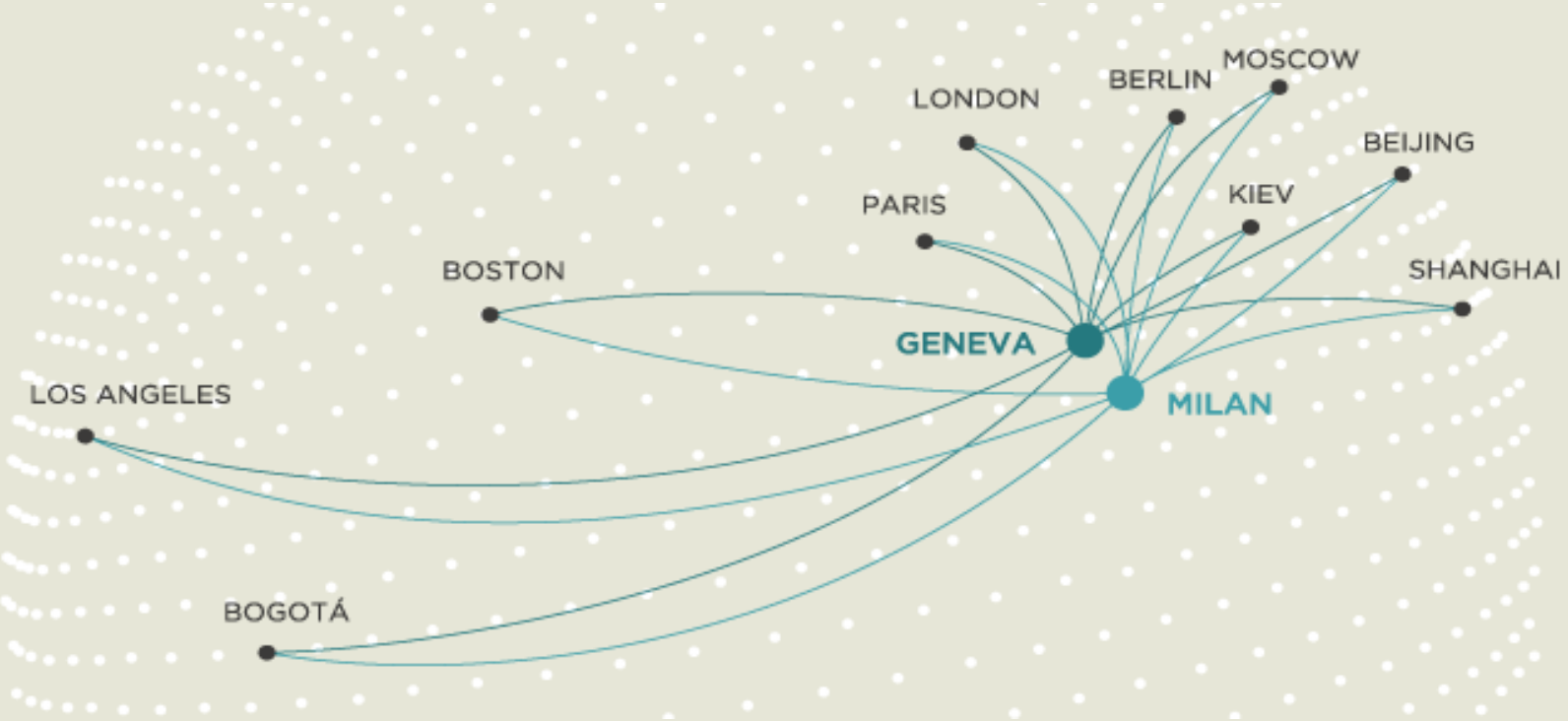
CLEAN SPACE INDUSTRIAL DAYS

24TH – 26TH OCTOBER 2017

POTENTIAL MARKETS OPENED BY ADR MISSIONS

LCA IN BRIEF

Leoni Corporate Advisors (LCA) is an independent strategy consulting boutique with a consolidated global footprint, specialized by region, industry and topic.



