

ACCEDE COTS 2019

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

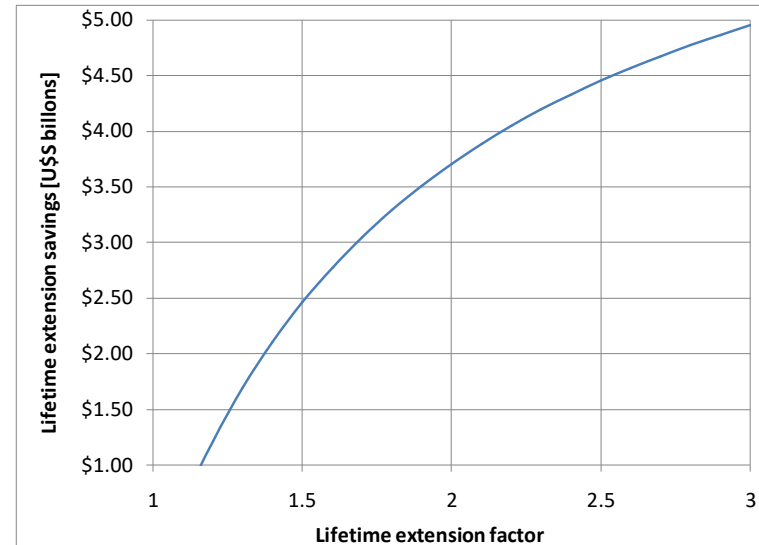
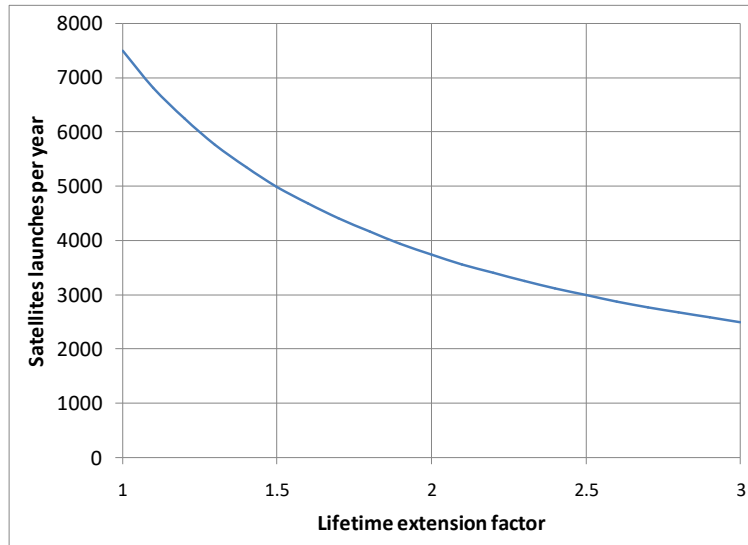
- It can be seen here an **explosive growing market**
- Assuming **\$1 million per satellite** it can be sized as **15 billion dollars investment** for the next years.
- What if there were a technology capable of **increasing the lifetime** of the New Space satellites at a very low cost?
- Those who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

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	
CONDUCTOR STRIPS	TDDDB		
	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

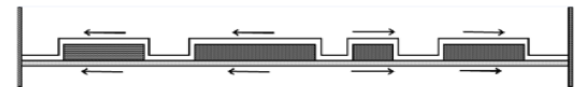
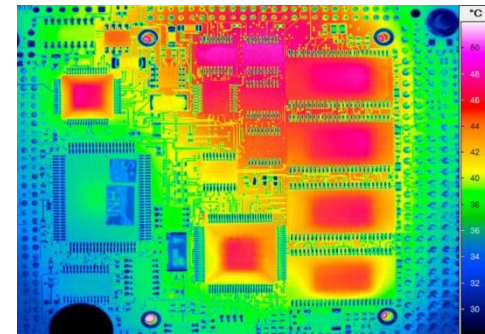
In INVAP we are developing new techniques with this aim

