

DEFINING THE LEO MARKET COMPLIANT TO SDM SOLUTIONS



EUROCONSULT & D-ORBIT FOR **ESA**

CLEAN SPACE INDUSTRIAL DAYS

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AGENDA

BACKGROUND

THE GLOBAL DEMAND FOR THE LEO SATELLITE MARKET

THE ACCESSIBLE LEO MARKET TO A EUROPEAN SDM SUPPLIER

THE LEO SDM COMPLIANT MARKET

NEXT STEPS

Objective of the study

ESA has selected Euroconsult and D-Orbit to assess the “Market for LEO Satellites Adopting the SDM Requirements” within ESA’s Clean Space office

The study shall outline **the business case for the SDM market** in Europe for the **next 10 years** taking into account the relevant demand dynamics and production costs of key SDM subsystems/technologies

The results from this activity will be used to prioritise those technologies that should be developed to comply with the SDM requirements based on the impact of competitiveness for each subsystem and provide an estimate for the size of the SDM market that will be available to European suppliers.

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Drivers of the manufacturing and launch markets in LEO for the next decade



SMALLSAT CONSTELLATIONS

- > Constellations of smallsat are a major market change as illustrated by two opposite cases: Planet Labs in the cubesat category (100 units with short lifetime permanently in operation) and OneWeb in the 150kg category (650 units)
- > Both projects require very low production costs to make them economically viable. They should remain unique in their markets, EO and comm., respectively
- > Government in established and newcomer space countries continue to push payload performance for unique mission satellites (EO/science) with launch mass >500kg satellites

ACCESS TO SPACE

- > Large constellations stay with large launch vehicles for orbital deployment. Dedicated small launchers may be used for orbital maintenance
- > Large constellations need guaranteed access to space first, launch cost is second factor
- > Launch service integrators emerge (e.g. Spaceflight) to ease access to space for smallsat

Drivers of the manufacturing and launch markets in LEO for the next decade



NEW TECHNOLOGY INTRODUCTION

- > Two technical innovations could significantly decrease satellite sizing by 2025
 - Electric propulsion for very small satellites in very low altitude orbit
 - Planar detector instead of telescope for electro-optical remote sensing
- > The combination of these technology advances could make smallsat (<100kg) more cost-effective for EO
- > Other technology advances (e.g. ASICs) will contribute to incrementally improve smallsat performance

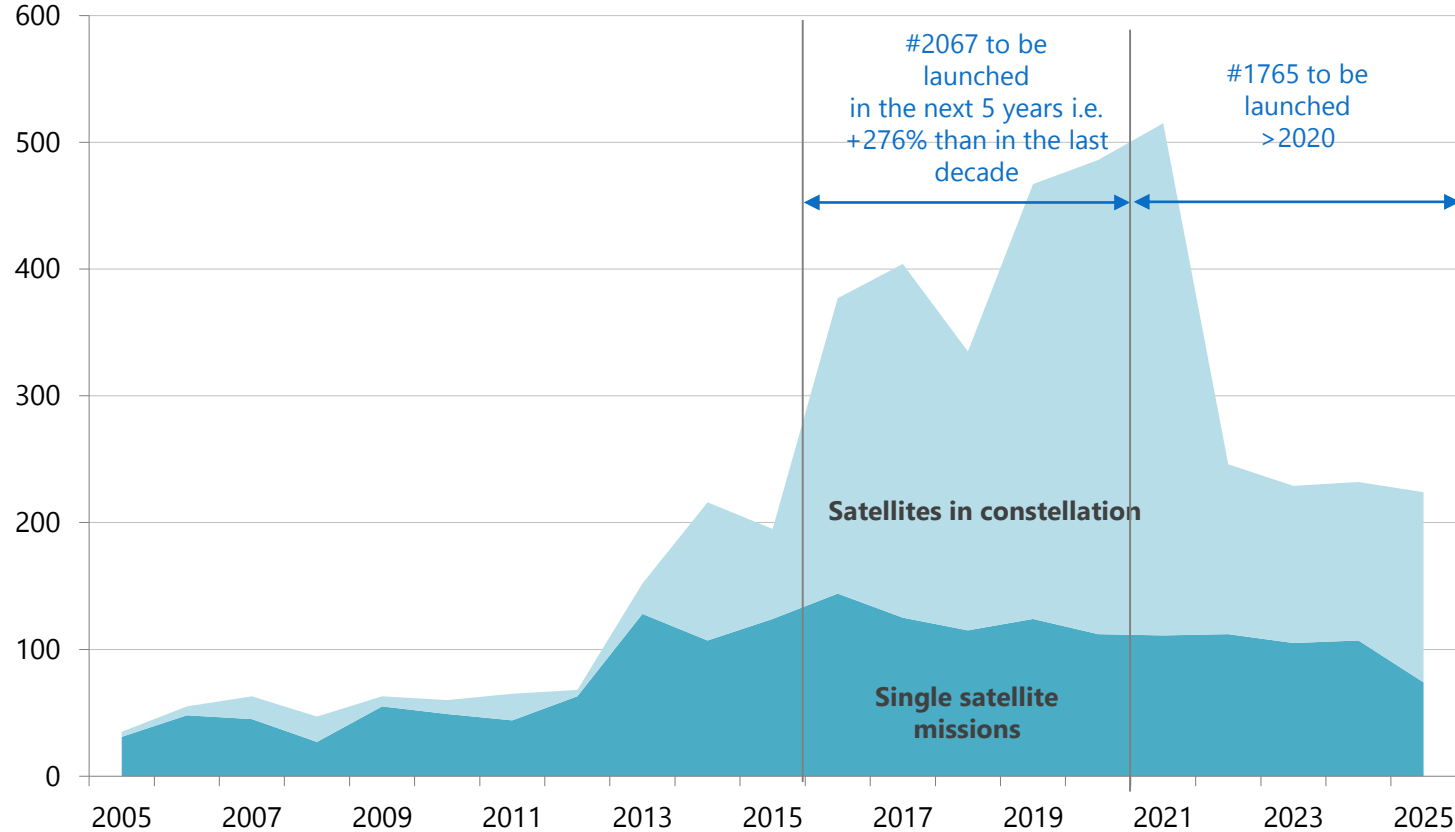
GROUND SYSTEMS

- > Ground systems required to work with constellations often under-estimated in cost, technology maturity, standardization
- > ISL acceptance not yet proved for imagery reception
- > New development for mobile broadband connectivity with phased-array antenna require partnerships

