

Science AMA Series: Schmidt Ocean Institute ROV Team - We are the team that created Remotely Operated Vehicle (ROV) SuBastian, capable of diving 4,500 meters - from original design to first dive - in less than 16 months. Ask us anything!

Schmidt_{Ocean}¹and_r/ScienceAMAs¹

¹Affiliation not available

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Abstract

We work for the Schmidt Ocean Institute, a non-profit established to advance oceanographic research of the ocean through exploration, innovation and data sharing. This is the first submersible vehicle SOI has built. Before SuBastian, SOI rented scientific robots to launch off our retrofitted ship, Falkor (an ex-German fishery protection vessel). Yes, both Falkor and SuBastian get their names from The Neverending Story. Every year we open a call for expressions of interest. Scientists from around the world can apply for ship time, and we're really focusing on high-risk, high-reward, cutting-edge science that wouldn't normally get funded by traditional funding agencies. Humanity still knows very little about the deep ocean. The ROV was built to have the power of a rugby player but the dexterity of a neurosurgeon - it is powerful and precise. It is able to take 4k video, sample underwater thermal vents and collect samples 2.8 miles below the ocean's surface: conditions where where darkness, near-freezing temperatures and intense pressure are just a few of the obstacles, and the ROV is able to stay underwater for days as needed. This summer the ROV crew is testing SuBastian in the open ocean, and in November they will conduct scientific experiments near Hydrothermal Vents in the Marianas Trench. We will be back at 4 pm ET to answer your questions, Ask us anything!

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SCHMIDT_OCEAN [R/SCIENCE](#)

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Very cool! And best of luck to you!

I did some work on ROV Nereus. I recall that there were some interesting design considerations for a vehicle going to the Challenger Deep. Such as: different materials compressing at different rates, ceramic spheres for flotation, and a hair-thin, miles-long fiber optic tether for minimal drag.

- What materials is the body of the ROV?
- What are you using for flotation?
- What is your tether?
- Are your electronics filled with oil?
- Any other engineering challenges that you think are interesting?

Thanks!

[marklar123](#)

The frame of the ROV is aluminium - a balance of cost, manufacturability, strength-to-weight ratio, and

original design to first dive - in less than 16 months. Ask us anything!, *The Winnower* 3:e147256.68717 , 2016 , DOI: [10.15200/winn.147256.68717](https://doi.org/10.15200/winn.147256.68717)

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corrosion resistance. The buoyancy/flotation comes from blocks of [Syntactic foam](#), which has been optimized to be as lightweight as possible without crushing at our designed pressure.

The tether (we call it the umbilical cable) is a steel-armored cable with copper conductors for power, and fiber-optic cables for comms. It's about 19mm in diameter and weighs over 1000kg/km. This type of cable is more difficult to deal with compared to e.g. Nereus, which used a bare fiber optic (very light, and almost neutrally-buoyant in seawater), but the advantages are that it's very reliable, we're not limited by battery capacity, and we can also use it to lift the vehicle in and out of the water.

The majority of our electronics are located in a pair of one-atmosphere titanium pressure vessels. This means that of course we need high-pressure seals and electrical/optical penetrations, but it also gives us the freedom to use almost any available electronics, even if they were never intended for use on an ROV. Some of our other systems, like the hydraulic valve packs, are designed for subsea use, so they have pressure-tolerant electronics inside and they are filled with oil.

Hello! Very interested in your project and will keep track of it in the future. I recently came across the story of the Devils Hole in Nevada ([Wikipedia](#)). It is very interesting to me that nobody knows how deep/large the cavern under the Devils Hole actually is (at least 150 m with currents according to one diver).

I know this ROV is probably not build for a mission into a relatively small cave like that but I still wanted to ask, do you have any idea if ROV exploration of this cave is feasible? Are there tethered ROVs that can be operated in deep caves like that? Do you know about any other teams that do operations like that?

edit: added wiki link

[DeliciousOwlLegs](#)

Ha, we saw that video+thread on the front page as well :) - ROV exploration of places like Devils Hole is certainly feasible. You should watch [Sanctum](#), where they use a SeaBotix LBV tethered vehicle inside a similar cave system.

As other redditors like [divermick](#) mentioned, the logistics of underwater exploration are often much more complicated than simply dropping robots with cameras into the water (and cave dives can be very treacherous). Researchers need to be careful about disturbances to species - several folks mentioned the Devils Hole Pupfish. One comment about "clogging up the hole with ROV's" sounds like a joke, but it is very true that lost vehicles and their tethers become an active hazard on further dives, not just a speed bump.

