

# Mechanical Ventilator Milano

The MVM Ventilator: Particle physicists, National Labs and Industry

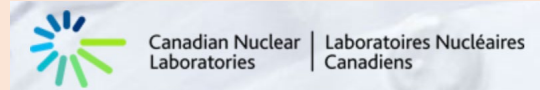
Presentation for: CAP Conference

June 9, 2021

Art McDonald

Gordon and Patricia Gray Chair in Particle Astrophysics, Emeritus

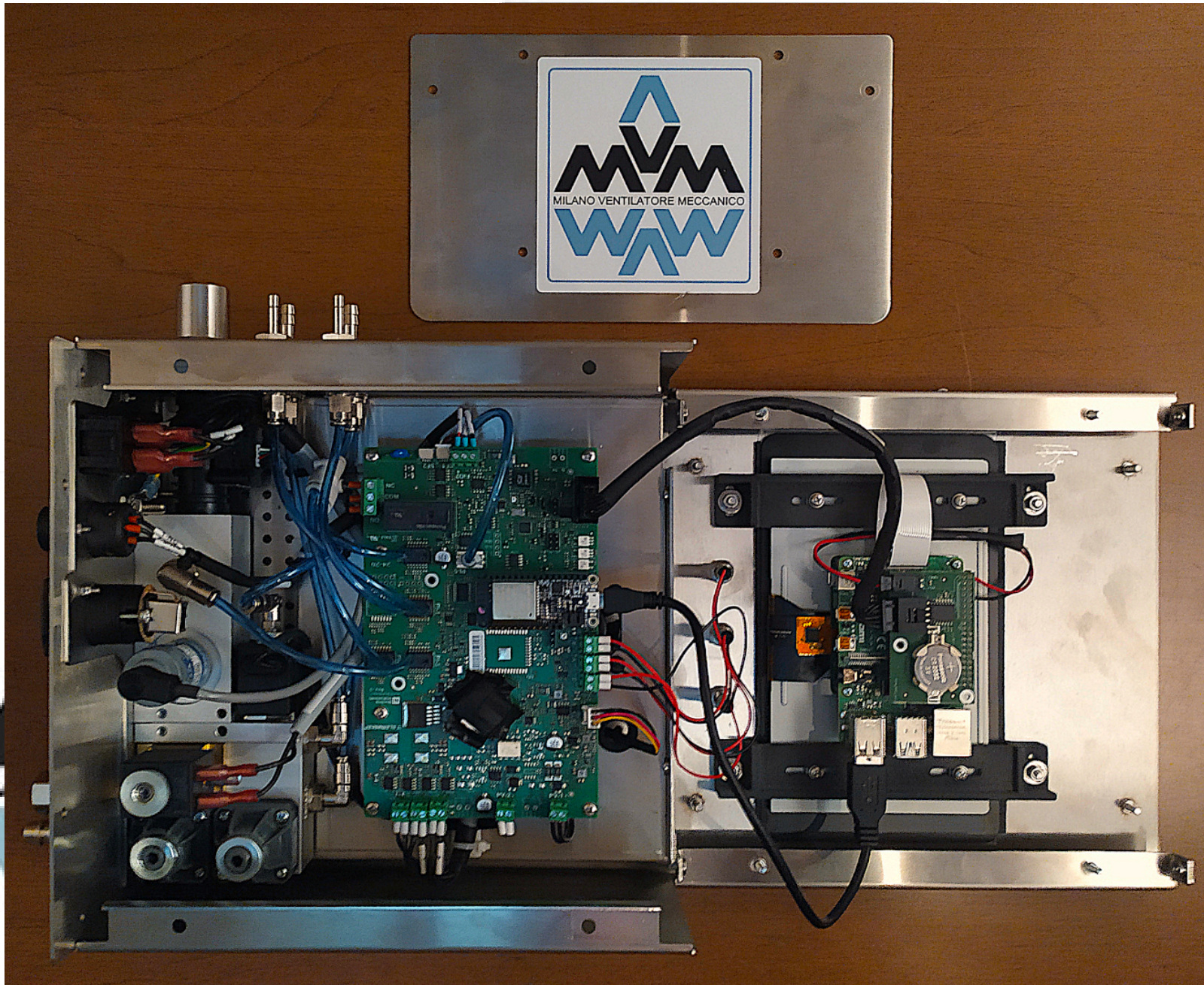
