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SEASTAR WT

Wind tunnel: a versatile infrastructure for validating gas releases simulations

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Outline

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2. The making of the SEASTAR Wind Tunnel
3. SEASTAR Wind tunnel features
4. How to use the SEASTAR Wind Tunnel
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   b. Hydrogen dispersion in congested spaces
   c. Food for thought:
      - Environmental dispersions
      - Renewable technologies testing
      - COVID-related simulations
5. Follow up and conclusions

Framework of the project 1/2

In the beginning was the SEADOG Lab (since y. 2015)

1. The SEADOG Laboratory @ Politecnico di Torino aggregates expertise of **three** Departments (Energy, Environment, Land and Infrastructure Engineering, Applied Science and Technology).
2. SEADOG stands for **Safety & Environmental Analysis Division for Oil & Gas**
3. The Laboratory is being supported by the Italian Ministry of Economic Development's Directorate General for Safety - National Mining Office for Hydrocarbons and Georesources.

Framework of the project 2/2

After a good record of successful activities (e.g. Guidelines for RoMH* reporting for Oil&Gas platforms, development of a fully sensored AUV**,…) the SEADOG Lab experience evolved in the foundation of the

SEASTAR Competence Center

(*Sustainable Energy Applied Sciences, Technology & Advanced Research*)

At present, 3 Labs are part of SEASTAR:

SEASTAR AUV **development and testing of AUV**

SEASTAR H2 **H2 injection in depleted reservoirs**

SEASTAR WT **Wind Tunnel**

*Report on Major Hazards

** Autonomous Underwater Vehicle

The making of the SEASTAR Wind Tunnel

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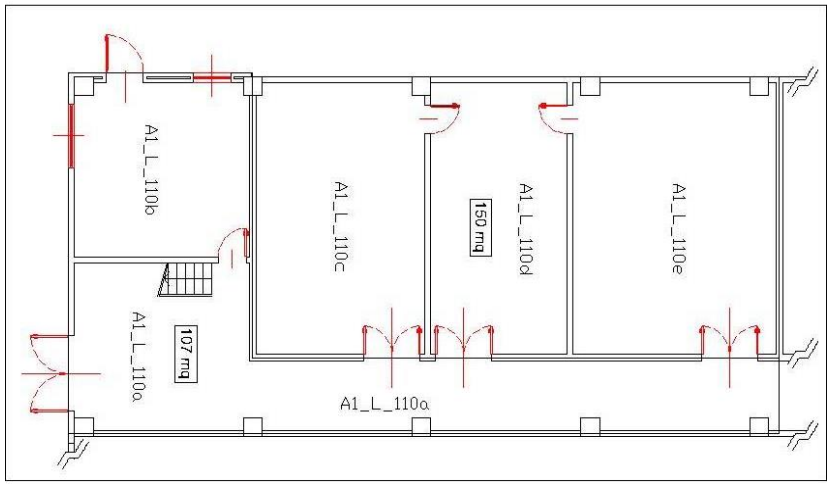
Steps

1. Identification of the **location** of the facility
2. Choice of the **type** and **size** of the facility
3. Preliminary design
4. Executive design
5. Realisation and commissioning

The making of the SEASTAR Wind Tunnel

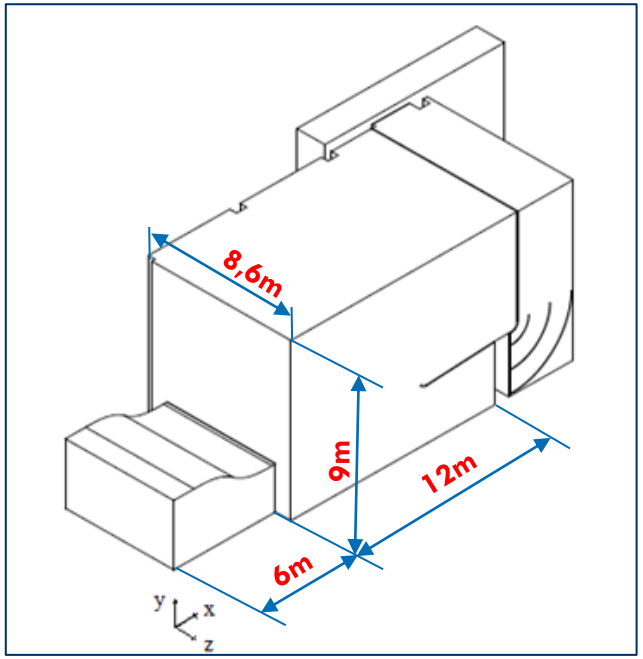
1. Identification of the **location** of the facility
   - Environment Park premises (Torino, Italy)
   - Available free spaces for experimental operations
     - ~ **200 m²** of which
       - 170 m² on ground floor
       - 30 m² on first floor
     - **9 m** in height
   - **100 kW** power installed and available

