POLAR QUEST 1928 2018

A POLAR EXPEDITION
ON THE TRACKS OF THE ITALIA AIRSHIP

©Paola Catapano
Polarquest2018 project leader

1.POLARQUEST2018: the expedition in short

POLARQUEST2018 is a polar expedition involving **exploration** and **adventure**, **science** and **history** and a powerful message for the **planet**. From July to August 2018, an international team of arctic researchers, experienced scientists and young future scientist will travel to the **Arctic** sea on board of **Nanuq** (i.e. polar bear in Inuit), a 60 feet sailboat designed and built by naval architect and Genevan explorer Peter Gallinelli for sailing in arctic regions in a **self-reliant** mode. The voyage starts from the North-East coast of **Iceland** (where the boat has spent the 2017-2018 winter) to reach the **Svalbard** archipelago, above the Artic Polar Circle, **circumnavigate** it and finish the expedition in **Tromsø** (Norway). Our mission: we will be looking for answers to one of the greatest **challenges** of our time, climate change, and raise awareness about its consequences. Polarquest2018 takes inspiration from the very first scientific expedition to the North Pole, the **ITALIA Airship** 's, the very first airborne scientific laboratory led by Air Force General and Airship engineer Umberto Nobile in 1928.

Like the ITALIA, our vessel Nanuq will carry **scientific experiments** of special interest for Arctic regions, so far never performed before above 78°N and up to 82°N that we will reach:

- PolarquEEEst, the **cosmic ray** explorer – the first cosmic ray detector that will measure the intense 8due to the magnetic pole attraction) cosmic ray flow above the Arctic circle.
- Mantanet for **Microplastic** – the first study to assess the presence and distribution of micro in the Arctic waters.
- AURORA (Accessible **UAVs** for Research and Observation in Remote Areas) surveying remote and inaccessible areas along the coast of the Svalbard archipelago to observe ice cover variations, floating ice distribution, vegetation and fauna, including polar bears.

POLARQUEST2018 will take advantage of the unprecedented level of melting ice in the region to make a **pioneering attempt at locating the sunken wreck of Umberto Nobile's Airship Italia**, on the 90th anniversary of its crash. The marine institute (ISMAR) of Italy's CNR (National Research Council) has made available for this search the most advanced instrument for the study of the seabed, **a high-resolution multi-beam echo-sounder** (**MBES**), a Kongsberg EM-2040 compact dual-head multi-frequency system (Appendix 1), already used in 2013 to cover the entire network of tidal channels and inlets of the Venice Lagoon, Italy. The dataset comprises also the backscatter (BS) data, which reflect the acoustic properties of the seafloor, and the tidal current fields simulated by means of a high-resolution three-dimensional unstructured hydrodynamic model. We have identified the ideal ship to carry such an instrument, the **Swiss Arctic vessel San Gottardo** (https://swissarcticproject.org/, currently in Norway, already scheduled to be in Svalbard in August and available to be fully dedicated to the Airship search, with scientists, geographers, airship experts and descendants of the crew members on board, as well as a film director and small crew for the production of an **internationally distributed documentary**. At the same time, Nanuq will focus on their scientific research as well as on the identification of the wrecks of the rescuers' camps left on the North- East coast of Svalbard.

1. A POLAR ADVENTURE – Searching for airship ITALIA's wreck 90 years later

On **May 25 1928**, Airship Italia, commanded by Umberto Nobile, one of the founding fathers of Arctic exploration, crashed on the way back from the **North Pole**, about 120 km northeast of Nordaustlandet, Svalbard (81°14 N 28°14 E), killing part of the crew trapped in the still drifting airship envelope and leaving the survivors stranded on the pack ice. The crew managed to salvage several items from the crashed airship gondola, including a radio transceiver, a tent which they later painted red for maximum visibility, and, critically, boxes of food and survival equipment which quick-witted engineer Ettore Arduino had managed to throw onto the ice, before he and his five companions were carried off to their deaths by the wrecked but still airborne airship envelope and keel.

