6. *Italian Space Design*. Birth and Affirmation of an Avant-garde Discipline at Politecnico di Milano

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6.1 The Challenges of *Design for Space*

6.1.1 Synthesis of Innovation, Advanced Research and Strategic Vision

While this essay is being written, the book *Design Spaziale Italiano* 1↘ is being published, which collects the results of more than twenty-five years of exploration and design activities in a sector at the forefront in our country, of which Politecnico di Milano has been a pioneer since the late 1990s, contributing to its development and international affirmation. In those years, there were not yet the initiatives of SpaceX or other private companies interested in space tourism or the conquest of Mars. There was no talk of the *space economy* as a world driving market and there were no space architects and designers. *Design for Space* was born in 1997 as part of the Doctorate program in *Industrial Design* 1↘ 2↘ with the intention of exploring and deepening cutting-edge design themes at a crucial historical moment. In 1998, the in-orbit assembly of

Note 1.
Design Spaziale Italiano is an itinerant multimedia project conceived and curated by Annalisa Dominoni and Benedetto Quaquaro, Department of Design, Politecnico di Milano and promoted and financed by the Ministry of Foreign Affairs and International Cooperation (MAECI).

1. *Industrial Design for Space*. Document→

Note 2.
Annalisa Dominoni, *Disegno Industriale per la Progettazione Spaziale*, Doctorate in I*ndustrial Design* XII Ciclo (novembre 1997-ottobre 2000).

the International Space Station began, destined to permanently house astronauts for conducting scientific experiments. Alenia Spazio plays a leading role in the production of habitable pressurised modules, confirming Italy's leadership position in space exploration. This tradition dates back to the launch of the *San Marco 1* satellite in 1964 and continues with the *Rosetta* and *ExoMars* missions, in which Politecnico di Milano has distinguished itself for its projects of excellence, thanks to the contribution of Amalia Ercoli-Finzi.

In this context, living in a new environment characterised by confinement and microgravity conditions fosters the development of habitability studies hitherto considered unnecessary. Space agencies and industries began to realise that it was necessary to extend the scale of needs – from safety to comfort and usability – considering not only the physiological sphere but also the psychological one, in order to increase the crew's well-being and performance quality.

And it is here that the contribution of design becomes fundamental and strategic for Space. Design is a process of innovation that places the person at the centre, interpreting their needs, humanising technology, to restore a dimension of beauty to life, beyond survival, in which values such as inclusion, sensitivity and sustainability can have concrete application.

Design for Space is undoubtedly a fascinating field. Aesthetics, functionality, safety and well-being: its value lies in the ability to create versatile environments that support human life under extreme conditions. This is why designing new environments in Space means, first of all, innovating and experimenting, developing unexplored solutions that can find applications on Earth and improve our daily lives. I am thinking, for example, of the technologies for efficient management of resources and recycling of water and air; the cultivation of 3D food and the use of microalgae on the Moon; new materials and alternative fabrics… All this makes Space Design a multidisciplinary field that requires creativity and skill, design and a deep understanding of human needs. The challenges posed by Space – from research to economics and society – are indeed manifold and complex. (Donatella Sciuto, rector of Politecnico di Milano)

Since the beginning of this journey of research, education and design of environments and equipment for astronauts, the aim has always been to move the limit of comfort forward, both physically and psychologically, to support the activities and increase the success of a Space mission and to generate knowledge transfer between Space and Earth and vice versa. Today, this aspect is even more important, as the commercial exploitation of Space is redefining the meaning of Space travel and the figure of the astronaut. They are no longer just a scientist or a specialised technician, but also tourists, with limited training and in search of unique and extraordinary experiences. It has been, and continues to be, an exciting journey, which over the years has generated the *VEST* and *GOAL* experiments conducted in orbit on the International Space Station, the first and only Space Design course in the world supported by the European Space Agency Space4InspirACTion 3↘, the ESA_Lab@PoliMi_Design 4↘ laboratory and the *Design Spaziale Italiano* project. And all this thanks above all to the meetings, the many companies, people, and avant-garde technologies that represent the best our country has to offer in terms of ingenuity, creativity, and the ability to innovate. Between science, technology and beauty.

Note 3.
Space4InspirACTion has been created by Annalisa Dominoni and Benedetto Quaquaro in 2017 at the School of Design, MSc in Integrate Product Design.

