EPCI European Passive Components Institute

Commercial versus COTS+ versus Qualified Passive Components in Space Applications

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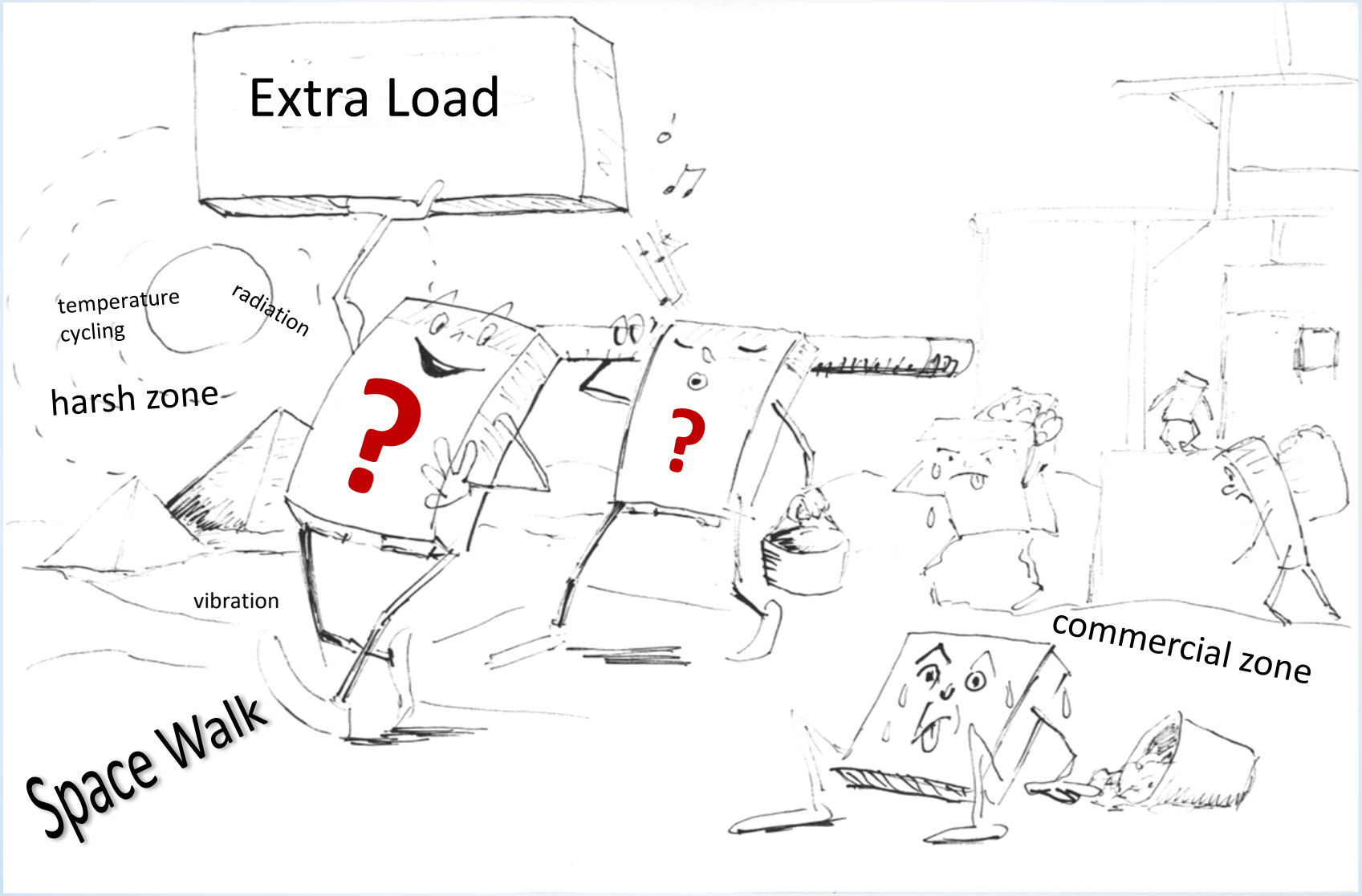
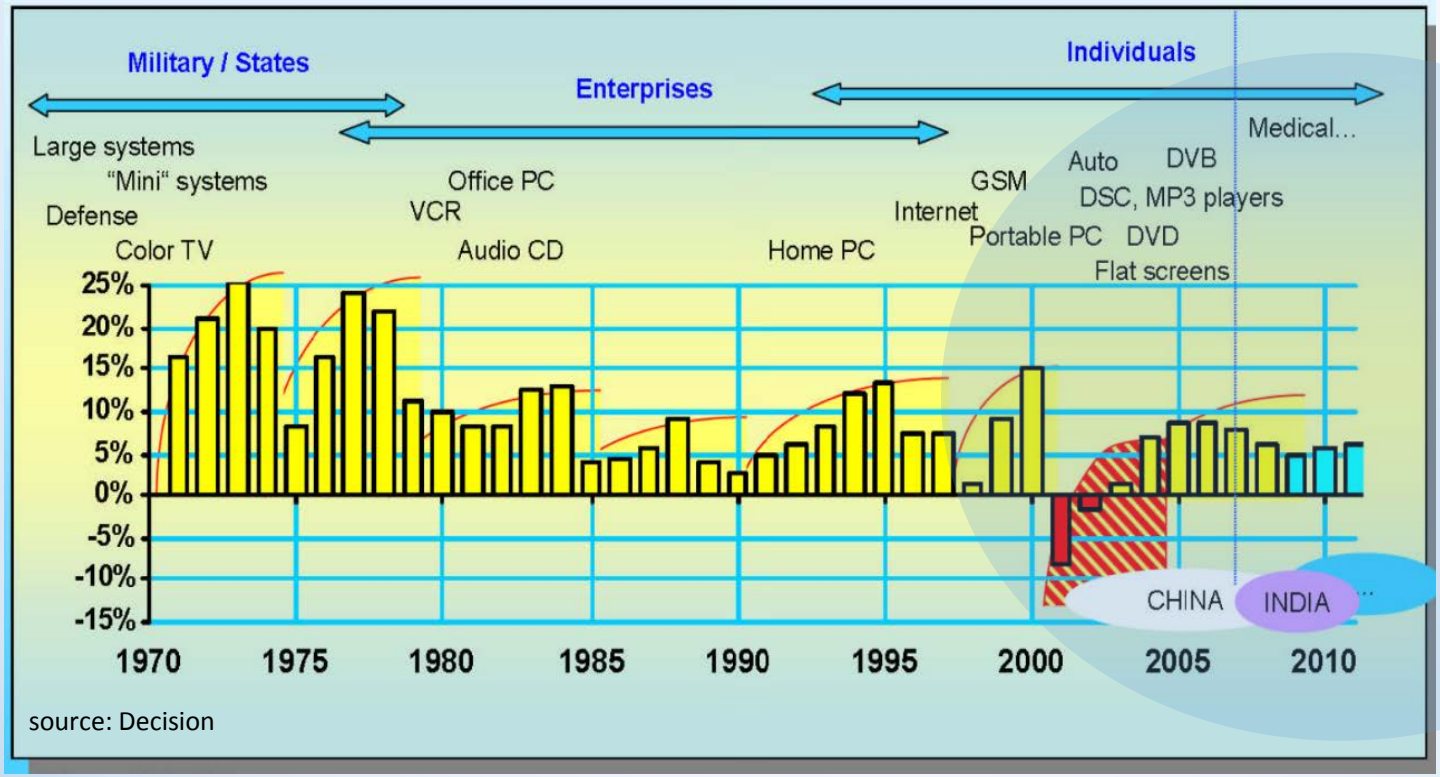
Outline


