


[créateurs pour la vie](#) / **Makair**

 Mass-producible open-source Covid-19 ARDS ventilator. Aims at helping hospitals cope with a possible shortage of professional ventilators during the outbreak. Worldwide.

[makair.life/](#)

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valeriansaliou Mise à jour CONTRIBUTING.md ...

on 15 Jun  1,688

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README.md

MakAir - Ventilateur Covid-19

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Nous sommes une équipe distribuée de [plus de 200 contributeurs](#) (ingénierie, médical, réglementaire, etc.), répartis principalement en France. Des décideurs, des développeurs, des professeurs d'université, des chercheurs et des équipes médicales ont collaboré à ce projet. Nos opérations de test et d'assemblage sont situées en France.

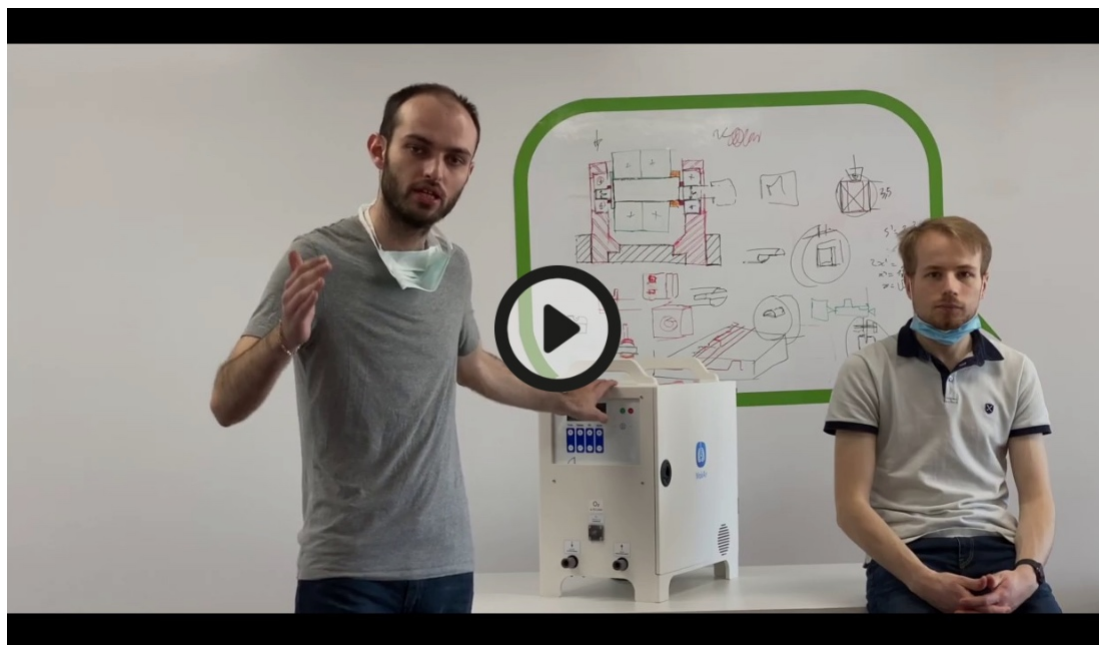
As to ensure international outreach, we made sure that contents required to build your own MakAir ventilator are available in English. The MakAir project has [a website of its own](#).

If you're new there, please read the explanations below. *Your contributions are much welcome!*



MakAir

Quick introduction video:



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Roughly, the idea is as follows: as of April 2020 and due to the Covid-19 pandemic, hospitals throughout the world may start lacking mechanical artificial ventilators. We built a pump, and a valve system (controlled by electronics). This way, the breathing cycle can be enforced by proper air routing through the valve system.

Our ventilator is able to handle pressure-controlled breathing, stabilized using a [PID controller](#) in the software.

In order to ensure a proper breathing cycle (inhale + exhale), multiple valves need to be connected together to form a circuit. The motors needs to be controlled in harmony so that the air routing between each valve unit is consistent.

