

# Public Invention Annual Report, 2020

-- Robert L. Read, 1/25/2021

This is the annual report of Public Invention for 2020. It mentions a small part of January 2021, in which we held our annual Conference.

## Executive Summary

- Fundamentally, Public Invention positioned itself at the center of the open source response to the COVID-19 pandemic, particularly in the ventilator shortfall. Public Invention is now mentioned in the same sentence with much larger organizations, such as Helpful Engineering (HE) and Open Source Medical Supplies (OSMS).
- Our major project, the VentMon T0.3, shipped 20 units free of charge to teams all over the world, some of whom used it successfully. We basically fulfilled our obligation under the MOSS grant, and have spent about \$19,000 of the \$20,000 grant manufacturing and shipping these units.
- We are ordering parts to make 15 units of the improved VentMon T0.4.
- Public Invention has also provided thought leadership in the form of a [major essay](#). Additionally, we have pushed for standardizing software across the world via the PIRDS standard and by co-leading the VentOS project.
- In response to a learned need, we created a new project to build an open source Oxygen Concentrator.
- We launched the “Wet Poo” Stay-at-home-Stem project, which has so far flopped. However, a team for Rice University is working on a mini incubator, similar to our own Moonrat project which is making progress.
- Our robot publication with Avinash Baskaran was accepted to the now virtual ICMME conference, and I will present it in November. Rob Read, Lauria Clarke, and Geoff Mulligan sent a paper on the VentMon to the peer reviewed journal HardwareX, which asked for revisions, which have been re-submitted.
- We have \$39,000 in cash on hand.
- The PolyVent ventilator project has joined Public Invention, bringing us a new project with a great Invention Coach, Victor Sutin, and 10 new volunteer engineers.
- We hosted a successful conference on Jan. 9th which was attended by 66 people.

## Welcoming Four New Board Members this Year

Public Invention is happy to welcome four new board members:

1. Dr. Sarah Benson-Konforty, MD,
2. Victoria Jaqua, registered radiology technologist.
3. Dr. Sabia Abidi, PhD, of Rice University,

4. Avinash Baskaran, graduate student at Auburn University.

We thank Mr. Keeshan Patel for his service on our board. The complete list of our current board can be found [here](#).

## Hiring an Outreach Coordinator

A major milestone occurred when we hired Rachel Carp, recent graduate of Tufts University, to act as an executive assistant and outreach coordinator. We are paying her \$20/hour for approximately 10 hours a week. Rachel has supported the “Wet Poo” project, interviewed Lauria Clarke, and helped with your social media promotion and the constant adjustments and updates to our website that we require.

## Context: The Global Ventilator Shortage

In March of 2020, humanity did not know how to treat COVID-19, and we did not know how easily transmitted it was. We have since learned a great deal. In March it seemed possible that many in the “West” might die due to a lack of ventilators, because the pandemic seemed to require a high percentage of people to be invasively ventilated. We now know this will likely not occur, for four reasons that were not known in March:

1. The disease produces low pulse oximetry readings which are not life-threatening but would be life-threatening indicators for invasive ventilation if produced by other causes.
2. Steroids work, at least partially.
3. Social distancing works, at least partially.
4. Large corporations, such as Ford, GM, Dyson and Tesla produced some 50,000 extra ventilators.

We must therefore now ask: should we continue working on ventilators? I believe Public Invention should, because:

1. We have learned a great deal, especially on the VentMon project, which has not yet been fully documented. To leave this undocumented is to miss a great opportunity.
2. The ventilator shortage remains a serious problem in the developing world. However, there are other pressing shortages as well, such as therapeutic oxygen. Supplying ventilators alone may not directly save very many lives, but it will help.
3. We can contribute to and lead a movement to create open source medical supplies.

## Projects

A majority of Public Invention’s work is organized into projects; our main mission is to invent things that help all people. These are our most active public invention projects:

## Covid19 VentList

The COVID-19 VentList continued to be extremely influential into July, but interest has now decreased. This project is a large [spreadsheet](#) that evaluates every known open source pandemic ventilator project. For a time, this was a critical resource in drawing together the community from disparate teams. It has been widely mentioned and praised, including by Dave Jones of the famous EE Vlog YouTube channel. Much of this work was done by public inventors Avinash Baskaran, Keeshan Patel, and Enrique Villacres. This project seems to be drawing to a close.

