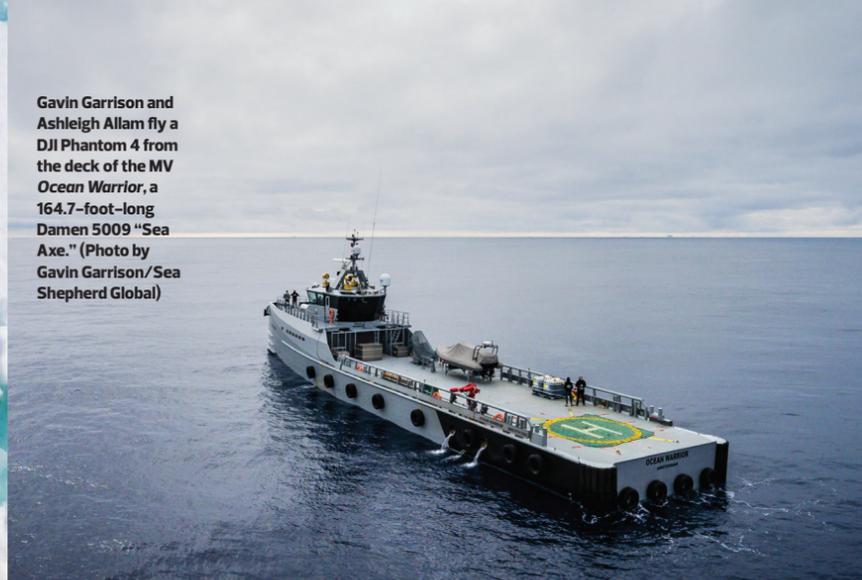




A herd of Antarctic fur seals sun themselves on an ice floe. Antarctic fur seals grow up to 6.5 feet long and weigh up to 474 pounds; each seal eats approximately one ton of krill and fish every year. (Photo by Gavin Garrison/Sea Shepherd Global)



Gavin Garrison and Ashleigh Allam fly a DJI Phantom 4 from the deck of the MV *Ocean Warrior*, a 164.7-foot-long Damen 5009 "Sea Axe." (Photo by Gavin Garrison/Sea Shepherd Global)



Gavin Garrison helps guide Simon Ager as he pilots his Phantom 4 to a target in the distance. (Photo by Ashleigh Allam/Sea Shepherd Global)

ANTARCTIC ADVENTURE

WHERE CAN'T A DRONE GO?

BY GAVIN GARRISON

In late 2016, I was driving north through Alaska when I stopped in a quaint town, the not-so-aptly named "North Pole," which sits at 64°N. Knowing that the Arctic Circle was still several hours north of me, I looked into the town's coordinates, curious to see how far away I actually was from the North Pole. The town was nowhere near the actual North Pole (90°N) or the North Magnetic Pole (86°N); North Pole, Alaska, was just a place. But this research revealed a chance discovery for me: There are more than just two poles. As we'll see, the Earth's magnetic pull has quickly become the biggest thorn in my droning, here in the iceberg-laden waters off the coast of Antarctica. I'm sailing along the continent's edge with the ocean-conservation group Sea Shepherd Global on a brand-new \$12-million-dollar patrol vessel *MV Ocean Warrior* on the annual campaign to save whales from being poached in the Australian Whale Sanctuary.

SIGNS OF TROUBLE

For years, I've flown drones from ships, so I didn't expect there to be any particular challenge when flying a Phantom from the considerably large deck of this Damen FCS 5009 Sea Axe. When I boarded the ship in Hobart, Tasmania, I was warned by Simon Ager, the first mate, photographer, and drone pilot, that "something" in the ship had caused a loss of control and crash of a Phantom a month earlier. The leading theory was that there was a strong electromagnetic field emitted by the generators onboard. The few people that had had a chance to fly from the ship had also reported other strange instrument behaviors, but nothing was confirmed.

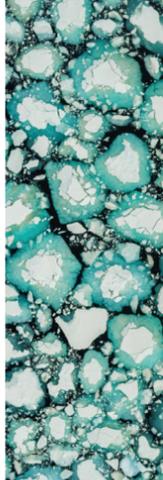
While preparing to depart for Antarctica, Simon and I flew a handful of test flights while we were still docked. Everything seemed to be in order: the Phantom's Inertial Measurement Units (IMUs), compasses, and positioning were all checking out, and the drones flew fine. The transit to Antarctica is renowned for being unpleasant, so we left the drones stored in their CasePro cases until we made it through to the Antarctic coast. Because we were on a mission to patrol the Southern Ocean for illegal whaling activity, it meant that we wouldn't get an opportunity to stop and drone; we had to fly at a moment's notice while the ship was on the move. We would wait for moments when the magical trifecta of perfect weather, lighting, and interesting subjects aligned, so we had to be prepared to get in the air quickly if we wanted to get great imagery.

