

Pietro Guerrieri, Rocco Scolozzi



WHAT SPACE LOGISTICS IN 2050?

Big Pictures, Trends and Scenarios in the Emerging Space Economy



WHAT SPACE LOGISTICS IN 2050?

Big Pictures, Trends and Scenarios in the Emerging
Space Economy

Pietro Guerrieri, Rocco Scolozzi
What Space Logistics in 2050?
Big Pictures, Trends and Scenarios in the Emerging Space Economy

© Italian Institute for the Future 2023

ISBN 978-88-997-9032-5

Editing: Roberto Paura, Simone Musella, Giulia Guerrieri

Graphics: Leonardo Degni (original images) + courtesy Bryce Tech and
SIA, Seraphim Capital.

Layout: Chiara Manzillo

Italian Institute for the Future
Via Gabriele Jannelli, 390 – 80131 Napoli
www.instituteforthefuture.it
info@futureinstitute.it

With the contribution of



IMPULSO.SPACE

CONTENTS

Foreword by Simonetta Di Pippo	5
---------------------------------------	---

Chapter 1 – The Emerging Space Economy and the Need of Long-Term Perspectives

An Entire Orbiting Economy	9
----------------------------	---

Chapter 2 – Voices from Key Actors

About Possible, Desirable, and Undesirable Directions	61
A Desirable Future	66
If Things Go Wrong	72
Directions of Development	76

Chapter 3 – Explorative Scenarios for Space Logistics

The Rationale of Using Scenarios	81
Key Elements in the Scenarios	91
Delphi Survey and Strategic Interviews	108
From Horizon Scanning: Significant Events and elements for a Space Industry	
SWOT Analysis	128
Synthesis From the Different Analyses	131

Chapter 4 – Strategic Scenarios

Drafting the Scenarios	133
Scenarios	146
Deeper Understanding of Scenarios with Causal Layered Analysis	175
CLA Scenarios	179

Chapter 5 – Strategic Suggestions for Space Logistics Policies Using Systems Thinking

Desirable and Undesirable Dynamics in Future: Application of Systems Archetypes to Scenarios	183
Limits to Growth	185
Shifting the Burden	189
Success to the Successful (or competitive exclusion)	193
Escalation	195
Glossary	201
Afterword by Roberto Paura & Gennaro Russo	207
Acknowledgements	215

Foreword

Simonetta Di Pippo¹

2022 marked the 50th anniversary of the last Apollo mission to the Moon, Apollo 17, and it marked also the 60th anniversary of the most famous inspirational speech ever pronounced. We are talking about the speech delivered by the President of the United States of America John Fitzgerald Kennedy at the Rice University on 12 September 1962. The speech famous for: *we choose to go to the Moon before the decade is out and to do these things not because they are easy but because they are hard*. The US did it, on 20 July 1969, they indeed landed humans on the Moon, opening up a new era in Space exploration. And so, when the NASA SLS mission brought Artemis I orbiting the Moon in November 2022, we all had the feeling that we were back in history on one side and projected towards the future on the other.

Back to the Moon, and this time together. The Artemis Accords, proposed by NASA and as per the end of 2022, signed by 23 countries, including the US, are a concrete sign of the interest of a group of countries to approach a systematic exploration of the solar system responsibly. 2022 has been defined the golden age of Space exploration. Few reasons have been mentioned already. An additional element to be considered is the increasing presence of entrepreneurs who are monopolizing the scene with private investments and recently, also with private objectives. In other words, when Elon Musk started the development of the Dragon capsule, it was mainly, even if not only, to fulfill the NASA objective to fly again American people from American soil towards the International Space Station, after several years of Russian monopoly essentially due to the Shuttle retirement in July 2011. This is not the case for Starlink, the megaconstellation he is building up to provide internet to everyone everywhere. It was his own idea, and now it may be helpful also for strategic national reasons. On top of everything, Starship. It may bring, as declared by SpaceX, up to 100 people to the Moon and Mars, back and forth, with a reusable machine. A

¹ Professor of Practice of Space Economy at SDA Bocconi, former Director of the UN Office for Outer Space Affairs (UNOOSA).

revolution. NASA is taking advantage of these developments and Starship will complement the SLS launcher and the Orion capsule in building and operating a permanent settlement on the Moon to start with.