This project is a starting point of a [published academic project](#) by several students at Fraunhofer IPK in Germany which has interviewed a representative sampling of fourteen of the ventilator teams.

## VentMon

The VentMon project has been the main effort of myself since March, and was only possible due to extraordinary contributions from volunteer public inventor [Lauria Clarke](#), who has now taken a job.

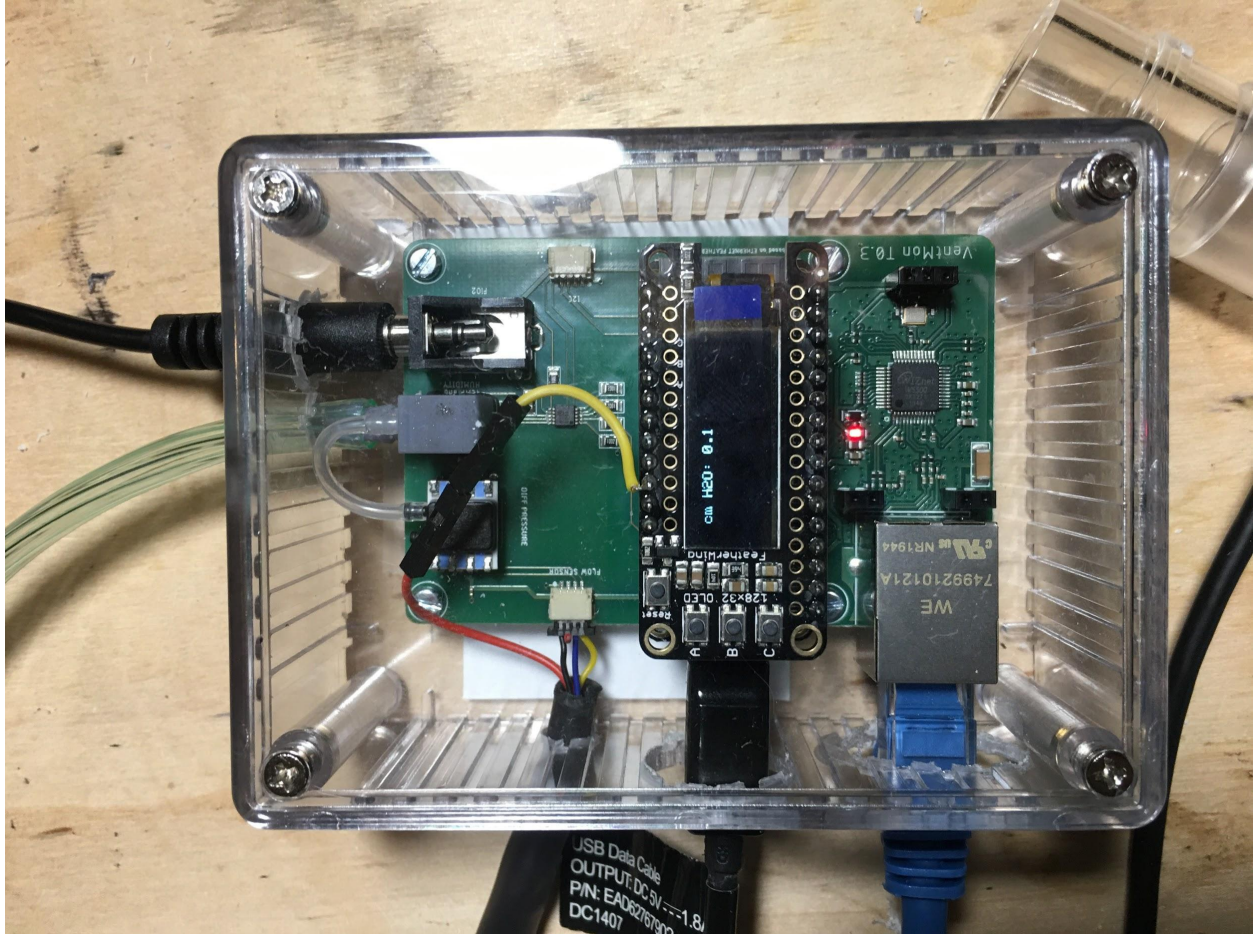
The VentMon is a tester/monitor for non-invasive and invasive ventilators. It measures most of the parameters a doctor needs to treat a patient with a ventilator, computed from a complete pressure and flow curve which it draws. Being completely open source, it could be incorporated into existing designs. However, we also received two grants to distribute VentMons free-of-charge to any team working on pandemic ventilators. We have distributed 20 such devices all around the world so far. The parts on VentMon cost about USD\$500. Including development costs, we have spent all of the money. The most restrictive grant was \$20,000 from the Mozilla Open Source Software Foundation; we will soon have successfully completed that project.

