COTS in Space EEE Componnts

Don’t close your eyes. Open your mind.

Dan Friedlander

ISRAEL

danfriedlander46@gmail.com

Seville ACCEDE 2019

COTS Population

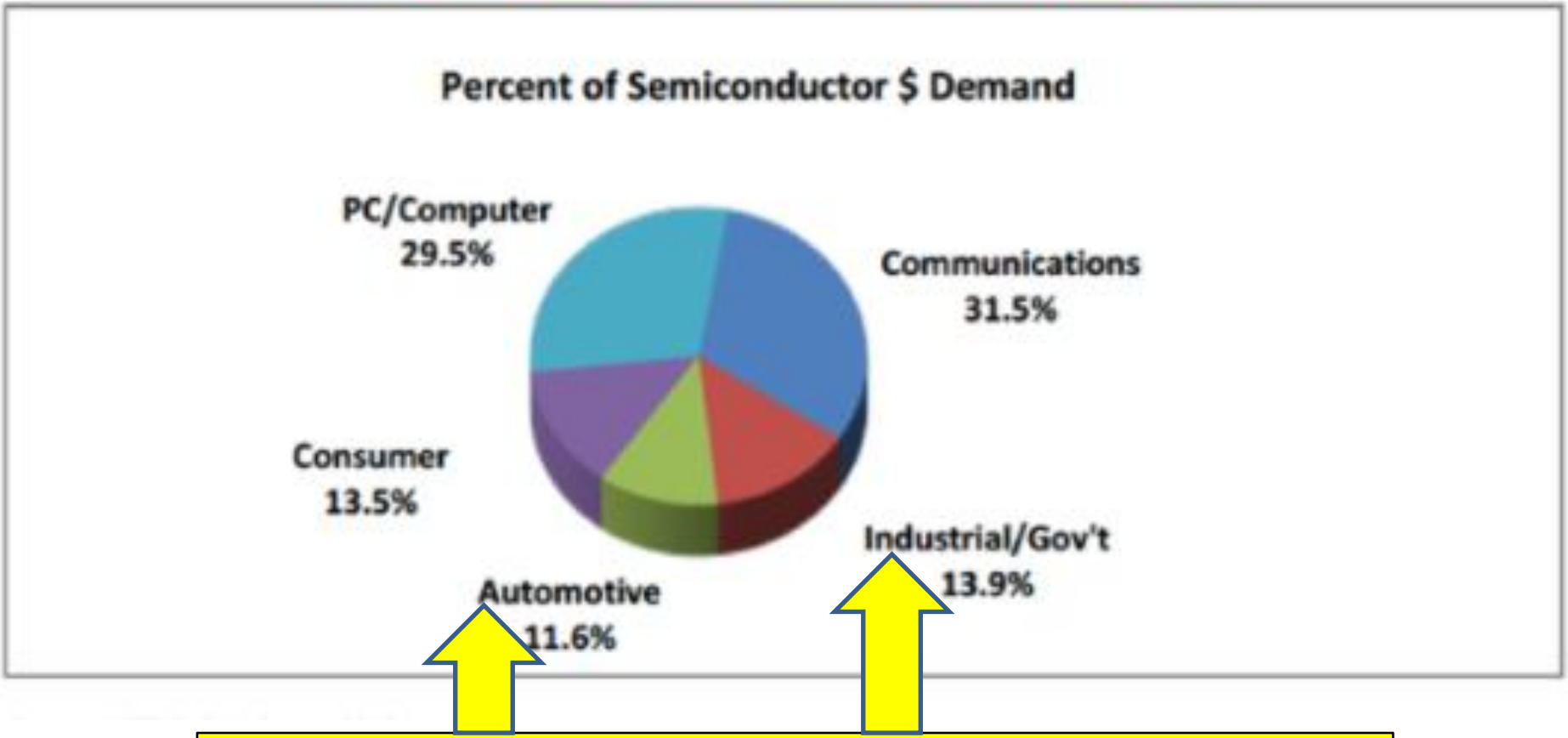
- The term “COTS” (Commercial Off-The-Shelf) refers to a huge EEE Components population, including all the commercial grade ones (industrial, commercial, consumers, automotive etc.).

- Referring to COTS, there should be no place for hasty generalization.

- **Quote**: "All generalizations are false, including this one." - Mark Twain.

