Between July 21st and September 4th 2018, an international research and communication expedition called "PolarQuest 2018" was conducted on board the eco-sustainable vessel “NANUQ”. The 18-meter, 23-ton sailboat cruised for a total of about 3,500 nautical miles most of which north of the Arctic Circle. The crew, consisting generally of 10 members, carried out a series of activities and observations, as well as three scientific programmes directed by several Italian and international institutions. Among the former, there were the Italian Geographical Society and the Geographic Research and Application Laboratory (GREAL) og the European University of Rome. The trip and the activities onboard, whose results will be presented in several scientific publications, have been documented via the Web and social networks. TV documentaries about the expedition are currently being prepared in France and Italy. .

The expedition took place on the 90th anniversary of the arctic flights of the airship ITALIA (1928); commemorations and ceremonies took therefore place, in the presence and / or endorsement of a delegation of descendants of the airship's crew.

The trip to PolarQuest 2018 began at the Icelandic port of Isafjörður on July 22nd. The boat reached Greenland and the Svalbard Islands. NANUQ arrived in the capital of the latter, Longyearbyen, on August 2nd. The second leg of the journey started from there on August 4th. After circumnavigating the two major islands of the archipelago, Spitsbergen and Nordaustlandet, NANUQ returned to Longyearbyen on August 24th. The last phase of the journey began on the evening of the 25th, as the boat departed Svalbard to cross the Barents Sea, bound to continental Norway. The expedition ended on September 4th, with the arrival in Tromsø. NANUQ was later moved to a smaller port for wintering.

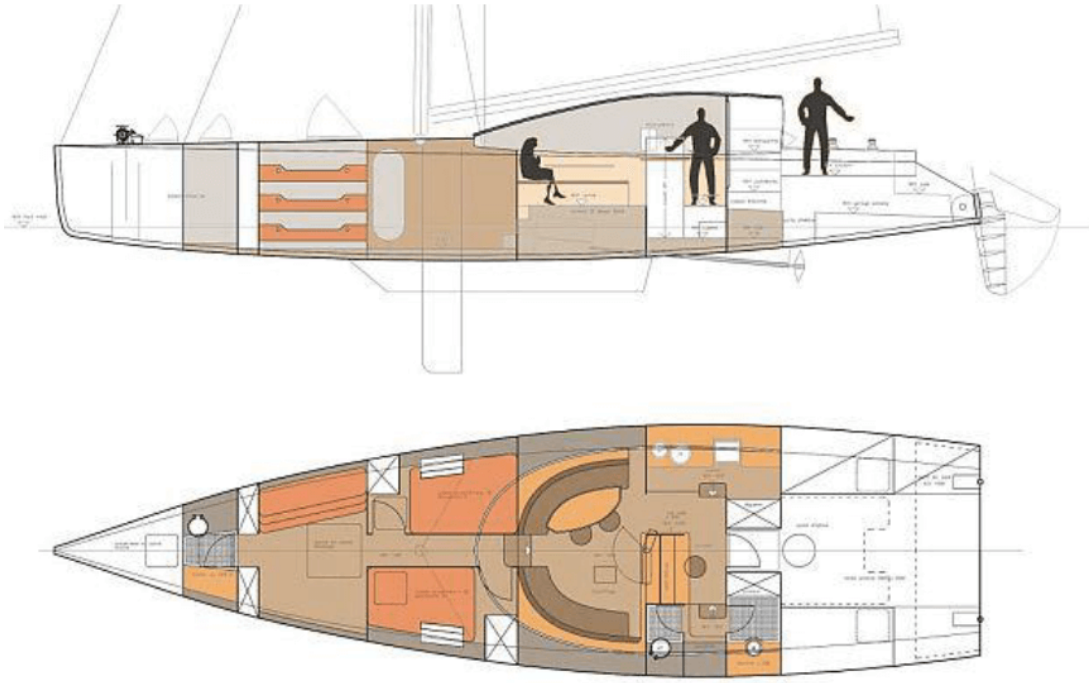
During PolarQuest 2018, on August 13th, NANUQ, reaching the northernmost point of its navigation, navigated along a fringe of icefloe, not far from the extreme edge of the Arctic pack, in coordinates 82 ° 07'N, 25 ° 25'E. The point was less than 900 km from the North Pole. In that area, a sampling of microplastics and a measurement of cosmic rays were carried out. Both are probably the absolute maximums in latitude for the respective activities.

The boat

NANUQ is a 17.8 m long sail-motor vessel with a displacement of 23 tons. It was designed by naval architect Peter Gallinelli, an expert in the construction of boats featuring high energy efficiency and low environmental impact. After a first sea trial in 2014, in 2015 NANUQ remained for 11 months - including the full wintering period - in Greenland. During the PolarQuest 2018 expedition, the boat carried out its 13th, 14th and 15th trips north of the Arctic Circle.

The vessel, which can easily reach and exceed 10 knots (18 km / h) on sail, is also equipped with a 85 Hp diesel engine. When the latter is used, the available range is about 2,000 nautical miles (3,700 km) at a cruising speed of 6.5 knots (12 km / h). NANUQ can accommodate up to a maximum of 12 people. It can support such crew with water, supplies and reserves ensuring, under normal conditions, complete self-sufficiency for about 30 days. The hull, made entirely of aluminum, is designed to sustain harsher environmental conditions than normally faced by boats of the same category and size.

NANUQ is a technological demonstrator of the innovative concept of boats with high environmental sustainability, intended to operate in the polar regions at any time of the year. A fundamental element of the project is the so called "Passive Igloo", i.e. a set of technical features around which spaces inside the boat are made. NANUQ draws a significant part of its electricity from a wind generator and four photovoltaic panels. These sources are useful to reduce the need for using a traditional generator. The walls, the portholes and the interiors are made of, or insulated with, high energy-efficient materials. They are able to store heat from the crew bodies and from various devices on board (systems, computers, kitchen, etc ...).



Profile and plan view of NANUQ with indication

(image: Peter Gallinelli)

NANUQ in the ice in its mooring area in Greenland during the Arctic cruise of 2015

(image: Kalle Schmidt)

NANUQ at the pier of Ny Ålesund scientific station on the night of August 5th, 2018

(image: Gianluca Casagrande).

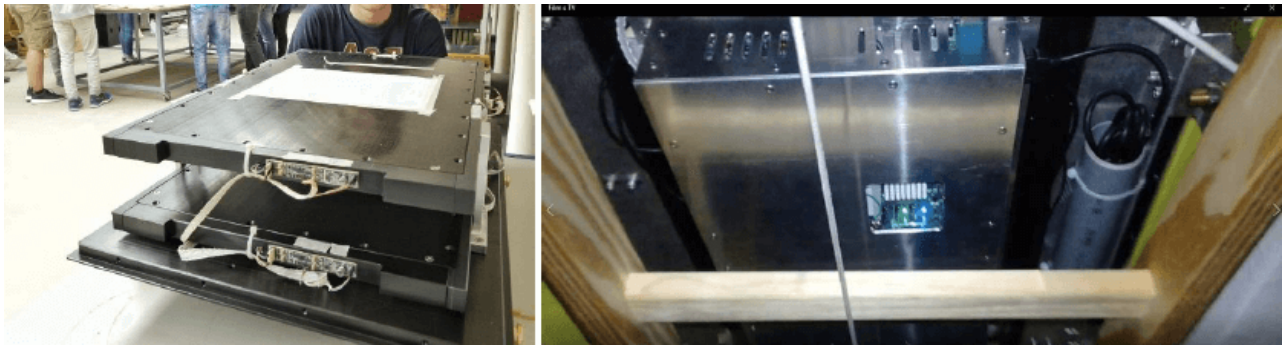
THE SCIENTIFIC ACTIVITY PROGRAMS

NANUQ, classifiable as a "technological demonstrator" of new eco-friendly solutions for naval constructions, has been configured as a sustainable research vessel for the PolarQuest 2018 expedition. The boat was therefore equipped as a laboratory for carrying out various observation and research task. A specific nature of the program for the entire expedition was the extensive use high accessibility technologies. They were specifically selected to be low-cost and, as far as possible, comparable to those available to citizens' science applications.

