

# SolarArcticPassage 2015 Expedition Report\*

## First polar solar navigation

Attempt to cross the Northwest Passage in a solar-powered kayak, from Tuktoyaktuk (departure 15/06/2015) to Tuktoyaktuk to (arrival 17/07/2015).

Written by: Raphaël Domjan, MI'11.

Expedition leader: Anne Quéméré

Date: 13/01/2016, Neuchâtel, Switzerland

Flags: 71#

Polar navigation through the Northwest Passage, 17/06/2015. Photo: Anne Quéméré



**Vessel: MS Nautiraid SolarArcticPassage**

**Designed and built by: Nautiraid, France**

**Model: Grand Narak 550 Expedition**

Outboard motor: Torqeedo, Germany

Solar system and MPPT: CSEM, Neuchâtel, Switzerland

Certifications: 94/25/EC and 2003/44/EC

Registration code: FR NTRFKSLSB515

**Ensign: Basel, Switzerland.**

Owner: SolarPlanet Foundation, Yverdon-les-Bains, Switzerland

Operator: SolarPlanet Foundation, Yverdon-les-Bains, Switzerland

**Technical specifications:**

Folding kayak with solar-powered electric outboard motor and paddles.

Fitted with a Torqeedo Ultralight 403 outboard motor with fixed-incline propellers.

Made from wood and synthetic hide.

Solar cells: Sunpower C65; yield: 23.9%; modules: 22%.

Surface area: 1.5 sq. m, 355 kWp.

Battery capacity: two Torqeedo 1003 batteries (532.8 Wh each). 10 kg of Lithium-Ion batteries, totalling 1,065.6 Wh.

**Dimensions and weight:**

Length: 553 cm; width: 79 cm.

Height (above unladen waterline): 22 cm.

Draught: 16 cm (excluding motor).

Unladen weight: approx. 80 kg.

Fully laden weight: 300 kg (max. weight 320 kg).

**Raphaël with his kayak during the initial tests**



**Performance figures:**

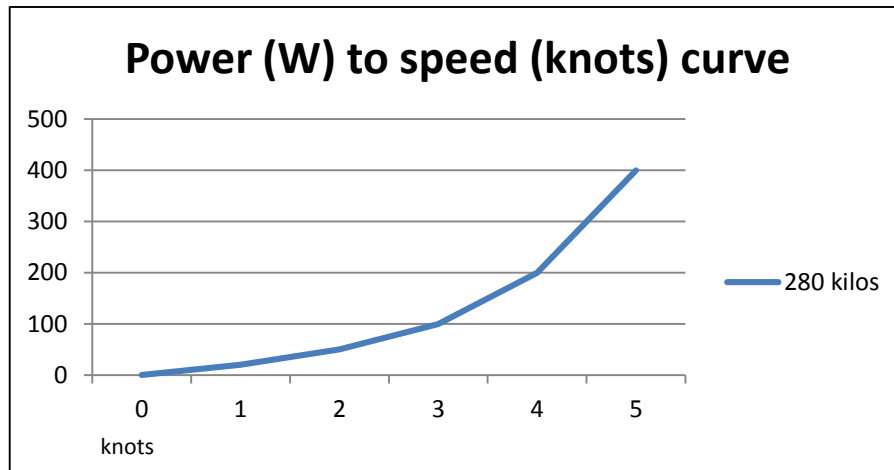
Record production: 3.1 kWh in 24 hours (00:00 to 23:59).

Average speed: 3 knots with approx. 100 W (0.25 HP\*)

Maximum speed: 5 knots with approx. 400 W (1 HP\*)

Maximum measured speed (at seabed): 6 knots (tailwind and favourable current).

\*Thermal equivalent



**Power consumption to speed curve, with total load of 280 kg**

Measured on calm seas with almost zero wind, using power consumption data from the Torqeedo system and seabed speed calculated via GPS.

**Accommodation:**

1 berth with sufficient space for approx. 2 months of solo navigation.

**Communication and safety equipment:**

iPad Mini with Navionics Boating app incl. maps.

1 portable VHF radio, Iridium Satellite Phone, Immarsat BGAN terminal for data streaming, inReach positioning device, specially designed emergency bag.

**Firsts and records:**

- First polar solar navigation.
- First attempt to cross the Northwest Passage in a solar-powered boat.

## Introduction

### An idea is born

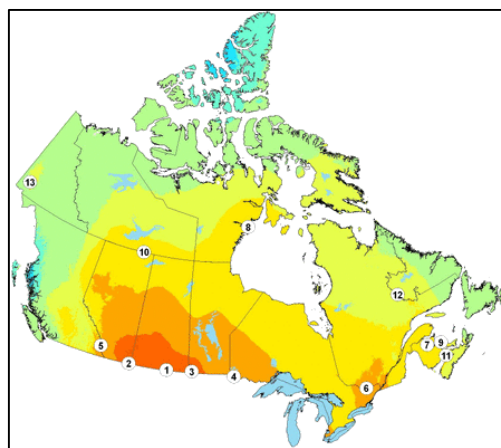
Back in 2011, I was crossing the Pacific on *PlanetSolar*. At the same time, Anne Quéméré was completing an expedition across the very same ocean in a kiteboat, and we were following her adventures via her blog. Our paths finally crossed, by chance, at an explorers' festival in Poland in 2013. It was during this meeting that I first heard about her plans to navigate the Northwest Passage in a kayak. After her first – unsuccessful – attempt in 2014, I started to consider whether it would be possible to create a solar-powered kayak. As luck would have it, I happened to see a film about a kayak made by French manufacturer Nautiraid, fitted with a Torqeedo electric outboard motor. I soon realised that it might just be possible to develop a prototype electric kayak equipped with solar modules to recharge the batteries.

