INITIAL USER-DRIVEN FRAMEWORK FOR DEVELOPING TRADE-OFF SCENARIOS FOR SPACE DEBRIS REMOVAL SERVICES

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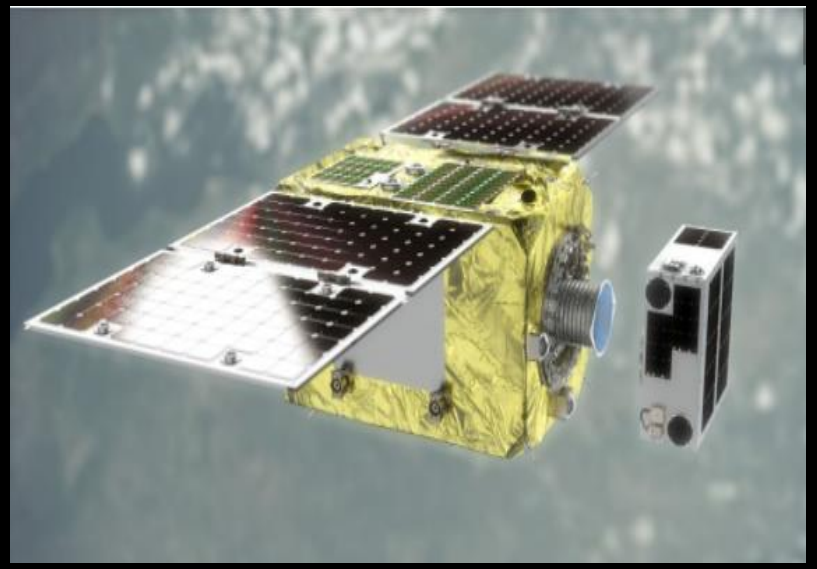
INTRODUCTION

- Background
- Stakeholders
- Space Debris Markets
- Challenges & Opportunities
- Drivers impacting the Trade-off scenarios
- Initial User Driven framework
- Hypothetical Examples
- Conclusions