On board - and on land during various stages of the journey - work was carried out related to the following three research programs:

1-PolarquEEEst (Direction: Centro Ricerche Enrico Fermi e Museo della Fisica)

The activity was directed by the Centro Ricerche Enrico Fermi e Museo della Fisica (Rome, Italy) in collaboration with the Istituto Nazionale di Fisica Nucleare (Bologna, Italy) and with CERN in Geneva. The three "E" in the name refer to an INFN multi-year research and education program called "Extreme Energy Events". The activity consisted in measurements and recording of cosmic rays at high latitudes by use of an innovative detector. The instrument was built specifically for installation on NANUQ. It therefore featured smaller dimensions and power consumption, in comparison to standard devices. Moreover, the hardware of the detector was custom-built with the use of low-cost components. The final assembly of the machine was conducted at CERN by Italian, Swiss and Norwegian high school students. The on board leading scientist for the PolarQuEEEst program was Dr. Ombretta Pinazza (INFN and CERN). Data recordings took place almost constantly during the entire navigation from Isafjörður to Tromsø.



The Cosmic-ray detector to be installed onboard NANUQ during the last assembly phases at CERN in Geneva (on the left) and in its housing on the ceiling of the boat's front cabin during navigation (on the right). (Images: PolarQuest)

2-MANTANET (Direction: ISMAR-CNR)

Thanks partially to a series of previous experiences - in other areas and previous times - by NANUQ, a floating microplastic sampling programme was carried out, both during the first leg of NANUQ's voyage (Iceland-Greenland-Svalbard), and during the second (circumnavigation of Svalbard). The project was directed by the Institute of Marine Sciences of the CNR (ISMAR) under the supervision of Dr. Stefano Aliani. The observations on board of NANUQ were carried out by two young operators, environmental activist Safiria Buono (age 19, Italy) and co-skipper Mathilde Gallinelli Gonzalez (age 22, Switzerland).

MANTANET towed at low speed by NANUQ during a sampling operation. A sufficiently fine net can effectively capture microplastic fragments. The samples are then preserved and transferred for laboratory analysis to allow for the study of the distribution and characteristics of this form of pollution (image: Gianluca Casagrande)

3-AURORA (Direction: Italian Geographical Society and GREAL - European University of Rome)

The project (whose name stands for Accessible UAVs for Research and Observation in Remote Areas) consisted of a *proof-of-concept* of observations and geographical documentation in Arctic environments, conducted by low-cost drones, sensors and *consumer-level* software. Tests were carried out in different places, where specific survey and observation profiles could be tested. These spanned from qualitative observation and aerophotogrammetry, expeditive cartography, observations of landscapes in the thermal and near infrared. Attention was also paid to verifying the effectiveness of the equipment in documenting and story-telling Arctic environments. This was considered to be relevant in a region like Svalbard, currently in transition from being an anaecumenic context into being a space increasingly subject to settlement, usage and tourism. The person in charge of the project was geographer Prof. Gianluca Casagrande.

A DJI Phantom 4 Pro drone with an additional camera, custom-installed to measure the NDVI indices of vegetation in (image: Gianluca Casagrande).

NANUQ's crew during the second leg of the journey: Circumnavigation of Spitsbergen and Nordaustlandet

The main phase of the PolarQuest 2018 expedition took place during the second leg. It included a circumnavigation of the largest Svalbard islands, namely Spitsbergen and Nordaustlandet. NANUQ left the port of Longyearbyen on August 4th and returned there on the 24th, after a 1,500 nautical mile journey. Stops were made in various locations and a memorial navigation was also carried out, to honor the 90th anniversary of airship ITALIA expedition. Such navigation took place in the open sea, north-east of the archipelago. It was later extended northbound, up to the external edge of pack. During this phase of PolarQuest 2018, there was a permanent crew of 10 people on board: 4 were mainly in charge of navigation and onboard operations; 6 were prevailingly involved in scientific and communication activities. On particular occasions for brief time, passengers were also admitted on board.

The permanent crew members in the second leg of the journey are listed below:

Peter Gallinelli (Australia)

Expedition Leader. Designer, director of construction and skipper of Nanuq. Architect. Sailor.

Paola Catapano (Italy)

Project Leader. Science journalist, CERN audiovisual communication director.

Michael Struik (Netherlands)

Technical Coordinator. Engineer, CERN

Ombretta Pinazza (Italy)

PolarquEEEst onboard scientist. Physicist, Ph.D. in Engineering, INFN and CERN

Gianluca Casagrande (Italy)

AURORA onboard scientist. Geographer, Italian Geographical Society and European University of Rome

Safiria Buono (Italy)

MANTANET onboard operator. PolarQuest 2018, environmental activist

Remy Andrean (France)

Navigation and operations. Architect. Sailor.

Mathilde Gallinelli (Switzerland)

Navigation and operations (co-skipper). Architect. Sailor.

Dolores Gonzalez (Spain)

Navigation and operations. Architect. Sailor.

Alwin Courcy (France)