The future LEO satellite market : total demand over the decade

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

of satellites/year

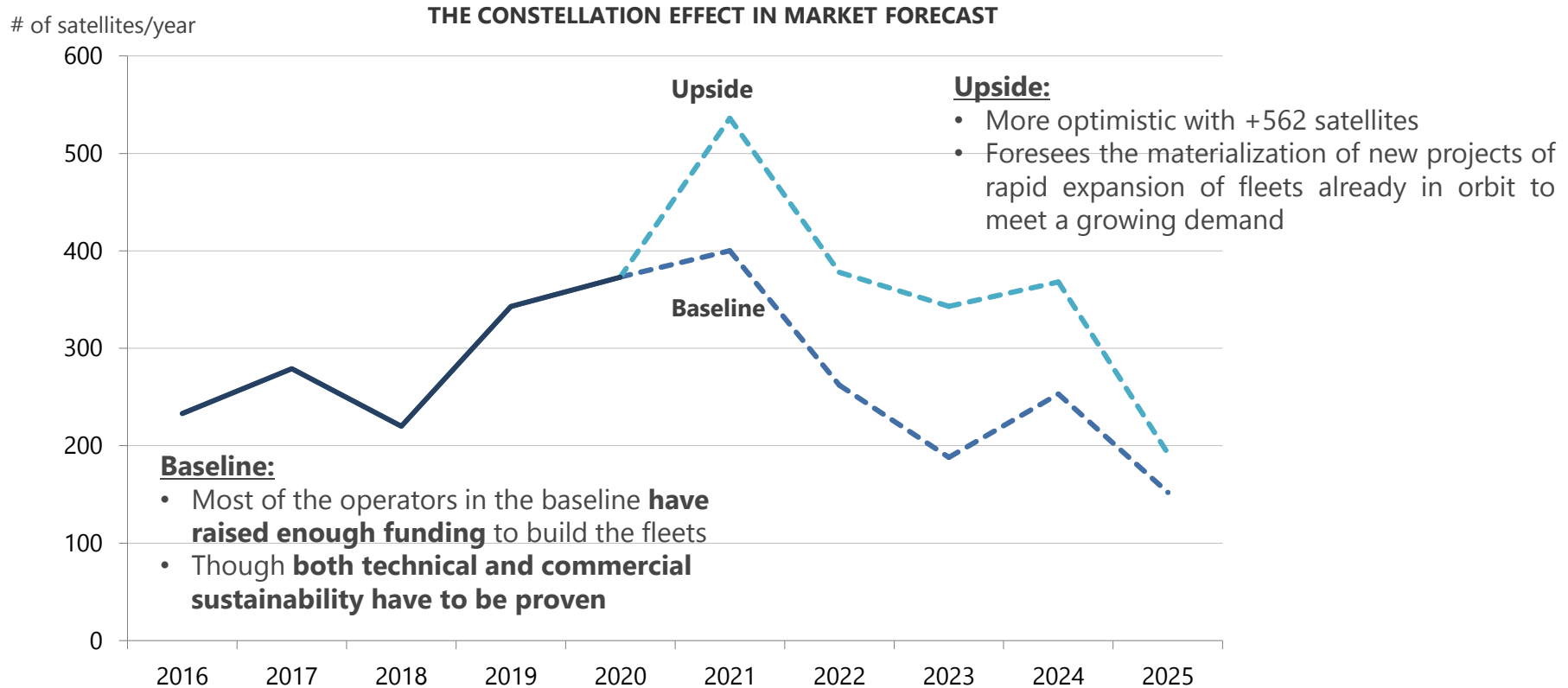


WORLD DEMAND FUELED BY COMMERCIAL CONSTELLATION

- > A total of 3832 satellites to be launched of which 65% in constellation vs 27% in the past
- > Non constellation segment is decreasing (-14%)
- > Constellation is experiencing a +385% growth

The rise of mega constellations considered in 2 scenario

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT



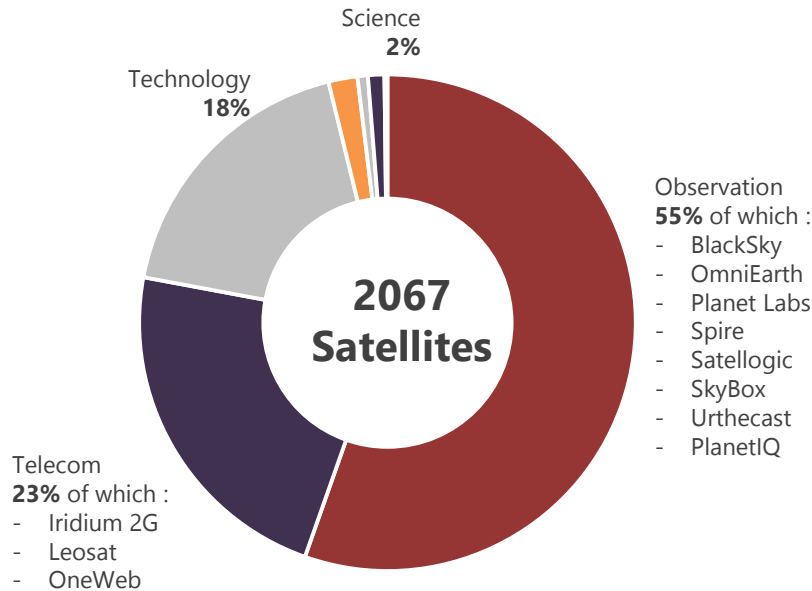
A NEW PARADIGM

- > With 70% of the total demand for the next decade and 98% of the commercial segment, the shape of the next decade is strongly reliant on the deployment of constellations
- > A peak is expected around 2020 as most of them target a fully operational service at this deadline

