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SEVILLE – SPAIN 6-8 NOVEMBER

INVAP – Argentina
COTS Lifetime extension for the New Space market

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Explosive Growing Markets: New Space

- **NewSpace**, or **new space:** is the **movement and philosophy** that inspires the emerging industry of private space flights worldwide.
- **Actors**:
  - **New private companies** of the aerospace industry
  - **Major traditional contractors** of the aerospace industry
- **Goals**:
  - "Faster, cheaper and better" **access to space** technologies driven by **purely commercial reasons**.

New Space Philosophy

- **New instrument:** the "SmallSats" constellations.
- **Lower production costs:** by automation and large-scale production.
- **Lower launching costs:** lower satellite mass and size**.**
- **Lower cost of components:** use of consumer market electronics.

- **Shorter satellite lifetime**

Big Players

PROJECT	SIZE	DRIVERS	MANUFACTURERS	ORBIT	MISSION	BEGINING
OneWeb	2.622 sats	Greg Wyler	OneWeb, Airbus	LEO, 1200 km	Communications Ku Band	2021
StarLink	1.600 sats	Elon Musk	SpaceX	LEO, 550 km	Communications	2019
	~2.800 sats			LEO, 1.150 km	Communications Ku & Ka Bands	
	~7.500 sats			LEO, 340 km	Communications V Band	
Kuiper	3.236 sats	Jeff Bezos	Blue Origin	LEO	Communications	-
Telesat	292 sats	Telesat (Canada)	Airbus Maxar Techs Thales	LEO	Communications	-
Kepler	140 sats	Kepler Communications (Canada)	-	LEO	IOT	-
LeoSat	108 sats	LeoSat (Netherlands)	Hispasat (Spain) Sky Perfect Jsat (Japan)	LEO, 1.400 km	Communications Ka Band	
Hongyang	320 sats	China Aerospace Science and Technology Corporation (CASC)		LEO, 1.100 km	Communications L Band Ka Band	2023

