



## Preface

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Dear reader,

This issue of *Aerotecnica* (#2, vol. 99) is dedicated to an overview of experiments conducted on the International Space Station, relevant to space medicine and related subjects in microgravity conditions; the results of these activities could be fundamental for future human exploration in the solar system. This editorial choice is rather unusual in the history of the Journal since its inception in 1920 but the importance of the medical aspects will become fundamental for the human space missions of the future. A human Mars landing is becoming a solid possibility in the next decade and the problems connected to a long permanence in space of a crew will be crucial for the success of this challenge. This issue will thus represent an innovation in view of the inter-sectorial research developments at hand.

*Aldo Frediani, Editor in Chief*

### 1 Foreword

It is with great pleasure that this journal dedicates an entire issue to the Italian participation in the ASI mission VITA and the ESA mission BEYOND. The publication of this issue falls dutifully in the institutional tasks of the journal and in the scopes of the Italian Aeronautics and Astronautics Association (A.I.D.A.A.) aimed at spreading and promoting the Italian aerospace activities of which the contribution to the missions VITA and BEYOND has been a remarkable example. The XXV International Congress of Aeronautics and Astronautics, organized by A.I.D.A.A., the Italian Association of Aeronautics and Astronautics, Rome Branch, was held in Rome from September 9th to 12th, 2019, at the Faculty of Civil and Industrial Engineering of La Sapienza University of Rome. At the Opening Ceremony, Prof.

Mario Marchetti, Congress Chair, greeted the authorities who attended: Prof. Eugenio Gaudio, Rector of the Sapienza University, General Basilio Di Martino, Head of the Aeronautical Engineers Corps of the Italian Air Force, Eng. Alessandro Cardi, Deputy General Director of ENAC, National Civil Aviation Authority, Eng. Paolo Bellomi, Director of Engineering and Development of AVIO, Eng. Enrico Russo, Technical Director, and Eng. Gabriele Mascetti, Head of Human Spaceflight, both of the Italian Space Agency, and Prof. Erasmo Carrera, President of A.I.D.A.A.. The Ceremony concluded with greetings from the European Space Agency Astronaut Luca Parmitano aboard the International Space Station.

The activities of the Congress continued for 4 intense days with the presentation of more than 300 papers, 6 Plenary Lectures from researchers from universities, research centers and industries, regarding all scientific, aeronautical and space sectors. However, the majority of the papers were by young researchers. This is the aim of all the A.I.D.A.A. Congresses: to give young people the opportunity to show their research activities to provide a global vision of the Italian aeronautical and space sectors.

A specific session of the A.I.D.A.A. congress called “The Italian contribution to the ISS research and the ASI experiments for the ESA Mission Beyond” focused on the most recent Italian research conducted on board the International Space Station (ISS). The works selected for this session described the experiments conducted during the missions ASI mission VITA and ESA mission BEYOND.

The ASI mission VITA took place in 2017 thanks to the ASI-NASA MoU signed in 1997. For this mission, ESA and ASI jointly proposed the ESA astronaut with Italian passport Paolo Nespoli. To complement the mission, the Italian Space Agency coordinated a pool of 29 different institutions and about 40 investigators who worked on the design and implementation of 11 investigations in the fields of human physiology, cell biology, technology demonstrations and education. ASI also provided support to scientists for the integration/safety process, logistics and operations thanks to a specific contract with Kayser Italia.

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Later on, the ESA mission BEYOND with the ESA astronaut with Italian passport Luca Parmitano lasted from 20 July 2019 until 6 February 2020. One of these successful mission goals was to carry out six experiments sponsored by the Italian Space Agency. Three investigations (Acoustic Diagnostics, Amyloid Aggregation and NutrISS) were performed on board the ISS thanks to a specific agreement between ESA and ASI. Two investigations (XenoGRISS and LIDAL) were performed through the ASI-NASA MoU for the MPLM/PMM modules. Finally, one investigation (Mini-EUSO) resulted from an international cooperation between Italy and Russia, which required a specific ASI-ROSCOSMOS agreement. This time, a contract between ASI and Argotec/Telespazio provided the support for integration/safety, logistics and operations. Thanks to the Italian role in the ISS program, in early 2020, ASI reached a total of 73 investigations on board the ISS since the start of the program.