PREVENTION & MITIGATION TECHNIQUES

Prevention & Mitigation Techniques

Thermally conductive & electrical insulator coating

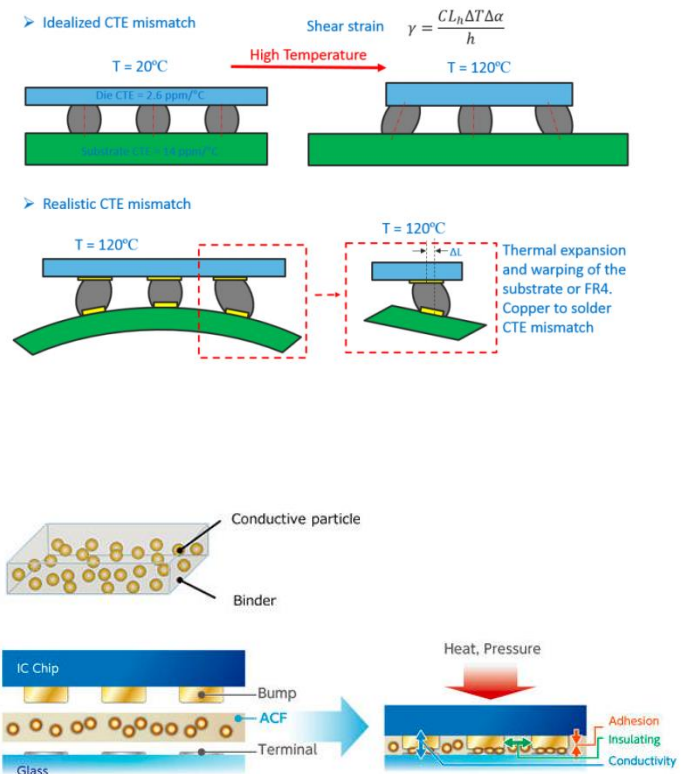
- ❑ Up to **50 degrees** ambient
- ❑ High **power density**
- ❑ High **thermal resistance**
- ❑ **No convection**
- ❑ **Upper surface** path



Prevention & Mitigation Techniques

Space Qualified Anisotropic Conducting Film

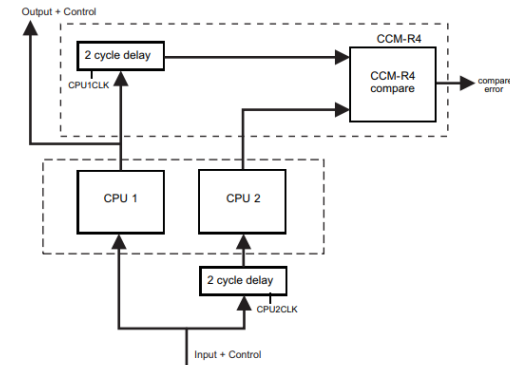
- ❑ 8760 thermal cycles per year
- ❑ Mainly BGA packages
- ❑ Difference between CTEs
- ❑ Extremely rigid solder joints



Prevention & Mitigation Techniques

Optimized Lockstep, checkpointing & rollback

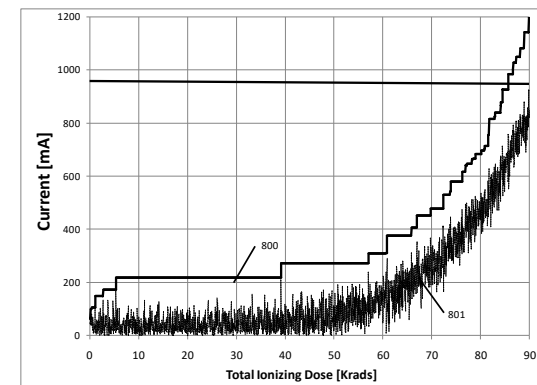
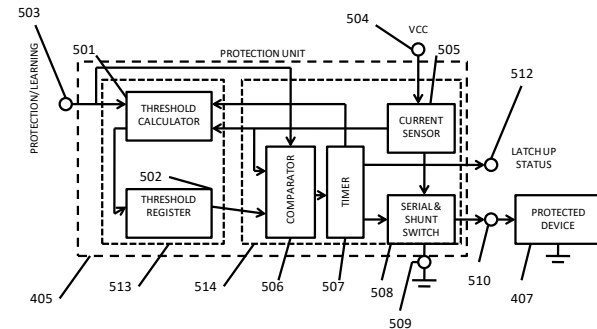
- Increased susceptibility to SEU/SEFI
- High impact on service availability
- Difficult implementation in consumer electronics