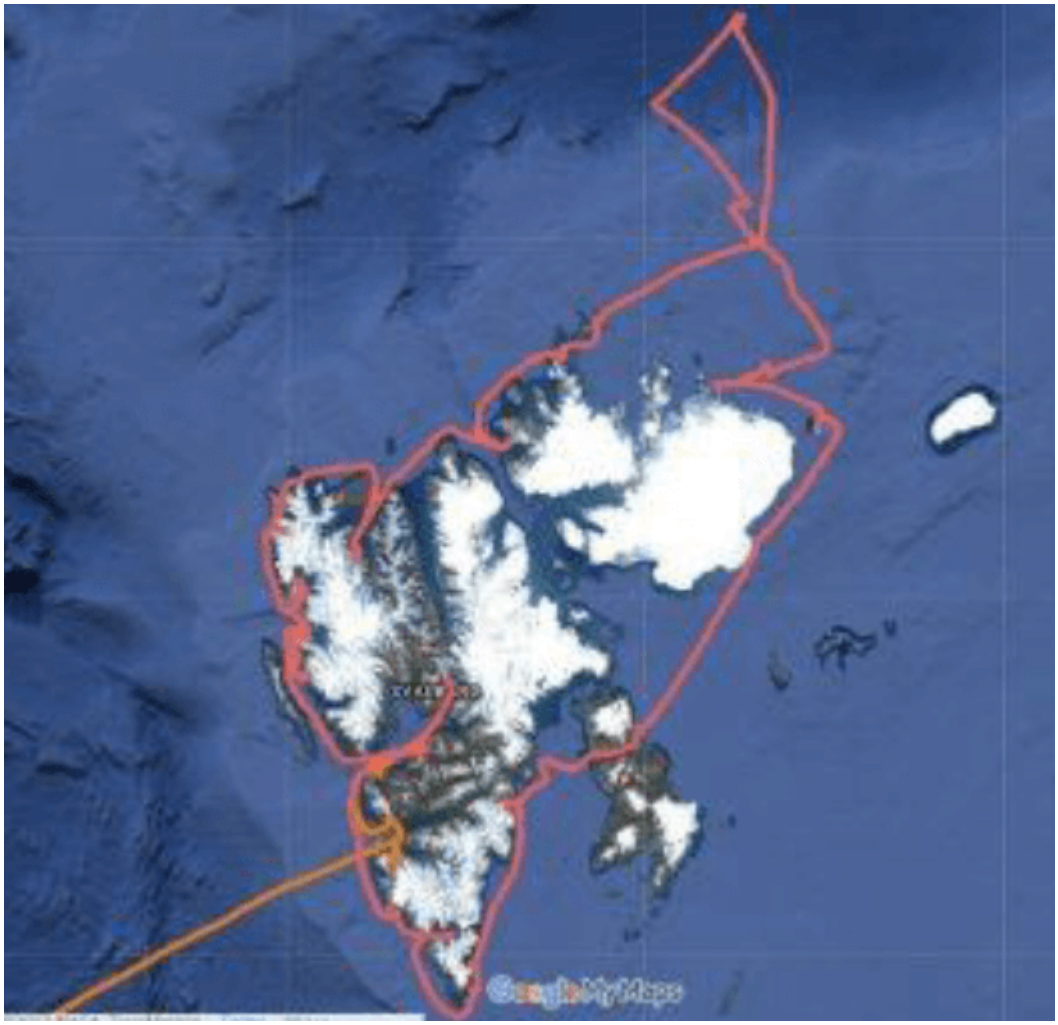
Cameraman and on board photographer

Route and activities around Svalbard

The second part of NANUQ'journey included stops in places of interest, essentially along the Longyearbyen - Ny Ålesund - Nordaustlandet - Austfonna - Freemansundet - Hornsund - Pyramiden -Longyearbyen route. At the northeastern edge of Nordaustlandet NANUQ interrupted the coastal navigation and took to the open sea for a historical-commemorative navigation to remember the expedition of airship ITALIA. On August 13th she reached a position in the immediate vicinity of the point from which the first SOS of the shipwreck survivors was launched on 26/5/1928 (81 ° 14'N, 25 ° 25'E). There, on behalf of a delegation of descendants of the airship's crew, a brief ceremony was held in memory of the missing aeronauts. Represented institutions were the Italian Geographical Society (ITALIA's operator at the time of its 1928 polar expedition), the Italian Air Force, the Italian Navy, as well as the Associazione Nazionale Marinai d'Italia. NANUQ then headed north, reaching an area at the extreme edge of the pack (82 ° 07'N, 25 ° 25'E).

During the whole trip, activities related to research and communication programs on board were carried out.

In the following pages, a series of images and brief descriptions summarize the work on board NANUQ, with particular reference to the AURORA project.



The red track shows PolarQuest 2018's second leg around Svalbard (image: Michael Struik).

AUGUST 4TH

VISIT TO NY ÅLESUND (KINGS BAY) AND CEREMONY WITH A DELEGATION OF DESCENDANTS OF ITALIA'S CREW

The first stop-over of the expedition took place at Kings Bay, the old base for both the NORGE (1926) and ITALIA (1928) polar airships. The mooring pylon for the blimps is still preserved as a monument. Nearby, it is possible to see remainings of the wooden hangar that was designed by Italian engineer Felice Trojani and built by Norwegian craftsmen. Kings Bay, with the small settlement of Ny Ålesund is today home to an important international scientific settlement (image Gianluca Casagrande).

"Dirigibile ITALIA" scientific base, managed by Italy's National Research Council, i.e. CNR. The on-site research staff provided a fundamental and kind assistance to the crew of NANUQ in carrying out some urgent maintenance interventions in the early stages of their circumnavigation of Svalbard (image: Gianluca Casagrande)

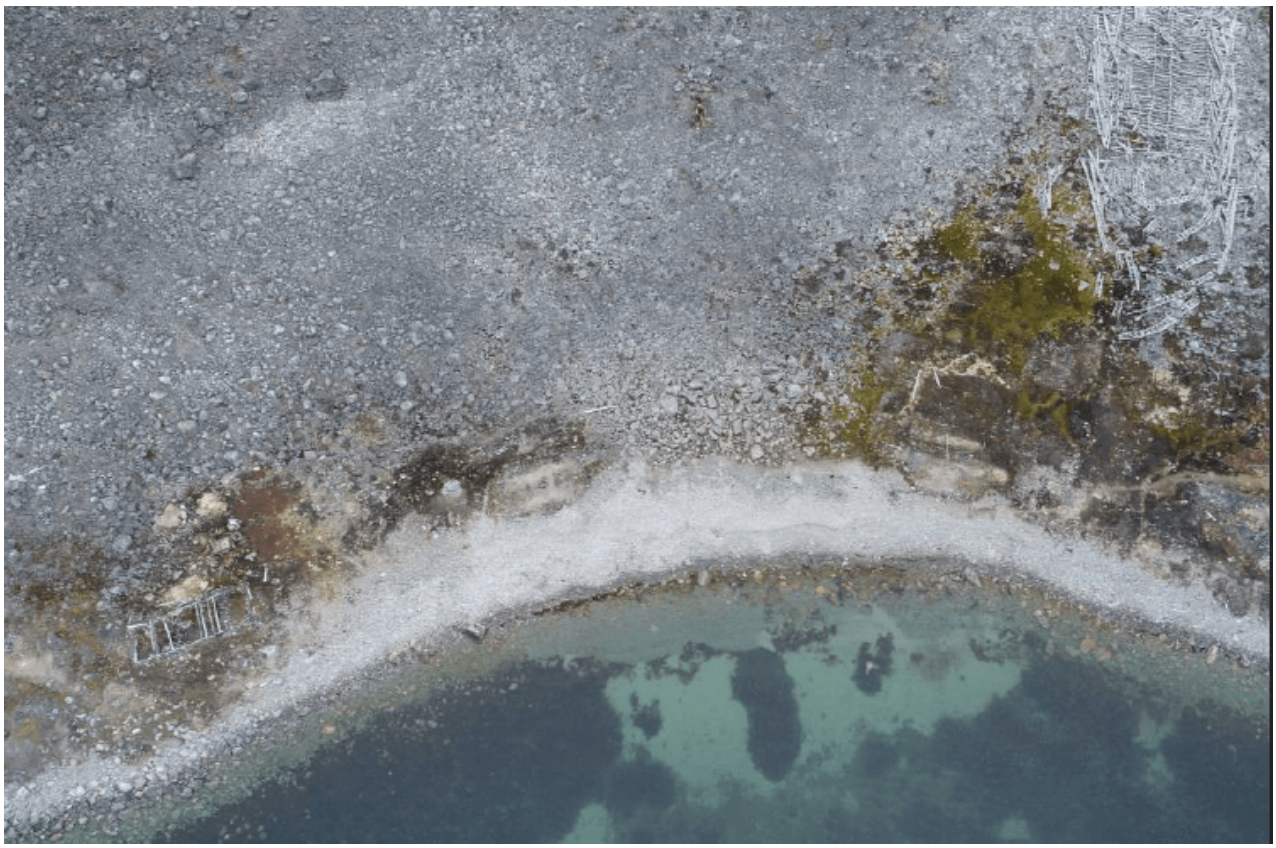
AUGUST 8TH.

EXPEDITIVE AEROPHOTOGRAMMETRIC SURVEY OF VIRGOHAMNA, DANES ISLAND (DANSKØYA)

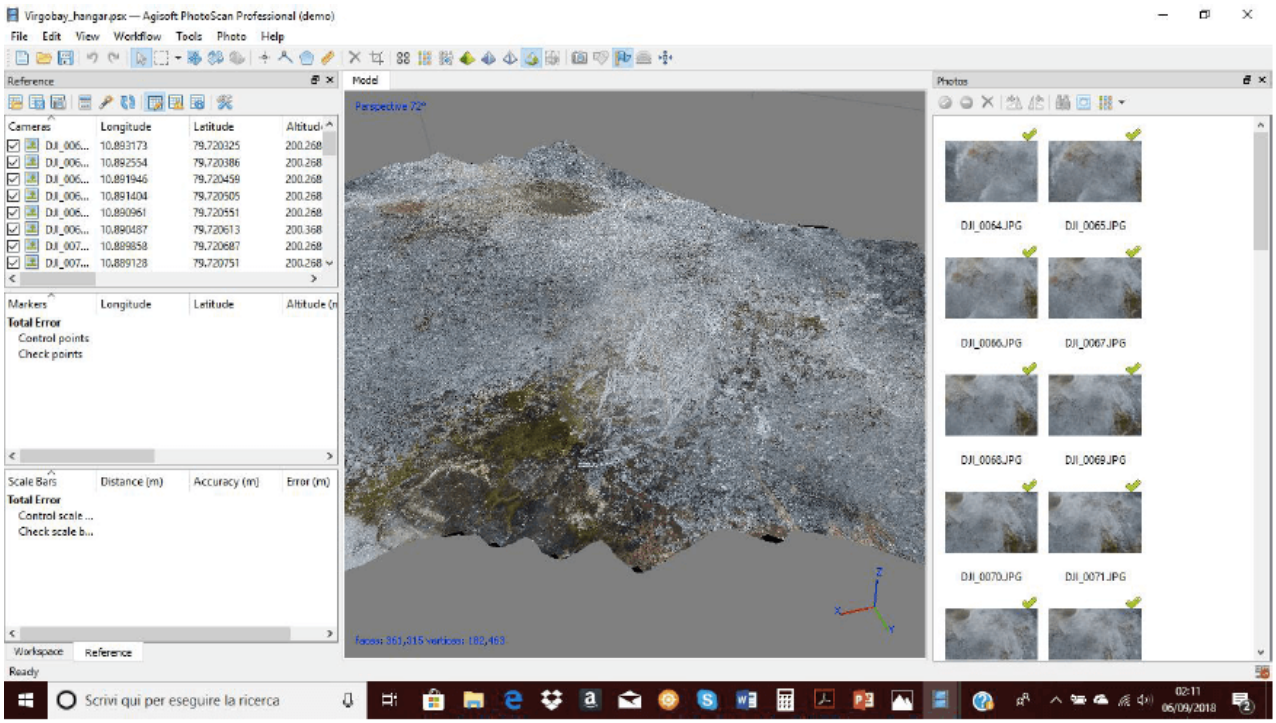
Screenshot taken from a drone approaching Virgohamna beach (Danskøya). The place was the departure site for Andrée's (1897) and Wellman's (1906, 1907 and 1909) polar expeditions. Formerly a popular landmark for tourism, Virgohamna is now heavily protected and access to it is regulated. An expeditive aerial reconnaissance about the current state of the site was carried out by launching two drones from NANUQ. The boat was anchored a safe distance from the beach (image: Gianluca Casagrande)