Note 4.
ESA_LAB@PoliMi_Design is the Space Design research laboratory of the Department of Design born from the collaboration agreement between the European Space Agency (ESA) and Politecnico di Milano in 2022.

2. *Disegno Industriale per la Progettazione Spaziale*. Document→

6.2 *Portable Caddy System* for Alenia Spazio: Testing Underwater

6.2.1 The New *Use & Gesture Design* (UGD) Methodology for Designing in Microgravity

As early as the first year of the PhD programme in *Industrial Design*, Space Design studies developed thanks to a multidisciplinary approach–fostered by a Poly-technique matrix–in a constant dialogue with the most advanced industrial reality to generate innovation 2↘.

In opening up to Space, two factors have proved decisive in the establishment of this new discipline: the support within the Ateneo, in particular Amalia Ercoli-Finzi, then director of the Department of Aerospace Engineering, who has always recognised the strategic importance of Design for Space, and

the collaboration with Alenia Spazio, an essential technological partner for the expertise and spatialisation of all the research and projects born within the Department of Industrial Design and Architecture Technology DI.Tec.

The first product/prototype, *Portable Caddy System*, was developed in 1998 at the request of Alenia Spazio, which was building the European Columbus Laboratory on the International Space Station. The Ergonomics and Human Factors Unit needed a tool caddy system for routine maintenance that would increase the efficiency of crew activities in microgravity conditions.

The idea behind the design was to imagine the containers close to the astronauts as useful assistants, *floating consoles* that could become rigid when tools needed to be secured and soft again to be rolled up after use, taking up less space. Compared to the traditional aluminium toolboxes used on board, this new system introduces an innovative concept in shape and materials: it is portable, made of fabric and inspired by jewellery cases.

The comfort and usability tests, *Neutral Buoyancy Test Facility*, were carried out by the astronauts wearing the prototypes underwater in the Alenia Spazio pool and gave excellent results, even when working outside the pressurised modules, despite the heaviness of the suits for extra-vehicular activities.

The experience gained during this first project has been fundamental in understanding the meaning and implications of designing for Space.

Designing for Space means dealing with an environment that is not part of our terrestrial experience – governed by different physical laws that alter many ergonomic, physiological, postural and perceptive parameters – and therefore do not allow the effectiveness of new products to be verified in advance.

Designing for Space therefore requires a great capacity for usability vision and *pre-vision* – which has been structured in a new methodology specifically for space, *Use & Gesture Design* (UGD) – to imagine how new environments and objects will be experienced by astronauts, how they will use them, how they will react and how their gestures and behaviour will change in the absence of gravity, and consequently to determine the morphological, functional, material and performance characteristics of new products. The experience of the *Portable Cad-*

Figure 1.
Portable Caddy System.

dy System project also shows how crucial it is for the success of the project to secure the best knowledge and technologies by involving design companies, such as USAG, that are able to produce prototypes in accordance with the NASA Standard requirements.
The ultimate goal of Design for Space is therefore to design new environments and equipment that can improve living conditions and activities in Space, but also and above all to act as a bridge between the Space industry and design companies to generate spin-offs and spin-ins with innovative applications in everyday life.

6.3 Projects for the International Space Station. Life in Space between Comfort, Technology and Beauty

Subsequent Design for Space projects were born thanks to the opportunity of the Italian Space Agency, which in 1998 launched the first call for *Technological Utilisation of the International Space Station* with the aim of selecting innovative projects to develop feasibility studies and space experiments to be tested with astronauts in Space. ASI's choice rewards both proposals, *VEST* and *AGILE*, submitted by the INDACO Department.

The project *VEST. Integrated Clothing System for Intra-Vehicular Activities (IVA)*, with technical partner Benetton Group, proposes a clothing system for the intra-vehicular activities of astronauts consisting of different types of clothing integrated with sensors to monitor biomedical parameters in a non-invasive manner and without requiring the active participation of astronauts.

At the first conference organised by ESA 5↘ on the topics of habitability and human factors, the *IVA Clothing Support System* paper 3↘ is the first and only one presented in which concepts of *comfort*, *hygiene*, *thermoregulation*, *wearability* and *aesthetics* are introduced for the first time to improve astronauts' *well-being* and *performance*, and represents an important step towards international scientific recognition of the innovative role of design in interplanetary human exploration programmes.

