Primo Piano - *Alfredo Garro, the first woman on the Moon: we are going!*

Roma - 17 ott 2022 (Prima Notizia 24) **Nasa's Artemis program and the contribution of the University of Calabria. Our interview with prof. Alfredo Garro, President 20-21 of the Italian Association on Systems Engineering (Aise), Incose Chapter “Italia”.**

Alfredo Garro is Associate Professor of Computer and Systems Engineering at the Department of Informatics, Modeling, Electronics and Systems Engineering (DIMES) of the University of Calabria. In 2016 he was Visiting Scientist at NASA Johnson Space Center in Houston (TX, USA), Software, Robotics, and Simulation (ER) division. His home is the Calabrian University Campus where the researcher spends most of his life when not on a mission abroad. Not only his home, but also the secret casket of his research, which is not easy and not at all obvious in a university like this one in Arcavacata, so "far" but also so "close" to the world of NASA. With him we try today to put together the pieces of the great international mosaic of the reconquest of the Moon.
-Professor, at what point is the research for manned space exploration today? I would like to remind you that about 50 years have passed since the Apollo 17 mission, the last one that saw a human being walking on our natural satellite. After this mission, the lunar experience almost fell into oblivion, probably due to the high costs and the low appeal for American public opinion. In recent years, the United States has again decided to invest in space exploration with human crews. -So, is it a new start? The first objective is essentially to return to the Moon, collaborating with other nations to create a human settlement that can serve as an outpost for future explorations of other celestial bodies, primarily Mars. -Cui prodest? It is a great challenge and it will allow us to tackle complex problems by defining solutions that, as is now common practice, will have concrete impacts on the daily life of each of us and will contribute to improving our life quality in a sustainable way for our planet. -Does this endeavor have a specific name, professor? Yes, absolutely. These challenges are taken up by Artemis, the program launched by NASA to bring the first woman and the next man to the Moon by 2026 and then plan to explore Mars. -Does it sound like a modern fairy tale? It is so much more. It is an ambitious program, with a total cost of 86 billion dollars of which 35 billion already committed by the American government, which involves the European (ESA), Italian (ASI), Japanese (Jaxa), British (UK Space Agency) and Canadian (CSA) Space Agencies and strongly relies on the cooperation between the various international partners. -Is there already an agenda of what will happen in the next few years? The Artemis program, as it was for the Apollo program, will include several missions. The first, Artemis 1, will have the objective of bringing the Orion spacecraft into lunar orbit in order to test all systems in their operational environment to allow the presence on board of human crews in Artemis 2, and the return of human being on the Moon in Artemis 3. - An “usual” spacewalk, then? This time, however, it will not be just a matter of planting a flag to demonstrate one's technological supremacy over the enemy. Instead, we will go to the Moon to stay there and

to ensure that it becomes an outpost of humanity for future space exploration missions. In fact, the Artemis program envisages the construction of a real habitable lunar settlement, called Artemis Base Camp, and of a space station in lunar orbit, called Lunar Gateway. -Are we talking about advanced and incredible science and engineering achievements? To carry out such complex space programs it is necessary to have advanced simulation technologies and the adoption of international standards is crucial. In particular, the Artemis program uses the distributed simulation standard IEEE-1516.2010 High Level Architecture (HLA) and the SpaceFOM (Space Federation Object Model), which describes and specifies the modalities that will allow the different mission elements, developed by the various partners, to interact and interoperate with each other successfully both in the design phases and in the implementation and deployment phases of the mission. -What was your experience in this world so far from the Calabrian Campus of your University? A long journey that of SpaceFOM, which began in 2016, when, together with my collaborator, Alberto Falcone, I became the first European to be hosted, as a "visiting scientist", at the "Software, Robotics and Simulation (ER)" Division of NASA Johnson Space Center (JSC) in Houston following a specific "Visiting Research Agreement (VRA)" between the University of Calabria and the NASA headquarters in Washington D.C. -Then, once back in Italy… After a nine-month period spent in the NASA center of Houston, back in Calabria, I continued my scientific collaboration with NASA in the following years, assuming the vice-presidency of the international standardization committee in SISO (Simulation Interoperability Standards Organization), which led in February 2020 to the publication of the SpaceFOM standard and, just over a year later, to its official adoption by NASA as part of the Artemis program. -I guess you also consider all this a personal achievement? It is not easy to answer. SpaceFOM took a long time to be developed as many aspects had to be considered for its definition. It is essential in such missions to be able to simulate the physics of the solar system, the behavior of the various entities involved, their space-time location, their interactions, communication and information exchange, the three-dimensional visualization aspects of mission scenarios, the ability to manage time flexibly and accurately. Furthermore, various problems must be addressed due to the distributed nature of these simulations: they envisage a unique infrastructure to which the various partners connect from their laboratories and development centers, also for reasons related to intellectual property, participating, each with its own modules, to the overall simulation scenario. Addressing these research issues and proposing innovative solutions, then adopted and improved thanks to the contribution of the other partners, has certainly been a source of immense gratification for me. -Do we want to talk of a shared and international success, then? Yes, absolutely. In order to develop effective and shared solutions, it was essential to involve various actors in the SpaceFOM project. NASA has launched and led an international effort that has involved various American space and research centers, the most important space agencies in the World, various companies providing technologies and operating in the aerospace sector, and several universities: the University of Calabria, the University of Liverpool, the University of Bordeaux, some French research centers, (in the last stages) the University of Rome Tor Vergata. It was a real honor for me to have contributed to this success by covering a key role. - At what point is this sort of joint venture between the University of Calabria, NASA, and the other

