RELIABILITY PREDICTION

- Assess whether reliability goals can be reached
- Identify potential design weaknesses
- Compare alternative designs
- Analyse life-cycle costs
- Plan logistic support strategies (ie, repairing ressources, ...)
- Establish objectives for reliability tests

FAILURE RATE λ

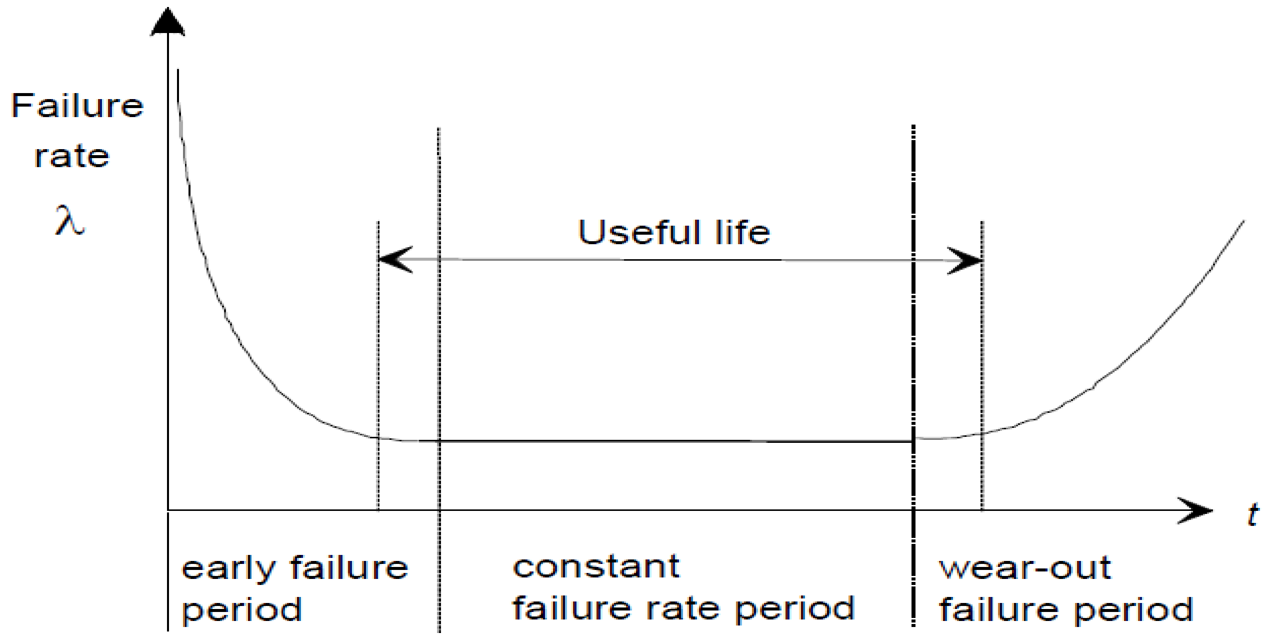


Figure 1.1 - The Bathtub Curve

λ : number of units failing per unit time

MTBF

Mean operating Time Between Failures

$$MTBF = \frac{1}{\lambda}$$

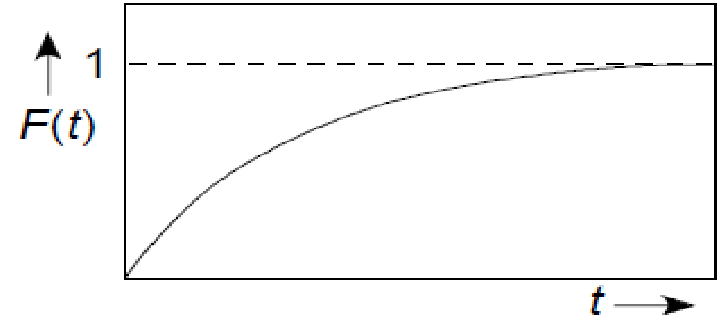
$$R(t) = e^{-\lambda t} = e^{\frac{-t}{MTBF}}$$