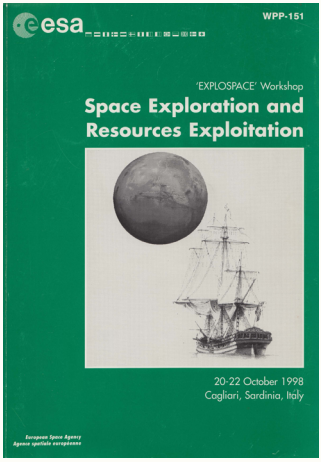
The project *AGILE. Attrezzi GInnici LEggeri for Intra-Vehicular Activities (IVA)*, with technical partner TechnoGym, consists of a system of fitness machines that are lighter and more comfortable than those existing on the ISS with the aim of increasing the efficiency of exercise and making daily hours easier and more enjoyable. This project has deepened numerous studies and research on human physiology in microgravity to identify new physical exercises as an effective countermeasure to muscle loss and bone decalcification in space.

In 2001, directly commissioned by the Italian Space Agency (ASI), the INDACO Department developed the *Habitability for the ISS* programme, which brought together 25 projects for equipment and objects developed involving, in addition to Alenia Spazio, companies such as Sailed Air, for an intelligent food packaging system, and Electrolux Zanussi, for new concepts for household appliances in microgravity using vacuum as a new form of energy.

The aim of the projects is to improve the comfort and performance of daily activities carried out by astronauts on the International Space Station – working, resting, moving and anchoring in microgravity, preparing, consuming and storing food – and explore new dimensions of living, such as entertainment, privacy, personal hygiene and self-care. In the same year, the European Space Agency

Note 5.
Annalisa Dominoni (1998). *IVA Clothing Support System*. In: Proceedings of ESA Explospace Workshop, Space Exploration and Resources Exploitation, 20-22 October 1998, Cagliari.

3. *IVA Clothing Support System*.
Document→



organised a workshop of experts in different disciplines [6↘] to explore the survival and adaptability of human beings during very long interplanetary journeys, with the aim of defining the requirements for crew selection and planning experimental sessions with an Earth simulator.

Note 6. Annalisa Dominoni is invited as an expert in *Architecture and Design for Space* to the Mars Mission Simulation Workshop, European Space Agency (ESA) 2001.

6.4 The First Book on Design for Space and the *Millennium Charter*

6.4.1 International Scientific Recognition and the Creation of the *Manifesto of Space Architecture*

The year 2002 was an important and challenging one, which projected the INDACO Department on an international scale, thanks to the constant scientific dissemination of the projects through important publications, including the first book *Industrial Design for Space* [7↘], and the participation in specific congresses on the themes of Architecture [8↘] and Design for Space [9↘], which began to interest the space agencies, in particular NASA.

Note 7. Annalisa Dominoni (2002). *Disegno Industriale per la Progettazione Spaziale*. Silvana Editoriale.

Note 8. Annalisa Dominoni (2002). *Space Architecture Education in Milan*. In Proceedings of the 1st Space Architecture Symposium (SAS), 10th-11th October, Huston. American Institute of Aeronautics and Astronautics (AIAA).

Note 9. Annalisa Dominoni (2002). *Designing for Space*. In Proceedings of the 1st Space Architecture Symposium (SAS), 10th-11th October, Huston. American Institute of Aeronautics and Astronautics (AIAA).

Note 10. Space Architecture Workshop. AIAA DETC Aerospace Architecture Subcommittee.

On October 12th 2002 [10↘], during the *1st Space Architecture Symposium* (SAS) in Houston, the *Space Architecture Manifesto* was launched, bringing together the results of many months of reflection and intense debate to define *what Space Architecture is* and legitimise the birth of a new discipline.

The *Millennium Charter* defines the fundamental principles of Space Architecture in a strongly multidisciplinary spirit, interweaving fields as diverse as aerospace engineering, terrestrial architecture, interface design, product and transport design, biology and medicine, human factors, human and space sciences, law and art (Osburg, Adams & Sherwood, 2003).

Among the 47 signatories and founders are NASA architects and engineers who have made important contributions to improving the habitability of human spaceflight, professional architects and designers who are carrying out innovative research in collaboration with the space industry, researchers and university professors from the world's most prestigious universities, including Annalisa Dominoni for the INDACO Department of Politecnico di Milano.

