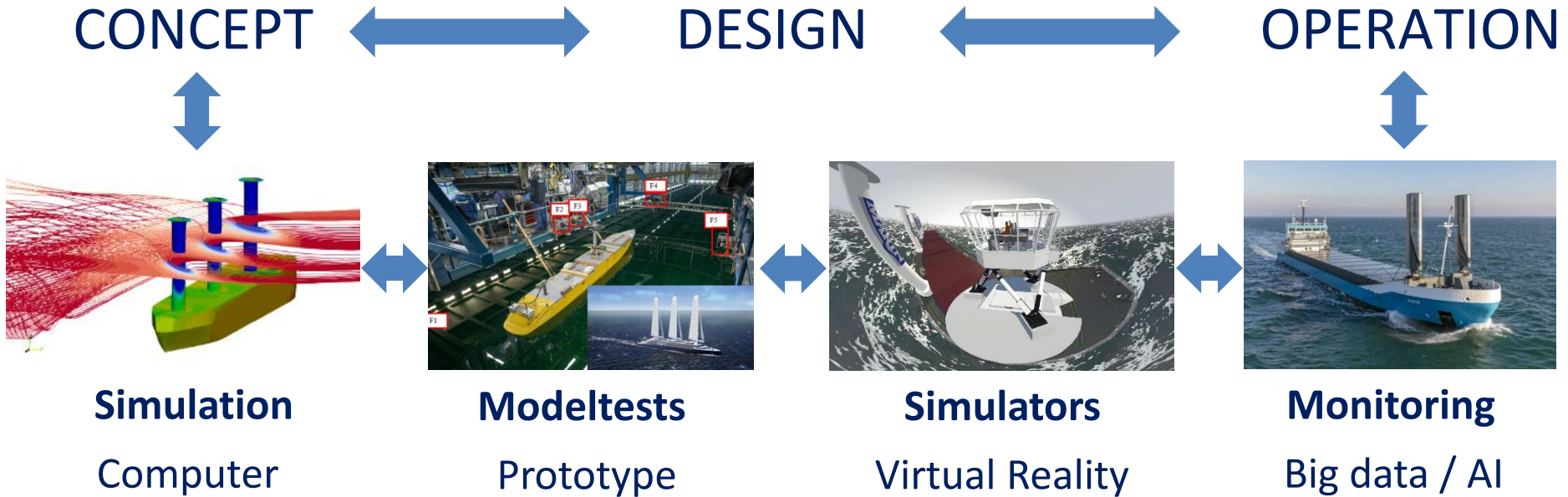




BETTER SHIPS, BLUE OCEANS

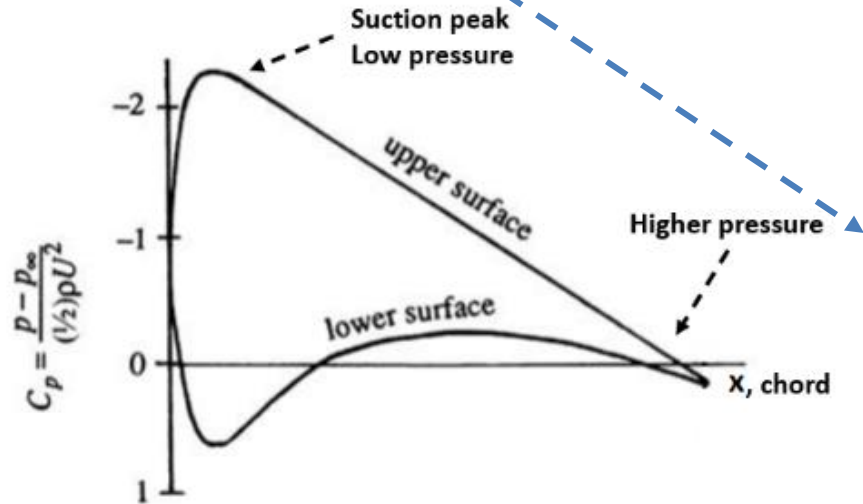
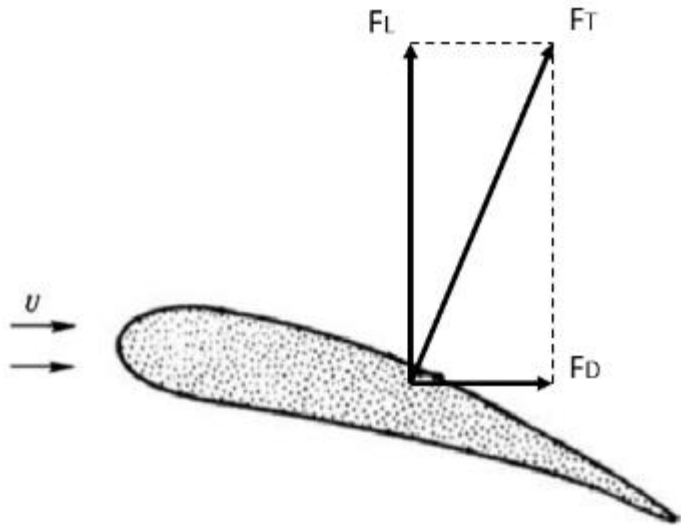
Suction wings: Working principle, evolution of the concept & performance assessment

