CHALLENGES AND OPPORTUNITIES WITH SMALL SATELLITES

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Sources

This presentation is based on proprietary information deriving from Euroconsult

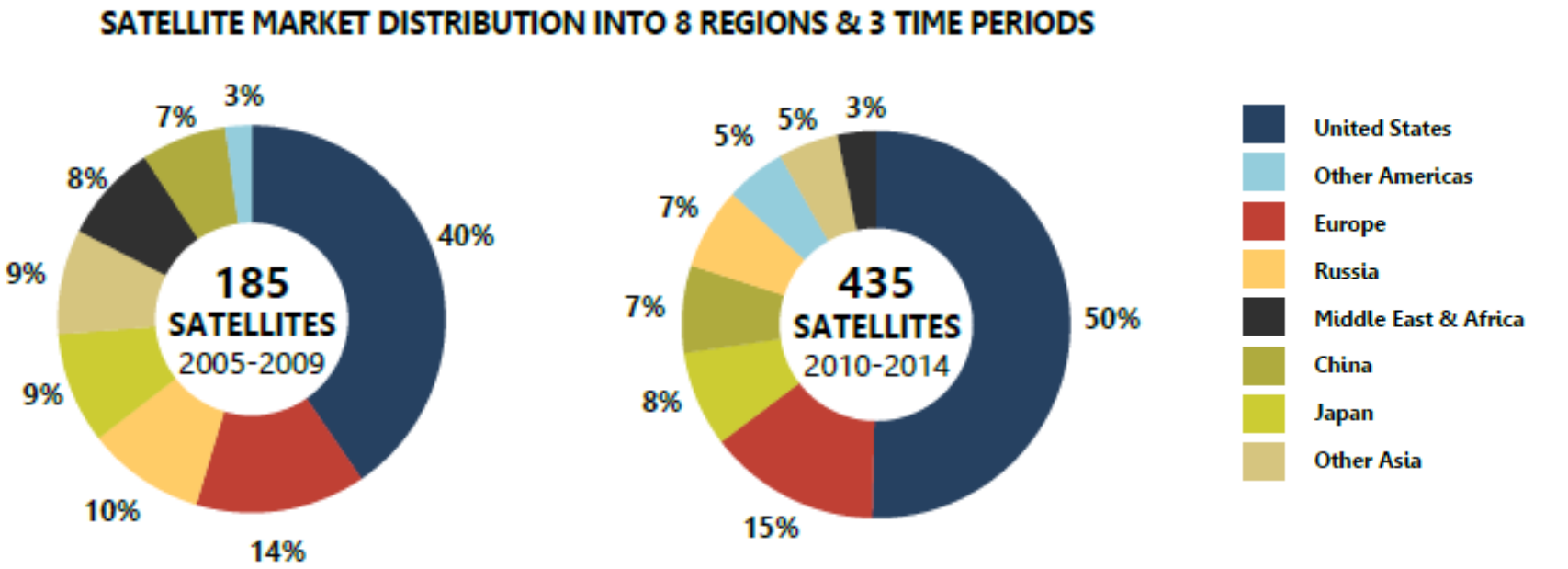
> internal research elements

> SmallSat research report

OUTLINE

- New Space and Small Satellites, the perfect story
- What is New Space?
- Are Small Satellites a real business?
- 10 years of Small Satellites
- What is next?
- Technological challenges in Small Satellites

New Space and small satellites, the perfect story



In the next 5 years Europe will increase its share up to ~26% and USA will be slightly lower (43%)