6.5 *VEST* e *GOAL*. The In-orbit Experiments with Astronauts

6.5.1 An Integrated Clothing System to Improve Crew Hygiene, Comfort, Wearability and Performance

Another important milestone was reached in 2002: the projects/prototypes of *VEST. Integrated Clothing System for Intra-Vehicular Activities* (*IVA*) are worn by astronauts on the International Space Station (ISS) during the *Marco Polo* mission led by the Italian Space Agency and the European Space Agency 11↘.

Up to that time there were no specific clothes designed for the confinement and reduced gravity conditions, and the purpose of the experiment was to demonstrate that providing a new integrated system of clothing to the crew, as well as ensuring less mass and volume, would have increased *comfort*, through the use of specific textile materials, and *wearability*, thanks to sartorial models tailored for the neutral posture 12↘ taken in microgravity.

Research into new fibres and fabrics, with thermoregulatory and antibacterial properties to increase the well-being and hygiene of the crew in confined environments, have produced immediate benefits throughout the mission and broad-spectrum pin-offs into underwear and sportswear. The results collected during and after the experiment validated the effectiveness and innovative aspects of the entire clothing system, encouraging further development for the implementation of some diversified typologies according to the activities to be carried out. The new evolved set *GOAL. Garments for Orbital Activities in weigthLessness* was tested with an experiment during the *Eneide* Mission, from the 15th to the 25th of April 2005, and received an

Note 11.
The launch of the Marco Polo mission took place on the 25th of April 2002 from Bajkonur, Kazakhstan.

Note 12.
Neutral Body Posture (NBP).

Figure 2.
VEST experiment for the Marco Polo Mission.

important recognition from the European Space Agency, the *ESA Team Achievement Award*, for contributing to the success of the mission with project innovations.

6.6 Beyond Space: from Antarctica to Natural and Anthropogenic Disasters

6.6.1 The Consolidation of Research and Design for Extreme Environments and Conditions in a Crossover between Space and Earth

In the nine years between 2006 and 2015, the development of research will extend from Space to other similarly extreme environments, such as Antarctica and the Arizona desert, in order to test the confined and difficult operating conditions that we may find on the Moon and Mars.

Among the most important projects, the proposal to reconfigure the layout of the Concordia Dome C base for the ENEA 13↘, in which the skills of Space Design have proved strategic to optimise the functional distribution, morphological and typological of the interior spaces of the two cylindrical buildings – noisy, dedicated to plants and experiments, and quiet, dedicated to the living and private activities of researchers – and to design new custom-made furniture to improve living together in shared and confined spaces. The optimisation of habitability and the integration of all possible aspects related to human factors have been fundamental in the *Meem Crew Operation* project, dedicated to testing the usability of scientific equipment on board the European Columbus laboratory and facilitating crew operations on the International Space Station 14↘.

In parallel with the feasibility studies developed for Alenia Space, such as the *FIPES Definition Study of a Facility for Integrated Planetary Exploration Simulation*, the need has arisen to go further and focus on long-term interplanetary exploration projects 15↘, as well as scenarios for future visions of habitable ecosystems based on the symbiosis between nature and technology 16↘, and advanced environmental projects involving immersive virtual experiences 17↘.

Note 13.
Ente per le Nuove Tecnologie, l'Energia e l'Ambiente.

Note 14.
The project was developed by the INDACO Department in close collaboration with ESA astronaut Umberto Guidoni.

Note 15.
Lunar Exploration Innovative Concepts & Technologies developed in collaboration with ESA-ESTEC.

Note 16.
Flying Moon Birdhouse Projects, developed at the invitation of Koizumi.

Note 17.
Heaven Health, Virtual Experience Narration, project promoted by ESA with E-Synergy and the Italian Council for the Social Sciences.

Part of the research has focused on textile materials and innovative technologies (Dominoni & Tempesti, 2015), with the creation of the *Tech Design* platform, in partnership with TexClubTec, to expand the network of Italian companies potentially interested in collaborating with space agencies.

The consolidation of experience in Space Design is also opening up to other extreme contexts, such as natural and anthropogenic disasters, to address emergency situations where it is essential to provide effective support in the early stages of self-help that precede rescues. (Dominoni, Quaquaro & Fairburn, 2017).

