



SmallSats mission opportunities for the Vega launch system: the Small Spacecraft Mission Service

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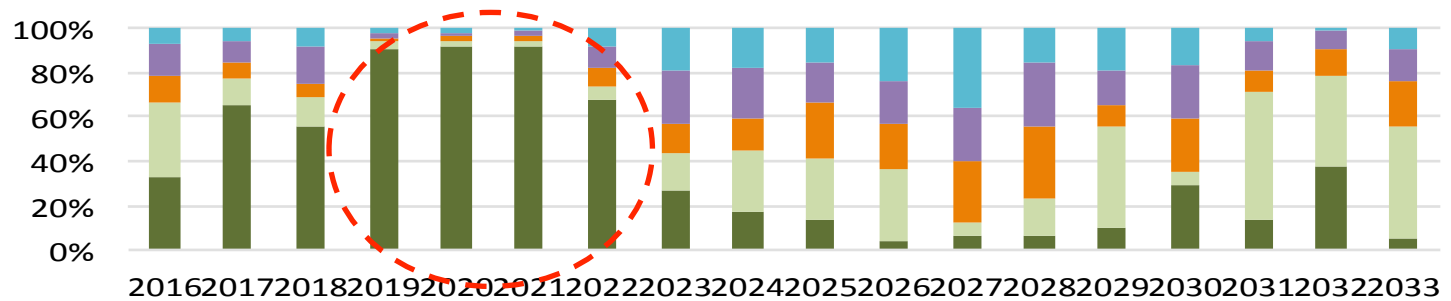
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Small Spacecraft Mission Service

SmallSat market forecast



AVIO courtesy



■ X-Small (100 kg > 350 kg) ■ Very Small (350 kg > 850 kg) ■ Small (850 kg > 1,500 kg)
■ Medium (1,500 kg > 4,000 kg) ■ Large (4,000 kg > 5,500 kg)

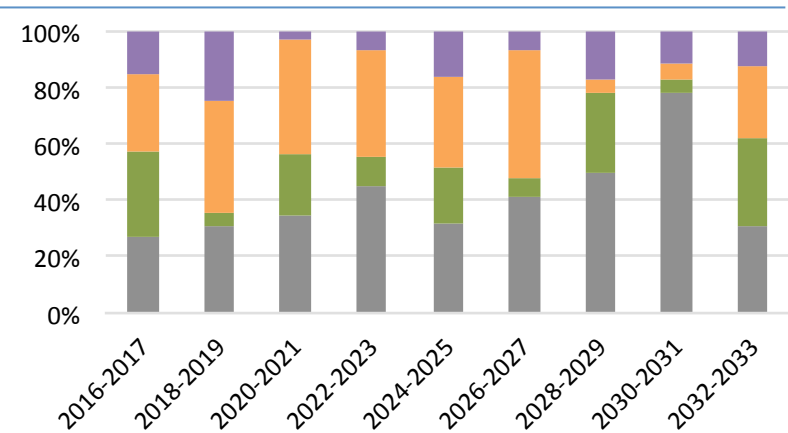
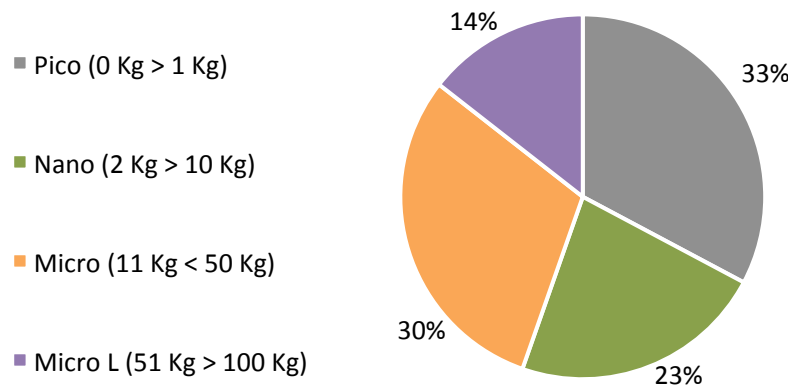
- **Major consulting Offices agree on clear SmallSat market increase next 5 years: 2017 - 2022 (short term)**
- **In particular MiniSats class 100-350 Kg will see a steep increase due to the entry on market of Constellations and Mega Constellations currently in development**
- **Recent study updates (ESA-2016) suggest trend will be maintained also at medium term (2022 – 2027)**

