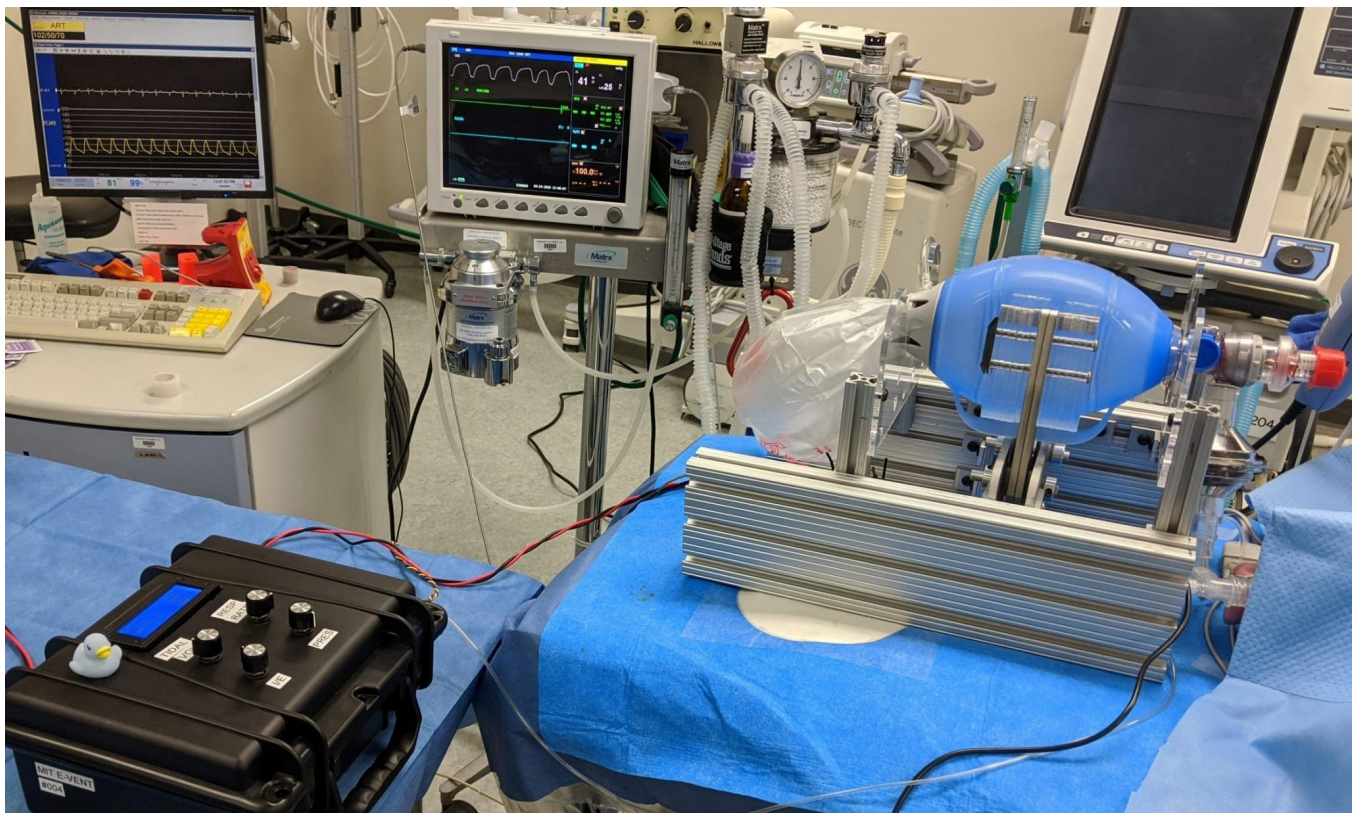
MIT Emergency Ventilator (E-Vent) Project



MIT E-Vent Unit 002 Undergoing Testing, Image by MD

Goal

The goal of this site is to provide the best information we can, focused around safety, on automating a manual resuscitator, as a potential means for longer-term ventilation. This is a completely off-label use, but we recognize the global interest when a hospital has used up all ventilators and the only option is manual bagging a patient. We hope that such systems may serve as bridge devices and help with the triage of available respirators and clinicians trained in respiratory therapy. This may allow less severe patients to be cared for by less specialized clinicians, while resources are focused on those most in need. However, at no time should a patient be unattended without someone skilled available to directly monitor their vital signs. Effectively, we are reprising the early days of safe ventilation where direct clinical observation of patient condition served as the key feedback.

Begin by reading the **Key Ventilation Specifications**, then the detailed clinical information. This is critical to understand the logic underlying the mechanical, electrical, controls and testing information. We have just posted essential safety information on **removing dead space**.

Background & Need

We are one of several teams who recognized the challenges faced by **Italian physicians**, and are working to find a solution to the anticipated global lack of ventilators. In the US alone, the COVID-19 **pandemic** may cause ventilator shortages on the order of 300,000-700,000 units (**CDC Pandemic Response Plans**). These could present on a national scale **within weeks**, and are **already being felt** in certain areas. An increase in conventional ventilator production is very likely to **fall short** and with significant associated **cost** (paywall warning).