6.7 *Couture in Orbit*. Space Fashion and Spin-offs

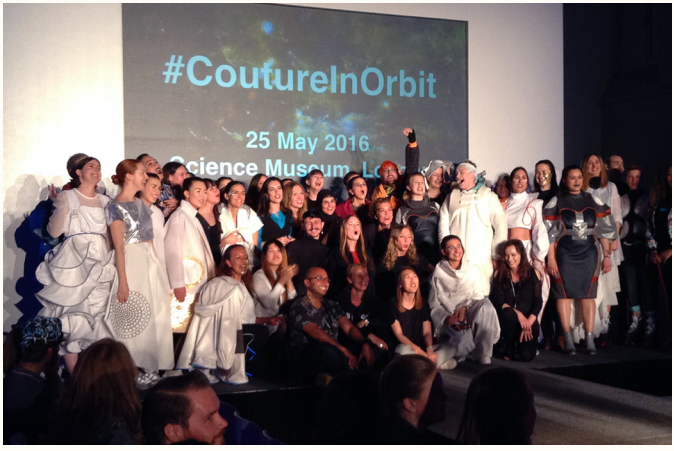
6.7.1 Space Technology is Reinterpreted by the Languages of Design and Fashion to Create New Applications in Clothing

The European Space Agency is launching the *Couture in Orbit* project in 2016, inviting Politecnico di Milano School of Design, together with four other European design schools, to design a collection of clothes to be worn on Earth, using innovative materials and technologies derived from Space research 18↘. This initiative is ESA's first public initiative to communicate, through the language of fashion, the importance of scientific research in orbit and its impact on everyday life. The results were presented at the London Science Museum during the *Taking Technology and Fashion to Higher Levels* event, which included an exhibition of study models and materials and a catwalk of prototypes, generating a cascade of media interest 19↘ 4↘. *Couture in Orbit ESA*

Note 18.
The *Couture in Orbit* collection was realised with the scientific support of ESA Technology Transfer Program (TTP) and the technical sponsors D'Appolonia and Extreme Materials, for the integration of space materials and technologies in the garments.

Note 19.
Link→

4. *Couture in Orbit*: from spacewalk to catwalk.
Document→



Note 20.
Link→

PoliMi 20↘ projects are inspired by the confined environment, observing the activities of astronauts in microgravity and the relationships with weightless objects that generate new behaviours and gestures, with the aim of finding links between Space and Earth that can improve the comfort and performance of clothing. Space technologies are reinterpreted through the language of fashion to create new applications in clothing: *cooling technology* – used in astronauts' spacesuits for thermoregulation through a system of pipes in which water flows – is reinterpreted in the *23.44°* project in an active decoration capable of releasing physiotherapeutic substances through micro-holes; an ESA patent for a three-dimensional *antenna* made of small cones is transformed in the *Tourist in Space* project into a two-dimensional pattern printed on fabric with conductive ink to create clothing that amplifies reception and transmission signals.

Figure 3.
a. *Couture in Orbit*, *23.44°* project.
b. *Couture in Orbit*, *Tourist in Space* project.

Couture in Orbit ESA-PoliMi has generated not only technology spin-offs, but also best practices and experiences that have been disseminated through conferences and events – such as *Space for Inspiration. ISS and Beyond*, organised by ESA at the London Science Museum, or the *European Researchers' Night* at ESA's Italian headquarters – and the creation of two Higher Education courses at POLI.design: *Fashion in Orbit* in 2017 and *Space Fashion Design* in 2018, both supported by ESA and industrial partners such as Colmar, Omniapiega and Sitip, where

the role of design as a development enabler for the *new space economy* is clearly emerging.

6.8 *Space4InspirACTion*. The First and Only Space Design Course in the World Supported by ESA

6.8.1 A New Challenge Combining Research and Education to Create Disruptive Projects for Space with Design Companies

Space4InspirACTion, the new Space Design course created and directed by Annalisa Dominoni and Benedetto Quaquaro, was launched in 2017 as part of the International Master of Science in *Integrated Product Design*, which will reach its 9th edition [21↘] in 2025. Each year, experts from the European Space Agency propose project themes to be developed in line with interplanetary exploration programmes and the testimonies to be involved, which may include astronauts, researchers and scientists. For each project, two companies are selected, one from Space and one from Design, whose role is to contribute to the development of design concepts through the integration of technological and production skills.