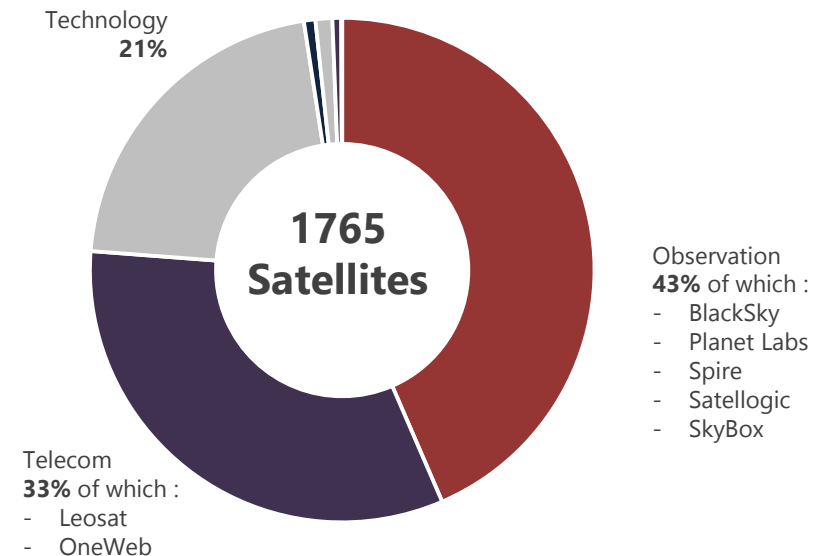
The future LEO satellite market by applications

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

2016 - 2020



2021 - 2025



NEAR REALTIME IMAGERY AND BROADBAND DRIVE THE DEMAND

- > EO remains the main application between past (36%) and future decade (49%).
- > Most of EO constellations will be launched within the 5 years while the deployment of Telecom constellation (new and/or large) is anticipated later for launch schedule issues
- > Technology is mostly driven by cubesats and test bed mission

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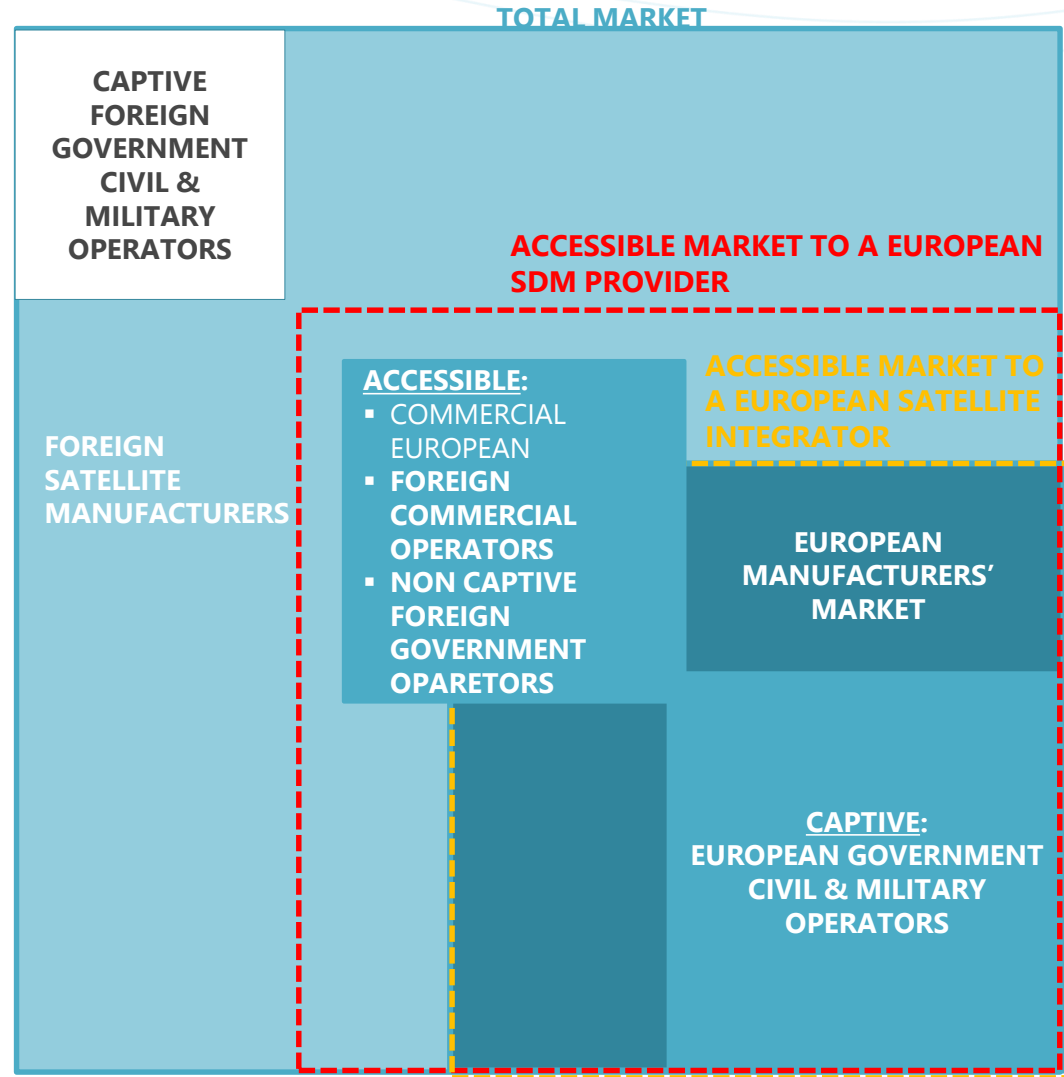
THE LEO SDM COMPLIANT MARKET