Small Spacecraft Mission Service

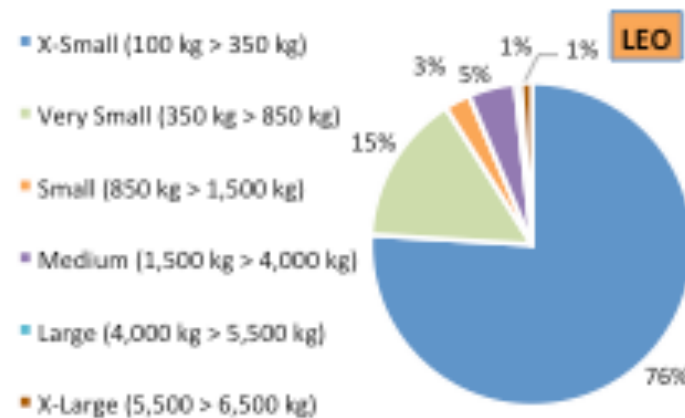
SmallSat market forecast

AVIO courtesy

Projected ≤ 100 Kg Payloads by mass class (2016-2033)



- **Microsats in the range of up to 100 Kg will cover almost 30% of the SmallSats market**
- **Up to 350 Kg mass, SmallSats will dominate LEO launch requests in number**

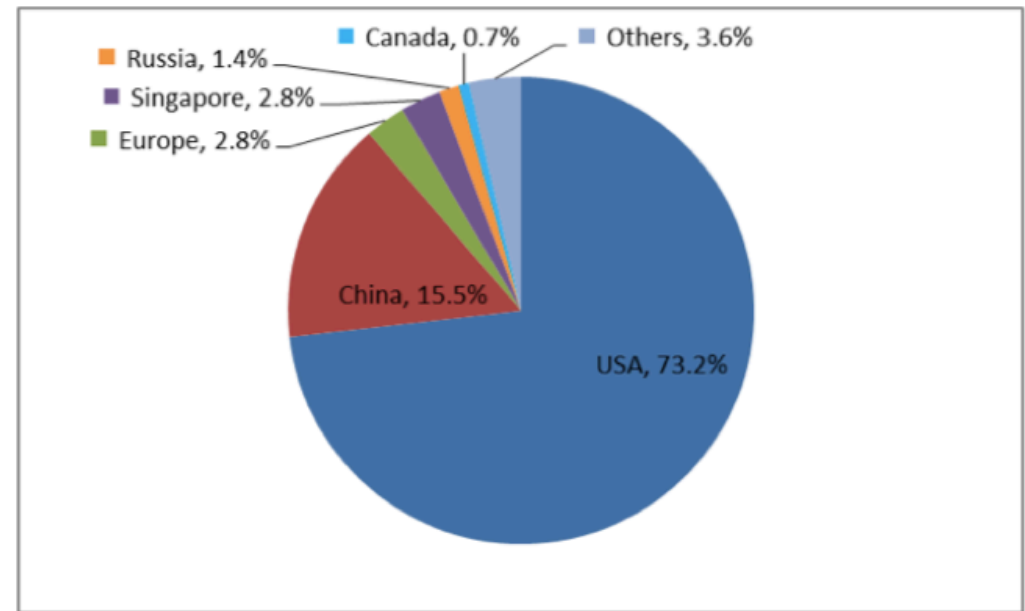


Small Spacecraft Mission Service

SmallSat market forecast



- **A large majority of SmallSat business will come from US in the next 5-10 years**
- **Therefore, initiatives devoted to implement this launch service shall take this element into account**
- **US launch prices will be the benchmark for SmallSat launch business**



Small Spacecraft Mission Service International competition



New launch systems in development or in initial exploitation

- **NASA Awards Venture Class Launch Service (VCLS) contracts to provide SmallSat access to LEO. Three selected companies:**

➤ **FIREFLY SPACE SYSTEM**

➤ >> Alpha Launcher Vehicle, two liquid stages (Q1/2018)

- **Launch rate: 12 - 52 launches/year**
- **Commercial Offering: 400 Kg @ 500 Km SSO (\$9M)**
- **Status: LOX/Ke Aerospike engine (1st stage) test fired.**

➤ **VIRGIN GALACTIC**

➤ >> LAUNCHER ONE, two liquid stages (Q4/2017)