BACKGROUND

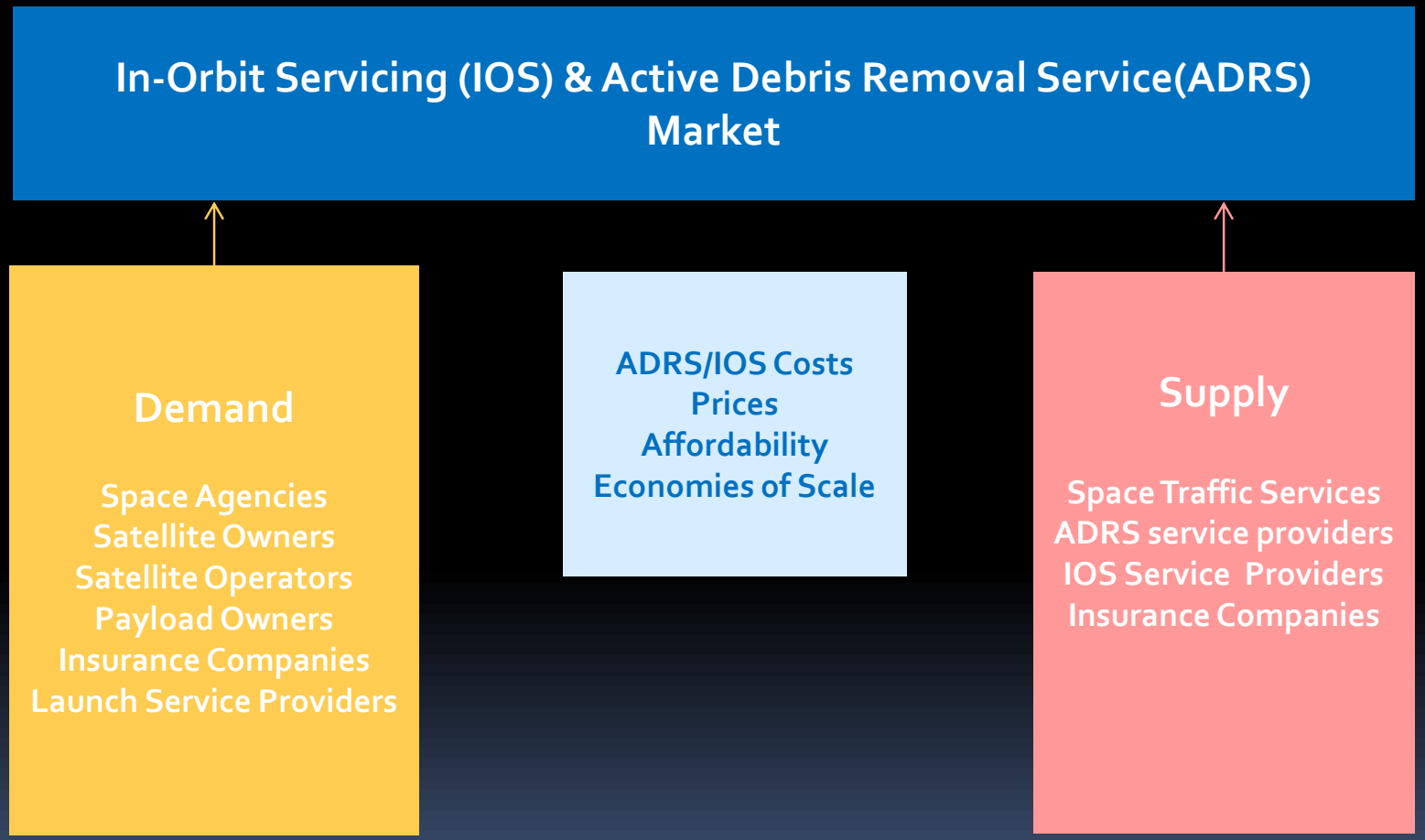
- Emergence of new IOS markets for GEO satellites and ADR markets in LEO
- ***ELSA- D*** successful technology demo for ADR servicing
- ***MEV - 1*** and ***MEV- 2*** successful in orbit servicing missions
- There is a ***need*** for inspection, maintenance, servicing, refueling and recycling of old satellites and unified space debris management and control.
- Lack of user-driven, cost-effective and affordable commercial In Orbit Services and unified space traffic management in the EU.
- There is an ***opportunity*** is to develop a user-driven framework for trade-off scenarios for space debris removal services for LEO/MEO/GEO/Lunar satellites



Courtesy: ELSA-D/ Astroscale

Courtesy: MEV-2/Northrop Grumman

STAKEHOLDERS



Courtesy: The commercial future of orbital services, Nederlandse Vereniging voor Ruimtevaart 2020/3

SPACE DEBRIS MARKETS

Spacecraft Inspection	Collision Avoidance Space Traffic Management	Spacecraft Removal	On-Orbit Servicing/On – Orbit Assembly	On-Orbit Assembly/MAIT
Tracking, locating and describing the targeted space debris Collect information of the satellite or s/c anomalies (e.g. antenna anomalies deployment, etc.)	Collision avoidance maneuvers On Orbit Satellite Servicing and Rescuing activities for collision avoidance	End of Life services and de-orbiting Placement in a graveyard orbit	Refueling Orbit raising AOCS P/L repair Detach certain parts of the satellite Robotic servicing and augmentation of the satellites capabilities Adding new payloads Augmentation of satellites capabilities	Modular satellite assembly in LEO/GSO Lunar missions