In addition to enhancing creativity and *visioning*, this process generates innovation through the transfer – from Space to Earth and vice versa – of technologies, good practices and behaviours. Many collaborations, both internal, with the Departments of Mechanics and Aerospace Sciences and Technologies, and external, with Italian research centres, such as the Italian Institute of Technology, and international universities, such as the International Space University (ISU) and the Fashion Institute of Technology (FIT).

The themes developed over the years deal with different complexities and scales: from food [22↘] to personal hygiene, from fitness [23↘] to clothing for extravehicular activities [24↘] , from the cis-lunar station Gateway [25↘] to future bases for the Moon and Mars up to futuristic *wellness hotels* [26↘] that investigate the theme of hospitality for commer-

Note 21.
***Space4InspirACTion* is part of the *PoliMi Ambassador in Smart Infrastructures* project.**

Note 22.
Argotec for the astronauts' bonus food and Barilla BluRhapsody for the 3D pasta.

Note 23.
TechnoGym.

Note 24.
Dainese D-Air Lab for the extravehicular suit.

Note 25.
Thales Alenia Space.

Note 26.
Virgin Galactic e Jacuzzi.

Note 27.
Axiom Space.

Figure 4.
a. *Space4InspirACTion*, Interplanetary Missions.
b. *Space4InspirACTion*, Cislunar Gateway Station di Altec.

cial space stations [27↘]. *Sustainability* is transversal to all projects, as well as *comfort* to increase *well-being* and *performance*, and recently also *inclusion*, thanks to the collaboration with the first ESA astronaut John McFall, a testimony to the course, prosthetic objects have been designed to define a concept of *new normality* for a *new environment*.

From the first edition in 2017 – with the exhibition *Space4InspirACTion. Projects and Visions for Space* at the Ulrico Hoepli Planetarium in Milan, which went on to Darmstadt [28↘] and Rome [29↘], to the recent *Space Design for New Human Beings* organised for the first *Festival of the New European Bauhaus* at the Brodolini Foundation during *Milano Design Week* – events and exhibitions have been held in prestigious venues to bring Space Design to a wider and more general audience.

At the *Focus Live Festival* at the Leonardo Da Vinci Museum of Science and Technology, *Space4InspirACTion* was awarded the *Raymond Zreick* for Technology and Innovation First Prize [5↘]. In the same year 2022, *Space4InspirACTion* is the author of a section of the 23rd International Triennial Exhibition Milano *Unknown Unknowns. An Introduction to Mysteries* [6↘], with prototypes of space objects designed for use in microgravity. In 2024 the partnership with *Wired Next Fest* at the Castello Sforzesco in Milan begins, involving *Space4InspirAction* in the presentation of talks and exhibitions dedicated to projects.

Note 28.
At the ***ESA Long Night of the Stars*** event to celebrate the 50th anniversary of the European Space Operations Centre (ESOC).

Note 29.
At the Italian ESA-ESRIN headquarters in Frascati for the European Researchers' Night.

5. Museo Leonardo da Vinci *Space4InspirACTion* vince il Primo Premio *Raymond Zreick per la Tecnologia e l'Innovazione*. Document→

6. *Space4InspirACTion* alla *XIII Esposizione Internazionale di Triennale Milano*. Document→

6.9 *Moony*. A Lunar Base Built in Lava Tubes

6.9.1 The Design of Extraterrestrial Habitats Evolves into Complex Scenarios to Simulate an Advanced *Biosphere* Concept

Moony represents one of the most significant experiences born within the Design Department, partner of the *IGLUNA* project – a collaboration between the most prestigious European universities coordinated by the ESA_Lab@ of the Swiss Space Centre – with the objective of designing an *analogue* of lunar habitat within the Swiss glacier of Zermatt, Matterhorn Glacier Paradise. This opportunity has allowed comparison with more complex scenarios, which require habitable systems

Figure 5.
a. *Moony*, lunar base in lava tubes.
b. *Moony*, exhibition inside the Matterhorn Glacier Paradise.

capable of behaving like living organisms, completely self-sufficient in terms of non-renewable resources and logistical support.

The *Moony* 7↘ habitat is a building system capable of producing energy, air, water, food and completely recycling waste. It consists of living cells and service modules that connect to other similar modules to form a lunar village.