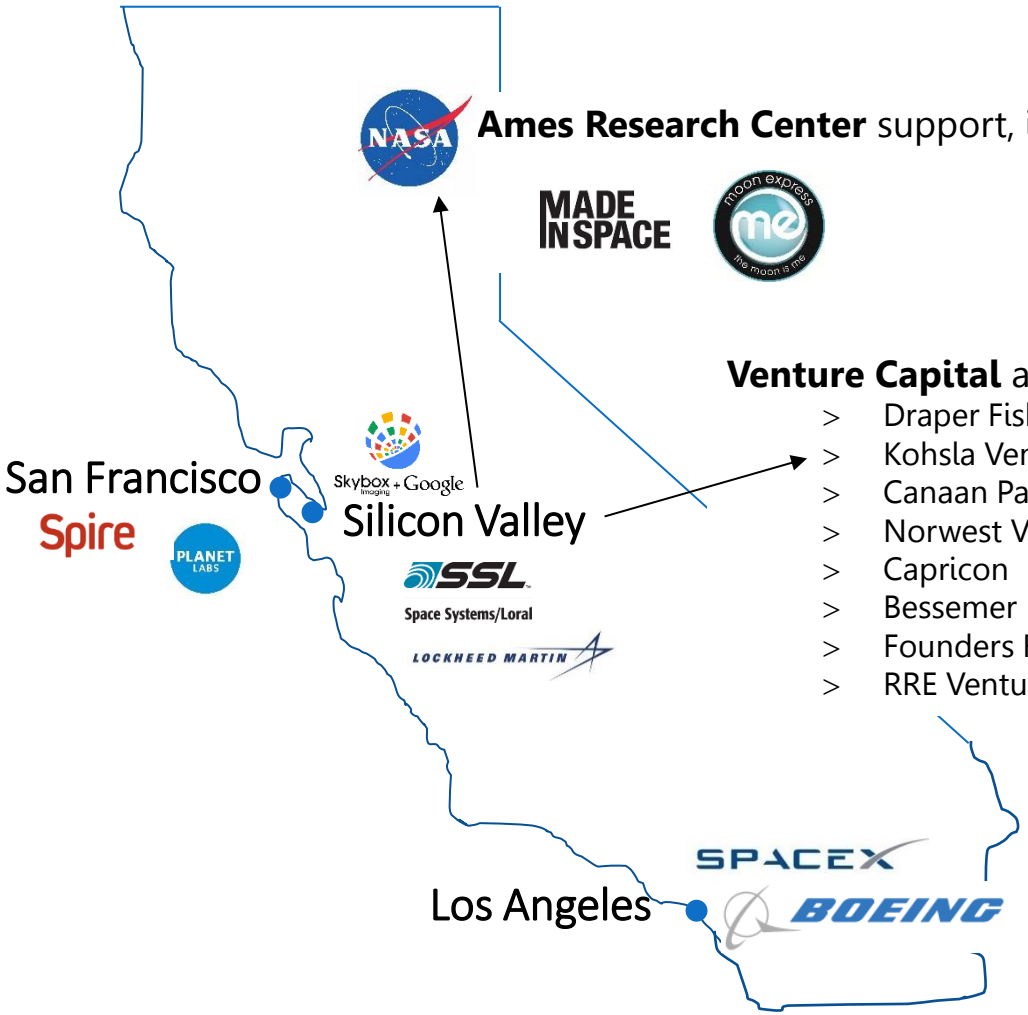
46% of those US satellites are used for commercial purposes

What is New Space?

	Creation	Emblematic Investor	Funds risen	Actions / strengths
SPACEX *Space transportation,* ***satcom constellation?***	2002	Elon Musk	~$470 M	New actor in the space transportation Service contract with NASA Diversification of client portfolio Future smallsats manufacturing
Skybox + Google *EO*	2009	Google	~$110 M, *acquired for $500 M by Google (2014)*	SW Development for EO Two launched satellites First commercial data distribution contracts obtained before Google's arrival
PLANET LABS *EO*	2010		~$65 M	Founded by former NASA employees Operartor of 100 cubesats constellation First partnership for data distribution
KYMETA *Antennae satcom*	2012 (*spin-off from IV)*	Bill Gates	~$82 M	Reception antennae made with nano-materials. Partnership with satelite operators Prototypes phases/ Test on going Industrial partnership with Sharp for the industrial phase

What is New Space?

CALIFORNIA, THE ECOSYSTEM OF NEW SPACE FOR ESTABLISHED COMPANIES AND NEWCOMERS



What is New Space?

A concept materializing in wave of investment

Private investors not yet involved in space activities commit money to develop systems/services thanks to:

- The US government leaves room to investors (i.e. stop funding new system development and instead purchase a service from a private operator) and boost the ecosystem
- Technological maturity allows to increase productivity or new uses

70s/80s

End of NASA's budget golden age, end of R&D telecom (ACTS)

Creation of private operators (e.g. PanAmSat), TDRSS commercial

90s

Private projects for telecom constellations (e.g. Ellipso), a domaine non participated by the government, ….. And so, for new private launch systems (e.g. Beal)

3 constellations funded (Iridium, Globalstar, Orbcomm); launcher projects were abandoned

2000s

Externalization to private sector, which is recognized by the government to be mature enough to fulfill their operational needs:

> 1st contract of imagery purchasing by NGA to DigitalGlobe, following a presidential directive

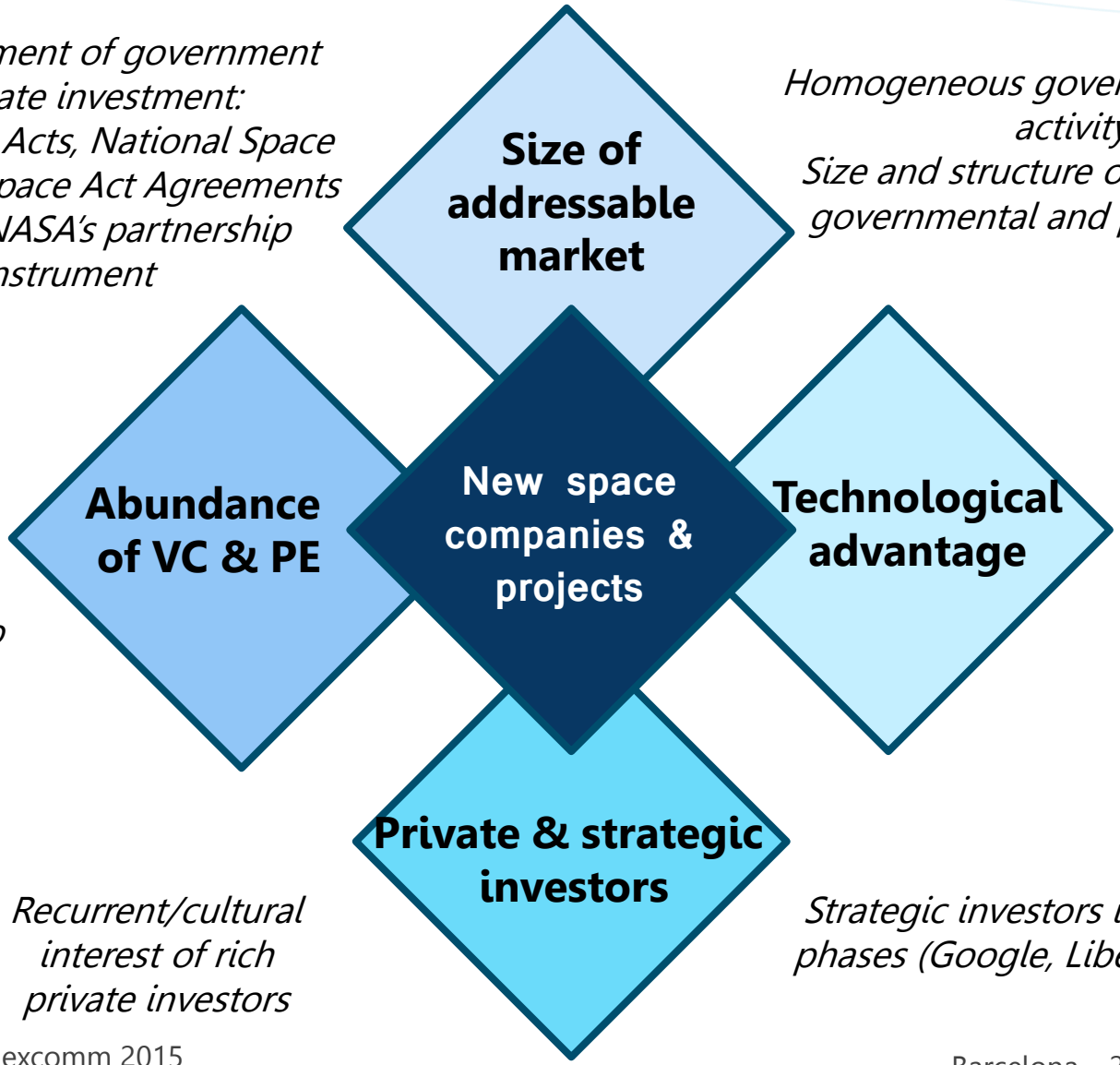
> 2 contracts NASA to SpaceX & Orbital Sciences for cargo delivery to ISS via COTS

What is New Space?

