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TechTalk

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How Do I Select the Right NAND Flash Solution for my Application

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AGENDA

NAND-Flash – A Primer

- History of NAND Flash
- NAND Flash Cell
- NAND Flash Technologies

Reliability – A key selection criterion

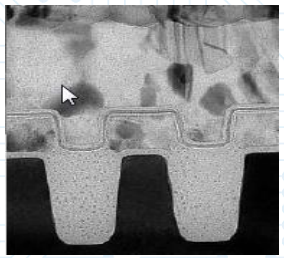
- Endurance
- Workloads
- Write Amplification Factor
- Mode of Operation
- Calculation of your individual TBW and Total Lifetime (in Years)
- S.M.A.R.T. Tools

Total Cost of Ownership – Real life examples

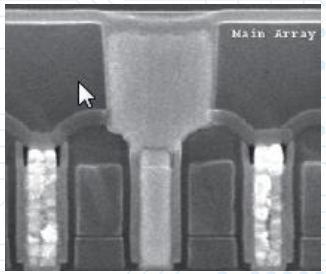
- The Ticketing Machine Desaster
- Tesla Model S & Model X Callback

HISTORY OF NAND FLASH MEMORY

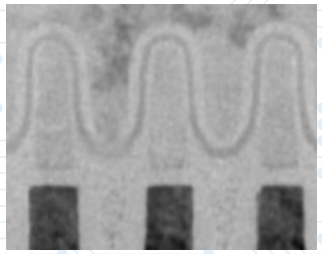
65nm



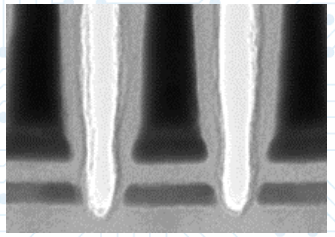
45nm



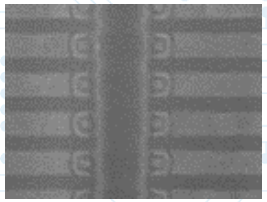
25nm



16nm

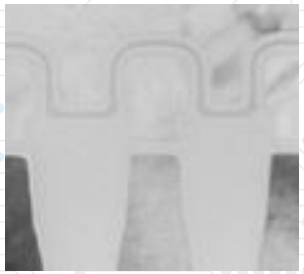


3D NAND
32L/TLC → 64L/TLC

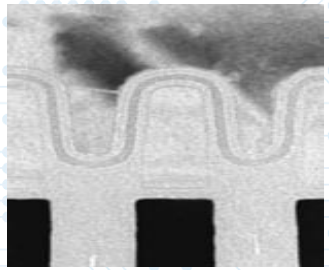


QLC NAND Technology
96L

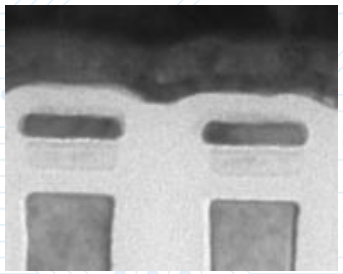
50nm



34nm



20nm



1987-2009

