

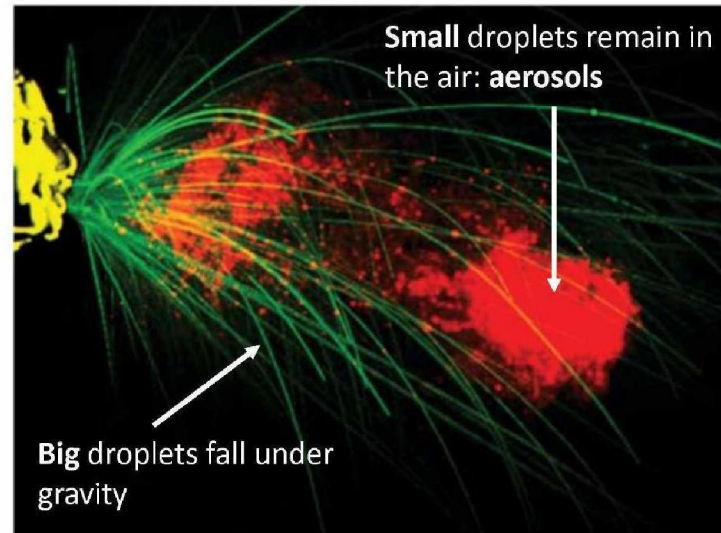
Ventilation strategies for infection control

Public-Private cooperation

4th September 2020

How is the virus transmitted?

- Respiratory droplets ($>5\mu\text{m}$)
- Fomites (infected surfaces)
- Aerosols ($<5\mu\text{m}$)



The role of aerosols in the spread of the virus

- More and more scientific studies suggest that aerosols play an essential role in the transmission of the SARS-CoV-2 virus

ACCEPTED MANUSCRIPT

It is Time to Address Airborne Transmission of COVID-19

Lidia Morawska, Donald K Milton

Clinical Infectious Diseases, ciaa939, <https://doi.org/10.1093/cid/ciaa939>

Published: 06 July 2020 Article history

VIEWPOINT: COVID-19

Reducing transmission of SARS-CoV-2

Masks and testing are necessary to combat asymptomatic spread in aerosols and droplets

Kimberly A. Prather, Chia C. Wang, Robert L. Schooley

Respiratory infectious viruses spread through the transmission of virus-containing droplets (1-10 µm) and aerosols (1-5 µm) exhaled from infected individuals during breathing, speaking, coughing, and sneezing. Traditional respiratory disease control measures are designed to reduce transmission by droplets produced in the aerosols and coughs of infected individuals. However, a large por-

portion of the spread of coronavirus disease 2019 (COVID-19) appears to be occurring through airborne transmission of aerosols produced by asymptomatic individuals during breathing and speaking (1-5). Aerosols can accumulate, remain infectious in the air for hours, and be easily inhaled deep into the lungs. For society to resume, measures designed to reduce aerosol transmission must be implemented, including universal masking and regular widespread testing to identify and isolate infected asymptomatic individuals.

Humans produce respiratory droplets ranging from 0.1 to 1000 µm. A competition between droplet size, inertia, gravity and evaporation determines how far exhaled droplets and aerosols will travel in air (1, 2). Larger respiratory droplets will undergo gravitational settling faster than they evaporate, contaminating surfaces and leading to contact transmission. Smaller droplets and aerosols will evaporate faster than they can settle out because, and then can be affected by air currents, which can transport them over larger distances. Thus, there are two-

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RIVM: verspreiding coronavirus via aerosolen is mogelijk



Bord in Amsterdam dat mensen oproept onderhuids masker afstanden te houden. JIP

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Coronavirus: WHO rethinking how Covid-19 spreads in air

8 July 2020 Share

Coronavirus pandemic

WHO underplaying risk of airborne spread of Covid-19, say scientists

Open letter says there is emerging evidence of potential for aerosol transmission

Coronavirus - latest updates See all our coronavirus coverage



Wearing masks indoors could help protect against airborne transmission. Photograph: Sam McWhirter/Reuters

The current guidelines

- The current guidelines are based on outdated knowledge on the role of aerosols
- This leads to various uncertainties:
 - What virus concentration is required to infect a person?
 - Do environmental parameters play a role? (humidity, temperature, external flow)
 - To what extent ventilation can help?
- This leads to heated debates in communities (civil and scientific)

The concerns of businesses

Businesses are asking:

- How can we ensure the safety of my personnel and customers?
- Under what conditions do we need to take actions for removing aerosols? What are practical ways to do this?
- Are the measures too or little strict in comparison with the actual risk?
- How can we communicate that the measures are safe and effective?
- How can a ventilation or sanitization system help?
- Do the current guidelines allow for a sustainable return to economic activity?