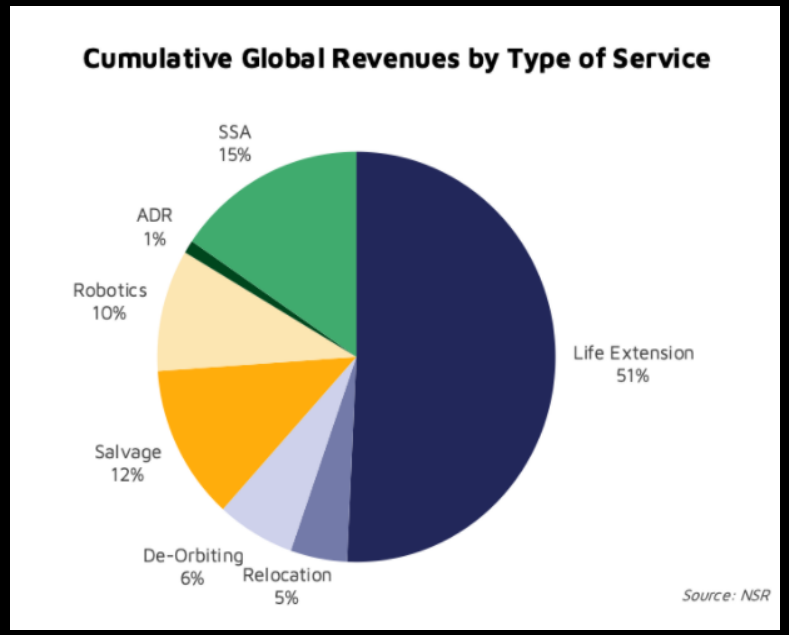
Courtesy: 71st International Astronautical Congress (IAC)- The Cyber Space Edition, IAC-20, E6,2,10 x ID58656, Alexandrova, S., J.Kreisel, T.Schervan, *Measuring the Direct and Indirect Economic Benefits of Commercial Active Space Debris Removal Services (ADRS) based on the utilisation of disruptive future modular satellite systems*

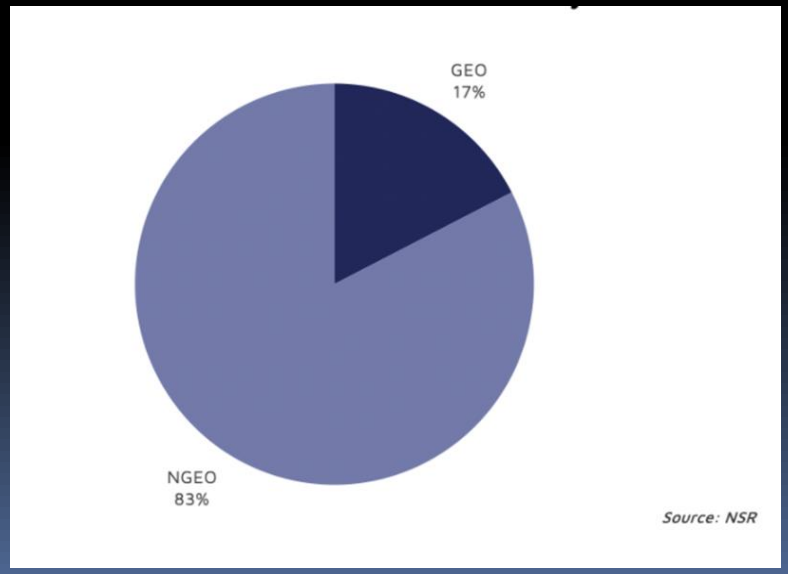
CHALLENGES & OPPORTUNITIES-Part I

- The ***biggest challenge*** in front of customers for IOS and ADR services, is whether IOS, ADR and recycling services are affordable for their business cases?
- ***Trade-off scenarios*** for satellite owners for extending the lifetime of their satellites or deciding whether to launch a new satellite, will be of critical importance for choosing future space debris services.
- Satellite profitability, keeping customers and cost-efficient IOS/ADR services are of importance for end-users
- IOS/ADRS service provides will have to define flexible and scalable solutions that generate economies of scale to become widely affordable