We particularly liked [experimenters](#) idea of reaching out to people working at the park and experienced ROV operators.

As a software engineer i'm interested in the following:

- what operating system is used on what kind of hardware?
- in what language is the onboard software written?
- what type of radio control do you use to communicate between the sub and surface?
- what bus/interface is used to communicate between the OS and other hardware (motor, steering,...)
- how is the exact position of the sub determined? I guess gps doesnt work underwater?

[oljoner](#)

Because the ROV is designed to operate tethered to the ship, we try to minimise the number of subsea computers. Anything that we can do topside, we'll do topside, because it's safer and easier up there.

Most of the subsea functions are accomplished using microcontroller-based embedded systems, but there are some ARM single-board computers running Linux too. The software is mostly written in C, but some parts are written in scripting languages like Python.

Most of the sensors and actuators communicate using ordinary serial interfaces, like the RS-232 serial port on your computer, or a similar variant called RS-485. These interfaces are not ideal, but they are well-understood and simple to implement, so they've become industry standards. Various systems on ROV SuBastian also use CANbus and Ethernet.

Sadly, water attenuates most radio frequency signals, so any long-range subsea communication needs to be acoustic (sound waves), or through an electrical or fiber-optic cable. ROV SuBastian communicates through fiber-optics inside the umbilical cable (a heavy, armored, cable which also carries the vehicle power).

For positioning, you're right, GPS is out. We use an acoustic system to triangulate the vehicle relative to the ship ([USBL](#)), as well as a gyroscope/accelerometer system for dead reckoning from there ([INS](#)). When we're near the bottom, we also measure our movement over the seafloor, using the same principle as that mouse you're holding, but with sound instead of light ([DVL](#)).

Hi! Thank you for doing this AMA! I have several questions for the team as posed by my children.

(Son) I'm curious about ballast tanks, the pressure at 4,500 meters depth and how the ROV manages buoyancy? Is it similar to a dive vest with air bladders and a pressurized air tank?

(Son) While submarines don't suffer from nitrogen narcosis or the bends, do you have to manage climbs back up to the surface with any delay periods due to the pressure gradients?

(Daughter) Do you plan to do any kind of live streaming of the video signal during the exploration of the vents in the Marianas Trench?

(Me) Finally, can you build a big one so I can go down and ride along?

[Synssins](#)

Super excited that both you and your kids are interested! We do ship-to-shore video calls with classrooms on research cruises as much as possible, so if your children's class (or teacher) is interested, head to [our website] (www.schmidtocean.org) and get in touch!

Son 1 Some similar vehicles use a pressurized ballast tank system, but SuBastian has been designed without the need to adjust buoyancy at depth. We adjust its buoyancy at the surface by adding or subtracting syntactic foam blocks to the vehicle. Behind the side panels, there are compartments where the additional foam blocks are stored. However, we do use spring-loaded compensators to adjust for compression and air bubbles in the oil.

Son 2 One thing that does happen is the oil compensators, mentioned in the previous answer, start to fill back up again. So, as the vehicle descends and the water pressure rises, the oil, and the air bubbles in the oil, compress. The oil in the compensator fills these compressed areas to prevent the oil filled boxes from imploding, due to the reduction in volume. The reverse happens when the vehicle ascends to the surface. But the ascent speed is already pretty slow, so we don't need any waiting periods for this.

Daughter Yes, we livestream all of our ROV dives on our [YouTube page](#) and then they are saved for watching in perpetuity. We also announce all our dives through our social media pages, so you can follow us on Facebook, Twitter, Instagram and YouTube if you are interested in updates.

You How big are you and do you get claustrophobic? :) Well, we hope you will get the experience of a

ride along by watching our livestreams ;)

Edit - too many "you's" in attempt to joke

Hi guys!

First question: what will be/what was the first project to use the ROV from SOI? This sounds like a super useful tool given the purpose of creation, and I'm interested to know what the first applicant will get/got out of it or what their specific intentions are/were for its use.

Second question: Given y'all are a non-profit, might I ask under whom you work? Are you completely non-affiliated, or are you subject to a specific government and its oversight? I will hopefully be working for NOAA soon, so I am interested in the partnerships between groups.