What becomes clear from the evolution of this scenario, whatever details we will have to consider, is the need of Space Logistics. And this is exactly what the book is contemplating. The case for an exponential growth is well depicted, and how Space economy is creating new markets which didn't exist few years ago is underlined. But with an exponential growth in Space economy, and in the number of satellites launched, the safety, security and sustainability of outer Space and of outer Space activities is put in danger. Orbits are more and more congested and contested, in particular in Low Earth Orbit, but the Moon will be, and it is already in a way, the next logical step. While we need, in reality we needed it yesterday, a Space Traffic Coordination System and global governance for LEO, the same applies immediately to what we expect to become a systematic solar system exploration, both robotic and human. Outer Space is a global common, as defined by the UN Secretary General in his 'our common agenda', issued in September 2021, and it has to be preserved for future generations, also in line with what the Outer Space Treaty clearly spells out: Space is the province of (hu)mankind. And while we expect to be able to benefit more and more from the use of Space based data and infrastructures for improving the quality of life on Earth, the Space economy in its Space for Space component, is probably the most profitable, in the medium-long term. The question that the authors pose here is key: *what is the variety of possible future conditions under which Space products and services could evolve and profit?* Both in LEO and on the Moon, and beyond, Space Logistics becomes a fundamental sector which is predestined to bloom. Space Logistics, as well depicted in the book, is everything related to the development and operations of future infrastructure in Space. If we look at LEO, one of the main expected developments is related to commercial Space stations. Automated logistics operations will become routine, supported mainly by robotic systems. Even the construction of big infrastructures in Space, from laboratories to commercial hubs, down to hotels and recreations Space parks, could be built with the support of robots and artificial intelligence, which brings with it attention to one of the most interesting megatrends of our times: how humans and robots could, should and would interact, and how Space technologies can be integrated with AI and robotics to have more performant systems in Space. Refueling, refurbishment, change of orbits, in orbit maneuvers, are just few examples

of possible market developments in terms of satellites and stations services in Space, while the topic of Active Debris Removal is already trendy and needs regulation, in absence of which the market will develop in any case, simply because the Space community needs it.

The book is also quite interesting because it is a mixture of interviews to eminent experts in the field, review of sectors and definitions, science fiction when it comes to imagine future scenarios, technical evaluations and market analysis, all combined.

Allow me to think about a possible undesirable future regarding the Space economy and Space Logistics with it in 30 years from now. So, in 2050, we could find ourselves with the evidence that multilateralism failed, there is no existence of Space traffic coordination so everything is chaotic in Space. The Moon could be colonized in a non-responsible manner, Space resources cannibalized and not used for the benefit of all. The social tension could escalate as a result, and Space could become an additional reason for conflicts. What to do to avoid this scenario? We need to increase awareness in treating Space as a public good and a global commons, building a shareholder rather than a stakeholder Space economy. Through the implementation of existing normative framework, we would work to turn policy tools such the Space Debris Mitigation guidelines and the Long-Term Sustainability guidelines into actions. And in defining the rules for Space traffic coordination, the rules of the road in other words, we should look at multilateral sharing of Space situational/domain awareness information to improve safety and sustainability, as well as to international mechanisms for notifications, coupled with an enhanced registration set of practices to cope with the exponential growth of Space objects. I hear sometimes that the growing number of satellites is raising concerns. Well, we cannot simply stop launching, rather we need to launch responsibly.

As I always say, the Space economy is the backbone of the modern economy, the economy of the 21st century. Space Logistics as a subset of it will enable Space operations more and more, expanding the horizon of the potential Space economy growth.

Space Logistics and services is also extremely important for the safety of vehicles and humans, in particular when we talk about rescue of stranded astronauts or tragedies occurred in the past. We need to analyze what happened, take advantage of the lesson learned and develop Space Logistics accordingly. If something happens for example during the flight, we need to have everything in place to do inspection and eventually repair the damaged Spacecrafts and if not possible, logistics in orbit should allow

for a safe rescue. We don't want, anymore, be faced with realities such as the one we experienced on 1 February 2003, which the Shuttle Columbia didn't make it to the end of its mission and exploded when re-entering the atmosphere, with seven crew members on board. The type of risks we have to face in the Space economy of the future are not only the ones just mentioned, but also the ones associated with investments in Space exploration ventures and the need to better define viable and affordable options for investors to seize uncertainties. Also, the basic question of whether investments in Space exploration activities are 'unique' and distinct from more traditional ones needs to be fully addressed and understood to identify the right tools to translate uncertainties into measurable risks and create a favorable environment to stimulate investments. This book is a valid support also for investors, who can find interesting hints for their evaluation. Space is bottom line not easy, and while we see launches almost every day right now, it is still difficult, and, as someone is used to say, failure is not an option, specifically with humans on board. Not to forget that Space economy and logistics is also an integral part of actions and initiatives towards a socio-economic sustainable development approach in particular in developing and emerging countries. Space is with us, it is embedded in our current activities, connects us, and it will be more and more instrumental for the future we want. We need cooperation, technical skills in a modern workforce, we need to look ahead and beyond, nothing is impossible. When looking at our Earth, a pale blue dot from outside, this is still the only planet we call home. Soon, we will be a multiplanetary species and our home will be the solar system. And whatever we do on Earth, we will have to replicate or better to adapt knowledge and expertise in the various fields – constructions, architecture, agriculture, medicine, and counting – to a different Space environment. One point on our side, if we will be able to grasp it: there are no boundaries in Space yet and it is a public good. Let's make some exercises of a better future and of a new social contract while we start exploring, and there will be jobs for everyone, on a Space station or on another celestial body in the solar system. Hopefully, in peace.