Almost every bed in a hospital has a manual resuscitator nearby, available in the event of a rapid response or code where healthcare workers maintain oxygenation by squeezing the bag. Automating this appears to be the simplest strategy that satisfies the need for low-cost mechanical ventilation, with the ability to be rapidly manufactured in large quantities. However, doing this safely is not trivial.

Use of a bag-valve mask (BVM) in emergency situations is not a new **concept**. A portable ventilator utilizing a manual resuscitator was introduced in 2010 by a student team in the MIT class 2.75 **Medical Device Design** (original paper **here** and news story **here**), but did not move past the prototype stage. Around the same time, a team from Stanford

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developed a lower-cost ventilator for emergency stockpiles and the developing world. It looks similar to a modern ICU ventilator (**Onebreath**), but “production for US hospitals would start [in] about 11 months”, making it “a second wave solution” (**MIT Tech Review Article**). Last year, the concept was re-visited by two student teams, one from Rice university (**here** & **here**), and another Boston-based team who won MIT Sloan’s Healthcare prize (**MIT News: Umbilizer**). Other teams currently working on this challenge can be found linked on our “Additional Resources” page.

Key Research Question

We have launched an emergency research project with a team of MIT Engineers and American clinicians to address the question:

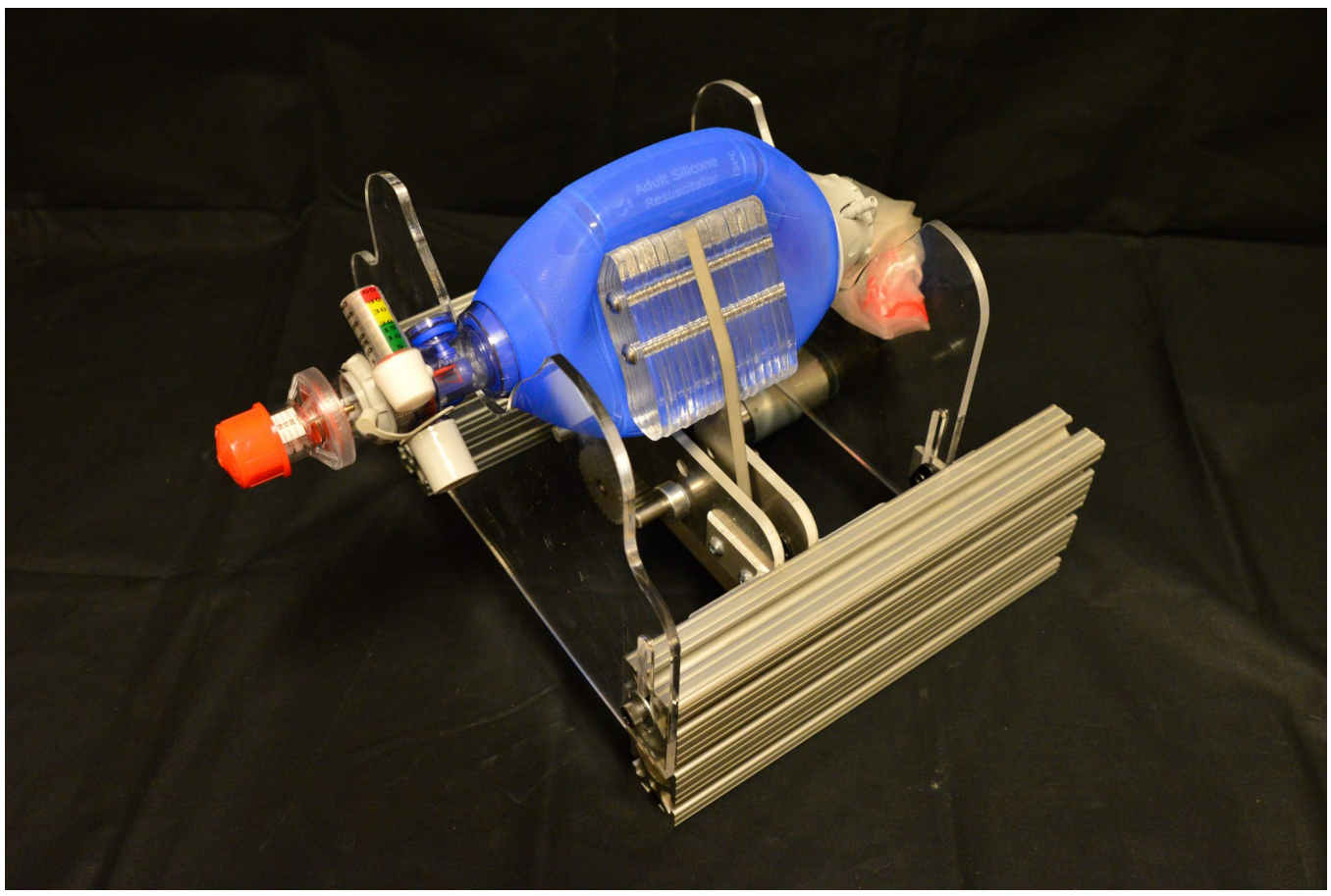
Is it possible to safely ventilate a COVID-19 patient by automatically actuating a manual resuscitator?