Thanks for your time guys, and best of luck through the remainder of this project and the ROV's use!

[mpcfuller](#)

Thanks for those great questions! 1) We are excited to use ROV SuBastian for our first research cruise this coming November. We will begin with a science verification cruise in mid-November with expert deep-sea biologists from all around the world. More details on this cruise can be found [HERE](#).

Following this expedition, we will conduct our first full science cruise with ROV SuBastian in Guam, exploring the Mariana Back-Arc. We will visit three hydrothermal vents that we discovered last year with Chief Scientists David Butterfield and Bill Chadwick. More details can be found [HERE](#). We're really looking forward to this expedition - last year we discovered rare fresh undersea lava formations and this year we will be looking more intently for new species.

2) Schmidt Ocean Institute is a private not for profit organization, founded by Eric and Wendy Schmidt. We of course are subject to rules and regulations of the Falkor's flag state and comply with all permitting needed to conduct research in the various waters we travel in, which means planning and clearing the expedition with a lot of countries' government bureaucracies.

However, unlike government organizations we have some autonomy to select higher-risk research projects that may not always be funded by traditional government-based agencies. We work with [a lot of partners](#), including government organizations like NOAA as well as universities and labs.

Edit: Grammar

As a software guy and someone who spends every free moment they can on the water here in South Florida, in the back of my mind I'm always looking for opportunities to contribute to open source technology solutions that are being used by researchers, marine scientists and institutes like your own.

I have a few questions:

1. I saw [OpenVDM](#) linked to on your website - what are some other open source projects for me to contribute to?
2. What technologies do you predict will make the biggest impact (for good) on our oceans and marine ecosystems?
3. Besides WHOI and yourselves, what other non-profits are doing the most impactful work?
4. Are there any for-profit companies that are doing exciting things in this space?

5. How much do the deep oceans impact our fisheries and reefs? What are measures that can be taken place to fix any damage that has been done? How realistic is it that this will come to pass?

[codelitt](#)

1. We use a wide variety of open source software on this project, both directly and indirectly. The vehicle and topside systems all run Linux with everything that entails. Our data processing pipeline is also open-source heavy - with OpenVDM as you noted, a video and imaging pipeline based on GStreamer and ImageMajick, and a bunch of lower-level tools that never get any credit. As for what you could best contribute to...
2. The technology I predict will make the biggest impact is not hardware, but scaling of data processing techniques, either through crowdsourcing or machine learning. We've created this vehicle which has a core suite of sensors recording and publishing data for every dive (CTD, depth, O2, temperature), as well as multiple channels of HD and 4K video. Now we have a data reduction problem - we need to identify and study the important bits. We recently used a program called [Squidle](#) designed by the Australian Center for Field Robotics on our coordinated robotics cruise in 2015. This allowed the public to participate in annotation of reef images. Programs like these are bringing science to the public through computer annotation/recognition of images which will be the next wave of technology assisting scientists in obtaining quick and accurate research annotation capabilities.
3. There are so many amazing teams of people working to help better understand and conserve our oceans. If you like ocean exploration and research we encourage you to check out NOAA's Office of Exploration Research Vessel Okeanos Explorer and Ocean Exploration Trust E/V Nautilus.
4. Great question, but right now we have been so focused on SuBastian we haven't been looking up much lately. Space X does exciting things so they might be a good place to look :)
5. We still know so little about the deep oceans that scientists can not provide a definitive answer on their impact to shallower reef areas and fisheries. We have hosted several cruises that have begun to try to answer this questions and you can learn more on our website. I recommend exploring the [Perth Canyon cruise here](#).

Edit - formatting

What are your chances of discovering a new form of life or species ? Do you think about it ?

[pebbelrebel](#)

Yes, the chances are very good and we think about this a lot. We still know so little about the deep sea. In late 2014, we discovered the world's deepest fish at 8,143 m with a [full ocean depth lander](#) that we built. Check it out [HERE](#), we nicknamed it the Ghost Fish and think you will see why. We anticipate several new discoveries, potentially during our first cruise with ROV SuBastian in the Mariana Back-Arc [later this year](#).

Cool! Just to mention, there's a very inactive subreddit called [/r/oceandrones](#) that could use some traffic.

So, from remarks in the first video on your site (unlimited power, can stay down for months), this is strictly a tethered ROV, correct? Are there any provisions for "oops the cable snapped"?