Maxime Garenaux, MARIN

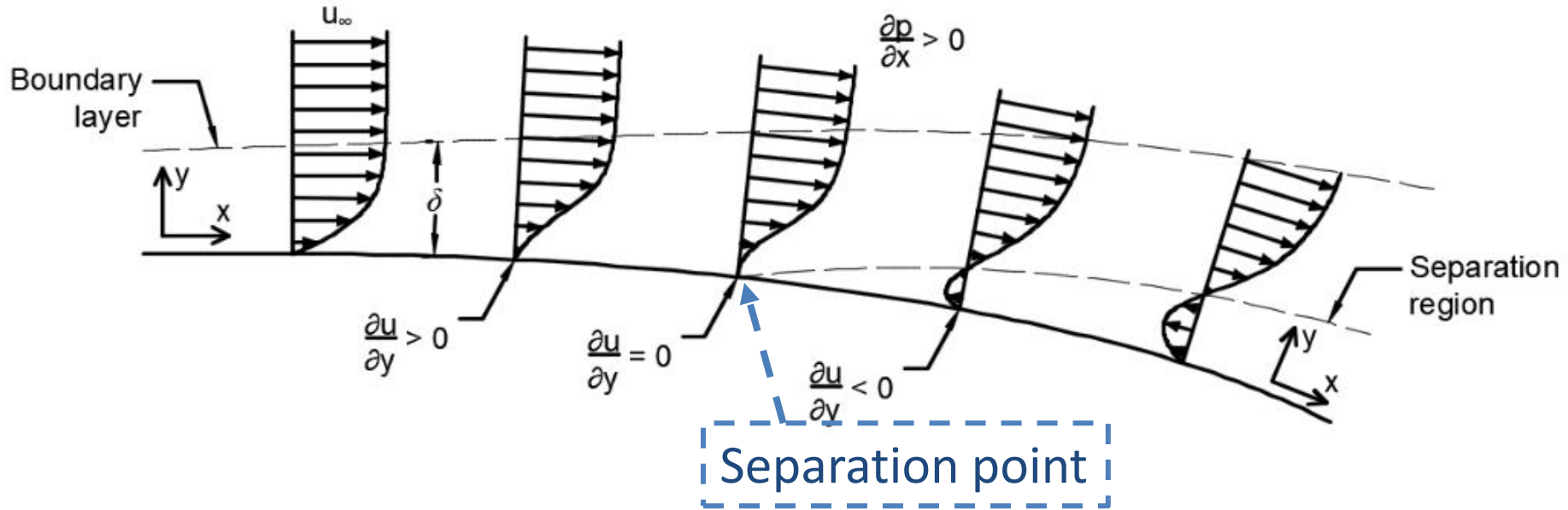


- Introduction – Working principle
- Evolution of the concept
- Performance assessment