serial number	assembled by	owner	organization	MOU Signed	Nation	ship date	Usage Notes
001	LC	Rob Giseburt			USA	05/01/2020	Used for calibration
002	LC	Artemio Mendoza	ARMEE		USA	05/01/2020	Very successful use, referencable
003	LC	Trevor Smale	OpenLung		Canada	05/12/2020	Not sure in use
004	LC	Ethan Chaleff	RespiraWorks		USA	05/12/2020	Lost it
005	LC	Trevor Smale	OpenLung		Canada	05/26/2020	Not sure in use
006	LC	Ethan Moses	PopSolutions	Y	USA	06/23/2020	
007	LC	Ben Coombs	OxyCon	Y	New Zealand	06/23/2020	Used for oxygen concentrator
008	LC	Erich Schulz		Y	Australia	06/23/2020	

009	LC	Daniel Querol	Respirador-D Q3D-NICA	Y	Nicaragua	06/25/2020	Used to settle on design
010	LC	Bryan Glezerson	GlobalVent	Y	USA	06/25/2020	Alan Cohen seems happy with it
011	RLR	Martin Shetty	Respiraworks (East Coast)	Y	USA	9/5/2020	
012	RLR	George Kenefati	3DPaV	Y	USA	9/5/2020	Returned unused
018	RLR	Patrick Wilkie	gVent	Y	Canada	9/10/2020	
016	RLR	Gregor Tiemeyer	DIY-Beatmungsgerät.de	Y	Germany	9/8/2020	Used heavily and improved
017	RLR	Gregor Tiemeyer	DIY-Beatmungsgerät.de	Y	Germany	9/8/2020	
014	RLR	Tulasi Ravuri	Respiraworks (India)	Y	India	9/8/2020	Trying to connect
015	RLR	Tulasi Ravuri	Respiraworks (India)	Y	India	9/8/2020	
013	RLR	Adit Yargop	VentilLabs	Y	India	9/8/2020	
019	RLR	Seifallah Ben Ismail	Tunisia	Y	Tunisia	9/28/2020	
020	RLR	Victor Suturin	Polyvent	Y	Austria	10/2/2020	

We also got \$20,000 from Protocol labs, with less restrictive terms. We have used this money to support the VentCon and VentCon QA conferences, as well as other projects. We will spend the rest of this money on the VentMon if there continues to be demand for it; if not, we will pivot to spending on oxygen concentrators and other needy projects.

The VentMon has been underutilized. Three of the teams to which we sent it relied very heavily on it, while other teams have not used it as extensively as we hoped. This is common for test equipment. Therefore, I consider the VentMon successful in terms of influence, but only partially successful in terms of impact. Nonetheless, as Ben Coombs points out, it is one of the few pandemic response ventilator projects begun in March which is actually shipping, even though it is not a ventilator and is not ready to be used on patients.



The VentMon T0.3 as assembled by Rob from the PCB designed by Lauria

## Ventilation Standards and Utilities

Although they have received scant attention so far, I am quite proud of the unglamorous work of developing published standards to be used freely by the whole world. The problem of open-source ventilation demands such a standard, particularly around representing respiration data, so we have created the [Public Invention Respiration Data Standard \(PIRDS\)](#). This is a conceptual standard which has a JSON and byte-level binding. It is used by the VentOS project, as well as being used in the VentMon. Generally, once people become fully aware of it they tend to accept it; however it currently has little mindshare in the community.