NEW SPACE'S INGREDIENTS MADE IN USA

Encouragement of government to private investment: Commercial Acts, National Space Policy, and Space Act Agreements (SSA) as NASA's partnership instrument

Homogeneous governance of space activity, Size and structure of the national, governmental and public market



~1 billion $ risen by Silicon Valley actors (from $20M to 500M)

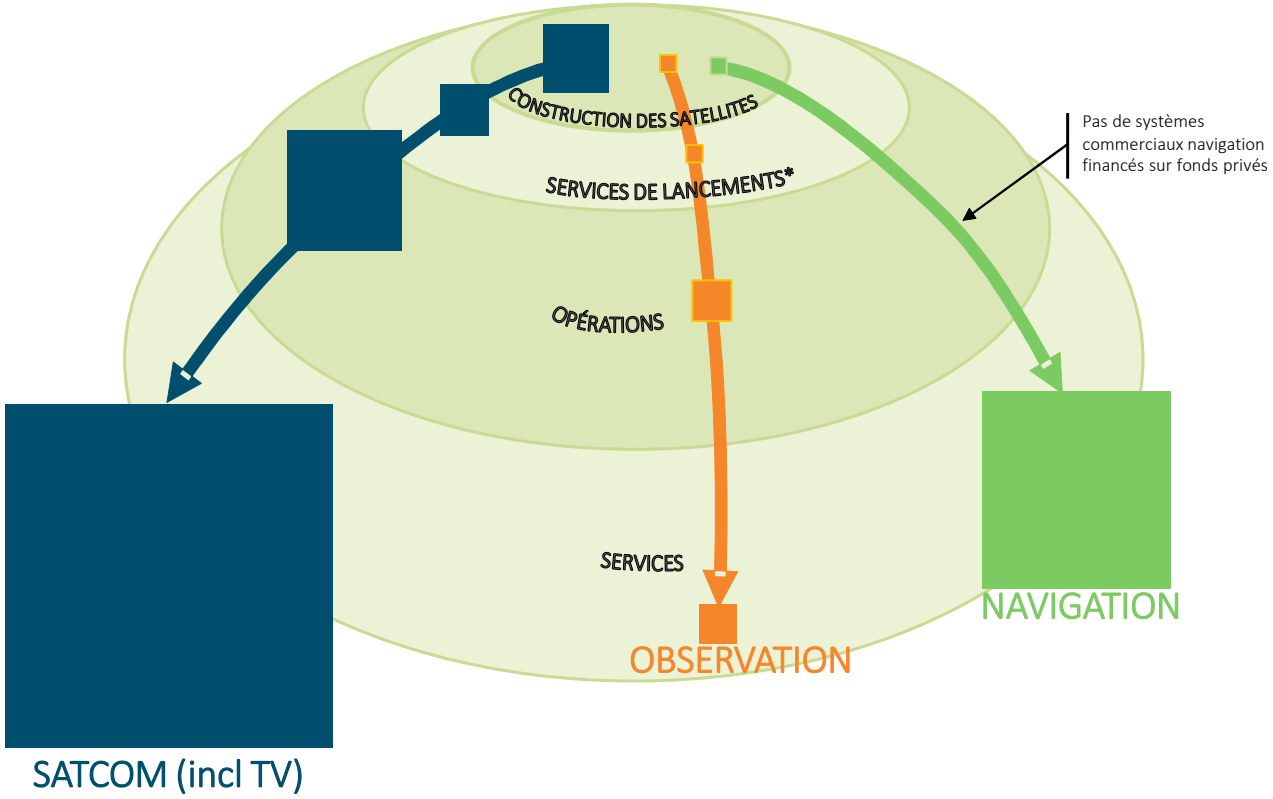
Possibility of technological and process innovation

Recurrent/cultural interest of rich private investors

Strategic investors in firsts project phases (Google, Liberty Media etc.)

Are Small Satellites a real business?