Extra Load
temperature cycling
radiation
harsh zone
?
?
vibration
commercial zone
Space Walk

Electronic Industry Market Changes

Electronic Industry Drivers

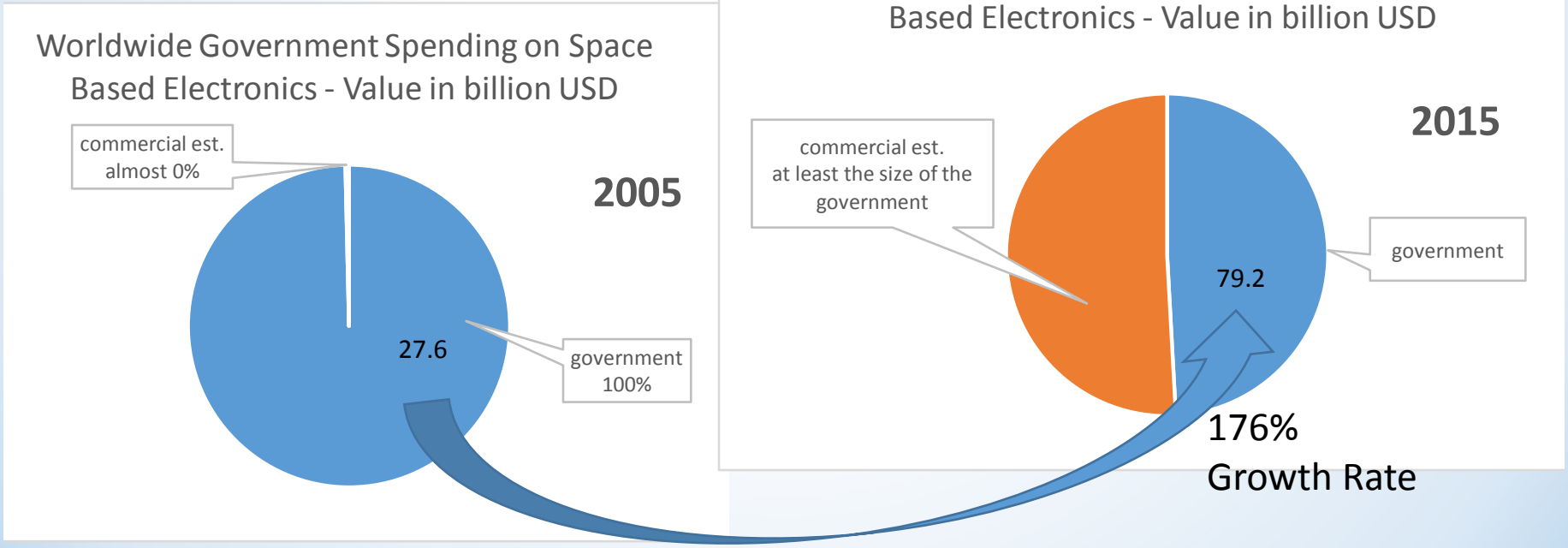
Pioneers (~1800 – ~1920), from the first discoveries to a "real" production
Military, State, Space (~20th – ~70th) - orders from military, state and space
Enterprises (~70th – ~90th) – industry automation, PCs for business use
Individuals (~90th – today) – personal PCs, DCR, mobiles … individuals



Space Is No More
The Market Driver

Changing Space Market Environment

- Space Based Passive Components represent only a minor subset of global passive components market.
- The value of worldwide government spending on space-based electronics increased from $27.6 billion U.S. dollars to $79.2 billion by 176% in past ten years, making it **one of the fastest growing electronics segments in the World.**
- **The commercial market for space-based electronics, which did not exist in 2005, is now at least as large as the government market**



Data source: Paumanok 2016

Space Component Supplier Types

"Universal" Mass Volume Manufacturers

- financial strength, long-term presence and experience on the market
- low cost manufacturing potential, high volume production
  - knowledge of the "true ppm failures" of the component technology
- experience with wide range of industries & global markets **innovation driven by wide industry presence** (automotive, medical, industrial, telecom, consumer …)
- **space, not necessary the prime focus application**, some better profit interests may exists elsewhere
- some low cost driven improvements may have an impact on overall product range performance (sometimes actioned without notice)

"SME" Specialist Manufacturers

- close to the product = new ideas, fast decisions, responsiveness, **innovation based on deep specific product knowledge**
- usually excellent product knowledge / problem solving capability
- flexible in low volume, high product variability versions
- can be space application oriented = high motivation for success
- limited access to market and market knowledge (compare to global companies)
- **small production – the ppm failures unknown or statistically not reasonable**