$$R(t) = e^{-1} = 0.37$$

- Probability of failure, distribution function

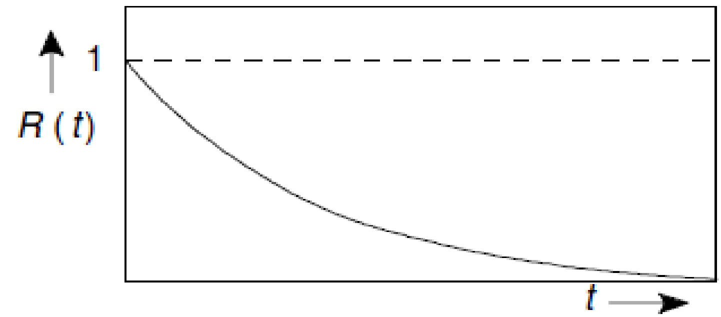
$$F(t) = 1 - \exp(-\lambda t), \qquad \lambda > 0$$

Parameter λ (failure rate)



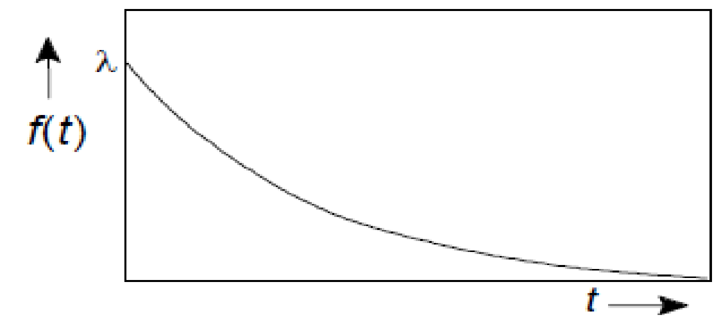
- Reliability

$$R(t) = \exp(-\lambda t), \qquad \lambda > 0$$



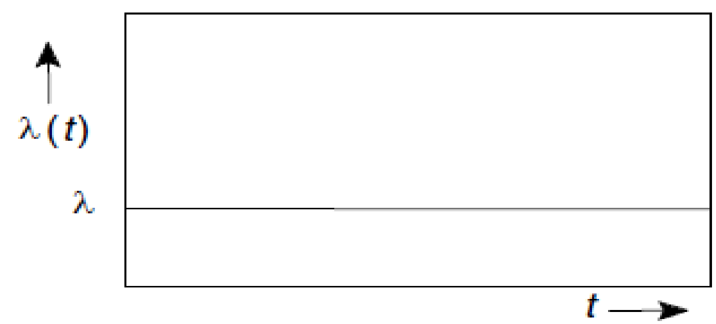
- Probability density function

$$f(t) = \frac{dF(t)}{dt} = \lambda \exp(-\lambda t)$$



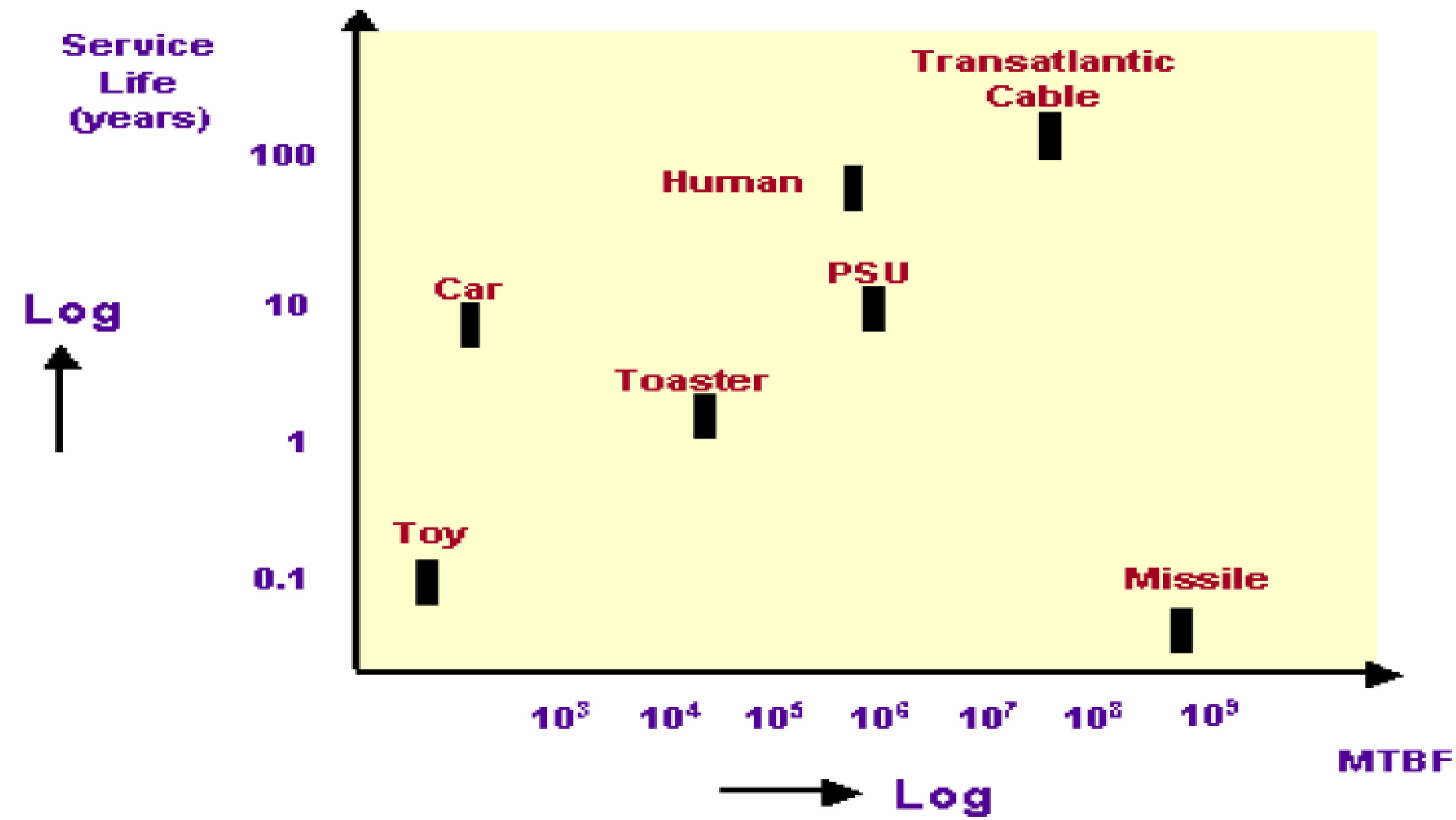
- Failure rate

$$\lambda(t) = \frac{f(t)}{1-F(t)} = \lambda = const$$



Service Life / Life Time

25 years old humans have an *MTBF* of about 800 years



Reliability Prediction Assumes:

- The design is perfect, the stresses known, everything is within ratings at all times, so that only random failures occur

- Every failure of every part will cause the equipment to fail.

  - The component reliability database is valid

Failure Rate Prediction

At Reference Conditions (Parts count)

$$\lambda_{S,i} = \sum_{i=1}^{n} \left(\lambda_{ref} \right)_i \quad ,$$

where

λ_{ref} is the failure rate under reference conditions;