Virgohamna in 1906 at the time of the first Wellman expedition. On the left of the photo is the hangar of airship AMERICA. On the right, in the foreground, remains of installations of the Andrée expedition, dating back to nine years earlier. At the time when the photo was taken, Andrée and his two companions Fraenkel and Strindberg were reported missing in an attempt to reach the North Pole aboard balloon Örnen. Their bodies, documents and

photos from their tragic expedition were unexpectedly discovered on Kvitøya (the "White Island"), eastern Svalbard, in 1930. (Image: North Pole Expedition Museum, Longyearbyen).



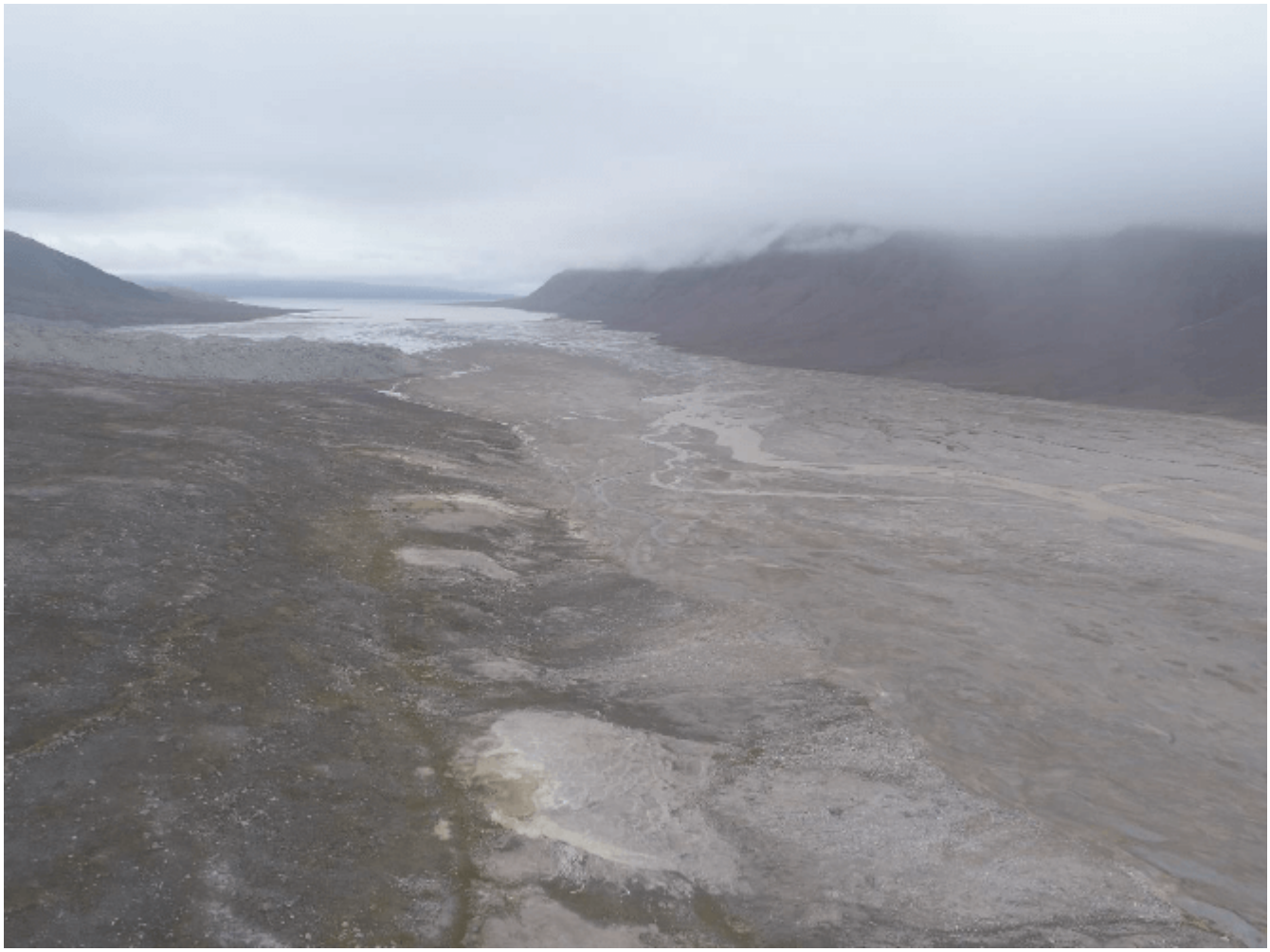
Nadiral photograph acquired by drone of the remainings of ancient installations at Virgohamna. On the left, along the shore, traces of Pike's House (1882), used by Andrée's expedition. On the right the wooden structure of Wellman's hangar, now completely collapsed, is visible (image: Gianluca Casagrande).



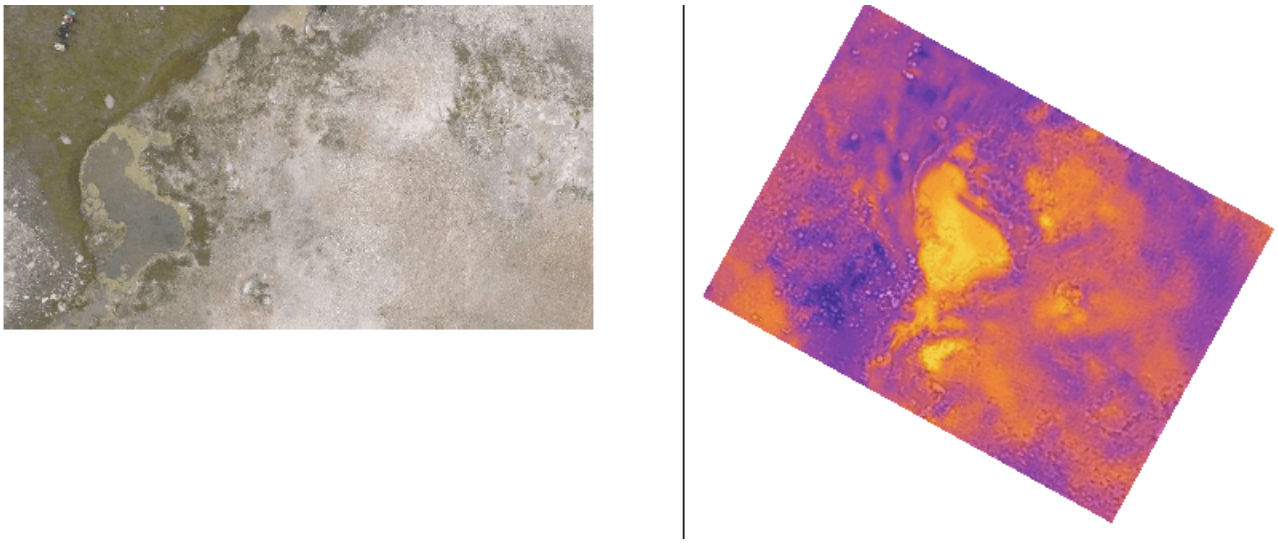
Elaboration of a provisional 3-d photogrammetric model of Virgohamna site processed immediately after the drone flights on board NANUQ. (images and elaboration: Gianluca Casagrande).