### Feasibility study

I began assessing the feasibility of the project in autumn 2014. I had to work out the solar resources and photovoltaic potential of the target polar region, and to ascertain whether this would be sufficient to power a propulsion system via solar energy alone. There were also some technical challenges to address, particularly when it came to installing the propulsion system and solar modules on the kayak.

### Solar resources

Fortunately, the Canadian government's website already included some useful solar resource maps. I used these maps to calculate the total amount of energy that would be available during the planned expedition dates. According to my initial calculations, the photovoltaic potential was higher in this region, in summer, than at the equator during the same period.



Solar resource map of Canada (annual averages) – see <http://pv.rncan.gc.ca/>

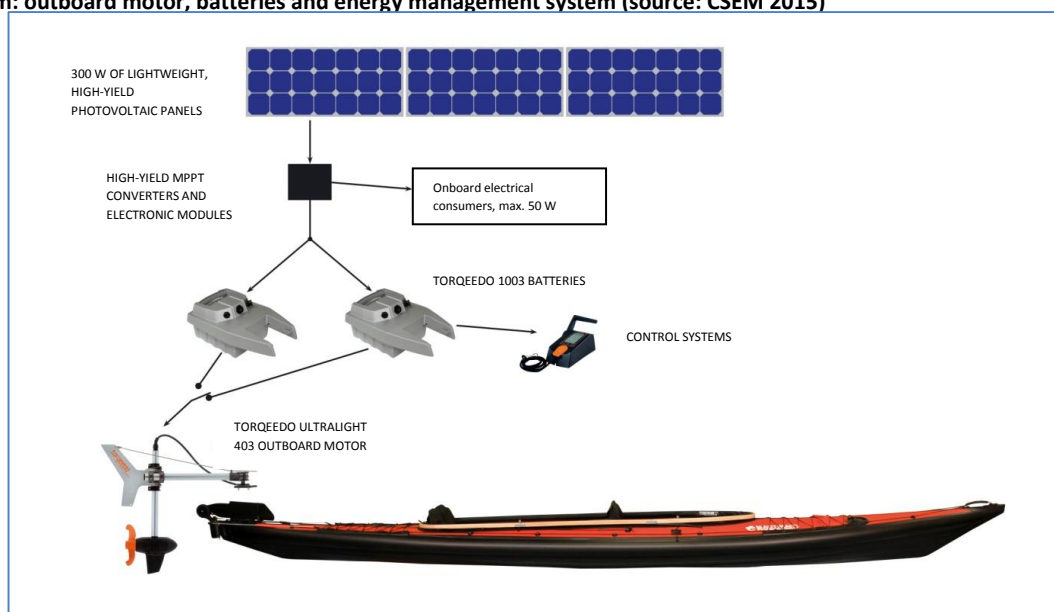
During our expedition at the equator on board *PlanetSolar*, we produced an average of five times our installed peak power. Our calculations indicated that energy production potential in the polar regions increased eight to ten fold in summer. In other words, the summer production potential in the polar regions was more than twice that at the equator. There are two important factors that affect solar power production in the polar regions. The first (negative) factor stems from the sun's low position in the sky, meaning that solar modules have to be inclined at a steep angle (around 70° to achieve the

theoretical maximum production values). The second (positive) factor comes from the much lower temperatures in these regions, which help to improve the yield achieved by the solar cells (by around 3% for every 10°C drop in temperature).

### A kayak, a propulsion system and solar energy

It proved relatively easy to develop our solution, particularly given that Nautiraid had already worked with Anne Quéméré in the past. It didn't take us long to show that a kayak powered by polar solar energy was, in fact, a technically feasible prospect. The answer was to take a Nautiraid expedition kayak similar to the one used by Anne, to fit a Torqeedo Ultralight 403 outboard motor to the craft (a motor that Nautiraid had already tested successfully), and to install detachable solar modules to the kayak. SolarPlanet Foundation partner CSEM also confirmed that this approach was, indeed, feasible, and agreed to develop the prototype solar modules for the kayak.

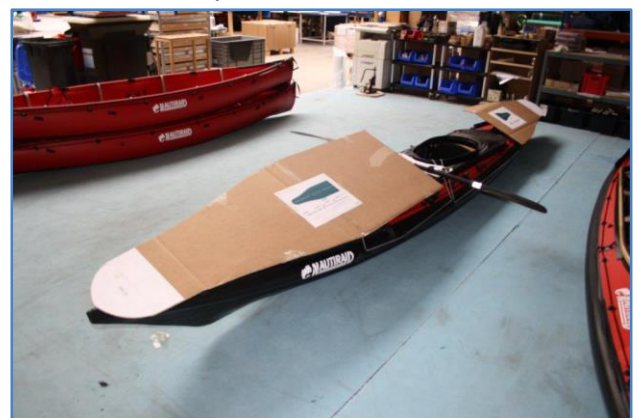
Diagram: outboard motor, batteries and energy management system (source: CSEM 2015)



Details of the Torqeedo Ultralight 403 outboard motor.



