COVID-19 pandemic inspires modifications to human-powered ventilator developed for space missions

An affordable, easy to use human-powered ventilator developed by the National Aeronautics and Space Administration (NASA) for use on space missions has been modified for use in treating patients with severe COVID-19.

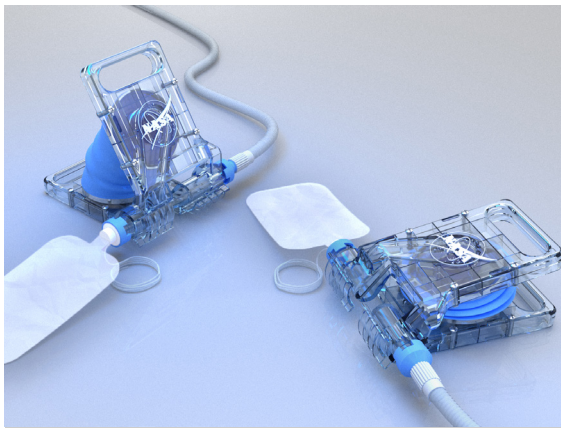
As the COVID-19 pandemic spreads rapidly, medical institutions around the world are experiencing an exponential growth of patients with severe respiratory problems. Some of the primary tools used to treat COVID-19 patients are ventilators.

Electrically powered ventilators are complex machines that assist a patient with inhalation and exhalation. These ventilators use a system of sensors to adapt the timing and pressure of the airflow to fit each patient's individual needs. The complexity of electrically powered ventilators makes these devices expensive and time consuming to manufacture; during the pandemic, these factors have contributed to severe global shortages of both ventilators and individuals with the skills needed to operate them. Resource-poor areas are experiencing additional hardships due to a lack of reliable power and maintenance support for electrically powered ventilators.

Manual "Bag-Valve-Mask" respirators can also be used to treat patients with respiratory problems. These devices rely on tactile feel and visual observation of the patient to determine the required amount and flow rate of air. Operation—squeezing a bag by hand to deliver air—is simple, but cannot be performed for long, continuous periods without fatiguing the small muscles in the operator's hand and wrist.

In 2017, NASA Johnson Space Center designed and prototyped a human-powered ventilator to be used on future long duration space missions, such as Orion's missions to Mars. This human-powered ventilator design was resurrected in March of 2020 and modified for terrestrial application.

The Human Powered Ventilator design uses bellows and a push-pull arm motion to pump air to a patient. Similar to a "Bag-Valve-Mask" design, this device relies on tactile feel for correct operation. The push-pull arm motion required to operate the human powered ventilator utilizes the large upper-body muscles in a person's shoulders, arms, chest, and back. By using these large muscles, the operator is not heavily taxed and is therefore able to operate the device continuously for hours. The device is made from plastic injection-molded or 3D printed components, involves a simple assembly process, and does not require sensors or electricity to operate.



Above: The Human Powered Ventilator design uses bellows and a push-pull arm motion to pump air to a patient. The device is made from plastic injection-molded or 3D printed components, involves a simple assembly process, and does not require sensors or electricity to operate.

Team members from various groups within NASA Johnson Space Center (JSC) worked together to develop the conceptual design of the human-powered ventilator. The JSC team consisted of NASA civil servants and contractors with Dallas-based Jacobs Technology, Inc.

Partnerships were also formed with domestic and international partners in industry and academia. Houston-based re:3D, a developer and manufacturer of 3D printing equipment, assisted with 3D prototyping of the device. The Anheuser-Bush International (ABI) Brazil Division engineering team has invested great effort in refining the device design for use in underserved areas of Brazil. The University of Kentucky is also pursuing design iterations that can be used elsewhere in the developed world. The JSC Technology Transfer office is managing the partnership agreements with all of these supporting entities.

During the COVID-19 pandemic and thereafter, this technology will be a valuable asset for hospitals around the world without access to electrically powered ventilators, whether this is due to supply shortages or a lack of resources.