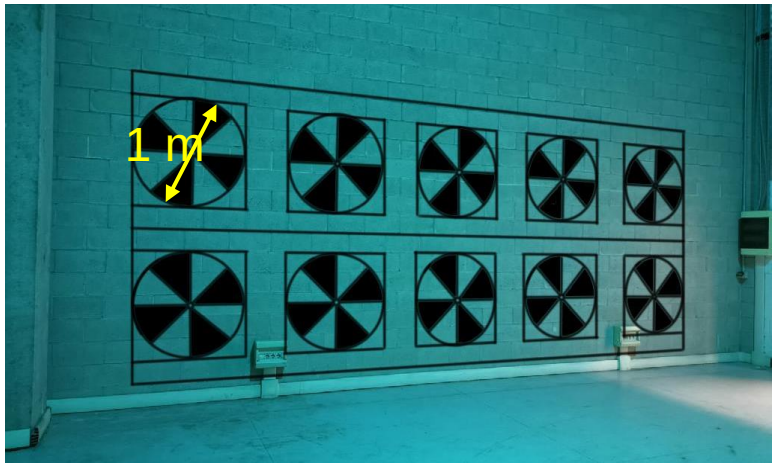
https://it.freepik.com/foto-vettori-gratuito/sfondo



The making of the SEASTAR Wind Tunnel

2. Choice of the **type** and **size** of the facility
   - **Subsonic, open flow wind tunnel**
   - Considering the available space, **total volume: 8,6 m x 16 m x 9 m**
     test room: 6 m x 5 m x 2 m