Adverse pressure gradient

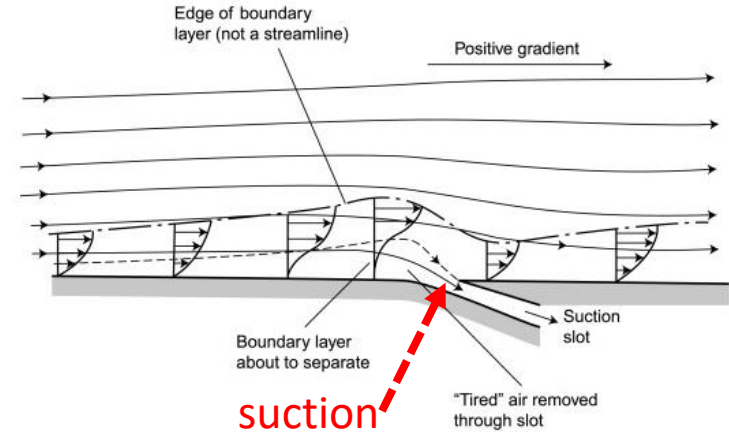
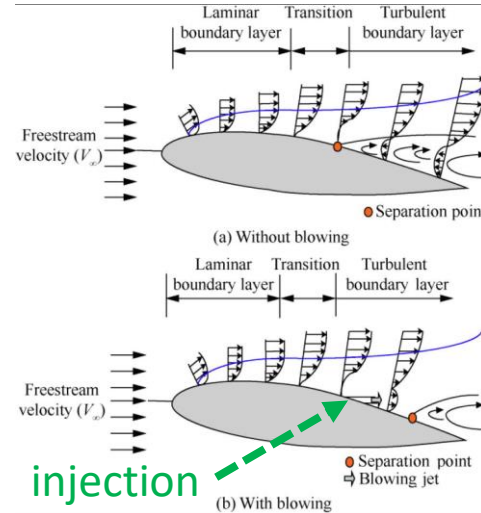


Adverse pressure gradient



Separation can be controlled:

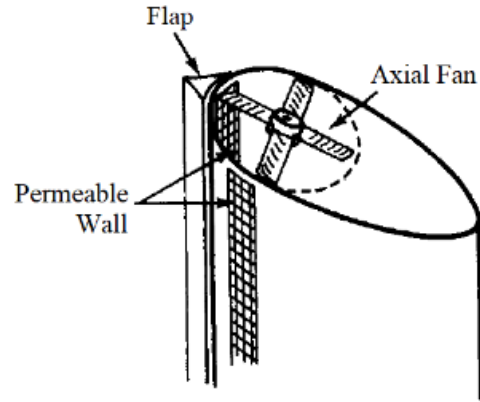
- Passive boundary layer control (**vortex generator**)
- Active boundary layer control (**injection**, **suction**)



Source :

- Vortex generator: Bill Abbot, <https://www.flickr.com/photos/wbaiv/4898075792/>
- Air Injection: N.Ganesh, S.Arunvinthan, S.Nadaraja Pillai, Effect of surface blowing on aerodynamic characteristics of tubercled straight wing, Chinese Journal of aeronautics, 2019
- Suction: E.L. Houghton, ... Daniel T. Valentine, Aerodynamics for Engineering Students (Seventh Edition), 2017