2010-2014

2016-2017

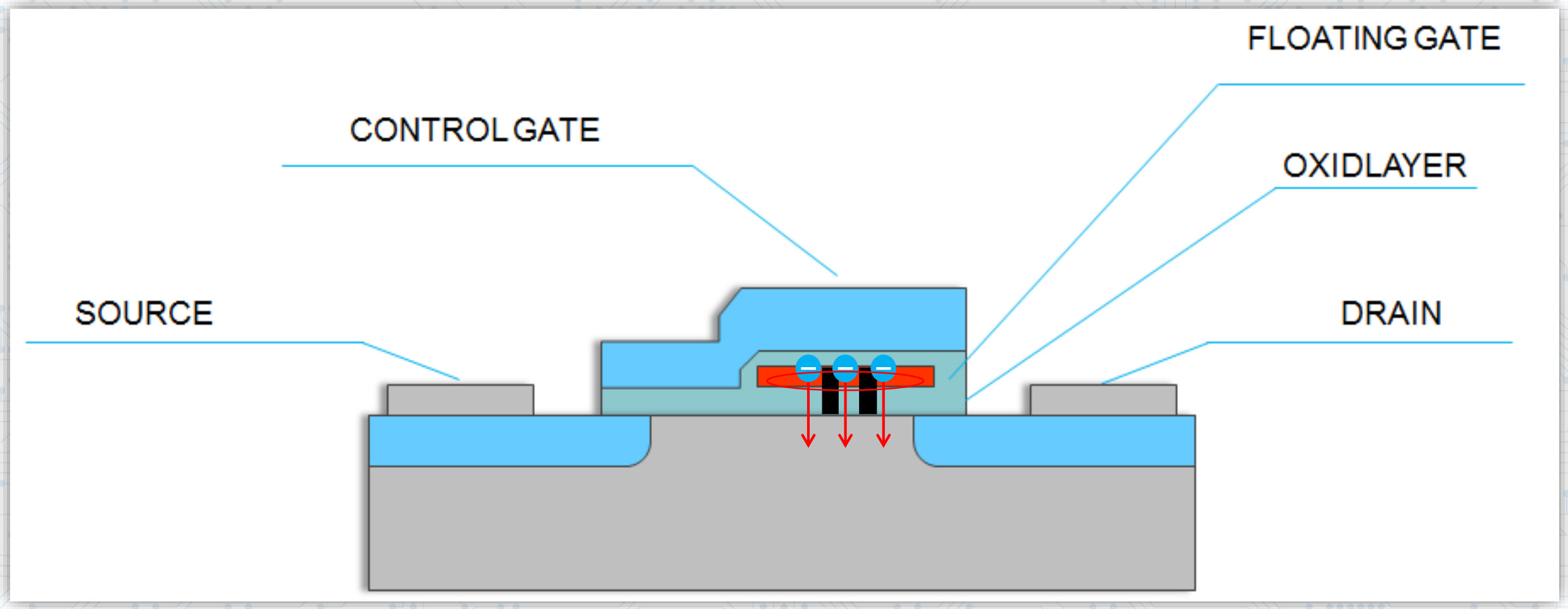
SLC - 1 bit/cell

MLC - 2 bit/cell

TLC - 3 bit/cell

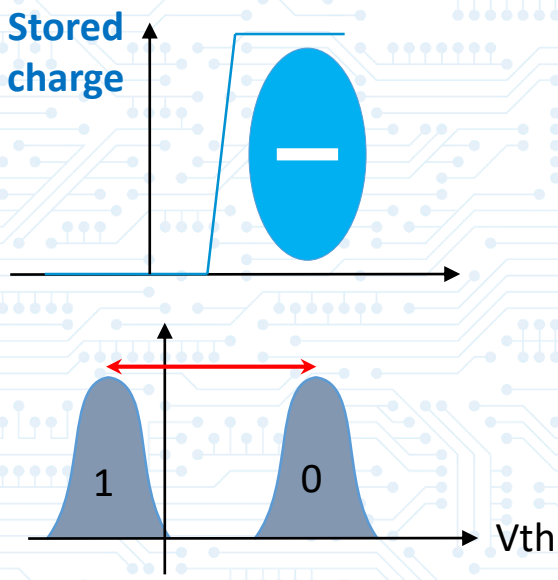
QLC – 4 bit/cell

NAND Flash Cell



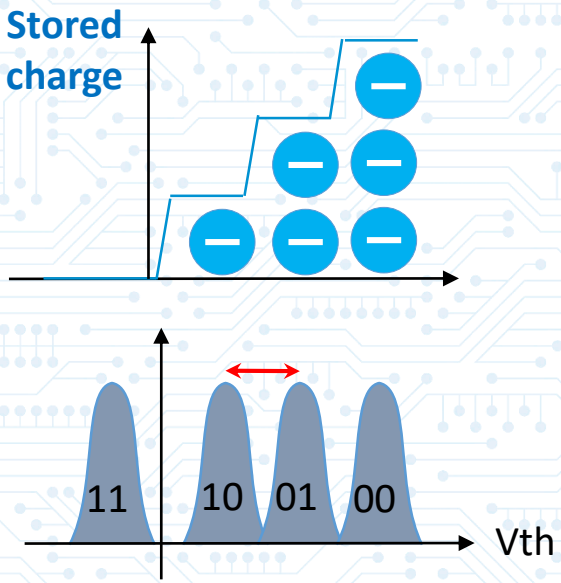
NAND Flash Technologies

SLC



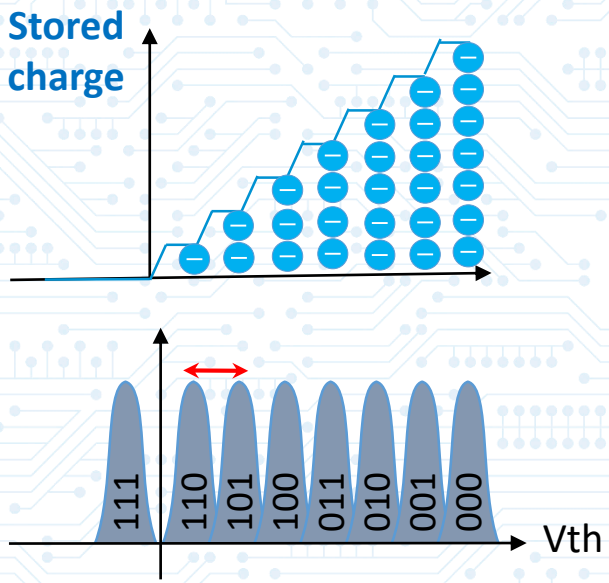
(P/E Cycles)	100.000 – 60.000

MLC



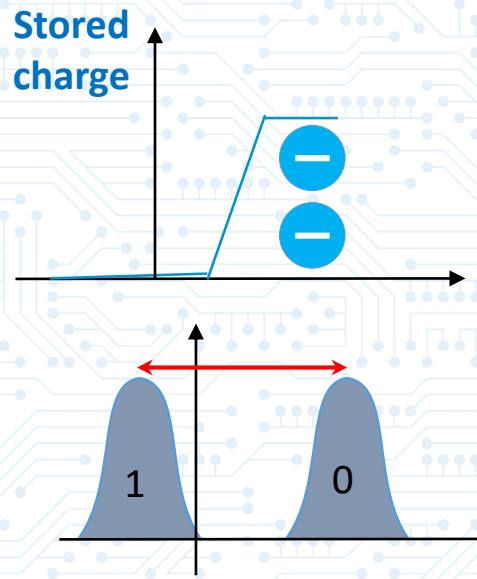
3.000

TLC



3.000 - 300

pSLC



50.000 - 20.000

Endurance

Definition

The amount of data that can be written on a Solid State Drive before the storage media becomes unreliable