In the wake of the crash, a collection of nations, including Soviet Russia, Norway, Sweden, Finland, and Italy, launched **the first polar air and sea rescue effort**. Norwegian polar hero Roald **Amundsen**, first man to conquer the North and the South poles, put aside his past differences with Nobile (who had built the Norge airship, the first aircraft to fly across the North Pole from Europe to America) and boarded a French seaplane headed for the rescue headquarters. His plane disappeared between Tromsø and Svalbard, and though a pontoon from the craft was later found, the bodies of Amundsen, the pilot René Guilbaud and the four others on board were not. After a month, the first rescue plane, a Swedish Air Force Fokker ski plane, piloted by Lieutenant Einar **Lundborg**, landed near the crash site. Lundborg refused to take anyone but Nobile, who was airlifted to Ryss Island, base camp of Swedish and Finnish air rescue efforts. When Lundborg returned alone to pick up a second survivor he crashed his plane on landing, and was trapped with the other five. After **48 days on the ice floe**, the last five men of his crew were rescued by the Soviet icebreaker Krassin. Nobile insisted that he wanted to continue the search for the six crew who were swept away by the airship when it disintegrated, but he was ordered back to Rome (by Mussolini) with the others.

POLARQUEST will continue the search with a **pioneering attempt at relocating the sunken wreck** of Umberto Nobile's Airship Italia, on the 90th anniversary of its crash, taking advantage of the melting ice in the region for the first time in centuries. The estimate of the GIS location of the airship wreck is based on a deep analysis of the archival documents and the amply documented crash location and successive positions of the survivors' tent on the floating ice, which they were regularly taking and communicating via radio for the 48 days of their ordeal on ice (see Appendix 2). We have identified the ideal ship to carry such an instrument, the **Swiss Arctic vessel San Gottardo** (https://swissarcticproject.org/, currently in Norway, already scheduled to be in Svalbard in August and available to be fully dedicated to the Airship search, with scientists, geographers, airship experts and descendants of the crew members on board, as well as a film director and small crew for the production of an **internationally distributed documentary**.

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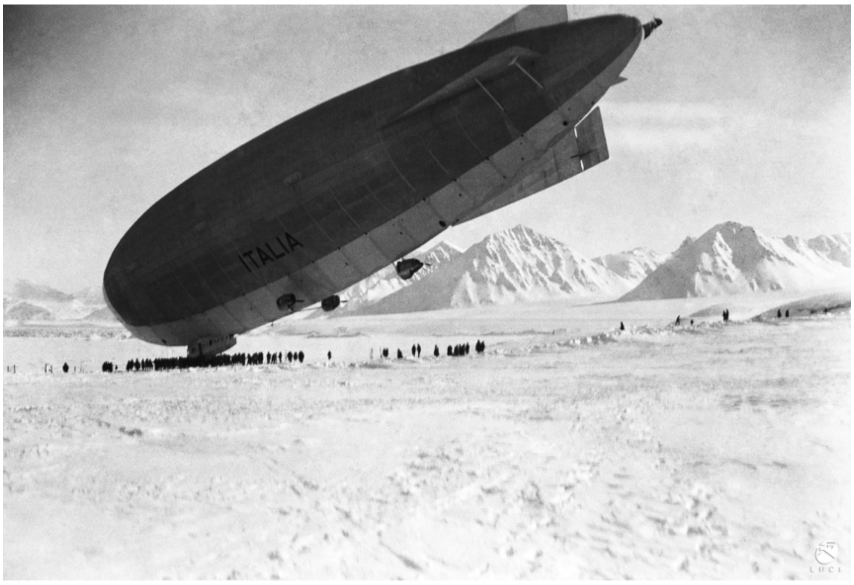