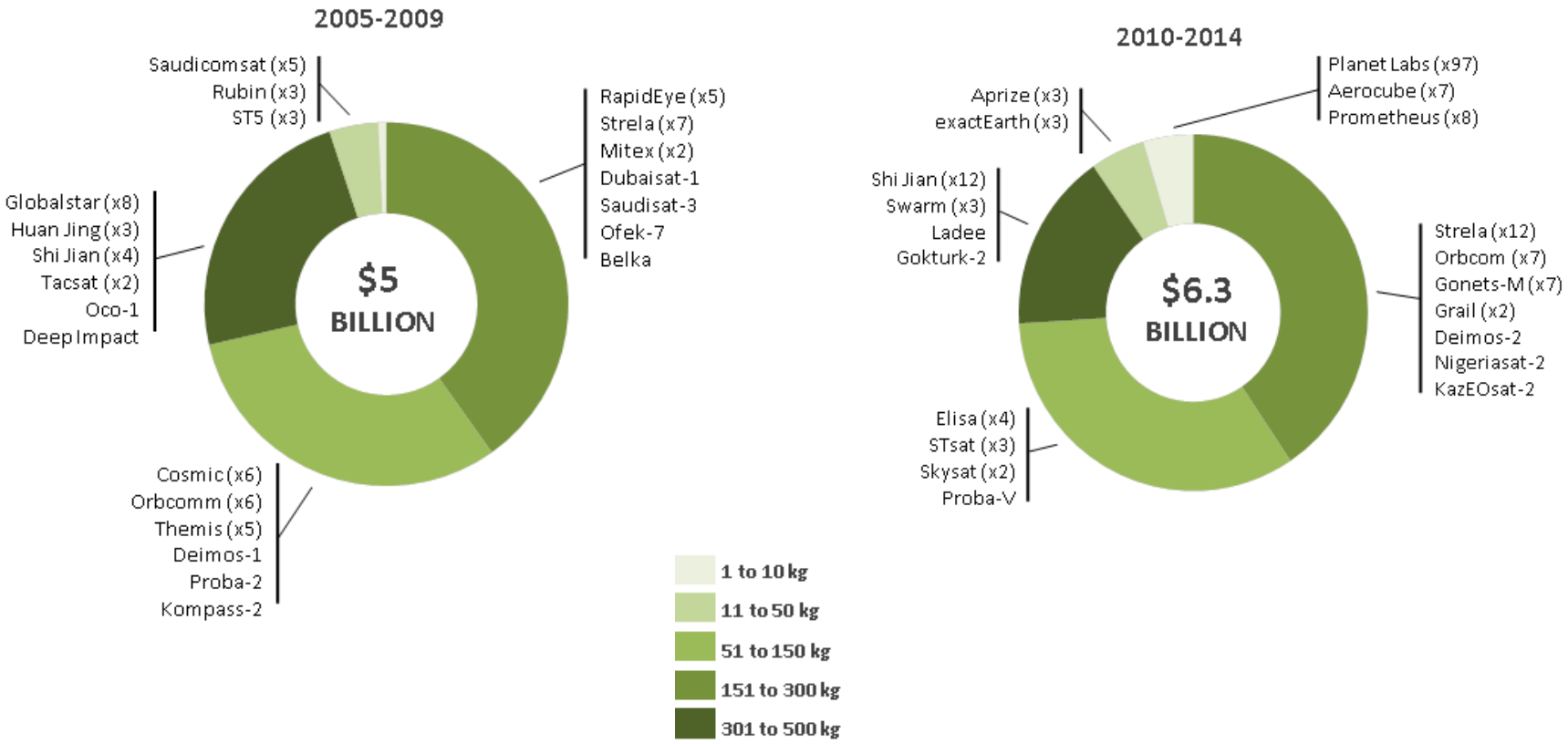
VALUE CHAIN IN SATELLITES WITH COMMERCIAL FINAL UTILIZATION (2013)



*Market value in 2013 billion € at launch

Are small satellites a real business?

PAST DECADE OF THE SMALLSAT MARKET IN TWO LAUNCH PERIODS



Are Small Satellites a real business?