Queen's University





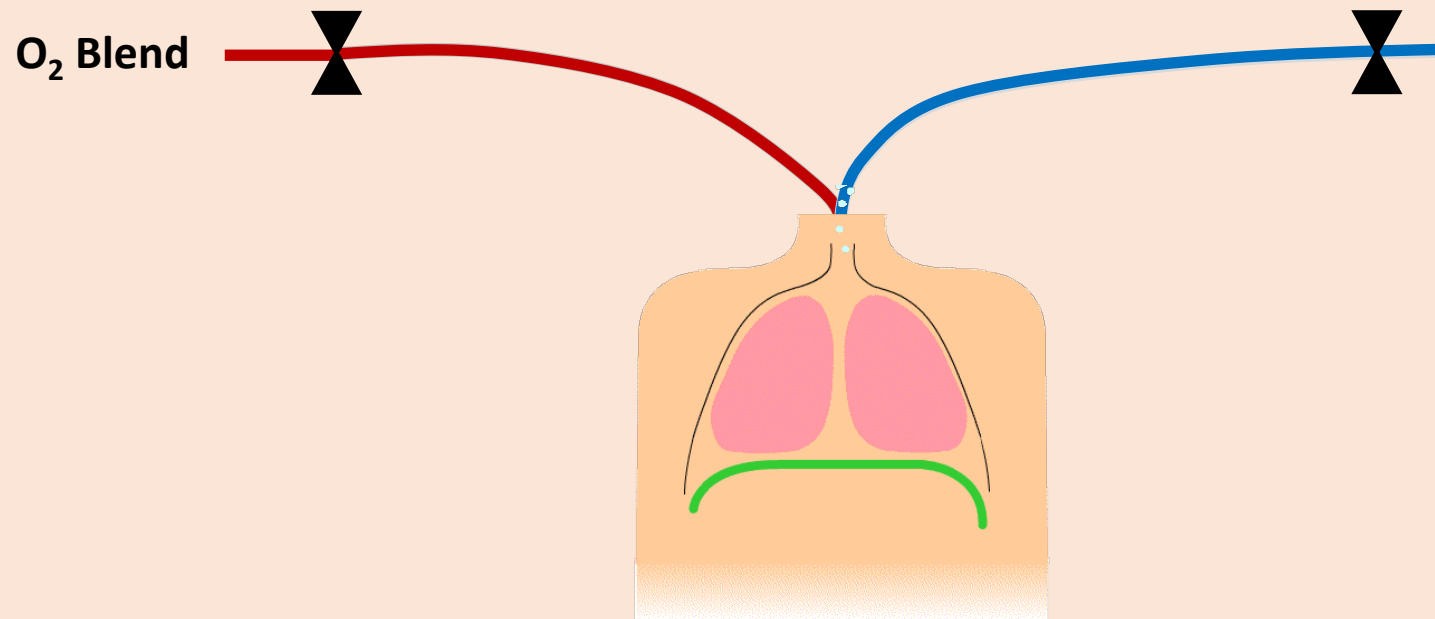


## How the ventilator works



**MVM was conceived as a low-cost, well controlled, and easy to operate electro-mechanical ventilator that could be produced quickly, at large scale, based on readily-available parts.**