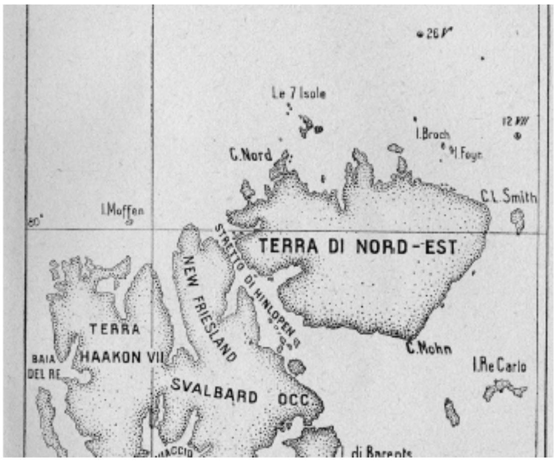

2. ITINERARY

DEPARTURE NANUQ FROM Isafjordur, ICELAND (66° 04’ N, 23° 07’ W)	21 JULY
CROSSING OF THE ARCTIC OCEAN AND STO OVER IN Jan Mayen	
ARRIVAL NANUQ IN Longyearbyen, Svalbard (78° 13’ N, 15° 39’ E)	1 AUGUST
DEPARTURE NANUQ TO Ny Alesund, Svalbard (78° 55’ N, 11° 55’ E)	4 AUGUST
ITALIA AIRSHIP EXPEDITION Nordaustlandet, Svalbard (81° 14’ N, 28° 14’E)	MID-AUGUST
Circumnavigation Archipelago	
Retour à Longyearbyen	24 AUGUST
Départ de Longyearbyen pour Tromsø	25 AUGUST
Arrivée à Tromsø, Norvège	4 SEPTEMBER

3. NANUQ, the PASSIVE « IGLOO »

Nanuq (meaning polar bear in the Inuit language) is a 60-foot Grand Integral sailboat designed, built and skipped by Genevese architect Peter Gallinelli to sail in the polar region and withstand arctic winter in a self-sufficient mode, using only renewable energies (sun, wind, environmental heat), thanks to its innovative thermal insulation and heat recovery systems, coupled with an optimized energy management system.

The passive igloo is a minimal habitat designed to serve as a scientific base camp and dwelling to accommodate, in complete self-sufficiency, a team of six during an arctic winter, taking in master students, doctoral students and researchers motivated by an interest and passion towards research in the Arctic regions. It is a demonstration project that illustrates that simple, robust, constructive and technical solutions may challenge low-cost energy scarcity in a credible way. Transposed to temperate climates, the experience feedback will be useful to outline the habitat of tomorrow, providing more independence and quality of life to its inhabitants.

4. The SCIENCE on BOARD NANUQ

Nobile's research programme on board airship ITALIA covered geography, geophysics, gravimetry, weather, oceanography, earth magnetism and electromagnetic wave propagation. PolarQuest2018 's scientists are the heirs to the ITALIA scientists, with their search for answers to some of the greatest challenges of contemporary science, from climate change to the origin of cosmic rays and their impact on the planet.

4.1 PolarqEEEst, the cosmic explorer

Cosmic rays were discovered in 1912 by Austrian physicist Victor Hess, who made a series of ascents in a balloon to take measurements of radiation in the atmosphere, including one at 5300 metres during a near-total eclipse of the Sun. Since ionization of the atmosphere did not decrease during the eclipse, he understood that the source of the radiation could not be the Sun – it had to be coming from further out in space. High in the atmosphere, the amount of radiation increased, contrary to all predictions and theories, wrongly stating that the source of this radiation should be under the Earth crust. Hess had discovered a natural source of high-energy particles, a discovery for which he shared the 1936 Nobel Prize for Physics and which heralded the beginning of sub-nuclear (or particle) physics.

More than 100 years later, cosmic rays are still a new frontier in physics. High energy cosmic rays interacting with our atmosphere have travelled in the cosmos for hundreds, thousands or even millions of years. Their energy is so high that it cannot be generated by supernovae, pulsars or even black holes. What we observe on Earth is mostly the last stage of this phenomenon, enormous "muon" (i.e. a heavier version of the electron) showers, often as large as a small town. Where do they come from? Their origin is not yet understood, In spite of years of theories and research. But cosmic rays are not just a puzzling scientific mystery to solve for physicists and astrophysicists. Recent studies suggest that **cosmic rays may influence cloud cover** either through the formation of **new aerosols** (tiny particles suspended in the air that can grow to form seeds for cloud droplets) or by directly affecting clouds themselves.