Concerns in the maritime sector

- Onboard of cruise ships and ferries

Here's Why The Cruise Ship Quarantine Turned Into Such A Disaster

Bad ventilation and a botched quarantine on the *Diamond Princess* likely caused hundreds of illnesses and two deaths in the largest outbreak outside China.



Source: <https://www.buzzfeednews.com/article/danvergano/cruise-ships-quarantine-botched>

Sail Safe



Cleaning and hygiene measures onboard

- Increased opportunities for hand wash and disinfection in public areas.
- On-board announcements, posters, and digital signage about hygiene guidelines onboard.
- Increased frequency of cleaning and disinfection onboard, especially of "Hand Contact Points" such as door handles, access touchpads, telephones.
- Our ventilation systems are running on 100% fresh air, no recirculation.

Source: <https://www.stenaline.com/sail-safe/>

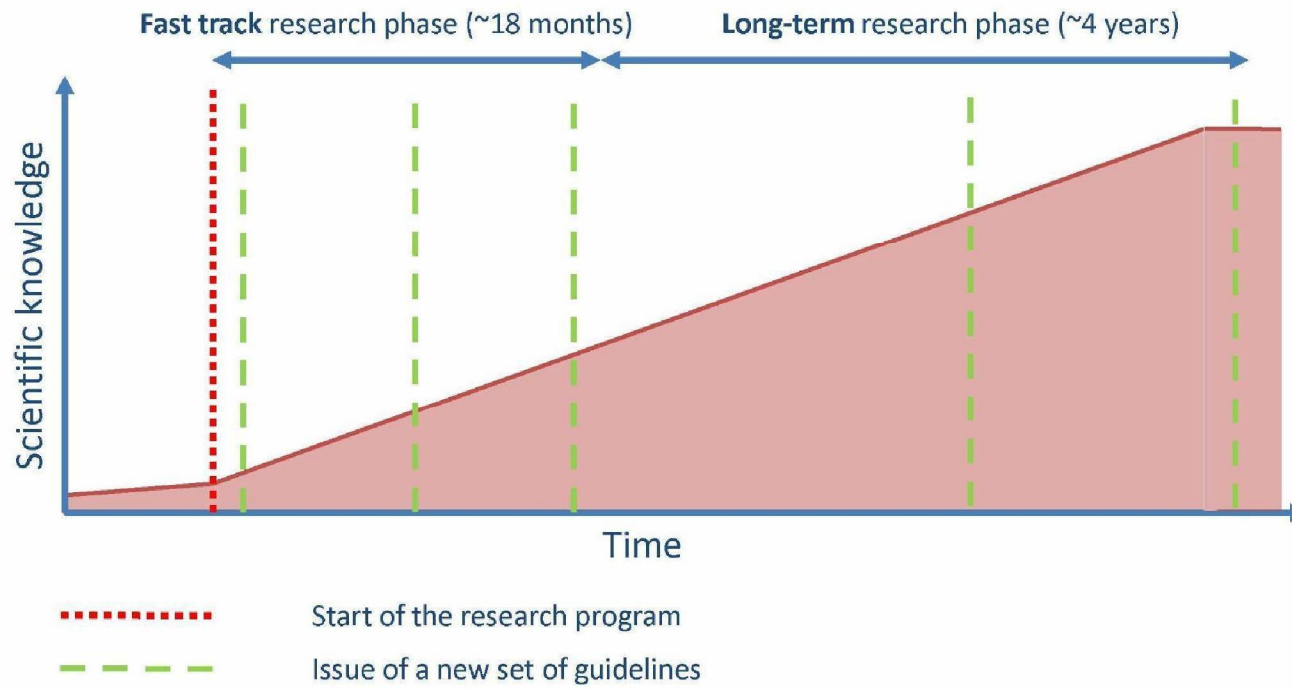
Project Goal

- In view of our health and economy we aim to develop effective guidelines on ventilation strategies for infection control
 - Based on up-to-date scientific knowledge
 - Functional
 - Widely supported by business and society
- These guidelines should address how the concentration of a virus in the air can be limited in the **most efficient and sustainable** way for **specific spaces** where a certain amount of people are performing a certain activity
- These guidelines are applicable for the current COVID19 pandemic, but also for other viruses (e.g. common cold, influenza, new future viruses) so as to reduce their economic and societal impact