CHALLENGES & OPPORTUNITIES- Part II

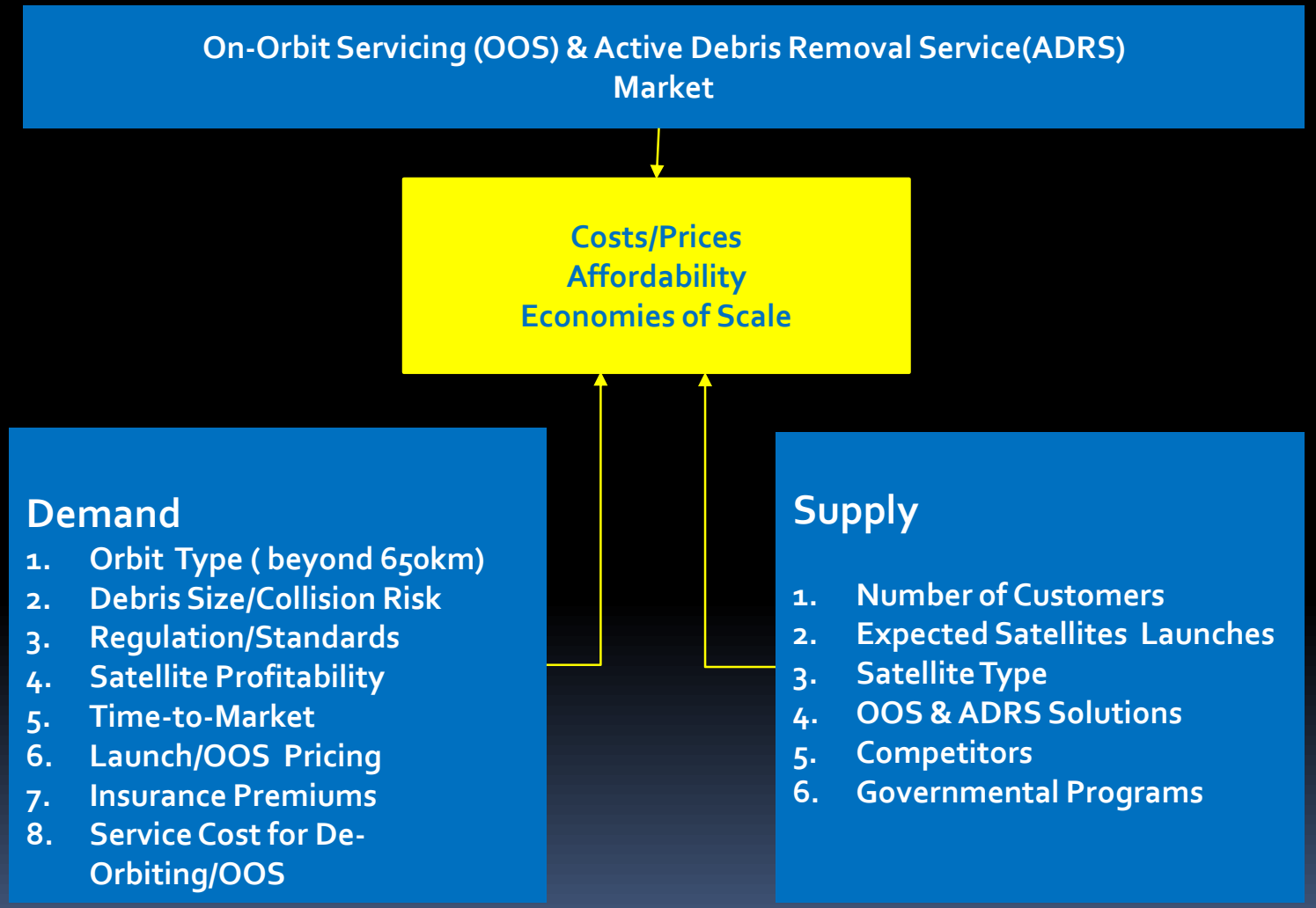
- Aging satellites in GEO orbits
- Diverse space debris markets in a nascent stage of development
- Unclear direct and indirect benefits
- In-Orbit Satellite services (IoS) and SSA cumulative revenues of $6.2 billion by 2030 (Ref: NSR)
- High technology and market entry barriers for European companies, may be a challenge for European satellite owners and services providers for protecting European space infrastructure