AUGUST 9TH

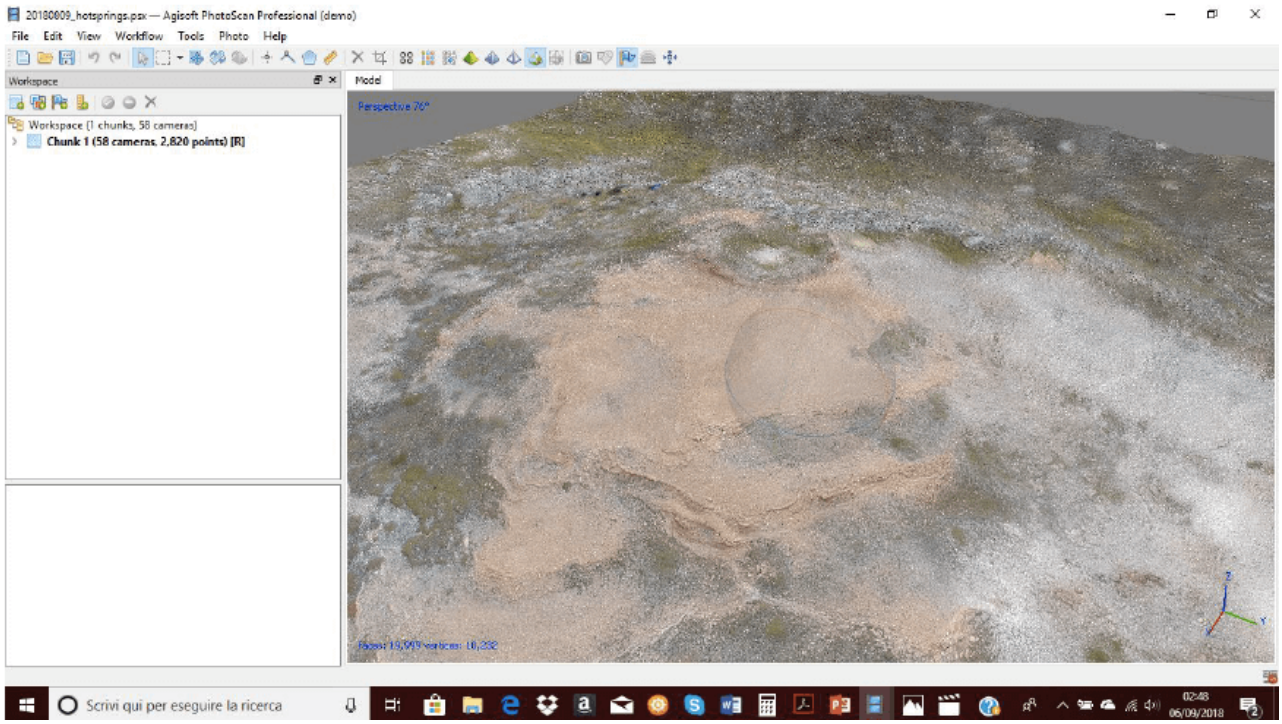
TROLLSPRINGS, BOCKFJORDEN.



Aerial picture of the valley at the southern limit of Bockfjorden. The site was visited on August 9th by a PolarQuest 2018 survey group. The reason for interest towards this site was the presence of residual hydrothermal activity. The area, also defined by the toponym of "Trollsprings" is visible in the picture and corresponds to both sides of the evident strip of vegetation at the bottom of the image. On that site there are pools of water at a constant temperature of approximately 20 ° C (image: Michael Struik).



Pair of images in visible light (left) and thermal infrared (right, rotated). The acquired data demonstrated the overall capability of a small thermographic sensor to identify the presence of hotspots in the ground all around the hydrothermal sources (images by Michael Struik and Gianluca Casagrande)



3-D aerophotogrammetric model of the Trollsprings area, based on the images acquired by an FTD Spark microdrone. In this site a research group of the CNR had left, in 2008, some probes for carrying out environmental measures. Since a planned later expedition was cancelled, it was no longer possible to recover the sensors and logged data stored with them. The PolarQuest 2018 survey group was therefore requested to retrieve the probes if possible. The staff, however, gave up the attempt after finding that in the points indicated as positions for the instruments, a natural ecosystem appeared to be abundantly developed. (photo and processing: Gianluca Casagrande)

AUGUST 11TH

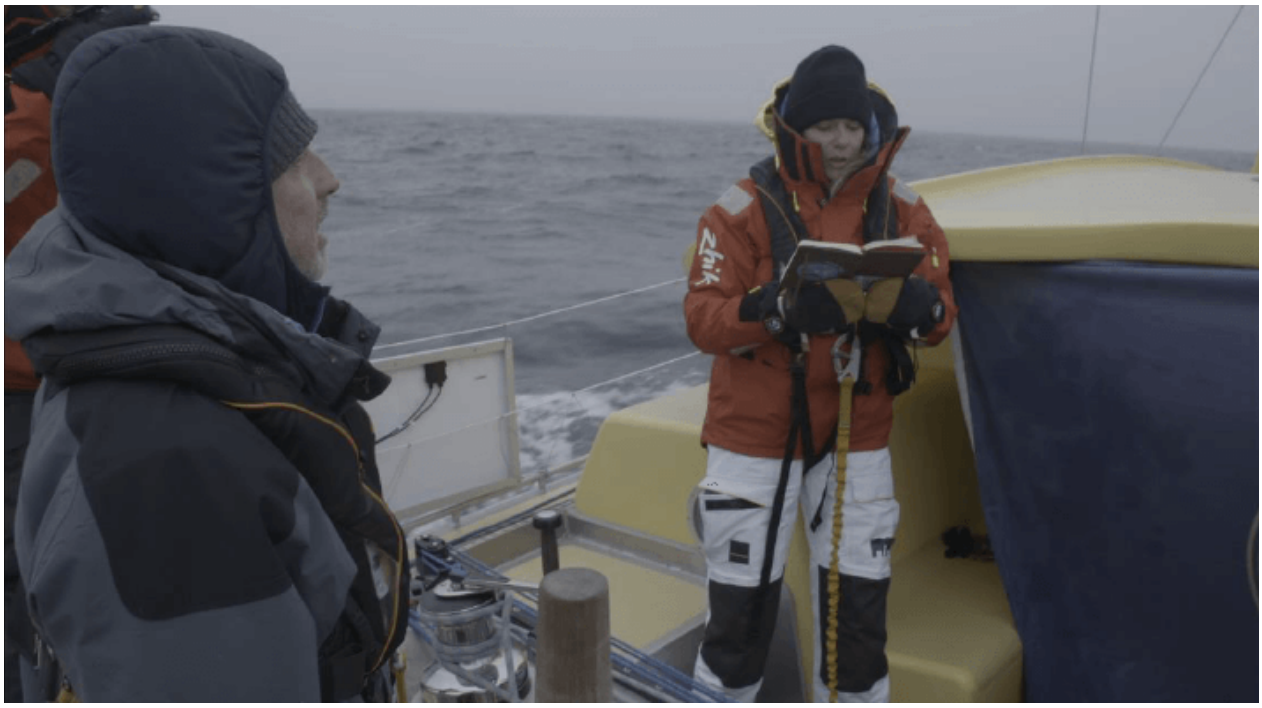
KAPP RUBIN AND NORD-KAPP - IDENTIFICATION ATTEMPT OF HISTORICAL CAIRNS

A series of drone flights was performed at both Kapp Rubin and Nord-Kapp in the attempt of spotting historical "cairns" (small stacks of stones) associated to the Albertini expeditions (1928-1929) in both areas. Two cairns were video-recorded on the top of Nord-Kapp. In the area between Nord-Kapp, Kapp Rubin and Kapp Platten, the research group carried out extensive surveys by on-foot search, observation of the shores from a dinghy, and by aerial view by drones. Although the identification attempt did not provide conclusive results, the validity of the working method was easily ascertained. Among other things, it was possible to verify the particular effectiveness of the drone for this type of archaeological reconnaissance. (image: Gianluca Casagrande).