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The Earth's **global cloud cover** has a crucial impact on climate and **understanding how this works in detail is necessary to develop an effective mathematical model** able to explain the past and predict the future evolution of the earth's climate. The **CLOUD** experiment at CERN has recently demonstrated that cosmic rays may influence cloud cover either through the formation of new aerosols (tiny particles suspended in the air that can grow to form seeds for cloud droplets) or by directly affecting clouds themselves. See:

http://science.sciencemag.org/content/344/6185/717

Clouds exert a strong influence on the Earth's energy balance; changes of only a few per cent have an important effect on the climate. Better understanding the connection between cosmic rays and clouds is therefore key to improving our ability to make more accurate mathematical models able to predict how climate will evolve. A data taking campaign in the polar regions is particularly relevant in this respect as the cosmic ray flow has been proven to trigger the production of isotope3 in the ice cap, which has a direct impact on the production of solar spots. When solar spots increase, the protective shield of the sun's magnetic screen becomes stronger and the flow of cosmic rays is reduced. These variations seem to have a correlation with the glacial and interglacial eras of the earth.

See: https://www.youtube.com/watch?v=sDo7saKaEys

The **Polarquest2018 cosmic ray campaign** will be an **absolute first** as no study has ever performed **detection of Extensive Air Showers of cosmic rays of extreme energy at such latitudes**. The main objective of PolarquEEEst, after design validation, is to build at CERN three such cosmic detectors with the help of three schools, one from Switzerland, one from Italy and one from Norway. The three instruments will be assembled at CERN in May, two of them will be placed in operation in the schools and one on board Nanuq. We will collect data from the three instruments during the same period of the expedition to compare data at different latitudes.

The main scientific goal of the project is studying the **cosmic radiation**, and in particular the one characterized by an **energy greater than 1018 eV**. No supernova, black hole or pulsar have enough energy to accelerate particles at such high energy. This radiation lies in a still **partially unexplored region of the cosmic ray spectrum**, where problems related to its exact flux, composition and origin, probably extragalactic, together with the precise shape of the spectrum still hold unsolved. The data collected will bring new insights on cosmic events such as the formation of stars, their collapses, and still ununderstood phenomena such as Gamma Ray Bursts (GRB). High energy cosmic rays are real messengers from the deep cosmos: the higher their energy, the deepest and furthest areas of the Cosmos we will be able to reach and study. High energy cosmic rays enable us to study the structure of our Galaxy's gravitational field and there are, in addition, candidates to explain genetic mutations.

METHODOLOGY - The current configuration of the EEE cosmic detectors is based on the use of a wider and cheaper version of the **Multigap Resistive Plate Chambers** (MRPCs), a technology invented and used for the Time of Flight system of the **ALICE detector at LHC**. This technology is ideal for this project since it has a good tracking performance with an excellent time resolution, is reliable on a long-term time line, easy to use and is relatively cheap. Each EEE station is composed by a telescope made of three MRPCs, for a total active area of about $2m^2$ and the detection of cosmic showers is performed by searching for muon events in coincidence among different stations. The MRPC have six gas gaps each, 300 μ m thick, obtained by separating glass plates, 80 × 160 cm by means of **commercial nylon fishing lines used as spacers**. The outer glass plates are coated with graphite paint, and act as high voltage electrodes, and obtain the desired electric field in the gas gaps; when an ionizing particle passes through the gas, it creates a certain number of primary ion-electrons pairs, which are amplified in the usual avalanche process and finally induce a signal on the external readout strips. The gas mixture filling the gaps is C2H2F4/SF6 mixed in 98/2 proportions, while each MRPC is equipped with 24 copper strips 160 cm long, having a pitch of 3.2 cm. See figure 1.

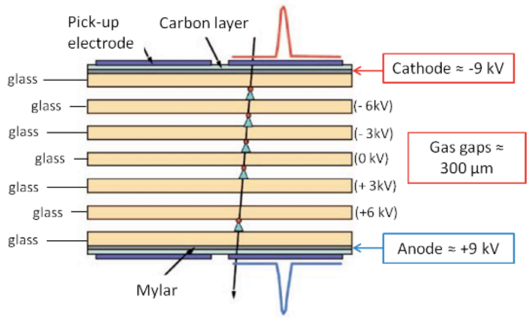

Figure 1. Layout of a MRPC used for the EEE experiment.