NEXT STEPS

Accessibility from a SDM supplier is wider than for an integrator

ACCESSIBILITY'S SCOPE

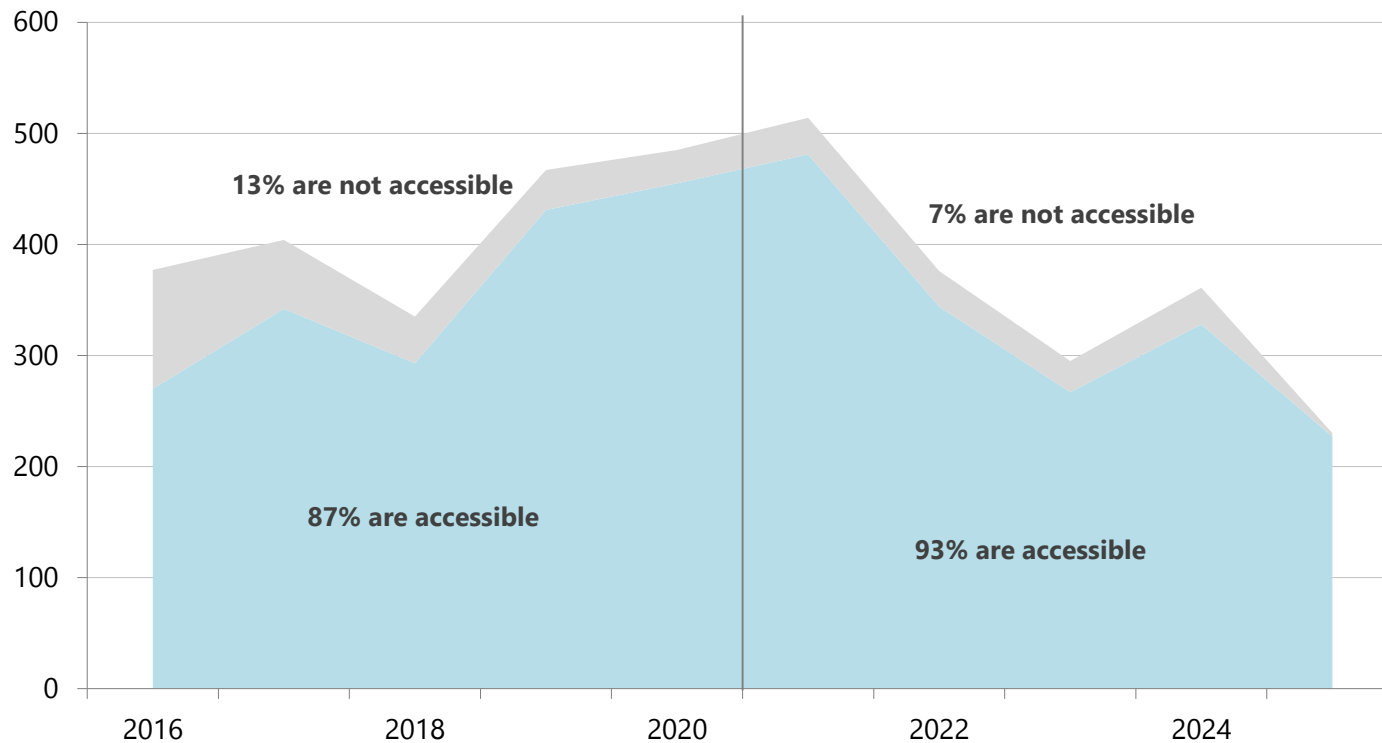
- > Accessibility of a sub-systems supplier is wider than the "traditional" accessibility of a European satellite integrators as a supplier can sell products to foreign manufacturers and address their captive market
- > Success of a European provider beyond its traditional accessible market relies on its ability to penetrate foreign markets and to offer a competitive and affordable solutions



The accessible LEO satellite market over the next decade

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

of satellites/year



89% OF THE TOTAL MARKET IS ACCESSIBLE

In the next 10 years a total of 3427 satellites will be accessible to a European SDM supplier through the satellite integrator or its operators.

77% of the accessible satellites will be launched in constellations and 65% in LEO

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Assumptions on SDM compliancy : overview

REGULATORY FACTOR

Question :
Does Law or Regulations make the adoption of SDM solutions mandatory ?

- Pivot:**
- 4 groups of countries
 - Satellite mass categories

No

↓

Not SDM compliant

Yes

→

TECHNICAL FACTOR

Questions:
Does the SDM technology available at the moment of the launch?

- Pivot:**
- Satellite mass categories
 - SDM technologies categories
 - Year of launch
 - Orbit

No

↓

Not SDM compliant

Yes

→

ECONOMICAL FACTOR

e.g. Institutionnal users for which economical factor is less relevant

Question :

- What is the financial impact of the solution in the total cost of the mission ?
- Is this cost affordable for the operator ?
- Economically / strategic importance

- Pivot:**
- 4 groups of Operators' countries
 - Satellite average manufacturing cost by mass categories
 - SDM average cost by mass categories

Yes

↑

SDM compliant market

No

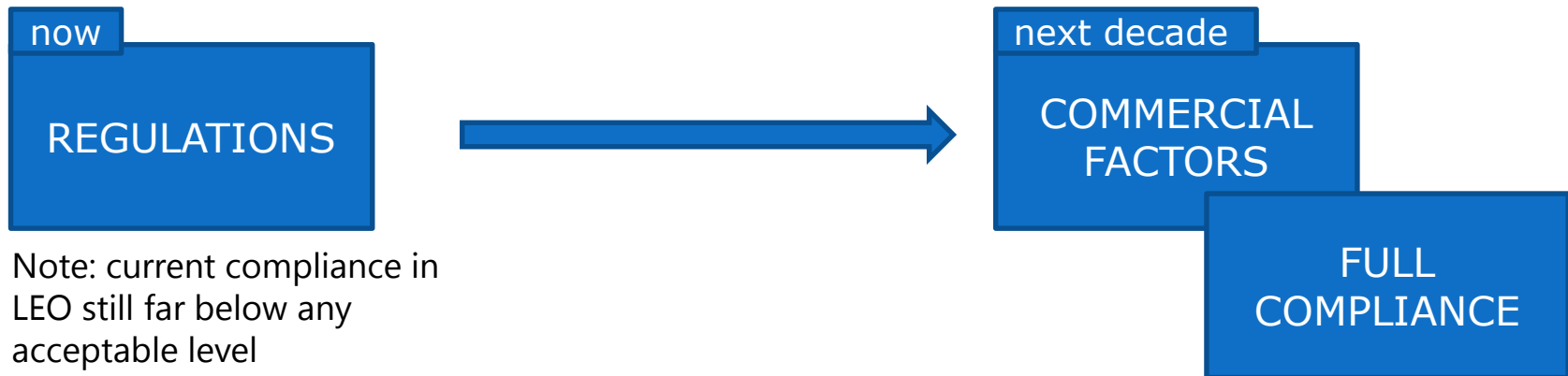
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Not SDM compliant

Review of the SDM Requirements

SOURCES OF SPACE DEBRIS MITIGATION REQUIREMENTS

MAIN DRIVERS FOR USING SDM TECHNOLOGIES



EXAMPLES OF INCREASING IMPORTANCE OF COMMERCIAL FACTORS:

- *Cost Impact*: OneWeb satellites EOL manoeuvre in less than 5 years from EOM for reducing operational costs and collision risks.
- *Operator sensibility*: Italian Space Agency RFO for "PLATiNO" small satellite, requirement for re-entry in less than 6 months (goal controlled re-entry) after EOM.