15,000 new satellites in LEO orbits in the next years

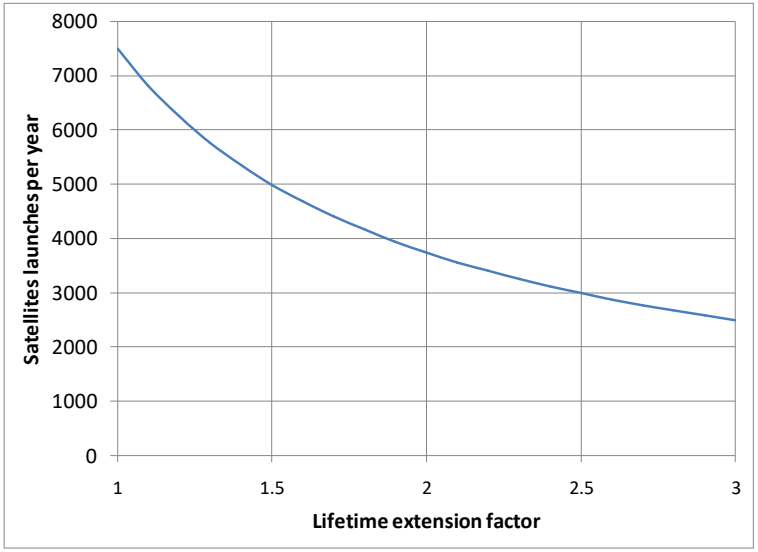
Strategic Technology

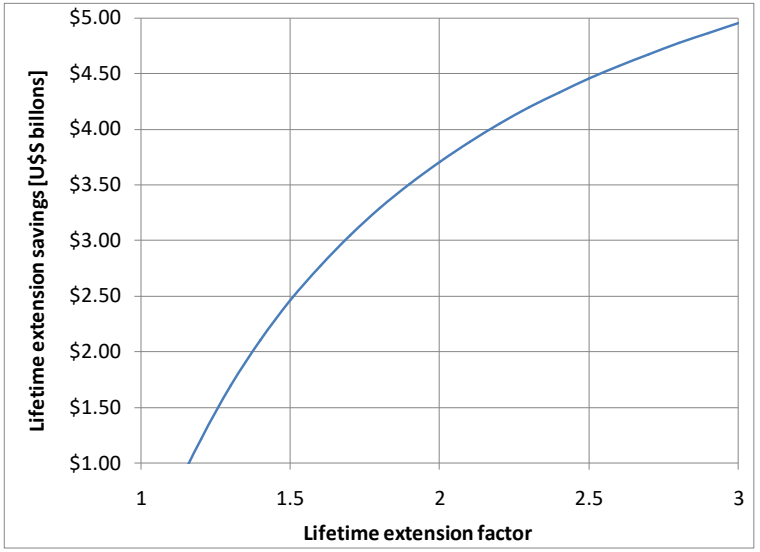
- It can be seen here an **explosive growing market**
- Assuming **$1 million per satellite** it can be sized as **15 billion dollars investment** for the next years.
- What if there were a technology capable of **increasing the lifetime** of the New Space satellites at a very low cost?
- Those who used this technology would be able to have a:

Huge reduction of their costs.

Satellites launches per year
Savings from lifetime extension

Assuming a 2 years satellite lifetime





Several Billion dollars savings

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Vulnerability of electronic components

Technological advance

Squeezed electronics**: reduce satellite size, mass and power**

CMOS relevance grows: a whole PCB is replaced by a single IC

CMOS vulnerability grows:

- Electromigration
- Time Dependent Dielectric Breakdown
- Bias Thermal Instability
- Hot Carrier Injection
- Solder joint fracture (BGA)
- Multi-bit Upsets
- Single Event Latchup

What does the lifetime of CMOS integrated circuits depend on?

ENVIRONMENTAL CONDITION	AFFECTED ELEMENT	MECHANISM	PREVENTION & MITIGATION
Temperature	OXIDE	BTI	THERMAL COATING
		HCI	
		TDDB	
	CONDUCTOR STRIPS	EM	
Thermal Cycles	SOLDER JOINTS	THERMOELASTIC STRESS	ANISOTROPIC CONDUCTIVITY FILMS
Radiation	OXIDE	TID	SHIELD
	DATA	SEU	EDAC
	DISPONIBILITY	SEFI	LOCKSTEP, CHECKPOINTING, ROLLBACK
	OXIDE	SEGB	DESIGN
	CONDUCTOR STRIPS AND SEMICONDUCTOR JUNCTIONS	SEL	OVERCURRENT SWITCH

In INVAP we are developing new techniques with this aim

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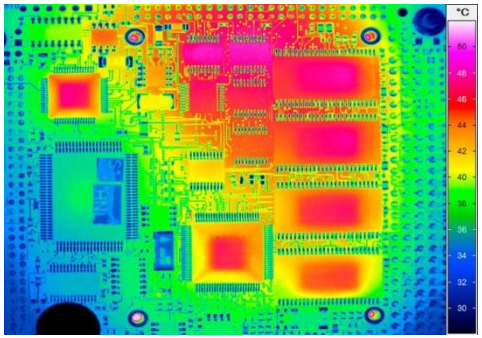
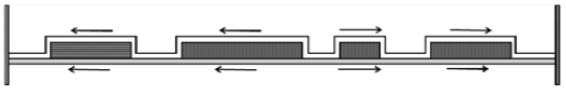
PREVENTION & MITIGATION TECHNIQUES

Prevention & Mitigation Techniques

Thermally conductive & electrical insulator coating

- Up to **50 degrees** ambient
- High **power density**
- High **thermal resistance**
- **No convection**
- **Upper surface** path

