CHALLENGES AND OPPORTUNITIES WITH SMALL SATELLITES
This presentation is based on proprietary information deriving from Euroconsult

- internal research elements
- SmallSat research report
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?

<table>
<thead>
<tr>
<th>Creation</th>
<th>Emblematic Investor</th>
<th>Funds risen</th>
<th>Actions / strengths</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>SpaceX</td>
<td>~$470 M</td>
<td>New actor in the space transportation, Service contract with NASA, Diversification of client portfolio, Future smallsats manufacturing</td>
</tr>
<tr>
<td>2009</td>
<td>Google</td>
<td>~$110 M, acquired for $500 M by Google (2014)</td>
<td>SW Development for EO, Two launched satellites, First commercial data distribution contracts obtained before Google’s arrival</td>
</tr>
<tr>
<td>2010</td>
<td>Planet Labs</td>
<td>~$65 M</td>
<td>Founded by former NASA employees, Operator of 100 cubesats constellation, First partnership for data distribution</td>
</tr>
<tr>
<td>2012</td>
<td>Kynta</td>
<td>~$82 M</td>
<td>Reception antennae made with nano-materials, Partnership with satellite operators, Prototypes phases/ Test on going, Industrial partnership with Sharp for the industrial phase</td>
</tr>
</tbody>
</table>

*Space transportation, satcom constellation?*

*Skybox + Google*

*EO*

*SPACEX* 

*Antennae satcom* 

*Euroconsult - Nexcomm 2015*
What is New Space?

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

San Francisco

Silicon Valley

Los Angeles

Ames Research Center support, including:

Venture Capital actives in New Space:
- Draper Fisher Jurveston
- Kohsla Ventures
- Canaan Partners
- Norwest Venture
- Capricon
- Bessemer
- Founders Fund
- RRE Ventures
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

End of NASA’s budget golden age, end of R&D telecom (ACTS)
Creation of private operators (e.g. PanAmSat), TDRSS commercial

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

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
- ~1 billion $ risen by Silicon Valley actors (from $20M to 500M)
- Recurrent/cultural interest of rich private investors
- Private & strategic investors
- Abundance of VC & PE
- Size of addressable market
- Technological advantage
- Possibility of technological and process innovation
- Strategic investors in firsts project phases (Google, Liberty Media etc.)

Euroconsult - Nexcomm 2015
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

**2005-2009**
- Globalstar (x3)
- Huan Jing (x3)
- Shi Jian (x4)
- TacSat (x2)
- Oco-1
- Deep Impact
- Cosmic (x6)
- Orbcomm (x6)
- Themis (x5)
- Deimos-1
- Proba-2
- Kompass-2
- Saudisat (x5)
- Rubin (x3)
- ST3 (x3)
- RapidEye (x5)
- Strela (x7)
- Mitex (x2)
- Dubaisat-1
- Saudisat-3
- Ofek-7
- Belka

**$5 BILLION**

**2010-2014**
- Shi Jian (x12)
- Swarm (x3)
- Ladee
- Gokturk-2
- Elisa (x4)
- STSat (x3)
- Skysat (x2)
- Proba-V
- Planet Labs (x97)
- Aerocube (x7)
- Prometheus (x8)
- Strela (x12)
- Orbcomm (x7)
- Gonets-M (x7)
- Crail (x2)
- Deimos-2
- Nigerialsat-2
- KazEDsat-2

**$6.3 BILLION**

Legend:
- 1 to 10 kg
- 11 to 50 kg
- 51 to 150 kg
- 151 to 300 kg
- 301 to 500 kg
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

MASS

68 tons

8.2 tons

0.7 t

UNIT

1 to 6,700 kg

10 to 500 kg

1 to 10 kg

* Including 93 cubesats for Planet Labs

* Euroconsult - Nexcomm 2015
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 projects
  - 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

<table>
<thead>
<tr>
<th>Smallsat constellations projects</th>
<th>EO and meteo missions</th>
<th>Telecom missions</th>
<th>Other missions</th>
</tr>
</thead>
</table>
| 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?

<table>
<thead>
<tr>
<th>Partners</th>
<th>OneWeb (L5)</th>
<th>No name</th>
<th>LeoSat</th>
<th>Steam 1&amp;2</th>
<th>Comstellation</th>
<th>MCSat</th>
<th>CANPOL -2</th>
<th>3ECOM -1</th>
<th>ASK-1</th>
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<td>Qualcomm, Virgin Galactic, Honeywell</td>
<td>SpaceX, Google, Fidelity</td>
<td>TAS</td>
<td></td>
<td></td>
<td></td>
<td>Thales</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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<table>
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<tr>
<th>System</th>
<th>OneWeb (L5)</th>
<th>No name</th>
<th>LeoSat</th>
<th>Steam 1&amp;2</th>
<th>Comstellation</th>
<th>MCSat</th>
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<tr>
<td>648 sats</td>
<td>4,025 sats</td>
<td>80 then 120-140 sats</td>
<td>4,257 sats</td>
<td>794 sats</td>
<td>800 to 4,000 sats</td>
<td>72 sats</td>
<td>264 sats</td>
<td>10 sats</td>
<td></td>
</tr>
<tr>
<td>200 kg 1,200 km</td>
<td>300-400 kg</td>
<td>1,800 km</td>
<td>43 planes</td>
<td>12 planes</td>
<td>8 planes</td>
<td></td>
<td></td>
<td></td>
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<td>1,200 km</td>
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- 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 paradigm for the satellite suppliers which may become risk partners in the projects and also satellite operators (make/buy decision of operation service)
Technological challenges

- **POWER**
  - 4junction solar cells
  - Flat lithium ion polymer batteries

- **COMMUNICATIONS**
  - High gain deployable antennae
  - Software Defined Radio
  - Optical communications

- **PROPULSION**
  - Electrical propulsion
  - Miniaturization of liquid & solid propulsion systems

- **OBDH**
  - High performance FPGAs
  - Wireless bus
  - High capacity SRAM memories

- **AOCS**
  - Miniaturization AOCS actuators
  - Integration of attitude control system

- **THERMAL**
  - Miniaturization of active thermal control system

- **STRUCTURE & MECHANISMS**
  - Satellite platform standardizations
  - Development of MEMS
  - New structure materials

- **PLATFORM**
Technological challenges

LAUNCHERS

HEAVY LIFT

ADAPTERS (ESPA for ATLAS 5, DELTA4 & FALCON 9)

MEDIUM LIFT

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

Santiago Pérez, Consultant