



*'This Innovation is made possible with funding from the Government of the Republic of Uganda through the Makerere University Research and Innovations Fund (Mak-RIF)*

## **DEVELOPMENT OF THE BULAMU MEDICAL VENTILATOR IN RESPONSE TO THE CORONAVIRUS PANDEMIC AND NEED IN CRITICAL CARE SYSTEM**

### **BULAMU MEDICAL VENTILATOR BRIEF**

The Ministry of Science, Technology and Innovation and Makerere University are collaborating in the development of a Low-Cost Open Design Medical Ventilator that can be manufactured locally. Makerere University is providing the project leadership through the ResilientAfrica Network (RAN) and key collaborating teams from the College of Health Sciences (CHS), College of Veterinary Medicine (CoVAB) and College of Engineering, Design, Art and Technology (CEDAT). The Ministry of Science, Technology and Innovation is represented by Kiira Motors Corporation whose core role is leading the technical design and development process towards a refined functional ventilator to inform approvals and certification before production commences.

The collaboration adapted an open access design from the University of Florida and other Open Design Medical Ventilator Technology Developers. The Team has developed a fully functional prototype with a brand name of *Bulamu* meaning Life. The project in this pilot stage is now conducting extensive engineering trials and endurance tests which are necessary before conducting animal trials, clinical tests and certification for emergence use. The *Bulamu* medical ventilator is envisaged to bolster the country's surge capacity to provide critical care in case the demand for such care increases even post the Coronavirus pandemic.

3D printing precision manufacturing technology has been deployed to manufacture a wide range of components in the *Bulamu* medical ventilator including; plumbing air flow pipes and connectors, printed circuit board holders, component supporting brackets, branding logos and valve components. This activity is supported by the African Institute for Capacity Development (AICAD) led by Prof. Noble Banadda, the director of AICAD.

The *Bulamu* medical ventilator initiative is aimed at informing key interventions toward developing Uganda's Capacity for manufacturing key medical equipment for import substitution and regional export.