Solar module development work at Nautiraid.





## Route

The Northwest Passage is a natural sea route connecting the Pacific and Atlantic Oceans, between northern Canada and the North Pole. From east to west, the passage begins to the north of Baffin Island and ends to the east of the Bering Strait. The passage is dominated by northerly winds, with statistics showing a prevailing wind direction of north-north-east. The passage is covered with sea ice between October and late June, although the ice has tended to form later and melt earlier in recent years due to climate change. There are two possible routes through the Northwest Passage:

### West to east:

**Advantages:** Favourable tailwinds, particularly in the section through the Bellot Strait.

**Disadvantages:** A starting point far to the north, with sea ice lingering later into the season, resulting in a narrower window for the shorter crossing (August to September).

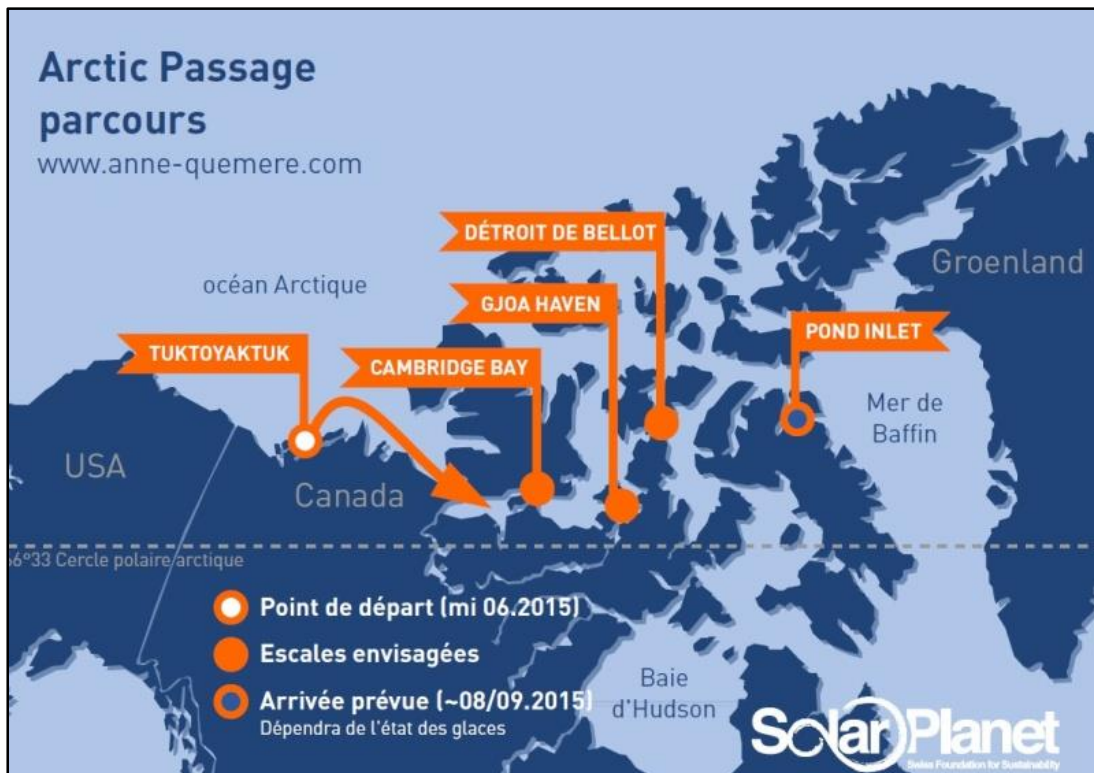
### East to west:

**Advantages:** An earlier and faster thaw due to the presence of warm currents from the Pacific and a more southerly latitude, resulting in a longer window of time to complete the expedition (June to September).

**Disadvantages:** The need to travel north from Gjoa Haven to the Bellot Strait and to the north of Baffin Island, against headwinds.

In the end, we decided to attempt the crossing from west to east.

### The planned route.



- Departure point (mid-Jun. 2015)
- Planned stopovers
- Expected arrival point (Aug./Sep. 2015)  
Depending on sea ice conditions

## Expedition journal

### The adventure begins... destination north!

#### Thursday, 11 June 2015

We set off from Switzerland, with some 300 kg of luggage in tow, towards our agreed meeting point – VieVert Village's premises in the Parisian suburbs. We crossed the border into France and, after a stopover in Pontarlier, Michel, Véronique and I jumped into a hire car. The weather was glorious, and the Arctic seemed another world away. We arrived at our base camp that afternoon, and the final member of our team, Anne, joined us later in the evening with her own equipment. It was almost time to start our big adventure.

#### Friday, 12 June 2015

We spent most of the day on our final preparations. Michel and Coralie had also arranged a press conference and had invited AFP photographer Patrick Filleux, another photographer from *Le Figaro* and a handful of other journalists along to learn more about our expedition. They were all extremely nice to us.