This project provides all the parts required to build a good-enough [ARDS](#) ventilator from mass-produced components. We provide all the required mechanical parts, electronics designs & boards, and firmwares. This ventilator can be 3D-printed and ran on an Arduino board (the maker way), though we **highly advise** that you work with industrial processes as to mold medical-grade plastic parts and assemble the whole ventilator (this would be required for the built ventilator to pass all medical certifications).

We target a per-unit cost well under 500 EUR, which could easily be shrunk down to 200 EUR or even 100 EUR per ventilator given proper economies of scale, as well as choices of cheaper on-the-shelf components (eg. servomotors).

Mechanically-speaking, the overall system is composed of sub-components that can be plugged together and wired to form an air circuit, namely:

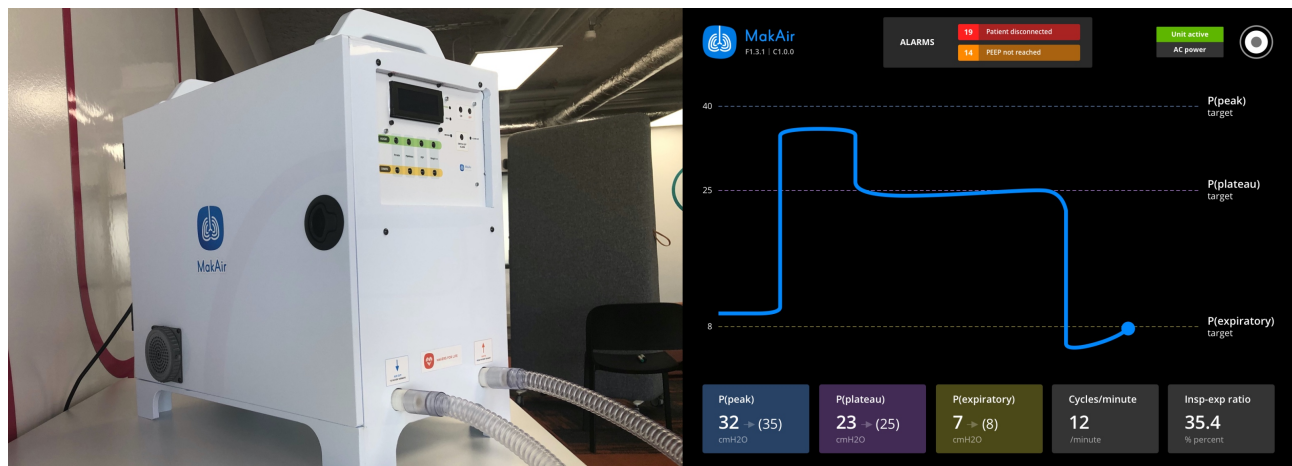
- **Air pump** (called "Blower");
- **Air pump casing fit** (called "Blower Holder");
- **Valve system** (called "Pressure Valve");
- **Oxygen Mixer valve** (called "Oxygen Mixer");
- **Air filter casing (patient variant)** (called "Patient Filter Box");
- **Air filter casing (machine variant)** (called "Machine Filter Box"; intake + outtake);
- **Connectors** (called "Pneumatic Connectors");
- **Fan support** (called "Fan Holder");

All those components are fitted in box (ie. a casing) that we designed:

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Warning Notices

A few important words before you start:

1. Though 3D-printing (FDM and SLA) can be used to build your own ventilator — this will definitely not scale well to mass-produce MakAir ventilators, and parts might be brittle or leak air. Please work with proper industrial methods and processes if you want to build your own MakAir ventilators.
2. As ARDS patients are sedated, their breathing cycle is forced by mechanical ventilation, while they are intubated. A failing ventilator (due to bad mechanics, pneumatics or software) could kill the patient (O2 desaturation), or permanently damage their lung alveoli (overpressure). It is critical that any self-built MakAir ventilator is tested against a lung simulator system (eg. [ASL 5000](#)), and validated by medical experts.
3. Medical-grade plastic should be used to produce ventilators, and any kind of grease or adhesive chemicals must be avoided in the ventilator. The ventilators should be produced in a [cleanroom](#) as to avoid dust & germ contaminations.
4. The pneumatic circuit should be thoroughly tested for leaks and its ability to withstand elevated positive air pressure. Joints should be used where relevant, and medical-grade flexible pipes should be used between components.
5. While the MakAir ventilators produced on-site in France were validated by a medical

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responsable for its safety validations & use.

Projects

As the MakAir ventilator project grew up to be quite large, it is split up in sub-repositories (eg. firmware, PCB designs, etc.).

Software:

- [makair-firmware](#): The firmware software source code and builds, that runs on the motherboard;
- [makair-control-ui](#): The control user interface, that shows realtime graphs of the ventilator while running, on a LCD display;
- [makair-telemetry](#): The telemetry library (and CLI tool), used as a protocol bridge between the Firmware and Control UI;

Electronics:

- [makair-motherboard](#): The motherboard electronics and PCB design;

Mechanics:

- [makair-parts](#): The mechanical parts that can be 3D-printed and assembled to build the pneumatic circuit;
- [makair-casing](#): The MakAir casing which houses all electronics and pneumatics;

How To Build?

This section aims at introducing you on how to manufacture your own MakAir — *the 3D-printed way*. In other words, we will explain there how to build a DIY MakAir using on-the-shelf parts and 3D printers.


1 Print all the parts

In order to 3D-print your MakAir, please first ensure you have access to a [SLS](#) 3D printer at best (eg. [HP Multi Jet Fusion](#)), or otherwise a [SLA](#) printer (eg. [Formlabs Form 3](#)). If you want to use a [FDM](#) printer (eg. [MakerBot Method](#)), please note that some precise parts have

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 **To sum up:** at best, use a SLS metal printer, else, use a SLA resin printer. If you do not have access to either of these, you may fallback on a FDM filament printer (using [PLA](#) or [ABS](#) filaments).

1. Parts

You can find a list of all parts that should be 3D-printed, as well as the number of parts that should be printed for each one (pick the last active version for each part):

- 1 x **Blower** — Print [all STL parts](#) using the same printer (SLA or SLS; FDM discouraged; 50 microns minimum);
- 2 x **Pressure Valve** — Print [all STL parts](#) using the same printer (SLA, SLS or FDM; 200 microns minimum);
- 1 x **Oxygen Mixer** — Print [the STL part](#) (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Patient Filter Box** — Print [all STL parts](#) using the same printer (SLA, SLS or FDM; 100 microns minimum);
- 1 x **Machine Filter Box (Intake)** — Print [all STL parts](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Machine Filter Box (Outtake)** — Print [all STL parts](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Pneumatic Connectors (Blower)** — Print [the STL part](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Pneumatic Connectors (O2)** — Print [the STL part](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Pneumatic Connectors (No Pressure)** — Print [the STL part](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);
- 1 x **Pneumatic Connectors (Pressure)** — Print [the STL part](#) using the same printer, make sure that you pick the proper sub-part (SLA or SLS; FDM discouraged; 100 microns minimum);

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2. Casing

Now that you got all parts printed, you may assemble them in the MakAir casing box. We recommend that you build the casing using laser-cut acrylic panels. You may find the casing CAD model for [Fusion 360](#) or as a [STEP file](#).


Please ensure that you cut your acrylic panels using the same sizes than stated on our models; as those sizes are optimized to contain all required parts and electronics in the minimum amount of space.

2 Setup the electronics

Electronics are comprised of two parts: the firmware controller board (typically, an Arduino), and the "raw" PCB electronics (LCD, interface buttons, alarm beeper, etc.). Those parts make up the motherboard, on the top of which a rigid panel is mounted, and user instructions are printed (eg. control button bindings).