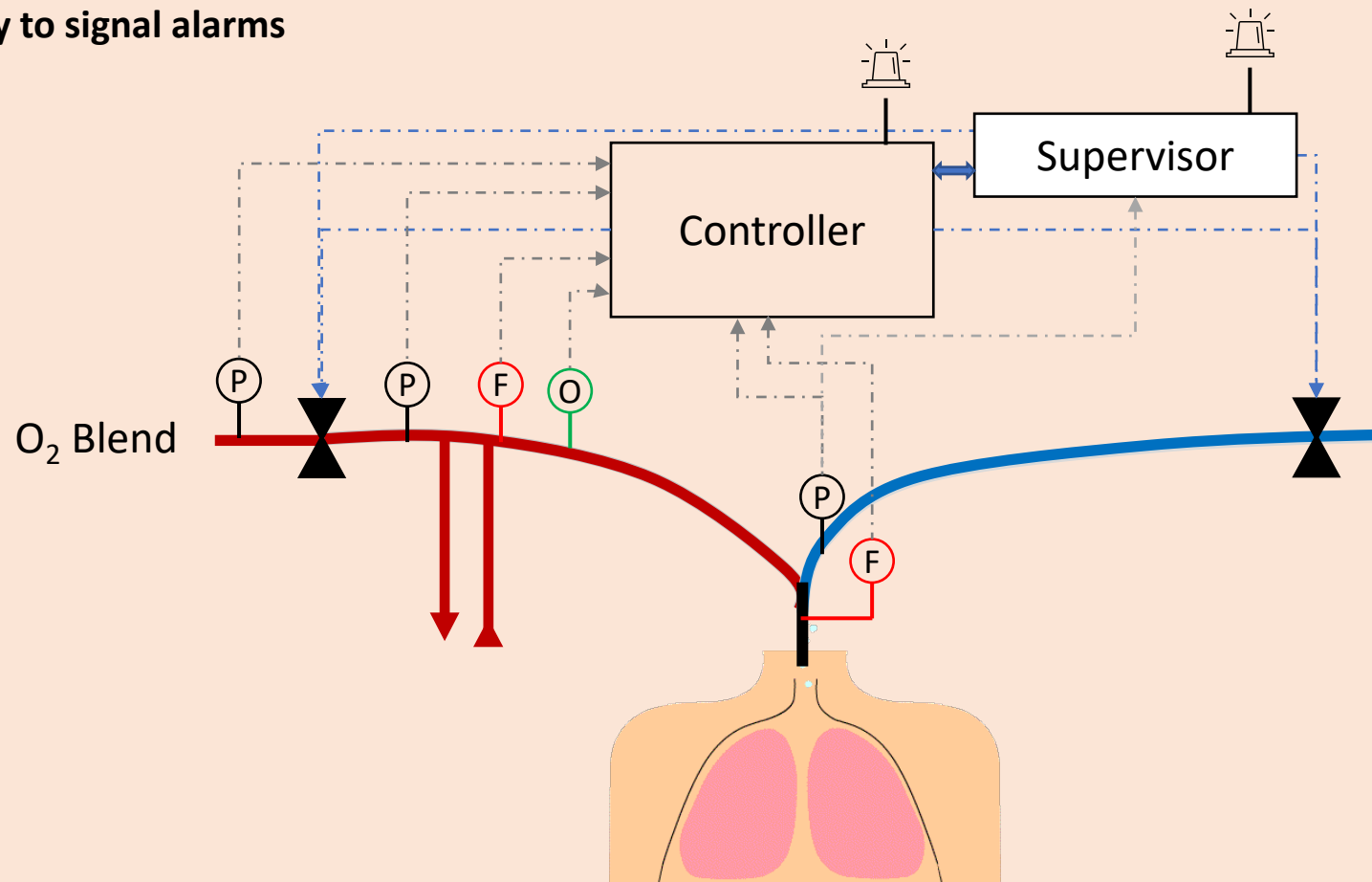
**The basic principle is simple: Push oxygen enriched air into the lungs, and allow the elasticity of the lungs to exhale it.**