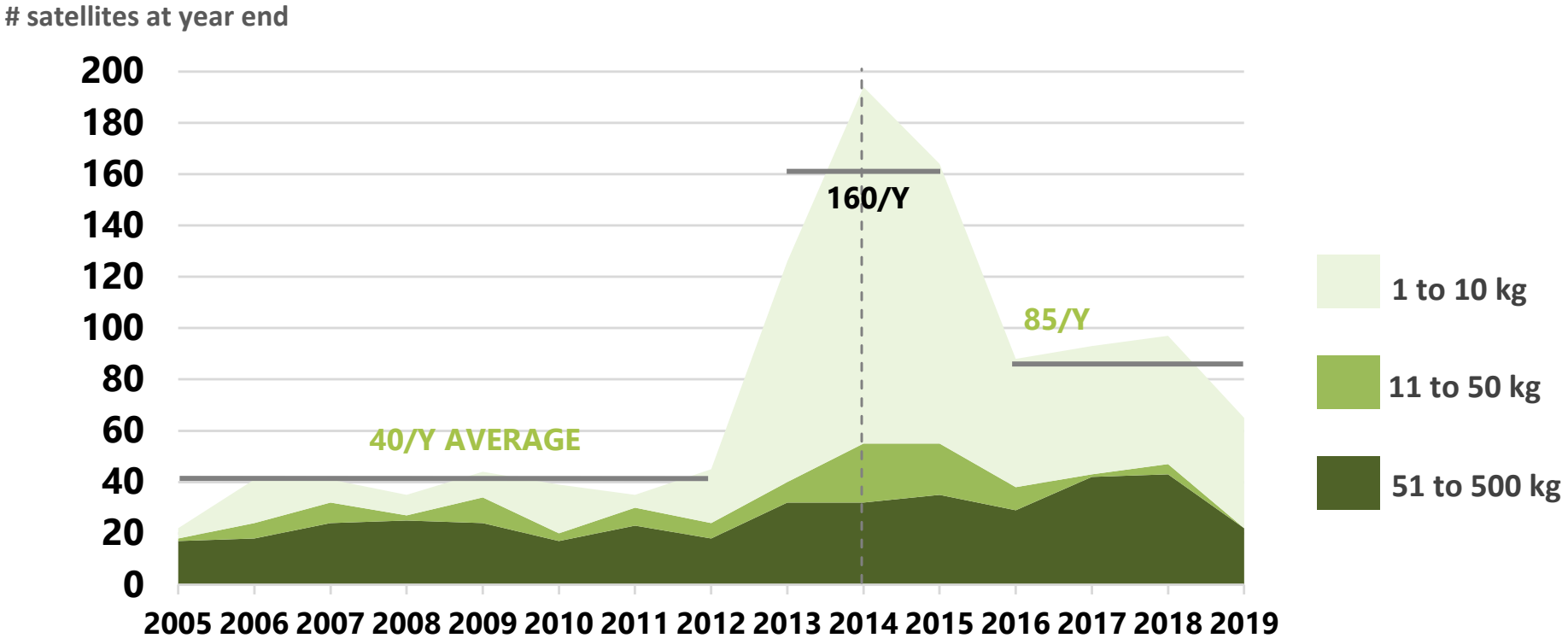
AND… WHAT IS NEXT?

AN INCREASE OF ~17% IS EXPECTED IN THE PERIOD 2015-2019

7.4 BILLION EXPECTED

YES WE CAN!