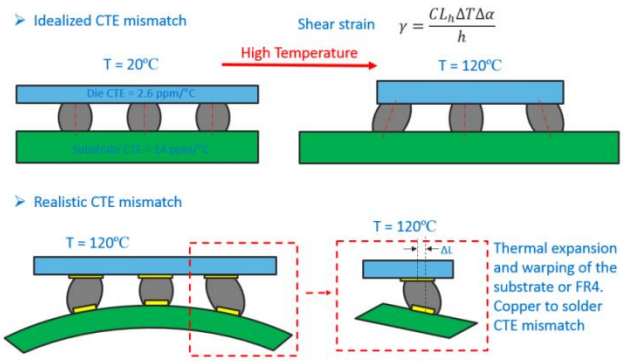


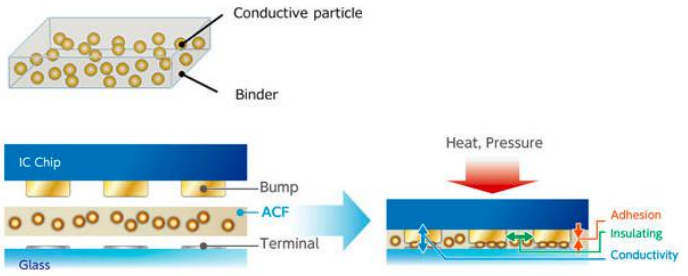


Prevention & Mitigation Techniques

Space Qualified Anisotropic Conducting Film

- 8760 thermal cycles per year
- Mainly BGA packages
- Difference between CTEs
- Extremely rigid solder joints

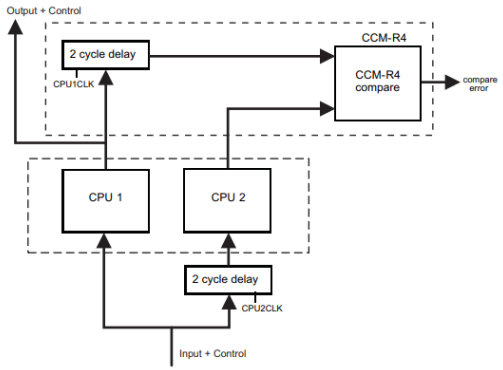




Prevention & Mitigation Techniques

Optimized Lockstep, checkpointing & rollback

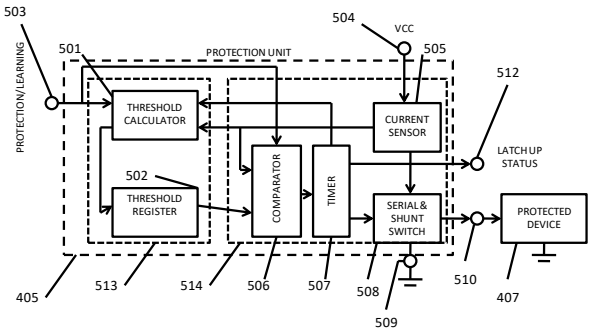
- Increased susceptibility to SEU/SEFI
- High impact on service availability
- Difficult implementation in consumer electronics

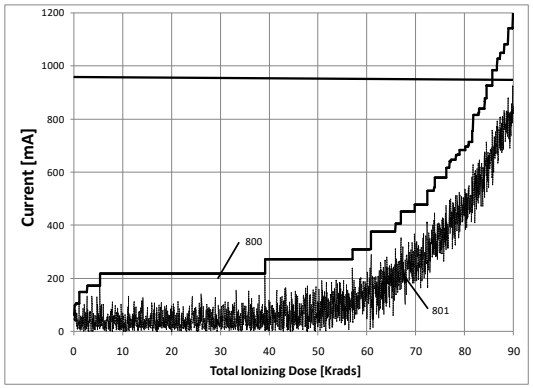


Prevention & Mitigation Techniques

Adaptative Single Event Latchup Protection

- Low LET threshold
- High cross section
- Expensive Qualification
- Increased consumption
- Adaptative Threshold





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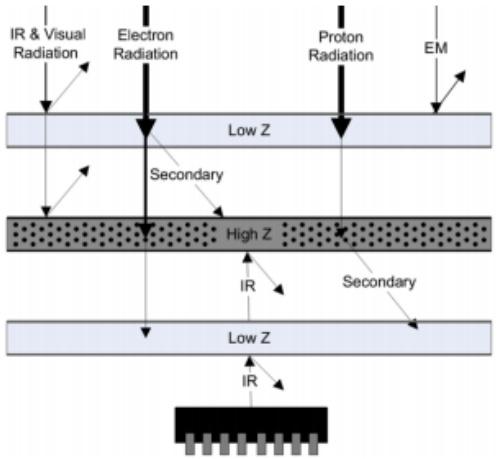
Prevention & Mitigation Techniques

New materials for Spot Shielding

- CMOS tends to be more TID tolerant
- Lifetime expectations tend to decline
- Spot shielding is still useful



