SPACE ECONOMY EVOLUTION LAB ANNUAL REPORT 2022

SDA Bocconi
SCHOOL OF MANAGEMENT

SEE LAB
SPACE ECONOMY EVOLUTION

INDEX

FOREWORD

Stefano Caselli
Dean, SDA Bocconi School of Management

If the quest for creativity and new challenges is at the very heart of the spirit of our School, reflecting on the space economy and starting an initiative like SEE Lab best expresses the pioneering sense of this initiative. The comparison with "space" is by definition a combination of the unknown, technology, freedom, risk and research into new paradigms that can improve life on Earth. A deeper reflection is needed: if economics is born as a science of resource scarcity and management as a discipline of resource management and competition, space bursts onto the scene as a factor that breaks up this established and unchanging game pattern. By its nature, space represents an extraordinary and limitless logic, which allows us to extend the playing field of scarce resources by opening up reflections and opportunities that until recently were unthinkable. This is the real revolutionary aspect of the space economy and its fascination in determining a clear discontinuity in the way we think and urging us to imagine new ways of interpreting our concept of management.

What we now define as a "space economy" has three fundamental areas of development and research. The first is that of innovation, the second is that of development and the third that of geopolitics. Innovation is the term that is immediately associated with the theme of space, because space more than any other human field requires us to push technological progress and it generates as a return effect further technological progress, thanks to an unstoppable dynamic.
In this sense, the more the space economy becomes concrete, does not remain relegated to a world of professionals and is configured as main stream activity, the more this effect becomes powerful. Development must be understood in the deepest sense: from the creation of new trajectories of GDP growth to the search for better living conditions for mankind in the short and long term. Geopolitics: space opens a new playing field that can become an extraordinary place of cooperation or further conflict. The hope is that the complexity of the challenge will push different countries to promote cooperative games that will then bring benefits from space to Earth.

This complexity becomes an exciting playground for a management school that, by its nature, loves to face new challenges head-on, promoting the meeting of different cultures and skills. In space we still have to develop everything, and develop it perhaps better than we have done so far on Earth. SEE Lab, thanks to the energy of Prof. Di Pippo and her researchers, seeks to make a decisive contribution to this challenge, which has a very long perspective, almost as infinite as space itself. But the most important challenge is to use space as a privileged and unique laboratory in which to experiment, to identify new solutions - from technology to law - that generate positive effects on Earth. Venturing into fascinating and perhaps imaginative hypotheses of life in other places in space is a reflection that I leave to other more competent people, Surely it is more concrete to bind space to Earth to improve the way we exist and grow on our planet.

Starting from the title of a successful movie like "The world is not enough", this time we can say it is true and maybe we can also say " space is more than enough". Good luck to everyone with the research and its challenges.

Simonetta Di Pippo
Director, Space Economy Evolution Lab

2022 has been a very important year for SEE Lab. I joined as Director in March, and a lot of things have changed since then. Throughout the year we conducted a set of initiatives with the aim of reinvigorating the Lab, expanding our network, conducting more and more solid research, organizing events and conventions, while always paying special attention to education. This has been a fundamental step in order to clarify what we have been working on so as to make our Members and partners more conscious of our growth prospects. The Lab has made use of its extensive network of scientific partners, industry experts and professionals to promote and stimulate the dialogue among its Members and stakeholders. Indeed, open discussions are highly valued by SEE Lab as a method of disseminating information, viewpoints and best practices. Our goal is ambitious yet reachable in the very short term: becoming the center of excellence in the space economy at a global level, guided by the vision of 'building up the economy of the future'.

A major innovation concerns the expansion of our range of action and the renovation of our governance model. This approach has allowed us to attract several new Members, partners and overall interested stakeholders, such that the Lab has underpinned a number of activities throughout the year: we joined forces with the national and international industry, institutions and Universities. As mentioned in the Report, we developed research together with Telespazio, AVIO, AIPAS, La Sapienza University in Rome, Fondazione Leonardo; we offered a preferred platform for events, workshops and conferences; we participated in national and international events.

Moreover, we launched what will be the key core asset of all SEE Lab's activities in the future, the SEEData, which aims to become the primary database at national and international levels for the space economy.
It will address the dearth of comprehensive, unambiguous and uniform data and information on the space industry. In 2022, we primarily focused on collecting reliable financial data on Italian firms belonging to the space value chain, but this project will be continuously carried out in the future, to create a constantly updated asset for SEE Lab and its Members.

We have been able to achieve these results and to become an important player in the space sector also thanks to our Members and our Partners. Our collaboration and continuous communication with them represent one of our main resources, and I'm sure that this network we created (and that we'll expand in the future) will enable us to achieve more and more important results.

Finally, I would like to share a thought. We have only just started: we are ambitious and we will continue to pursue our objectives, which will always be increasingly challenging and inspiring. The best is yet to come. This is just the beginning.

1. SPACE ECONOMY EVOLUTION LAB

1.1 THE LAB

VISION

SEE Lab is the SDA Bocconi School of Management's research laboratory aiming to provide space-oriented businesses, non-space industries, financial operators and public actors with the in-depth understanding and strategic insights necessary to leverage the opportunities presented by the evolution of the space economy.

Its activities are built on four key pillars:

1. **Robust interdisciplinary research approach**
2. **International scope**
3. **Out-of-the-box thinking**
4. **Enhancement of the interconnection between space and non-space sectors**

MISSION AND OBJECTIVES

SEE Lab is committed to training leaders capable of having a disruptive approach and an unconventional perspective. With this intent, it generates and disseminates in-depth knowledge on the space economy, identifying demand, supply and technological innovation trends in the short, medium and long term at the global level.

More specifically, SEE Lab aims to:

- **Supply knowledge on space economics and business to space-related private corporations and public institutions;**
- **Enlighten non-space industries and financial operators about the opportunities of the space economy to set up a common ground with the space industry;**
- **Become a meeting point for academic and non-academic research centers to share their knowledge on market, political, regulatory, financial and technology aspects of the space economy;**
- **Become an internationally recognized point of reference for entrepreneurial spirits and policy makers of the space sector.**

ACTIVITIES

At SEE Lab, we believe that the combination of in-depth and cutting-edge knowledge and pragmatic insights drive the impact of education programs and the value of dissemination events, bolstering new ideas and perspectives in the context of the space economy. Thus, applied research projects represent the primary focus of the laboratory's activities through which it provides strategic thinking to private and public actors.

The Laboratory generates and disseminates knowledge on two major topic areas:

- **Space for Earth – including all the activities carried out in space to generate benefits for humanity on Earth;**
- **Space for space – including all the activities carried out in space to develop and enhance human presence and activities outside of the Earth's atmosphere.**

The laboratory's core activities – applied research, idea generation, dissemination and education – build on a reliable and updated proprietary dataset, the SEEData, and on academic methods of analysis.

SEEData

The SEEData is a dataset representing SEE Lab's main core asset and the basis for all its activities. The general purpose of this on-going project is to respond to the lack of detailed, univocal and homogenous data and information regarding the space sector. The SEEData is set up with a modular structure. This means it will be composed of different blocks, released with separate timelines, but thematically complementary to one another. The dataset will be gradually extended to eventually include the economic and financial data of space companies, mainly focusing on key performance indicators; investments, in the dual fashion of private capital investments and merger and acquisition (M&A) operations; macroeconomic data about countries active in the space industry and information regarding the world's Space Agencies' budgets. As a result, the SEEData will allow the laboratory to conduct any kind of analysis using proprietary data, thus granting Members meaningful and trustworthy information. Our mission is to create the first space sector-oriented database at the service of space as well as non-space companies, but also agencies, institutions and policy makers.

Applied research

SEE Lab carries out independent, multidisciplinary and scientifically robust research projects. Adopting such an approach implies analyzing space-related themes through various lenses and fitting them all into academically reliable methodologies. To do so, SEE Lab combines economic, technical, political, and regulatory points of view, holistically addressing the space industry's inherently multi-faceted nature. At the same time, the laboratory leverages on the know-how of SDA Bocconi School of Management and Bocconi University's faculties concerning academically validated research methodologies to provide its stakeholders with scientifically robust results.

Aimed at providing concrete support to private and public players, SEE Lab conducts commissioned studies, offering ad hoc analysis, and, thanks to its far-reaching network, it substantiates its findings not only with academic evidence, but also with information derived from international industry experts and professionals, offering, as a result, a markedly practice-oriented perspective. As well as commissioned projects, the laboratory will supply its Members with Strategic Insights and Outputs, namely SEEData data elaborations and key analyses on specific topics in which they are interested.

