OpenPAPR
Open-source ecosystem for a modular Powered Air-Purified Respirator (PAPR)

https://github.com/OpenPAPR

OpenPAPR Team

April 2, 2020
Motivation

“True PAPRs are in short supply nationally.”
– Dr. Robinowitz, UCSF Anesthesiologist

"He, like most of us, are currently working under the assumption that most people are Covid19 positive and asymptomatic, but in order to save our dwindling supplies of PPE, are only using them for known cases of Covid19. In order to safely intubate all patients he had to jerry rig his own gear. He put on a CO2 sampling nasal cannula. He then put on a regular old plastic bag on over his head with a seal (you can see he taped it tightly around his neck). He ran the oxygen at 10 L/min. He sampled his CO2 to monitor. He did this for 10 min (long enough to intubate a patient). THIS is what we have to do because we have no PPE. I am horrified. I cannot even begin to know if this is safe and cannot recommend it. But, sure, we'll be safe with bandanas, scarves, and homemade cloth masks. (That, folks, is sarcasm). For my friends who are fellow physicians, please be safe, and for those of you who are not, please call or tweet or write your elected officials to demand that we are given adequate equipment in order to treat you safely"
Inception ~ Mar. 21, 2020

From: eecs-profs-request@lists.eecs.berkeley.edu <eecs-profs-request@lists.eecs.berkeley.edu>  On Behalf Of Stuart RUSSELL
Sent: Saturday, March 21, 2020 3:57 PM
To: adi@eecs.berkeley.edu
Cc: Niloufar Salehi <nsalehi@berkeley.edu>; Rikky Muller <rikky@berkeley.edu>; Michel Maharbiz <maharbiz@berkeley.edu>; Nicholas Weaver <nweaver@icsi.berkeley.edu>; Shafi Goldwasser <shafi.goldwasser@gmail.com>; EECS Faculty <eecs-profs@eecs.berkeley.edu>
Subject: Re: [urgent] Personal Protection Equipment and UCSF

Here’s a suggested solution from a friend who has some practical engineering experience. He has talked it over with a manufacturer and it seems practical, but he needs a bit of electrical help. If someone has a good hands-on student who can help right now, please have them contact Lakin directly.
Thanks
Stuart

How it all started: with an email to faculty for “a bit of electrical help”… “This is quite a simple circuit, so we likely just need couple hours of help to design it”
And we realized the mechanicals weren't working!

And it was going to take a lot more than 1-2 hours!

Oh, no! Amazon won't deliver until Apr 21!

Time for a more custom solution
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How it all started: with an email to faculty…

FedEx overnight orders shipping every night

Discussing CAD design details over Zoom (and getting the grad students involved!)

Doing handoffs at a socially safe distance
Expand the Scope (and the Blower Fan) ~ Mar 25, 2020

Modular PPE Concept

Stanford Snorkel Mask PPE

Positive Air Pressure

Indicator Light Panel

Egress Filter

Belt

Back Cover Plate

Captive Bolts

HEPA Filter

(Protects Fan from Contamination)

@Prabal Dutta Let’s connect - I think the modularity is very important and we have someone in our team that was already building the computer fan blower option for different use cases. Let’s combine that effort. What’s your email contact?
Growing Sense of Urgency from UCSF Doctors

“PAPRs and respirators are hard to find these days for obvious reasons.”

“Supplies are short for PAPRs in hospitals, and the surge is not here yet... How’s the progress? Anything I can do to help?”

“I actually have a small grant that’s unrestricted. Send me the receipt and I’ll help out.”
Vision: An Ecosystem of Open/3DP Components*

- **Hoods**
  - 3M S-605-10
  - Allegro 9904
  - Bullard 20 TJ
  - Stanford Snorkel Mask
  - Pilawa Plastic Bag

- **Hoses**

- **Adapters***

- **Filters**

- **Couplers***

- **Blowers***
  - Berkeley Blower

- **USB-based Recharge / Opt. External Power Boost**
Connecting the “Dots”…to a First Prototype

- Hoods
  - 3M S-605-10
  - Allegro 9904
  - Bullard 20 TJ
  - Stanford Snorkel Mask
  - Pilawa Plastic Bag

- Hoses

- Adapters*

- Filters

- Couplers*

- Blowers*
  - Berkeley Blower

CAD → Fully Working Prototype ~ April 1, 2020 [no joke!]

M-CAD

Status UI

E-SIM

E-CAD

3DP Parts

Berkeley Blower
Easy-to-sanitize enclosure, containing on-board lithium-ion battery, electronics, and blower fan. All components selected to be widely available commercially.

$1.50 medical in-line viral filter, 99.999% efficient.

Off-the-shelf USB battery bank “range extender”, enabling 4-5 additional hours of run-time and easy charging.

3D printed adapter, to accommodate a wide range of filters and hoses. Library of open-source parts available on project website.
Only consumable can be a $0.10 polyethylene bag that is widely available. Continuous airflow and positive pressure makes it comfortable and safe to wear. Airflow tested to match commercial medical-grade PAPRs.
“PAPRs and respirators are hard to find these days for obvious reasons.”

“Supplies are short for PAPRs in hospitals, and the surge is not here yet... How’s the progress? Anything I can do to help?”

“I actually have a small grant that’s unrestricted. Send me the receipt and I’ll help out.”

“All I can say is amazing work.”

“I’ll back you out of my savings account if necessary.”

“Should I have our leadership speak with your leadership about permitting you to focus on this potentially life saving work?”
OpenPAPR Team

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Roadmap & Needs

• Mechanical engineering assistance
• Laboratory testing for fit & function
• Documentation and user manuals
• Compliance and safety “verification”
• Legal guidance on emergency liability
• Manufacturing contracts to scale up
• Logistical support for distribution
• Financial resources for production
American Society of Anesthesiologists: Update on the Use of Personal Protective Equipment by Anesthesia Professionals (link)
  - Airway procedures are high risk for exposure to aerosols – which are not filtered by standard surgical mask.
  - ASA recommends n95 respirators or PAPRs for all anesthetic cases and for airway procedures.
  - N95 Respirators are under a world wide shortage, therefore, PAPRs are in very high demand.
• Physicians, and those Performing Aerosol Generating Procedures (AGPs) Are at Higher Risk both of COVID-19 and Worse Outcomes (link)
• What is an air-purifying respirator? (https://www.cdc.gov/niosh/docs/2018-176/default.html)
• General Cautions and Limitations for Powered Air Purifying Respirators (https://www.cdc.gov/NIOSH-CEL/Limitations/Papr)
• Bay Area Situation (https://www.sfchronicle.com/bayarea/article/Coronavirus-Nurses-are-wearing-trash-bags-at-one-15172777.php)
• National Stockpile Nearly Depleted (link)
• Governments Calling for Help with PPE Manufacture (link)