- LCA has more than 15 years of experience and a successful track record in the Aerospace, Defense & Transportation also thanks to the business partnership Bryce Tech (formerly Tauri Group)

LCA COMMITMENT TO STRATEGIC INSIGHTS: GLOBAL SPACE MARKET OBSERVATORY

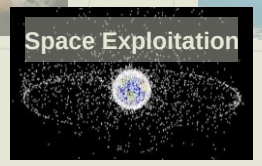
LCA has more than 15 years of experience in the Aerospace & Defense industry, working on strategic issues of leading players worldwide

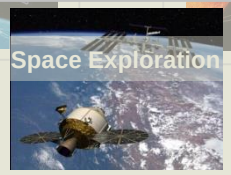
Considering the fast market evolution, LCA runs a Global Space Market Observatory gather valuable strategic insight and always be up to date with the current trends and dynamics of the market from a worldwide prospective, with a specific focus on 3 main regions: USA, Europe and Russia

LCA Global Space Market Observatory

Main Geographies

Value Steps





Objectives

- To monitor stakeholders dynamics and long term trends
- To monitor business models evolution and value chain plays
- To qualify potential cooperation axes among stakeholders at regional and global level

Methodology

- Desk analysis
- In-Depth-interviews with Senior Management and Experts
- Stakeholders mapping and profiling

Scope

- From a Geographical viewpoint: EU, Russia, USA, India, Japan, Brazil
- From a stakeholders categories point of view: Policymaker, R&D, Industry, Aggregators, Space Agencies
- From a business and technical point of view: all the value steps of the space market (i.e. Satellites, Ground Segment, Services, Space Transportation, Science,..)
- From a client segments viewpoint: military, institutional and commercial

LCA COMMITMENT TO CORPORATE CITIZENSHIP: FOSTERING RESEARCH AND INNOVATION

At LCA we believe that corporate citizenship is an integral part of everyday business

- we are **committed to creating value** through **responsible business practices**, and **promoting conscientious citizenship** aimed at improving social and environmental sustainability
- LCA prouds itself of being a good corporate citizen, and fostering science and innovation lays within its foundations. **LCA sponsors and runs scientific research initiatives**, as the 2015 **Round Table with the Graduate Institute of Geneva**

GIG/LCA
Round Table on Space Debris

THE GRADUATE INSTITUTE GENEVA

LEONI
COR PORATE
ADVIS ORS

"Corporate Citizenship is not separate from our business strategy; it is a key component of the company DNA"

AGENDA

THE SPACE DEBRIS ISSUE

ADR MISSION GOVERNANCE AND FUNDING

SPACE TUGS NEW POTENTIAL MARKETS

LOWERING THE RISK RELATED TO SPACE DEBRIS IS A CRITICAL CHALLENGE IN ORDER TO PRESERVE THE VALUE OF FUTURE SPACE ACTIVITIES AND TO ALLOW A MORE SUSTAINABLE SPACE EXPLOITATION

Human intense space activity has its externalities, also known as **"Space Junk"**. Space debris can hinder human exploitation of space thorough disruption of missions, with a **huge economic and environmental impact**

- Humankind and modern civilization are heavily dependent on Space infrastructure for an ever increasing number of activities.
- Looking at the evolution of the Launch Service Market it is clear that the level of space activity is not going to be lower in the years to come (increased launch activity, Mini launchers, etc.)

Cosmos/iridium collision in 2009 generated **>1.260** debris; intentional destruction of **Chinese Fēngyún** in 2007 generated **>2.840 high-velocity debris**

- **29 000** objects in space **>10 cm**
- **750.000** objects in space from **1 cm to 10 cm**
- Over **17.000 debris regularly monitored**, of which:
  - **>12.000** in **LEO**
  - **>2.500** in **GEO/EGO/GTO**

How to mitigate the risk related to Space Debris for Space Activities and related operations?

TO ASSESS THE FUTURE ECONOMIC BENEFITS OF MITIGATING DEBRIS RELATED RISKS, IT IS NECESSARY TO IDENTIFY KEY STAKEHOLDERS IMPACTED, RECONCILING DIFFERENT PROFILES IN TERMS OF OWNERSHIP STRUCTURE (PUBLIC VS. PRIVATE), INTERESTS AND ISSUE AWARENESS

Economic Potential Value of Orbital Activities and related applications

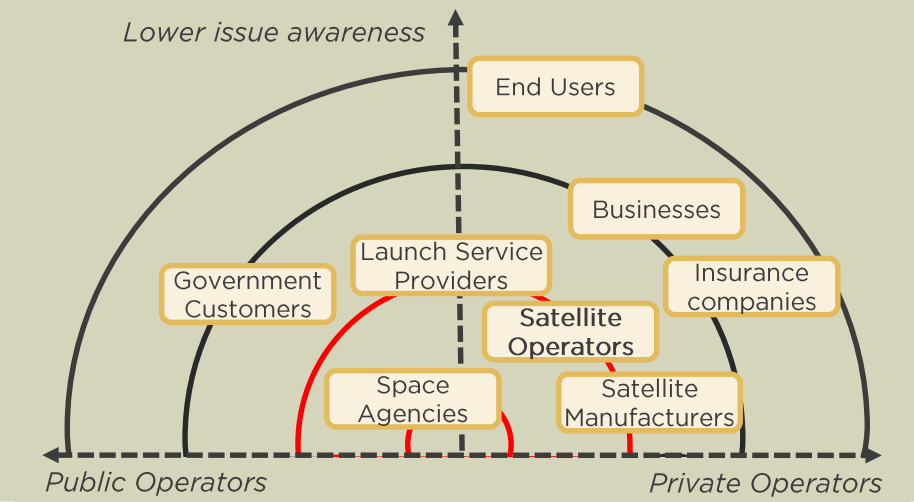
Risk related to Space Debris

Economic Potential Value of Space Debris Market

Future Economic Benefit

- Which are the Space Value Chain step on which to evaluate Economic impacts?
- Which are the Stakeholders on which to evaluate Economic impacts?