Idea generation

SEE Lab strongly values open debates as a means of disseminating knowledge, opinions and best practices. To foster the dialogue among its Members and stakeholders, and to expose them to inspirational perspectives, the laboratory leverages on its broad network of scientific partners, industry experts and professionals, and organizes events aimed at sparking the generation of ideas and strategic thinking. More specifically, SEE Lab Members can take part in Titan Brain Trusts, high-level roundtables with external subject experts to discuss political, market, and technology topics, and in the General Assembly, during which the center's activities, achievements and future perspectives are presented to its stakeholders.

Dissemination and education

Dissemination and education activities, including events and customized courses, are key drivers of SEE Lab's research projects. To maximize the impact of our thinking, SEE Lab enhances its findings by collaborating with its network of scientific partners and encouraging future-oriented discussions. Featuring lectures delivered by the thought leaders of the space industry and institutions, the center's events and courses are designed to stimulate debate, incubate innovative ideas and apply them pragmatically to the most pressing challenges in space commerce. They also provide space stakeholders with valuable opportunities to connect, boosting academic alliances and business and institutional relations alike.

- **Education Programs: SEE Lab aims to design and deliver customized courses, combining the target organization's strategic objectives with individuals' professional and personal development. In 2022, the Lab took part in various seminars and courses, both within and outside SDA Bocconi School of Management.**
- **Events: SEE Lab organizes Annual Conferences, webinars, workshops and seminaries, hosting national and international guests.**

Moreover, the laboratory participates in third-party organized conferences to disseminate its research outputs and to establish new connections within the scientific community. SEE Lab is also a member of the International Astronautical Federation.

TEAM

SEE Lab's team features the Director, the SEE Lab Acceleration Board and the Core Space Team. As a whole, the group is composed of different profiles with dissimilar backgrounds, ranging from policy to finance, business management and economics. This configuration concretely achieves our goal of adopting a multidisciplinary and holistic approach.

*The SEE Lab builds on a core **team**, relies on SDA Bocconi and Bocconi University **faculty's** support, and makes its Members and Partners actively engage into its activities.*

DIRECTOR
Simonetta Di Pippo
Professor of Practice

SEE LAB ACCELERATION BOARD
It gathers SDA Bocconi and Bocconi facolty to maximize synergies, to facilitate collaborations in order to foster-cutting and multidisciplinary research activities.

Severino Meregalli
Devo Lab Scientific Director
Associate Professor of Practice

Gianluigi Castelli
Devo Lab Director
Associate Professor of Practice

Space Team
Clelia Iacomino
Researcher

Space Team
Mattia Pianorsi
Researcher

Space Team
Aristea Saputo
Researcher

Space Team
Andrea Conconi
Researcher

Simonetta Di Pippo – Director

At SDA Bocconi School of Management, Simonetta Di Pippo is a Professor of Practice of Space Economy and Director of the Space Economy Evolution Lab (SEE Lab). Before joining SDA Bocconi, she served as Director of the United Nations Office for Outer Space Affairs (UNOOSA), and prior to joining UNOOSA, she served as Director of Human Spaceflight at the European Space Agency (ESA), Director of the Observation of the Universe at the Italian Space Agency (ASI) and led the European Space Policy Observatory at ASI-Brussels. She holds an MSc in Astrophysics and Space Physics from University "La Sapienza", an Honoris Causa Degree in Environmental Studies and an Honoris Causa Degree of Doctor in International Affairs.

Gianluigi Castelli – Acceleration Board Member

At SDA Bocconi School of Management, Gianluigi Castelli is an Associate Professor of Practice of Information Systems and Director of the Digital Enterprise Value and Organization Laboratory (DEVO Lab). He has led large technology research projects within the framework of EC funded programs (OMI) and work groups drafting the ICT strategic guidelines for major European Institutions. He has been CIO for large multinational companies in Italy and abroad (Infostrada, Fiat, Vodafone, Eni and Ferrovie dello Stato Italiane). He has also been President of Ferrovie dello Stato Italiane and of the Union Internationale des Chemins de Fer (UIC). From 2020 to 2022, he collaborated as an expert with the Ministry for Technological Innovation and Digitization.

Severino Meregalli – Acceleration Board Member

At SDA Bocconi School of Management, Severino Meregalli is an Associate Professor of Practice of Information Systems and Scientific Director of the Digital Enterprise Value and Organization Lab (DEVO Lab). At SDA Bocconi, he was head of the Information Systems Unit (2007-2012). He has conducted research and education projects for major multinational companies. He is the founder and partner of a consulting and advisory company in the field of corporate IT. He has been a member of the Board of Directors of national and international companies. He has been a Visiting Scholar at the Carlson School of Management in Minneapolis. Severino earned a degree from Bocconi University.

Andrea Conconi – Researcher

At SDA Bocconi School of Management, Andrea Conconi is a Knowledge Analyst and a SEE Lab researcher. Before graduating, he worked at SEE Lab within the SES-Italy (Socioeconomic Study) research project for the European Space Agency, investigating the socioeconomic impacts of satellite services in non-space industries. After this experience, he worked as a Junior Economist in a financial intermediary, conducting research on the macroeconomic stability of emerging markets, and eventually came back to SEE Lab. Andrea holds an MSc in Economics and Social Sciences from Bocconi University, with a Major in Macroeconomics and Economic Policy.

Clelia Iacomino – Researcher

At SDA Bocconi School of Management, Clelia Iacomino is a Junior Lecturer in space economy and a SEE Lab researcher in policy impact analysis, market analysis and international business strategy. At SDA Bocconi, she organizes dissemination events, coordinates research projects for space agencies, space and non-space industries and international organizations, and takes part in training activities in the field of space economy. Clelia earned an MSc in Political Science – International Relations from La Sapienza University and a Master in Space Institutions and Policies at SIOI (Italian Society for International Organization), Rome. She is currently a PhD Candidate in Management & Innovation at the Università Cattolica del Sacro Cuore in Milan.

Mattia Pianorsi – Researcher

At SDA Bocconi School of Management, Mattia Pianorsi is a Junior Lecturer in space economy and a SEE Lab researcher. He coordinates research projects and delivers lectures for MBA and MEBI students and he has been a Learning Coordinator of custom programs for senior executives. He collaborates with the European Space Resources Innovation Center (ESRIC) in Luxembourg, and he is a member of the Lunar Commerce and Economics Working Group (LCE) of the Moon Village Association. Mattia holds an MSc in Management from Bocconi University. He also attended the Executive Management Program in Banking in 2015 and the Teaching Excellence Program in 2017, both at SDA Bocconi. Currently, he is a PhD candidate at St. Gallen University.

Aristea Saputo – Researcher

At SDA Bocconi School of Management, Aristea Saputo is a Junior Researcher in Sustainability and a SEE Lab researcher. She has had three years of experience at the Sustainability Lab, where she has explored corporate social and environmental sustainability through multi-sector studies commissioned by companies, public bodies and non-profit organizations. After this experience, Aristea started to collaborate with SEE Lab and with AGRI Lab, the School's research center dedicated to agribusiness. Aristea earned an MSc in Economics and Social Sciences from Bocconi University, with a period as a visiting student at Sciences Po, Reims. Currently, she is a PhD candidate at St. Gallen University.

1.2 ACTIVITIES IN 2022

RESEARCH

Socio Economic Impacts of Satellite Services: Italy

– In collaboration with e-Geos a Telespazio/ASI Company

SEE Lab carried out this study for the European Space Agency (ESA) with the aim of providing a preliminary analysis of the Italian satellite services and applications innovation ecosystem, focusing on a selection of its players, namely private providers, private customers and public institutions, to offer an initial understanding of its dynamics and possible deficiencies. Through the identification of the major gaps between the supply's value proposition and the demand's value perception, the study detects possible areas of improvement to be addressed by public organizations to enhance satellite services and the dissemination of applications at national level. SEE Lab thanks all the companies and public organizations that have contributed to the projects by giving interviews and providing documents: Airbus, Allianz, An Fed Agri, IBF Servizi, Enel, the European Space Agency, the European Union (Italian Permanent Representation), the European Union Agency for the Space Program, Rete Ferroviaria Italiana, the Italian Space Agency, OneWeb, Planet, TIM, and Vodafone.