#### Saturday, 13 June 2015

The three of us – myself, Anne and photographer Alain Blanc – arrived at Orly Airport in southern Paris with 300 kg of luggage, ready to head north to the Arctic. We'd also brought along our ambassador, Happy Lilly, to represent Switzerland. There was just enough time to enjoy the mild conditions and catch the last few rays of sunshine before our departure. The weather forecast for Tuktoyaktuk didn't make good reading: over the next few days, we could expect temperatures between -5 and 0C°, 90% humidity, rain and strong gusts. It was going to be a cold one. Our plan was to stop over in Montreal the next day before heading to Vancouver on Sunday, and then on to Whitehorse.

#### Goodbye Orly (Alain Blanc et Anne Quéméré).



The time had finally come to check in our luggage (including our rifle – essential protection against polar bears!) for our flight to Montreal. As it happened, we were charged an extra €200 for excess baggage. Given the sheer volume of equipment we were taking with us, it was a small price to pay. After landing in Montreal, we reclaimed our bags and breezed through our second customs

checkpoint. We packed our things into the baggage lockers at the airport before heading off to our city-centre hotel for a well-needed sleep.

### Sunday, 14 June 2015

We left our 60s-style hotel in Montreal the next morning and made our way back to the airport to collect our bags and check in for an Air Canada flight to Whitehorse. This time, things didn't go quite as smoothly. We had to endure several checks and luggage inspections, and ended up paying C\$900 in excess charges. Eventually, our bags were loaded onto the aircraft and we were ready for the next stage of our adventure. We arrived in Whitehorse later that morning, after a brief stopover in Vancouver. Anne's friend, Jacky, met us at the airport, along with our mountain of luggage. We had arranged for Torqeedo to ship our two batteries directly to Whitehorse via DHL. So it was with great relief that we found the batteries waiting for us at reception when we arrived at our hotel. The positive mood was soon dampened, however, when we discovered that one of the batteries had been damaged in transit.

Our hotel in Whitehorse.



Battery damaged in transit.



The battery was in a bad way. Following a brief test, we were surprised to find that it worked. Impressive build quality from Torqeedo! We still had to fix the damaged box and make it watertight. So after locating some high-strength adhesive, we spent the afternoon making our repairs.

Repaired Torqeedo battery





### **Monday, 15 June 2015**

The time had come for the last leg of our outward journey. We made our way back to the airport, this time with our two batteries in tow. The further north you go, the smaller the planes become, and the sheer volume of our luggage was becoming something of an issue. This time, we had to pay €900 before finally getting everything on-board. We settled into our seats and prepared to take off for Inuvik, the last town before the Arctic Ocean. It was an incredible flight, with forests, lakes, rivers and stunning landscapes as far as the eye could see.

Upon arrival in Inuvik, we were once again forced into protracted negotiations over our equipment. This time, the plane – a DHC-6 Twin Otter – was even smaller. The crew told us we would have to load our bags onto a different flight, with no guarantee of when they would arrive. As it turned out, a young man had passed away a few days earlier and had to be repatriated in his coffin. This sad event actually worked in our favour, and we agreed to board the cargo flight along with our luggage. There were a few spare seats at the back of the plane, and there was just enough space next to the coffin to store our kayaks and solar panels. It was late in the day when we finally took off for Tuktoyaktuk with our equipment and kit – five days after leaving Switzerland.

**Alain, Anne and our kayaks in the Twin Otter.**



**The Arctic Ocean is within reach...**



### **Tuesday, 16 June 2016**

Our first day in Tuktoyaktuk was cold and wet. We spent most of the day checking that we had all our equipment and building our kayaks. My solar-powered craft was ready later that same day. It was time to soak up the first few rays of polar sunshine and charge the batteries! Everything was ready for the next stage of our adventure... we just had to wait for the ice to melt and the passage to open.

**Building the kayaks outside the B&B in Tuktoyaktuk**



## **Expedition: Tuktoyaktuk to Tuktoyaktuk (30/06/2015 to 17/07/2015)**

### **Day 1: Tuktoyaktuk to Kukjuktuk Bay (69°40.858'N/132°37.818'W) – 30/06/2015**

#### **Navigation**

Departure: 12:15 LT (prod. 2,964.1 Wh)

Batteries: 84%/84%

Arrival: 22:30 LT (prod. 4,250 Wh)

Batteries: 25%/80%

Production: 1,300 Wh (charge at midnight LT: 45 W)

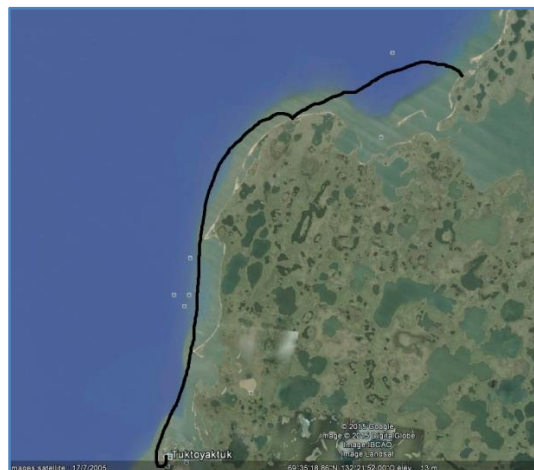
Distance travelled: 20 NM

We loaded up the kayak and left our B&B. It had been our temporary home for the last two weeks, while we waited for the sea ice blocking our route through the Northwest Passage to thaw. We launched the craft into the water for the first time, fully laden with 30 litres of fresh water – hopefully enough to see us through the entire leg around Tuktoyaktuk Point.