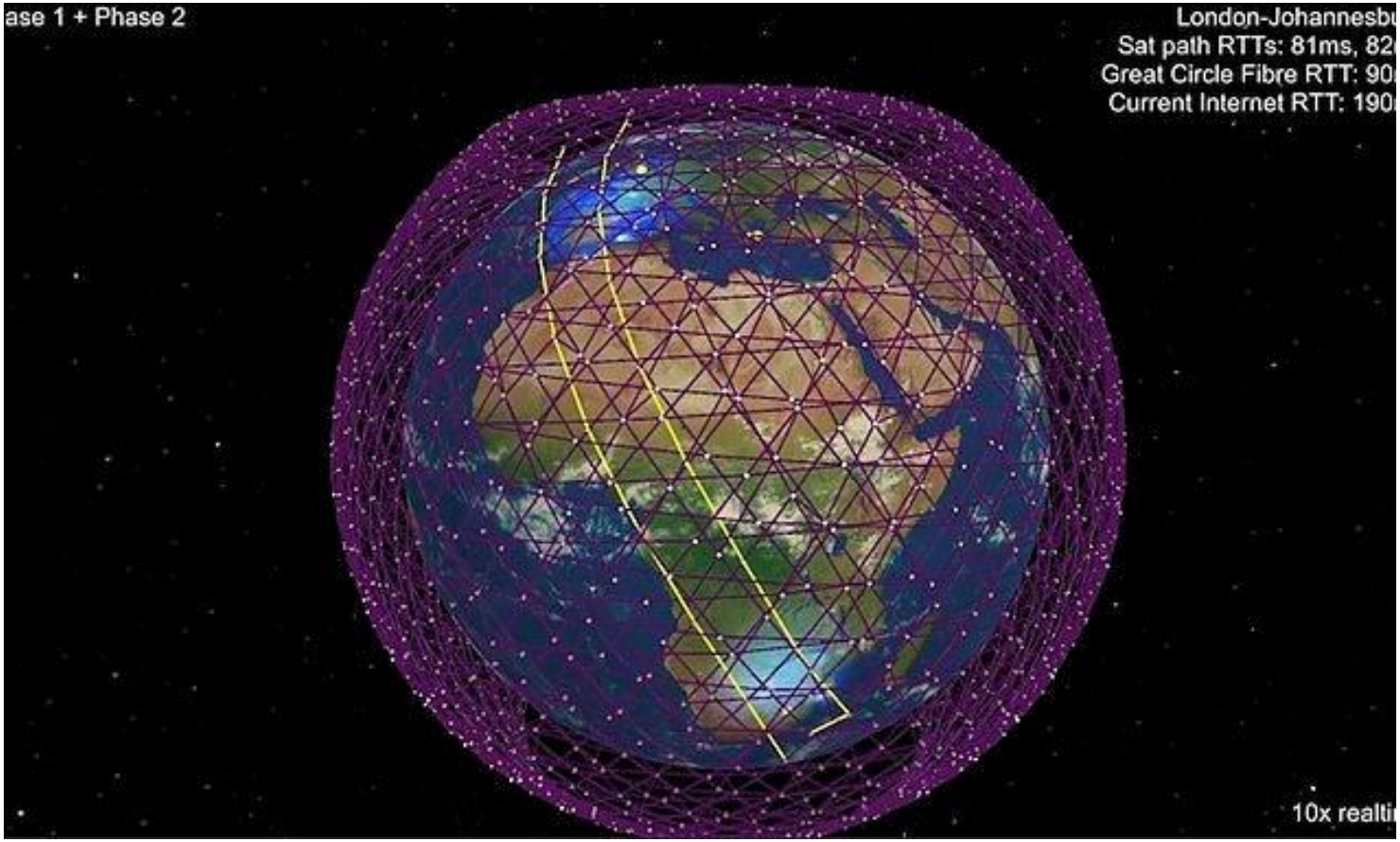
Conclusions

1. There is an **explosive growing market** for the manufacture of small-sized satellites for LEO orbit constellations using COTS.
2. The leading edge **CMOS Ics are the key** to reduce the size and mass of the New Space satellites.
3. There are **few or no qualified versions**.
4. The **up-screening** process is **expensive and risky**.
5. It is possible to **extend the lifetime** of these components through low-cost techniques.
6. The constellation manufacturer that uses these techniques will achieve a **significant cost reduction**.