It is consumed by [VentDisplay](#), yet another open source repo we have created as part of our attempt to modularize the entire communal approach to open source ventilators. Another example of this is a nascent work: “[Dynamic Flow at Pressure: A Potentially Useful Concept for Pandemic Ventilators](#)” and the [Public Invention Respiration Control Standard \(PIRCS\)](#). Following best practices in open source software, we prefer to release many small composable projects, so long as they may have independent utility. A further example of this is a utility originally written by Geoff Mulligan, the [PIRDS-logger](#).



## PIOC -- Public Invention Oxygen Concentrator

One of the learnings of the global health community in the COVID-19 response is that in addition to ventilators and other medical supplies which are in short supply, having sufficient therapeutic oxygen on hand is necessary and may be a critical shortage in some locales. According, Mr. Ben Coombs of New Zealand suggested the creation of a new Public Invention project, [PIOC](#), to build a cheap and reliable open-source oxygen concentrator on approximately a 20-bed scale. Public Invention has spent a few thousand dollars supporting this effort.

## Patient Inflating Valve

Public Invention 2019 inventor of the year Avinash Baskaran has moved to Auburn, Alabama to attend graduate school in robotics there. In addition to helping with the critically important COVID-19 VentList project, Avinash completed another small project, a stand-alone [patient inflating valve](#), that is more important than its modest size may indicate. Many pandemic ventilator teams did not recognize the need for a valve.

## Moonrat: A Portable Incubator

A portable, battery-powered incubator allows bacterial analysis of drinking water, a special concern to Public Invention and Engineers Without Border due to the severe burden of water-borne diseases around the world.

During the summer, public inventor Sam Daugenbaugh worked with Invention Coach Chris Ferguson to build a portable, highly programmable incubator. He developed a functional breadboard-level prototype. Breadboard prototypes are fragile and can't really be used for field testing. We have code-named this project "[Moonrat](#)"---a slang term for an opossum, the only North American marsupial which completes gestation in a warm pouch. (Get it?)

New Public Inventor Halimat Farayola has just begun making software improvements to the Moonrat. She may design a physical enclosure as well. Interestingly, this work is proceeding in parallel with the Rice University Minicubator team, who may use her work as a starting point. Public Invention has never attempted this before; it is an experiment in University cooperation and team organization that we hope will be a fruitful learning project.

## Wet Poo: A Stay-at-home STEM Project

I am very proud of the [Wet Poo project](#), but at the time of this writing it is a complete flop. The idea was conceived by Shreya Bhatia in response to schools being partially shut down, forcing science education to use new channels and media. For students stuck-at-home, we created a

fun hands-on activity to learn about both water quality and basic biological plating techniques. For a \$20 donation, we will mail you a complete kit to allow a youngster to inoculate and culture E. coli and coliform bacteria from a local stream or pond. We hope to mail out 20 such kits. Volunteer Jerry Chang worked very hard with me to create what I consider to be an [excellent video](#).

At the time of this writing, we have at most 5 takers of this excellent project. We are continuing to learn how to promote it. We believe at present it is a great project that will be successful---if we can figure out how to reach the right audience. We have decided to shift our focus toward marketing to teachers to use in classrooms, but we have yet to begin our new marketing campaign.

When started in March, we conceived of this as a fund-raising project that would promote the Public Invention brand. At present, we don't really need the small amount of money it would raise---but do believe it is a gift to students stuck at home, and plan to continue promoting it.

## Math Tablet / Euler Notebook

The Math Table project has been renamed "Euler Notebook". David Jeschke and I did limited work on Euler Notebook due to the pandemic and other priorities. However, we recently returned to work on this project, and have made some interesting progress.

## PolyVent

On January 27th, the [PolyVent](#) team of 10 engineers and Invention Coach Victor Sutin accepted our share-alike licensing policy and agreed the PolyVent ventilator project would become a Public Invention project. Of the coming months we hope to fully support and accelerate the PolyVent team. The addition of this project means Public Invention is supporting all of the pieces needed to make a complete, FDA-approvable ventilator design.

## Outreach

From inception, Public Invention has planned to hold events and publish inventions through peer-reviewed academic publishing and non-peer-reviewed popular media.