We set off from Tuktoyaktuk under clear skies and bright sunshine. The kayak worked perfectly, allowing me to travel alongside Anne at around 3 knots (requiring power output of 100 W). As the headwind strengthened, I fell behind Anne and carried on in her wake. With the sun beating down on the solar panels, we made steady progress.

We decided to stop off just after Toker Point. On the beach, we met Ronald, a Canadian who was heading towards Paulatuk in his kayak. I'd come across Ronald previously in Tuk. After resting, eating and recharging my batteries, we parted company with Ronald and set off towards the other side of Kukjuktuk Bay, around 5 nautical miles away. Conditions out on the water were poor. We faced strong headwinds, counter-currents and choppy, triangular waves that washed over my kayak. The solar panels on the bow of the craft were completely submerged on numerous occasions. It took us two hours to reach our first stopover point. The moment we set foot on dry land, we were attacked by swarms of bloodthirsty mosquitoes. A herd of caribou was moving along the fringe of the beach, but they seemed unaware of our presence. We set up camp and lit a fire to ward off the mosquitoes. Our efforts were to little avail... we would have had to stand in the fire to keep them away!

**Route map - Day 1.**



**Day 2: Kukjuktuk Bay to Hutchison Bay (Marsh) (69°43.608'N/132°3.733'W approx.) 01/07/2015**

#### **Navigation**

Departure: 12:00 LT (prod. 4850.0 Wh)

Batteries: 100%/100%

Arrival: 22:00 LT (prod. 6750 Wh)

Batteries: 29%/58%

Production: 1,900 Wh (charge at midnight LT: not measured)

Distance travelled: 18 NM

Just as we were preparing to set off once more, three caribou approached us. They must have looked at us with bewilderment, as we stood there dressed head-to-toe in our wetsuits.

We navigated our way past Warren Point, travelling alongside a sandbank that seemed to go on for miles. Once again, we had to battle headwinds and counter-currents. We were unable to stop because the coarse sand and pounding waves would have damaged our boats, so we had to remain out on the rough open water. On two separate occasions, the panels on the front of my kayak were submerged by a breaker. Despite the challenging conditions, we managed to make our way around the cape and find a sheltered spot in the bay. My batteries were fully drained in the process. That day, we spotted caribou, beluga whales and several seals.

**The batteries installed on the kayak.**





**Day 3: Hutchison Bay (Marsh) to Atkinson Point (69°56.320'N/131°25.225'W) 02/07/2015**

### **Navigation**

Departure: 10:00 LT (prod. 7345.0 Wh)

Batteries: 100%/100%

Arrival: 22:00 LT (prod. 9400.0 Wh)

Batteries: 29%/25%

Production: 2,000 Wh (charge at midnight LT: not measured)

Distance travelled: 29 NM

With my batteries fully recharged during the “night”, we began the next leg of our journey, this time towards Atkinson Point. It was quite astonishing to see my predictions come true. I could, indeed, travel for an entire day and simply recharge my batteries while we rested at the end of each day. Conditions were much better on this day, with bright sunshine and no wind. This meant we were able to up our speed to around 4 knots. We encountered our first icebergs, drifting through water, almost expecting our arrival.

We had to take a detour of around 10 km to avoid a sandbank. Despite breaking the motor lift on my kayak and one of the brackets holding the solar panels in place, we finally made it to Atkinson Point. Our shelter for the night was a small cabin on a former military airstrip. We were extremely grateful to have a roof over our heads. Compared with our previous accommodation, this truly was 5-star luxury!

**Repairing the motor lift system.**





## **Logbook: 3 July to 15 July 2015 (Atkinson Point)**

### **Friday, 3 July**

While we were eating breakfast, a helicopter touched down next to our cabin. As it turned out, the pilot (who happened to be Swiss) had landed here to pick up some barrels of kerosene. There were hundreds of litres of fuel at the site, but what we really needed was water. The crew – a group of scientists where on a climate change observation mission – gave us a small amount of water then promptly departed as suddenly as they had arrived. I spent the day repairing my kayak, while Anne boiled water she had collected from the nearby lake. We faced a daunting prospect: three or four days navigating our way between the sandbanks, against a headwind and with no likely source of drinking water.

### **Saturday, 4 July**

The stormy weather prevented us from making progress. Thankfully, it also kept the ravenous swarms of mosquitoes at bay. We decided to make the most of the opportunity and set off to explore the area around Atkinson Point.

It was an eerie experience. This place was once inhabited by people, and although nature had largely reclaimed the landscape, there was still the odd sign of human colonisation – electrical cables that appeared seemingly out of nowhere and vast pipes buried deep into the ground. We could only image what the area would have looked like a few years ago. We saw caribou, swans, thousands of birds and Arctic squirrels which, in their infinite wisdom, decided to take a drink from my hydrator, chewing the end piece to shreds in the process.

### **Sunday, 5 July**

Outside, the storm raged. We were glad to be inside our little cabin. During the night, we heard the wind sweep away our bivouac. Fortunately, my solar panels survived the ferocious gusts. This was due, in no small part, to the sterling work done by Nautiraid in designing the kayak and the module brackets, and by CSEM, which developed the modules themselves. The panels were subjected to the challenging Arctic Ocean conditions for two solid days.