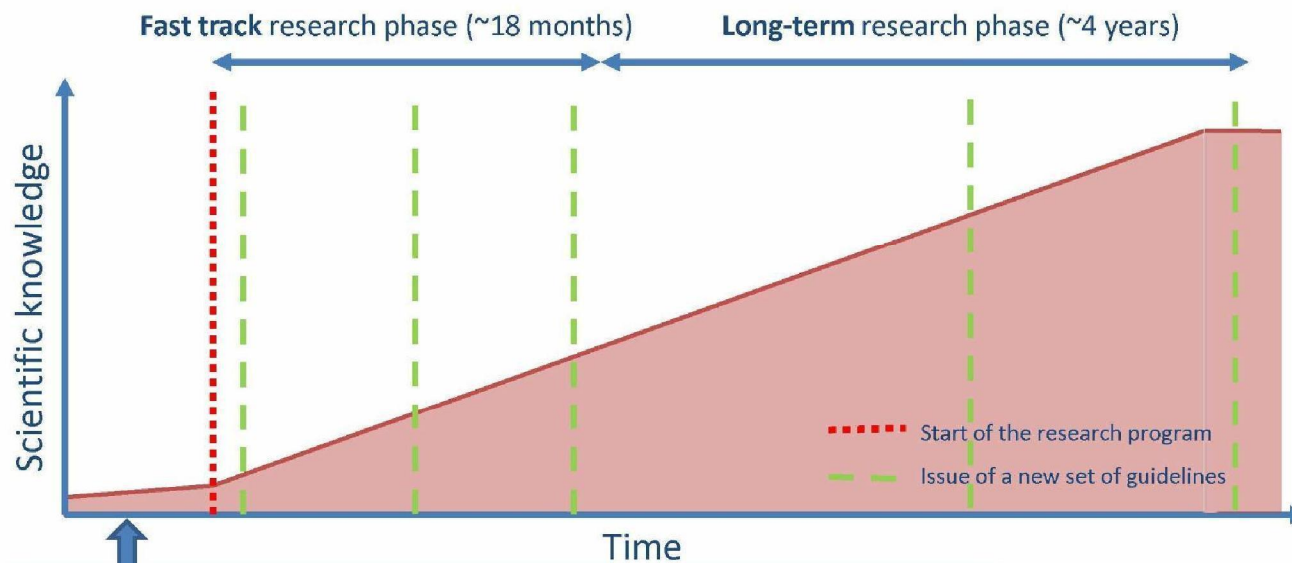
The approach

- The ideal approach in “normal times” would be:
 - Achieve a complete scientific basis starting from the fundamentals
 - Make and implement guidelines
- However, we do not have the luxury of **time**: we need to address the societal needs as quickly as possible, while maintaining a high level scientific basis
- Thus, we propose a phased approach where first, a “**Fast Track**” phase will generate knowledge and guidelines on an accelerated manner. This will be followed by a **long-term** research track where a more comprehensive and fundamental approach will take place.

