
Required input	Relatively much	Relatively much	Relatively fe
Supported components	Many components, some are obsolete	Relatively few components	Many compone
Quality assessment	Very complex	Complex	Easy



Derating diagram

Reliability software:

-ReliaSoft

-RAMS (Reliability, Availability, Maintainability and Safety)

How? Reliability Standards

Component name	Description	Number of components at stress fact			Failure rate at stress fact			N*Lamda
		20%	50%	80%	20%	50%	80%	0,000000001
Resistors								
	Metal low pow.	0	19	0	1,5	2	3	38
	Metal high pow		0		8	10	13	0
Fixed Wire	Precision	0	2		3,5	5	8	10
	Power	1	0		8	15	30	8
Variable Wire	Precision		0		320	400	440	0
	Power	0	0		170	210	275	0
Trim	Cermet		0		5	6	7	0
Capacitors								
Elco	Solid		0		45	75	175	0
	Wet Mini		0		25	55	135	0
	Wet Small							
	Wet Large							
X - Y								
Film								
Ceramic								
Semiconductors								

Opto	LED	1	20	35	80	20
	Opto-coupler	1	20	35	80	20
Total failure rate						**1027,69**

Factor for ambient temperature

Kt=	0,8 for	15	Kt=	1
	1 for	30		
	1,2 for	45		
	1,5 for	55		
	2 for	70		

Factor for environment

K3=	1 for	gnd benign	K3=	3
	3 for	gnd fixed		
	9 for	gnd mobile		

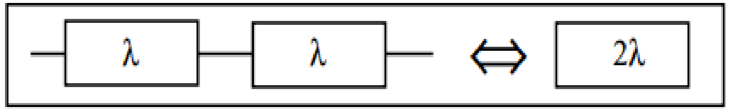
N*L*Kt*K3= 3083,07

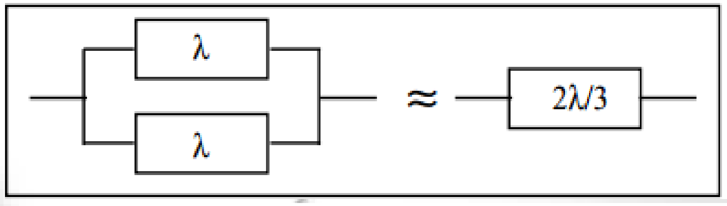
M.T.B.F 324352,0257

Failure Rate λ = 1 / MTBF

FIT , Failures In Time (10^9h)

FIT = 10^9 / MTBF





How? Test

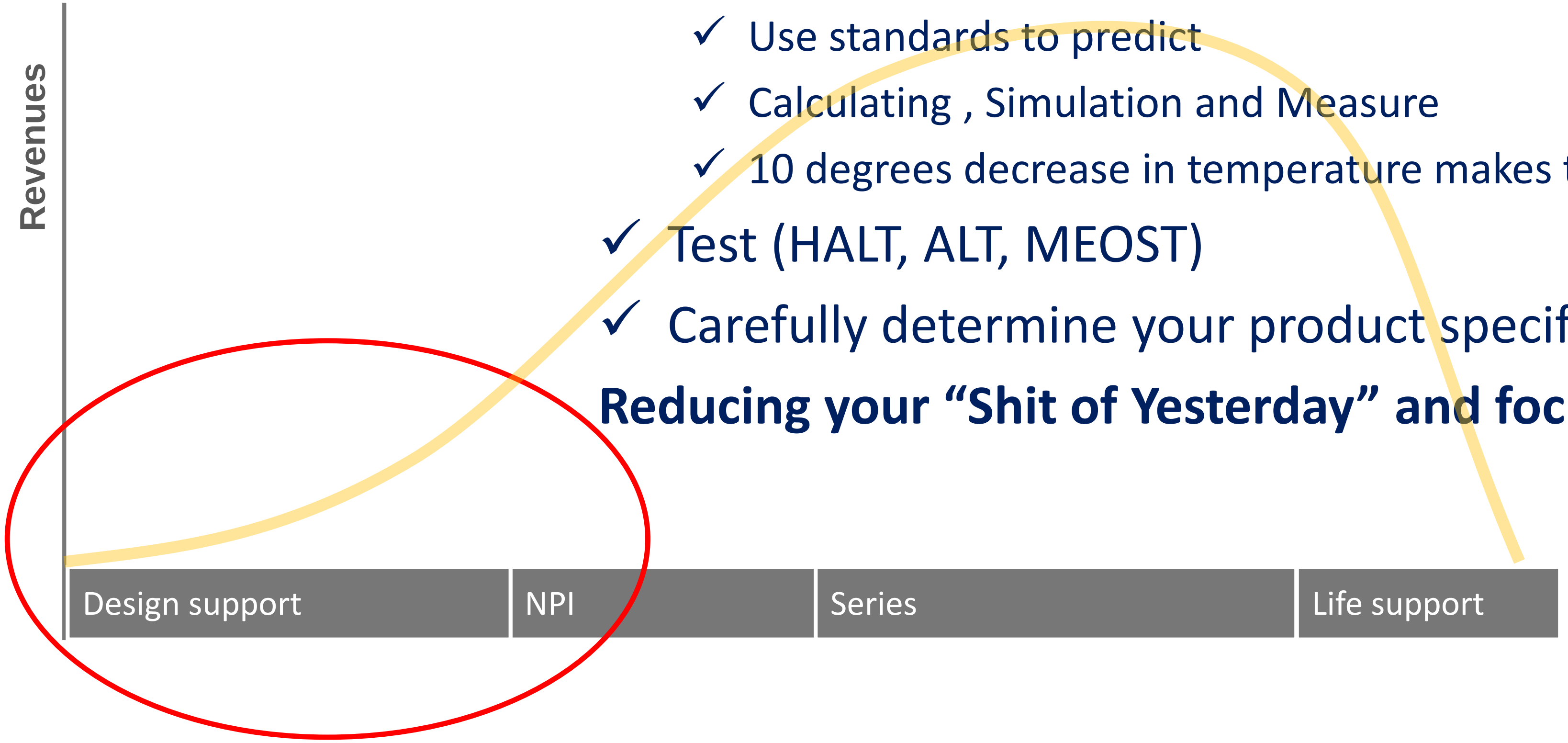
- ✓ HALT (Highly Accelerated Life Testing)
  - ✓ “smoking out failures”
  - ✓ Testing for Failure and Robustness
  - ✓ Define weak components for improvements
- ✓ ALT (Accelerated Life Testing)
  - ✓ Testing for live
  - ✓ Reliability
  - ✓ Predict lifetime
- ✓ MEOST (Multiple Environmental Over Stress Testing)
  - ✓ Determine or Demonstrate field failures
  - ✓ Combined more stresses
  - ✓ No Standards

Summary

Reliability is determined at the design stage

- ✓ Beware of the environment
- ✓ Keep a QA database
- ✓ Design for eXcellence checks (Variass DfX tool)
  - ✓ Read the datasheet
  - ✓ Use standards to predict
  - ✓ Calculating , Simulation and Measure
  - ✓ 10 degrees decrease in temperature makes the lifetime double
- ✓ Test (HALT, ALT, MEOST)
- ✓ Carefully determine your product specifications

Reducing your “Shit of Yesterday” and focus at new innovations



VARIASS

follow our lead

Learn how we can help you to avoid Shit of Yesterday

We enable your success!

VARIASS