10 years of Small Satellites

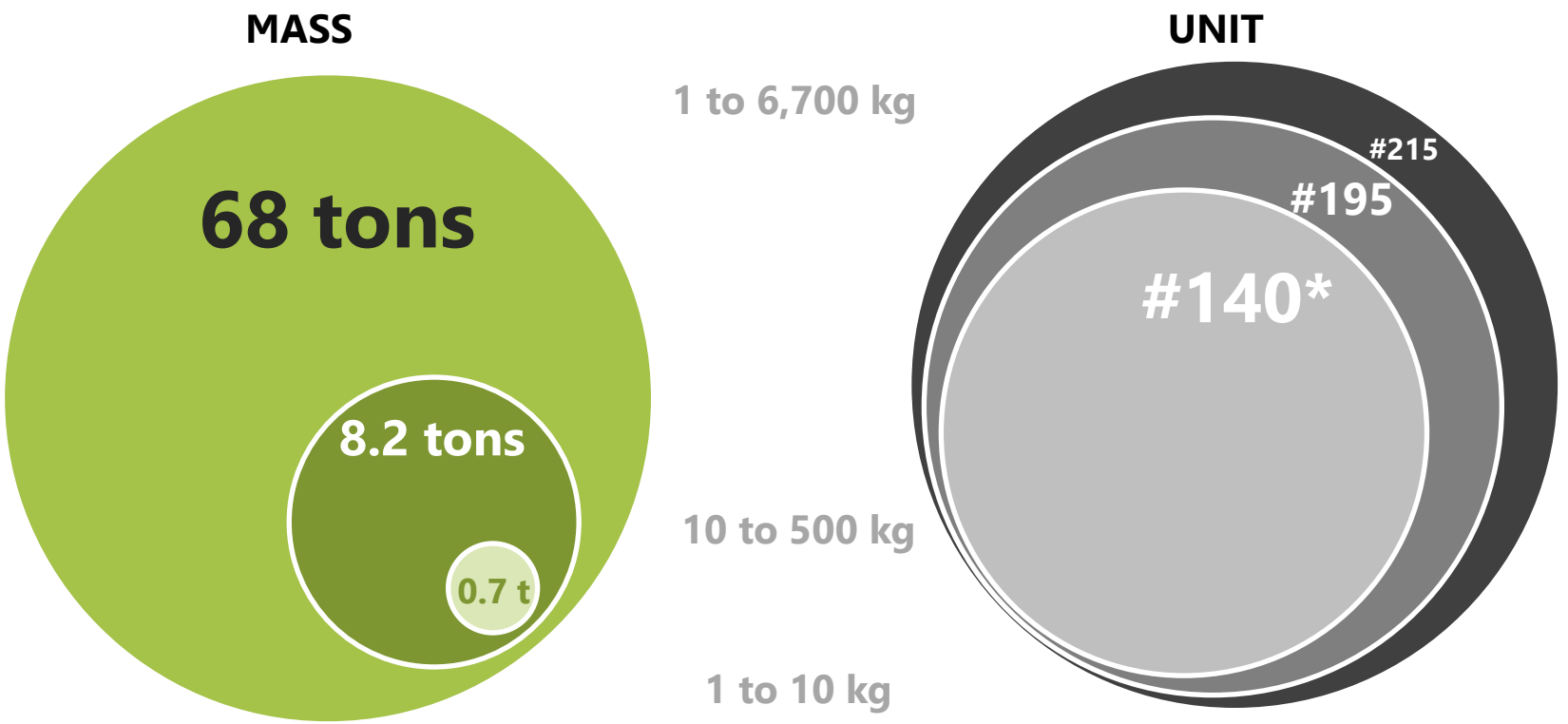


32 % FROM NANO SATELLITES COMES FROM UNIVERSITIES /ACADEMIC WORLD (2005-2019)

10 years of Small Satellites

LET'S ANALYZE 2014…

ALL SATELLITE MARKETS IN LOW EARTH ORBIT (LEO) IN 2014



* Including 93 cubesats for Planet Labs

What is next?

MEGA CONSTELLATIONS?

- There is a flurry of US commercial projects in the comsat, EOsat and metsat domains. Many believe that all are not fundable and that many changes are possible at different stages of the projets
  - No-go or merger possible at paper concept, qualif satellites, 1rst batch launch, 1G replenishment
- Constellations projects are mainly in competition for the same market (permanent metric imagery, met data with GSP-RO, AIS, IoT, M2M), however, with vastly different architectures and capex volumes
- Most of them have not yet selected a satellite manufacturer: except Skysat (SSL/MDA)
- Constellations are deployed in batches