Questions?

BACKUP SLIDES

New instrument:
the “SmallSats” constellations



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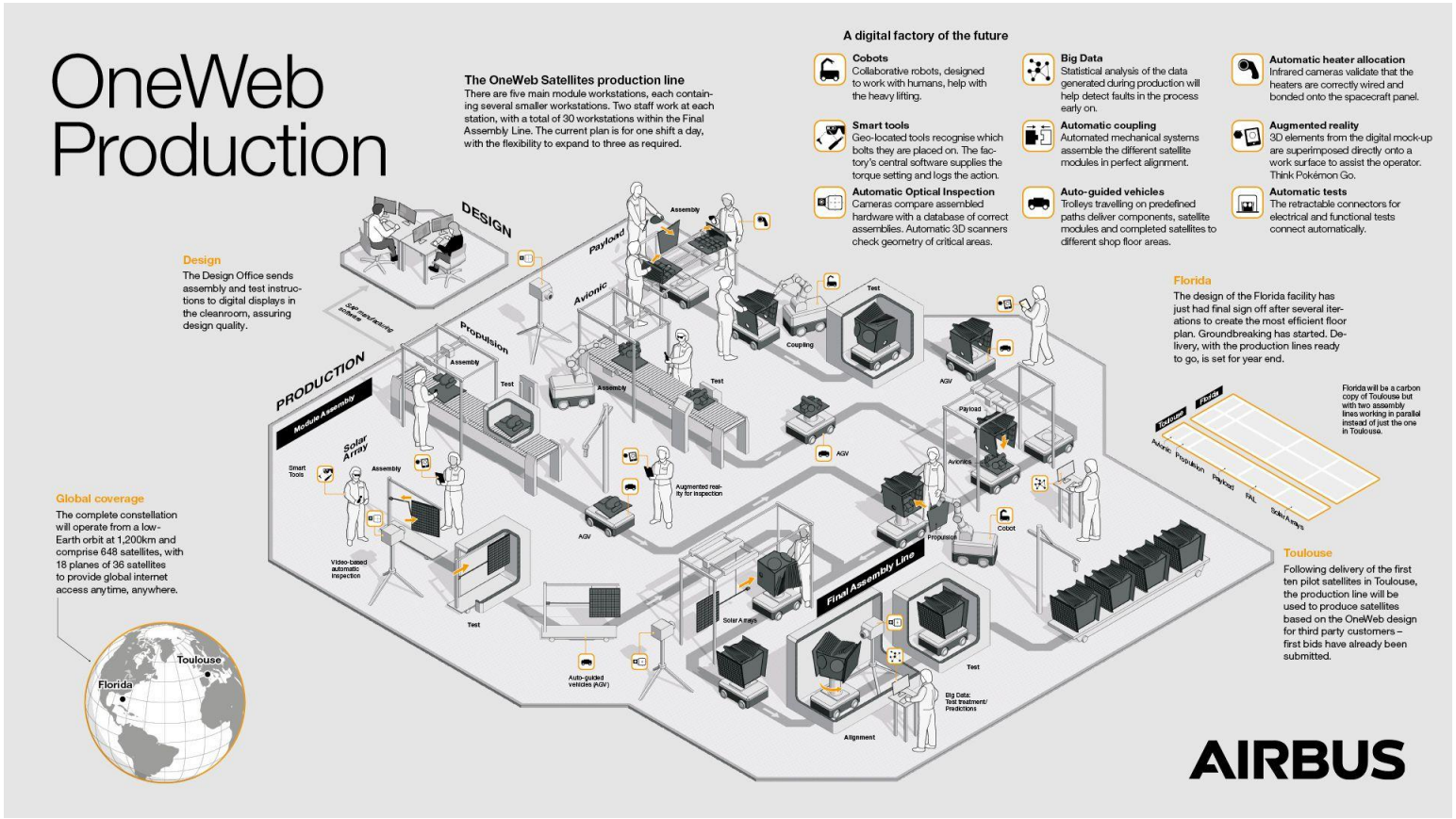
Lower production costs:
automation and large-scale production



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Lower launch costs:
lower satellite mass and size

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