- **Released by a dedicated reusable carrier aircraft 747 "COSMIC GIRL" at ≈ 11.000m. Two liquid stages complete the spacecraft(s) delivery to desired orbit and then deorbited.**
 - **Launch rate: 12 - 52 launches/year**
 - **Commercial Offering: 300 Kg @ 500km SSO (\$10M)**
 - **Status: 747 COSMIC GIRL customisation to be a "Flying launch site" ongoing.**

➤ **ROCKET LAB**

➤ >> Electron, two liquid stages (Q1/2017 - VCLS in July 2017)

- **Launch rate: 52 launches/year**
- **150kg @ 500km SSO (\$4.9M) - 1U Cubesat from \$50k; 3U Cubesat from \$180k**

**Status: Second stage qualification tests completed; First stage qualification tests ongoing;
Campaign of three test flights.**

Small Spacecraft Mission Service International competition



New launch systems in development or in initial exploitation

- **CASC (China)** >> LONG MARCH
- Long March 6, 3 liquid stages (19 Sept 2015) - N.20 SmallSats released in SSO
- Long March 11, 3 solid stages + 1 liquid stage (25 Sept 2015) – N.4 Micro Satellites released in SSO
- Prices of Long March program not available

- **SPACEFLIGHT** >> Falcon 9 "2017 Sun Synch Express" Mission *
- Dedicated Rideshare mission: Spaceflight aggregate of SmallSats to be delivered in SSO
- (5kg 3U CubeSats << >> 575 kg).
- Falcon 9 Launch price \$62M*
- 3U CubeSat ≈ \$250K, 50kg SmallSat ≈ \$2M, 150kg SmallSat ≈ \$5M

*Official Falcon 9 launcher price (SpaceX web site)

Understanding SmallSat Customer Needs

- **GUARANTEED AND TIMELY ACCESS TO SPACE >>**
not feasible with Piggy Back concepts
- **AFFORDABLE LAUNCH PRICE STANDARDS >>**
to tailor current launch preparation processes
- **DIVERSITY OF REQS >>**
commercial vs. Institutional/Education stds

Anticipating SmallSat ride-share missions constraints

➤ **SPACE DEBRIS LIMITATIONS**>>

most SmallSats have no on-board propulsion >>
orbit altitude constrains

➤ **SHORT AND LONG TERM COLLISION RISKS**>>

Short term: complex separation sequence

Long term: limits on # of SCs separations on same orbit
and orbit selection constraints

>> versatile upper stage, limited # of SCs in aggregate

Launch systems operational capability

Launch systems

- **HEAVY LIFTERS** >> high energy availability, lower Euro/Kg, ride share with high # of SCs but complex aggregate and mission preparation, low flexibility
- **MICRO LAUNCHERS** >> new concept, launch cost namely attractive provided prod. rate high, none currently available, several initiatives on going
- **SMALL LAUNCHERS** >> existing concepts suited for majority of SmallSats orbital reqs (LEO), compromise between two above cases, need limited # of SC in the aggregate to reach positive business case

Operational tailoring to SmallSats

- Independent from launch system choice, **OPERATIONAL TAILORING** is key to enable launch of **SMALLSAT MISSIONS**
- Not all launchers worldwide can ensure both guaranteed and timely access to space at affordable prices since not operationally tailored to perform dedicated SmallSat missions

Innovation on mission service is a primary enabling element for SmallSat launches

Vega Launch system – VERTA flights

Flexibility demonstration flights to secure the competitiveness of the Vega launcher through a smooth learning approach

- one robust and stable configuration of the launch vehicle dimensioned for a wide range of missions;
- implementation of the multi-payload configuration;
- flight data and testing experiences to improve reliability, refine margins, strengthen technology.



VV02 – May 7, 2013

Qualification status of the launch System certified at Post VERTA FQR

- Qualified perimeter and relevant justifications
- Reserves to Qualification, Limitations of Use
- Functional files updated based on Flight data
- Mathematical models and simulators calibrated
- Complete set of guidelines as outcomes from the qualification process to guarantee the operability of the Launch System (definition of boundaries and requirements)



VV03 – Apr 29, 2014



VV04 – Feb 11, 2015



VV05 – June 23, 2015



VV06 – Dec 3, 2015

Vega C Launch system

Objectives:

- Consolidating the VEGA position against competitors in terms of performance to capture market up to radar satellite (i.e. > 800 kg with respect to the current version at the same reference orbit, 700 km PEO), without increasing exploitation costs;
- Reducing the VEGA dependency on non-European sources by introducing European equipment and components, without increasing exploitation costs.