Lunar Communication and Navigation Services

– In collaboration with Telespazio

SEE Lab was part of the consortium led by Telespazio with the aim of conducting a preliminary analysis on the feasibility of the Lunar Communication and Navigation Services (LCNS) project, the ESA initiative – Moonlight - for positioning the European space industry in the provision of lunar communication and navigation services. SEE Lab – which was the only non-industrial actor involved in the research – made its contribution by conducting an economic analysis involving the definition of the potential long-term lunar communication and navigation markets, support for the creation of the economic-financial plan and the identification of the possible options for public-private partnerships.

UltraGreen Launch and Space Transportation System

– In collaboration with Avio

SEE Lab supported Avio in assessing the environmental footprint of its new launch and space transportation systems (LSTS). By selecting an appropriate impact assessment methodology and green parameters and applying them to both a selection of the current set of LSTS and to concepts of the future generation of LSTS, SEE Lab and Avio were able to make environmental concerns count in the choice of the future LSTS. More specifically, building on ESA's guidelines, the project adopted the Life Cycle Assessment (LCA) methodology and its mid-point and flow indicators to detect different launch, space and ground segment pressures on the environment, with a particular focus on the carbon footprint.

AIPAS SME4IRIDE

– In collaboration with AIPAS

SEE Lab supported AIPAS (Associazione Delle Imprese Per Le Attività Spaziali Association Of Enterprises For Space Activities) in analyzing the potential impact of the IRIDE program on small and medium Italian enterprises (SMEs) and startups along the proposed constellation's value chain, providing a framework to measure it dynamically in the coming years. At the same time, the study explored how the expertise of SMEs and startups may contribute to the evolving Earth observation (EO) value chain and highlights the market conditions needed to guarantee their involvement and, consequently, the development of a competitive and sustainable market framework. Finally, it proposes some considerations about the overall system configuration necessary to maximize the positive impact of IRIDE on SMEs and startups in coherence with European EO programs and with the long-term sustainability of IRIDE.

A "new" Space Law for Italy

– In collaboration with Fondazione Leonardo

SEE Lab joined Fondazione Leonardo and La Sapienza University of Rome in the conceptualization of a formal request to the Italian Government for the creation of a "new" Italian space law. The project aims to highlight the need of industry actors, space trade associations, public and private space research entities and other general stakeholders to rely on a new, clear, robust set of rules able to discipline the space sector and to let it thrive according to what is happening at the global level, fully in line with international guidelines and regulations. In the initial phases, SEE Lab conducted a quantitative market analysis on the growth trend of the Italian space industry between 2012 and 2021, mainly looking at the sector's revenues, investments and employees. Those were compared to the European and Italian space agencies' (ESA and ASI) budgets distributed over the selected time frame. This first part of the study was presented at the Italian Lower House on December 16th, 2022, in the presence of the Minister of Enterprises and Made in Italy, Adolfo Urso, and of the Minister of Defense, Guido Crosetto. The project started in 2022 and will continue with several new phases throughout 2023.

Small Internet Satellites

– contribution to DEVO Lab's HIT (High Impact Technologies) Radar

SDA Bocconi's Digital Enterprise Value and Organization (DEVO) Lab publishes its HIT Radar on a yearly basis. The Radar aims to assess the readiness and implementation levels of frontier technologies in the standard business of companies. SEE Lab offers its collaboration on this project by directly conducting the evaluation of one of these technologies, namely small internet satellites. This commonly indicates the activity of assembling private, very large constellations of small satellites in low Earth orbit (LEO), with the twofold advantage of being able to cover the whole globe, hence also providing connectivity services to remote areas that are currently not covered by terrestrial infrastructures; and to provide upload and download connection speeds faster than the commonly used telecommunications satellites in the geostationary orbit (GEO). The technology's evaluation within the HIT Radar is based on three dimensions: Distance, meaning the adoption grade of the technology; Speed, meaning how much its readiness level has been growing over the years; Impact, meaning how influential the technology is within the companies' businesses. The methodology is based on desk research, specialized report analyses, sector news and expert evaluations.

SEEData

As mentioned above, , during the last few months, the SEE Lab team has started the SEEData journey focusing, at first, on retrieving reliable financial data about the Italian firms belonging to the space industry value chain. While geographically and thematically restricted, this first block is opening the way to SEEData's next sections and, as such, it is addressing the most challenging aspects of building a one-of-a-kind database. Defining the boundaries of the space sector value chain, identifying every company belonging to it, finding out their business lines to classify and position them along the supply chain and exploring multiple information sources to detect the most trustworthy are some of the activities that SEE Lab is currently carrying out and that will provide the basis for the entire SEEData's structure.

INSTITUTIONAL EVENTS

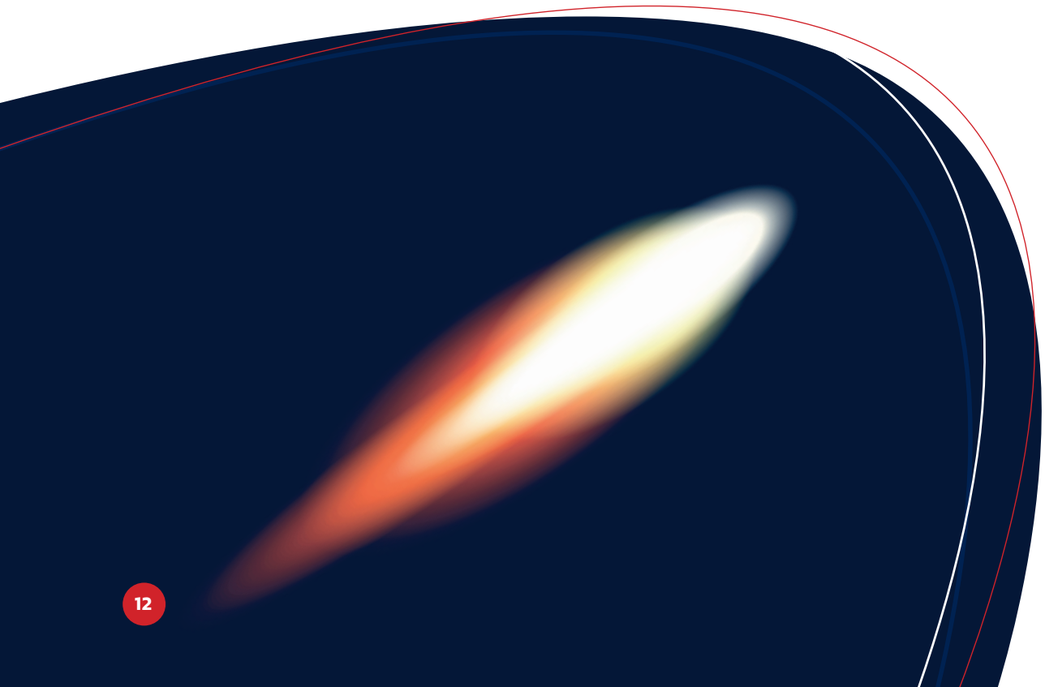
Annual Conference 2022

– Fostering multidisciplinary research for the future of space.
Following in Andrea Sommariva's footsteps.

SEE Lab's Annual Conference 2022 was aimed at commemorating the great contribution of Professor Andrea Sommariva's research activities on the space economy and his joint efforts with Giovanni Bignami to bring the space economy into the context of business schools. At the same time, the event highlighted the role of multidisciplinary research for the space industry, stressing the importance of a comprehensive combination of economic, business and technical understandings to successfully navigate the space industry's next and most urgent challenges and opportunities. Finally, the event launched the laboratory's future program by welcoming its new Director, Professor Simonetta Di Pippo, who outlined the center's renewed vision and mission, as well as its strategic activities, comprising research, education and knowledge dissemination, to support every stakeholder in the space industry.

