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# NATO Science presents: High-altitude balloon-borne radar

Interview: Questions and Answers with scientist**: Professor Marco Martorella**

**Prof Marco Martorella** received his Laurea degree (Bachelor+Masters) in Telecommunication Engineering in 1999 (cum laude) and his PhD in Remote Sensing in 2003, both at the University of Pisa.

He is now an Associate Professor at the Department of Information Engineering of the University of Pisa where he lectures "Fundamentals of Radar" and "Digital Communications" and an external Professor at the University of Cape Town where he lectures "High Resolution and Imaging Radar" within the "Masters in Radar and Electronic Defence". He is a regular visiting Professor at the University of Adelaide and at the University of Queensland in Australia.

He is author of about 150 international journal and conference papers, three book chapters and a book entitled "Inverse Synthetic Aperture Radar Imaging: Principles, Algorithms and Applications". He has presented several tutorials at international radar conferences and organised a special issue on Inverse Synthetic Aperture Radar for the Journal of Applied Signal Processing. He is a member of the IET Radar Sonar and Navigation Editorial Board, a senior member of the IEEE and a member of AFCEA.

**He is also chair of the NATO SET-196 on "Multichannel/Multistatic radar imaging of non-cooperative targets"**. He has been recipient of the 2008 Italy-Australia Award for young researchers, the 2010 Best Reviewer for the IEEE GRSL and the IEEE 2013 Fred Nathanson Memorial Radar Award.

His research interests are mainly in the field of radar imaging, including passive, multichannel, multistatic and polarimetric radar imaging.

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**Location:** Pisa, Italy

**Project name:** *High-altitude balloon-borne synthetic aperture radar*

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**Project description:** NATO has a key role to play in emergency response and disaster relief. When a disaster strikes, getting an overview of the site is key to saving lives and stopping further damage. Until now, the only two options to get the big picture from far above have been aircraft or satellites, both of which are expensive and require infrastructure. But high-altitude balloons equipped with a new kind of radar promise to be cheap, rapid and fuel-saving. In this episode of NATO Science, we travel to the **University of Pisa**, where NATO scientists are working on the system in partnership with the **University of New South Wales in Australia** and with support from **NATO's Science for Peace and Security (SPS) Program**.

1. **The high-altitude balloon-borne radar ("BALSAR") project has been ongoing since 2017. What are some of the key lessons learned or advancements that you have made since then?**

   There have been many lessons that we have learned since we started the BALSAR project together with the University of New South Wales (UNSW). One of the key lessons that we have learned is that stratospheric missions have a set of strong differences with respect to space (above 100 km) and air (below 13,000 m) missions. Such differences greatly affect the design of the system, as they require a lot of attention to the environmental conditions, which change drastically from the moment the platform takes off to the moment it reaches the stratosphere. A lot of devices have ranges of operation that do not satisfy the requirements for large deviations of temperature and pressure.

   Nevertheless, we have managed to progress with our project to the point where both the platform and the payload have been assembled and we are ready to integrate our system (radar and platform) as soon as we will be able to travel to Australia, where the system will fly its first mission.

2. **What are some of the biggest challenges or obstacles that you have overcome – or that you are still grappling with – while working on this project?**

   Both **Professor Elias Aboutanios** from UNSW (our partner in this project) and I were fully aware of the number of difficult challenges that were behind our idea. One of our biggest challenges is associated with heat dissipation at high altitudes. In an environment where temperatures drop down tens of degrees below zero, one may think that the high temperature of some components would not be a problem. The truth is that certain components, such as the power amplifier, produce a lot of heat that must be dissipated. Typically, the air flow generated by fans is enough to cool down such components. The problem is that at such high altitudes, the air is so thin (about 1 per cent of the air pressure at sea level) that it is not sufficient to cool down the power amplifier. We had to create a special design to make sure that the temperature is kept below the safety threshold.

3. **If anything went wrong during the balloon's flight, what would happen to the balloon and the radar technology it carries?**

   There are a number of things that can go wrong during a mission. Regardless, the balloon is an expendable part of the system, as it never makes it back to the ground. The costs associated with the balloon and the helium to make it fly are part of the mission costs. The payload, which consists of the radar and the housekeeping devices that accompany the radar (such as batteries; telemetry, tracking and command (or TT&C) system; stabilizer; etc.) are attached to a parachute, which brings them back to the ground. If anything went wrong and the balloon burst during a mission, the parachute would automatically open during the descent. The system is equipped with a GPS and a radio emitter, which reveal its position every second. A tracking device allows the staff on the ground to reach the system and retrieve it. It is worth pointing out that this recovery system is used in missions that are regularly terminated with a command from the ground, not just in emergency situations.

4. **How was your background relevant in the development of this project?**

   My personal background focuses on radar and it was necessary to develop an ad-hoc radar for this mission. Together with the UNSW, where expertise is present that is relevant to the platform (balloon and housekeeping devices), we have combined our knowledge to build and integrate all parts that compose the BALSAR system.

5. **What is it like to work with teams based in Italy and Australia? Are the distance and time difference hard to manage?**

   The distance is surely a factor to consider, as physical meetings are possible only on very limited occasions (once or twice per year). Also, the time difference makes it difficult to have virtual meetings, as one party has to work outside of regular hours to participate in a meeting. Nevertheless, knowing this in advance, we have planned and divided our work so that we could develop chunks of it independently and keep the coordination needs to a minimum. Of course, the COVID-19 pandemic further complicated our plans. It has reduced to zero our ability to meet in person and is currently preventing us from completing the system integration and carrying on with our first balloon launch.

6. **How does your research and the BALSAR project contribute to greater security?**

   In peace and crisis, there are many situations where sensors are needed to obtain a level of situational awareness that can complete an operational picture. Among such sensors, radar has the advantage of seeing in any weather and illumination conditions, due to the much lower frequencies at which it operates. As with any other sensor, though, radar has limitations in terms of line-of-sight visibility as well as range. For this reason, it is typically carried around by platforms that may take the radar closer to and in visibility of the area of interest. Typical platforms that are used during such missions are aircraft, helicopters and satellites, although nowadays the use of drones and unmanned aerial vehicles (UAVs) is becoming more and more prevalent. Nevertheless, the use of balloons introduces another potential platform that allows for large areas to be monitored at a low cost. This technology can be used to extend the coverage of sensors at a low cost, enabling a more effective surveillance system that can be employed during peace and crisis times, contributing to border control, disaster assessment and other tasks.

7. **How do you imagine the results of this project being used in the future?**

One potential use of this technology may help in the surveillance of the Mediterranean Sea. In particular, the illegal trafficking of humans, weapons and drugs must be monitored continuously and across vast areas of sea. A balloon-borne radar system would be ideal, as it would be launched by a ship at sea before rising up to stratospheric altitudes where it would start gathering radar data and complete the mission after travelling for a few hundred kilometers. The system would be able to cover vast areas and the data gathered would be used to detect and image objects at sea and identify those that are conducting illicit actions. A second ship would be used to recover the payload and reuse it for another mission. A set of such systems would be necessary to guarantee a persistent surveillance of the area, and the low cost of the BALSAR system would satisfy the requirements in terms of cost of this kind of operation.