This Special Issue reports a selection of the papers issued for the Symposium “The Italian contribution to the ISS research and the ASI experiments for the ESA Mission Beyond” chaired by Giovanni Valentini (ASI ISS Utilization Manager) and Marino Crisconio (ASI PMM Program Manager). It does not intend to give only wide information to the large audience of readers and give hospitality to the research groups that have carried out the activities in space as a completion of hard, long and many times underestimated collateral and preparatory work on the ground, nor be a final report (the results are not yet definitive and available at the time of going to print). Rather, it wants to testify that these results are the confirmation of the Italian capability to carry out a space program by aggregating, coordinating and organizing activities from various industrial and scientific research centers and to be able to fruitfully cooperate with the International Partners of the ISS Program.

This issue is completed with the messages received at the congress from Giorgio Saccoccia and Gabriele Mascetti (Italian Space Agency), and the ESA astronauts Paolo Nespoli and Luca Parmitano.

*Mario Marchetti and Giovanni Valentini, Guest Editors*



*International Space Station (credits NASA-ROSCOSMOS)*

## 2 Message from Gabriele Mascetti, Head of Human Spaceflight Unit, Italian Space Agency

The ASI Human Spaceflight Unit has the mission and responsibility of coordinating and harmonizing the activities relating to human spaceflight and International Space Station at the national and international level. In this context, our mission is to manage scientific training programs and activities for human spaceflight, to perform programmatic management of resources and national usage rights on the ISS, to participate in ESA Boards and in international initiatives in the relevant field, and to manage the implementation of the relevant EU projects. In the coming years, ASI will encourage microgravity research through new calls for research on board the ISS and future platforms such as the Gateway in view of future lunar and Martian explorations, to be carried out within the ASI-NASA MoU or on other International Partner resources to be used for ASI by specific agreement. In addition, it will promote research in support of the ISS4Mars ASI concept, i.e. the use of the ISS as a simulator of Martian missions. The calls for the realization of research on the ISS will favor the strategic research lines for the ASI and, in particular, in the areas of national excellence such as biomedicine, bioengineering, biotechnology and diagnostics, as well as promoting functional initiatives for the commercial development of the LEO. In addition, the ASI will reward research initiatives in LEO and on Gateway on enabling issues related to "health in space" (remote diagnostics, telemedicine, Lab on Chip devices for rapid diagnostics, portable low-cost mobile devices, development of intelligent processes and materials that avoid the generation and/or proliferation of pathogens in Lunar environments or in ISS, new biomarkers, innovative diagnostic technologies, artificial intelligence, manipulation of liquid media and nanoparticles), both in support of the Italian role in space exploration and as strategic lines for the country in terms of positive effects on the national health system.

### 3 Message from Giorgio Saccoccia, President of the Italian Space Agency



The International Space Station is a fantastic example of peaceful international cooperation and a unique platform on which to test a wide array of experiments in microgravity in a variety of fields ranging from life and physical sciences to technology development and educational activities.

Italy boasts unique access rights to the ISS thanks to the double access in multilateral through the European Space Agency (ESA) and in bilateral via a Memorandum of Understanding (MoU) signed in 1997 with NASA. We can proudly say that nearly 50% of the pressurized modules of the ISS have been built by our national space industry and Italy is the European country with the largest number of astronauts and number of experiments performed on board the station. More than 70 Italian experiments have been performed thus far on board the ISS, 11 of which by ESA astronaut, Paolo Nespoli, during the “VITA” mission and 6 by Luca Parmitano during the mission “Beyond”. Soon another platform will be available for research in microgravity, launched by VEGA C, the reusable spacecraft, Space Rider, the ESA program to which Italy is the major contributor. Looking at the future of space exploration, NASA’s ARTEMIS program will be the next step for a sustained long-term presence on the lunar surface and a test bed for future missions to Mars. In particular, the Gateway—the first orbital cis-lunar base—will offer a new space laboratory for experiments in microgravity. Italy participates to this exciting program both through ESA and in the near future in bilateral with NASA in alignment with the ASI-NASA Joint Statement of Intent for Cooperation in Space Exploration signed on October 2019, which regards, in particular, the collaboration on the ARTEMIS program. At a national level, the research in microgravity will be implemented through the development of national research programs that will be launched with research calls for experiments, on-ground and microgravity, to promote the enhancement of our scientific and technological community in this field as well as many small- and medium-sized enterprises through public–private partnerships.

### 4 Message from Paolo Nespoli, Astronaut of the European Space Agency



Credits ESA/NASA.