The particle impact point is reconstructed by the hit strip in one direction and by the time difference of the signal arrival at the strip ends in the other direction. The signals coming from the front-end cards are collected and processed when a triple coincidence of the MRPCs generates the trigger for the data acquisition. Since the main goal of the EEE network is to detect **coincidences in time among stations located at different positions**, each event acquired must be provided with the relative time stamp; this is given by a Global Positioning System (GPS) VME module integrated in the system and readout by the DAQ program.

Since EEE stations operate in high schools, particular attention has been put on safety issues. For instance, the gas mixture does not contain any flammable component, like, for instance, isobutene, which is routinely used with this kind of chambers. High voltage is provided by small DC/DC converters of the EMCO-Q series, providing an output voltage up to ± 10 kV when powered with 0–5 V, packed in small boxes and connected directly to the electrodes of the detector.

For the specific requirements of the <polarquest2018 Arctic campaign, the EEE collaboration accepted to **build a more compact version of this instrument**, adequate for a data taking campaign on board a sailing boat like Nanuq, a 60-foot vessel designed to sail in the Arctic region and withstand arctic climate in all seasons in a self-sufficient mode, using only renewable energies. The EEE collaboration came out with a new compact design of the EEE telescope, which we call **PolarquEEEst cosmic explorer**. In its current design state, this modular compact detector is characterized by the following main improvements compared to the original design:

- total volume of 50X50X30 cm^3 and a total weight of 7 kg
- two planes of scintillators
- silicon photomultipliers (SiPM) readout: the passage of cosmic muons and electrons causes light emission, amplified by SiPM
- Low consumption electronics
- Water and air tight

- Plexiglas or plastic + glass fiber
- Atmosphere: Nitrogen

The EEE collaboration already built a 15X15 prototype, which is already working. See figure 2.

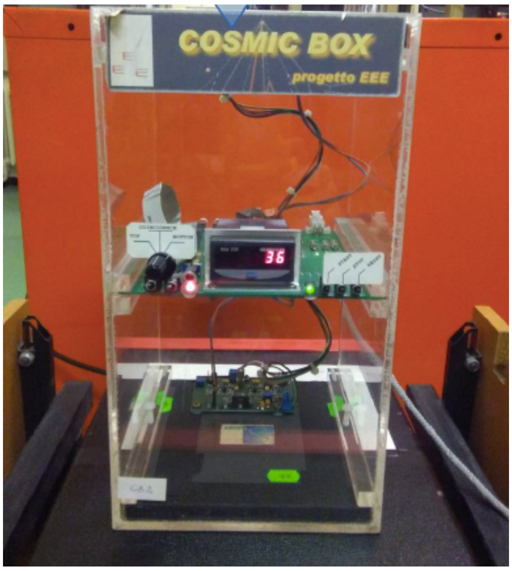

Fig. 2

We have identified the main detector specifications and layout as follows:

- 2 planes detector, each made of 4 tiles (see Fig. 3)
- Detector Surface 50X50 cm2
- Distance between planes: 22 cm
- Each tile 2 SiPM (Silicon photomultipliers)
- Muon rate: 10-15 Hz

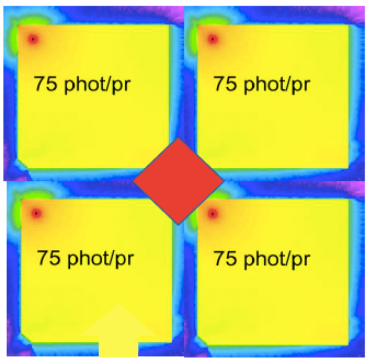

Fig. 3

We have also discussed the following requirements with the Nanuq boat owner:

- Max Temperature excursion without a conditioner: 15 →25 Celsius

- Power consumption 20-60 Watt. An independent solar panel (100 W) should be foreseen (1 m2).
- PTU (Pressure/Temperature/Humidity)
- both internal and external, 1 data string each 10 minutes. Very important for corrections.
- Expected data amount: < 7 Mbyte/hour (60 GB/y) if NMEA GPS
- string with UTC time + lat+ long + East/West + checksum.