Status:

- VEGA-C Launch System RKP(SRR) – Completed on 12/2015
- VEGA-C Launcher System PDR – Completed on 03/2016
- VEGA-C+ Launcher System CKP – Completed on 04/2016
- VEGA-C+ Launcher System Delta-PDR – Planned on 10/2016
- VEGA-C+ Launch Base GPM PDR – Planned on 10/2016
- VEGA-C+ Launch System SDR(PDR) – Planned on 12/2016
- VEGA-C+ Launch System Phase-C/D Start – Planned on 01/2017

Short Term Priorities:

- Completing the industrial negotiations for VEGA-C+ by 10/2016



Objective

- ***TO DEVELOP A TAILORED MISSION SERVICE OPERATIONAL CAPABILITY WITH THE VEGA SYSTEM***
- ***SUITABLE TO GUARANTEE ACCESS TO SPACE TO SMALLSAT USERS AND OWNERS***
- ***TO THIS END, IN COLLABORATION WITH ARIANESPACE, DEFINE AND MAINTAIN A COMPETITIVE BUSINESS CASE***

Ground rules: on going work

- **Standardisation of SmallSat requirements**, in collaboration with main Players (i.e.: **Customers and Operators**)
- Development of **standardised and modular launcher elements** dedicated to SmallSat missions to minimise missioning needs
- **Innovation on missioning and launch preparation technologies and processes**
- Adoption of **marketing and commercial policy** adapted to SmallSat business case, linked tight with **DTC approach** to development and industrial activities

Continuous up-to-date business case studies all along development of mission service will enable realistic SmallSat launches