Later in the day, with the wind shielding us from the hordes of biting insects, we decided to head out to see the ocean under the full force of the storm. We made our way over to the small peninsula and began hunting for buried treasure in the sand. Suddenly, I heard a cry of alarm from Anne. “Raphaël, there’s a polar bear right behind us!”

The locals had told us there was no chance of encountering a polar bear at this time of year, so we’d left our rifle in the kayak. But here we were, backed into a corner, with a ferocious-looking polar bear just 500 metres behind us.

It was an extremely humbling experience. We were no longer at the top of the food chain. Instead, we were trapped and unarmed. We quickly headed back towards the cabin to seek shelter, while the bear simply continued its tour of the peninsula, with no apparent interest in our presence. The animal remained at a safe distance and displayed no signs of aggression whatsoever. Once back at our cabin, we climbed up onto the roof and watched the creature scouring the peninsula for prey

through our binoculars. At last, the bear disappeared out of sight. It was a great privilege and honour to be able to see a polar bear in the wild.

### **Monday, 6 July**

Although the wind had abated, the outlook suggested that a new depression was expected to arrive during the night. We could do little else but wait. In this part of the world, everything is governed by the ice and the weather. The Arctic is a place that springs new surprises on you each and every day. Today, the monotony was broken by a Canadian Air Force Twin Otter landing in front of our cabin. The co-pilot came over to check that everything was OK, before promptly climbing back into the aircraft and taking off, leaving us alone once again.

According to the weather forecast, we could expect more favourable conditions on Thursday, with tailwinds. With our fingers tightly crossed, we hoped to be able to continue our journey eastwards later in the week.

### **Tuesday, 7 July**

Contrary to the positive outlook, it turned out to be a stormy day. Peter Semotiuk, our long-suffering route planner, was as bewildered as we were. We had to spend the whole day barricaded inside this tiny cabin as the fierce, icy polar winds whipped around us outside. We came to realise that just getting here – in a solar-powered kayak, no less – had been an incredible feat in its own right. And despite the overcast conditions, the sun had continued to supply us with the less than 100 W of energy we needed. It was a remarkable demonstration of the potential of renewable energy sources... and of what can be achieved in terms of energy efficiency.

### **Wednesday, 8 July**

This time, the weather forecast was right. Conditions were atrocious. The wind battered the walls and roof of our cabin all night long. We had no option but to wait inside, left to our own thoughts. I recall working through my whole life in my head that night. We got our kayaks and equipment ready for an early departure the next morning.

### **Thursday, 9 July**

We stepped out of our cabin with every intention of setting off on the next leg of our adventure. Instead, we were greeted with rain, wind and a churning seascape with vast, impenetrable waves. The forecasters had got it wrong, and once again we could do little but wait. Even the 6-hour outlook was wide of the mark, and we realised we would have to take weather forecasts with a pinch of salt in the future.

We hadn't seen the sun for a whole week and we began to wonder whether it would ever return. Another depression was expected to hit on Saturday, but there were more positive signs for Wednesday onwards. We still had a month's supply of food, so we would afford to wait a little longer. If conditions failed to improve the following week, however, things would become somewhat trickier. After deciding to spend the day away from our cabin, we found evidence of previous human activity – exploratory gas or oil digs, apparently in the middle of nowhere. The human race has left its mark in every corner of our planet.

**Wednesday, 15 July**

We were now postponing what was becoming an almost inevitable decision. Having waited for an opening in the ice for two weeks, Anne and I had managed to travel around 180 km eastwards. And here we were, trapped by the whims of the Arctic weather, with strong headwinds, torrential rain and dense fog blocking any further progress.

The evidence was clear – we had already spent a month waiting, and there was no sign of a let-up in the atrocious conditions. There wasn't enough time left to complete the planned expedition through the Northwest Passage. Our food supplies were running low, and there was no guarantee that we would even make it to the next village, Paulatuk, some 700 km away by sea. With heavy hearts, we decided to head back to Tuktoyaktuk during the next window of opportunity.

When you set out on an expedition like this, your main goal is to return in one piece. We had already achieved something that nobody had ever done before – the first polar solar navigation in history. Our achievement had left the door open for other explorers to tackle this route in a solar-powered craft. Our expedition had pushed the boundaries of solar-powered navigation to their limits. Giving up and turning back is a normal part of this type of adventure.

Atkinson Point.



#HappyLilly\_



**Atkinson Point to Toker Point (69°38.396'N/132°55.543'W) – Thursday, 16 July 2015**

**Day 4 at sea**

Departure: 07:54 LT (prod. 11037.0 Wh)

Batteries: 79%/81%

Arrival: 22:50 LT (prod. 12880 Wh)

Batteries: 13%/65%

Production: 1,843 Wh

Energy consumption: 2,453 Wh

Distance travelled: 39.6 NM

Average speed: 2.6 knots

Maximum speed: 5.3 knots

This time, with the easterly winds at our backs, we expected to make steady progress towards Tuktoyaktuk. We left our temporary home, where we had spent two long weeks sheltering from the fierce storms and swarming mosquitoes. Happy Lilly, meanwhile, decided that she wanted to stay and guard this little cabin perched on top of the world. We headed west and made our way past the former landing strip at Atkinson Point for the final time. The fog was so thick we could barely see 10 metres ahead. We climbed into our kayaks with some trepidation about the challenge that faced us – navigating through sandbanks almost completely blind.