At 1atm/10.33m approximately, 4500m design depth, that's what, 435atm? (Video 5 sounds like one guy says 1600psi and another says 6600psi? I'm assuming the latter is correct.) In addition to the glass

foam block, which I'm guessing is for nearly neutral buoyancy at maximum depth, do you need additional tanks for finer control at higher depths? What sort of pressures do you use in your buoyancy tanks? Or do you have to use something incompressible like large oil-filled pipes, or permanently-sealed steel tubes? Can you give any more information on the glass foam -- adhesives used, what's the coating?

For the pressure vessels for your control systems, I see that they're cylinders -- in another recent AMA on rockets and fuel tanks, it was mentioned that spherical tanks are better able to hold up to stresses for fuel tanks because stress on a cylinder is double the stress on a spherical tank. Is the choice of cylindrical vessels just convenience, or are cylindrical tanks better for when they're under compression? Are the control pressure vessels filled with anything more than air (plus control systems, of course)?

For the cable, is any data being transmitted over the copper, or is it all done over the fiber optics? Do the fiberoptic lines have separate functions, or are all communications able to be sent over any and all of them, with multiples solely for redundancy -- five paths just in case something damages four of them?

Lastly, are there any papers, engineering specs, design documents, full CAD diagrams and all the code on GitHub? :-)

[richardtheassassin](#)

Yes, ROV SuBastian is a tethered vehicle. Safety is our number one priority onboard, and as part of the integration of the vehicle onto Falkor we do a lot of training with the crew and engineering team. This means planning for scenarios where a cable would be snapped, or if the vehicle were to get stuck.

You are right, the syntactic foam blocks are designed to achieve nearly neutral buoyancy at the dive depth (we shoot for slightly negative buoyancy, so the vehicle won't float around if we lose power for any reason). Though some vehicles use ballast tanks as you describe, we use a small amount of vertical thrust to trim our buoyancy instead. Doing this consumes some constant power, but it avoids the need for a separate system.

Again - you're correct in that spheres are the ideal shape from a hydrostatic pressure/materials stress perspective. But boxes are the ideal shape from an off-the-shelf electronics perspective. Our cylinders are a happy medium. We purge the pressure vessels with dry nitrogen to avoid condensation.

The copper conductors are only used for power - 4500V three-phase for the hydraulic pump, and 3300V single-phase for everything else. All of the communications is done over the fiber optics. Right now, we use one fiber (eight wavelengths) for vehicle telemetry, one fiber (three wavelengths) for two 4K cameras, and one fiber (four wavelengths) for four HD cameras, leaving two dark fibers available for spares or science. We haven't implemented any method for real-time redundancy, because systems like that introduce additional complexity and can be points of failure themselves. The fibers are inside their own steel tube deep inside the umbilical cable, so it's really unlikely for them to get damaged. If one of the fibers should fail mid-dive, then we'll just haul up the vehicle and re-terminate it at the surface.

Yes, you can find the specs [here](#) and find more information including the development survey and mission requirements on our website [here](#)

How rapidly can your team respond to a research application? For instance, if an earthquake occurred somewhere underwater how quickly would you be able to get crew and equipment mobilized to do a survey of the area (minus the travel time from port to the epicenter which would be event dependent)? I know it would depend on your experiment schedule which is probably determined months and years in

advance, but since you mentioned that you are filling a niche left by traditional funding agencies I figured I'd see if you could respond more quickly.

[seis-matters](#)

Every year we have an [open call for expressions of interest](#) that are due the first Friday in December. Scientists from anywhere in the world can apply for ship time through this process. The applications are then peer reviewed and approx. 30 are invited back for a full proposal. These applications are for research taking place two calendar years later (e.g.) this December, scientists will apply for ship time in 2019. We have also recently added a [research on transits program](#). This allows scientists to apply for ship time on specific legs that we are doing. There is a much shorter turn around time of six months to a year. We have also been able to accommodate projects of need when we are in the area on case-by-case basis. For example, earlier this year while in Tongan waters we took time to help [NASA map a newly formed island](#).

It looks like only way to communicate with ROV's untethered is by acoustic communication. What is the pros/cons for that?

[Hmolds](#)

You are correct: for long-range untethered underwater communication, acoustic comms are the only practical alternative. Unfortunately, the underwater comms channel is very restrictive compared to free space or open air. Light, radio frequencies, acoustics - everything is attenuated.