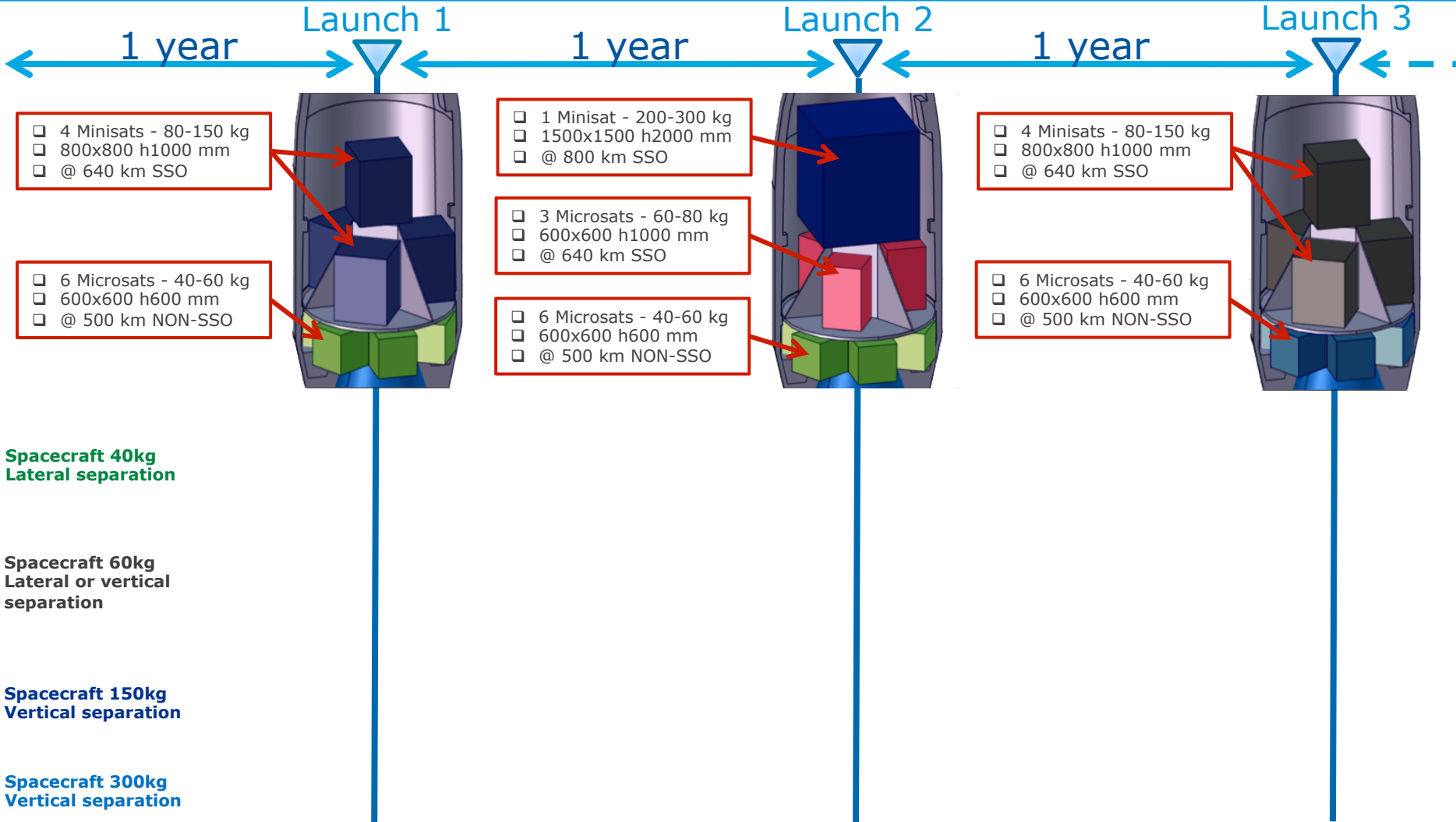
VEGA Bus Service to Space

- *To define pre-planned launch dates according to launch rate capability and **Arianespace** exploitation manifest*
- *To issue AOs accordingly*
- *To allocate well in advance to launch date, optimised PL aggregates to each launch*
- *To define advanced overbooking and replacement logic to mitigate risks of SC withdrawals or delays*
- *To define a tailored launch price list based not only on SC mass/dimensions but also on requested services*
- *To enable Missions Service modularity to cover both FLEXI (Rideshare) and PIGGY BACK missions according to **Arianespace** needs, to develop Dispenser modularity accordingly*
- *To enable ride share launch of at least **15 SmallSats on Vega**, increased on VegaC*