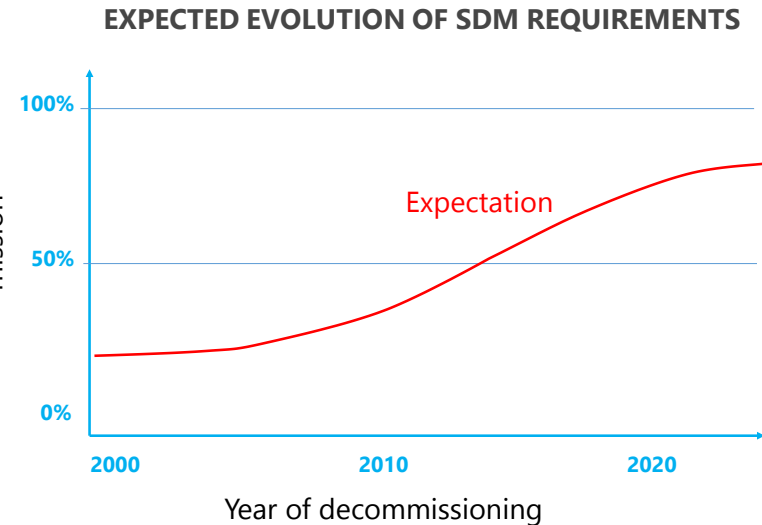
Assumptions on SDM compliancy : evolution of regulations

DRIVERS OF THE EVOLUTION OF SDM REGULATIONS

Voluntarism and level of SDM compliancy fluctuates between space nations:

- > Most of the states are members of the OST and the Liability convention
- > Most of the OST member states are members of IADC working group and have adopted its guidelines
- > However, it practices, enforcement in domestic law and actual compliancy leads us to define 4 categories of launching state or registration states and 2 levels of compliancy (yes or no)

Share of compliant mission



Assumptions on SDM compliancy : technical

AVAILABILITY OF THE SDM SOLUTIONS

The SDM solution **concept** shall be available at the time of **RFO issued** by the operators: in the RFO (or ITT or RFQ) the operator usually specifies the SDM requirements for that particular mission. The RFO comes between 1 and 5 years before launch, depending on the mission.

The **development roadmap** (e.g. development, manufacturing, testing and, possibly, demonstration in space) of the SDM solution shall be compatible with the main milestones and deliveries of the satellite.

It is assumed that the feasibility of the solution has been already verified by the operators/manufacturer.

Technical Compliancy (availability of the technology) has to be verified satellite one by one according to the **mass category, year of launch and orbital altitude.**

LEGAL COMPLIANCE "YES" means that SDM technologies are required in the RFO/RFQ/ITT, and therefore the customer expects a description of the solution in the proposal.

The SDM technology required should be "**available**" (even if not fully developed/tested) at the moment of the consolidation of the satellite design (e.g. PDR), and available as an hardware at the moment of launch.

The consolidation of the satellite design is assumed to occur:

Cubesats	1 year before launch
Small sats <200kg	2 years before launch
Small sats 200-500 kg	2 years before launch
Small sats constellations	2 years before launch
Medium sats uncontrolled	3 years before launch
Medium sats controlled	3 years before launch
Large sats	4 years before launch

Assumptions on SDM compliancy : technical

AVAILABILITY OF THE SDM SOLUTIONS

Iteration i) assumptions (in order to have some first early results):

Medium Satellite Type 500-2000 kg	Uncontrolled Re-Entry	Availability Year
Electrical Passivation	Actuator/switch to disconnect SA or battery	2018
	Update to the PCDU software to suppress charging	2018
Propulsion Passivation	Adding a propulsion venting valve for depletion at EOL	2017
	Tank – micro perforator	2020
	Depletion burns (delta qualification for thrusters at low pressure)	2016
EOL Disposal Manoeuvres	Aerodynamic drag devices - Sails/Membranes	2017/2020
	Aerodynamic drag devices - Inflatable Structures	2017/2020
	Electrodynamic tethers	2017/2020
	Active Propulsion - Electric Propulsion (for nanosatellites)	2016
	Active Propulsion - Liquid propulsion system (monopropellant) (for nanosatellites)	2016
	Active Propulsion - Solid propulsion system (i.e. SPADES)	2017
Casualty Risk	D4D (new propellant tank, pressurant tank, reaction wheel, SADM, Magnetotorquer and Structure materials)	2018

Assumptions on SDM commercial compliancy : commercial

MASS CATEGORY

Satellite manufacturing cost model (M€) based on application

- Earth Observation
- Meteorology
- Science
- Technology
- Security
- Navigation

Differeniating between:

- Western manufacturing cost
- Non western cost model

SDM solution cost model (M€)

THRESHOLD

Does the price of the SDM solutio exceeds % of the price of the satellite ?