AUGUST 13TH.

CEREMONY AT SEA NEAR ITALIA'S CRASH LOCATION.

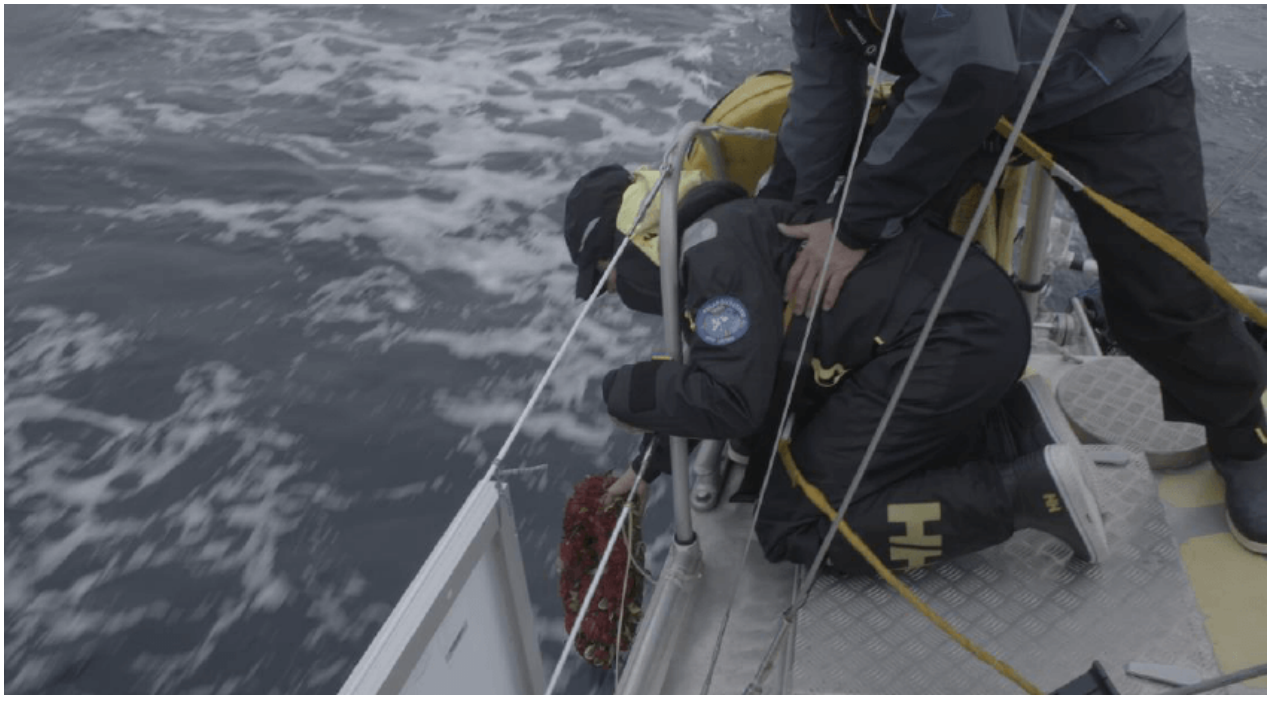
The ceremony was held by the NANUQ's crew according to the original plab, despite increasingly poor weather conditions.



Project Leader Paola Catapano reads, in French and Italian, the introductory text of the ceremony (image: Alwin Courcy)

Onboard geographer Gianluca Casagrande reads the "Prayer of the explorers of airship 'ITALIA'" (originally composed for the crew in 1928, before the disaster). (image: Alwin Courcy).

Expedition leader Peter Gallinelli lays at sea the wooden cross handed over to the crew of NANUQ by the Rector of the Pontifical Gregorian University. The cross is tied to a weight by a small rope, to ensure its descent to the sea bottom. (image: Alwin Courcy).



MANTANET operator Safiria Buono puts a crown of flowers onto the sea. The crown was given to PolarQuest 2018 by descendants of the crew of airship ITALIA. (image: Alwin Courcy)

AUGUST 13TH TO 14TH.

CRUISE TO HIGHEST LATITUDE LIMIT (82 ° 07'N, 25 ° 25'E)

Co-Skipper Mathilde Gallinelli at the bow of NANUQ while sailing to the ice limit (picture: Gianluca Casagrande)

The first area of floating pack, detached by the ice-shelf periphery, was reached by NANUQ at 4.50 PM on August 14th (image: Gianluca Casagrande)

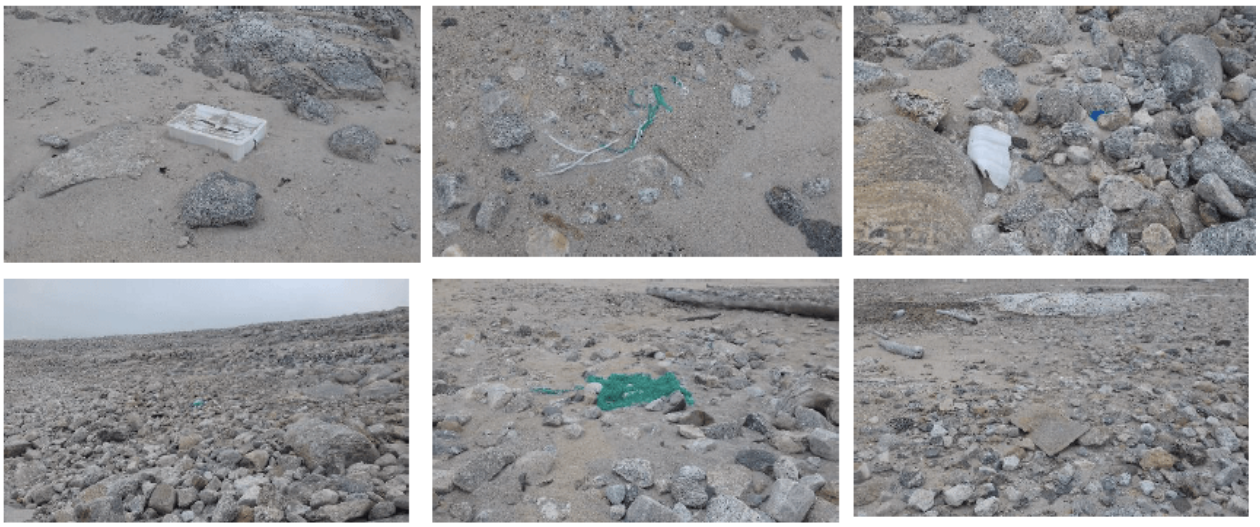
AUGUST 16TH.