7. *Moony*. Una base lunare gonfiabile costruita nei tunnel di lava – Progetto *Igluna*. Document→

The single cell has a flexible main structure and a hemispherical inflatable chamber covered by a lightweight rigid protective structure 3D printed from lunar regolith by the Italian company D-Shape. The project explores principles for improving the quality of life and human-nature relations to compensate for the lack of natural stimuli and to lay the foundations for an advanced concept of the lunar *biosphere*.

6.10 The *Sensory Space Station* for Thales Alenia Space

6.10.1 The Avant-garde of Space Architecture and Design Feeds on New Materials and Technologies to Counter the Effects of Confinement

The *Sensory Space Station* project 8↘ has been defined by Thales Alenia Space as a cutting-edge solution for future space stations. It presents, for the first time, a module dedicated to the *entertainment* of astronauts, with innovations capable of compensating for the lack of natural elements by using technologies and materials that stimulate the senses.

8. La *Stazione Spaziale Sensoriale* progettata per Thales Alenia Space. Document→

In a confined environment, everything is amplified: the light, the noise, the visual and tactile sensations that colours and materials give us, the prossemic relationships, the need for privacy.

The main challenge is to design *sensory spaces* that go beyond the functional aspects and considering the physiological and emotional aspects that have a great influence on our behaviour. Light, which can change colour and intensity, reproducing the natural cycle of day and night, can help to balance circadian rhythms.

Acoustic materials can reduce the background noise of instruments. Interior surfaces are enriched with visual and tactile qualities to give the whole room a more comfortable and homely feel.

Figure 6.
a. *Sensory Space Station*, interior.
b. *Stazione Spaziale Sensoriale*, textile partitions to create privacy.

This new concept results in an open and reconfigurable habitat, with furniture that changes according to the different activities of the astronauts, cylinders/storage covered with fabric that rotate on rails to compose *chaise longues* of different sizes 30↘, and light partitions that move to create personal areas of privacy.

This project is an example of how design can act as a bridge between the space industry and Italian design companies. Caimi SnowSound, involved in the *Sensory Space Station* project for its internationally recognised expertise in sound-absorbing textile materials, is now supplying its acoustic panels, tested by NASA, to Thales Alenia Space to cover the internal structure of the new generation of Cygnus pressurised modules.

Note 30.
Replacing the current racks, the furniture/containers that cover the interior surfaces of the International Space Station.

6.11 The Work of Disseminating Space Design to Inspire Values of Sustainability, Inclusion, Beauty: *ESA_Lab@PoliMI_ Design*

6.11.1 More than Twenty-five Years of Events, Exhibitions and Publications of Projects and Research that Have Helped to Establish Design for Space

The growth of the network of relations and the increased interest in the Space Design developed at Politecnico di Milano have favoured an extensive participation in national and international events and exhibitions dedicated to scientific audiences, such as *Design in Orbit* 31↘, the speech that inaugurated the *Space Week* at Expo 2020 in Dubai 9↘, or *The Cutting Edge of Design and Architecture* for Space 32↘ , the session of the IV International Conference *Crossroads/Incroci* in 2023.

There have also been opportunities to disseminate the results of research to the general public, with *Il bello dell'Italia. Altri mondi* organised by *Corriere della Sera* in 2017, TEDx *Spaces* in 2022 or *Design for Innovation, Sustainability and Inclusion in Space* 33↘ on the occasion of the *Italian Design Day* 34↘ in 2024.

Note 31.
Space 4 Sustainability Forum.

9. *Space4InspirACTion* a *Space 4 Sustainability*, Expo 2020 Dubai. Document→

Note 32.
With contributions from Annalisa Dominoni (*Space4InspirACTion*), SOM Architects (Moon Village) and Blue Origin (Orbital Reef).

Note 33.
Frankfrter Kunstverein.

Note 34.
Design Ambassadors Annalisa Dominoni and Benedetto Quaquaro.