1. Motherboard

The motherboard electronic schematics and wiring diagrams [can be found there](#). Please pick the last version available.

 *If you need help on this step, you may [open an issue](#).*

2. Control Unit Screen

The control unit is made of a [Raspberry Pi 4](#) computer, plugged to a [Raspberry Pi Touch Display](#).

 *If you need help on this step, you may [open an issue](#).*

3 Flash the firmware

1. Ventilator Firmware

Now that both mechanical parts and electronics are ready, you may flash the latest MakAir


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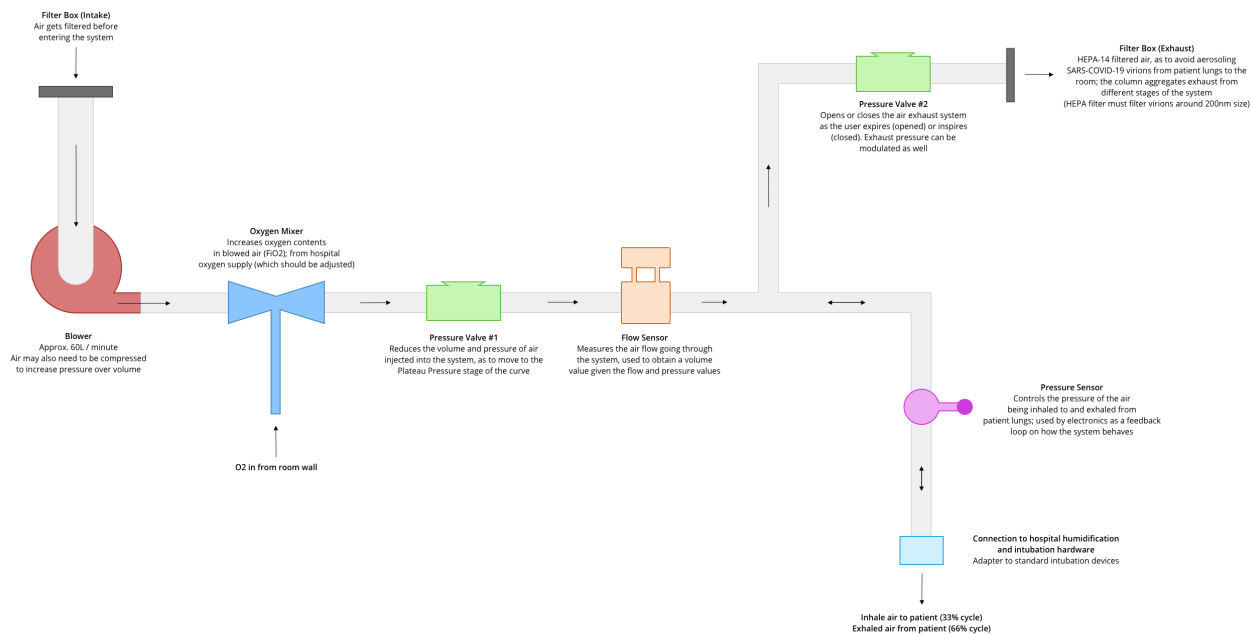
2. Control Unit Runtime

The Control Unit should be built and ran on the Raspberry Pi 4 using instructions available on the [Control Unit](#) documentation.

 If you need help on this step, you may [open an issue](#).