An aerospace engineer, I was selected as a candidate astronaut by the Italian Space Agency in 1998 and incorporated into the Astronaut Corps of the European Space Agency (ESA). ESA sent me to Houston/NASA to be trained as Mission Specialist for the Space Shuttle and Space Station. My first space flight was in 2007: STS-120 Esperia, a 15-day mission with the double objective of delivering to the station the Node-2, a mechanically complex pressurized module needed for the attachment to the station of the Japanese and European laboratories, and of repositioning the solar array P-6. Three years later in 2010–11, I participated to a second spaceflight: Exp-26/27 MagISStra, a 159-day mission for the utilization of the International Space Station. Then in 2017, I flew a third time in space on Exp-52/53 VITA, a 139-day mission to the ISS. The total time spent in space is 313 days. During the time on the ISS, as a crew we carried out hundreds of experiments in all possible fields as, for example, biology, human physiology, physics, biotechnology, Earth observation, physical sciences technology and even educational experiments. Among these, there were a dozen of experiments sponsored and coordinated by the Italian Space Agency; I had the privilege to carry out personally most of the Italian experiments. The high number of Italian experiments compared to the other European space agencies is due to Italy’s dual relationship to the ISS Program: the first one directly with NASA through a Memorandum of Understanding signed ’97; the second through ESA’s Space Station Program, program that Italy has supported since the beginning. For example, during the mission VITA, this double agreement allowed ASI to use around 14 h of my work time in space to complete the Italian experiments. In addition to completing the official scientific tasks, during my free time I had the chance to take many photos from the Cupola, activity that gave me the opportunity to integrate one of my passions into my work. I also used Social Media to both publicize the work we do in space for us on Earth and

increase the awareness of the state of health of our planet and the fragility of our presence on it.

From the point of view of public outreach, I participated in various video links from the ISS with institutional entities and the media, and I was involved in the ARISS program, taking part in over thirty radio contacts with school groups around the world.

## 5 Message from Luca Parmitano, Astronaut of the European Space Agency



Credits ESA/NASA.

For the past 20 years, the International Space Station programme has made history as a unique example of international cooperation, which sees Europe, the United States, the Russian Federation, Japan, and Canada collaborating in one of the largest partnerships in the history of science. At the same time, the Space Station itself is one of the greatest engineering works ever made by humankind, showing unequivocally that it is possible to live for long periods in space. The results of the research conducted in the only orbiting human post teach us, among other things, how to manage many aspects of future human missions in space, including interplanetary flight. That was the thought behind the name of my second mission on board the International Space Station, 'Beyond': a term, and an invitation, chosen to indicate our desire to explore the universe, to look farther than the low orbit of our planet, and to expand our knowledge. During the mission, for the duration of Exp. 61 (Oct

3rd, 2019–Feb 6th, 2020), I had the rare privilege of assuming the role of ISS Commander: as the first Italian and the third European astronaut to take on this important assignment, I was well aware of the responsibility that comes with a leading role, and it was my goal to spend every ounce of my energy in support of the program. Space is a tough and inhospitable frontier. Astronauts, engineers and scientists must work together to pave the way for future explorers, who will be able one day to live and work far from Earth. While continuing to conduct studies on board the ISS, today we aim to reach the Moon: to do so, we must perfect the studies on human physiology, biology, and on new technological systems, to allow astronauts to live in a safe and comfortable space. We will need materials and technologies that have not been invented yet: for this reason, the experiments that my crew and I had the opportunity to conduct on board the ISS during the Beyond mission aimed, among other things, to study new life support systems, as well as to deepen the knowledge of how our body adapts to space and reacts in a microgravity environment—from the muscular–skeletal systems, to the cardio-vascular one, all the way to the neurological aspects. Therefore, it is quite appropriate that four of the six experiments of the Italian Space Agency, chosen to fly during Exp.60/61, focused on the optimization of the astronauts' diet, on the measurement of specific parameters to monitor the efficiency (and possible changes) of the auditory system, and on the possible evolution of neurodegenerative diseases in space. The other two aimed at observing the Earth, in a spectrum (and with a volume of data) never achieved before, and on measuring the radiation level on board the ISS. The steps taken by science and technology during my mission help bringing us closer to our next aspiration: to send the first European astronauts to the Moon—and beyond—placing Europe at the center of one of humanity's greatest explorations.

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