Component Level

P/E Cycles
=Program and Erase Cycles

Device Level

TBW
= Terabytes Written

DWPD
= Drive Writes per Day

Workloads

2.5“ SSD
32GB
2D SLC (24nm SLC)
100k P/E Cycles

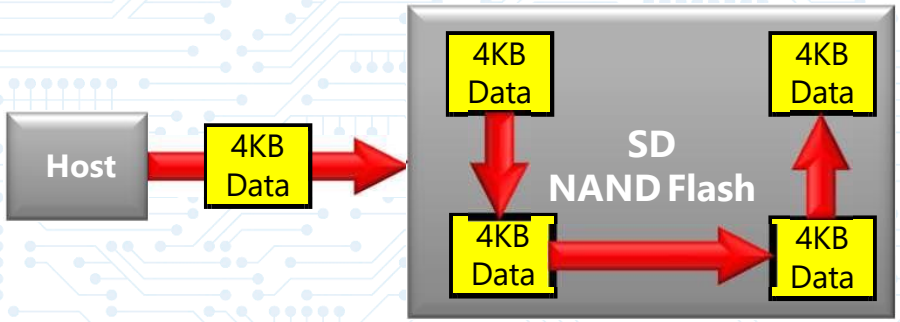
Expectation → **TBW** 3,200.00

Reality →

Client Workload	Enterprise Workload	Embedded Workload
TBW 1042,94	**TBW** 279,89	**TBW** 625,00

Write Amplification Factor

$$WAF = \frac{\text{Total Data Written To NAND}}{\text{Total Data Written By Host}}$$



Mode of Operation

Read → Modify → Erase → Write

Device

Device

Block

Smallest erasable entity in a NAND flash device

Page

Write operations happen on a page level

SSD Endurance Measurement Example

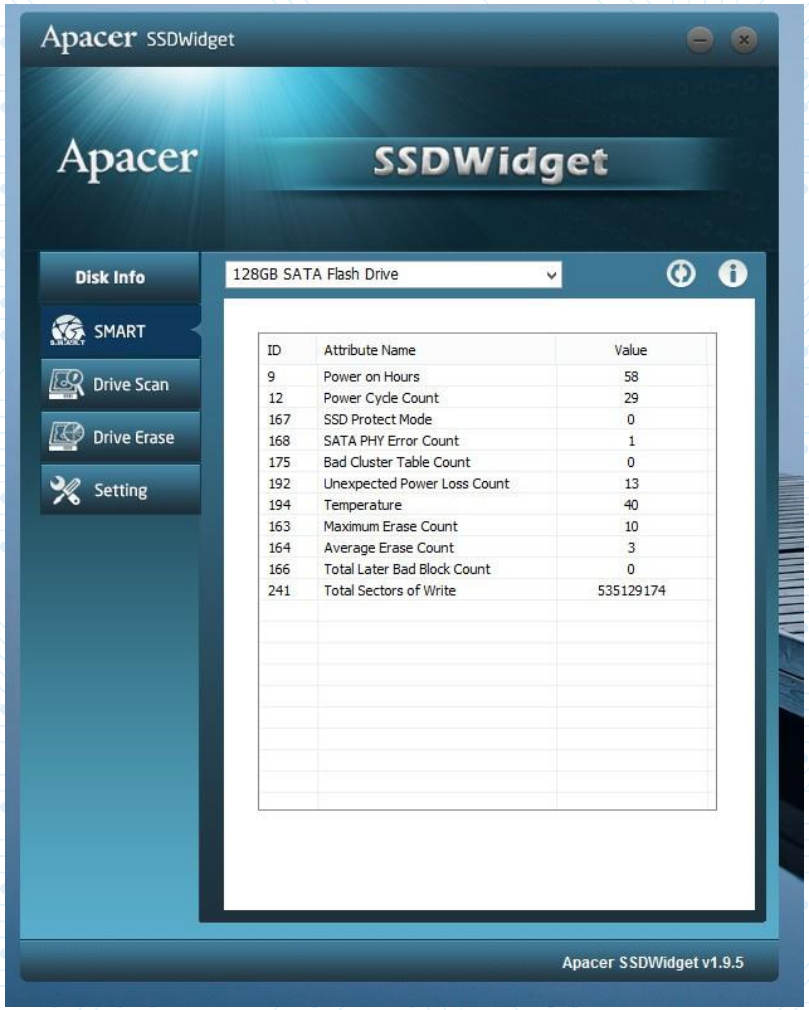
TeraBytes Written Equation

$$TBW = \frac{(NAND\ Cycles) * (SSD\ Capacity) * (Wear\ Leveling\ Efficiency)}{(Write\ Amplification\ Factor)}$$