COTS Population (cont)

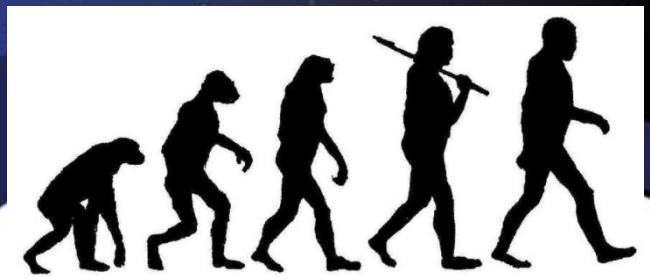
2016 Total Global Semiconductor Market $339 Billion



COTS Candidates for space applications

COTS Characteristics

- High Volume Production ensure efficiency of using statistical tools.
- Statistical Process Control (SPC) used in production line to prevent defects, translated into reliability.
- Better lot homogeneity, higher the value of sampling.
- No screening.



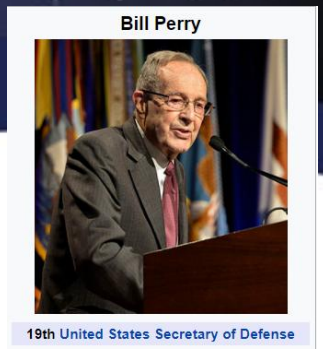
Global Developments

- **Decrease of Military/Space Components** market today to 0.1% of the world market (in dollars) from 60% in the 1960.
- **Components Availability** are dictated by manufacturers' decisions based on market demand.
- **Huge Technological Progress** in solving reliability issues encountered in the last four decades.

Global Developments Impact

GLOBAL DEVELOPMENTS
lead to
Cultural Change
from
Use of Space/Military EEE Components
to
Use of Commercial EEE Components

1994 Perry memo



- 1994 Perry's memo legalizes the use of COTS in military applications.
- Space applications are exempted.
- **Main drivers**:
  - Defense Budget shrinking.
  - Military components shrinking availability.
  - Need for advanced technologies.

1994 Perry memo (cont)

- The memo states "The use of military specifications and standards is authorized as a last resort, with an appropriate waiver.“
- The reversed components selection priority order is clear.
- It is big step to recognize officially the global developments, in an atmosphere of strong resistance to change.

1994 Perry memo (cont) Cost Saving

REMEMBER

- The transition to COTS has a big potential for cost savings in **military applications**.
- The cost savings are realized with COTS **used as is**.
- For **space applications** the COTS are **not used as is**.

Methodology Change

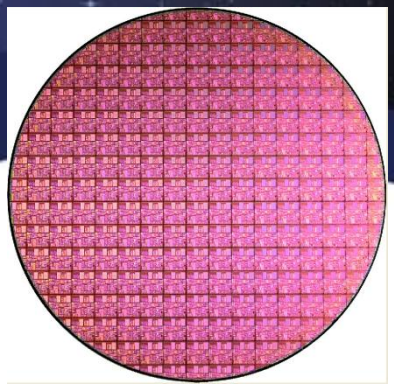
- The global developments lead to the need for a new methodology adapted to deal with **COTS** for military projects. The space applications were exempted from 1994 Perry's directive.

- The EEE Components Selection Policy has been changed to **COTS becoming first priority selection**.

- A 20 years retrospective summary of **properly selected COTS** use across various military (air, ground, sea) and space applications (LEO) proves that **COTS are OK**.

MIL-PRF/QML Methodology

- Liberalized methodology following 1994 Perry's directive.
- Transition from MIL-SPEC cookbook "how to" specifications to performance specifications.
- Transition from component level QPL to product line level QML.
- Components manufacturers get the authority to eliminate justified non-value added screening/ testing steps.



COTS

- Following 1994 Perry's directive Commercial Off-The-Shelf (COTS) has been legalized for use in military applications.
- COTS dominate the global market (99.7% in $).
- Market Size = Incentive to invest in technological developments.
- High Volume Production = Valued Statistical Tools in Process Control = Reliability.
- Most failures are due to component manufacturing defects.

COTS in Space Official Policy

- The main leading COTS in space policy documents:
  - NASA PEM-INST-001 (June 2003) - Instructions for Plastic Encapsulated Microcircuit (PEM) Selection, Screening, and Qualification.
  - ESA ECSS-Q-ST-60-13C (21 October 2013) - Space product assurance commercial electrical, electronic and electromechanical (EEE) components.

COTS in Space Official Policy (cont)

- The traditional methodology of dealing with space/military grade EEE components has been extended (with some tailoring) to commercial EEE components.
- The policy imposes on the user a **"last resort" a COTS** selection path vs. preferred Space/MIL components.
- The selection of COTS is penalized.