Project timeline

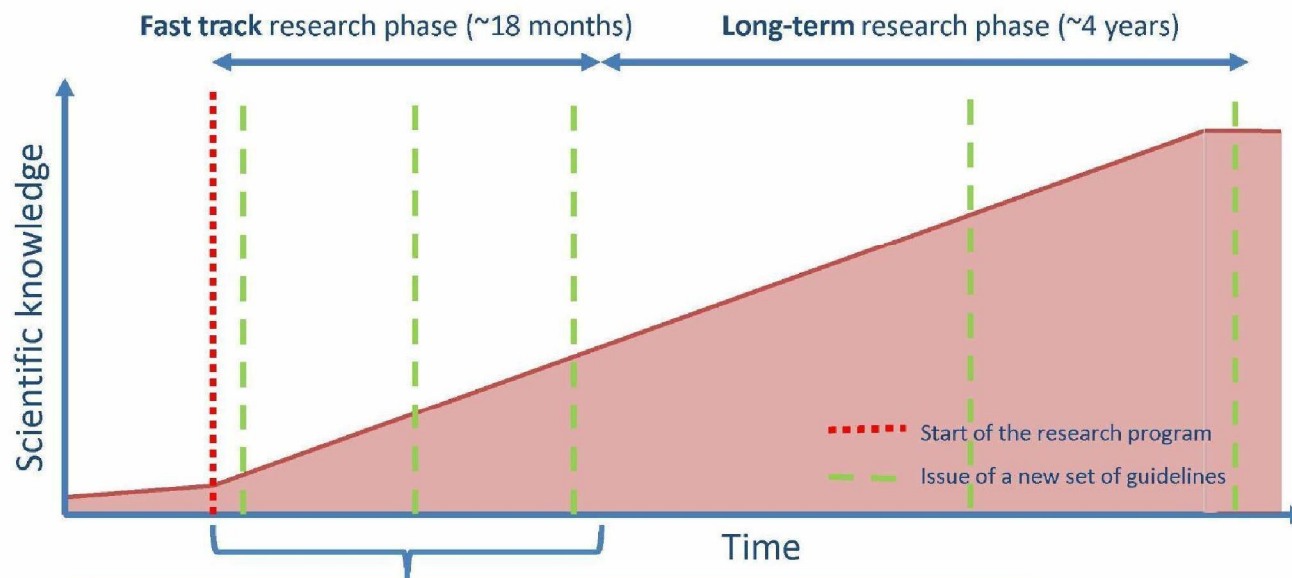


Project timeline



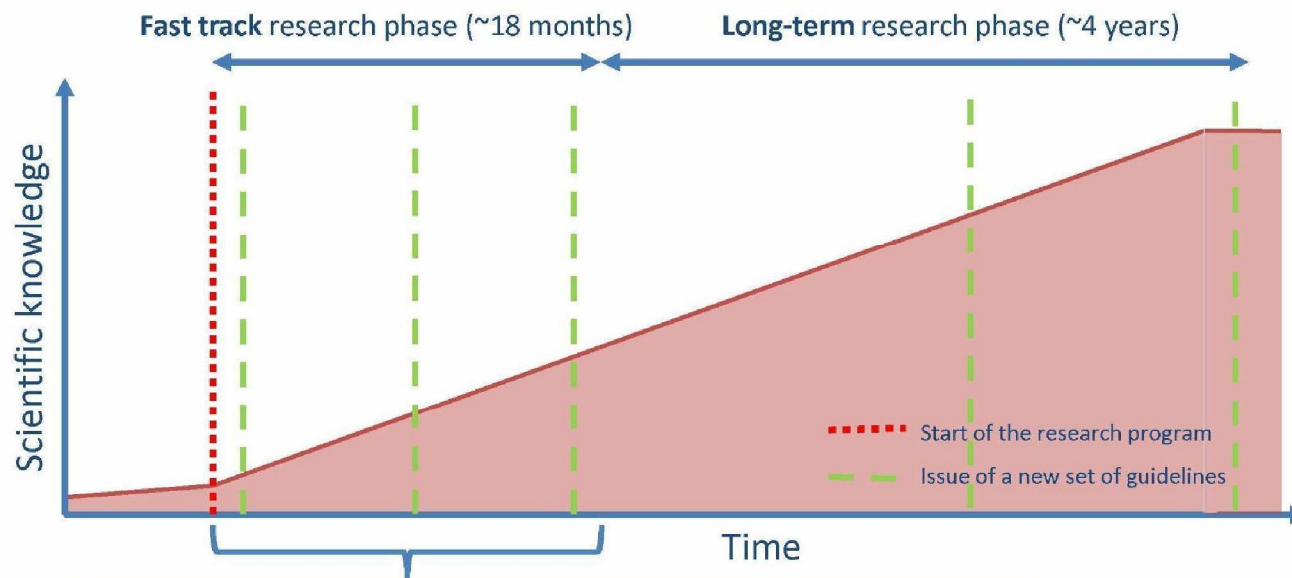
Currently many loose research initiatives from different sectors are running. This is an inefficient way of building knowledge. We aim to bring these actions together with the goal of making research more effective and achieve better guidelines on a shorter time frame.

Project timeline



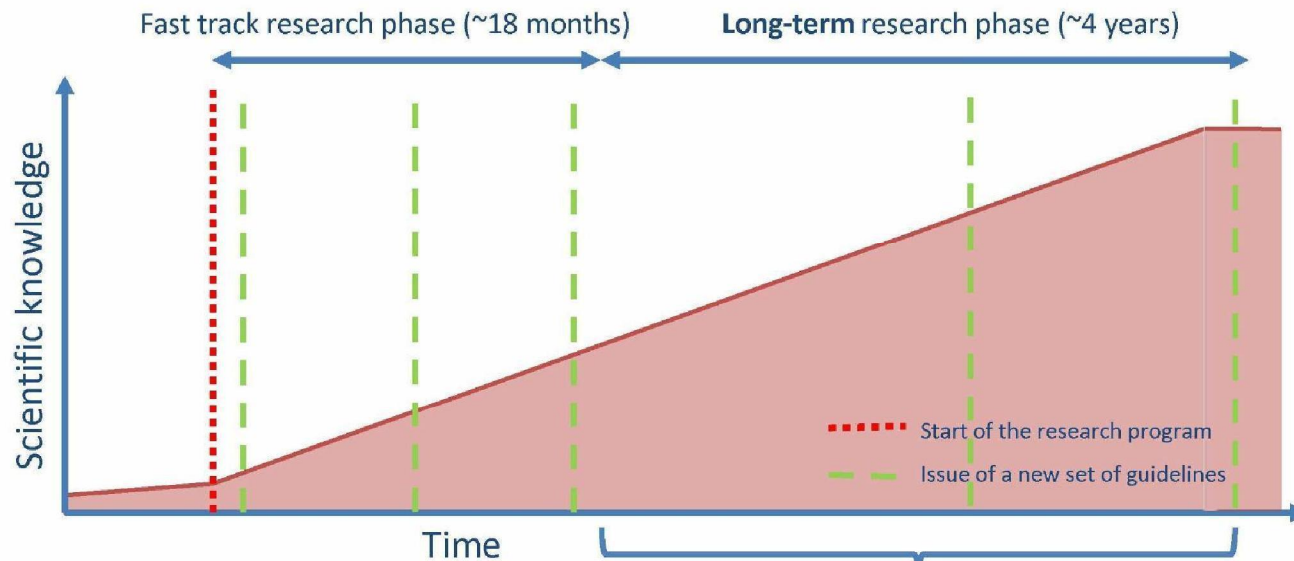
Initially a fast track phase will be initiated with a focus on the main influencing parameters. The goal is to deliver guidelines and up to date scientific knowledge on short notice to address societal needs.