The making of the SEASTAR Wind Tunnel

3. Preliminary design

- March 2018 - July 2018

Test room

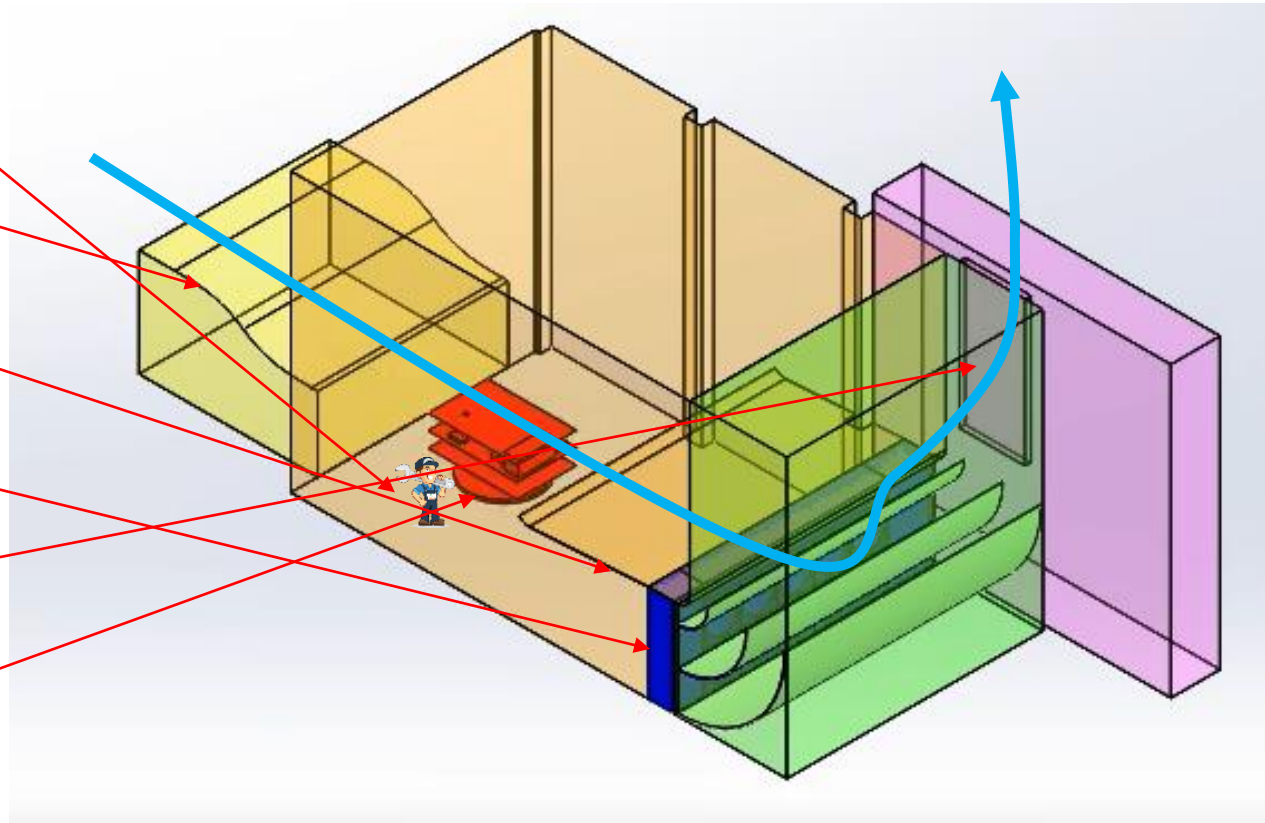
Convergent duct

Divergent duct

Fans

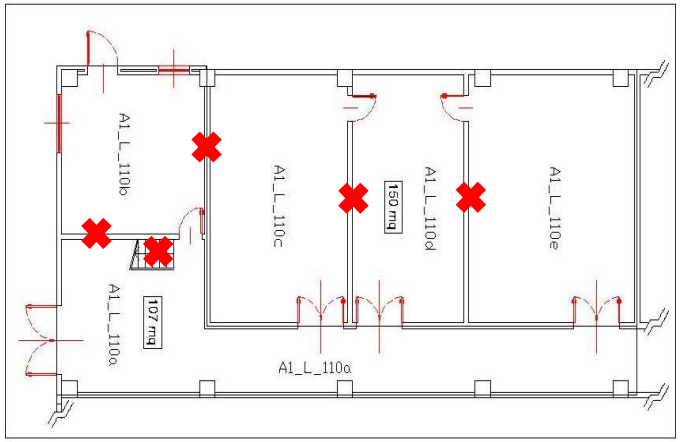
Air shaft

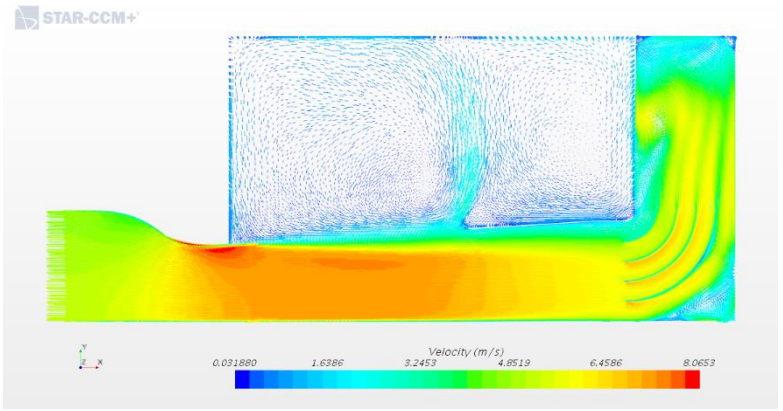
Test facility/mockup

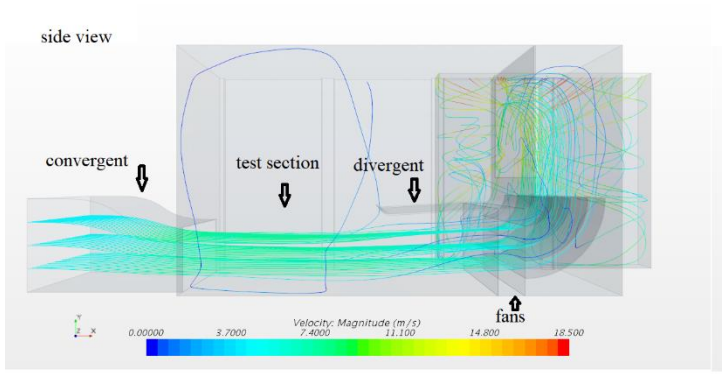


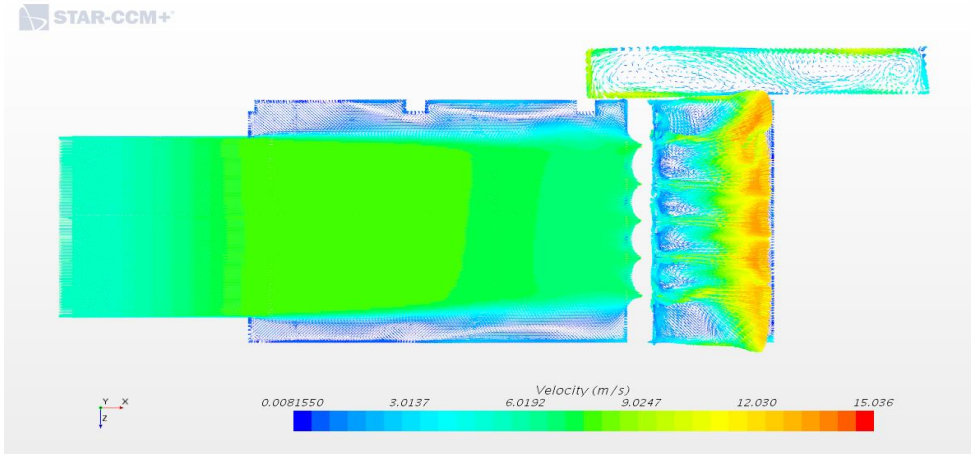