• **Participants:**

Clelia Iacomino · Researcher, SDA Bocconi School of Management; **Mattia Pianorsi** · Researcher, SDA Bocconi School of Management; **Giuseppe Soda** · Dean, SDA Bocconi School of Management; **Simonetta Di Pippo** · Director, SEE Lab; **Mario Monti** · President, Bocconi University; **Vittorio Colao** · Minister for Technological Innovation and Digital Transition, Italian Government; **Patrizia Caraveo** · Director of Research, INAF – National Institute of Astrophysics; **Henry Hertzfeld** · Professor of Space Policy and International Affairs, Space Policy Institute of George Washington University; **Ian Christensen** · Director of Private Sector Programs, Secure World Foundation; **Ian Lange** · Associate Professor of Economics and Businesses, Colorado School of Mines; **Roberto Vittori** · General of the Italian Air Force and former astronaut at the European Space Agency; **Maria Cristina Falvella** · President, Fondazione Amaldi and General Inspector Italian Space Agency; **Severino Meregalli** · Associate Professor of Practice, SDA Bocconi School of Management; **Kevin O'Connell** · Founder and CEO, Space Economy Rising; **Andrea Macciò** · Director of the Center for Astro, Particle and Planetary Physics, NYU Abu Dhabi; **Minoo Rathnasabapathy** · Research Engineer at the Space Enabled Research Group, MIT Media Lab; **Paolo Gaudenzi** · Professor of Aerospace Structures and Constructions, La Sapienza University; **Giorgio Saccoccia** · President, Italian Space Agency; Giulio Ranzo · CEO, Avio; **Luigi Pasquali** · CEO, Telespazio; **Massimo Comparini** · CEO, Thales Alenia Space; **Andrea Falleni** · CEO, Capgemini; **Luca Rossettini** · CEO, D-Orbit; **Marco Molina** · Managing Director Sales and Products, Sitael.



Titan Brain Trust 2022

– Pamela Melroy and space exploration's frontiers.

SEE Lab's first Titan Brain Trust (TBT) opened the periodic series of events designed to provide the SEE Lab's Members with the opportunity to discuss space-related political, market and technology topics with external subject-matter experts and the SEE Lab's Partners. The 2022 event consisted of an exclusive roundtable and, building on an inspiring speech by Dr. Pamela Melroy, NASA Deputy Administrator, the SEE Lab's Members and Partners were able discuss space exploration's most promising frontiers, from space stations in Earth's low orbit to Moon-and-beyond missions. Dr. Melroy's presence as well as that of the Laboratory's Members and Partners' representatives made the first TBT a one-of-a-kind-occasion where strategically crucial aspects of the rising space economy were discussed by its protagonists.

• **Participants:**

Pamela Melroy · Deputy Administrator, NASA; **Simonetta Di Pippo** · Director, SEE Lab; **Angelo Fontana** · Senior Vice-President Marketing and Strategy, Avio; **Eraldo Federici** · Aerospace & Defence Director, Capgemini; **Lee Annecchino** · Executive Vice President, Global Aerospace & Defense Leader, Capgemini; **Luca Rossettini** · CEO, D-Orbit; **Marco Molina** · Managing Director Sales and Products, Sitael; **Marco Brancati** · Chief Technology & Innovation Officer, Telespazio; **Walter Cugno** · Vice President Exploration and Science Domain, Thales Alenia Space; **Roberto Provera** · Director, New Initiatives and Innovation, Exploration and Science, Thales Alenia Space; **Patrizia Caraveo** · Director of Research, INAF – National Institute of Astrophysics; **Giorgio Metta** · Scientific Director, IIT – Italian Institute of Technology; **Minoo Rathnasabapathy** · Research Engineer, Space Enabled Research Group from the MIT Media Lab; **Ian Christensen** · Director of Private Sector Program, Secure World Foundation; **Henry Hertzfeld** · Professor of Space Policy and International Affairs, Space Policy Institute of George Washington University; **Andrea Macciò** · Director of the Center for Astro, Particle and Planetary Physics, NYU Abu Dhabi; **Luca Escoffier** · Manager of the EU-Japan Technology Transfer and Space Helpdesks, EU-Japan Centre for Industrial Cooperation; **Fabrizio Mura** · General Managing Director, EU-Japan Centre for Industrial Cooperation.

Private Workshop

– Space Infrastructure: Opportunities and Challenges of Commercial Space Stations

As one of the most discussed research themes within SEE Lab in 2022 and in the international space-related debate, commercial space stations had a dedicated platform of discussion between SEE Lab and the (currently) most important companies worldwide that are exploring the subject. The workshop included both public and private perspectives on the matter: first, the contributions of NASA's Commercial Spaceflight Office and of ESA's ESTEC Research and Payload Group, and then the industry's views that led to a final debate.

• **Participants:**

Simonetta Di Pippo, Director, SEE Lab; **Phil McAlister**, Director, Commercial Spaceflight, NASA; **Kirsten MacDonell**, Research and Payload Group Leader, ESA/ESTEC; **Walter Cugno**, Vice President Exploration and Science Domain, Thales Alenia Space; **Wolfgang Duerr**, Senior Vice President, Director Space, Airbus; **Tejpaul Bhatia**, Chief Revenue Officer, AXIOM; **Brent Sherwood**, Senior Vice President Advanced Development Programs, Blue Origin; **Eric Stallmer**, Executive VP Government Affairs and Public Policy Voyager Space Holdings; **Veronica La Regina**, Director of Global Engagement EU, Nanoracks; **Andrei Mitran**, Director Strategy and Business Development, Northrop Grumann.

MAIN CONTRIBUTIONS AND COLLABORATIONS

International Astronautical Congress (IAC)

– Paris, Sep. 18th – 22nd, 2022

At the international level, the International Astronautical Congress (IAC) is the most important and best attended event in the space industry. The Congress consists of an exhibition area, where participants showcase their business features, conduct networking events and host business meetings and presentations; and a conference area, where selected research studies – ranging from physics and engineering to space policy and economics – are presented to the Congress audience. In 2022, for the first time in its history, SEE Lab's presence at IAC was supported by a booth in the exhibition area, which offered the ideal location for lively debates between the Lab and the industry's most relevant stakeholders.

Food and Science Festival, Mantova

– Mantova, Oct. 2nd, 2022

The Food&Science Festival, promoted by Confagricoltura Mantova, is a scientific dissemination event that addresses and explores in a scientifically reliable, but also creative and accessible way, the challenges related to food production and consumption. SEE lab took part in the 2022 edition of the Festival to describe how space technologies represent a key enabler of the European strategy "Farm to Fork", the ten-year plan developed by the European Commission to guide the transition to a fair, healthy and environmentally friendly food system.

Malta Aviation Conference and Expo (MACE)

– Malta, Oct. 5th, 6th, 2022

Since 2019, Malta has hosted an international congress for business and policy actors that operate in the aviation industry. Both the private and the public sectors are represented in the event, which develops as a rolling discussion made up of formal speeches, technical presentations and panel discussions. In MACE 2022, the SEE Lab made one of the keynote speeches, presenting the interesting synergies in research and business that may involve aviation and space at the same time.

New Space Economy Expoforum

– Rome, Dec. 1st – 3rd, 2022

Every year, Rome hosts the New Space Economy (NSE) Expoforum, the most important exhibition for the space sector at the Italian Level. The main industry and business actors, public and private institutions and bodies, as well as academia are the main contributors to the event. At NSE 2022, the SEE Lab publicly presented its study on the Socioeconomic Impacts of Satellite Services in Italy together with e-Geos, ESA, IBF Servizi, in the presence of the Amaldi Foundation on behalf of the Italian Space Agency.

