FutureScape Engineering

CoVent–19 Challenge

Project Abstract

Version A, April 14th, 2020

Version History

Version #	Implemented By	Revision Date	Approved By	Approval Date	Changes
A	Sidharth Annapragada	April 14th, 2020	Sidharth Annapragada	April 14th, 2020	Initial Draft

Contents

Team Members

Engineers

FutureScape Engineering Team:

- Sidharth Annapragada – Electrical and Systems Engineer
- Trevor Giardine – Mechanical Engineer
- Demitri Kokoros – Mechanical Engineer
- Dominik Zajac – Electrical Engineer
- Caroline Zhu – Software Engineer

See our website for more information about us:
http://futurescapeengineering.com/

Expert Consultants

- Automation Research Group – Product Design House with 30+ years of experience in industrial and medical automation projects
- Bilal Ahmad, M.D. – Anesthesiologist affiliated with Lankenau Medical Center

Product Description

FutureScape Engineering proposes to build a low-cost, easily manufacturable ventilator, that uses 3D printing for the key gas control manifold (the design will be amenable to high volume injecting molding). In particular, FutureScape proposes an optimal way to build such a device by designing a scaled-up version of a "microfluidic array" to regulate the air flow. Essentially, by 3D printing a single manifold that contains all the tubing, control valves and sensors, the design can eliminate the need for complex assembly and reduce the overall number of parts and cost of the device.

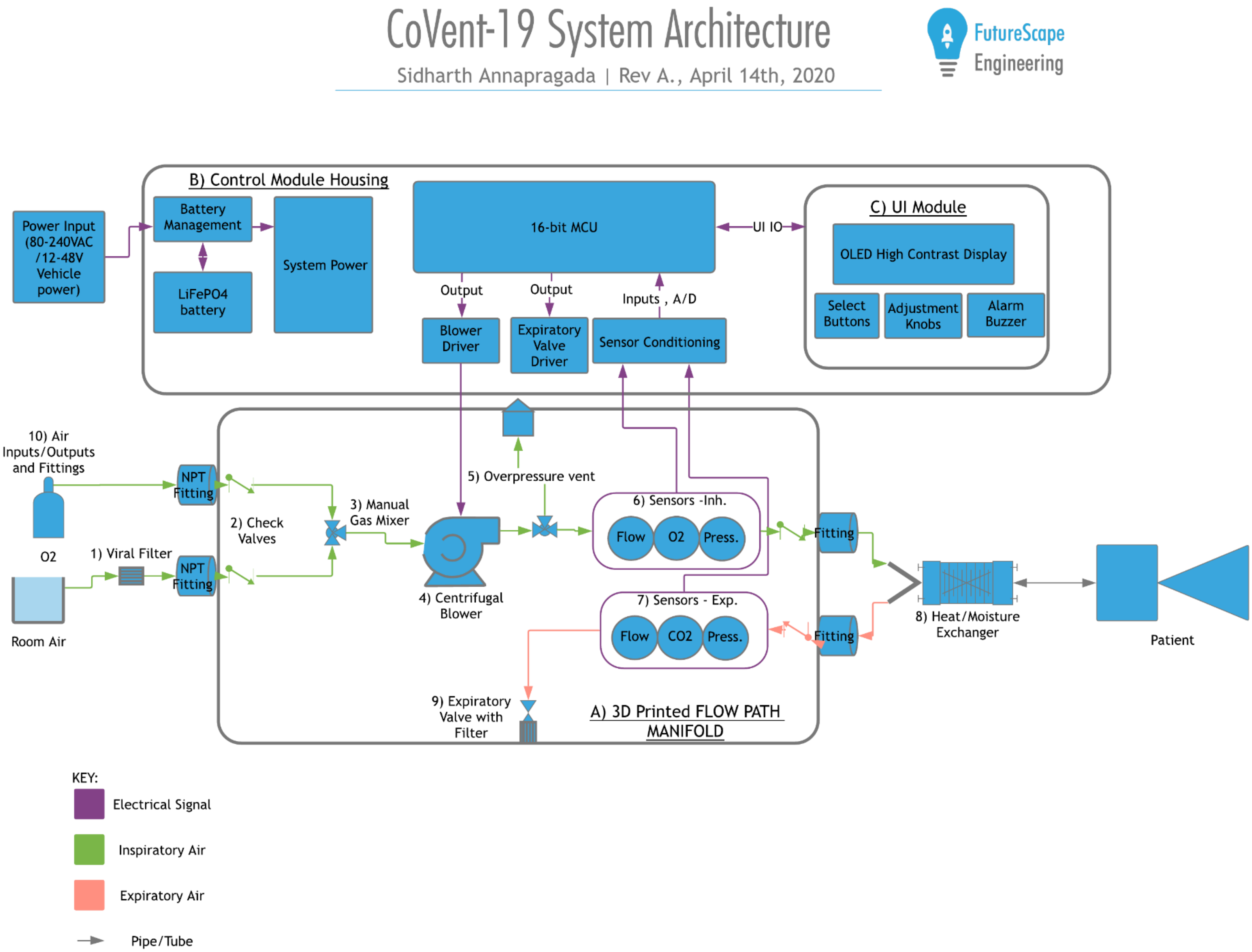
Our device would consist of three major components:

1) 3D printed -flow manifold
   a. Made of a top and bottom shell with O-ring seal. Blower, Motors, sensors, and valve pieces would be placed into bottom shell, wired, and then top shell would be put in place to form flow manifold
2) Control Module + UI module
   a. Compact off the shelf enclosure housing the UI, microcontroller and power management systems.
   b. The control module controls valves and reads from the sensors in the 3D printed manifold.
   c. The UI module includes a display, buttons, knobs, and buzzer alarm

Innovations:

- 3D Printed Air Flow Manifold
- Minimized valves and tubes
  - Check valves, single control valve
  - Manual air mixing valve with O2 readout

System Architecture



System Details

A) 3D Printed Flow Path Manifold

1) <0.29uM viral filter for room air input. "Click in" system on the input for easy replacement
2) Small COTS check valves that click into the manifold during assembly
3) Gas mixing valve system, with manual knob. Healthcare workers can manually adjust the gas mixer while observing O_2 readout on UI for simple and cost-effective mixing of O_2 with air
4) Centrifugal BLDC motor Blower with speed control for precise flow/pressure control loop
5) Overpressure safety valve to prevent lung damage from excessive pressures
6) Inspiratory line sensors, including flow, oxygen, and pressure. These are processed and displayed on UI
7) Expiratory line sensors, including flow, carbon dioxide, and pressure. These are processed and displayed on UI
8) COTS heat and moisture exchanger for simple air humidification: https://www.cpapdirect.com/parts-and-accessories/hdm-heat-moisture-exchanger-hme
9) Controlled expiratory valve, with <0.29uM click in viral filter. This valve will be normally open as a failsafe, so that the flow paths are at atmospheric pressure under any failure conditions. The valve is open when patient ready to exhale and closed during inhalation
10) Standard fittings for room air input, O2 tank input, and for endotracheal tube/face mask output