Total Lifetime (in Years)

$$Life\ Time = \frac{(TBW)}{(Daily\ Work\ Load) * 365\ days}$$

S.M.A.R.T Tool



NAND Cycles = 3,000
SSD Capacity = 128GB

Wear Leveling Efficiency Factor
Average Erase Count = 3
Maximum Erase Count = 10
WLE value = 0,3

WAF Factors
Total Data Written to NAND = 412,32 GB
Total Data Written by Host = 273,99 GB
WAF value = 1,50

Total Data Written to NAND Factors
Average Erase Count = 3
Capacity = 64GB
Total Data Written to NAND = 192 GB

Total Data Written by Host Factors
Total sector writes = 535129174 LBA
Total Datta Written by Host = 273,99 GB

SSD Endurance Measurement Example

Parameters

SSD Capacity = 128 GB
NAND Flash = 2D MLC with 3,000 P/E Cycles
Write Amplification Factor = 1,5
Wear Leveling Efficiency = 0,3
Daily Work Load = 6 GB

TeraBytes Written Equation

$$TBW = \frac{(NAND\ Cycles) * (SSD\ Capacity) * (Wear\ Leveling\ Efficiency)}{(Write\ Amplification\ Factor)}$$

$$TBW = \frac{(3000) * (128) * (0{,}3)}{(1{,}5)}$$

$$TBW = 76800$$
$$DWPD = 0{,}82$$

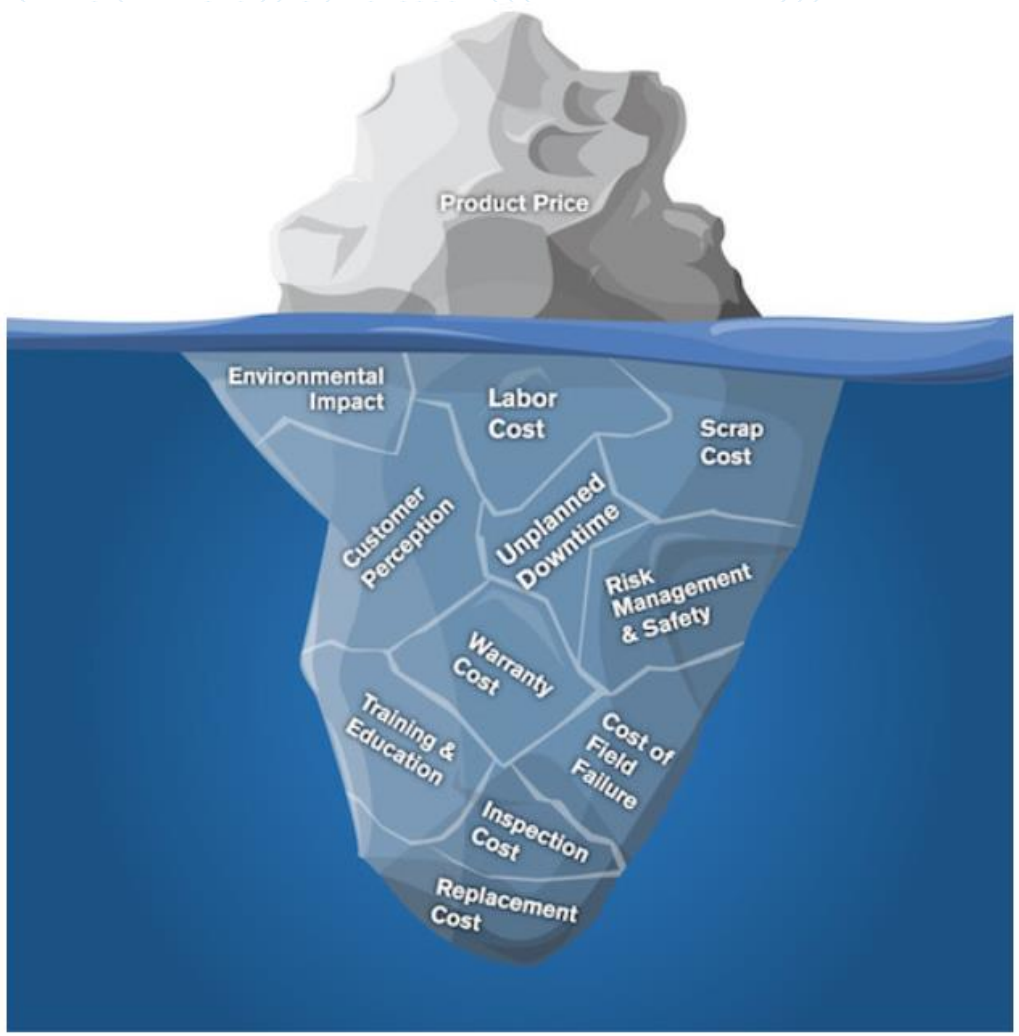
Total Lifetime (in Years)