international partners? The collaboration between my research group at the University of Calabria and NASA will continue. It cannot be stopped, because SpaceFOM is now a fundamental element in Artemis, a program that will characterize manned space exploration for the next few years. In addition, SpaceFOM is being adopted by the European Space Agency (ESA) to simulate future robotic exploration missions of celestial bodies. I currently hold the position of vice president of the SISO international committee that promotes and supports the adoption of the standard and oversees its evolution; SpaceFOM will probably also become a subject of study in university courses as an example of a robust and effective solution for the distributed simulation of interplanetary space missions. -In short, are we just at the beginning of a new space adventure? Many SpaceFOM-related research results have been published in articles that have appeared in international scientific journals and are all jointly authored by NASA, the University of Calabria and the other participating partners. Furthermore, the writing of a volume dedicated to the topics that we have addressed with our NASA colleagues during the creation of the SpaceFOM is in progress so as to provide the scientific community with a unique reference on that. -Can we talk about the Artemis 1 launch date? The launch of Artemis 1, originally scheduled on August 29, 2022, has been postponed due to technical problems that emerged on the launch pad during the crucial phase of filling the propellant tanks that powers the four RS-25 engines, coming from the program Shuttle, and which constitute the first stage of the Space Launch System (SLS), the huge rocket that will be used in the Artemis program. -Can you help us to better understand, professor? The four RS-25 engines provide the 25% of the considerable thrust needed by the SLS to allow the insertion into lunar orbit of a heavy load such as the Orion spacecraft (about 20 t), the remaining 75% of the thrust is provided by the two powerful Solid Rocket Boosters (SRBs) that you can see on the sides of the central body of the SLS. The four RS-25 engines are powered by 820 t of hydrogen (fuel) and 144 t of oxygen (oxidant) that are stored, in liquid form, in the two huge tanks located in the central body of the SLS (specifically in the orange part) at very low temperatures, -253 °C and -183 °C respectively. Given the complexity of these systems and of the filling procedures, it is therefore not surprising that technical problems may be encountered on the launch pad. -And the World keep waiting… What I can tell you is that in these cases, while understanding the enthusiasm and expectation of public opinion towards the launch of Artemis 1, it is necessary to be patient and to operate with extreme attention to reduce the risk of failure of the mission: failure that would produce not only serious economic losses but also a slowdown of the entire Artemis program. -So, we have just to wait the Artemis 3 mission and see the first woman and the next man on the Moon… Of course, but Artemis 1 is a fundamental step towards reaching that goal; however, the key moment, certainly for us involved in the program but so it should be for everyone, will not be the long-awaited launch but rather the splashdown in the Ocean of the command-and-control module of Orion. -Why are you telling me this? Because at that point the Artemis 1 mission has ended successfully and a new page of human history, in which we have been an active part, has really been written.

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