SURVEY OF ALPINI ISLAND (ALPINIØYA)

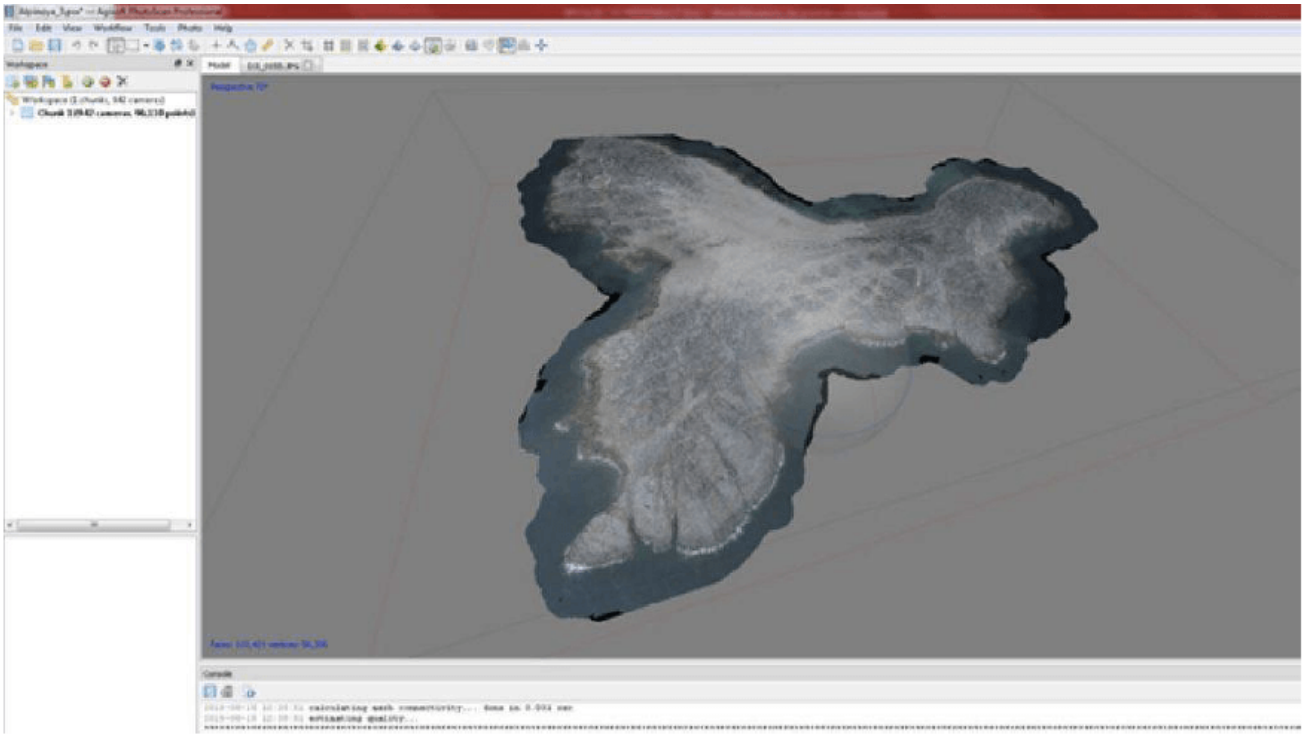
The “Isola degli Alpini” was officially discovered in summer 1928 by Italian Royal Army officer Gennaro Sora, of the Alpine Corps. He and fellow Arctic explorer Sief van Dongen were travelling through northern Svalbard in search for the survivors of airship ITALIA. Alpiniøya is a small rock formation. Although it is completely depopulated and visited very rarely, the island appeared cluttered with plastic debris and waste. The latter was present in considerable quantity and, for the most part, it could be interpreted as deriving from fishing activities. This form of pollution has been observed by PolarQuest 2018 in a large majority of the land area visited during the expedition north and east of Svalbard.

After ferrying some crewmembers top the shore, Michael Struik restarts the dinghy, leaving for NANUQ -visible in the background- to pick up a second group (image: Gianluca Casagrande).

Safiria Buono monitors for polar bears around the group of observers on Alpiniøya beach. In addition to the large-caliber rifle, the observers had flares and maintained radio contact with NANUQ. According to Svalbard regulation, all persons accessing depopulated areas must have at least one armed escort, trained to deal with possible - albeit very rare - attacks by bears. A few days before NANUQ moved to north Svalbard, a polar bear had been shot in the same area. It had attacked a group of tourists, just landed from cruise ship Bremen. During the PolarQuest 2018 expedition, the crew spotted a total of 7 bears (one lurking on a beach on the island of Storøya, later on August 14th). Nevertheless, the crew never faced any contact with polar bears which might have required self defense with weapons (image: Gianluca Casagrande)



Plastic materials scattered on Alpiniøya beach (image: Gianluca Casagrande).

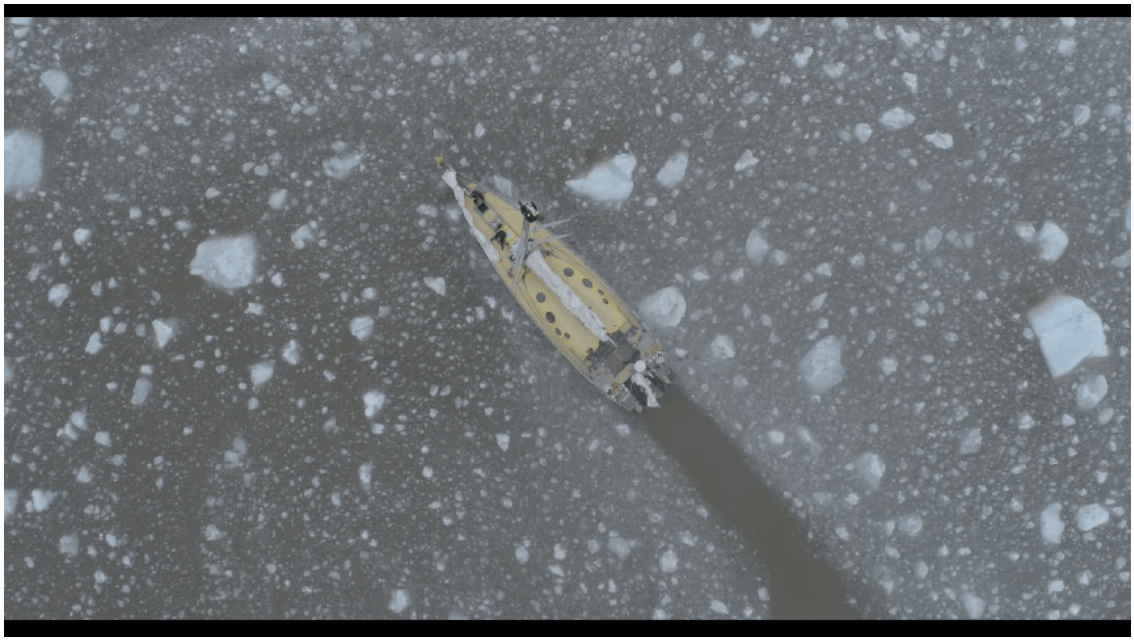


3-D aerophotogrammetric model of ALPINIØYA. The images were acquired in about 40 minutes flight with a drone. The development of a first provisional model took about 60 minutes of computer processing on board NANUQ (images: Michael Struik, processing: Gianluca Casagrande).

AUGUST 16TH.

NAVIGATION ALONG EASTERN AND SOUTHERN FRONTS OF AUSTFONNA GLACIER.

August 16th. Michael Struik and Alwin Courcy during their navigation watch on NANUQ. Among the duties of all crew members, without distinction - except during short journeys or anchor periods - there were 2-hour surveillance shifts. Each shift was followed by 7 hours free for other jobs or rest. These 9-hour cycles, along with continuous presence of daylight, contributed to disrupt perception of time and sleep-wake cycles in the less experienced crewmembers (image: Gianluca Casagrande).



Screenshot from aerial shot with drone showing NANUQ as it crosses an area of small floating ice, cracking them (picture: Michael Struik).