Courtesy: NSR, In-Orbit Servicing & Space Situational Awareness Markets, 4th Edition (IOSM4)

DRIVERS IMPACTING THE TRADE-OFF SCENARIOS



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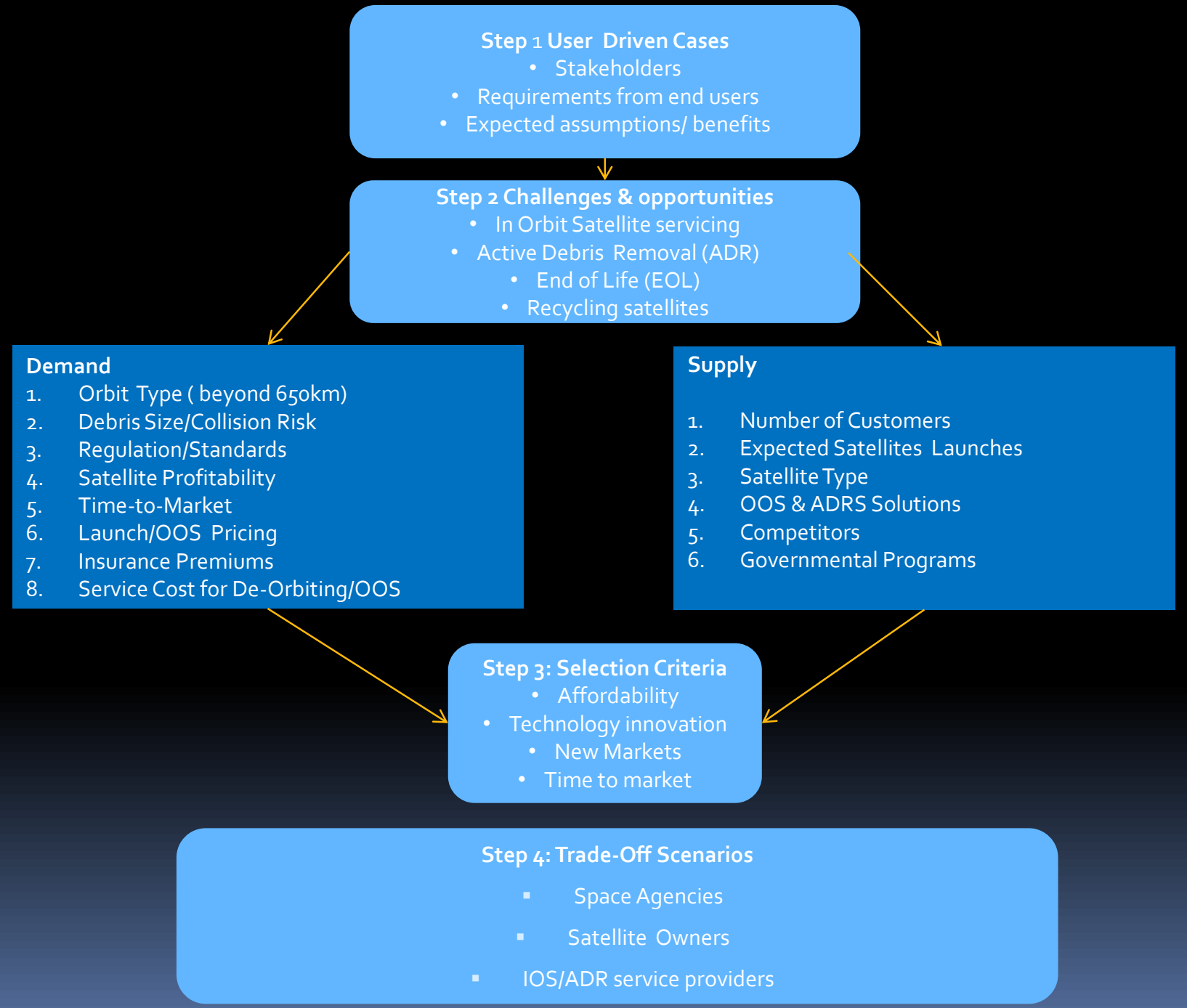