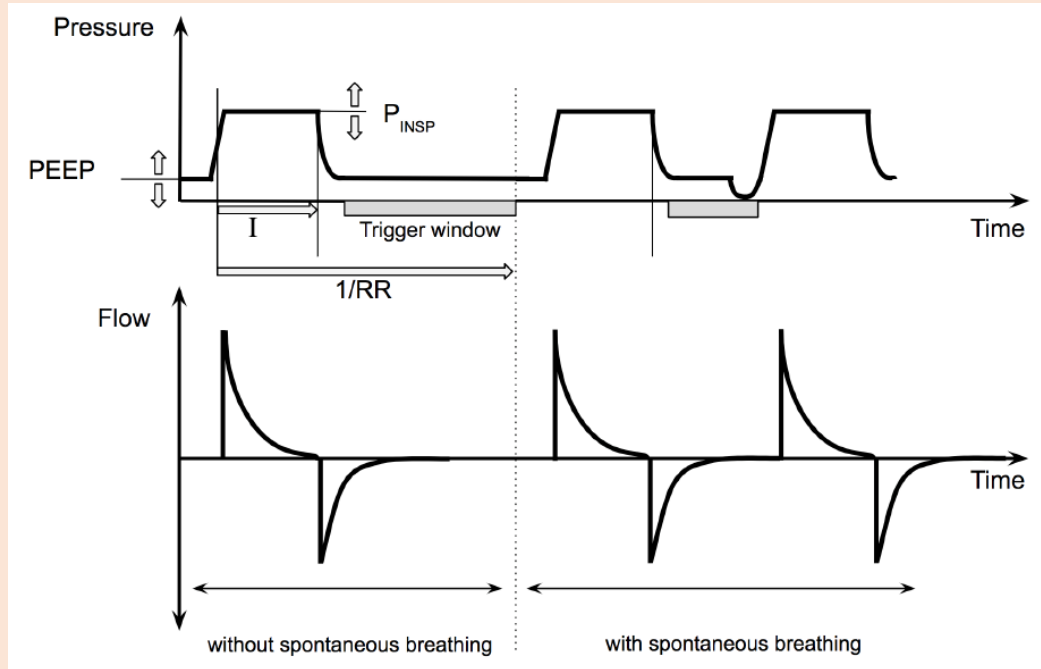


## Of course it ends up being much more complicated in the end:

- You need high precision controller to get the pressure profile correct
- It needs to measure the pressure at various points to do that control
- We also monitor for flow and leaks
- And the oxygen
- We also need to make sure that there are safety relief valves for high pressures, blockages etc
- We add a redundant independent cpu to monitor that there are no problems
- Add the ability to signal alarms



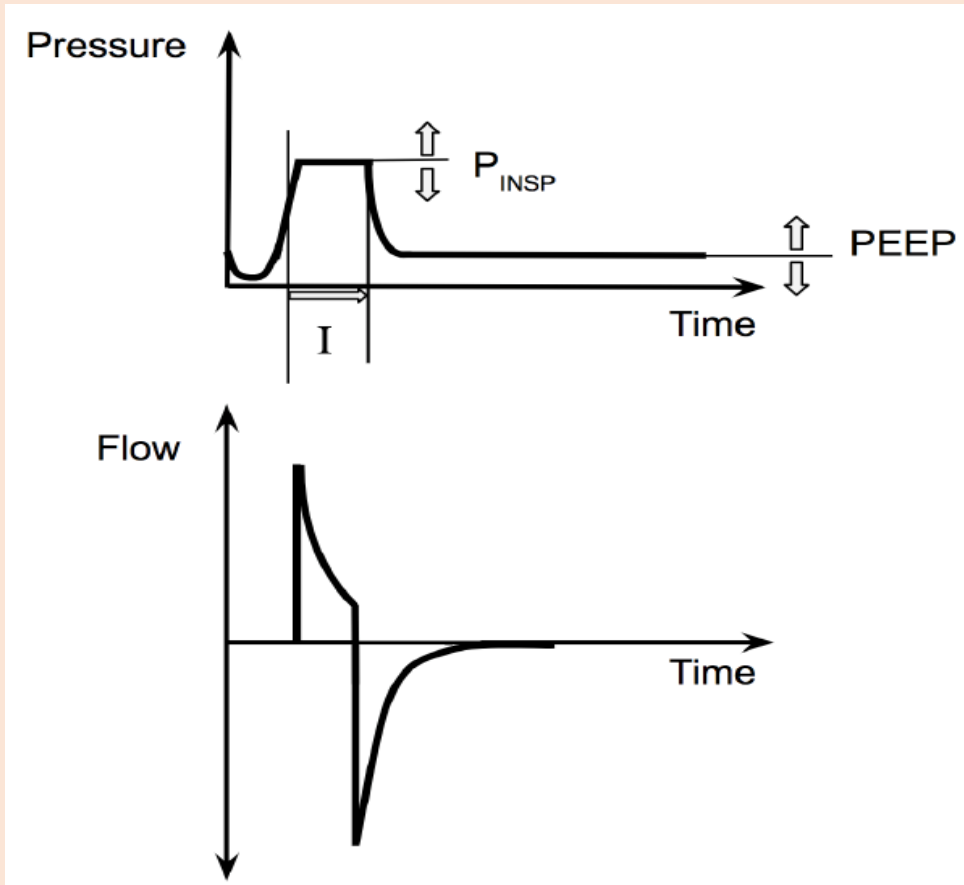
## Pressure Control Ventilation: (PCV)