Schemes

Pneumatic Circuit Scheme



(design by [Valerian Saliou](#))

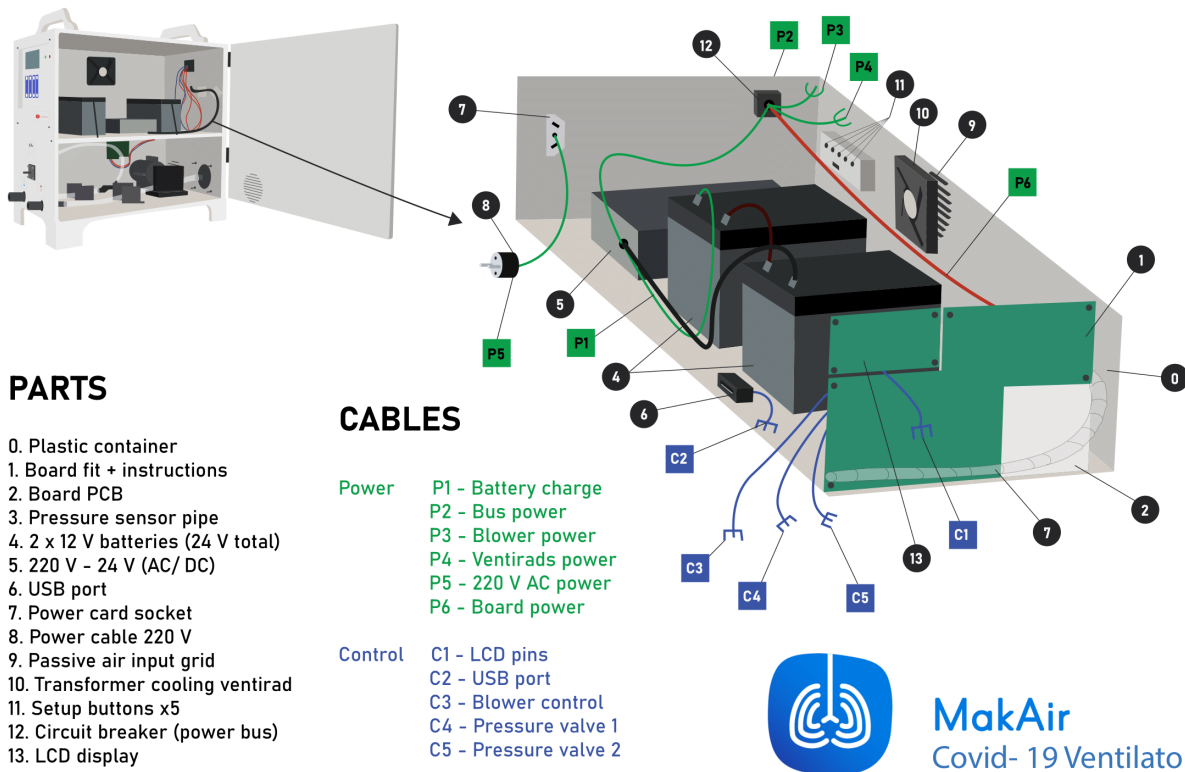
Casing Layout

Top Part: Electronics (Power & Controllers)

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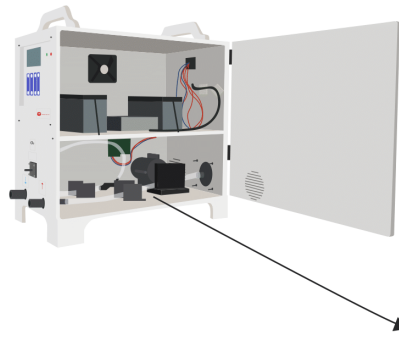
(design by Arthur Dagard; drawing by Valerian Saliou; remake by Lāsma Fedotova)