Abu Dhabi Space Debate

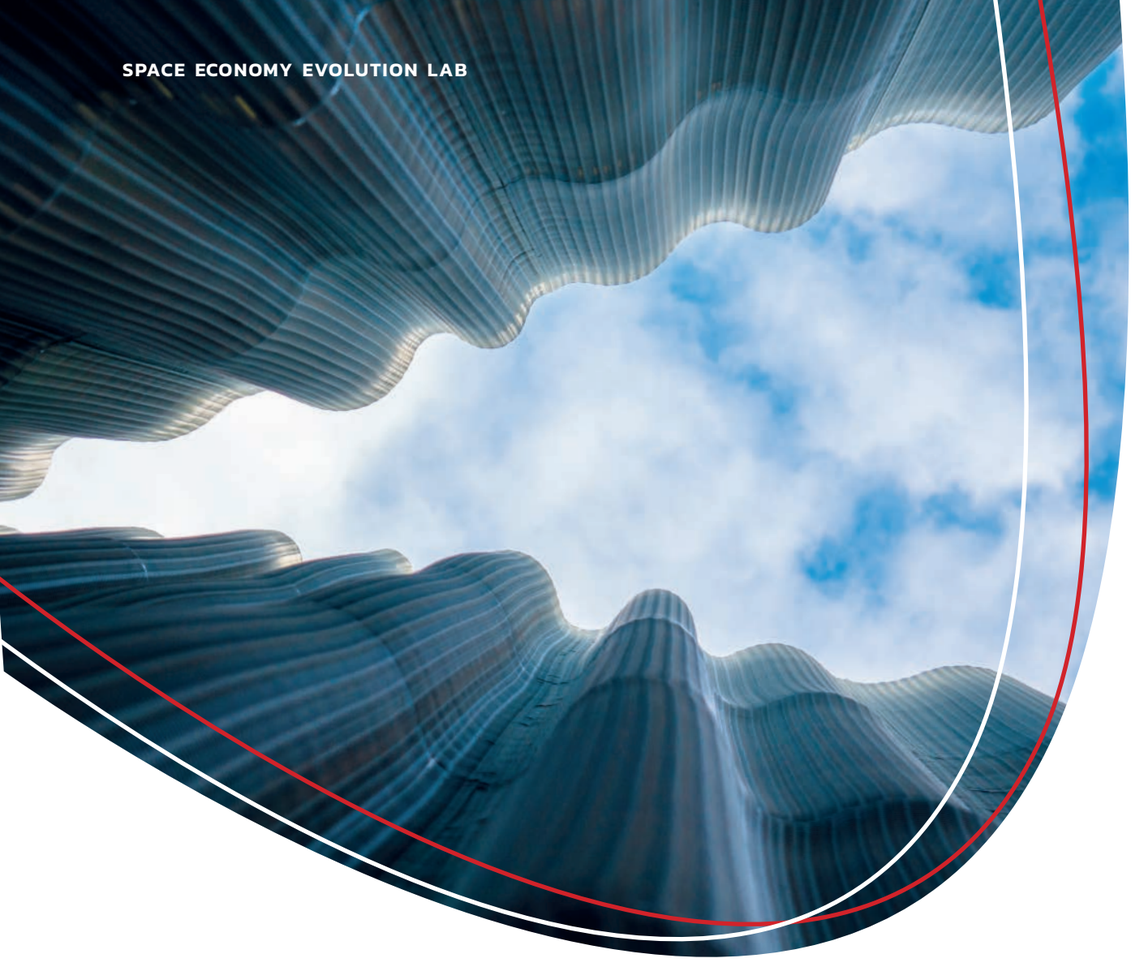
– Abu Dhabi, UAE, Dec. 5th – 6th, 2022

The Abu Dhabi Space Debate is a meeting forum in which global space leaders come together annually. During the two-day event, influential figures from industry and government gather to deliberate on the most critical challenges facing the space industry and to advance the growth of the new space economy. In the 2022 edition, SEE Lab was represented its Director who, on the one hand, took part in the panel discussion regarding how space policies can drive technological innovation and on the other hand, coordinated the Space Sustainability roundtable.

A "new" Space Law for Italy: project presentation at the Italian Lower House

– Rome, Dec. 16th, 2022

As part of the joint project between SEE Lab, Fondazione Leonardo and La Sapienza University in Rome, aimed at underlining the need for an Italian law on space, SEE Lab and its two partners led a presentation at the Italian Lower House in the presence of the Minister of Defense Guido Crosetto and of the Minister for Enterprises and Made in Italy Adolfo Urso. The conference saw the involvement of SEE Lab's Director Prof. Di Pippo, who presented a quantitative analysis of the Italian space market conducted by the Lab, Fondazione Leonardo's



1.3 THE SEE LAB MEMBERS

Within the SEE Lab machine, the most important core component is its Members. Members are companies involved in the industrial, commercial and financial private sector, both space and non-space, that have a special interest in collaborating with SEE Lab and in expanding its research, education and dissemination activities.

By providing funds to the Laboratory, Members collaborate in several different ways. Joint studies, research ventures, event organization and management, special meetings with the sector's top-level experts, networking activities, knowledge dissemination and promoting business relations are some examples of what can be gained by becoming a SEE Lab Member.

As one of the first strategic interventions under Director Di Pippo's tenure, the Laboratory improved its Governance system by modifying the Membership scheme, so as to guarantee a greater arena of actors the opportunity to join. Moreover, the Lab chose to differentiate Membership along different levels, both in terms of contribution and of associated benefits; indeed, it is now possible to join SEE Lab in one of the following four levels: Silver, Gold, Platinum and Diamond.

The Lab seeks to promote a constant, close relationship with each and every Member and considers their market-oriented views as strategically fundamental for the development of its orientation and positioning in the national, regional and global perspectives.

DIAMOND MEMBER

INTESA SANPAOLO

PLATINUM MEMBERS

SPACE ALLIANCE

AIRBUS

GOLD MEMBERS

Capgemini

AVIO

tyvak International SRL

SILVER MEMBERS

SITAEL

SITAEL is one of the most important Italian players in the space field, and a worldwide leader in the Small Satellites sector.

D-ORBIT

D-Orbit is a global leader in the space logistics and transportation industry, thanks to the development of proprietary technologies and solutions.

INTESA SANPAOLO – Diamond Member

Intesa Sanpaolo Group is one of the leading banking groups in Europe, with a strong commitment to ESG, a top-ranking position for social impact and a strong focus on climate.

As the largest banking group in Italy, with over 13.6 million customers and more than 3,600 branches, it is a leader in financial activities for families and businesses in the country. It has a 19% market share in loans and a 22% share in deposits, as well as being a leader in pension funds (24%), managed savings (25%) and factoring (26%).

The Group also has a strategic international presence, with over 950 branches and 7.1 million customers. It is among the main banking groups in several Central-East European and Middle Eastern and North African countries, thanks to its local subsidiaries. It ranks first in Serbia, second in Croatia and Slovakia, fourth in Albania and Slovenia, sixth in Bosnia and Herzegovina and Egypt, seventh in Moldova and eighth in Hungary.

Moreover, the Group has an international network specialized in supporting corporate clients, with a presence in 25 countries, particularly in areas where Italian companies are most dynamic. The Group supports the development of small and medium-sized enterprises and large companies, both locally and globally, also supporting their ecological transition, digital transformation and innovation of processes, products and services.

Innovation is a fundamental pillar in the strategy of Intesa Sanpaolo Group. To learn about new technologies and continuously incubate new ideas, the Group has initiated an open dialogue with industrial leaders, FinTech and academic excellence. It also develops models of offer and investment and financing solutions dedicated to startups and innovative companies.

The development of the Space Economy is a crucial element for the competitiveness and economic and social growth of the country. In this context, the Intesa Sanpaolo Group has launched an acceleration and valorization program for innovative startups, with the aim of identifying the most promising realities operating in the Space Economy and in the related technological sectors, to guide and support them in the various phases of their business development. In addition, to support investments in R&D, the Group has developed an innovative financing tool (Nova+ Space&Security), unique in the banking landscape, capable of financing intangible assets, i.e. disruptive ideas and projects in the Space Economy sector, in line with the objectives of the European Space Strategy and the National Space Economy Plan, taking into account the specific characteristics of the sector, the development phase in which the company finds itself, and the investment projects that it intends to carry out.

Collaboration with SEE LAB allows Intesa Sanpaolo Group to participate in a dialogue with experts in the sector, academics, companies, research centers and public and private institutions, to understand trends and seize the opportunities offered by the space sector.

AIRBUS ITALY – Platinum Member

Airbus Italia, part of Airbus Defence and Space, is a leading Italian space company with more than 30 years' experience in space technologies. It is an industrial leader recognized at international level and owns a large number of international patents related to antennas, radars, sci¬entific software and digital signal processing.

Airbus Italia provides innovative and flexible operating solutions, with a qualified portfolio in four main macro-areas: SatCom Mobile Solutions, System En¬gineering, Connectivity Prod¬ucts, Security & Resilience solutions. It is a leader in Airborne Satcom technology and its product portfolio also includes on-board equipment for data transmission (Inter-Satellite-Link), passive RF components, passive and active antennas, antenna radiating elements, ground operational software for configuration and spectrum monitoring of telecommunication flexible payloads, ground and flight firmware for digital signal processing and modems. Thanks to its competence in design, integration and testing, throughout its history Airbus Italia has participated in major European space programs like MetOp-Second Generation, Quantum, Biomass, Galileo, Pléiades NEO, EDRS Inter-Satellite Link, COSMO-Skymed 1 and 2, Alphasat TDP#5. The company has also been involved in major national space programs like SICRAL, PLATiNO, ItalGovSatCom. Airbus Italia also plays an important role in the Eurodrone program.

In its industrial plant in Rome, mainly dedicated to the validation and qualifica¬tion of onboard and ground components, equipment and subsystems for space appli¬cations, it pro¬vides services for the integra¬tion and testing of flight units and payloads.