As if by magic, the sun emerged through the fog just a few metres offshore and we found ourselves in almost perfect conditions. With a welcome tailwind behind us, Anne deployed her kite and the sun set about recharging my batteries. We made good headway and, after a short stopover at Warren Point to eat and recharge my batteries, we set off again for another 8 hours at sea. We set up camp to the west of Toker Point, where we found a great spot less than 15 nautical miles from Tuk. In a single day, we had managed to cover an impressive 39.6 nautical miles.

**Stopover at Warren Point.**





## **Toker Point to Tuktoyaktuk Friday, 17 July 2015**

### **Day 5 at sea**

Departure: 14:38 LT (prod. 13616.0 Wh)

Batteries: 100%/100%

Arrival: 19:30 LT (prod. 14130 Wh)

Batteries: 9%/30%

Production: 514 Wh

Energy consumption: 1,319 Wh

Distance travelled: 13.9 NM

Average speed: 2.8 knots

Maximum speed: 4.9 knots

Having not seen the sun for almost two weeks, I was awoken by warming rays penetrating the thin outer layer of my tent. After being at sea for 14 hours and travelling almost 100 km on Thursday, I took great pleasure in staying in my sleeping bag a little longer to enjoy the sun's warmth. We had set up camp on a small hill, where a hunter's cabin stood exposed to the ravages of the Northwest Passage winds. The sun recharged my batteries, and at 14:00 we set off again towards Tuktoyaktuk, around 20 km away by sea.

As we travelled into a headwind and passed through localised storms, the sights and smells we encountered were a stark contrast to our experience over the previous three weeks. I noticed that the battery management system had two charging modes: slow and fast. It became clear that charging performance was poorer than expected during periods of fluctuating sunlight, and that the system would need to be modified for future expeditions. We finally arrived back at Tuktoyaktuk early in the evening, where I indulged in a long, hot shower.

### **Return to Tuk.**



## Saturday, 18 July

To complete the solar navigation process, I had to recharge my batteries to the level they had been at when we left Tuktoyaktuk in June (around 30% in each battery). Despite the rain and the overcast conditions, the batteries were almost fully recharged by the end of the day.

According to my initial calculations, the system had produced a record amount of solar energy. In fact, it had generated some seven times the nominal power of my photovoltaic panels in 24 hours. I had travelled in open water, in a fully laden kayak weighing around 300 kg, consuming 35 Wh per kilometre. This was equivalent to 0.28 litres of fuel per 100 km, or almost 253 miles per gallon – truly outstanding energy efficiency figures! Of course, these were only rough calculations. They would have to be checked and examined by the talented engineers at CSEM that had developed the modules.

Solar systems switched off on: 19 July at 13:51

Batteries: 65%/49%

13:51 LT (prod. 14989 Wh)

Total production since arrival: 859 Wh

Anne Quéméré, Raphaël Domjan and the Explorer Club flag.



**Conclusion:**

Although we didn't manage to make it all the way across the Northwest Passage, I am extremely proud to have navigated the Arctic Ocean in a solar-powered kayak. As far as I am aware, my kayak was the first solar-powered craft to travel at such a northerly latitude. I had the chance to see caribou, beluga whales, a polar bear, seals and thousands of birds in the skies above us – all in their natural habitat. The polar regions are extremely challenging and inhospitable. Yet they are places that make a long-lasting impression on anyone fortunate enough to visit them.

**Key issues addressed by our expedition:****1. Eco-friendly technology experiment and demonstration**

Our expedition clearly demonstrated the potential for using solar energy in polar regions. We produced up to 10 times our nominal installed power, despite issues with the battery management system. For comparison purposes, our record during the *PlanetSolar* experiment was six times our nominal installed power. This proves that solar potential is greater in the polar regions than at the equator. However, this applies only to the relatively short summer periods in the Arctic and Antarctic.

The polar solar-powered kayak was the first of its kind. It performed as expected, and survived the journey from Switzerland as well as the three-week expedition. However, it was only used at sea for a total of five days, and we cannot therefore confirm whether the system is reliable over a longer period of time.

**2. Physical endurance**

From a physical endurance perspective, we only partially achieved our aims. Due to the poor weather and the persistent sea ice at the start of our expedition, we were forced to wait for conditions to improve for around one month in total. The Tuktoyaktuk peninsula was particularly challenging, with open seas, a jagged coastline, inaccurate maps and numerous sandbanks blocking our route. The lack of available fresh water meant that we had to be entirely self-sufficient. It is possible to bypass this peninsula by taking a different route via Liverpool Bay. Dutch explorer Yuri Klaver managed to secure an all-terrain vehicle and travel to the western point of Eskimo Lakes just four days after we departed. The benefit of this alternative itinerary, which avoids the peninsula entirely, is that it involves 100 km of navigation in waters sheltered from the Arctic Ocean. Had we opted for this route instead, we may well have been able to progress further with our expedition.