Prevention & Mitigation Techniques

Adaptative Single Event Latchup Protection

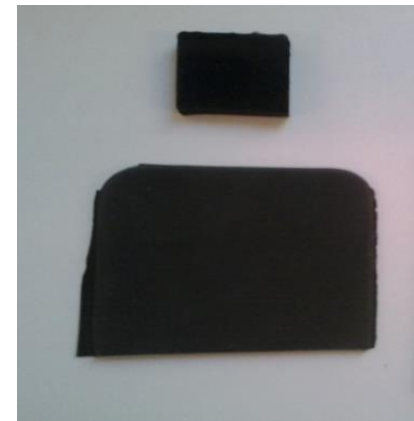
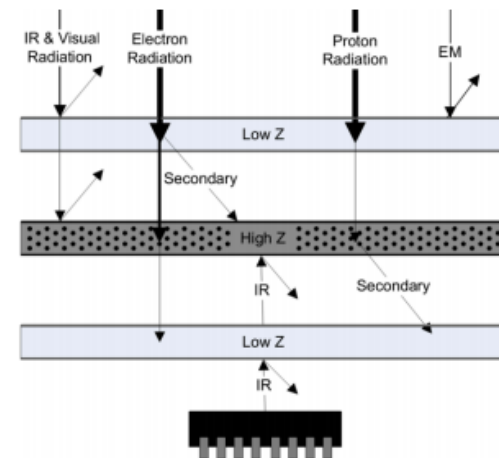
- ❑ Low LET threshold
- ❑ High cross section
- ❑ Expensive Qualification
- ❑ Increased consumption
- ❑ Adaptative Threshold



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



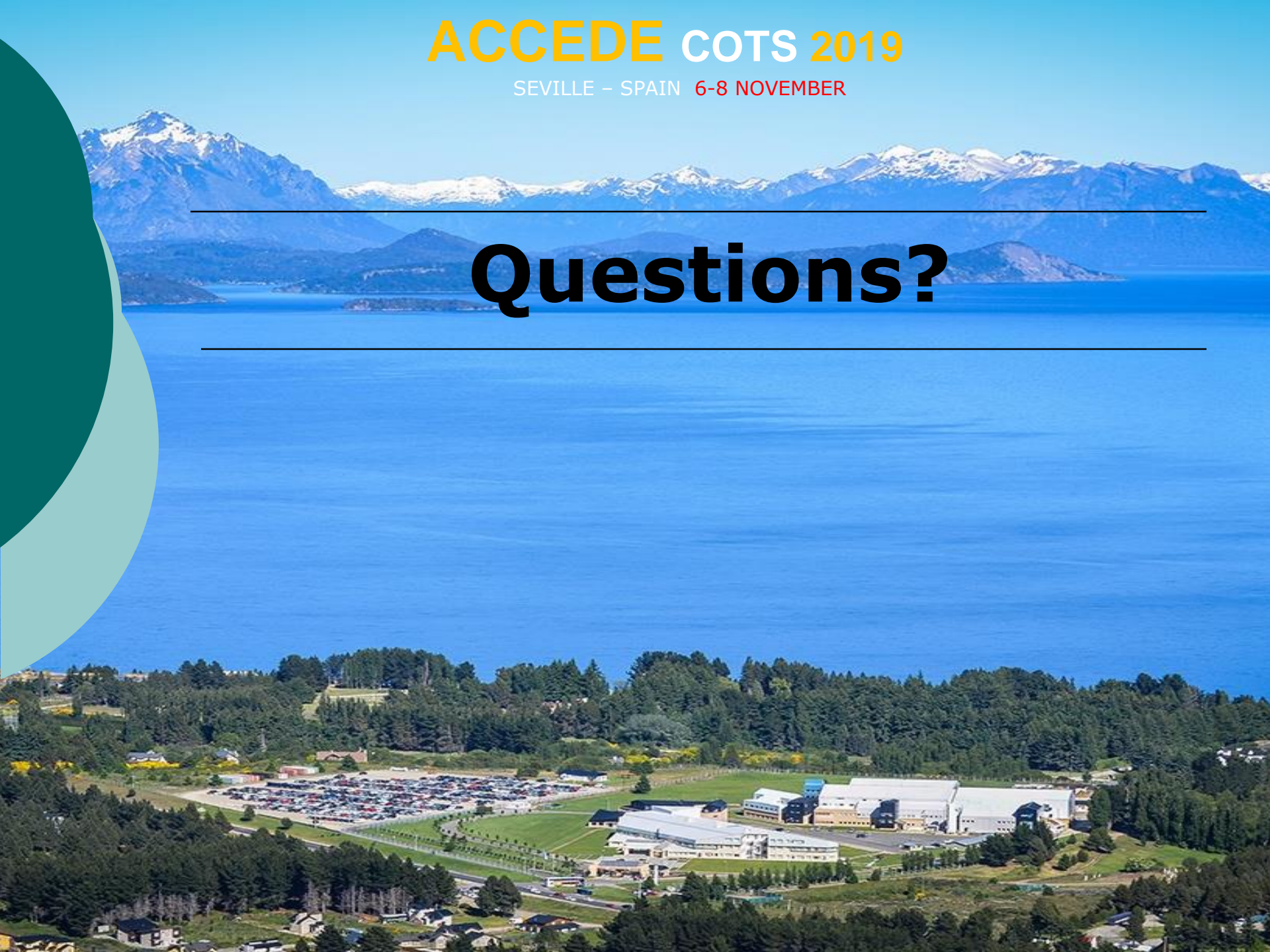
Conclusions

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**.