COTS in Space
Debunking Myths

- **<u>Myth 1</u>:**
  Incorrect interpretation of the term "space qualified".

- The environmental requirements to be met are various, depending on many parameters like orbit, mission criticality, mission duration, etc.
- The term "space qualified" shall be fully understood in context of the specific component specification and in context of the intended application.
- The term “space qualified” refers often to the component quality level, unless RHA is specified.

COTS in Space Debunking Myths

- **<u>Myth 2</u>:**
  The main drive to use COTS in space is cost savings.

- Compare apple to apple, namely component ownership cost.
- Component Ownership Cost = Component Pre-procurement Cost (NRE) + Component Procurement Cost (RE) + component Post Procurement Cost (NRE).

- The main drive: component availability to meet performance and/or Size, Weight, Power (SWaP).

COTS in Space
Debunking Myths (cont)

- **<u>Myth 3</u>:**
  Incorrect interpretation of the term "space heritage“.

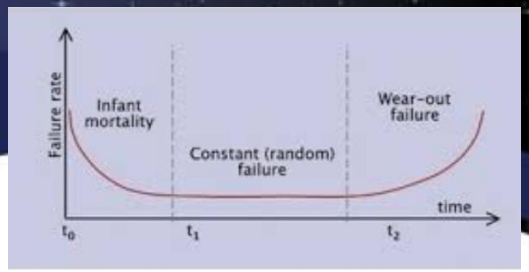
- Compare apple to apple, namely mission to mission.
- Space missions are various:
- Scope: scientific, in orbit demonstration, operational …
- Orbits: LEO, GEO.
- Mission duration: <1 year to 15 years.

COTS in Space
Debunking Myths (cont)

- **<u>Myth 4</u>:**
  Use of terms "quality" and "reliability“ interchangeably.
- Quality and reliability are two terms referring to two entirely different aspects of the behavior of a component over its lifetime.
- Quality measures how well the facility produces components that meet the specifications at the start of use.
- Reliability is the probability of a component meeting the relevant specification over the lifetime.

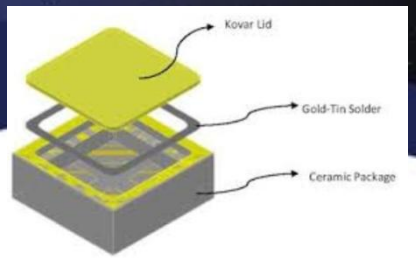
COTS in Space
Debunking Myths (cont)

- **<u>Myth 5</u>:**
  COTS reliability cannot be ensured, unless they are 100 percent tested and screened.
- Reliability cannot be tested into the component.
- The qualification and screening are not considered as a substitute for manufacturing control, but rather as risk-mitigation measures.
- Process (design followed by manufacturing) builds reliability into the component.
- Statistical Process Control (SPC) addresses the reliability issue.



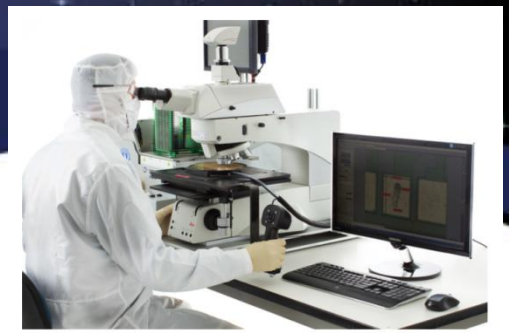
COTS in Space
Debunking Myths (cont)

- **<u>Myth 6</u>:**
  Meeting absolute quantitative limit of reliability is required in technical specifications in order to achieve the needed mission reliability.
- MIL-HDBK-217F explicitly states: “A reliability prediction should never be assumed to represent the expected field reliability.”
- As MIL-HDBK-217F admits, "those who view the prediction only as a number which must exceed a specified value can usually find the way to achieve their goal without any impact on the system.”



COTS in Space
Debunking Myths (cont)

- **Myth 7:**
  Plastic encapsulated semiconductors (PEM) cannot be used for space applications.
- The problems encountered in early stages (from the 1960s) with non-hermetic plastic encapsulated semiconductors caused the military and space components policymakers to taboo (avoid or ban) their use in military and space applications.
- If properly stored, there is no problem using non-hermetic components in space.
- In space there is no moisture.