Commercial compliancy : Y / N

The two faces of the compliant market

The 3 SDM compliance domains considered autonomously between each other

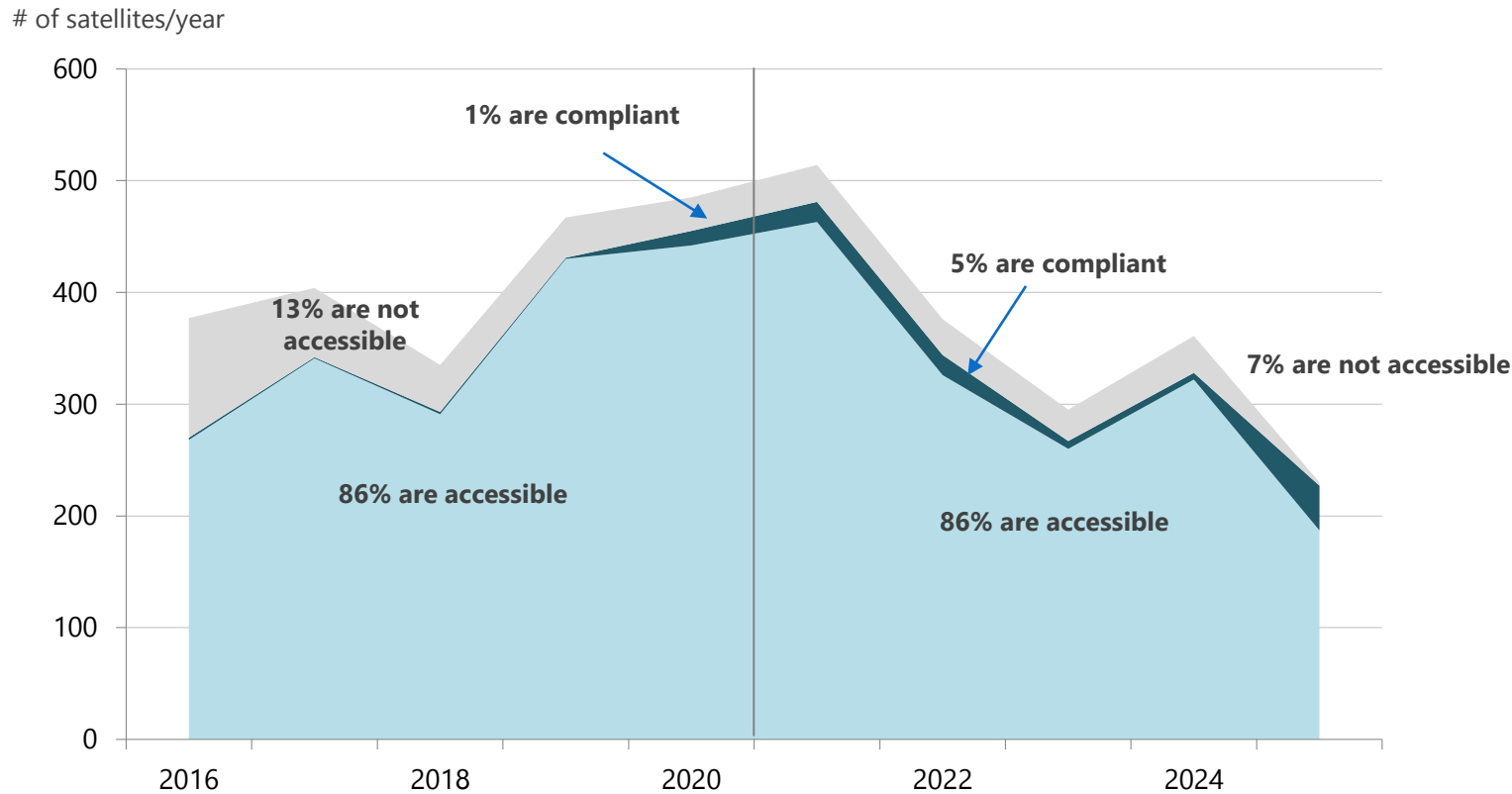
		2016 – 2020	2021 - 2025	
OR	→	# of satellites expected to be compliant with SDM regulations	80% of the accessible market	81% of the accessible market
OR	→	# of satellites expected to adopt be SDM compliant regarding the availability of SDM solutions	35% of the accessible market	93% of the accessible market
OR	→	# of satellites expected to be compliant regarding the price of SDM solutions	11% of the accessible market	5% of the accessible market

The 3 SDM compliance domains cumulated between each other

		2016 – 2020	2021 - 2025	
AND	→	# of satellites expected to be compliant with SDM regulations	80% of the accessible market	81% of the accessible market
AND	→	# of satellites expected legally compliant + adopting available SDM solutions	29% of the accessible market	81% of the accessible market
	→	# of satellites expected legally compliant + adopting available SDM solutions + able to afford them	1% of the accessible market	5% of the accessible market

The SDM compliant market

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

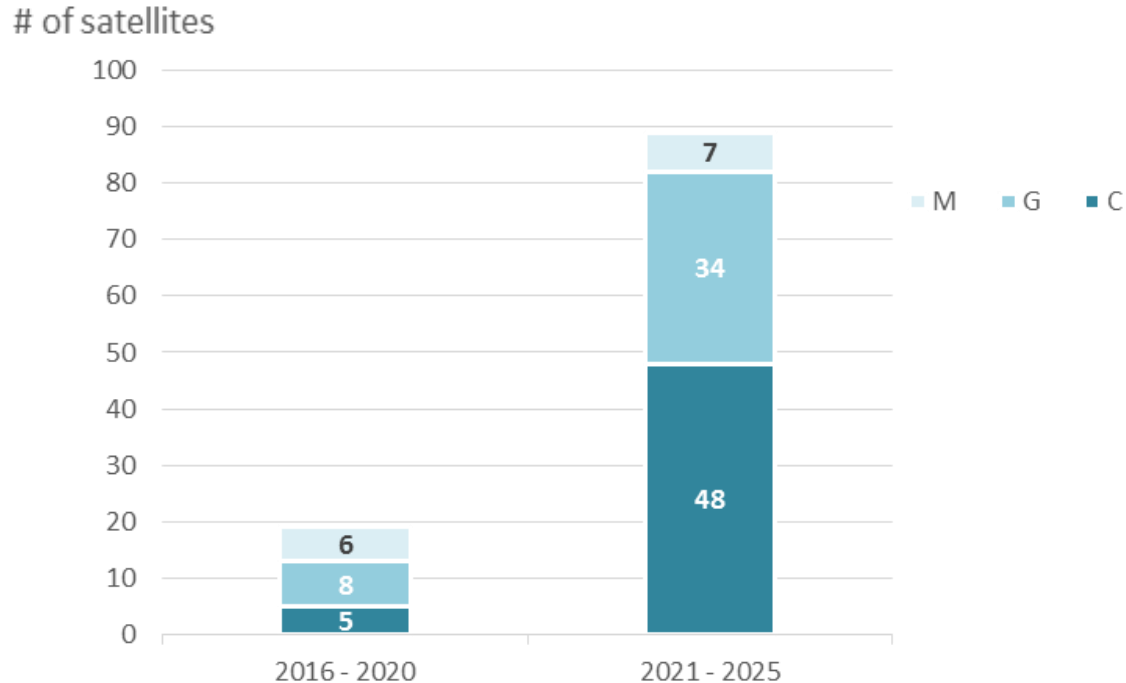


COMPLIANT MARKET ACCOUNTS FOR 3% OF THE ACCESSIBLE MARKET

In the next 10 years 108 satellites will be compliant SDM considering: 1/ the requirement to do so, 2/ the availability of the SDM solutions and 3/ their affordability for the operators