- **Patient normally unable to breathe on their own**, so machine is doing all the work.
- **Regular pattern of breaths with profile and rate tuned to patient needs.**

- **New breath starts at the end of the previous, or if the patient tries to initiate a breath.**
- **PEEP: Positive end expiratory pressure: ensures alveoli in lungs do not collapse, improving oxygenation.**
- **Needed to introduce sighs, deal with coughs, recognize weak patient attempts to breathe...**

## Pressure Support Ventilation: (PSV)



- **Patient able to breathe weakly, so machine is supporting their efforts.**
- **Regular pattern for each breath when patient demands a breath.**

- **Useful when patients are being weaned off the MVM to regain control of their own breathing**
- **Ventilator needs to recognize if they stop breathing and switch back to pressure control ventilation (and raise alarm)**

## Design Evolution:

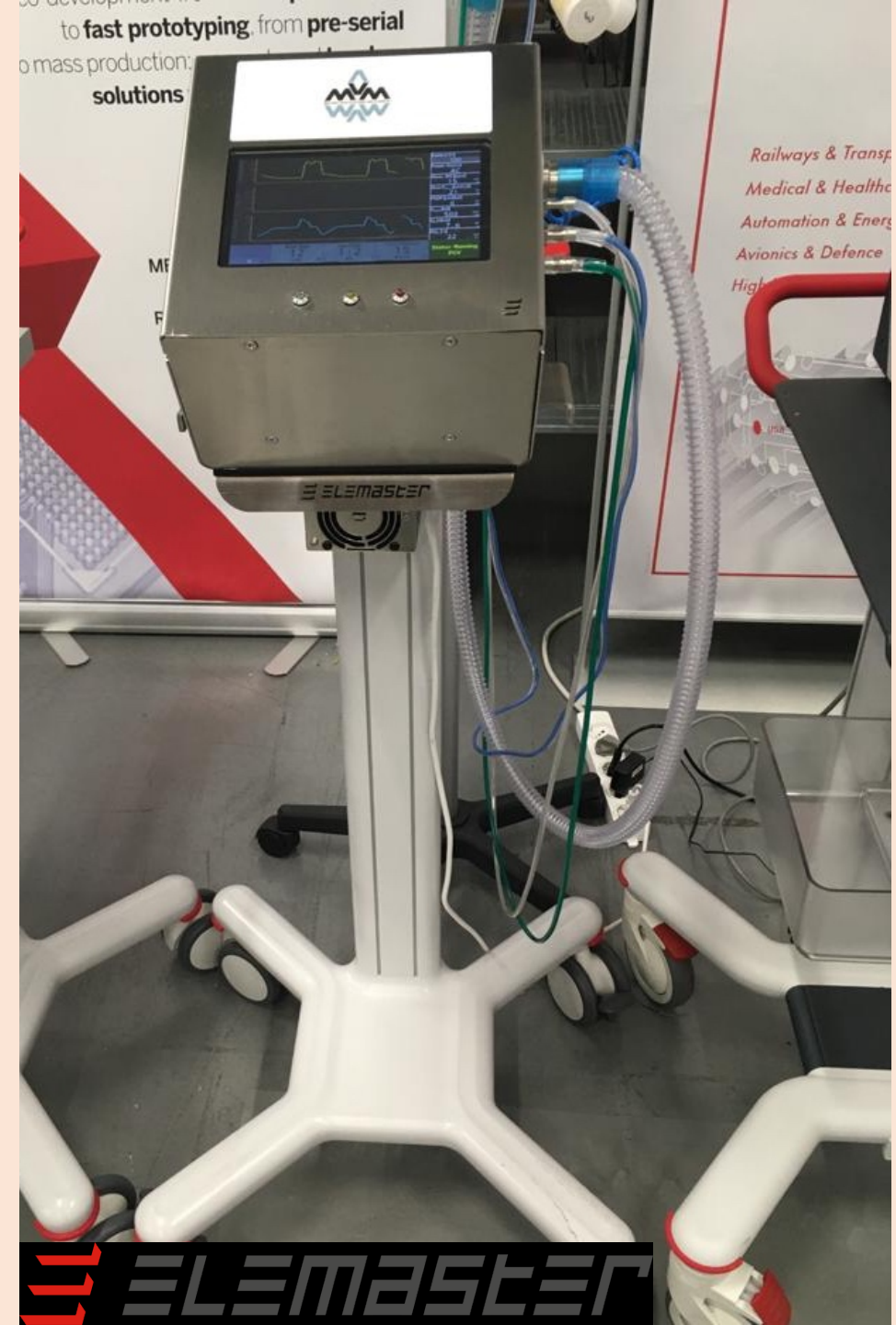


- **Medical:** Enormous guidance from medical ventilator experts, including medical device designers, medical doctors, respiratory therapists, nurses, trainers, .... To design the MVM to provide proper patient care for covid-19, be easy to use and learn, integrate with typical hospital infrastructure. Operational safety is key factor in all design considerations.
- **Manufacture:** Developed in very close cooperation with manufacturing companies in Italy/USA (Elemaster) and Canada (Vexos, JMP Solutions)