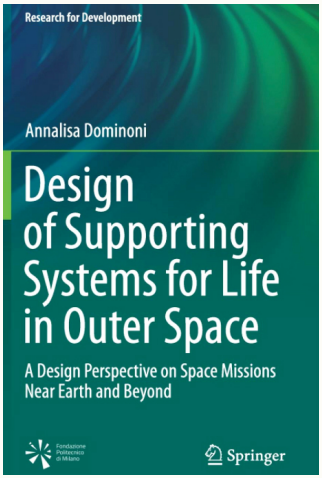
Among the most important exhibitions: *Futuristic Space Technologies*, organised by the Italian Space Agency at the Science Park in Trieste in 2002, which presented some of the projects of the *Habitability in Space*; *Marte. Futuro Remoto. Un Viaggio fra Scienza e Fantascienza* in 2004, in partnership with ESA, NASA and INAF, with projects of Mars rovers and light furnishings for the Mars environment; *Milano Made in Design*, promoted by the Province and the Chamber of Commerce of Milan, which presented the prototypes of the *GOAL Garment for Orbital Activities in weightLessness* space experiment through a travelling exhibition in New York, Toronto, Tokyo, Beijing and Shanghai between 2006 and 2007.

The projects have been presented at international conferences and published in scientific papers and monographs. *Design of Supporting Systems for Life in Space. A Design Perspective on Space Missions Near Earth and Beyond*, published by Springer, summarises the experience of Space Design [35↘] from its beginnings in 1997 to 2021. *Le Città dell'universo. Come sarà abitare nello Spazio*, published by Il Saggiatore in 2023 and dedicated to the general public, has been presented at several national events [36↘]. *Design for Sustainability and Inclusion in Space. How New European Bauhaus Principles Drive Nature & Parastronauts Projects*, to be published by Springer in 2024, will present new habitat projects and tools for growing microalgae on the Moon, as well as the disruptive concept of *New Normal* for a *New Environment*, developed with the first European parastronaut John Mc Fall.

Note 35.
The book was presented at the event *Design for Life in Space*. PoliMi Digital Talk, Fondazione Politecnico.

Note 36.
Genova Science Festival and *Salerno Literature Festival* in 2023.

Figure 7.
Design of Supporting Systems for Life in Outer Space.



In 2022-2023, the collaboration with the European Space Agency is institutionalised and the *ESA_Lab@PoliMi* is established with the Departments of Design, Electronics, Information and Bioengineering, Civil and Environmental Engineering, Aerospace Science and Technology. This is an important year for the Design Department, which is recognised with *ESA_Lab@PoliMi_Design* for its scientific research, projects and teaching activities over a period of more than twenty-five years, which have contributed to confirming the strategic role of space design. On October 19th 2024, at the International Astronautical Congress (IAC) in Milan, the event *Space Archi-*

tecture Symposium is held by the founders of the *Millennium Charter* (2002, Huston), a historic meeting that seals more than twenty years of scientific collaborations of research and educational projects.

6.12 *Italian Space Design* is Born

6.12.1 An Important Tribute Celebrating the Polytechnic Excellence of *Italian Space Design* Around the World

The *Design Spaziale Italiano* 10↘ project concludes this testimony that has traced over a quarter of a century the birth and evolution of an avant-garde discipline on Architecture and Space Design born within Politecnico di Milano. Promoted by the Ministry of Foreign Affairs and International Cooperation and curated by Annalisa Dominoni and Benedetto Quaquaro, it consists of events and exhibitions of physical products, digital content, installations, animations and videos that develop different forms of site-specific storytelling that can communicate how the *shape* and *sense* of the objects we use in our daily activities can change during the transition from Earth to space.

10. *Le città dell'universo*. Document→

> **With its strong cultural and technological impact, *Design Spaziale Italiano* is an important contribution to the growth of the Italian space sector. The innovative aspect of the project lies not only in its ability to respond to global technological challenges, but also in its ability to combine our country's tradition of excellence in the design sector with the latest scientific trends. The added value of this initiative lies in the synergy between universities, research and institutions, a combination that promotes the growth of highly professional and innovative skills in an international context. (MAECI)**

Presented in the diplomatic representations of Brussels, Prague, Paris, London and Vienna on the occasion of the National Space Day 2024, it will be extended in 2025 to other diplomatic representations around the world to testify, through visionary projects, the importance of Design for the future of interplanetary exploration.

Figure 8.
Italian Space Design, exhibition at the Scuderie of the Embassy in Prague.

This prestigious recognition confirms an important commitment to communicate and share with the general public a vision that will be part of our evolution and rewards the excellence of the *Poly-technical system*, capable of working as a team and putting into practice different fields and knowledge with determination and passion.

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