Stakeholders implicated in the Space Debris Issue



- Which is the Value of the assets in orbit affected by the Space Debris Issue in the next 20 years?
- Which stakeholders would benefit most from risk modulation?

Replacing currently active satellites will cost around $ 200 billion and excluding indirect impact on the overall economy

UNCLEAR "SPACE DEBRIS" DEFINITION AND BLURRED LIABILITY PERIMETER BETWEEN PUBLIC AND PRIVATE PLAYERS ARE CURRENTLY THE MAIN LEGAL CHALLENGE TO ADR IMPLEMENTATION…

Legal Challenges

Issue	Challenge	Implications currently limiting ADR
Space Debris Definition	• **Ambiguous legal definition** of space debris • Lack of a legally binding definition **undermines efforts directed to regulation** of the phenomenon	• "Space debris" to be classified as "debris" once it becomes a collision hazard to other functioning space objects
Liability	• **Lack of clear liability** for debris removal • **Ambiguous preventative liability** for debris mitigation • Inadequate liability for **dispute settlement**	• Under 1972 "Convention on International Liability for Damage Caused by Space Objects", states bear the responsibility for all space objects launched from their territories • The complaint of space debris only to be conducted between state parties. States may then attribute liability to non-state actors through their respective domestic judicial processes

WHILE POLITICAL CONCERNS ADDED ON FINANCIAL HURDLES BROUGHT BY THE "TRAGEDY OF THE COMMONS" WILL FURTHERLY HINDER ADR MISSIONS FUTURE POTENTIAL MARKET

	Issue	Challenge	Implications currently limiting ADR
Political Challenges	**Sensitive technology**	• Numerous **satellites have dual use** – civil / commercial and military • Presence of sensitive **proprietary/military technology reduces** degrees of freedom of future ADR **players**	• Limitation of assets accessible by each player vs. Qualification of players authorized ADR players • Complex and costly procedures to dispose of sensitive technology
Financial Challenges	**«Tragedy of the Commons»**	• **Lack of clear incentive to insurance underwriting** (High potential cost of and low potential occurrence of damage caused by debris) • **Lack of clear Equitable distribution of ADR cost**	• Absence of mandated collision liability insurance, covering space debris' damage • Absence of a levy on the major beneficiaries of space activities to allow financing of ADR missions