Satellite connection to send data, (<170 MB/day)

Improving scientific culture among young generations

Beyond its interesting scientific goals, the peculiarity of the EEE project lies in the fact that most of the activities related to the experiment are carried out by **high-school students and teachers**, working in close contact with the scientists and technicians of CERN, Universities, INFN and Centro Fermi. Students participate in the construction of the chambers, starting from simple materials to get to sophisticated high precision detectors. This task is accomplished at CERN, one of the most important particle physics laboratories in the world, which is made open to students specifically for this project. Students have also the task to control the correct operation of the telescope installed at their school.

Currently about **fifty** high schools distributed across Italy host a EEE cosmic detector (see fig. 4). **Fifty** more institutes participate to the project by analysing data. More than **40 billion tracks** have been collected in the past years and are presently studied by students and professional researchers performing interesting analysis, some of which have already been published in various international scientific journals (see: http://eee.centrofermi.it/collaboration/pubblicazioni).

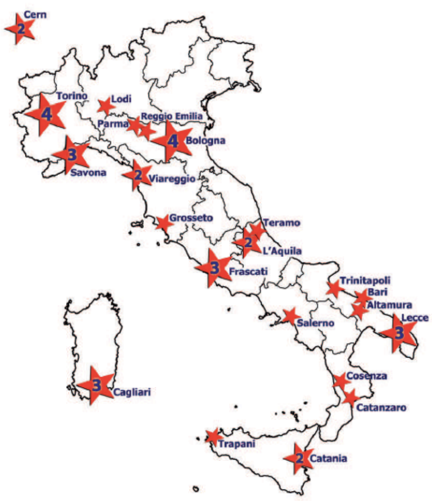

Fig. 4

With the introduction of the more compact version of the detector that Polarquest required, it will be much easier for schools to put together and operate the instrument. Moreover, the data taking campaign in the Arctic (Svalbard, up to 82°N) and in Switzerland and Norway in summer 2018 will considerably improve the quality and quantity of data and definitely increase the probability of a major discovery.

4.2 NANuQ MANTANET MICROPLASTICS – The **first study ever to assess the presence and distribution of microplastic in the Arctic waters above 78° N and up to 82°N**.

Microplastics, i.e. plastic particles smaller than five millimetres in size, are a pervasive pollutant, widely dispersed in the marine environment and can be found in the water column, on beaches and on the seabed. They can be related to increased production of anthropogenic materials and our growing global dependence on plastic products: world-wide production rates are estimated today at **300 million tons** (http://www.plasticseurope.org/). Microplastics have been shown to affect the feeding behaviour of marine animals and to interact with other pollutants to affect cell function in fish. They're also able to move from the digestive tract of organisms into the bloodstream. Potentially affected species include primary producers at **the base of the food chain** from zooplankton all the way up to macro invertebrates, fish, and mammals. Cell damage, infections, tumour formation, death are just some of the reported harms. As such, microplastics and marine litter have been incorporated into national and international policies and legislation, to assess the risks on the environment and marine animals (e.g. EU Marine Strategy Framework Directive (2008/56/EC), NOAA Marine Debris Programme).

Recently, microplastic presence was reported **in ice cores** from remote areas of the Arctic Ocean. This is particularly worrying as polar waters, and the Arctic region in particular, support an important and diverse marine food web and ecosystem, from planktonic communities to marine mammals, which is very vulnerable to marine pollution. In spite of the potential threat of this emerging pollutant, there are **few regulations** in terms of production, use or emissions of microplastics, very few ways of **monitoring** it, and, last but not least, there is a lack of **awareness** among people worldwide of the gravity of this threat. Field studies have not yet validated microplastic distribution within polar waters and the first study is very recent, published on Nature in 2015: https://www.nature.com/articles/srep14947. It was carried out South and Southwest of Svalbard, Norway.

There is therefore an urgent need to assess the levels of microplastic pollution in the Arctic, to allow for future microplastic monitoring and to assess the risk of the potential impacts of decreasing sea ice, increasing shipping and commercial activity in the area, as well as a need for a pervasive public awareness effort(http://www.globalgoals.org/global-goals/life-below-water/). This objective is perfectly in line with Goal #14, Life Below Water, agreed in September 2015 by the 193 world leaders who committed to **17 Global Goals**, that over the next 15 years should help end extreme poverty, fight inequality and injustice and fix climate change.