n is the number of components

Failure Rate Prediction

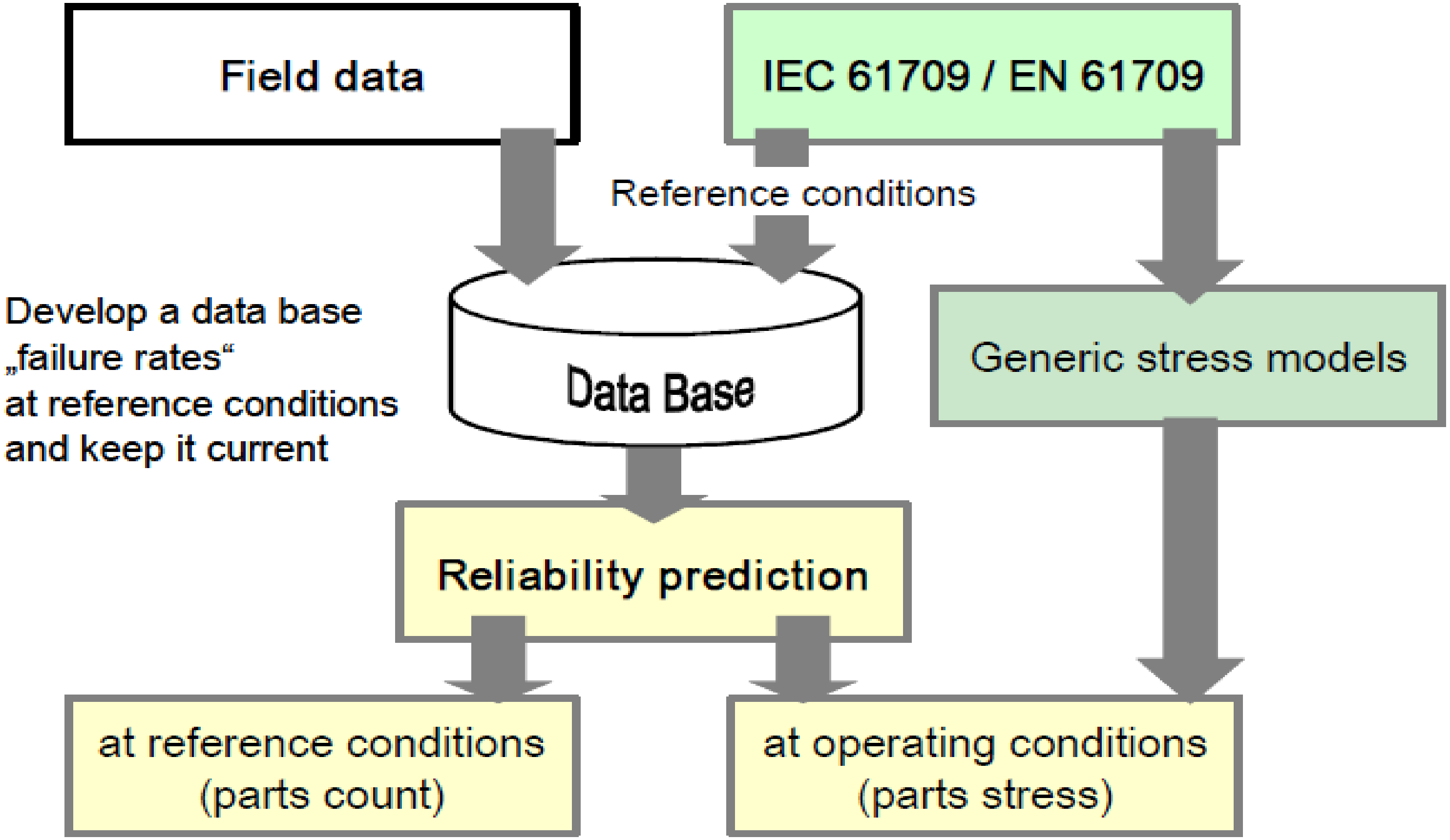
At Operating Conditions (Parts Stress)

$$\lambda = \sum_{i=1}^{n} \left(\lambda_{ref} \times \pi_U \times \pi_I \times \pi_T \right)_i$$

where

λ_{ref}	is the failure rate under reference conditions;
π_U	is the voltage dependence factor;
π_I	is the current dependence factor;
π_T	is the temperature dependence factor;
n	is the number of components

Prediction Methods



=>MTBF (250 kHours) @ Toperating (50°C)