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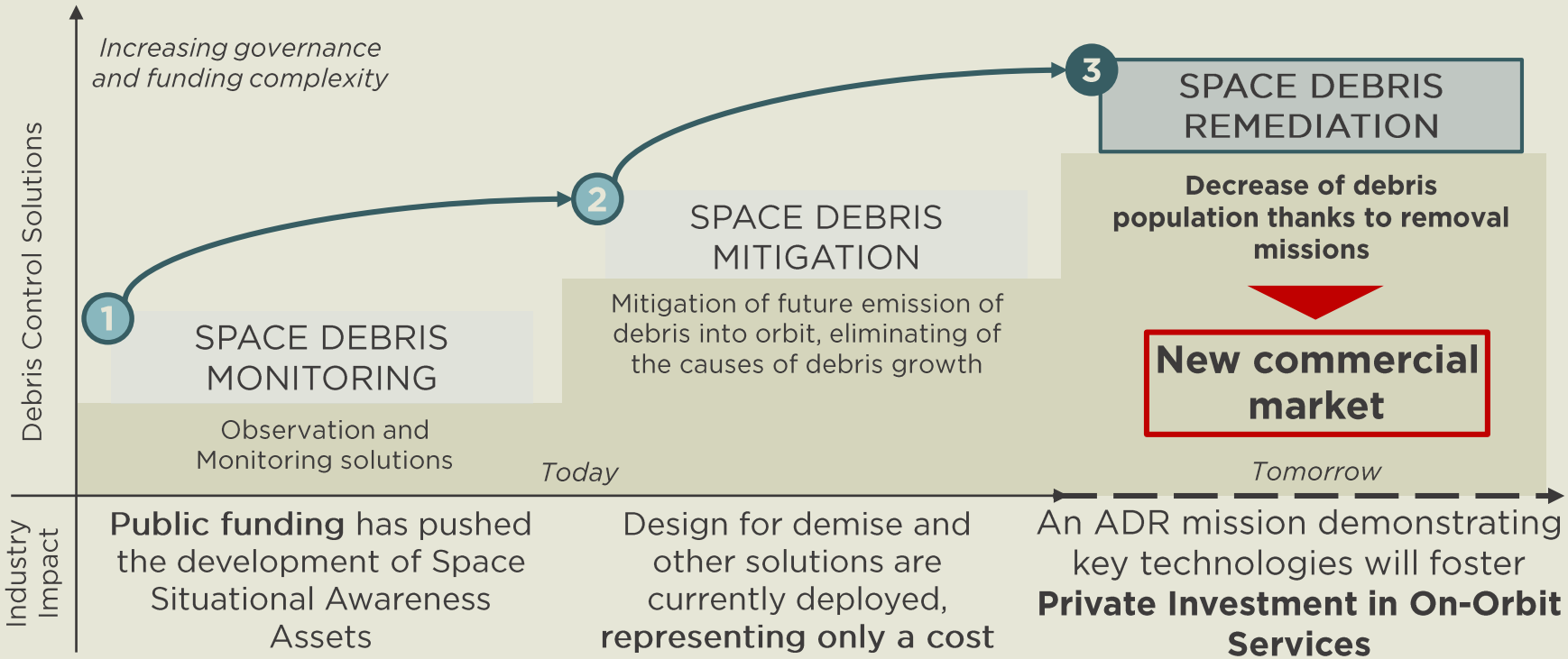
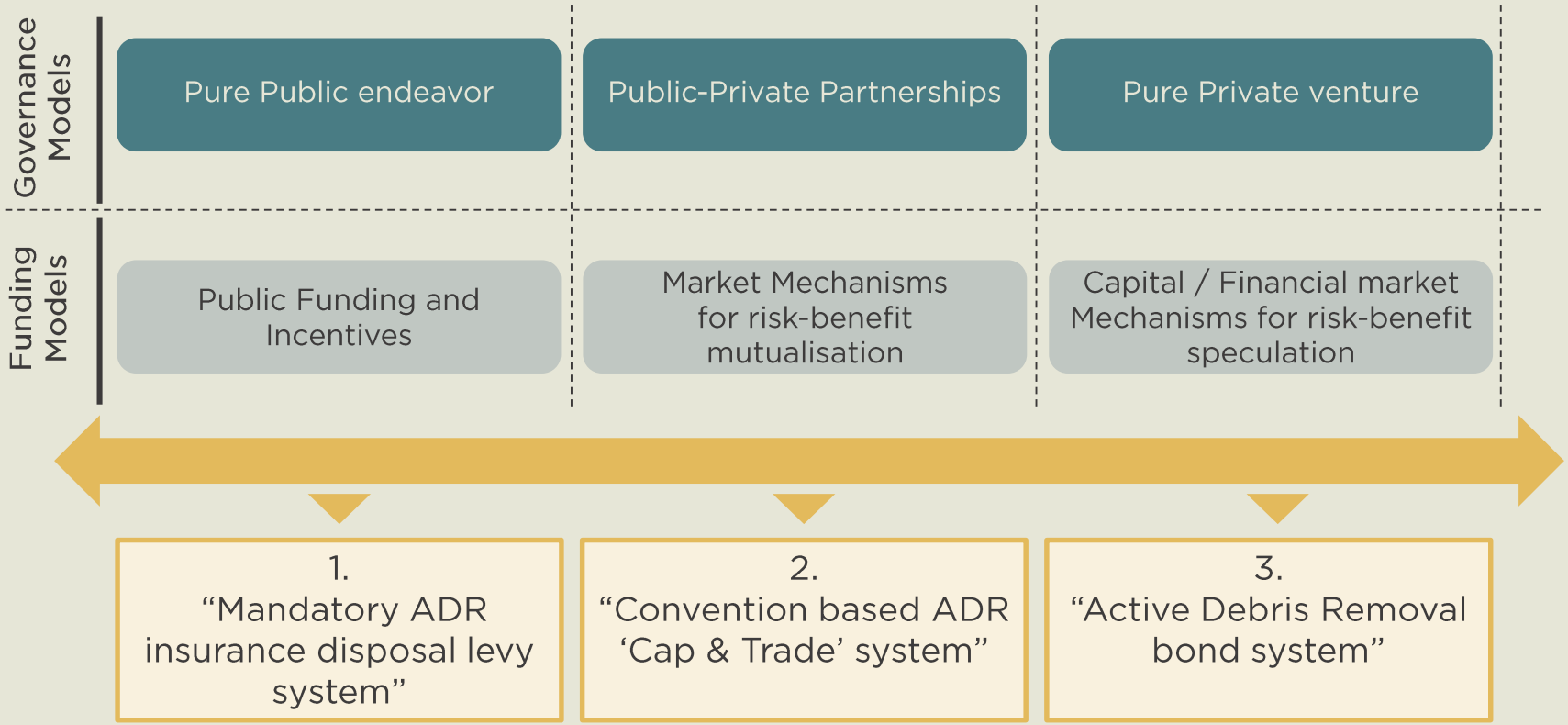
TODAY'S MAIN CHALLENGE IS TO DEVELOP A COMPREHENSIVE GOVERNANCE AND GATHER FINANCIAL RESOURCES TO GUARANTEE THE DEVELOPMENT AND EXPLOITATION OF ADR SOLUTIONS