The limiting factors for acoustic comms are the distance travelled, the noise of our own ship, the noise of the ocean, and reflections and multipathing. In practice, we can use it for voice transmission or slow data rates (like a 1980s modem), but we don't think it will ever be feasible to transmit real time video over long distances. This is why we have to use fiber-optic tethers or on-vehicle recording.

1. How do you deal with the weight of the tether, when it is fully extended?
2. Would filling ROV with non-conductive oil make it capable achieving any depth?

[texasguy911](#)

The tether weighs about 5-6 tonnes, so when it's fully extended, it hangs pretty much vertically under its own weight (it is supported by the ship, not by the ROV). We do use a system of floats near the ROV end of the tether to stop it weighing down the vehicle when it moves away from the ship. To maintain any kind of air (or other compressible) spaces down there, the ambient ocean pressure needs to be supported by something. When we fill some of our enclosures with oil (and allow them to equalize with the ambient ocean pressure), this just moves the burden of supporting the pressure away from the enclosure itself and on to the parts inside. In many cases, it can be smaller/lighter/cheaper/easier to design the internals to support the pressure, rather than the enclosure, and we call this [pressure-tolerant electronics](#). But if you need an air space inside any component, the pressure will always have to be supported by something.

Hey there!

I've lately gotten hooked on some live ROV feeds on YouTube, and they got me wondering -- would it be feasible to add a compartment onto an ROV containing an auto-focusing microscope? Maybe it could use a special arm that would reach out and clamp a sample between two glass slides. Then it would retract and insert the slides under the 'scope. Do you think such an addition could help much in

characterizing deep-sea ecosystems?

[OmniscientTexan](#)

A lot of our scientists are interested in studying the environment in-situ as you describe. But creating a subsea microscope is really tough. If it operates in an air volume inside a pressure vessel, then you need a way to move the sample from the high-pressure environment into the microscope chamber - this kind of thing is possible to do, but it's pretty difficult and expensive. A lot of our equipment avoids this problem by filling with water and operating at the ambient ocean pressure instead. But for cameras and microscopes, this is really tough because common lens materials have a refractive index close to that of water, so they lose most of their lensing ability in water. It's not ideal, but with the technology we have right now, it's much easier to bring samples back to the surface and analyse them on the ship or shore. Hope you are getting a chance to check out SOI's archived dives on our [YouTube page](#).

How big is the ROV, physically?

[burgleshams](#)

ROV SuBastian weighs approximately 6,500 lbs. And is the size of a small minivan, dimensions 8' x 6' x 7'

What do you think the key things were that enabled you to design and build it so quickly?

[marklein](#)

We maintained a strict requirements list, and avoided a lot of potential for scope creep. This allowed us to focus on the critical items, and not cause our schedule to extend past what we set out in the beginning. We also tried to use as much proven technology as possible, while still trying to be innovative and produce a top of the line vehicle.

Hey there! Super interested in this project. I'm currently taking the ROV/AUV program at Marine Institute in Newfoundland, Canada.

Any advice for someone getting into the industry? Focus on electrotech, hydraulics, piloting...?

[joshconan](#)

These are all feasible paths into the industry. If you want to work on ships offshore, you could become a pilot/tech (almost every pilot started as a tech). You'd need a basic knowledge of everything - electronic, hydraulic, mechanical. You don't need to design whole systems, but you'd need to be able to understand and operate them (with training). Alternatively you could come from the engineering side, typically specializing in electronic or mechanical. You'd spend less time off-shore, and more time in a design office - it's type 2 fun. Whatever floats your ROV.

Since there are a number of ROVs available for rent and a handful of companies out there that make commercial ROV units, why did you decide to make your own? Is there some major shortcoming that all the others have? Were none of the existing vendors willing to work with you?

I tried to get hired by a few of the ROV companies and their end users back when I first came out of college. Didn't work out, but it seemed like an awesome line of work!

[yacht_boy](#)

Great question! We wanted to build an ROV that was designed to work with our research vessel *Falkor* and that was modular enough to accommodate the unique and cutting-edge science that takes place onboard. Because each cruise is unique and with different science needs, it was important to design something that had space to add on instrumentation. ROV SuBastian also has 4K cameras which allow our team to get the highest resolution possible, helping scientists on board to better view and navigate the deep sea. By building a vehicle in-house, we were able to learn and train our own team, which would be critical for the building of any future underwater vehicles. And yes, it is an awesome line of work - with lots of excitement and challenges.