As a Member of the SEE Lab, Airbus Italia aims to work together with the Lab, its Members and Partners to analyze and have an in-depth understanding of the opportunities offered by the evolution of the Space Economy, firmly believing in the key importance of this sector as a driver for economic and social growth, benefiting the national industrial ecosystem.

SPACE ALLIANCE – Platinum Member

Space Alliance is a strategic partnership between Telespazio and Thales Alenia Space, both representing Leonardo's and Thales' operational arms in the space sector. As two of the world's leading companies in this industry, they aim to offer a complete range of solutions for space exploration, satellite communication and Earth observation. The Alliance has a significant global presence, with over 10,000 employees in 12 countries worldwide and it is committed to sustainable development on Earth and in space. It offers advanced services and technologies that help mitigate the environmental impact of space exploration, while facilitating it through the creation of innovative technologies and the establishment of a lasting human presence in space.

Exploiting the combination of Thales Alenia Space and Telespazio's capabilities and competences, the Alliance is a pioneer of the New Space markets, to the benefit of governments, the private sector and citizens on Earth. With its role, Space Alliance is a leader for the space value chain as a whole, therefore favoring the development of startups, SMEs, research centers and other interested stakeholders.

In this context, Space Alliance's collaboration with SEE Lab is intended to further aid the space economy evolution on both the industry and research side, thus preserving the space sector's distinctive trait of being a high-level, exceptionally innovative sector which is always projected towards the future.

CAPGEMINI – Gold Member

Capgemini is a global leader in partnering with companies to transform and manage their businesses by harnessing the power of technology. The Group is guided every day by its purpose of unleashing human energy through technology for an inclusive and sustainable future. It is a responsible and diverse organization of 360,000 team members in more than 50 countries. With its strong 55-year heritage and deep industry expertise, Capgemini is trusted by its clients to address the entire breadth of their business needs, from strategy and design to operations, fueled by the fast evolving and innovative world of cloud, data, AI, connectivity, software, digital engineering and platforms. In 2022 the Group reported global revenues of €22 billion.

Moving from its strong know-how on the most advanced IT technologies and counting on its sound engineering experience, Capgemini is supporting the European Space Agency and the key industrial players in the evolution of the space sector, where the exploitation of the enormous amount of data and the need for digital transformation is increasingly in demand and will foster the development of the new space economy.

AVIO – Gold Member

Avio is a leading international group engaged in the construction and development of space launchers and solid and liquid propulsion systems for space travel. The experience and know-how built up over more than 50 years puts Avio at the cutting-edge of the space launcher sector, solid, liquid and cryogenic propulsion and tactical propulsion. Avio operates in Italy, France and French Guyana with 5 facilities, employing approximately 1,200 highly-qualified personnel, approximately 30% of whom are involved in research and development. Avio is a prime contractor for the Vega and Vega C program and a sub-contractor for the Ariane program, both financed by the European Space Agency ("ESA"), placing Italy among the limited number of countries capable of producing a complete spacecraft.

TYVAK INTERNATIONAL – Gold Member

Tyvak International has developed, launched and successfully operated 10 satellites in 3 years, an Italian and European record. The company is consolidated in the European panorama as a leader in small satellite systems and develops ad-hoc advanced solutions in the class of nano and micro-satellites for LEO, GEO and deep space exploration. Tyvak and partners created Earth Observation missions for environmental monitoring, telecommunications satellites for geolocation applications, data generation satellites for numerical weather forecasts, a constellation of satellites for global "Internet of Things" connectivity and 5G applications. Tyvak International is also specialized in proximity operations and in-orbit servicing missions that involve the use of agile autonomous platforms in the vicinity of other orbiting bodies (satellites, debris, stations) as a system integrator for several Government Programs. Tyvak is also the prime contractor for a planetary defense mission, ESA's first scientific microsatellite in deep space. Tyvak International has its roots in Torino, Italy where it will maintain its headquarters while rapidly expanding throughout the country to extend the business to the serial production of microsatellites for constellations, leveraging the great value generated in the first 8 years of its history, to enlighten and further develop the excellence of Italy's space-domain ecosystem.

1.4 THE SEE LAB PARTNERS

Associazione Delle Imprese Per Le Attività Spaziali (AIPAS)
– Rome, Italy

AIPAS is a non-profit association of private Italian companies operating in the manufacturing and services sectors of the space industry. AIPAS' goal is to represent its member companies on both national and international levels, to support their growth, as well as to promote initiatives for supporting space industrial policy development.

Association for Space-based ICT Technologies, Applications and Services (ASAS)
– Rome, Italy

ASAS is an Italian industrial association developing and enhancing applications and services based on space to bring technologies and capacity "from Space to Earth". ASAS' members are small, medium and micro enterprises, all focused on Space-based Services and Applications.

The EU-Japan Centre for Industrial Collaboration
– Tokyo, Japan

The Eu-Japan Centre was established by the European Commission and the Japanese Ministry of Economy, Trade and Industry to promote all forms of industrial, trade and investment cooperation between the European Union (EU) and Japan.

The Moon Village Association (MVA)
– Vienna, Austria

MVA is a non-governmental organization with the goal of fostering the creation of the Moon Village, which includes the element of lunar commerce as an integral part of a sustainable presence of humans on the Moon.

New York University In Abu Dhabi Corporation
– Abu Dhabi, UAE

NYUAD is a liberal arts college that is part of the global network of New York University campuses and offers the highest quality education on its Saadiyat Island campus. The Abu Dhabi campus offers undergraduate, graduate as well as research careers in the fields of Arts and Humanities, Science, Engineering and Social Sciences.

The Secure World Foundation (SWF)
– Washington DC, USA

SWF is an organization working with governments, industry, international organizations and civil society to develop and promote ideas and actions to achieve the secure, sustainable and peaceful use of outer space.

The Board of Trustees of the Colorado School of Mines
– Golden (CO), USA

Mines is a public research university focused on science and engineering and its Center for Space Resources is a multi-disciplinary research program focused on educating scientists, engineers, economists, entrepreneurs and policy makers in the developing field of space resources.

Polispace - Politecnico di Milano
– Milan, Italy

Polispace is an association with the objective of filling the gap between industry and academia in Italy and to provide students with the opportunity to participate in real hands-on engineering projects.

Space Policy Institute at the George Washington University
– Washington DC, USA

The George Washington University Elliott School of International Affairs is a world leader in research, graduate study and informed discussion related to issues of science, technology and public policy. The Space Policy Institute conducts research, offers graduate courses and organizes seminars, symposia and conferences on topics related to domestic and international space policy.

University of Franche-Comté
– Besancon, France

UFC is a public, multidisciplinary teaching and research university, in which the Centre de Recerche sul les Strategies Economiques (CRESE) carries out studies in various sectors, including the space sector.

Politecnico di Torino
– Turin, Italy

PoliTo is a public university based in Turin, Italy specialized in engineering, architecture, urban planification, technology and design. Its engineering courses feature important specializations in space-related topics.

The International Institute for the Unification of Private Law (UNIDROIT)
– Rome, Italy

UNIDROIT is an independent intergovernmental organization with headquarters in Rome, Italy. Its purpose is to study needs and methods for modernizing, harmonizing and coordinating private and commercial law between states and groups of states and to formulate uniform law instruments, principles and rules to achieve those objectives

Fondazione Nord Est
– Mestre, Italy

Fondazione Nord Est is an economic research center created by the Chambers of Commerce of the Northeast of Italy, together with confederations and private sector associations (Confindustria). It aims to study and understand the present and the economic future of the North-eastern Italian regions, including data collection and analysis regarding the space economy market.
Italian Institute of Astrophysics (INAF) – Rome, Italy
The National Institute of Astrophysics (INAF) is the main Italian public research institution for astronomy and astrophysics. The research carried out by INAF covers the entire range of Universe sciences from both an observational and experimental as well as a theoretical point of view. INAF also maintains close collaborations with other organizations conducting astronomical research in Italy and abroad, in particular with the National Institute of Nuclear Physics (INFN) for particle astrophysics, ASI, ESA, and NASA.

Esercito Italiano – Primo Reggimento Trasmissioni
– Milan, Italy

Primo Reggimento Trasmissioni is the Italian-led NATO Rapid Reaction Corps' direct support transmission regiment. It is directly subordinate to the NATO Rapid Deployable Corps-Italy Support Brigade (NRDC-ITA) and responsible for ensuring C4 support to the multinational high command with high readiness and deployability, both in permanent bases and in operations/exercises or training activities.