- As of today, the most relevant solutions to lower the risk related to Space Debris problem range from debris monitoring to mitigation and finally remediation,
- Tomorrow, with a new governance in place and higher public and Private Funding, Active Debris Removal will focus on space junk remediation, potentially opening new markets



LCA AND THE GRADUATE INSTITUTE OF GENEVA STUDY IDENTIFIED 3 MODELS, RANGING ACROSS A WIDE RANGE OF POTENTIAL SOLUTIONS IN TERMS OF GOVERNANCE, FUNDING AND BUSINESS MODELS

When tackling the space debris issue a multidisciplinary approach is essential in order to develop an effective ADR governance model.



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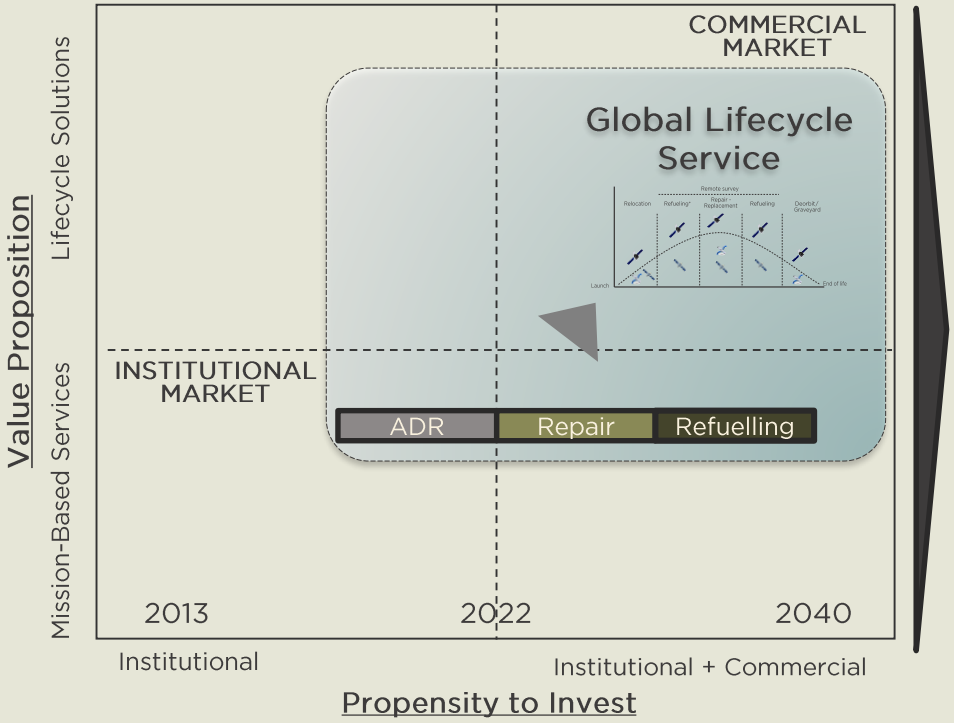
SPACE TUGS NEW POTENTIAL MARKETS

SPACE TUGS AND RELATED KEY TECHNOLOGIES DEVELOPED FOR ADR MISSION WILL FOSTER PRIVATE INVESTMENT AND OPEN SEVERAL HIGH POTENTIAL MARKETS

Market / Application	Services	Market Outlook and Investments
On-Orbit Servicing	On-Orbit Services: • Surveying • Refuelling • Repairing • Relocation • Active Debris Removal	• **Servicing currently valued 10$M, expected to hit 80$B in 2030, focusing on Fueling, and Relocation Services**
Access to Space	• Constellation Spacing • Satellite In-orbit Raising • Active Debris Removal	• **Currently valued 5 B$*, expected to increase due to higher launch activities and to be reshaped by innovative launch services**
In-Space / Off-Earth Facilities	• Servicing stand-alone LEO, NEO and Deep Space outpost (e.g. Cis-lunar outpost, Moon Village, etc.)	• **Currently valued 20M$, expected to reach 100$B* in 2050, focusing on Off-Earth Logistics activities**