The making of the SEASTAR Wind Tunnel

- CFD simulations to verify flow stability in the available volume





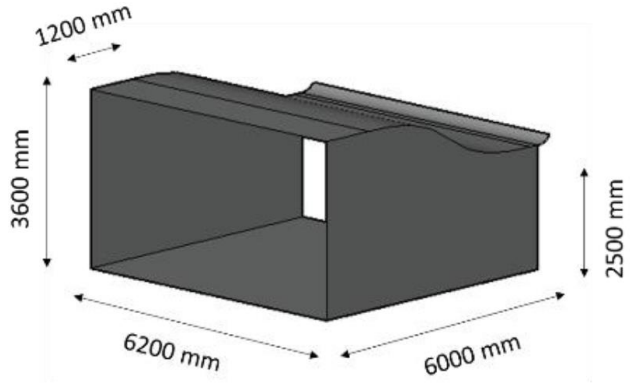


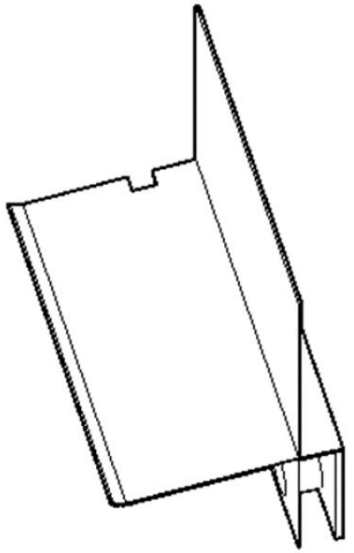


The making of the SEASTAR Wind Tunnel

4. Executive design

- July 2018 – July 2019
- Choice of fans
- Details on convergent and divergent geometries
- Details on honeycomb