Passive Component Application Characteristics

Parameter		Space	Automotive	Industrial	Medical (life support)	Consumer
Market size (component volume)		small	high	medium	small	very high
Component cost		high	medium	medium - high	high	low
Main Component Feature 1 - 5 (5 most sensitive)	reliability	5	4	4	5	2
	cost sensitivity	1-2	3	3	1	5
Time to Market		2-10 years	2-3 years	~ 2-5 years	~ 10 years	3-6 month
Component Longevity		2-25 years	10 years	15-20 years	10 years	1-2 years
Component "ON Time"		90%	**5%**	60-90%	100%	30 - 80%
Specification & Test Methods	responsibility	**agency**	**AEC**	custom,CECC, IEC	**FDA**, custom	CECC,IEC
	requirements	strict	semi strict	strict	strict	custom
Manufacturing & Quality System	responsibility	agency	ISO,TS16949	ISO 9000, IRIS ...	ISO13485	ISO 9000
	Requirement	mandatory	expected	expected	custom strict	recommended
Alert System		**Yes**	No	No	No	No
Certification / Compliance		**agency**	self	self/customer	**FDA**	self
Periodical Audits		agency	customer	customer	FDA/customer	NA
Typical Load / Qualification	life at Hi Temp	> 2000 hrs	2000 hrs	>2000 hrs	BT operation	1-2000 hrs
Environment	Hi/Lo temp	No/Yes	Yes	Yes / Harsh	No	No
	thermal shock	Yes	Yes	Yes	No	No
	vibrations	strong	continuous	appl. specific	No	No
	radiation	High	No	No	No	No
	humidity	No	Yes	Yes / Harsh	Yes	Yes
	oxidisation	No	Yes / Harsh	Yes / Harsh	No	No
Typical Application Characterisation		highly derated	rarely harsh	demanding	benign	no margin

source: EPCI, 2016

Automotive Components

Automotive Industry **Advantages**

- common AEC standards under control of AEC council
- large, homogenous, cost competitive market (space industry non-dependence)
- common accepted qualification standard AECQ-200 (mainly US and Europe)
- expected (not mandatory) quality system TS16949 (audited by third party) including PPAP, FMEA, 8D Problem Solving …..
- change notification system in place

Differences & Limitations

- minimum modular order quantity may apply
- commercial drivers for component technology (pure tin)
- manufacturer may reserve a right to supply a “better” part than ordered (incl. different construction)
- manufacturers “self-certification” to AECQ, no independent compliance verification
- region of origin, can be in labour cheap countries (self-certified to AEC, most are TS16949 certified but it is not mandatory AEC requirement)
- unique automotive PN not strictly required (issues with traceability, …distributors …)

COTS+ Considerations & Limitations

- "quality must be manufactured, not screened", basic technology ppm failure level of the screened technology is the same as the original commercial product.
- "burn in" is not mandatory for commercial COTS parts
- main purpose of COTS+: remove infant failures, minimise risk of maverick lot and maverick part and quantify the individual batch reliability level (at least relatively) using statistical models & stress factor calculations.

BUT

- reference MIL document for failure stress acceleration factors is tenth years old, validity for todays / new technology ? … so how to screen the product ?
- the statistical models has been set up for "high level" of catastrophic failures of older components. The new high tech technologies may need to use higher acceleration stress factors to induce catastrophic failures for life calculations … **Is this relevant ?**
- parametric shift is of more serious concern today than catastrophic failures.