* Launch industry Value as a whole
** Including activities related to Off-Earth facilities

ON-ORBIT SERVICING WILL OPEN NEW MARKET OPPORTUNITIES FOR BOTH THE LAUNCH AND SATELLITE INDUSTRY, WHICH WILL NEED TO EVOLVE TO A "GLOBAL LIFECYCLE SERVICE"



SIS ("Space Infrastructure Services") vehicle to inspect, repair and refuel satellites in GEO to be launched in 2021

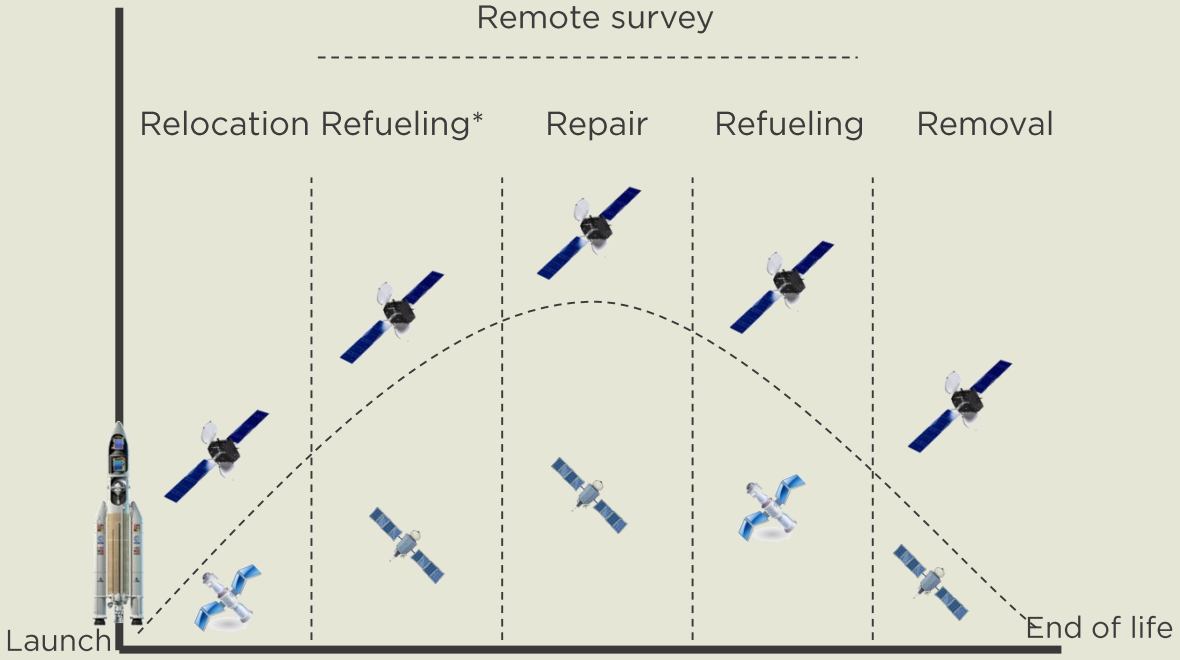
SES to be anchor commercial customer for first mission, with option for further missions

"Mission Extension Service" to be launched In 2019, providing propulsion and attitude controls

5-year contract with Intelsat, with the option to service multiple satellites using the same MEV

From a Technical Performance driven Service to a Global Service Value Proposition with a wider portfolio of on orbit services (e.g. Surveying, Refueling, Removal, etc.)

GLOBAL LIFECYCLE VALUE PROPOSITION MEAN SEVERAL ON-ORBIT SATELLITE SERVICES TAILORED TO A SPECIFIC, BOTH COMMERCIAL AND INSTITUTIONAL, CUSTOMER