The making of the SEASTAR Wind Tunnel

5. Realisation and commissioning

SEASTAR Wind tunnel features

- **Homogenous test room: 6m x 5m x 2m**
- Elevated Control Room with large window with possibility of complete remote control of testing
- Auxiliary spaces for dressing and locker rooms
- Access control with badges
- Environmental Safety systems (gas sensors) and alarm system
- 10 fans (5x2 rows) individually controllable (and replaceable up to 100kW power absorption)
- Pitot system for characterisation
- A gas release assembly
- **Wind speed 0-6 m/s**

How to use the SEASTAR Wind Tunnel

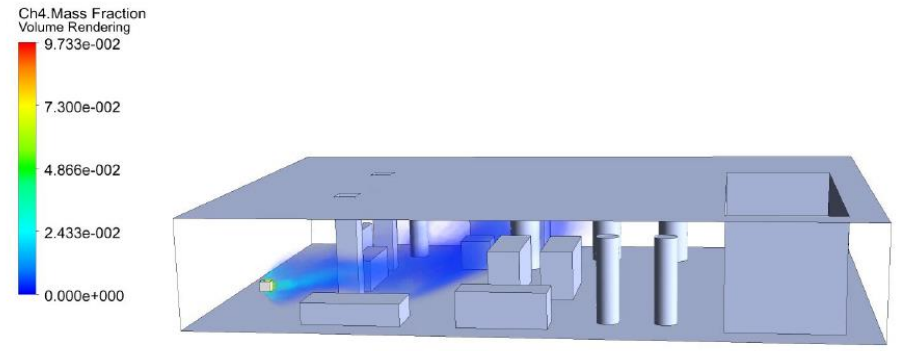
1. Validation of CFD simulations (present application)

Context: Oil&Gas Risk assessment → Consequences evaluation → release of high pressure methane from small fractures in equipment on-board an offshore platform

Domain: intermediate deck on an oil&gas platform, North Adriatic sea typical wind stream

A CFD new model (SBAM: Source Box Accidental Model) developed to obtain fast and reliable dispersion clouds results

A model that needs **experimental validation.**

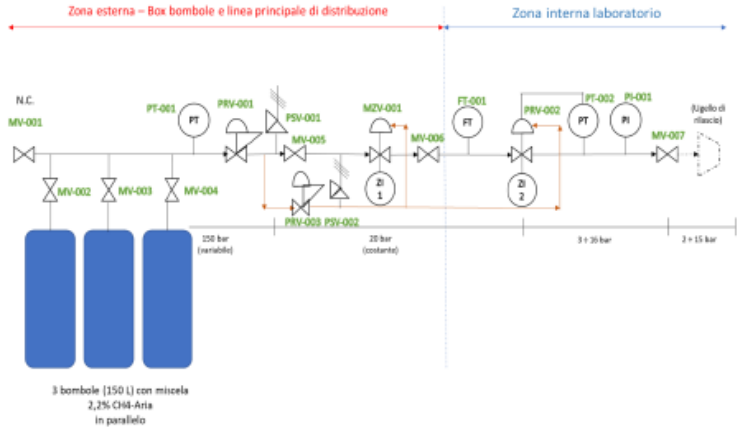


How to use the SEASTAR Wind Tunnel

Experimental setup:

Scaled mock-up of a platform, with one deck completely sensorised and remotely controlled