Bottom Part: Pneumatics

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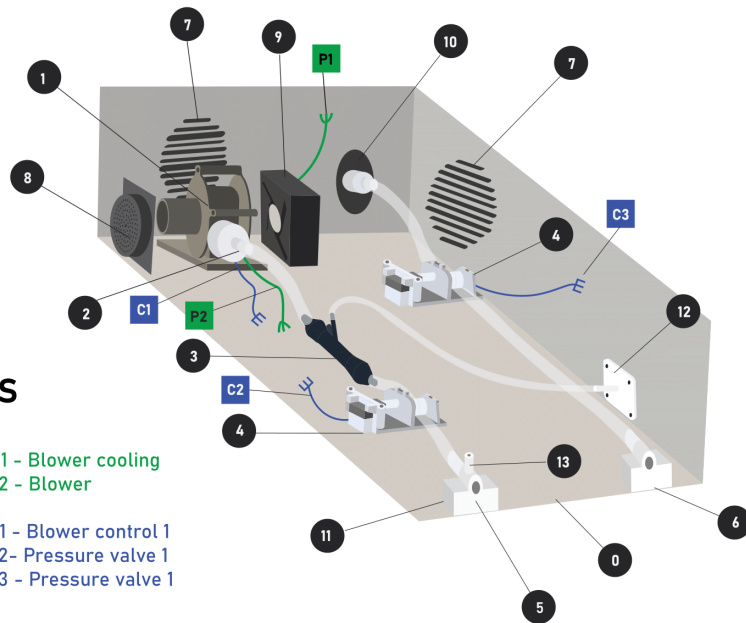
MakAir
Covid- 19 Ventilator

PARTS

0. Plastic container
1. Blower
2. Blower- to- pipe connector
3. Oxygen mixer
4. Pressure valve (x2)
5. Pneumatic connector : outlet
6. Pneumatic connector : inlet
7. Passive air input grid
8. Machine filter box (air in)
9. Blower cooling ventirad
10. Machine filter box (air out)
11. Flow sensor connector
12. Oxygen inlet
13. Pressure sensor adapter

CABLES

- | | |
|---------|---|
| Power | P1 - Blower cooling
P2 - Blower |
| Control | C1 - Blower control 1
C2 - Pressure valve 1
C3 - Pressure valve 1 |



(design by Arthur Dagard; drawing by Valerian Saliou; remake by Lāsma Fedotova)

News & Contact

Updates

- Live updates on Telegram: [join "Newsroom MakAir \(Covid-19 Ventilator\)"](#)
- YouTube channel: [view "MakAir" on YouTube](#)
- Coordination on Slack: [request to join "Makers For Life"](#) (open an issue)

Contacts

- Open-source & questions: [please open an issue on GitHub](#)

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- Engineering contact (software): [David Stenizza \(email\)](#)

- Engineering contact (electronics): Vincent Le Cunff ([email](#))

Sponsors & Contributors

This project would not have been possible without the support of those companies and organizations, which have put human, real estate and/or financial resources at work on the project:

- [Clever Cloud](#) (founding team)
- [Crisp](#) (founding team)
- [Cooprint](#) (CAD)
- [SenX](#) (electronics)
- [Tronico](#) (PCB design)
- [Renault Group](#) (manufacturing)
- [SEB Group](#) (manufacturing)
- [Le Palace Nantes](#) (team offices)
- [Parrot](#) (hardware provider)
- [STMicroelectronics](#) (hardware provider)
- [Diabeloop](#) (regulatory help)
- [Legrand](#) (hardware provider)
- [RTsys](#) (engineering provider)

We are supported by public entities as well, namely:

- [Defence Innovation Agency](#) (Ministry of Armed Forces of France)
- [CEA](#) (France)
- [CHU of Nantes](#) (France)
- [University of Nantes](#) (France)
- [City of Nantes](#) (France)
- [Region of Auvergne-Rhône-Alpes](#) (France)

En plus de cela, plus de 200 membres individuels du projet qui ont contribué à des sujets techniques, juridiques, médicaux et de presse (et plus).

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- [France 3, 21 avril 2020](#) (francophone)
- [TF1, 26 avril 2020](#) (francophone)



Journaux

- [Le Monde, 20 avril 2020](#) (francophone)
- [Le Parisien, 21 avril 2020](#) (francophone)
- [Le Figaro, 26 avril 2020](#) (francophone)
- [Le Point, 6 mai 2020](#) (francophone)

Communiqués 138



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on 29 Apr

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Paquets

Aucun package publié

Contributeurs 27



+ 16 contributeurs

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