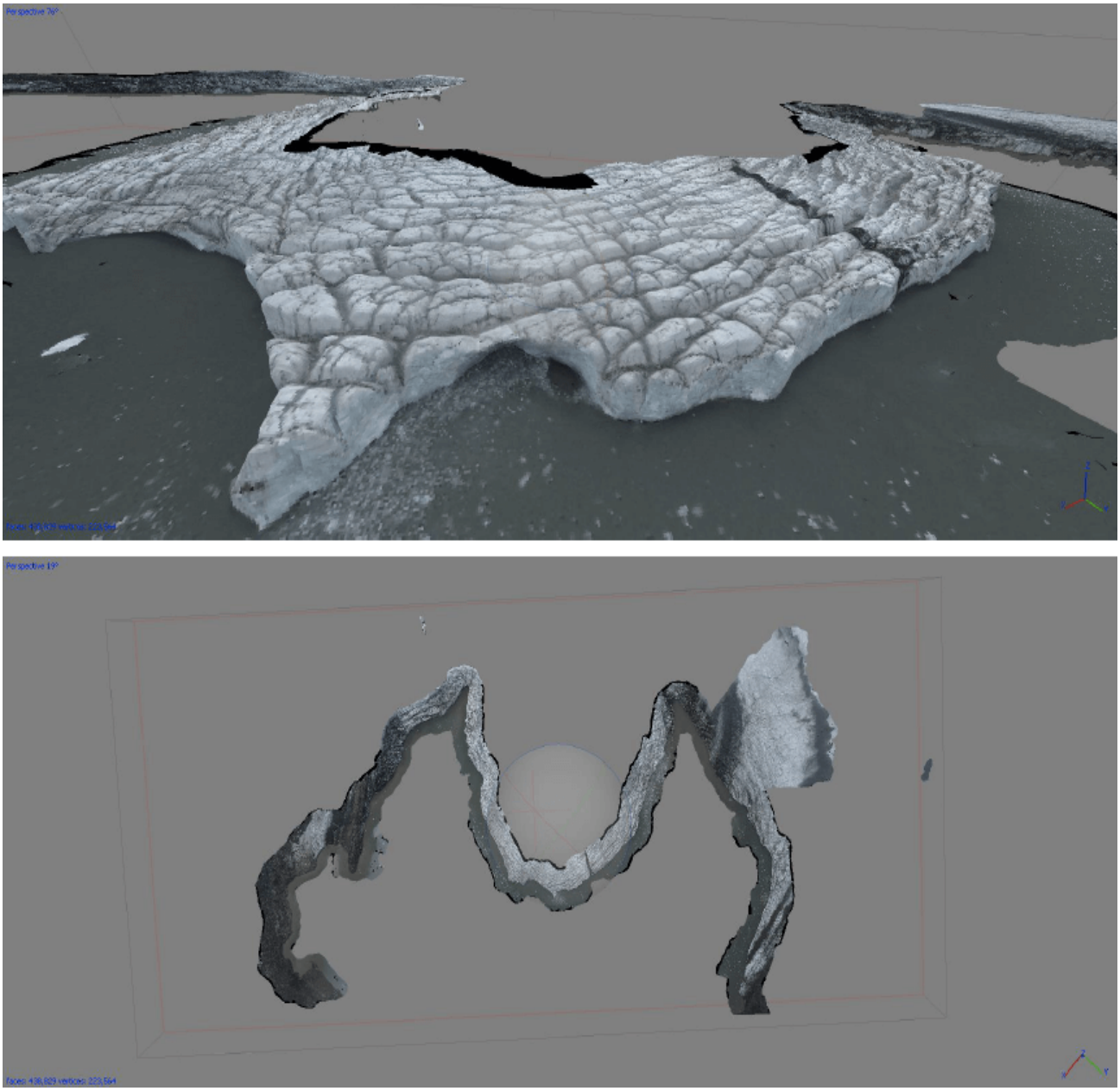
Icebergs of every shape, size, color and transparency are drifting in front of a glacier (image: Gianluca Casagrande).

(image: Gianluca Casagrande)

AUGUST 19TH.

EXPEDITIVE AEROPHOTOGRAMMETRY OF INGLEFIELDBREEN GLACIER

One of the PolarQuest 2018 objectives was to reach Inglefieldbukta to make an observation of Inglefieldbreen glacier. This glacier had previously been subject to periodic monitoring by the working group of the scientific observation boat "Vagabond". The “Vagabond” team, once informed about PolarQuest 2018, had explicitly requested a visit to the glacier. In this context, a georeferenced expeditive aerophotogrammetry of the glacier front was taken by drone, for an extent of about 3 kilometers.



Screenshots of the 3-d aerophotogrammetric model of Inglefieldbreen (images: Michael Struik. Elaboration: Gianluca Casagrande)

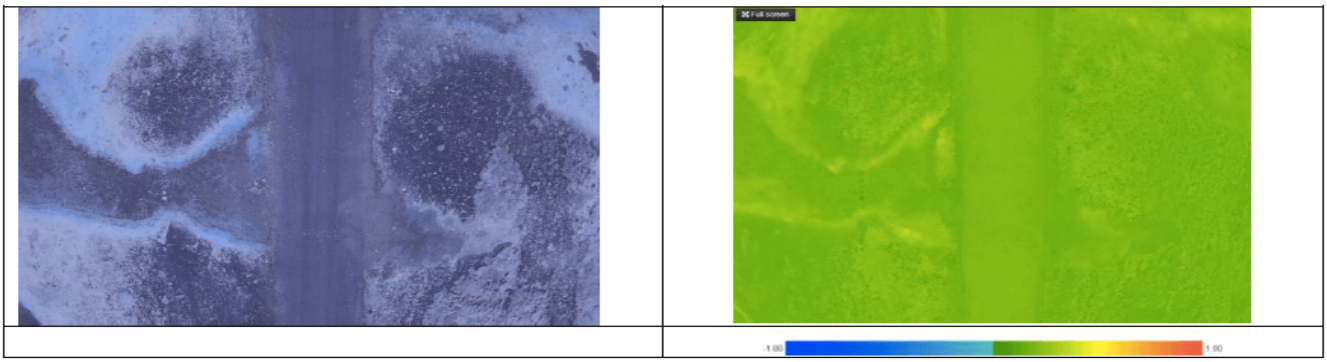
AUGUST 21ST

VISIT TO HORNSUND FJORD

On August 21st, Hornsund was visited. The large fjord is home to the Polish Research Station, established in the late 1950s. The area is of particular naturalistic relevance.

NANUQ as viewed from the drone on August 21st. (screenshot from a video by Michael Struik)

The Polish Research Station at Hornsund (image: Gianluca Casagrande)



On the left, a NIR+R image of a small area of Tundra at the Polish Research Station, acquired by an experimental FTD Spark micro-drone. The device is a custom 350 gram-drone, featuring two separate cameras (RGB and NIR+R respectively). On the right, NDVI index values calculated from that image. Yellow spots on the right image indicate the presence of vegetation with a slightly higher photosynthesys. (images: Gianluca Casagrande).

"Close Encounter" with a female bear (right) leading two cubs. The animals had just fed on a seal and rested on some slabs ice slabs. NANUQ could come close to them, in very slow motion, up to a distance of 40-50 meters, without causing any concern to the animals (images: Gianluca Casagrande).

AUGUST 23RD

VISIT TO PYRAMIDEN

Pyramiden was a Soviet (now Russian) mining city, founded in 1927. It was established to extract coal from mines in the mountain nearby, featuring a typical natural "pyramid" at the top. The city was run and is currently owned by mining company Arktikugol. It was shut down and abandoned in 1998. Most of the buildings and structures are now under official protection; surveillance and maintenance services are now active all-year round. After having being a ghost settlement for decades, Pyramiden appears to be increasingly qualifying as a historical landmark and a tourism asset. During the summer season the site, where a hotel has been fully reactivated - is a typical destination of frequent guided tours. The PolarQuest 2018 group visited the site with specific interest in the structures that are still completely abandoned. Among these, there is an industrial warehouse and the complex system of the funicular that climbed from the city in the valley up to the mine entrances higher on the mountain slopes. The visit in those sites evidenced an ongoing state of considerable deterioration and the presence of potential hazards (asbestos, residues of mining activities). Such conditions should be promptly addressed, if wider tourist access to Pyramiden is planned.

The area towards the port of Pyramiden, as viewed from the top of the funicular (image: Gianluca Casagrande).

The Culture House is one of the buildings that can be visited on guided tours (image: Gianluca Casagrande).

A section of the abandoned service funicular (image: Gianluca Casagrande).

The decaying wreck of a large bulldozer still stands next to an abandoned industrial warehouse (image: Gianluca Casagrande).

The NANUQ crew immediately after its arrival to Longyeabyen on August 24th. Standing, left to right: Gianluca Casagrande, Paola Catapano, Peter Gallinelli, Alwin Courcy, Safiria Buono, Mathilde Gallinelli, Dolores Gonzalez, Michael Struik. Sitting on the Cosmic Ray Detector: Ombretta Pinazza and Remy Andrean (image: Ludovico Machet)