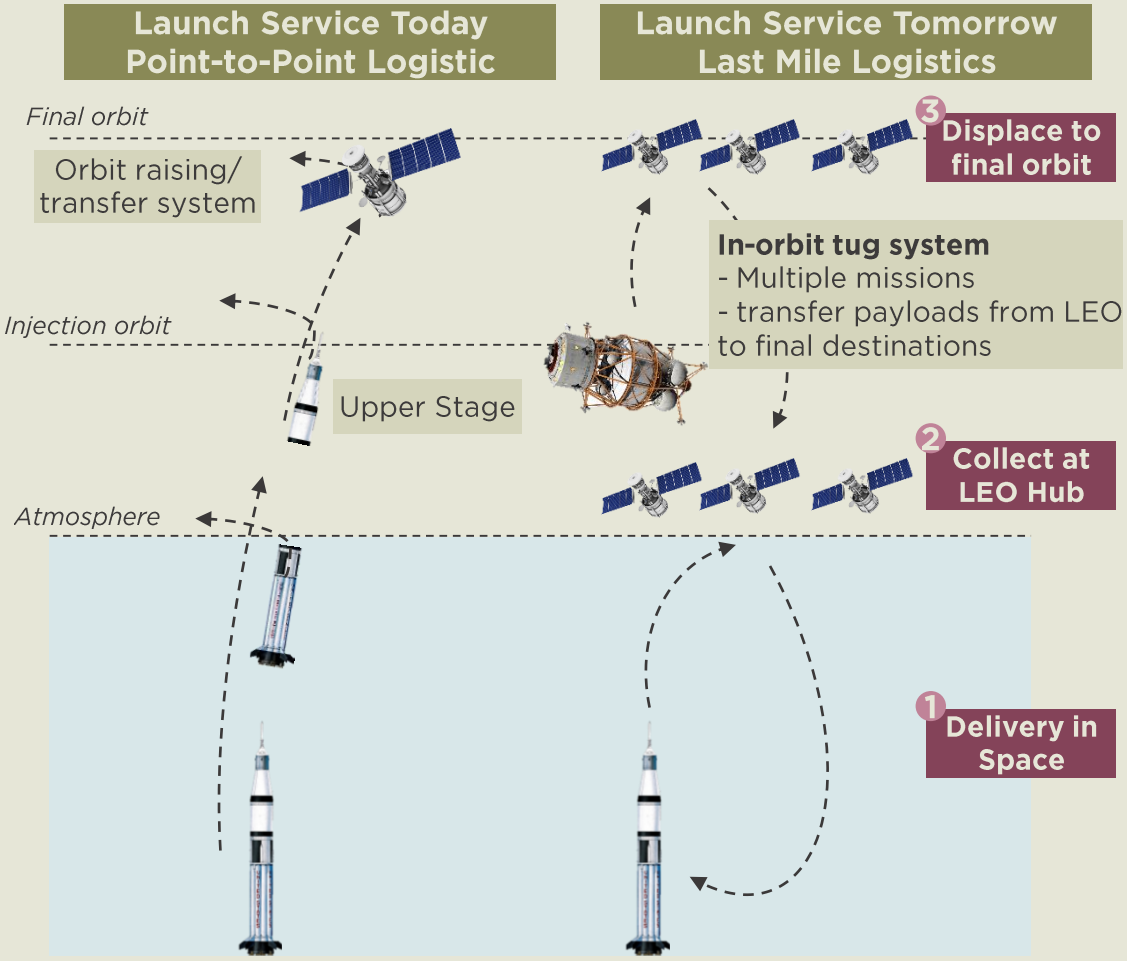
Customer Benefits

- Reduce fuel consumption in orbit
- Extend satellite useful lifetime
- Reduce launch service cost
- Save precious orbit positions

A Global Lifecycle OOS devoted to Logistic, Inspection, Maintenance and Disposal seems commercially viable in GEO. Nonetheless, in LEO services focused on logistics and removal will be appealing for large Mega Constellation operator and Institutions

* OOS allow to launch with less fuel and more payload. Refueling can then be necessary at the early stages of life

DEVELOPMENTS OF NEW PRODUCTS, SUCH AS SPACE TUGS, WILL LOWER ACCESS TO SPACE COST THUS ENABLING NEW BUSINESS OPPORTUNITIES