The future LEO satellite market by customers

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

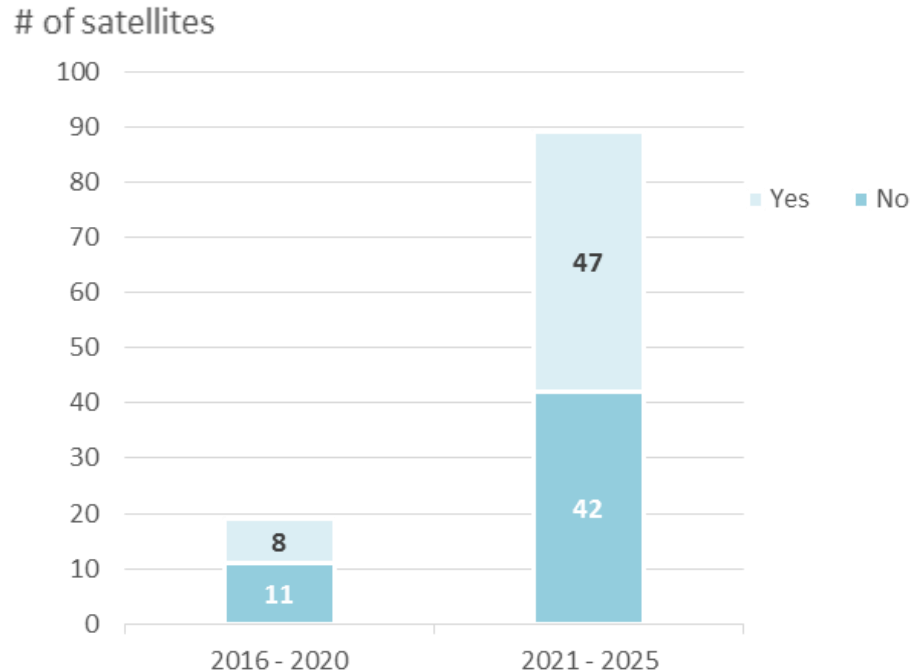


THE SDM IS EQUALLY DIVIDED BETWEEN COMMERCIAL AND INSTITUTIONAL USERS

- > Among the 108 compliant, 49 % belong to commercial operators, 39% to government operators and only 12% to military operators
- > Although 2% of the commercial accessible market is expected to be compliant. On the government and military sides, 6% and 52% of the respective accessible markets are compliant.

The future LEO satellite market by constellations

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

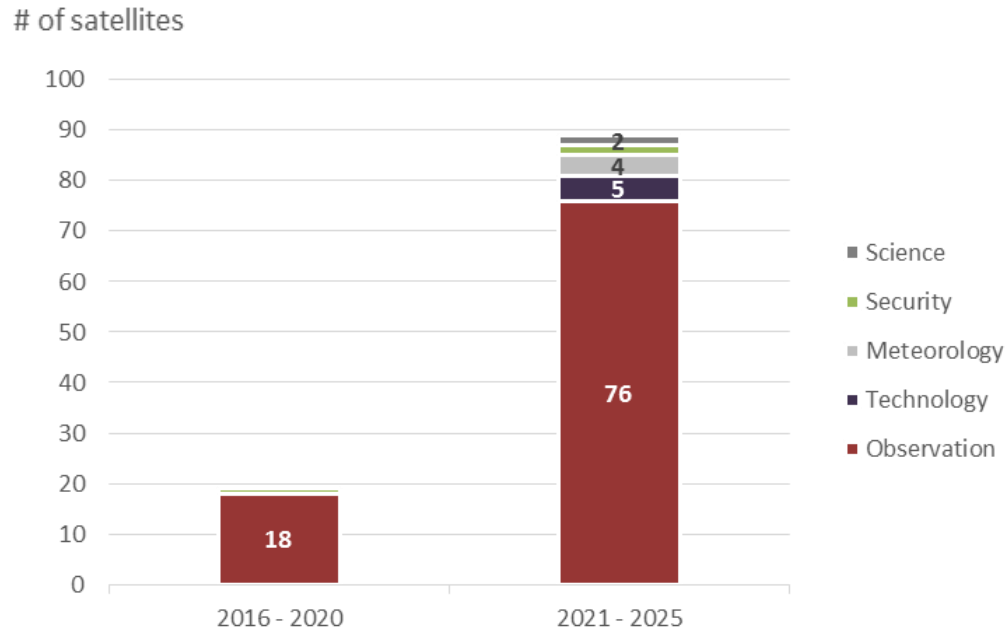


THE COMPLIANCY THROUGH CONSTELLATION EASES THE ADOPTION OF SDM SOLUTIONS

- > 51% of the SDM compliant satellites to be launched in the next decade will belong to a constellation
- > With more than the half of compliant satellites in constellations, the market's fragmentation is limited, easing their targeting by a SDM supplier

The future LEO satellite market by applications

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

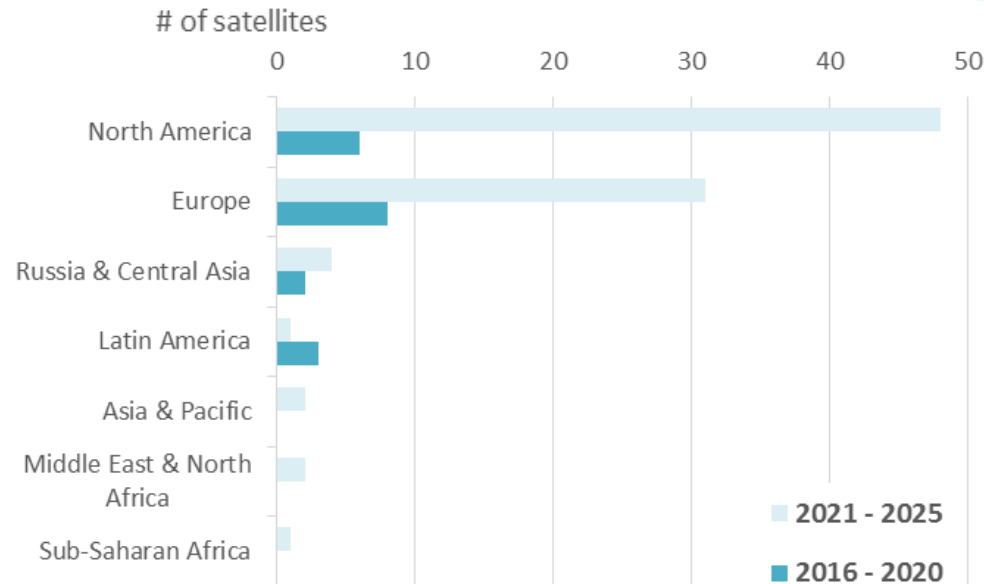


COMMERCIAL EO DOMINATES

- > With a distribution similar to the accessible market EO is the first application with 87% of the satellites to be launched
- > The other applications' share fluctuates between 2% and 5% of the compliant market and less than 1% in the technological accessible market, which is the third biggest accessible market