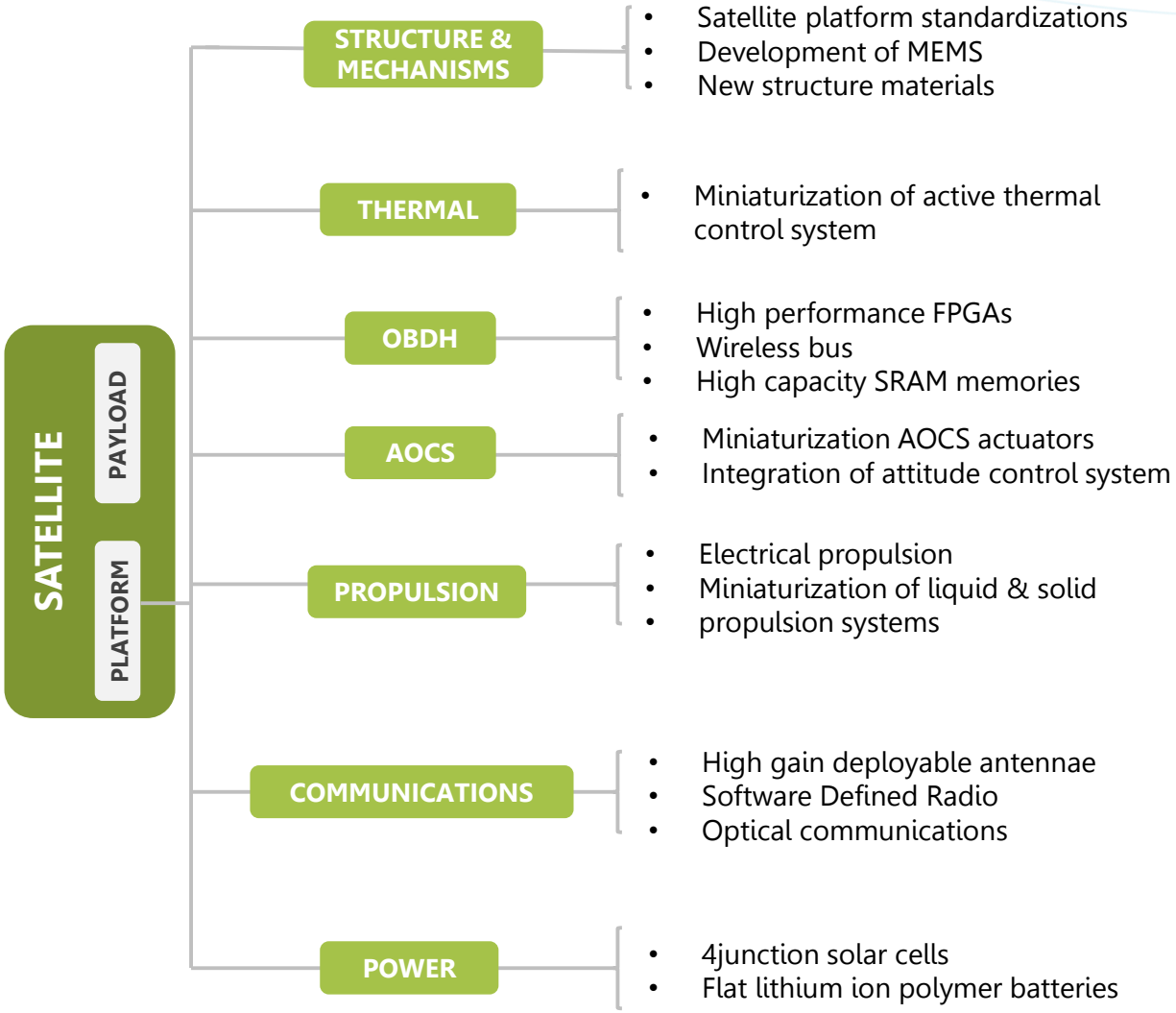
Smallsat constellations projects	EO and meteo missions	Telecom missions	Other missions
Cubesat/nanosat (< 20 kg launch mass)	• Planet Lab • Perseus • Spire	• Outernet	• QB50 • ESDN • S-Net
Microsat/minisat (< 500 kg)	• Skysat • BlackSky • OmniEarth • PlanetIQ • AxelGlobe	• OneWeb • SpaceX / Google • LeoSat • *+ 6 other ITU filings (see next page)*	• cygnss

What is next?

	OneWeb (L5)	No name	LeoSat	Steam 1&2	Comstellation	MCSat	CANPOL -2	3ECOM -1	ASK-1
Partners	Qualcomm, Virgin Galactic, Honeywell	SpaceX, Google, Fidelity	TAS			Thales			
System	648 sats 200 kg 1,200 km	4,025 sats 300-400 kg 1,100 km	80 then 120-140 sats 1,800 km	4,257 sats in 43 planes	794 sats 12 planes	800 to 4,000 sats	72 sats 8 planes	264 sats 12 planes	10 sats

- At least 9 projects to provide communications anywhere on Earth with smallsat constellations have been filed at the ITU
- One project more visible than the others because it is supported by one GAFA company (Google). The GAFA companies study all comm infrastructure solutions to expand the reach for their services
- The two most advanced projects are OneWeb and LeoSat: both are backed by entrepreneurs that are not new to space technology (O3b and Kymeta)
- A new paradygm for the satellite suppliers which may become risk partners in the projects and also satellite operators (make/buy decision of operation service)

Technological challenges



Technological challenges

LAUNCHERS

HEAVY LIFT

MEDIUM LIFT

- ***ADAPTERS (ESPA for ATLAS 5, DELTA4 & FALCON 9)***
- ***SPACE TUGS***
- ***ISS (NASA'S NLAS, 12 QUADPACK…)***

DEDICATED LAUNCHERS

- ***AIR LAUNCHED (Launcher One, SOAR…)***
- ***SMALL LAUNCHER (Rocket Lab's Electron,Firefly Alpha …)***
- ***ADAPTERS (i.e. for multiple nanosats)***
- ***DIRECT LAUNCH (one smallsat)***

THANKS FOR YOUR ATTENTION

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