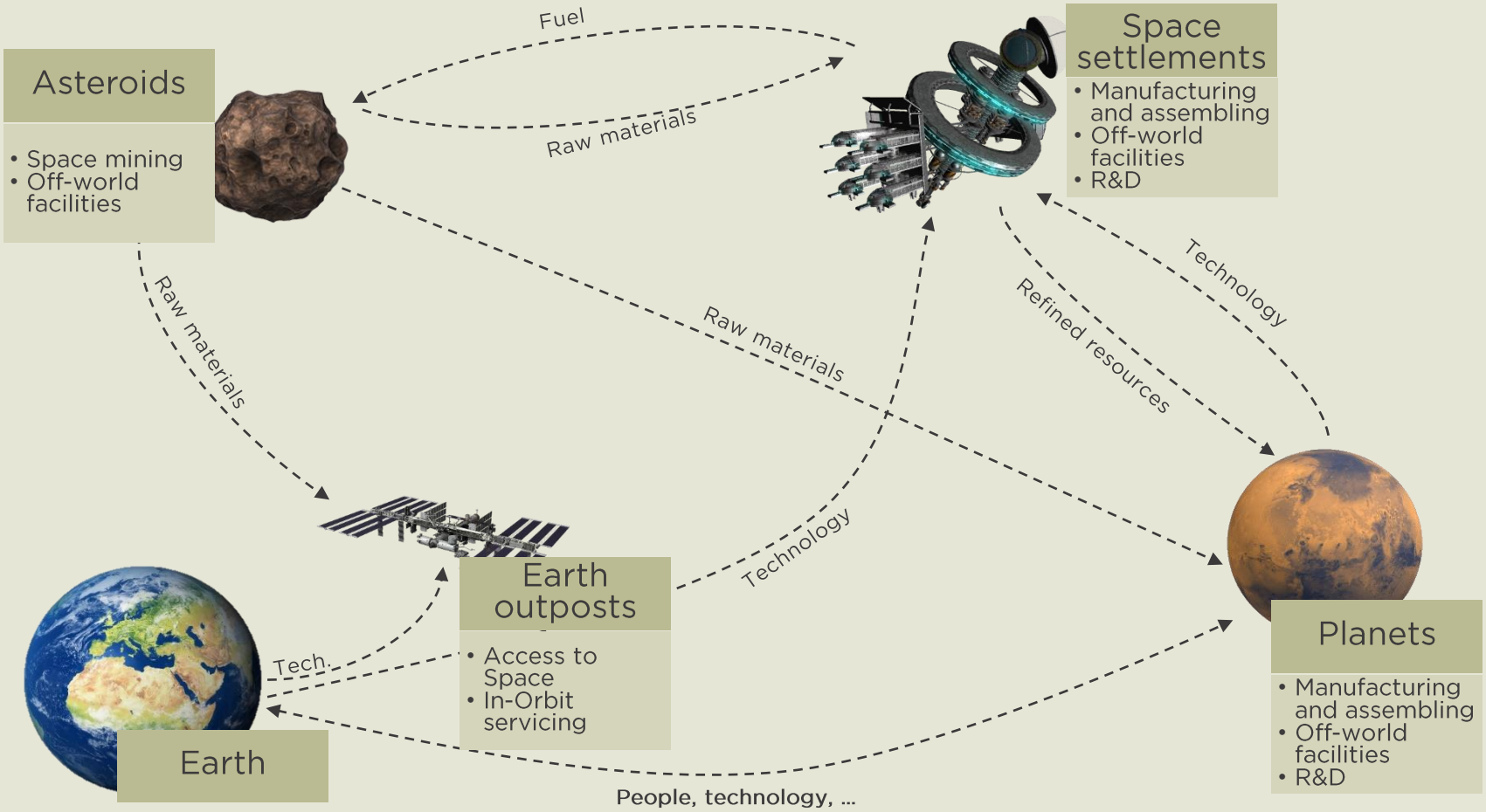
New Market Opportunities

Satellites In-Orbit Service
- Relocation
- Refueling
- Surveying
- Repairs
- Removal

In-Orbit Logistics
- Constellation Spacing
- In-orbit Raising
- Active debris removal
- ...

Advanced Services
- In-Space Manufacturing Assembly
- Asteroid Mining
- ...

SPACE TUGS ENABLING SPACE LOGISTICS WILL POTENTIALLY FOSTER THE DEVELOPMENT OF A SPACE-TO-SPACE ECONOMY ACROSS IN-SPACE SETTLEMENTS AND FACILITIES



SUMMING UP: CHALLENGES STILL AHEAD, BUT HIGH POTENTIAL MARKET OPPORTUNITIES FOR ON-ORBIT SERVICES, WHICH ARE VIRTUOUSLY INTERTWINED WITH ACTIVE DEBRIS REMOVAL

CHALLENGES

- **Technological Challenge**, ADR technologies must be furtherly investigated
  - ➔ Need for an in-orbit validation of the several technologies enabling ADR
- **Legal / Regulatory Challenge,** The incomplete legal framework should be bridged with specific regulation controlling Ownership, Liability and Insurance Policy
- **Political Challenges,** Military Space Objects are National Security Assets involving Protection of Sensitive Information
  - ➔ Need for extensive international cooperation and Public support
- **Financial challenges**, need for sizeable Public and Private Investment, while demonstrating potential for revenues
  - ➔ Need for an extensive cost benefit Analysis and Business Plan

MARKET OPPORTUNITIES

- **Satellite Servicing devoted to Logistic, Inspection, Maintenance and Disposal seems commercially viable in GEO, with Satellite Operators as the main customers**
- **Active Debris Removal in LEO will be a necessary activity for Space Activity sustainability, nonetheless LEO services focused on logistics will be appealing for large Mega Constellation operator and Institutions**

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