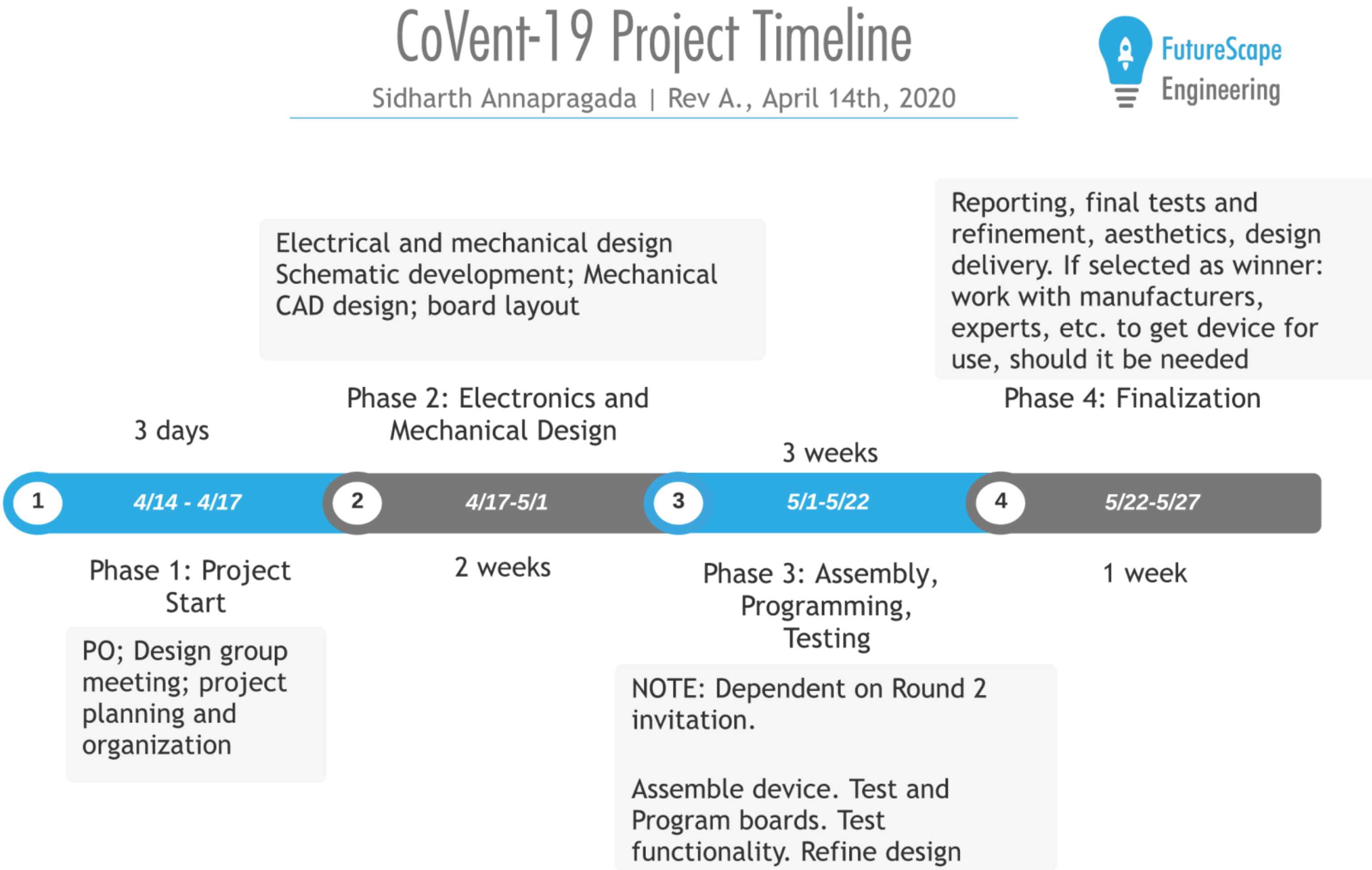
B) Control Module Housing

1) Power Management: takes in power from AC (80 – 240VAC external power pack) or battery (including car battery). Uses the input power to charge internal battery and/or power system via battery management module
2) Control: 16-bit PIC microcontroller for control. BLDC motor driver for precise speed control of the Centrifugal blower. RC Servo motor control for driving the expiratory valve vane in the manifold. Sensor signal conditioning and communications (analog and digital) for reading the inspiratory and expiratory sensors. This module will regulate alarms and monitor system. An optional Bluetooth LE module is on the control board allowing remote monitoring.

C) UI Module – housed with Control module

1) OLED High Contrast display for healthcare workers. Menu selection buttons. Adjustment knobs to modify parameters and set alarms. Real time plots and lung compliance readouts as well as alarm displays. Buzzer for alarms. Housed in same off-the-shelf enclosure as the control module electronics

Project Timeline



Product & Design Specification Source Notice

Please note that the product and design requirements, including, but not limited to, the scope and deliverables, general system architecture, system requirements, design methods and manufacturing considerations, limited background research, and timeline were inspired by resources from the CoVent-19 challenge GrabCAD site: https://grabcad.com/challenges/covent-19-challenge-round-1

As this is an abstract, these details were not included in this document. The details of the requirements for this product can be found in the documents entitled “CoVent_Design_Brief.pdf” and “ChallengeInstructionManual_updated.pdf”