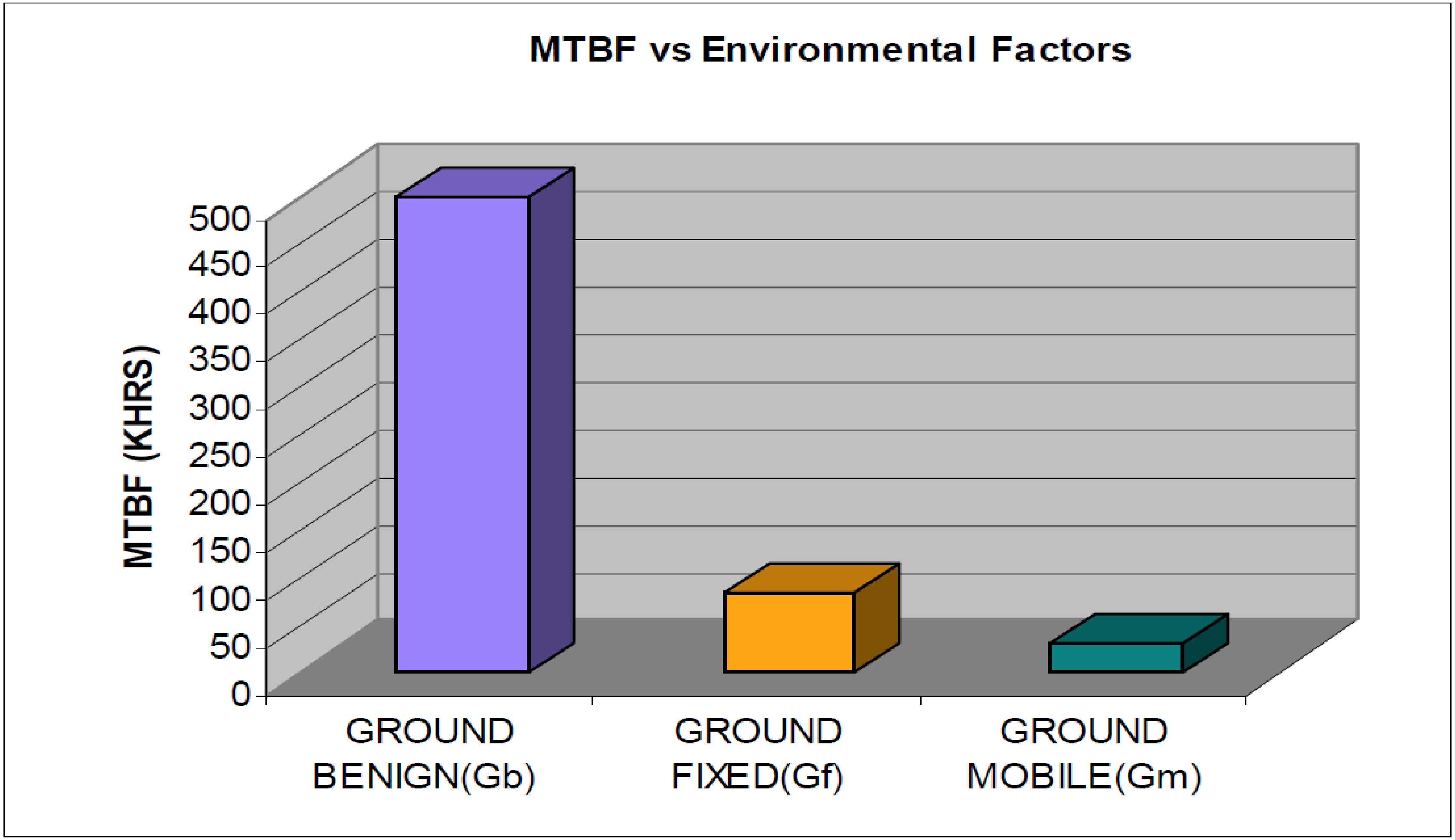
Accelerated Life Testing

$$\text{Acceleration Factor } AF = \frac{tf_1}{tf_2} = \exp\left(\frac{E}{k}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)\right)$$