NEED FOR NEW EVALUATION, QUALIFICATION, SCREENING AND APPLICATION PRACTICES

Lessons Learnt (I)

COTS validation for the Solar Orbiter, ESA & Alter, presented at ESCCON 2016

EEE parts were procured for instruments on Solar Orbiter project. The main driver to set up the instrumentation separately from the main project was that ESA need to assure that the instrument consortia would succeed in ***procuring in a timely manner*** *components compliant to the quality and technical requirements of the Solar Orbiter mission. After a quite extensive standardisation activities and proposals of alternative qualified parts* ***still many exotic parts and commercial parts were needed*** *without any valid qualified alternative suitable for the specific instrument design.*

Experience / Lesson learnt:

- *issues with credibility and completeness of datasheets*
- *issues with communication with manufacturers – slow response, wrong information provided*
- *re-tinning process and solderability issues*
- *film capacitor low temperature application issues*
- *lack of knowledge on product capability and performance by suppliers*

Lessons Learnt (II)

Commercial Satellite Perspective on EEE parts, SSL, presented at ESCCON 2016

The commercial satellite industry is robustly competitive on a global scale. Nine years summary of EEE parts usage on some fifty spacecraft. While the trend of late unit failures due to EEE parts is much improved, any EEE parts issue can become significant. ***As the industry evolves, new technology parts are becoming "standard" without flight heritage****. COTS parts are being considered where the reliability and quality can be demonstrated. "Standard" usage parts are the parts with highest ESA qualification, "non-standard" parts are screened and qualified to be equivalent to the closest MIL standards. T grade capacitors are used where available, but R/S acceptable.*

Experience / Lesson learnt (cross program issues):

- *1uF ceramic capacitor caused a million dollar rework issues in 2006 and modification of the internal process program*
- *rigorous use of the highest available EEE parts* ***has reduced but not eliminated the number of issues***
- *tantalum capacitors improved with surge screening, still issues with ceramic capacitors*
- *resistors general reliability is excellent*
- *strong pressures to lower costs using COTS parts*

Lessons Learnt (III)

NASA Automotive Component Reliability Studies

NASA Automotive components evaluation of risk assessment for space systems.

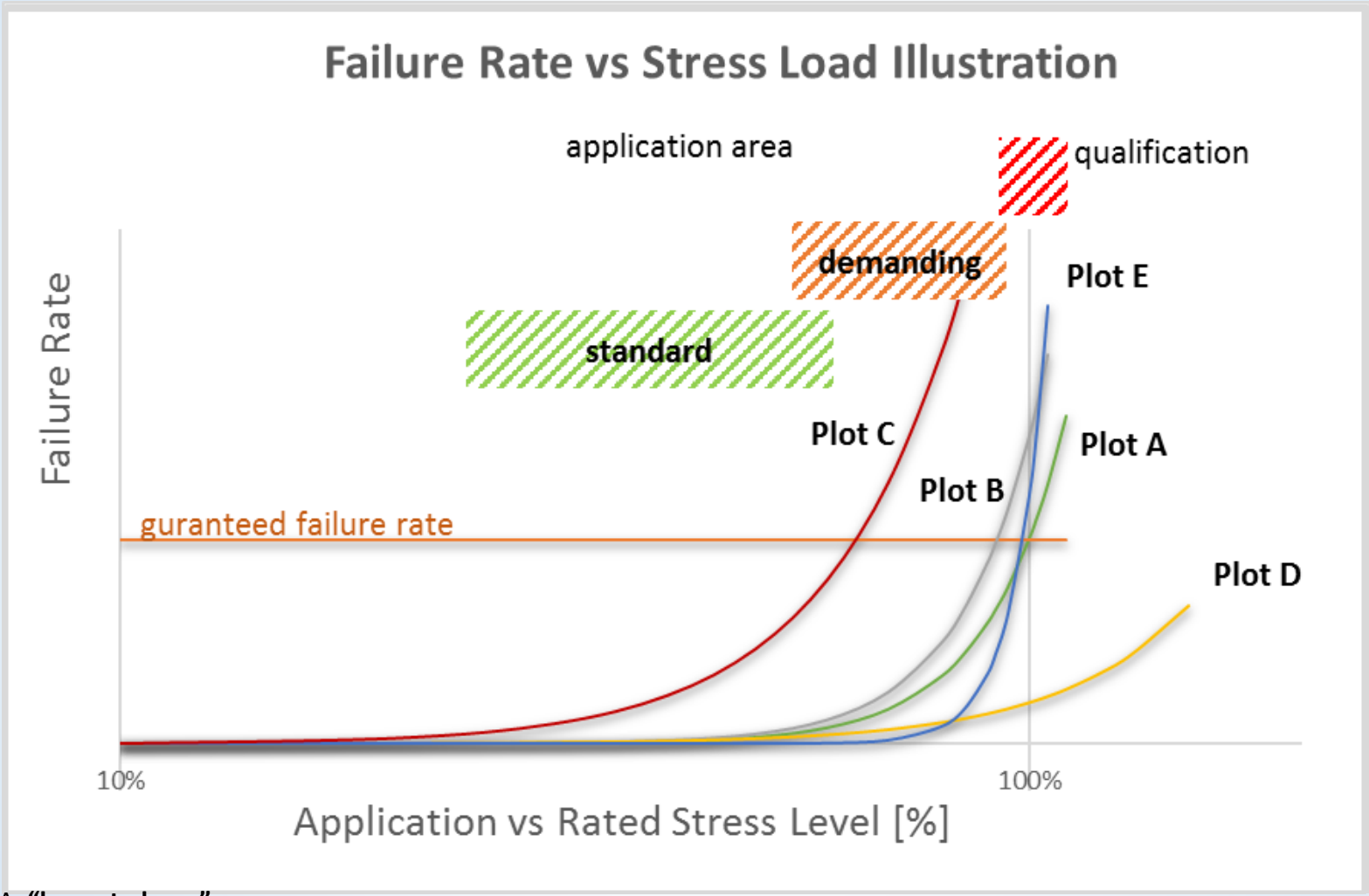
Experience / Lesson learnt from purchasing:

- *many large volume automotive manufacturers DO NOT buy "catalogue" automotive EEE parts. Instead,* ***they procure via internal SCDs based on "AEC Q" catalogue items***
- *SCDs used to tailor specific needs (e.g., unique test requirements, internal PNs)*
- ***Some distributors demonstrated no knowledge of AEC components and suggested other parts they had in stock as replacements***
- *Traceability needs careful control – distributor documentation may not have same details as manufacturers*
- *Some AEC Q ceramic chip capacitors may be supplied with either "flexible termination" or "standard termination"* ***at the discretion of the supplier.***
- *so far, all parts tested, passed datasheet limits as received (basic electrical parameters)*
- *0805* ***Capacitor DPA showed different termination materials***
- *Datasheet gave a typical value for only one electrical parameter at* ***high temperature and testing showed actuals were about 2x this "typical" value***

COTS Lessons Learnt - Observations

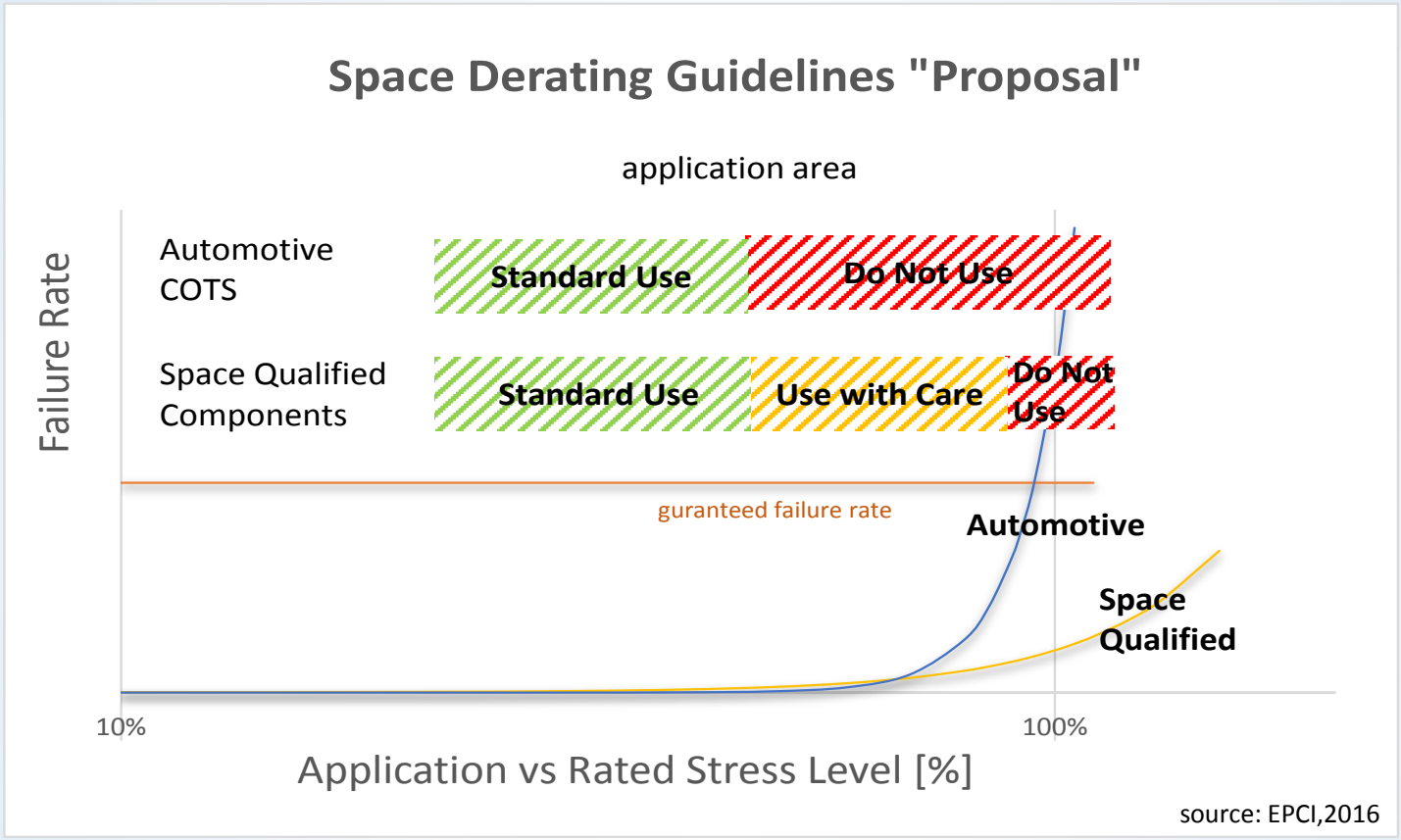
- Motivation for adoption is not only the LOW COST but also the NEW capabilities ENABLING new missions.
- supply chain may present lack of product knowledge and documentation expected in standard space systems. Distributors many times demonstrated limited/no product knowledge
- when automotive parts are used in real space applications (under the space derating rules), the failure rate is so low that it can be considered as not significantly different to the base reliability level of space qualified components