Project timeline



At the start of the project we will collect all knowledge that is being generated as we speak, and converge it into a first set of guidelines on short notice. Such guidelines will then be updated on the new scientific knowledge on regular basis, if necessary.

Project timeline



A second long-term research phase will follow where a more fundamental knowledge development will take place. This phase will be key into our readiness for possible future pandemics and the reduction of the economic damage due to other viruses such as common cold and influenza

Cooperation

- Multidisciplinary Research Team



5.1.2e



UNIVERSITY OF AMSTERDAM

5.1.2e

Physics of Fluids
UNIVERSITY OF TWENTE.

5.1.2e



umcg

5.1.2e

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EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

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RIVM

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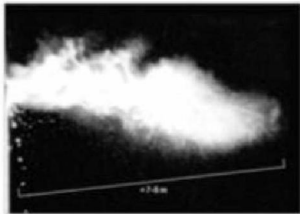
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Cooperation

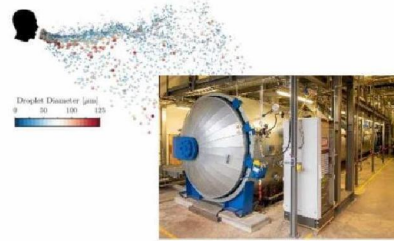
- In contact with businesses and organizations (open for extension)



Project Structure (open for extension)



P1: Infectivity of viruses in aerosols (Lead: UMCG)



P2: Spreading of Aerosols (Lead: UT)



P3: Ventilation concepts for the removal of aerosols (TU/e)



P4: Real world use cases (MARIN?)



P5: Strategies for Infection control (TU Delft?)

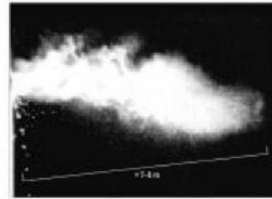
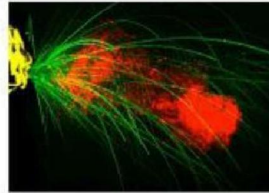
Project 1: Infectivity of viruses in aerosols (Draft plan)

P1: Infectivity of viruses in aerosols (UMC Groningen)

WP 1.1 : Assessment of infection transmission methods

WP 1.2 : Required conditions for infection (emission of droplets, concentration, size distribution, infection status)

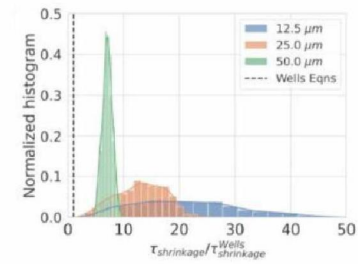
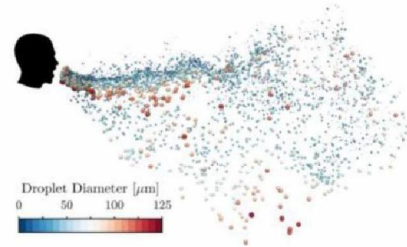
WP 1.3 : Virus inactivation methods (e.g. UV-C lights, plasma filters etc)



Project 2: Spreading of Aerosols (Draft plan)

P2: Spreading of Aerosols
(UT)

WP 2.1: Numerical study of
droplet deposition (DNS)



WP 2.2: Experimental study of
environmental parameters
(temperature, humidity,
airflow)