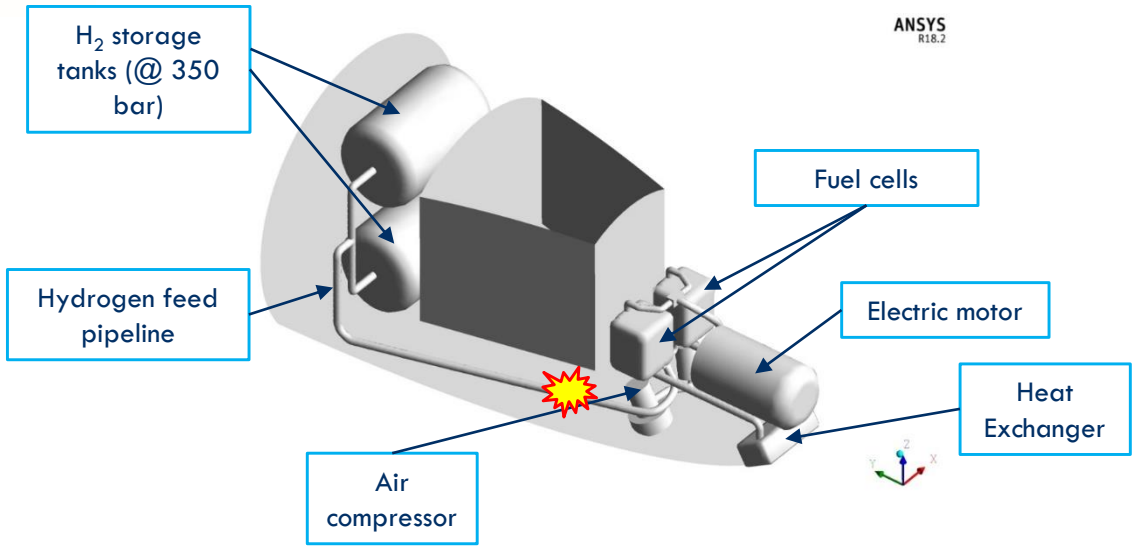
A gas release setup for releasing high pressure (up to 16 bar) methane on-board the mock-up

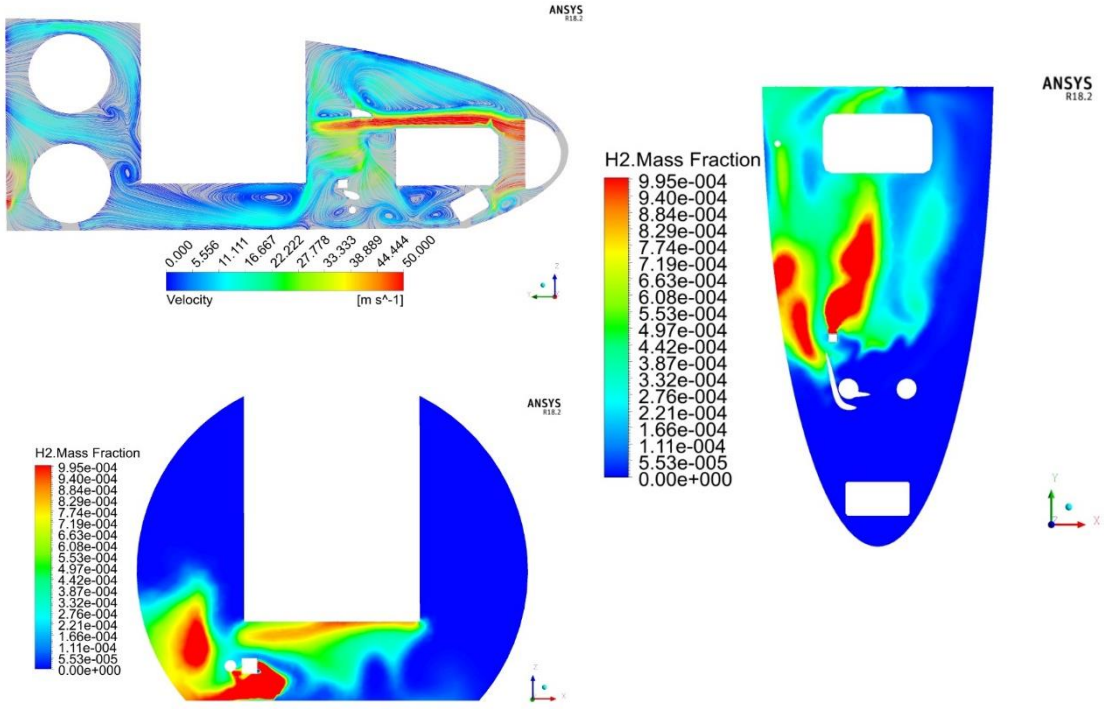


How to use the SEASTAR Wind Tunnel

2. Hydrogen dispersion in congested spaces

SBAM model has been used with hydrogen releases in congested spaces (e.g. small aircraft cabins) → **Validation needed**