Once we located the first iceberg of the season, after our week-long transit south, the drones came out. Out on the rear deck, all sensors checked out on our two Phantoms; we got "green across the board," as they say. We launched Simon's P4 first, preferring our hand-launch method to keep the aircraft away from the ship's metal. After 30 seconds of some preliminary checks at low altitude, things got weird. The P4 shot off, away from the ship, apparently under its own volition. Simon fought to bring it back, successfully doing so only after a series of unconventional inputs—up was down, forward was back; no input made sense. After a tense couple of minutes, the P4 thumped down on the deck.

Thinking that something was wrong with Simon's P4, we tried one of mine—Eagle-3, which appeared to fly relatively well once it was in the air. After confirming that nothing weird was happening, I flew out toward the iceberg to capture some video of the iceberg and the *Ocean Warrior* together. Reaching the iceberg, which was relatively close at less than a mile away, I lined up the shot I wanted. After I rolled the camera, the gimbal suddenly slammed to maximum rotation in one direction, then the other, and then the aircraft catapulted itself at a blazing 52mph away from us and toward the water. For a heart-stopping few seconds, the aircraft was nonresponsive. Though I had a full-strength signal, I could only watch as the Phantom dragged itself toward a watery end.

As seconds stretched into forever, I became convinced that my accident-free streak was over (90 days and counting!). I went through everything I could think of to regain control—flipping into Attitude mode, making inputs that would counter the current flight path—nothing worked. The drone executed a series of horizontal loops, something that's sometimes referred to as the "spiral of death." I didn't think this phenomenon was possible with this newest generation of Phantoms because of their new redundant IMU system, which helps keep faults like these to a minimum. After executing three loops, wherein the aircraft got progressively closer to the water, Eagle-3 slowly came to a pause, hovering about 20 feet over the water.

Realizing that I had control back, I climbed away from the icy waters and pointed the nose home. Even though my



WE WERE INCREDIBLY CLOSE TO THE SOUTH MAGNETIC POLE (SURPRISE!). THIS WAS LIKELY THE REASON FOR ALL MANNER OF COMPASS WEIRDNESS. THE SOUTH POLE WAS OUR LOCAL VERSION OF THE BERMUDA TRIANGLE, ATTEMPTING TO SUCK OUR DRONES INTO THE VOID.

Opposite, top: A raft of Adélie penguins scuttles toward a small pool on an iceberg. This species of penguin is the basis of the characters in the animated feature film *Penguins of Madagascar*. (Photo by Simon Ager/Sea Shepherd Global)

Opposite, bottom left: Simon Ager holds a Phantom 4, while Gavin Garrison prepares for takeoff. (Photo by Ashleigh Allam/Sea Shepherd Global)

Opposite, bottom right: The starboard life ring aboard the MV *Ocean Warrior*. (Photo by Gavin Garrison/Sea Shepherd Global)

inputs were creating the wrong results, they were at least consistently wrong, so I was able to guide the Phantom back over the deck and into Simon's waiting hands. Breathing a deep sigh of relief, we packed up the drones for the day. Later, I learned two things. First, we were incredibly close to the South Magnetic Pole (surprise!). This was likely the reason for all manner of compass weirdness; even the magnetic compass on the bridge of the ship had inverted itself. Second, Phantoms should not be flown in Polar Regions (in P mode). This piece of advice that came from a Phantom forum, pointing out there's a Polar Region warning on page 40 of the P4 manual.

More research revealed that others were flying drones in Antarctica—one of the U.S. icebreakers, *Nathaniel B. Palmer*, had a research team specifically tasked with finding out whether they could fly their Inspires and Phantoms from the ship. Another guy posted some video of Antarctica taken with a Phantom 2 from his sailboat. So what was with this Polar Region stuff? After several more hours of reading, it was clear that the issue was our proximity to the South Magnetic Pole, because flying in Attitude mode did not resolve the problems. We'd have to wait until we got away from the pole before we flew again. We later decided that the South Pole was our local version of the Bermuda Triangle, attempting to suck our drones into the void.

FROM HERO TO ZERO (PERCENT)

Weeks later, after putting a fair bit of distance between ourselves and the South Pole, Simon and I again took to the skies—or at least tried to. Finding that neither my Eagle-1 nor Eagle-3 would agree to take off (despite endless compass calibrations), I grew frustrated and decided to calibrate their IMUs, which turned out to be an incredibly bad decision. At the time, I thought that anything, even a shoddy IMU calibration, would be better than repeatedly getting the "Cannot Takeoff" message, but I was wrong. Given that we're on a boat that never stops rocking, the IMUs failed calibrating every time—or said that they had succeeded but really hadn't. Without access to a stable surface on which to do a real IMU calibration, which requires that the drone not move for five minutes while it makes sense of the world around it, my Eagles would no longer fly. Simon, however, had success with his P4; on the next flight out, he was able to capture an incredible vista as we skirted an enormous ice floe. He was also able to capture one of the most beautiful drone photos I've ever seen: a bird's-eye view looking directly down over an iceberg.