- some automotive part failures are occasionally occurring during the qualification / AEC testing at the corner conditions (max load), few failures on qualified parts (with significantly lower occurrence)

Component Reliability – Illustrative Model



PLOT A **"honest player"**
PLOT B **"consumer high volume supplier"**
PLOT C "**looser**"
PLOT D "**reliability guardians**"
PLOT E "**technology masters**"

Component Reliability – Illustrative Model



- the basic failure rate level of AEC may not be far different to the space QPL upon **the appropriate application derating is applied**.
- However, the AEC may not be suitable for continuous operation in demanding conditions close to their specification limits.

Summary

Challenge	Proposed Solution
Faster Adoption of New Technologies	New Evaluation & Qualification Procedures
Component Technologies without Flight Heritage (“unknown risks”	Cont. Nanosattelite Space Flight Prove Program
Vibration, Radiation Hardness, Vacuum operation …	List of Qualified / NO GO Technologies
Lead-Free Pure Tin Termination Coatings	Lead-Free Policy for Specific Micro Electronics
Supply Chain Control & Traceability, country of origin, incl. storage	Specific COTS Control Inspection
Distribution Suport Level	Qualified Distributors
Fault Tolerant Systems	New Application / Circuit Design Practices
Basic Failure Rate	Insisting on Space Derating
Controlled Quality System	Use of Automotive Components with dedicated PN
Failure Alert & Investigation, Get power over Large Manufacturers	Co-operation with AEC Committee, joint Alert system
Burn-In, Statistical Control, Maverick lot/part Control	Joint push with AEC Committee to Auto Suppliers