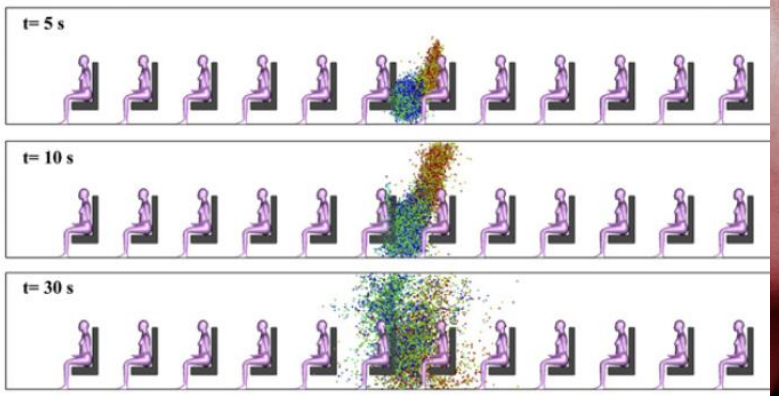
Design from: G. Romeo et al., «ENFICA-FC: Design of transport aircraft powered by fuel cell & flight test of zero emission 2-seater aircraft powered by fuel cells fueled by hydrogen», International Journal of Hydrogen Energy 38, pp 469-479, 2013.

How to use the SEASTAR Wind Tunnel

3. Food for thought:
   - Environmental dispersions, smog and pollutants dispersion in congested environments (like cities)
   - Renewable technologies testing (e.g. scaled wind towers)

- COVID-related simulations:

Coughs and sneezes droplets dispersion pattern in a ventilated and congested environment



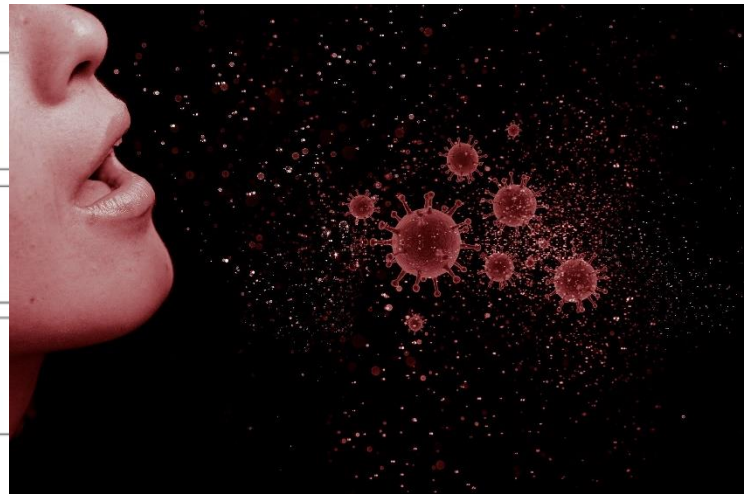


Illustration from: Lei Zhang, Yuguo Li, Dispersion of coughed droplets in a fully-occupied high-speed rail cabin, Building and Environment 47 (2012) 58-66

Follow up and conclusions

1. A new open flow wind tunnel has been built and it is operating in Torino (IT) for simulations involving wind speeds in the range 0-6 m/s
2. The wind tunnel is flexible for being used with gas releases under pressure (including hydrogen): a supply line is on site
3. The facility is neighbour of a hydrogen excellence research lab (Hysylab) with which it shares auxiliaries and supplies
4. The facility can be upgraded with more powerful fans and it is planned to be equipped with more sophisticated detection systems (like Particle Image Velocimetry - PIV)
5. Located in the premises of an innovation accelerator focused on sustainability and environmental issues, it is an optimal site for testing new energy technologies and emerging resilience tools.

Thank you for your attention

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SEADOG DENERG laboratory

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