On another flight, Simon took his P4 out over the ice to look back on the ship, angling to get the sun behind the camera, knowing that this would make for the best photos. After a flight full of ice, penguins, and incredible scenery, at 44 percent remaining battery, he decided it was time to bring the P4 in. Unfortunately, this was precisely the moment he completely lost signal—both video and RC. A challenging aspect of flying from moving ships, especially small ones, is that, at any given moment, a large block of steel, aluminum, or whatever—in this case, the superstructure of our ship—could move between your transmitter and your drone. As anyone who has attempted to fly around buildings knows, any obstacle between your transmitter and your aircraft is bad news for signal strength.

Simon shot up the outside stairs to the upper deck of the ship, transmitter in one hand, turning in all directions to try to reacquire the signal. After a few seconds, the Return to Home (RTH) function chimed in, letting Simon know that the drone was going to do just that. Unfortunately, "Home" was now about a mile and a half behind us, over open water. Quickly canceling that, we realized that Simon was still receiving telemetry: battery voltage, orientation, and altitude. Using





WILLING TO FIGHT UNTIL THE END, SIMON KEPT INPUTTING MORE THROTTLE AND GUIDED THE AIRCRAFT IN OUR DIRECTION. AS HE APPROACHED, THE BATTERY DRAINED FASTER. A FEW OF THE SHIP'S CREW HAD GATHERED BY THIS POINT AND WERE LINED UP ON THE DECK, READY TO CATCH THE PHANTOM AS IT CAME IN.

Above: A massive ice floe at the edge of the Antarctic continent shows the first signs of the Austral summer. Below: A bird's-eye view of the icy shore of an Antarctic iceberg. (Photos by Simon Ager/Sea Shepherd Global)

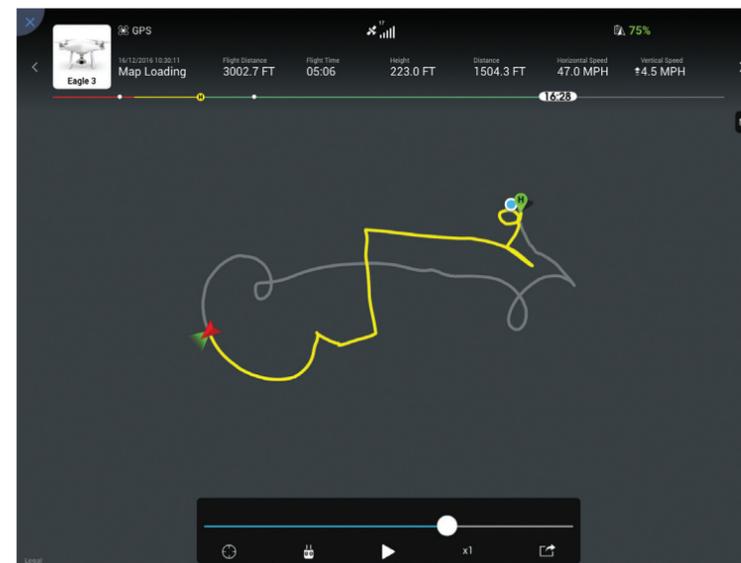


The sun sets over the bridge of the MV Ocean Warrior. (Photo by Gavin Garrison/Sea Shepherd Global)

the orientation arrow, he pointed the P4 in our direction and accelerated at full throttle—only to be told that power output was limited due to the low battery, which was now hovering at about 30 percent.

It occurred to me that we might be able to counteract RTH's forced descent. I suggested to Simon that he input full throttle (up on the left stick, in this mode), and it worked. Instead of plummeting to the ground, the drone actually gained altitude. Now down to about 5 percent, we got an image back on the

Screenshot from the DJI Go app showing the resulting flight path of a malfunctioning compass. (Photo by Gavin Garrison/Sea Shepherd Global)



screen and realized that the aircraft was much farther away than we had thought, but it could see the ship, which was a tiny, glinting speck in the camera's huge 94-degree field of view.

Willing to fight until the end, Simon kept inputting more throttle and guided the aircraft in our direction. As he approached, the battery drained faster: down to 3 percent almost right away. While he was still almost 500 feet away, the battery ticked over to 0 percent and the aircraft was still flying, which I didn't even know was possible (don't try this at home). Undeterred, Simon lined the P4 up over the deck and gave it full down, thinking that at every inch of altitude he might lose power—so the closer the aircraft was to the deck, the better.

A few of the ship's crew had gathered by this point and were lined up on the deck, ready to catch the Phantom as it came in. Antoine, a French firefighter who has endured more stressful situations than this one, leapt in and caught the Phantom by the skids as it plummeted, at 0 percent, onto the deck. He dropped to one knee as he did so, ending in a kind of drone-catch power stance. The crowd erupted into applause. The close call was over, and the Phantom would live to fly another day.

Having learned quite a bit about flying in Antarctica, Simon and I came up with a wish list of items we'd need to knock our flying out of the park, including a new approach that would help us recover the Phantoms intact, even with a water landing. In next month's issue of *RotorDrone*, I'll show you how a few inexpensive tweaks to our setup reinvigorated our flying and enabled us to unleash the beauty of Antarctica in ways that we had never before thought possible.