- **Technical:** 100's of physicists and engineers with expertise in software development and safety, electronics, instrumentation, fluidics, project management, quality assurance, quality control
- **Performance Standards:** Designed to meet the required standards for certification as laid out by:
  - FDA Emergency Use Authorization
  - Health Canada Interim Order for medical devices
  - Canadian Standards Association certification, requiring a repeat of almost all of the testing
- **Donations:** Early support from Canadian donors to enable the purchase of critical parts in short supply and pieces of testing equipment.



# 8 months from idea to certified medical device

- March 19/20** project initiated in Italy
- March 23** First paper on archive
- March 29** Prototype working on the bench
- April 19** first series production units in Italy
- May 1** US FDA Emergency Use Authorization
- May 22** Govt. of Canada contract for VEXOS
- July 30** Health Canada submission
- Sept. 30** Health Canada Interim Order approval
- Nov. 30** Canadian Standards Association (CSA) certification
- Nov. 30** Canadian Production starts
- Feb./2021** 7300 ventilators delivered to Can. Govt.
- Apr. 2021** Elemaster obtains CE mark



## **CURRENT STATUS**

- **Over 7300 units produced and accepted by Health Canada.**
- **Added to the stockpile for Canadian needs.**
- **Donation to developing countries in need has been considered from the beginning of this initiative. Donation is actively being pursued at the present time with assistance from the MVM group.**