Step 1 User Driven Cases
• Stakeholders
• Requirements from end users
• Expected assumptions/ benefits
Step 2 Challenges & opportunities
• In Orbit Satellite servicing
• Active Debris Removal (ADR)
• End of Life (EOL)
• Recycling satellites
Demand
1. Orbit Type (beyond 650km)
2. Debris Size/Collision Risk
3. Regulation/Standards
4. Satellite Profitability
5. Time-to-Market
6. Launch/OOS Pricing
7. Insurance Premiums
8. Service Cost for De-Orbiting/OOS
Supply
1. Number of Customers
2. Expected Satellites Launches
3. Satellite Type
4. OOS & ADRS Solutions
5. Competitors
6. Governmental Programs
Step 3: Selection Criteria
• Affordability
• Technology innovation
• New Markets
• Time to market
Step 4: Trade-Off Scenarios
▪ Space Agencies
▪ Satellite Owners
▪ IOS/ADR service providers

HYPOTHETICAL EXAMPLES - Part I

Space Agencies

- Collision risks (ADM-Aeolus with Starlink-44)
- Cost savings from avoiding costly collision avoidance maneuvers
- Safety& Contingency
- Technology innovation
- Space debris protection & reduction
- Job creation, economic and industry spillovers

Satellite Operators

- Sustaining customer base
- Technology innovation from new satellite technologies
- Profitability, due to new customers
- Cost savings
- Reduced launch and insurance costs
- Job creation

HYPOTHETICAL EXAMPLE- Part II

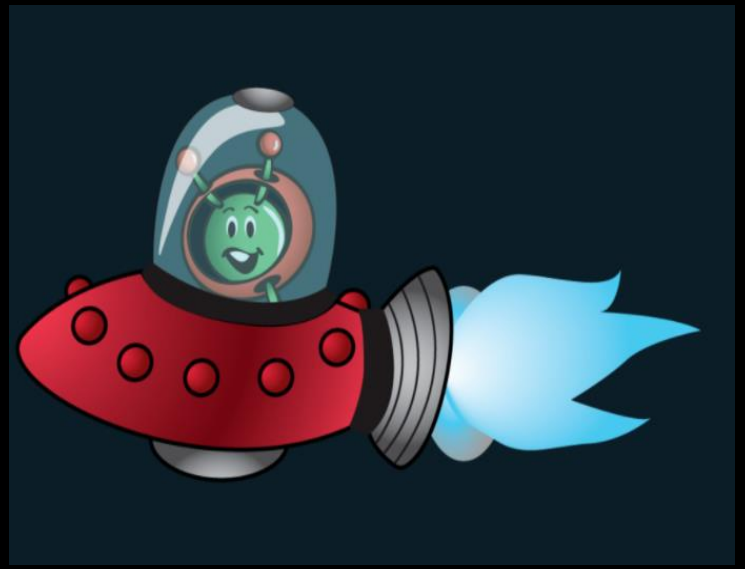
IOS/ADR service providers

- Technology innovation
- Interoperability & scalability
- Safety & Contingency
- Space Infrastructure Evolution
- International partnerships &new markets
- Revenue Growth & profitability
- Job creation

Courtesy: ESA

CONCLUSIONS

- The ***initial user-driven framework*** will help all stakeholders to identify and develop trade-off and cost-effective mission scenarios
- Understanding the factors and benefits influencing the end-user choice, will help ***satellite owners*** develop economically viable trade-off scenarios , choose space debris services and extend affordably the life time of their satellites
- ***IOS/ADRS service providers*** will be able to crystallize their business models, develop market scenarios (optimistic, realistic, pessimistic), attract private investors, perform risk analyses and offer competitive prices



Courtesy: ESA

Thank You ☺