I work as a commercial diver in the Gulf of Mexico. How long do you think it will be before ROV's have taken all of my work?

[DamnNearRectum](#)

As you know, meatbags are inherently limited to hundreds of feet (slightly deeper for saturation divers). And if we have to put you in an atmospheric diving suit, then you lose most of the flexibility and dexterity benefits of being human. But designing electro-mechanical things which work underwater is hard, and I think there are so many and various intervention tasks that divers will always be required for shallow operations.

ROVs, AUVs, and human-occupied submersibles are the only practical ways to reach deep sites. This vehicle is designed for use at 4500m depths, which is many times deeper than any human diver could possibly achieve. Some research groups send scientists to similar sites in submersibles, which must be an amazing experience. But from a scientific perspective, we can achieve more with less by deploying a telepresence vehicle from the comfort of our shipboard control room.

How much does it cost to operate a submersible per day? I remember reading Alvin cost ~\$50k figures per day to deploy.

[TrillianSC2](#)

Well, the nice thing about Schmidt Ocean Institute is that we are a non-profit that offers scientists shiptime at no cost. What that means is that they do not have to pay for the use of [R/V Falkor](#) or any of the equipment on board including ROV SuBastian - we do not provide monetary grants but the access to our ship and ROV is completely without cost (fuel, food, crew, etc). As stated above, these are the costs that really add up when you are out at sea for weeks at a time. It is hard to put a number on the value of all the knowledge we gain with each expedition - in we're hoping that having an ROV distributing open source information will be priceless!

HI SOI!

What are some of the most important design features you had to consider when designing the SuBastian? What was one of the most difficult design compromises you had to make?

Thanks!

[paradiddle65](#)

The ROV was purpose-built for scientific research, with multiple interfaces that scientists can plug into, and designed to carry payloads useful to scientists, including various sensors and containers. The

biggest design challenge that the team faced was creating something that worked with the space constraints of [R/V Falkor](#) when making the plans for ROV SuBastian. We also had to build the vehicle in a very short amount of time, while making sure that the ROV was lightweight, but could handle a variety of science instrumentations, cameras, etc.

Hey, your project is very interesting and revolutionary I must say. My question is what do you think of the future prospects in this industry?

[Exile21](#)

There are very few ROVs globally that can go down to full ocean depth (11,000 meters). The pressures at these depths are so great, and designing a vehicle that can perform the needed tasks for science while operating in these challenging environments is very difficult. With improving technology, syntactic light-weight foam, and new vehicle designs, we feel this will be an important component of future design and research. Additionally, annotation capabilities of the ROV video with computer recognition of species is another area of interest and research and the present moment.

Greetings.

This is a great first step, but when do you see yourselves supporting the full ocean depth ROV that was planned?

Doing so would be a great, world-leading, unique capability now that Nereus is no longer with us.

[Wrathchilde](#)

Yes, having a full-ocean depth ROV is a high priority for the oceanography field. Our engineering team first wanted to see if we could build an ROV for research vessel *Falkor* in a timely and efficient manner using the existing technology. Now that the vehicle is built, we are going to spend the next year ensuring that the science teams on *Falkor* make good use of the vehicle as we continue to learn from this build. We will spend this time assessing our capacity to continue with possible plans of a future vehicle.

What are your thoughts on the practicality of deploying an ROV on the Saturnian moon Titan's Kraken Mare?

Aside from engineering challenges, a Titan ROV out of necessity would operate nearly autonomously. Does SuBastian possess any self-directing guidance programs or is it entirely operated by a crew onboard *Falkor*?

[mahayanah](#)

Exploration of oceans on other planets with AUV's is a very real possibility. Some of us joke that that ROV/AUV exploration in Earth's oceans is just a trial-run or stepping stone to these interplanetary missions. ROV SuBastian will not be headed into space, and it does not have enough autonomous guidance programs to operate without a pilot.

Is your ROV tethered or free swimming? If free swimming, what do you use for communications back to the surface? If tethered, how big/what diameter is the tether? How do you avoid it becoming too much mass for the ROV to tow around?