Universidade Nova de Lisboa (UNL), NOVA SBA
– Lisboa, Portugal

Nova SBE, as an organic unit of UNL, is a point of reference in the areas of management, economics and finance. Its mission is to educate and prepare students for the global market, to develop internationally recognized research activities, to contribute to the formulation of public policies and to expand the international recognition of teaching and research in Economics and Management carried out in Portugal.

Università degli Studi di Bari
– Bari, Italy

Università degli Studi di Bari Aldo Moro is one of Italy's biggest public universities. It offers a wide range of programs in humanities, social sciences, engineering and natural sciences, in which the Physics Department is prominent.

1.5 TESTIMONIALS & PRESS

- adnkronos/IGN
- Affaritaliani.it
- Airpress
- Avvenire
- Business People
- Class CNBC
- Class CNBC (Milano Finanza)
- Corriere del Mezzogiorno, L'Economia
- Corriere della Sera
- CorriereTV
- Corriere della Sera.it
- Cosmo
- Dealflower.it
- Donna Moderna
- Fidest
- Focus
- Focus MEDIASET
- Forbes
- Fortune (Ita)
- Gazzetta di Capri
- Gazzetta di Modena
- Gazzetta di Parma
- Global Science, la scienza racconta la scienza
- Il Foglio
- Il Giornale.ch
- Il Secolo XIX
- Il Sole 24 Ore
- Il Sole 24 Ore, Domenica
- IlMessaggero.it
- Italia Oggi
- La Lettura (Corriere della Sera)
- La Repubblica
- La Repubblica (Ed. Milano)
- La Stampa
- La Verità
- LA7
- LaRepubblica.it
- LaStampa.it
- Le Scienze
- Letture.org
- L'Indro
- L'Informatore
- Linkiesta.it
- LOGIN (Corriere della Sera)
- MediaOnIAF
- Milano Finanza
- MI-Lorenteggio.com
- Network Digital 360, SpaceEconomy 360
- Pambianconews Hotellerie
- Panorama
- Radio 24
- Radio DJ
- Radiotelevisione svizzera
- Rai 1
- Rai 3
- Rai Italia
- Rai News
- Rai Radio 1
- Rai Radio 2
- Rai Radio 3
- Rai Scuola
- RTL 102.5
- Sole24Ore.it
- Vanity Fair
- wam.ae/en/
- Wired.it

67

TOTAL NUMBER OF NEWSPAPERS/WEBSITES

97

TOTAL NUMBER OF MENTIONS/INTERVIEWS/ ARTICLES

SIGNIFICANT QUOTATIONS

> **Space Economy Evolution Lab – a new reality oriented to the creation of strategic synergies in the space economy, a sector that has an enormous geopolitical and economic scope.**

> **From national funds to private investments, Italy cultivates its astronomical ambitions. Bocconi University has a laboratory to develop the sector.**

> **Bocconi's Space Economy Evolution Lab is forming new professional figures to include them in the economic activity of this growing sector, thanks to the "cross-fertilization" of ideas and competences.**

NOTEWORTHY NEWS

1. *"Space Economy is ready to take off, but we need a multi-disciplinary approach"*
   Dealflower.it – 27th June 2022

2. *"Italy bets on Space Economy"*
   Wired.it – 03rd July 2022

3. *"Space Station: someone closes the tailgate. In Milan a new center for Space Economy"*
   Focus – 1st October 2022

4. *"Space Economy, SDA Bocconi on the launchpad with the new database SEE"*
   Digital 360, SpaceEconomy 360 – 28th June 2022

5. *"Simonetta Di Pippo at Bocconi: «Research and education for New Space Economy»."*
   LaStampa.it – 12th April 2022

2. FUTURE OUTLOOK: SEE LAB STRATEGY AND POSITIONING

2.1 STRATEGIC SUBJECTS

SUSTAINABILITY: the challenge of space debris

Sustainability of space is the first, crucial ingredient for the definitive ascent of the space economy. Among the many aspects of this complex topic, the current number and the potential growth of space debris is probably one of the most urgent. The number of uncontrollable space objects, mainly located in low Earth orbit (LEO), is indeed rapidly increasing, and the space congestion clearly enhances the risk of collision between active assets and debris. There have been several attempts to establish a framework for managing and resolving the issue at global level, including both international agreements and single state or non-public actors' unilateral initiatives: from the release of voluntary mitigation guidelines to the development of Active Debris Removal (ADR), technologies and economically viable business models for enabling debris-related commercial activities. However, despite these measures, not all satellite operators are keen to take a step in the direction of collision risk mitigation and, sometimes, unexpected and potentially harmful situations occur progressively, compromising the exploitability of orbits.

The reason why most operators do not comply with mitigation guidelines, or take different but still effective actions towards the sustainable development of orbits, is their perception of the costs associated with such precautions. On a different note, companies consider the expected benefit of undertaking risk mitigation practices as lower than their costs. This is the case because, if the former typically becomes evident in the medium-to-long term, the latter is a short-run weight on companies' balance sheets. As a consequence, space companies are currently convinced that the fulfilment of debris reduction measures is simply not in their economic interest as of today.

All the above may be a misjudgment, and a better understanding of the economic convenience of more sustainable behavior might help address debris-related issues. It is in this regard that SEE Lab intends to position itself on the topic of space sustainability in 2023 and beyond. In particular, the Lab will focus on research connected to the economic evaluation of the adoption versus non-adoption of risk mitigation measures. By implementing a bottom-up approach and offering a more comprehensive and realistic examination of collision-related costs, it may be possible to show the economic convenience behind mitigation strategies, hence increasing space operators' awareness and favoring a behavioral shift.

BUSINESS MODEL INNOVATION: the advent of commercial space stations

In 2031, NASA publicly plans to decommission and de-orbit the International Space Station (ISS) for reasons connected to structural issues and outdated features. At the same time, space-faring nations are engaging in independent efforts to assert their dominance in Earth-LEO endeavors: the US has granted multiple firms the opportunity to create designs for private space stations, Russia has unveiled the Russian Orbital Service Station (ROSS), and China is making strides with its Tiangong infrastructure. These nations are investing public funds in the development of innovative technology, and while the aim is to advance technology, these initiatives also seek to encourage private sector involvement to explore and exploit commercial opportunities in space, thus reducing dependence on the public sector as the sole client.

This implies that private companies receiving public funding are required to translate the strategic value of space infrastructure into economic value appraised by the market. This connects to the notion of the business model, i.e. how a company can make a value proposition to its customers while deriving a profit. As the design of space stations' business models is still at its infancy, and given their potential, SEE Lab will deepen its research into the field through a project featuring the most globally engaged companies in this area, thus also leveraging on industrial and professional expertise. By doing so, the Lab will confirm its positioning on the topic in the international debate (see *Space Infrastructure: Opportunities and Challenges of Commercial Space Stations*), hopefully leading to the advancement of the debate at global level.

FINANCE IN SPACE: uncertainty, risk and investments

In February 2023, SEE Lab and its partner the Space Policy Institute (SPI) at the George Washington University hosted a workshop entitled *Space Exploration Investments: turning uncertainties into measurable risk and benefits*. The workshop involved experts from the public policy, academia, industry and banking-financial worlds, who discussed how to translate space activities' considerable uncertainties into a measurable risk as a starting point for investment evaluation.

Assessing the risks associated with investments in space exploration ventures and better defining viable and affordable options for investors to seize uncertainties are certainly key steps for the evolution of the space economy. The basic question of whether investments in space exploration activities have "unique" and distinct features that distinguish them from non-space, more traditional ones needs to be fully addressed and understood to identify the right tools to translate associated uncertainties into measurable risks and create a favorable environment to stimulate investments.

In this context, private investors tend to seek priority criteria on the uncertainties of a given space project; companies might consider the investors' perspective on risk when drafting a new project or business model; public entities have the goal of favoring all the above from a policy and governance point of view. Given space exploration investments' multifaceted nature, SEE Lab and SPI were pleased to offer a meeting point in which the wide array of interested actors could express their perspectives and needs.

Building on the Workshop discussion, throughout 2023 SEE Lab will keep exploring the theme of risk perception, measurement and management related to space activities, particularly with a research project in collaboration with the same SPI and SWF, and stemming from the workshop's relevant takeaways.