The Atmosphere at MARIN



The Atmosphere at MARIN

$L = 15$ m

$D = 2.5$ m



Facility developed and built with the contribution of



Temperature

$$T \in [15, 200] \text{ } ^\circ\text{C}$$

Humidity

$$\text{RH} \in [0, 100] \%$$

Pressure

$$p_u \in [0.02, 10] \text{ bar}$$

Gas Composition

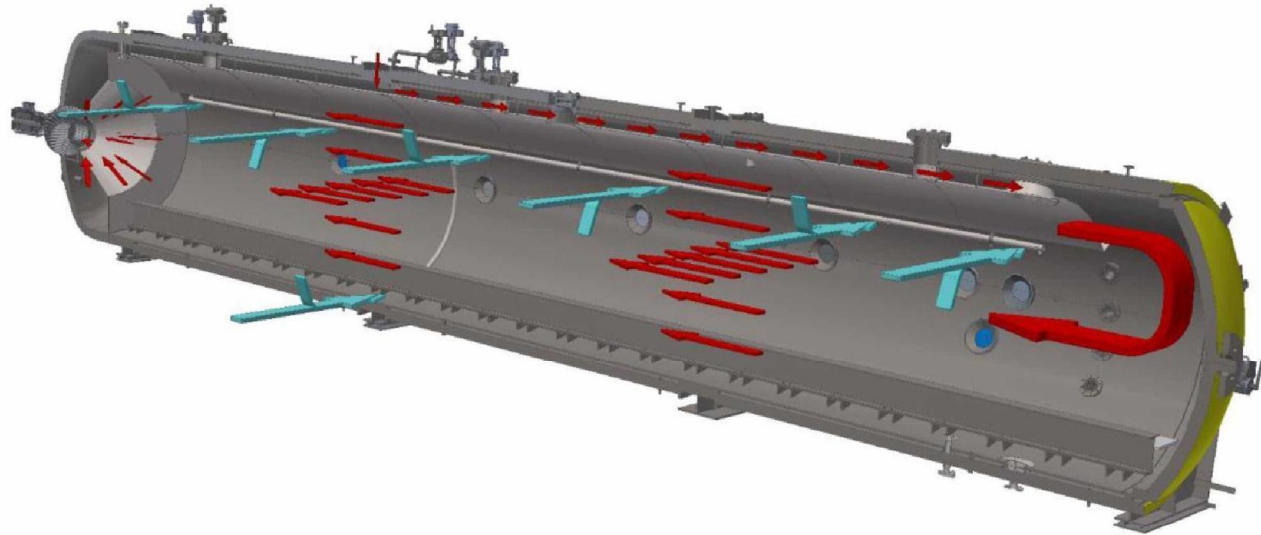
$$M \in [4, 146.06] \times 10^{-3} \text{ kg/mol}$$

Non-condensable : He, N_2 , SF_6

Condensable : water vapor

The Atmosphere at MARIN

- Optically accessible (17 windows)
- We can place equipment and test setups inside the autoclave and access them through several inlets for cables, pipes etc.
- In addition, **flows** can be created inside the autoclave



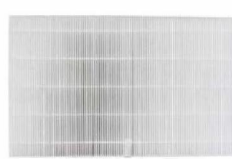
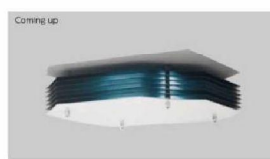
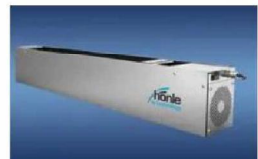
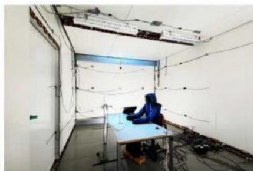
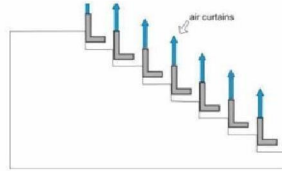
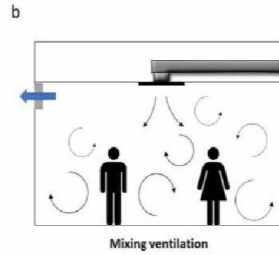
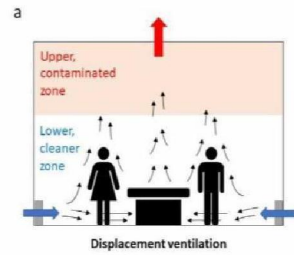
P3: Ventilation concepts for the removal of aerosols (Draft plan)

P3: Ventilation concepts for the removal of aerosols (TU/e)