Vega SSMS

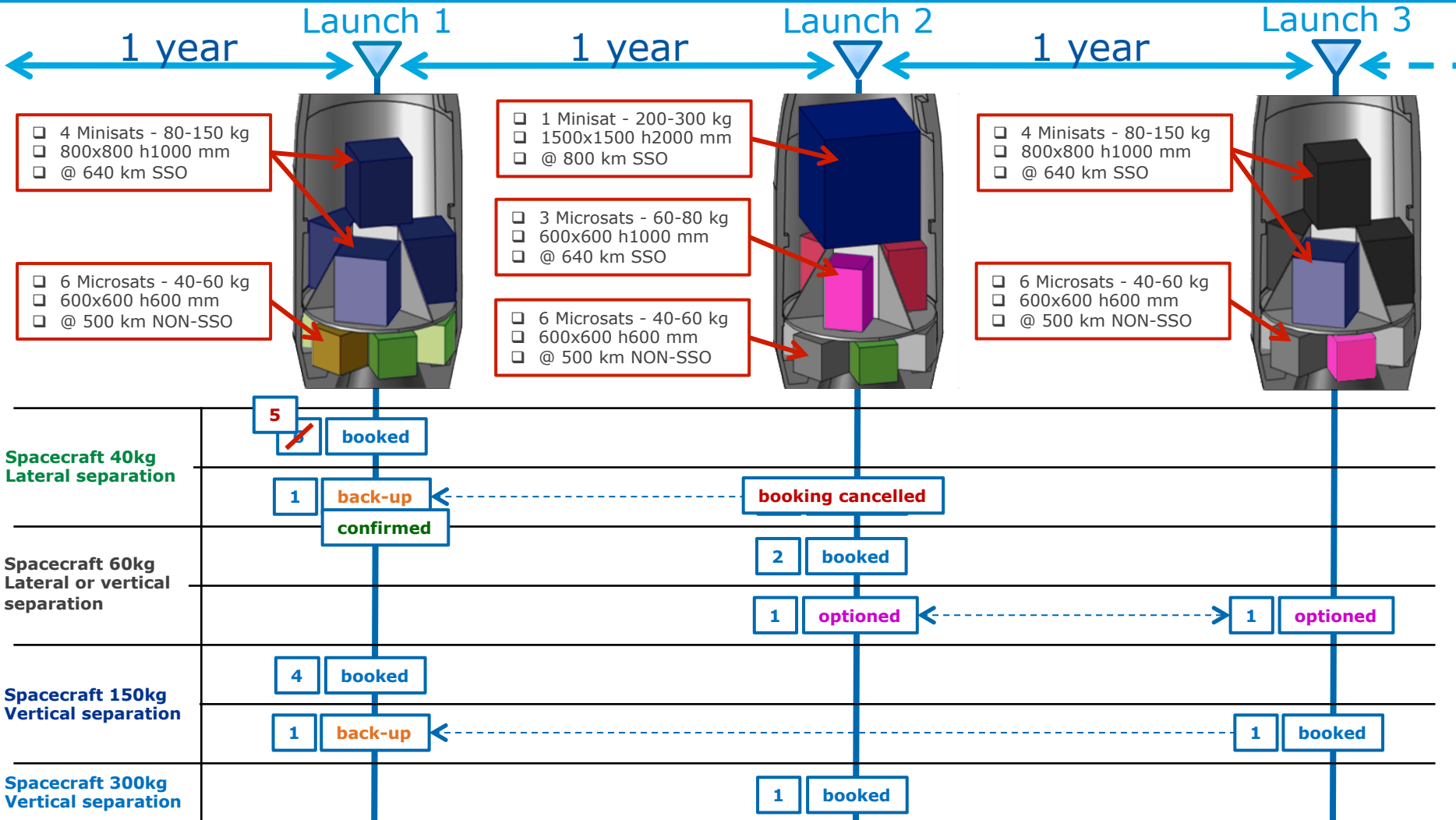


BUS service to Space



Vega SSMS

BUS service to Space

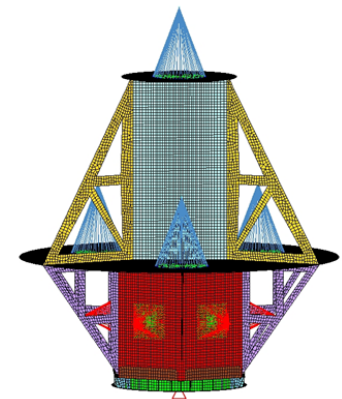
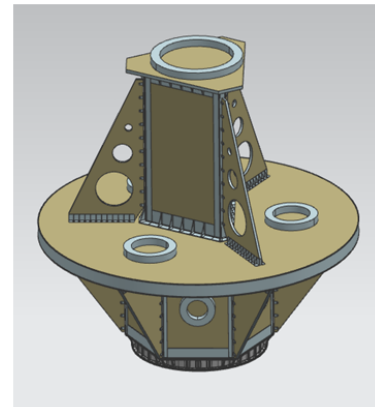
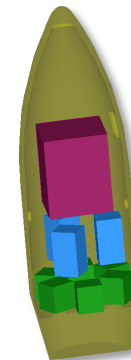
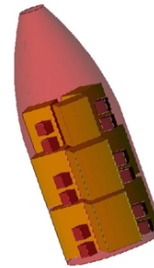


SSMS Implementation cornerstones

- **PROGRAMMATICS:** modular system to support **FLEXI (rideshare)**, **Constellation and Piggy Back** missions
- **HW:** low cost dispenser with **COTS HW and technologies**, maximise use of launcher existing features
- **Process:** SCs accommodation and Missioning tailored to SmallSats, **AGGREGATE** optimised accordingly
- **Process:** SCs Launch Preparation and AIT **standardised**, EU tasks maximised

9 Micro:
6 Micro 0.85x0.85 x1.20 [m] – Mass range: 100-200 kg
3 Micro 0.70x0.70 x1.00 [m] (up to 1.20) – Mass range: 100-200 kg
18 (up to) Nano 0.30x0.30 x0.30 [m] – Mass range: 1-10 kg

3 Micro 0.85x0.85 x1.20 [m] – Mass range: 100-200 kg
8 (up to) Nano 0.50x0.50 x0.50 [m] – Mass range: 1-100 kg
6 (up to) Nano 0.30x0.30 x0.30 [m] – Mass range: 1-10 kg
1 Mini 1.5x1.5 x1.80 [m] – Mass range: 300-500 kg



THANKS FOR YOUR ATTENTION

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