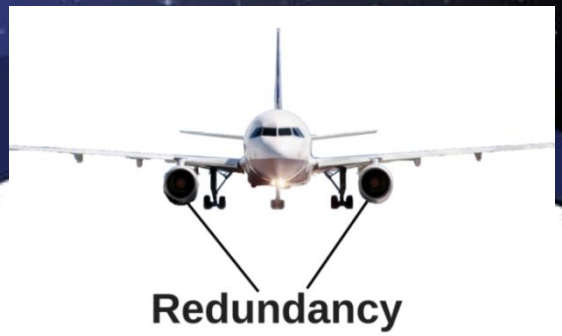
COTS in Space
Debunking Myths (cont)

- **<u>Myth 8</u>:**
  COTS manufacturing is not controlled sufficiently.
- The history does not show that a central control has been efficient for military components.
- The military-level qualified components (widely used in space) and COTS have the same lack of wafer traceability problem.
- The space industry turns a blind eye on the lack of wafer traceability for traditionally accepted military level components, but penalizes COTS in space because of the same traceability issue!

COTS in Space
Debunking Myths (cont)

- **<u>Myth 9</u>:**
  Success in space missions can be achieved only by means of a conservative approach.

- Space missions are inherently risky.
- No approach, not even a conservative one, can avoid failures.
- The name of the game is risk management.
- Today, there is enough proof (see U.S. private space industry) that progressing with a more liberal approach is a valid way to success.



COTS in Space
Debunking Myths (cont)

- **<u>Myth 10</u>:**
  Redundancy is a magic solution to enable the use of softer radiation components.
- Redundancy, if found necessary, is a good practical solution for lowering the probability of system failures.
- The same type of components are expected to fail independently in the same design.
- This may be outweighed by other risk factors, such as human design error, generic failure modes, etc.
- True redundancy: implementation with different designs designed by different teams.

COTS in Space - The Future Input to Forecast

- **<u>Input Data for the Forecast</u>:**

- The traditional MIL methodology for space and military applications, **based on heavy testing/screening of hermetically sealed electronic components,** is deeply rooted in the ongoing environment of resistance to change.
- EEE COTS components, in spite of huge technological developments, **were banned for decades to be used in military and space applications**.

COTS in Space - The Future Input to Forecast (cont)

- The MIL traditional methodology rigidity and the commercial market dominance lead to a **considerable technological lag** of military/space EEE components behind commercial ones.
- **The military/space EEE components market size** led to components manufacturers business decisions to leave the military/space market, further affecting the availability.
- It has been proven that **components manufacturers are independent** in taking business decisions.

COTS in Space
The Future (cont)

- **Budgets are shrinking**.

- After long debates the US DoD officially **was compelled** (by global developments) to recognize **the legitimacy of usage of EEE COTS components in military applications**.

- The decision to use of EEE COTS components in military applications has been proved as a **successful** one from every aspect.

COTS in Space - The Future Input to Forecast (cont)

- The above decision has led to replacing the MIL traditional methodology with the QML concept, a liberalized version of the traditional one, **infused with elements of commercial practices**.
- **The space applications have been exempted** (DoD is not responsible for space) from the above decision.
- Meanwhile, within local initiatives, **EEE COTS components were successfully used in space applications.**

COTS in Space - The Future Input to Forecast (cont)

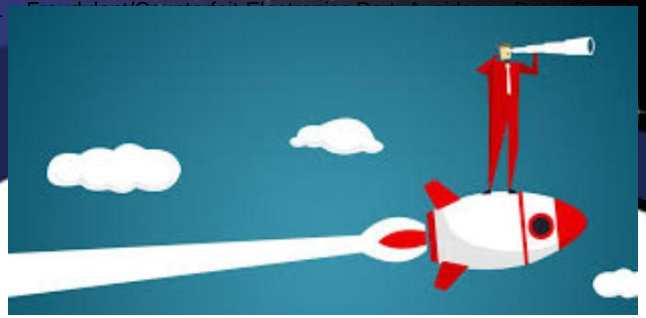
- Extremely slow space policy makers decision taking led to a **last resort** EEE COTS components penalized methodology.
- The present space policy leads to **preference** of military/space grade, hermetically sealed EEE components in space applications.
- The only thing certain about the availability security of the military/space EEE components is **uncertainty**.

COTS in Space - Forecast

- It is obvious that without electronics the space industry cannot survive. Consequently, the **availability** of the electronic components is a **MUST**.