[shiningPate](#)

SuBastian is a tethered vehicle. The umbilical is about 19mm in diameter. We utilize a catenary system to decouple the vehicle from the surface vessel, which helps reduce the drag of the umbilical, within a certain range from directly below the surface vessel. The catenary system is created by attaching fourteen floats to the umbilical, allowing the bottom ~100-200m of umbilical to be neutrally buoyant.

In basic terms, the vehicle only has to pull this lower section around through the water column until it gets too far away, and then starts pulling on the main section of umbilical. In reality, the vehicle is always pulling on the main section of umbilical as well, and the load increases as the vehicle gets farther away from directly below the ship.

I'm very concerned/involved in Human-Caused Climate Change,

How's the health of the world's oceans?

Any possibility of an entire ocean crash, making the ocean devoid of all life? (Krill disappearing, <http://www.scientificamerican.com/article/krill-are-disappearing-from-antarctic-waters/>, coral bleaching, radioactive waste, etc.)

[StonerMeditation](#)

This is a very important question that involves so many elements. We couldn't possibly answer this with a yes or no, as there are numerous considerations. We have had several cruises that address climate change and its effect on the ocean. I would recommend taking a look at some of the comments from the scientists during these cruises and their findings via the cruise logs.

[First exploration of Perth Canyon](#) - on this cruise scientists looked at the impact of warming ocean temperatures on deep sea corals.

[Timor Sea Reef Connections](#) - on this cruise scientists examined the remote Scott Reef and coral dynamics. This reef has since experienced major bleaching as a result of last years El Nino (details [here](#)) The data that we collected on this cruise, will serve as an excellent baseline prior to bleaching.

[Investigating Life without Oxygen in the Tropical Pacific](#) - on this cruise scientists explored oxygen dead zones in between Hawaii and Tahiti ([Here](#) are some great overview videos related to the cruise findings).

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Thanks for this link and information. Schmidt Ocean Institute is committed to open sharing of information. All data collected on our research cruises is publicly published (<http://schmidtocean.org/technology/data-management/>) and you can see what is happening on the ship in real time [here](#). We also live stream all ROV dives in perpetuity, and these can be found by cruise on our [YouTube page](#).

A lot of us would be curious to know what is next on the schedule for the ROV? Is there any chance it can be sent down Devils Hole in Death Valley National Park?

[LittleNatch](#)

We are excited to use ROV SuBastian for our first research cruise this coming November. We will begin with a science verification cruise in mid-November with expert deep-sea biologist from all around the world. More details on this cruise can be found [here](#) Following this expedition, we will conduct our first full science cruise with ROV SuBastian in Guam, exploring the Mariana Back-Arc. We will visit three hydrothermal vents that we discovered last year with Chief Scientists David Butterfield and Bill Chadwick. More details can be found [here](#) We also just released our [2017 cruise schedule](#), most of which will include use of ROV SuBastian.

Unfortunately we will not be using the ROV in Devil's Hole.

Got any pictures or videos of SuBastian?

[iAmNotARobotDamnl](#)

We keep [galleries](#) of photos, videos and podcasts to detail our expeditions and technology, as well as programs such as SOI's [Artist-at-Sea](#). and just for redundancy - here's a direct link to the [SuBastian gallery](#) Thanks sockpuppets and TechnoBill2k12

Edit: Link formatting+Grammar

At depths of 4,500 metres what is the pressure (in layman's terms) that your ROV can withstand, and how much time can it survive down there for? Also since any life down there will not be used to artificial light coming from the ROV how are you limiting your environmental impact at those depths?

[ScienceLit16](#)

The pressure must feel something like having a bus parked on your thumbnail - maybe two buses. Or you could imagine having a 4,500m high bucket of water balanced on your head. The ROV materials are designed to withstand that pressure indefinitely, without absorbing water, so we expect that it could survive there for a very long time. In practice, our dive durations are limited by the piloting, crew and ship constraints - we'll typically dive for 8-12 hours at a time. Our impact on the environment is a big consideration for any dive, not just artificial illumination, but also acoustic noise, and even our physical presence, prop wash etc... Sunlight hardly penetrates beyond about 1000m, so artificial light is a necessity for filming and imagery. Fortunately, many of our subjects don't have eyes.

Any plans to go roving under Antarctica?

[maileek](#)

At this point, we have ROV SuBastian and R/V Falkor scheduled till 2018 with no plans to go to Antarctica. Our location choices are dependent on the proposals we receive during the open call for expressions of interest every year. To learn more about how to propose a cruise please check out our website [here](#)