## Vent-Con, Vent-Con QA, and Public Invention 2021 Conferences

On May 21st, Public Invention hosted [Vent-Con 2020](#), the first conference on open source pandemic ventilators. This was made possible by volunteer Deepti Sharma with the assistance of Avinash Baskaran and Enrique Villacres-Perez. The conference had no less than 115 attendees throughout the whole 3.5 hours. It had 15 esteemed and renowned speakers, and me. It was co-hosted by [Make Magazine](#) and [HelpfulEngineering](#).

We followed this success with a separate conference, [Vent-Con QA](#), also co-hosted by [Make Magazine](#) and [HelpfulEngineering](#) and emceed by Mr. Ben Coombs of New Zealand. Although smaller, having some 50 participants, this conference was also successful in its way.

A third conference has now been instigated, which we will co-host with Open Source Medical Supplies as the likely primary sponsor. Public Invention helped instigate but did not co-host [Supply Shortage Solutions Symposium](#) on Nov. 12th.

On Jan. 9th (of 2021, not 2020, but reported here in the 2020 report) we hosted the first annual [Public Invention Conference 2021: Work to be Done](#). This reviewed all of our projects and had 66 participants. It very successfully fostered a number of conversations, and seems to have brought us some new volunteers as well.

## Peer-reviewed Publications

Based in part on the Covid19 VentList project which gave us perspective, I co-authored this short “letter” in the journal *Anesthesia*.

*The importance of characterising dynamic response and inertia in potential rapidly manufactured ventilator systems.* *Anesthesia*. Schultz, E. B., Read, R. L. doi: 10.1111/anae.15190 <https://onlinelibrary.wiley.com/doi/full/10.1111/anae.15190>

Public Invention volunteers Enrique Villacres and Megan Cadena have begun authoring a [longer version of this work](#) based on careful simulations using the MatLab Simulink software starting with an open source model from MIT.

When the pandemic struck in March, Avianash Baskaran and I quickly found a temporary stopping point for our work on the Tetrobot and Tetrocon demoed at last years retreat, which was accepted to the International Conference on Mechatronics and Mechanical Engineering ([ICMME 2020](#)). As mentioned earlier, this conference is in Singapore, but was luckily virtualized. I presented [this paper](#) in late November virtually.

Lauria Clarke, Geoff Mulligan, and I sent a [paper on the VentMon](#) to the peer reviewed journal HardwareX, which asked for revisions, and has been re-submitted.

## Popular Media

I was nominated for four “Noonies” --- writing awards from hacker noon, mostly around COVID-19. (They have 80 categories, so this is not so great an honor.) Apparently I did not win.



Make Magazine kindly published a long essay authored by myself and others:

[The Pandemic-inspired Case for an Open-Source Medical Hardware Ecosystem](#), which reflects significant learnings and proposes a path forward for open source medical devices. Public Invention intends to support these issues but will not deviate from its main mission to do so. I was invited to a [panel discussion](#) as part of Dale Dougherty's "Plan C" program focusing on the community response to the COVID-19 pandemic. This work was co-authored with Mark Roden of Tetra Bio Distributed and Victoria Jaqua and Agenla Forgues of Open Source Medical Supplies This is an example of our partnerships and cooperation with other organizations.

## Partnerships and Cooperation

Public Invention believes the future of invention is open collaboration; in that spirit, collaboration with other organizations is important to our mission, both for learning and teaching.

I have accepted a seat on the Board of Directors of Helpful Engineering, a closely aligned organization. Although this will take some time, it will assure the two organizations cooperate.

Additionally, I spoke at a [COSMIC](#) livestream, increasing our connection to that organization.

## Public Invention Projects at Rice University

Rice University has had two teams select Public Invention-defined projects as senior engineering capstone projects. The first, "Ecopot", is an attempt to build a more efficient cooking pot for the one billion people who still laboriously cook on open campfires, leading to pollution and carbon emissions. The second, "Minicubator", is an extension and continuation of the [Moonrat](#) project begun by public inventor Sam Daugenbaugh, senior EE at the University of Texas, and continued by public inventor Halimat Farayola, which in turn was based on [work I did previously](#) with Engineers Without Borders Austin.

One of the beauties of free-libre open source development is its ability to support both tight and loose cooperation. Although I am mentoring these teams, they are not "Public Invention Projects", and the Rice teams may take the work in different directions, bound only by the normal legal license on all of our work.