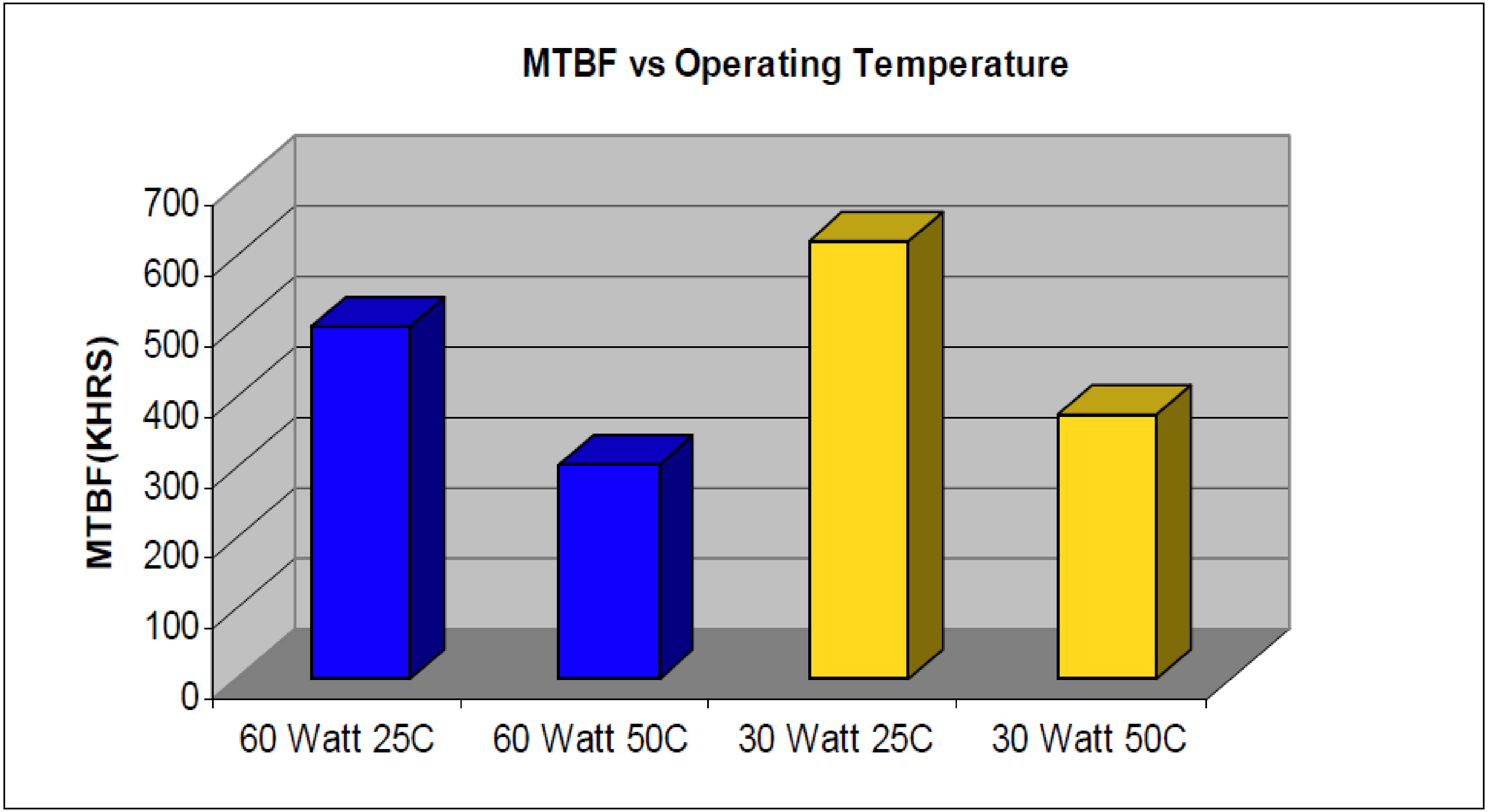
tf_1	= time to failure at temperature T_1
tf_2	= time to failure at temperature T_2
T_1, T_2	= temperature in degrees Kelvin (°K)
E	= activation energy per molecule (eV)
k	= Boltzmann's constant (8.617×10^{-5} (eV/°K))

E from less than 0.3eV (gate oxide defect in a semiconductor)
to more than 1.1eV (contact electro-migration)

MTBF vs Environmental Factors



MTBF vs Power Load & T°



Application

Buck Converter									
Composants	λ_b	π_q	π_e	π_s	π_t	π_a	π_c	λ_{part}	
Condensateur C1	0,05	0,7	6	1	1	1	1	0,21	
Condensateur C2	0,0044	0,7	6	1	1	1	1	0,01848	
				1	1	1	1		
Transistor TR1	0,012	0,7	6	1	2,5	4	1	0,504	
Diode D1	0,01	0,7	6	0,29	4,4	1	1	0,053592	
Self L1	0,026	0,7	6	1	1	1	1	0,1092	
Resistance de mesure	0,00044	0,7	6	1	1	1	6	0,011088	
Système								**0,90636**	
MTBF @ 50°C								**1103314,3563**	**heures**
								127	**ans**