The future LEO satellite market by region of the operators

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT

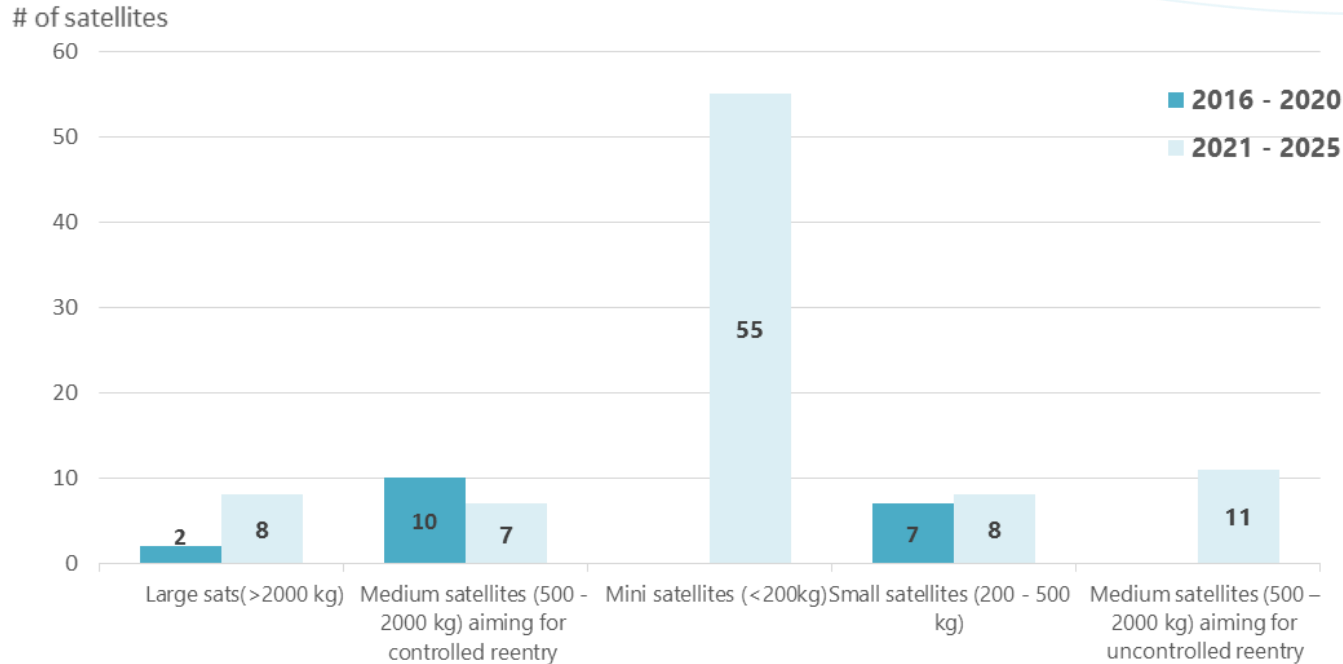


COMMERCIAL NORTH AMERICAN PROJECT WOULD BE THE 1ST CUSTOMERSS

- > half of the compliant satellites are from North America, which is also the most accessible market outside Europe. (only 5% of the accessible satellites in this region being compliant)
- > With 39 satellites, Europe accounts for 36% of the overall compliant market (only 4% of the European accessible market)

The future LEO satellite market by mass categories

TOTAL MARKET / ACCESSIBLE MARKET / SDM COMPLIANT



AMID THE SEVEN ACCESSIBLE MASS CATEGORIES, FIVE ARE COMPLIANT

- > CubeSat and small satellites in mega constellations are less likely to use SDM solutions, mainly because of economic factors
- > The most compliant satellites are the mini satellites, which become so at the second period and represent 51% of the overall compliant satellites.

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NEXT STEPS

THANK YOU FOR YOUR ATTENTION

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20TH SUMMIT FOR SATELLITE FINANCING

Sept. 12-14, 2016 / The Westin - Paris



13TH SYMPOSIUM ON SATCOM MARKET FORECASTS

Sept. 15, 2016 / The Westin - Paris



8TH SUMMIT ON EARTH OBSERVATION BUSINESS

Sept. 15-16, 2016 / The Westin - Paris

Assumptions on SDM compliancy : legal regime

SOURCES OF SPACE DEBRIS MITIGATION REQUIREMENTS

STANDARDS
GUIDELINES
NATIONAL LAWS
INTERNATIONAL LAWS

SATELLITES OPERATORS
LAUNCH SERVICE PROVIDERS
SPACE AGENCIES
SATELLITE INTEGRATORS

MAIN MOTIVATIONS:

- REDUCING COSTS **direct costs:** debris avoidance manoeuvre, higher insurance costs, ...
 indirect costs: tracking, manoeuvre verification, conjunction analysis, ...
 political costs: countries' legal liability, active debris removal political implication, terrestrial damages liability, ..
- REDUCING RISKS collisions, fragmentation, casualty in space and on ground,
- AVOIDING INTERNATIONAL DISPUTES

Assumptions on SDM compliancy : technical

SATELLITE SDM REQUIREMENTS CATEGORIES

PASSIVATION: the depletion of all forms of residual propulsive and electrical energy of the spacecraft, in order to avoid potential explosion risks (e.g. electrical passivation implies disconnecting the batteries, propulsion passivation implies emptying tanks to avoid potential explosion in case of a collision).

EOL DISPOSAL: the operation to be performed at the EOM of a spacecraft or launcher stage in order to reduce its chance of collision and clear up permanently its orbital position.

CASUALTY RISK: probability that a person on ground is killed or seriously injured because of an event originated by a re-entering debris.

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Technical Compliancy (availability of the technology) has to be verified satellite one by one according to the **mass category, year of launch and orbital altitude.**

- Availability of SDM Components will be verified in 2 different iterations:
 - i) assessment based on info on internet / internal info;
 - ii) assessment based on contacting some of the key people involved in the industry (list already prepared).
- The database will be populated on 2 different iterations:
 - i) based on groups of satellites;
 - ii) ii) "one by one" satellite (very extensive work)