"Conserve and sustainably use the OCEANS**, seas and marine resources for sustainable development"**

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5.3→AURORA **Accessible UAVs for Research and Observation in Remote Areas**

Small flying drones are becoming widespread as tools for scientific research and communication on remote environments. The current opportunity of using "consumer-level" technologies of this kind allows to remarkably widen their uses and therefore the potential of knowledge acquisition. This approach, however, depends highly on the fact that instrumental configurations and workflows are properly integrated with deployment needs in the specific conditions and environments.

The Scientific group onboard NANUQ will be equipped with several small multirotor drones, optimized for different and complementary research and documentation activity. They will be used to **acquire data and to validate methods of observation, analysis and documentation**. The overall purpose of activity program is to contribute to scientific knowledge and information on the present state of some relevant Arctic environments.

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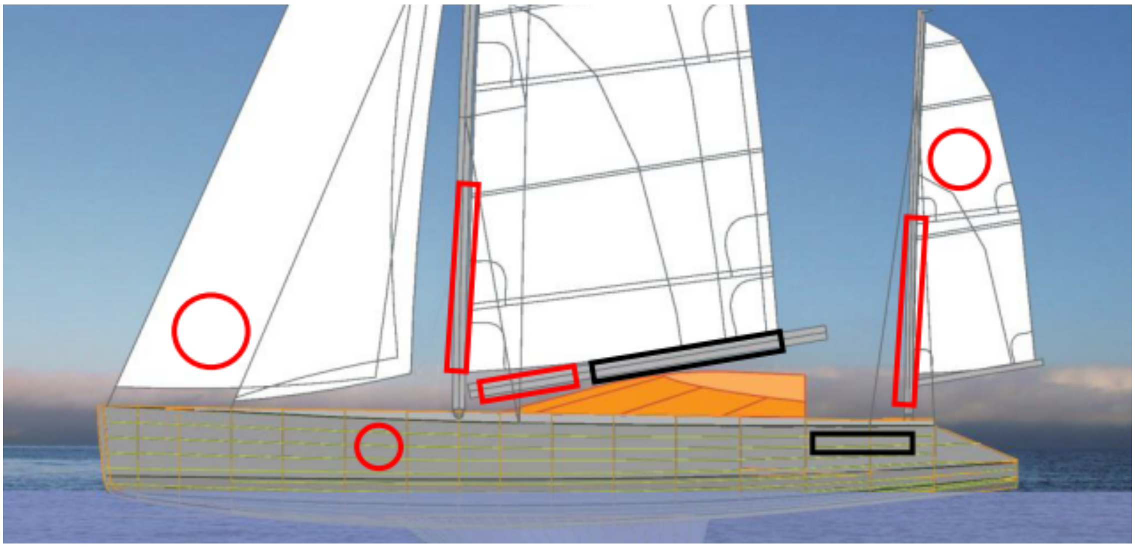
5. SPONSORS & PARTNERS VISIBILITY

The sailboat is an ideal support to offer visibility to poarquest2018 partners.

This is a non exhaustive list of the options :



HULL: stickers (maximum size 15m x 1m)

Superstructures 0.8m x 0.8m

Central Boards: 0.7m x 2m

Boom, Mast foot, winches: petits autocollants (+partenaires scientifiques)

Sails: Stickers

*Spi*nnaker: Asymmetric Spi ~180m2, to be supplied (including tangoon and accessories).

Custom communication packages can be proposed and we have total flexibiity to offer visibility to sponsors and partners through:
:

- Expedition website
- Social media, blog, journal and online videos
- Press releases
- Events in ports and countries linked to the expedition Switzerland, Iceland, Norway, Italy)
- By taking part in the expedition

Interviews to include in the documentary for TVs (Television Suisse Romande, Euronews, RAI, Ushuaia TV, Discovery Channel and National Geographic Channel)

- Stickers on scientific instrument
- Mention on scientific publications.

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WWW.POLARQUEST2018.ORG

polarquest2018@gmail.com

Project Leader

paola.catapano@cern.ch
+41 75 4113617
+39 345 087 3885