- Presently, most of the space designs are based on military/space grade hermetically sealed electronic components, meeting the space agencies' policies.

- The direct consequence is to commit those designs to **insecure components availability**.

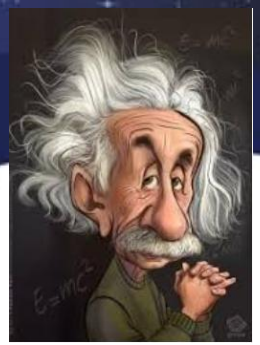


COTS in Space – Forecast (cont)

- The availability of military/space grade EEE Components depends solely on business decisions By Components Manufacturers, based on a miniscule space demand (less than 0.3% in $).
- The business minded movement of the semiconductor industry to economy of scale cannot be stopped.
- Not profitable markets will disappear.

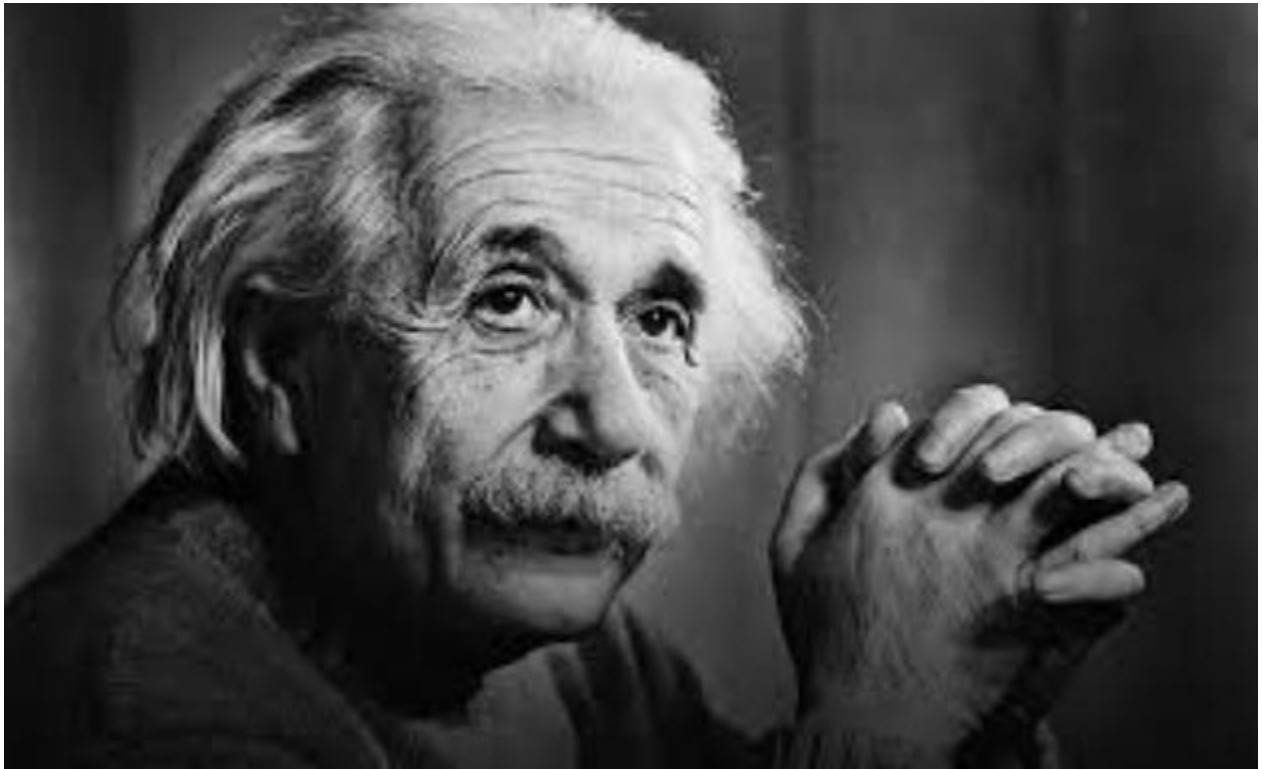
COTS in Space – Forecast (cont)

- Like for military, COTS in space is considered a viable disruptive alternative.
- The policy makers' duty should be to lead proactively the industry into the future.
  They have to adapt to the NewSpace philosophy, otherwise they may become irrelevant.
- New thinking is urgently needed to accelerate new policy creation efforts.



COTS in Space
Official Methodology
To be changed

- Albert Einstein wrote: “We cannot solve our problems with the same thinking we used when we created them.”




The
End