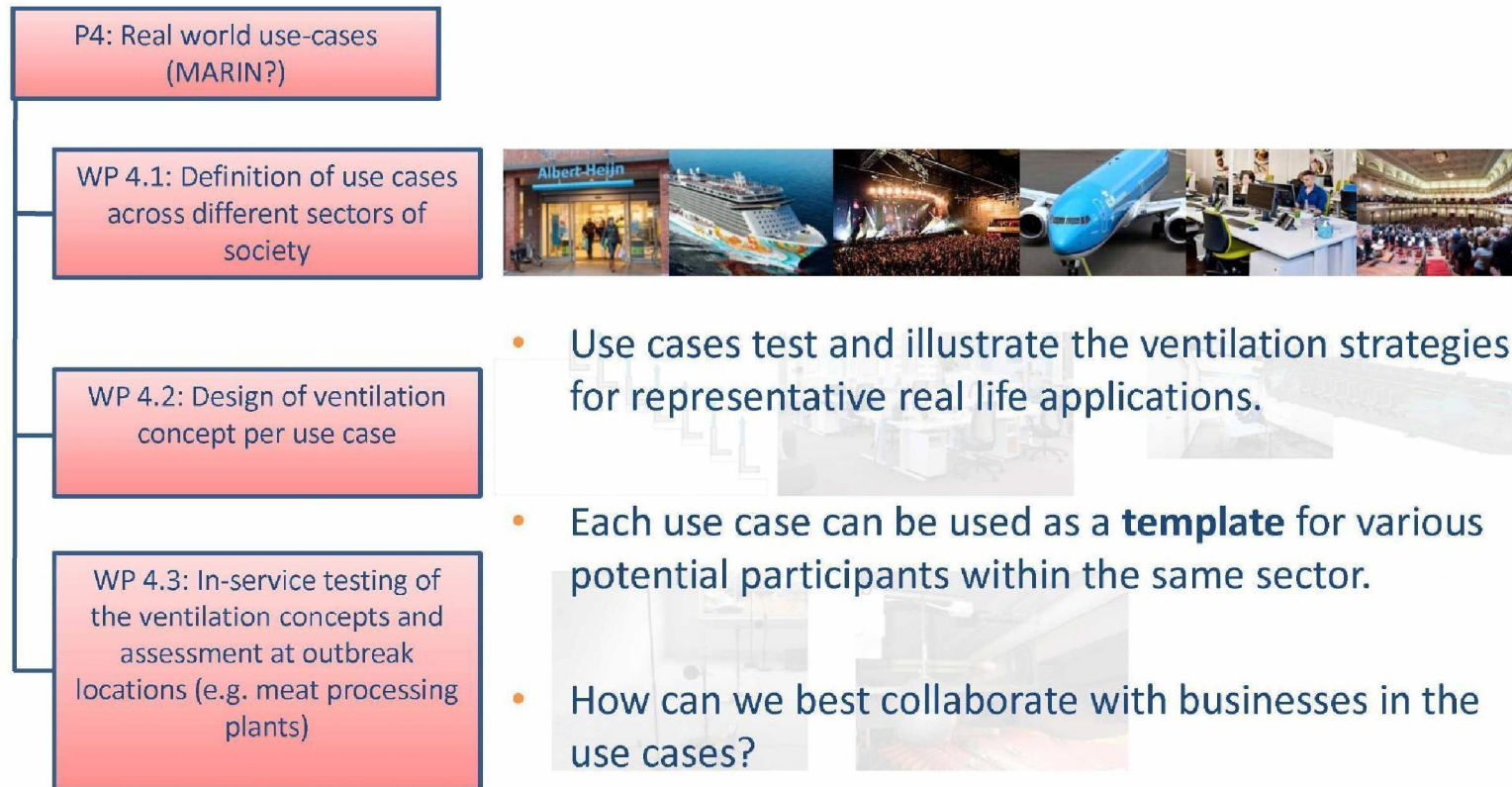
WP 3.1: Room ventilation concepts

WP 3.2: Local ventilation concepts

WP 3.3: Ventilation concepts with filtering and/or sanitization



P4: Real world use-cases (Draft plan)



P3: Ventilation concepts for the removal of aerosols (Draft plan)

P4: Real world use-cases
(MARIN?)

WP 4.1: Definition of use cases
across different sectors of
society



WP 4.2: Design of ventilation
concept per use case



WP 4.3: In-service testing of
the ventilation concepts and
assessment at outbreak
locations (e.g. meat processing
plants)



Use case example: air cabin

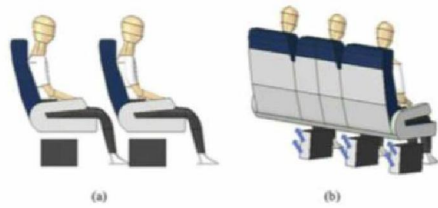


Fig. 1. Schematic of the proposed ventilation system: (a) individual diffusers under the seats and (b) the positions of the diffusers and the air supply directions.