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Questions?



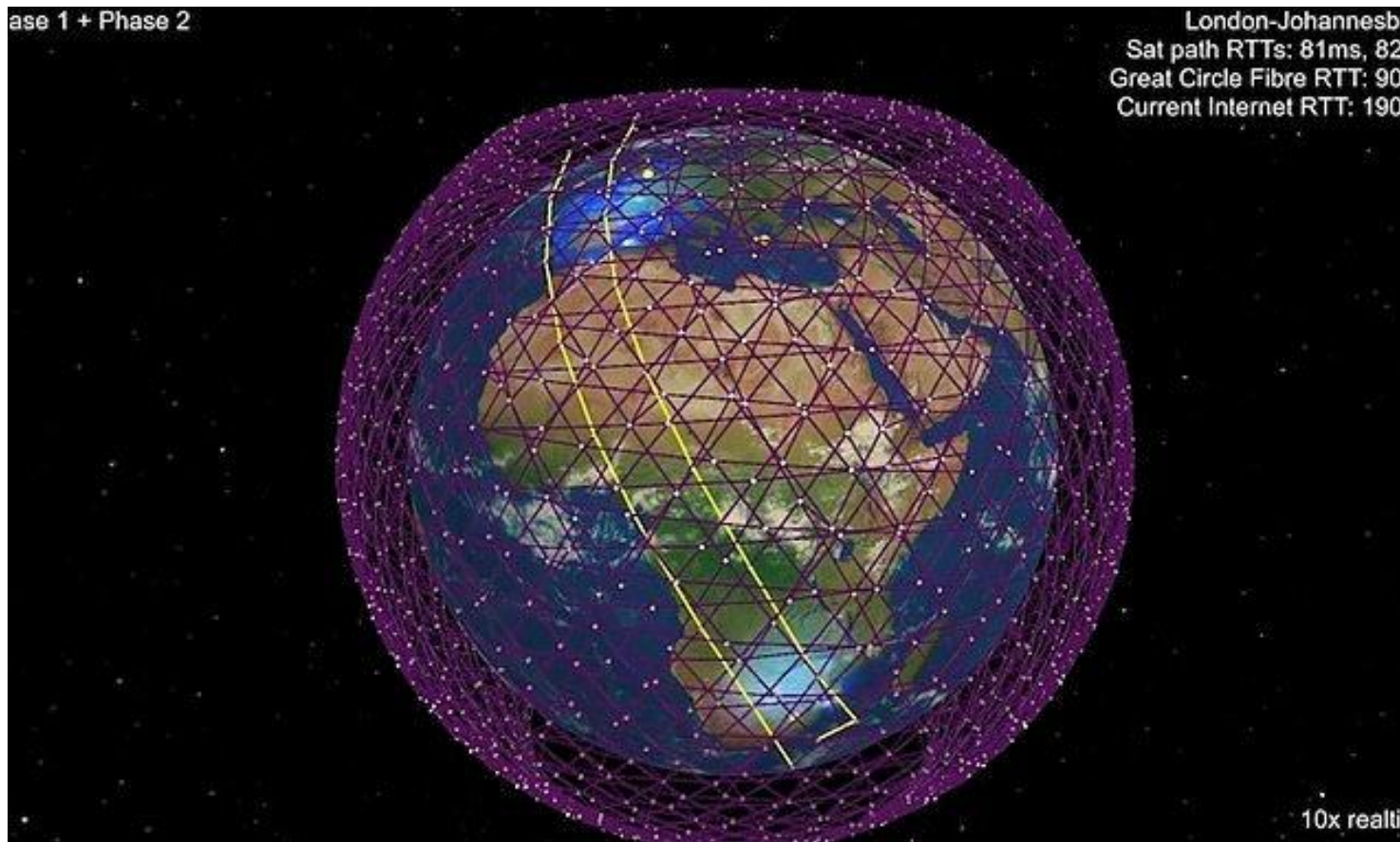


BACKUP SLIDES

New instrument: the “SmallSats” constellations

Phase 1 + Phase 2

London-Johannesbu
Sat path RTTs: 81ms, 82
Great Circle Fibre RTT: 90
Current Internet RTT: 190



10x realti

Lower production costs: automation and large-scale production

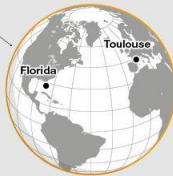
OneWeb Production

Design

The Design Office sends assembly and test instructions to digital displays in the clearroom, assuring design quality.