### **COLLABORATING PARTNERS**



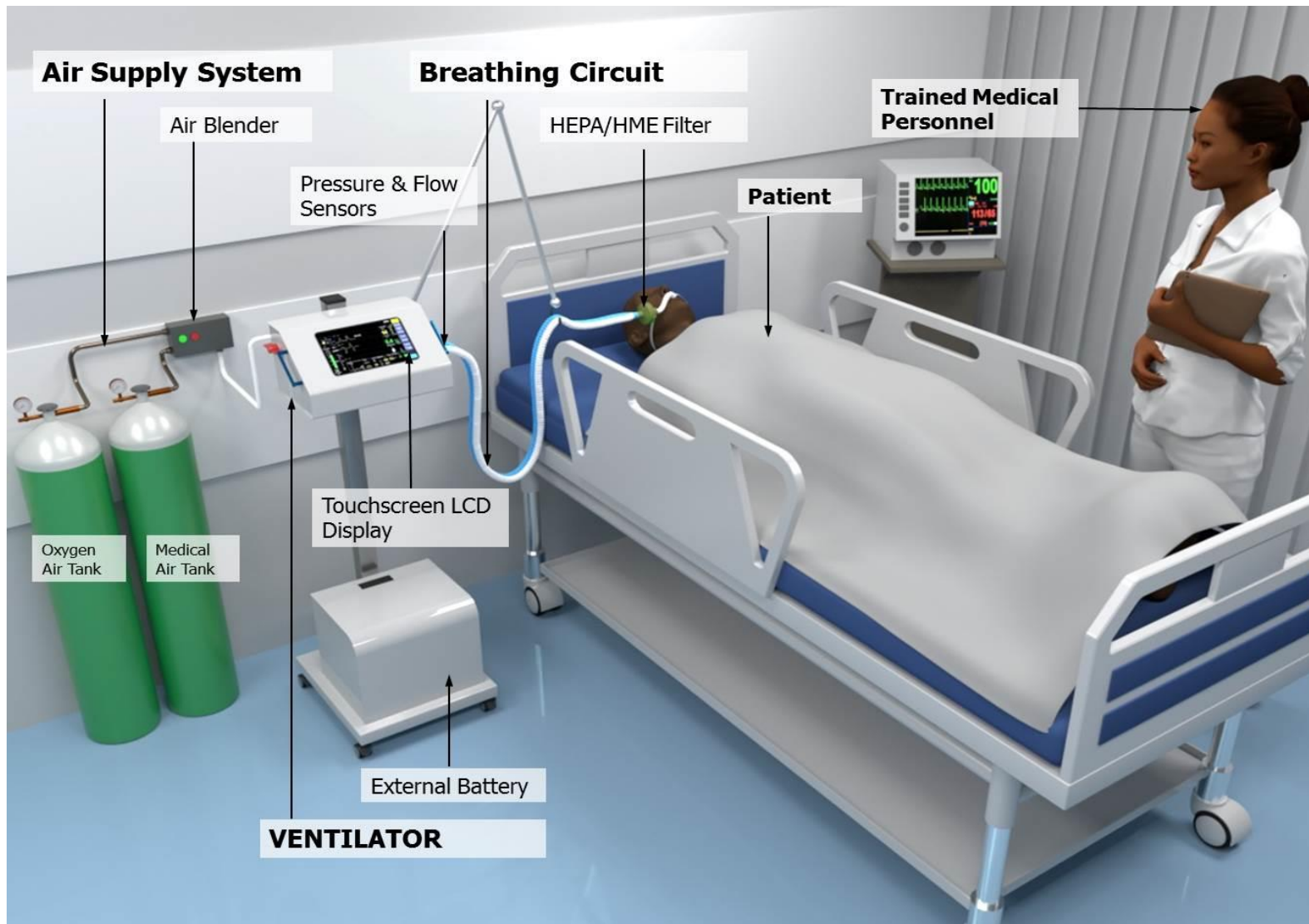
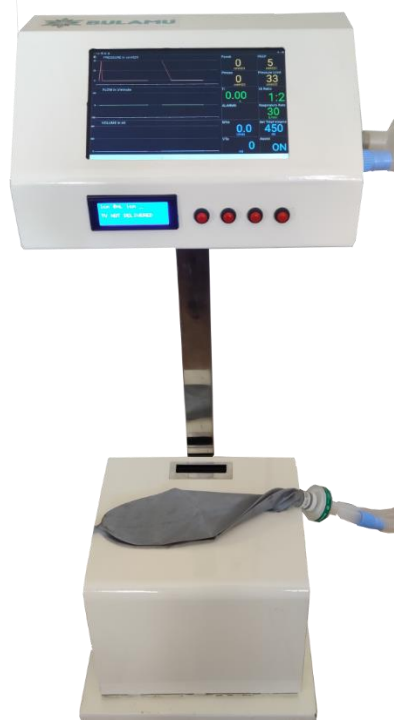


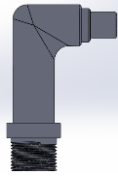
Figure 1: Environmental Context of the Bulamu Medical Ventilator