Fig. 5. (a) A close-up view of a diffuser and (b) the diffusers installed under the seats.

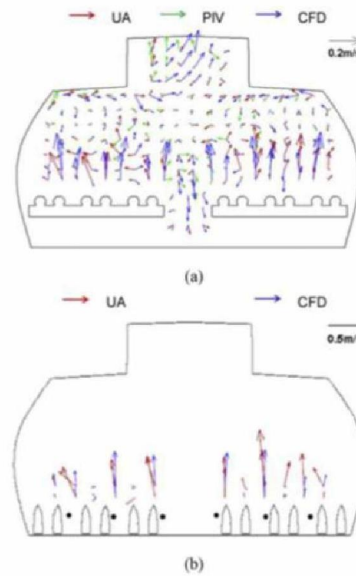


Fig. 7. Measured and simulated air velocity distribution in (a) CS4 and (b) the leg area that was located 0.15 m in front of CS4.

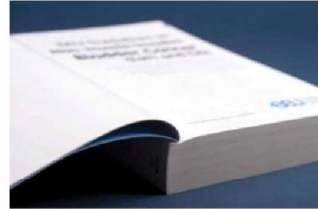
- No ventilation

- With ventilation

Project 5: Strategies for infection control (Draft plan)

P5: Strategies for Infection Control (TU Delft?)

WP5.1: Establishment of Guidelines

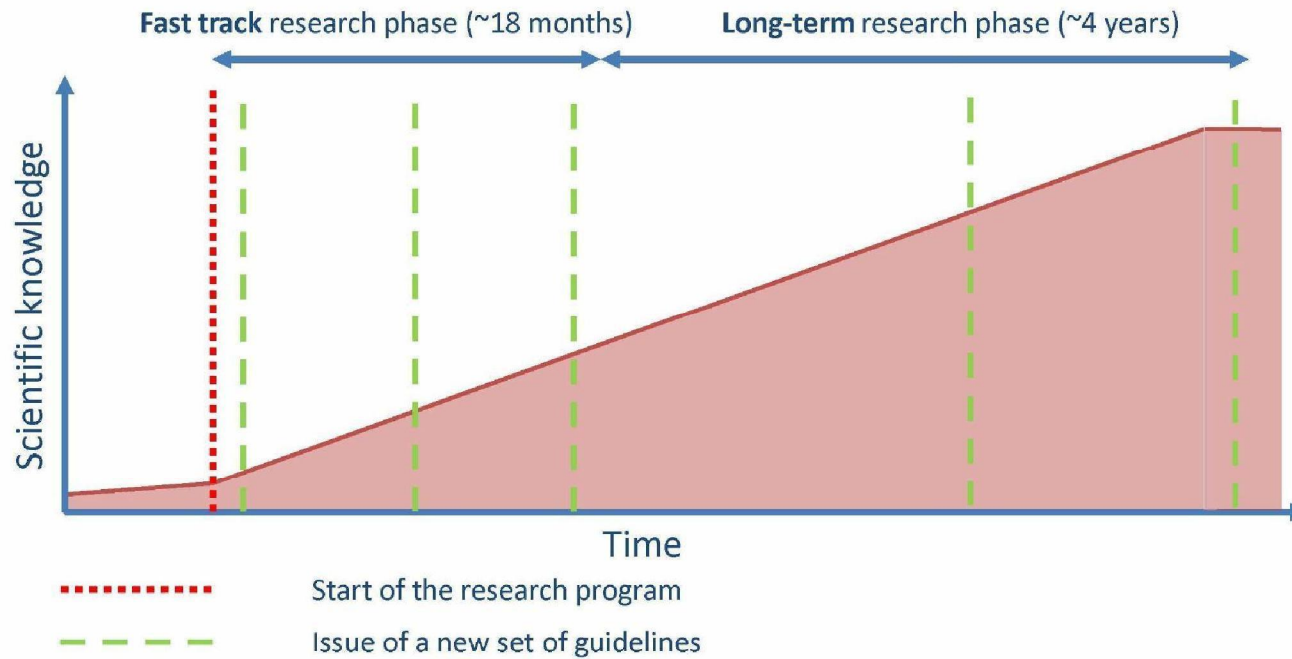


WP5.2: Cost effectiveness of proposed guidelines



Project timeline and budget

- Time line: start in Autumn 2020
- Total budget: 15 – 20 MEuro



Ongoing actions

- Drawing-up research program
- Defining the use cases with businesses
- Receiving letters of support from businesses
- Acquiring funding from government

Thanks for your attention!