Global coverage

The complete constellation will operate from a low-Earth orbit at 1,200km and comprise 648 satellites, with 18 planes of 36 satellites to provide global internet access any time, anywhere.



The OneWeb Satellites production line

There are five main module workstations, each containing several smaller workstations. Two staff work at each station, with a total of 30 workstations within the Final Assembly Line. The current plan is for one shift a day, with the flexibility to expand to three as required.

A digital factory of the future



Cobots
Collaborative robots, designed to work with humans, help with the heavy lifting.



Smart tools
Geo-located tools recognise which bolts they are placed on. The factory's central software supplies the torque setting and logs the action.



Automatic Optical Inspection
Cameras compare assembled hardware with a database of correct assemblies. Automatic 3D scanners check geometry of critical areas.



Big Data
Statistical analysis of the data generated during production will help detect faults in the process early on.



Automatic coupling
Automated mechanical systems assemble the different satellite modules in perfect alignment.



Auto-guided vehicles
Trolleys travelling on predefined paths deliver components, satellite modules and completed satellites to different shop floor areas.



Automatic heater allocation
Infrared cameras validate that the heaters are correctly wired and bonded onto the spacecraft panel.



Augmented reality
3D elements from the digital mock-up are superimposed directly onto a work surface to assist the operator. Think Pokémon Go.



Automatic tests
The retractable connectors for electrical and functional tests connect automatically.

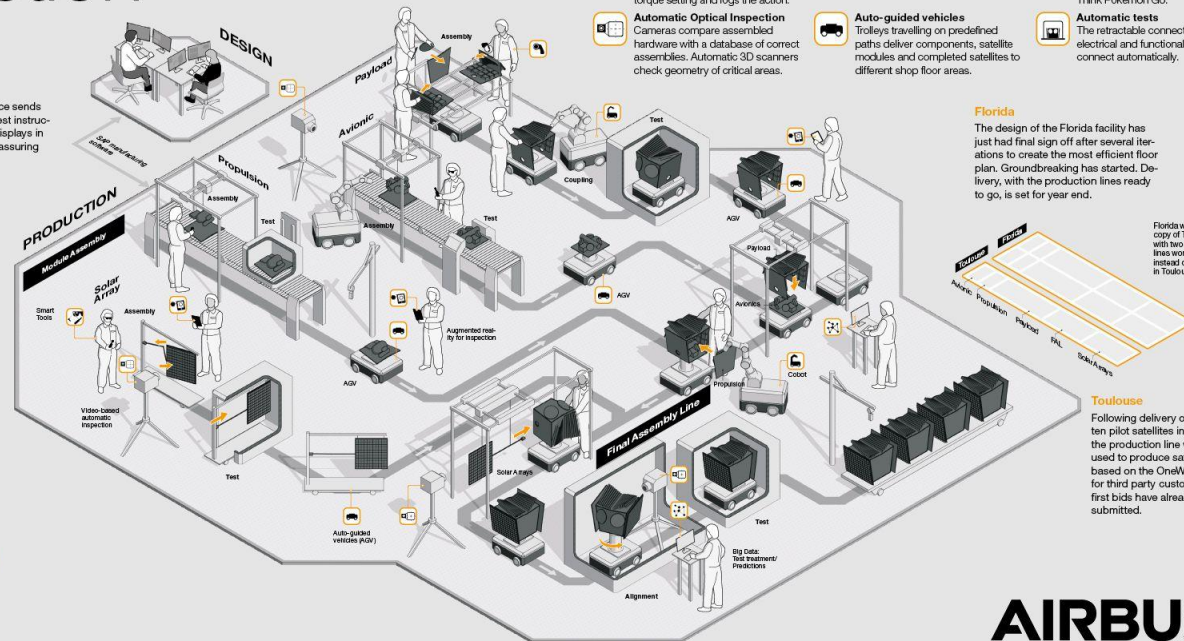
Florida

The design of the Florida facility has just had final sign off after several iterations to create the most efficient floor plan. Groundbreaking has started. Delivery, with the production lines ready to go, is set for year end.

Florida will be a carbon copy of Toulouse but with two assembly lines working in parallel instead of just the one in Toulouse.

Toulouse

Following delivery of the first ten pilot satellites in Toulouse, the production line will be used to produce satellites based on the OneWeb design for third party customers – first bids have already been submitted.



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Lower launch costs: lower satellite mass and size