**Table B: Bulamu Medical Ventilator Specifications**



SYSTEM PARAMETER		SPECIFICATION
<b>General</b>	Ventilation Type	Volume Controlled Assist Control Ventilation
	Target Patients	Adult
	Duty Cycle	100% duty cycle for up to 14 days
	Application	ICU, Emergency/Transport Ventilator
<b>Air Supply</b>	Air Supply	50 Psi Medical Air
	Oxygen (FiO <sub>2</sub> )	50 Psi Oxygen
	Blender	21%-100% Oxygen Blended in 10 % Steps
	Ventilator Input Pressure	1 Bar (Inlet Valve Controlled)
	Oxygen Consumption	Less than 6 LPM
<b>Pneumatic</b>	Connectors	Connects to wall pipeline or gas blender, Male Oxygen DISS connector (from hose); All gas connectors and hoses use standard non-interchangeable connectors and color coded
	Pipe Dimensions (OD)	22mm
<b>Electrical Specifications</b>	Air Flow Resistance	1.5 cmH <sub>2</sub> O at 60LPM gas flow
	Input Power	240 VAC (AC-DC Adaptor needed/ 12VDC)
	Power Consumption	210 Watts
	Back Up	2 Hrs. Battery Backup (50 AH)
<b>Control Settings and Ranges</b>	Power ON/OFF Switch	Single Pole Single Throw Switch
	Airway Pressure Rating	-20 cmH <sub>2</sub> O to 60 cmH <sub>2</sub> O
	Tidal Volume (Settable)	250-800 ml (Accuracy ± 25 ml)
	Respiratory Rate (Settable)	10 – 30 bpm (Settable in 1 bpm)
	I:E ratio (Settable)	1:1 to 1:4 optional, Default to 1:2
<b>Monitoring Parameters</b>	PEEP	5 – 25 cm H <sub>2</sub> O; Default setting 5 cm H <sub>2</sub> O (Increments of 1 cm H <sub>2</sub> O)
	Controls	Over Pressure and Under Pressure, Paw, PIP, PEEP, TV, BPM/RR, I:E, FiO <sub>2</sub>
	Graphical Patient Data	Waveforms and loops for TV, Air Way Pressure, Over and Under Pressure and Graphs
<b>Breathing Circuit</b>	Alarms	Power Failure, High /Low Pressure/ High/Low Tidal volume, Apnea, High or Low Oxygen, Alarm Mute
	Anti-asphyxia valve	Opens at -3 ± 1 cm H <sub>2</sub> O
	Over-Pressure Valve	Opens at 40 default, adjust up to 60- cm H <sub>2</sub> O ± 5 cm H <sub>2</sub> O
	Breathing Circuit Connectors	22mm (OD) 'male' standard connectors for connection to user supplied 22mm 'female' connectors
<b>Physical Characteristics</b>	Filters	HEPA and HME filters
	Package Overall Dimensions	402mm x 220 mm x 200 mm
	Weight	4-6.5kgs
	Material	Coated Mild Steel
	Installation/Portability	Free Standing with Floor Standing Mount
	Display	10 Inch LCD touchscreen Display
Degree of Protection	IP22	

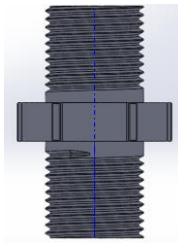
**Bulamu Medical Ventilator Components Manufactured using 3D Advanced manufacturing**



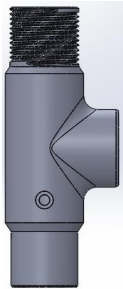
**a. Connector outlet**



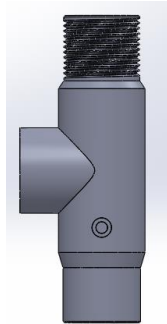
**b. Inlet Connector Pipe**



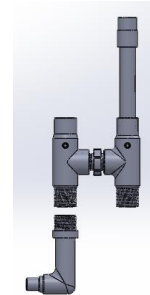
**c. Nipple**



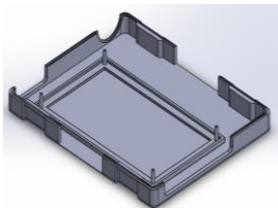
**d. Main Connector inlet**



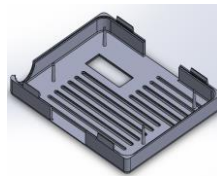
**e. Main connector outlet**



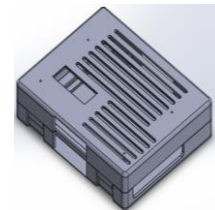
**f. Plumbing connection**



**i.) Printed Circuit Board housing**



**ii.) Printed Circuit Board top housing**



**iii.) PCB Housing assembly**

**g. Electronic PCB housing**



**h. Pipe support brackets and Taps**



**i. Tablet mounting frame**



**j. Valve Components**