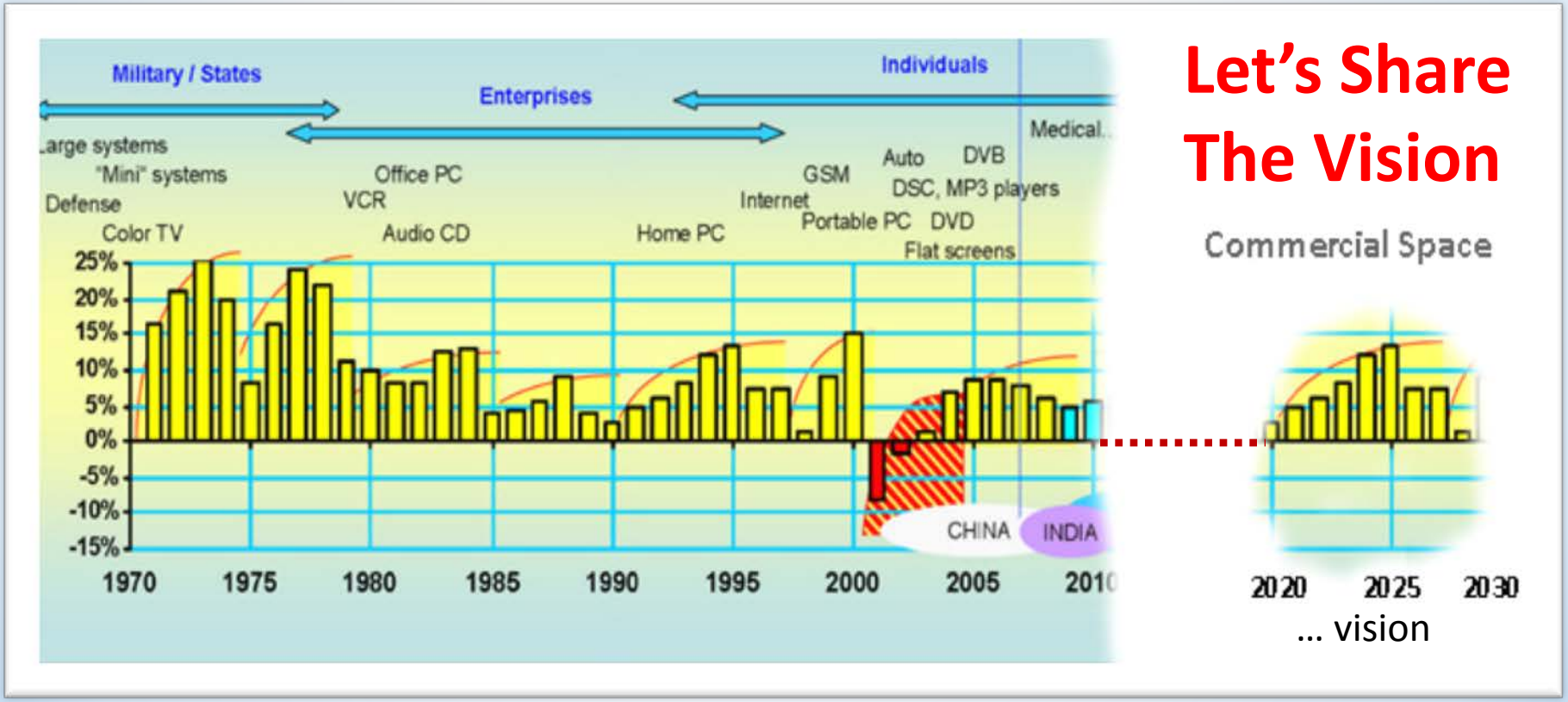
LESSON LEARNT:

BLIND “COPY & PASTE” OF COTS “STRAIGHT FROM THE BOX” TO SPACE APPLICATION IS RISKY

until the above challenges are addressed
on standard COTS products

Conclusion

- We have entered an important Space milestone
- The Space market is changing quickly and we have to adopt to this trend
- Important challenge is to find **a knowledge based** fast adoption of new component technologies to the benefits of lower cost and enabling new functionality / missions



Thank You

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