NEW MARKET EVALUATION: space exploration and the exploitation of the Moon

The *Return to the Moon* project launched by NASA in the official form of the ARTEMIS program opens up a full set of new opportunities. As stated on the agency's website: "We're going back to the Moon for scientific discovery, economic benefits, and inspiration for a new generation of explorers". The potential of the economic advantages of the Moon project and the fact that Italy is one of the first countries in the world to have agreed to the program place SEE Lab in a privileged position to deepen research in this specific field.

Humanity's return to the Moon and the economic reasons behind it offer an exciting set of unexplored research questions. The Lunar environment can indeed be exploited, at least in theory, for mineral and metal extraction, ice decomposition into propellant suitable for satellite maneuvers and spacecraft journeys to outer space targets (e.g., Mars), and for the broader, indirect involvement and enhancement of several terrestrial industries. At the same time, such an ambitious venture will eventually lead to a higher demand for skilled labor in the medium term, thus generating an increase in technical (STEM) education and a resulting stronger growth in highly skilled jobs. All the above is what is generally included in the expression "lunar economy".

SEE Lab aims to position itself in this field by conducting research that starts from the feasibility analysis of the possible lunar activities and that of their potential market (or markets), continues with the evaluation of the impact that such new markets may cause to our economy and then addresses the theme of potential space and non-space company cooperation and spillovers in terms of technological advancement and transfers, financial risk measurement and diversification, public policy development and infrastructural progress.

To better cover this research area, SEE Lab has strategically preempted other interested entities by signing an agreement with the Moon Village Association. As with all SEE Lab's partners, the technical competences of the counterpart will complement and complete SEE Lab's insights to produce top-quality research output.

INNOVATION AND INTEGRATION: the synergies between digital and space technologies

Despite their seemingly different natures, digital and space technologies share many fundamental similarities. Both fields require the use of cutting-edge technology and innovation, as well as a focus on global cooperation and collaboration. In recent years, the increasing integration of digital and space technologies has resulted in the development of many new applications and services, from satellite-based telecommunications and navigation systems to machine learning algorithms for analyzing satellite data. As these two fields continue to evolve and converge, it is becoming increasingly clear that they are, in many ways, "twins separated at birth" that are destined to work together and mutually reinforce each other to achieve a better future for all.

Therefore, one of the active fields of research of SEE Lab will be the potential synergies between digital and space technologies. Interesting findings might indeed concern how digital technologies can improve the space companies' efficiency and effectiveness. Indeed, the integration of digital technologies into space businesses and practices can lead to a wide range of benefits that may include improved product design and manufacturing processes, augmented data collection capability and analysis and the enhancement of innovation models.

On the other hand, the digital-related technological progress resulting from space activities could also be worth investigating. Everyday spin-off applications deriving from space programs are not only present in the fields of medicine, materials, chemistry or consumer goods, but also in the most advanced frontiers of digital transformation. Simple instances range from collaborative robotics to multi-material 3D printing.

SPACE FOR THE GLOBAL CHALLENGES: the Space Solar Power venture

Space solar power (SSP) is an innovative technology that has the potential to revolutionize the way we generate and distribute energy on Earth. SSP involves capturing energy from the sun in space through huge solar panels and transmitting it wirelessly to receivers on Earth. This technology might integrate the current energy mix on Earth with significant benefits for energy transition and energy poverty challenges.

One of the most significant benefits of SSP is that it might play a critical role in reducing greenhouse gas emissions and in mitigating the impact of climate change. Currently, most of our energy is generated through the burning of fossil fuels, which releases greenhouse gases into the atmosphere, contributing to both global warming and air pollution. Furthermore, SSP would reduce the amount of land that needs to be dedicated to energy production on Earth, thus preventing deforestation and habitat loss. On a different, but no less important note, SSP might also significantly contribute to energy transition. One of the biggest challenges associated with renewable energy is indeed its intermittency; as solar and wind power are dependent on weather conditions and energy can only be stored in a limited way to compensate for generation downtimes, a fully renewable energy mix still seems far from being achievable. By contrast, space solar power has the potential to generate energy around the clock, thus overcoming atmospheric and technological obstacles, and potentially competing with traditional sources of energy. Finally, energy collected via SSP might be transmitted to every place on Earth, bypassing terrestrial infrastructure issues that still prevent isolated communities from getting access to a reliable source of energy.

Whether SSP will be practicable in both its realization and its operation is currently open to discussion, and consequently, to research. SEE Lab, from its perspective, looks at the issue with the eye of economic feasibility evaluation, as well as of the series of potential impacts that such a technology may generate in terms of Earth's economic and political setting . The Lab's goal is to become a crucial actor for SSP-related discussion at several levels: industrial, political and institutional. In this field, too, SEE Lab has already gained experience through the work done with the International Academy of Astronautics Chair John Mankins during the writing of the textbook *"In Our Hands: what we got from space, what we have to give back"*, in collaboration with Telespazio.

MACRO CONTEXT: space technologies for strategy and defense

The launch traffic to Low Earth Orbit (LEO) is experiencing a significant increase, since LEO is enabling common use infrastructure critical for the growth of the space economy. The intensifying commercial use of LEO and the sustainability of the space environment are increasingly debated among policy makers. Moreover, the rapid increase in space debris is becoming of primary importance not only for international institutions but also for private companies.

In very recent years, several attempts have been made to assess solutions for providing remedies to the orbit's overcrowding, e.g., active debris removal (ADR) de-orbit technologies including net capture, sails, harpoons, laser systems, adhesive magnets, single and multiple robotic manipulators. The current legal framework does not mention who should be in charge of removing debris and the adoption of these technologies could cause instability and mistrust. Thus, many states view possible interference with their space assets or capabilities as serious national threats. Many of these threats come in the form of anti-satellite (ASAT) capabilities, which can be used to deceive, deny, degrade, disrupt or destroy space assets. For example, although ADR operations are not inherently ASAT activities, many of the technologies and techniques which are candidates for ADR operations could also be used to damage or destroy a spacecraft in an ASAT form of direct energy-based attacks, proximity co-orbital systems and high velocity or explosive kinetic interactions.

SEE Lab is also involved in this research stream, in which it aims to develop a framework for the identification of the risks associated with the use of dual-use technologies, and to outline possible strategies for their mitigation. Consistent with its mission to support the growth of the space economy, SEE Lab is committed to guaranteeing the safe evolution of space via its research activities.

FORWARD GUIDANCE

SEE Lab has always been an ahead-of-its-time center in the frontier topics of business and economics connected to space. Unlike other academic and research actors in the same arena, the Lab's added value is the multidisciplinary, holistic view with which it approaches the challenges of the space economy, while still applying strong vertical competence to each of the pursued research flows. While keeping its focus on this, the Lab has the goal of becoming the reference center at national, regional and global levels.

As it looks to the future, SEE Lab will continue to actively engage in the most interesting space-related fields of research. It will also seek to identify potential new areas of study that have not yet been explored, expanding its focus beyond the traditional boundaries of the space industry. With its team of experts in the fields of economics and management, SEE Lab is well-positioned to identify and analyze emerging trends and issues in the space economy, bringing cutting-edge research to the forefront of this rapidly evolving industry. By continuing to investigate new and exciting areas of research, SEE Lab is committed to pushing the frontiers of what we know about the space economy, creating a brighter future for the industry and the world as a whole.

SDA BOCCONI SCHOOL OF MANAGEMENT

For fifty years, we have been committed to fueling your educational experiences with our passion for knowledge and concrete know-how, creativity and scientific rigor, and cultural and international diversity. We were born to support the continuous growth, improvement and transformation of people, companies and institutions, and we will stand by your side through the toughest challenges.

Over the years, we have grown with our clients and students. We have learned to change and transform what we offer. We have gone from national to global leaders according to prestigious, international rankings. We have increased our commitment and the programs we offer to ensure we always have an answer to the need for new skills. We have transformed our research into relevant and applied knowledge and embraced the challenge of digital transformation. And we have designed and created a campus for the future, one of the most innovative in the world.

We are an international school with headquarters in Milan and Rome and a pan-Asian hub in Mumbai, India. Our classrooms reflect the globalization of modern society and the diversity of thought that cultivates progress and innovation.

Our strength lies in our ability to evolve, thanks to the contagious, innovative energy found at all levels of our community.

We do not fear the future. We want to play a leading role in the global market of higher education alongside small, medium and large companies and institutions. We are proud of our identity and the creative Italian ingenuity we represent, but we will always be open to the world.

SDA Bocconi
SCHOOL OF MANAGEMENT

SEE LAB
SPACE ECONOMY EVOLUTION

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