$$Life\ Time = \frac{(TBW)}{(Daily\ Work\ Load) * 365\ days}$$

$$Life\ Time = \frac{(76800)}{(6) * 365\ days}$$

$$Life\ Time = 35{,}07\ years$$

What is Total Cost of Ownership (TCO)?



Total Cost of Ownership

Case Study: Ticketing Machine Disaster

Total Cost of Ownership

Case Study: Tesla

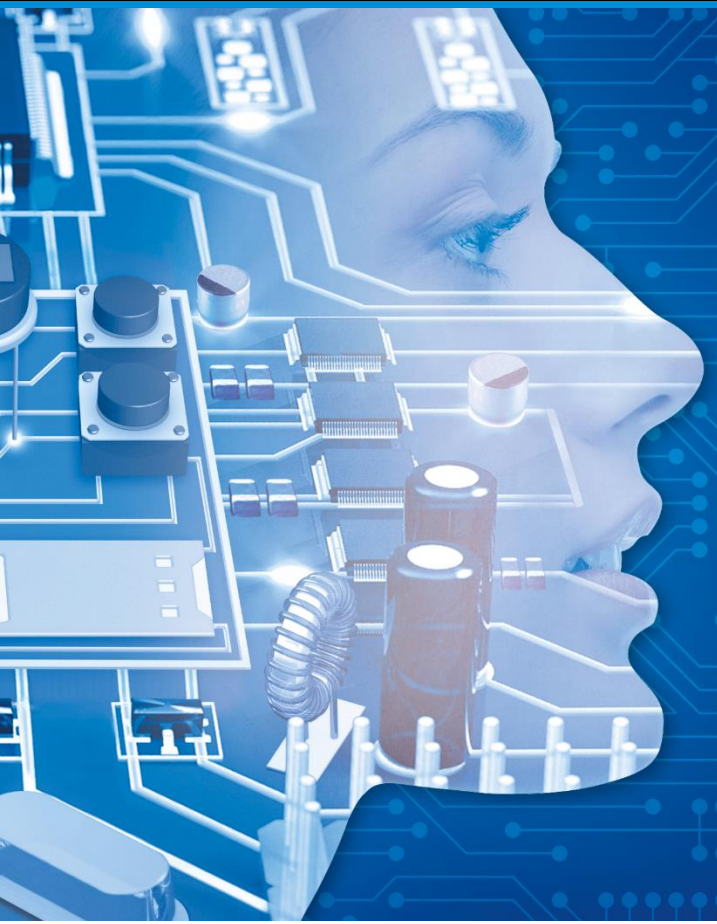
Conclusion

The Quality of Industrial Solutions

- Advantages of Industrial vs. Consumer solutions
- Move from known uknown to known known

Take the TCO into consideration

- It is more than just the material cost



Thank you for your attention

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