Our process in approaching this question is to first identify the minimum requirements for a low-cost ventilator, based on the collective wisdom of many clinicians, design against these requirements, conduct immediate testing, report the results, iterate and facilitate discussion.

Manual ventilation is a short-term solution in a critical care environment, without any apparent clinical evidence regarding the safety of long-term use (days-weeks). There are multiple scenarios in which respiratory support could be needed: patients can be awake or asleep, sedated or sedated and paralyzed, breathing spontaneously, weaning off of a vent, etc. Furthermore, changing clinical presentations with ARDS require shifting minute ventilation (tidal volume x respiratory rate) to “lung-protective” strategies, which place patient’s at risk for things like auto-PEEP. Some of these situations are simpler than others, with the simplest being ventilating a sedated, paralyzed patient, and at a minimum a safe emergency ventilator could be used in such a situation to free-up a conventional ventilator.

Any solution should be utilized only in a healthcare setting with direct monitoring by a clinical professional. While it cannot replace an FDA-approved ICU ventilator, in terms of functionality, flexibility, and clinical efficacy, the MIT E-Vent is anticipated to have utility in helping free up existing supply or in life-or-death situations when there is no other option.

Further, any low-cost ventilator system must take great care regarding providing clinicians with the ability to closely control and monitor tidal volume, inspiratory pressure, bpm, and I/E ratio, and be able to provide additional support in the form of PEEP, PIP monitoring, filtration, and adaptation to individual patient parameters. We recognize, and would like to highlight for anyone seeking to manufacture a low-cost emergency ventilator, that failing to properly consider these factors can result in serious long-term injury or death.



MIT E-Vent Unit 002 Setup, Image by MD

Open Source Design

At the present time, we are producing four sets of material, which we will be releasing and updating on this site in an open-source fashion:

1. Minimum safe ventilator functionality based on clinical guidance
2. Reference hardware design for meeting minimum clinical requirements
3. Reference control strategies and electronics designs and supporting insights
4. Results from testing in animal models

We are releasing this material with the intent to provide those with the ability to make or manufacture ventilators, the tools needed to do so in a manner that seeks to ensure patient safety. Clinicians viewing this site can provide input and expertise and report on their efforts to help their patients.

As with any research to design to scale-up to manufacture, we anticipated that there will be many problems and it is our goal to provide this site as a tool to “close the loop” and receive feedback. We will also do our best to publish the most relevant pieces of information in the discussion forum for all to see.

We invite anyone who is interested to follow this work.

Commenting is moderated and access to comment will be granted based on expertise and quality of comment. This is to ensure that the discussion is constructive and focused on safety.

Resources

For official information and recommendations on responding to COVID-19 please consult the following resources:

- **World Health Association**
- **FEMA**
- **CDC**
- **Commonwealth of Massachusetts**

Information on MIT’s internal response and resources can be found **here**.

MIT, along with schools across the nation, has asked all of us to work from home. The crisis has created a unique opportunity to experiment in online / distance education and we are all learning together.

Support the fight against COVID-19

If you would like to help the people who are working hard to care for those affected by COVID-19, please consider donating to a reputable organization in your local community. Also we encourage all individuals to please think of your elderly or differently-abled neighbors who may need support. Other options to consider if you would like to help:

- Nationally, the American Red Cross is **soliciting blood donations**.
- The WHO has set up a **response fund**.

Help Support the MIT Team

If you would like to help support the all-volunteer MIT team, please consider making a donation. Donations to MIT are tax deductible. We are working long hours, spending fast and, because this project was launched in under a week, we are not a funded research project. You may donate directly below. For large donations, contact the **team**.

DONATE NOW

Legal Disclaimer & Copyright

- The material on this site is provided with no warranties explicit or implied.
- No material on this site is intended to provide medical advice. All designs are intended for investigational use only.
- We are working to submit a specific variant of the MIT E-Vent design to the United States FDA for review under the Emergency Use Authorization (**EUA**) authority.

- The Department of Health and Human Services (DHHS) has declared **liability immunity** for medical countermeasures against COVID-19.
- This site does not represent any official policies or procedures of the Massachusetts Institute of Technology.

Latest updates

Plumbing, Pressure Sensing, Study #4.

5 April 2020

Good Evening from Cambridge! We have added some notes to the Plumbing page from colleagues on the West coast. We are also in the process of implementing Assist Control and have posted essential information describing how pressure sensing works. This is very important. We have also updated the control diagrams. We have also documented our ... **Read more**

Plumbing & Dead Space

1 April 2020

Good evening from Cambridge! We have just posted some vital safety information pertaining to removing dead space from breathing circuits. Please see the Plumbing page.

Updated Study Results & Non-invasive Ventilation

31 March 2020

Good evening from Cambridge! We have updated infromation on Studies 1, 2 and 3 and added a new page addressing the question "Why is CPAP and BiPAP enough? More to follow.