### 3. Communication and future attempt

Even though we had to abandon the expedition earlier than planned, it was a remarkable success from a communication perspective. Looking to the future we have decided, for various reasons, not to try to cross the Northwest Passage in a solar-powered kayak again. Our experience showed that it would be impossible to complete an expedition from Tuktoyaktuk to Pond Inlet in a single season without two months of fair conditions. The complex weather patterns in this part of the world also mean that the passage would only be free of sea ice for a maximum of three months. As such, there is no guarantee that such an attempt could be completed in just one summer window. Our adventure did, however, confirm the potential solar energy available in the polar regions. We intend to use the data we collected to plan an even more ambitious “polar solar” expedition in a seagoing craft. We will release more details in 2016, once we have completed the feasibility studies.

#### Acknowledgements:

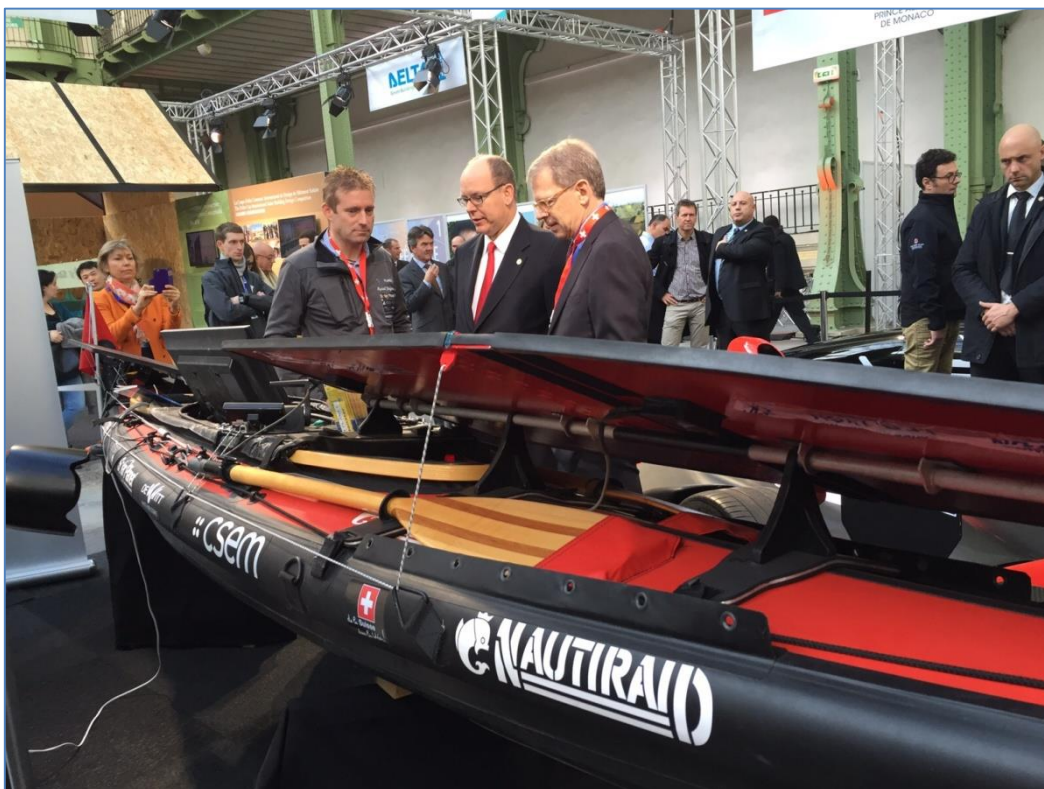
To all our partners and eco-donors.

To the entire SolarPlanet team.

To Alain Blanc, who accompanied us on our journey to Tuktoyaktuk.

To everyone who helped us during our expedition.

To H.S.H. Prince Albert II of Monaco.





**Team:**

**Initiator and founder:** Raphaël Domjan

**SolarPlanet Board:**

Caroline Platchta  
Gérard d'Aboville  
Philippe Guénat  
Jean-Marc Buchiller  
Daniel Domjan  
Jean-Francois Affolter  
Raphaël Domjan

**Field team:**

Logistics support: Sherpa Alain Blanc  
Security and webmaster: Alexis Domjan  
Expedition doctor: Patrick Shoetcker

Communication and press: Michel Gandillon, Coralie Jugan

**Expedition team:**

Expedition leader: Anne Quéméré (Brittany, France)  
Solar-powered kayak: Raphaël Domjan (Switzerland)

**Donors:**

- Prince Albert II of Monaco Foundation
- Yverdon-les-Bains Region
- Switzerland
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- Dewitt (Switzerland)
- Torqeedo (Germany)
- Nautiraid (France)
- CSEM (Switzerland)
- Venturi (Monaco)
- VieVert Village (France)
- E-Gestion (Switzerland)
- La Semeuse (Switzerland)

### **Competitors and pioneers:**

No known competitors.

Pioneer: Power of One, the first solar-powered car to reach the Arctic Circle (2009). See: [www.xof1.com](http://www.xof1.com)

### **Documentary:**

Teaser entitled *First solar polar navigation*, 3 minutes, HD, 16:9.

Directed by: Alexis Domjan, producer of *Fondation SolarPlanet 2015*

Anne Quéméré and Raphaël Domjan, penultimate day at sea.



**“Tomorrow’s world will reflect today’s wisdom”**

*Raphaël Domjan*

**Anne Quéméré**

**Expedition leader**

**Raphaël Domjan Ml’11**

**Eco-explorer**