## VentOS

I am a co-leader of the VentOS (Ventilator Operating Software/Open Source), a project of HelpfulEngineering. This is not exactly a Public Invention project, but is aligned with our other work, and strengthens our connection to HelpfulEngineering.

# Slow Social Media Growth

Despite our efforts, our social media presence has not grown as much as we would like:

1. Our [YouTube](#) channel has 128 subscribers.
2. Our [Twitter](#) handle has 76 followers.
3. Our [Google Group](#) has 48 members.
4. Our [LinkedIn](#) page has 78 followers.

## Finances

At this time we have slightly more than \$39,000 in cash, although \$11,000 of that is obligated to the VentMon T0.4. We have spent about \$20,000 of the VentMon grant from the Mozilla Open Source Software Foundation. We have spent about \$3,000 on parts for the OxyCon project. We have been spending small amounts of money on the Wet Poo Stay at Home Project on Twitter and Facebook as an experiment in marketing.

Because the grant from Protocol labs of \$20,000 was for the VentMon as well, I have earmarked at least \$23,000 remaining for pandemic response. However, I believe a pivot to therapeutic oxygen and other projects is warranted if we get no more requests for the VentMons. (The VentMon PCB is most inexpensively purchased in blocks of 15 or more.)

## Awards for 2020

Almost everyone who works for Public Invention does so as an unpaid volunteer. It is therefore especially important that we honor their contributions, and occasionally those outside our own community. Please join me in congratulating the 2020 winners of recognition from Public Invention:

Pierre Lonchamp  
Special Recognition, 2020  
For QA/RA Assistance to the Entire COVID-19 Pandemic Response Community

Erich Schulz  
Special Recognition, 2020  
For Community Leadership to the Entire COVID-19 Pandemic Response Community

Halimat Atinuke Farayola  
Best New Public Inventor, 2020  
For the Moonrat Project

Marc T. Jones  
Most Active Board Member, 2020  
For the FDA sharing proto-license and Libre Planet 2020

Megan Cadena  
Best Addition to a Research Paper, 2020  
For “Modelling the impact of rise time on ventilator performance”

Avinash Baskaran  
Best Academic Publication, 2020  
For “Controlling a variable geometry truss tetrobot with an isomorphic puppet controller”, ICMME 2020

Juan Enrique Villacres-Perez  
Best Student Contribution, 2020  
For COVID-19 Vent-List and “Modelling the impact of rise time on ventilator performance”

Jerry Chang  
Best Educational Media Production, 2020  
For Rapd E. coli Video Production

David Jeschke  
Invention Coach, Honorable Mention, 2020  
For the Math Tablet Project

Chris Ferguson  
Best Invention Coach, 2020  
For the Moonrat and Rapid E. coli Projects

Ben Coombs  
Greatest Contribution, 2020  
For the PIOC, VentMon, and VentOS Projects

Lauria Clarke  
Best Public Inventor, 2020  
For the VentMon Project

## Strategy for the Coming Year

Public Invention quickly pivoted to address the COVID-19 pandemic, and in hindsight this seems like the right thing to have done. Not only did we get the opportunity to play a role in pandemic relief, but our efforts have led to greater impact and influence for Public Invention.

Although the pandemic shortage has abated in the developed world, I continued working primarily on the pandemic ventilators for the remainder of 2020, but began working with David and Chris again on MathTablet and Rapid E. coli detection-related projects.

Having invention coaches Ben Coombs, Chris Ferguson and Victor Suturin leading projects is a major expansion of our operations compared to last year.

In the longer term, the general plan remains the same:

- Utilize events and writing to promote Public Invention
- Continue to recruit coaches and to focus on making invention projects successful
- Prioritize projects that address global warming and global health issues

At the board meeting of Jan. 9th and a meeting there after we did additional work to sharpen our strategy which is still under discussion.

## Conclusion

We have achieved several of the goals we set at the end of 2019. Compared to 2019 we have:

1. An expanded and strengthened board.
2. A much stronger record of peer-reviewed academic publications.
3. More money (\$39,000 vs. \$19,000) and a demonstrated ability to win grants.
4. Much broader recognition within the field of COVID-related Humanitarian engineering.
5. More invention coaches (5 vs. 2).
6. Thought leadership in the field of open source medical devices in general and mechanical ventilation in particular.