TurboVoile



Mass flux of the air suction

$$C_q = \frac{Q}{AU}$$

Planform area Advection velocity

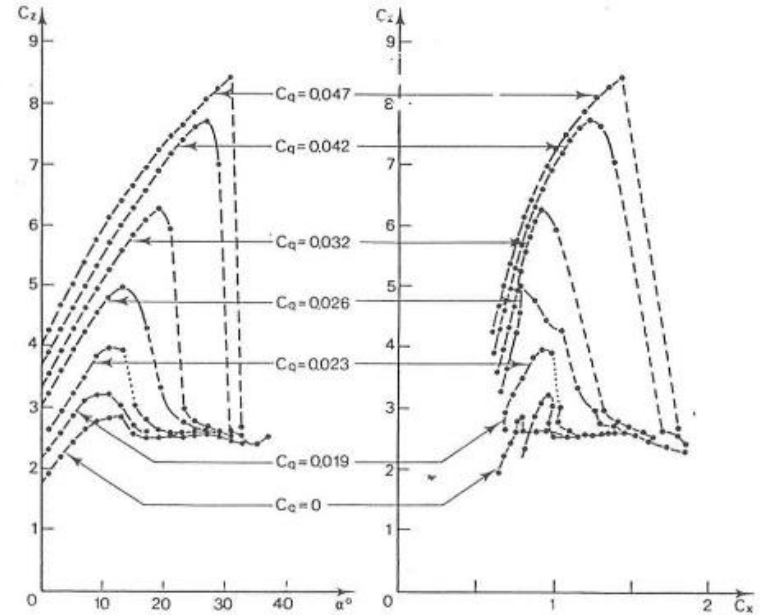
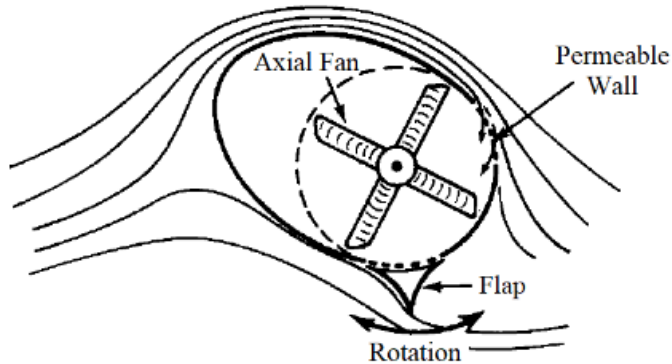
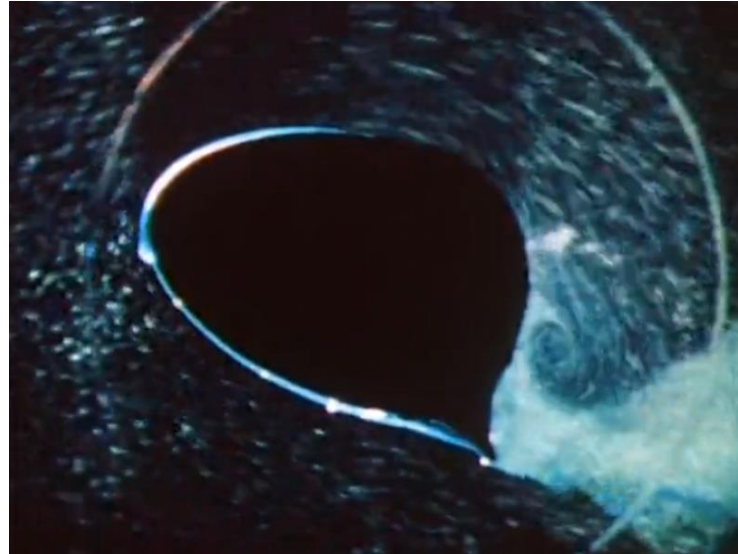
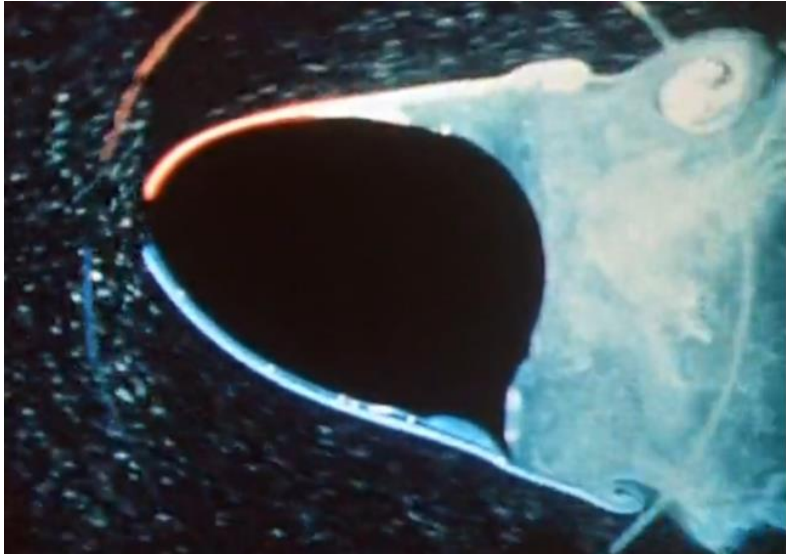


Fig. 8. — Variations du coefficient de portance C_z en fonction de l'angle d'incidence α pour diverses valeurs du coefficient d'aspiration C_q . (Les points \bullet sont expérimentaux).

Fig. 9. — Polaires d'un profil épais aspiré pour divers C_q (l'échelle des C_x est double de celle des C_z).

Source :

- L. Malavard. Un nouveau propulseur éolien de navire. Comptes rendus, tome 1(1):57–72, 1984.



Visualisations from 1984!



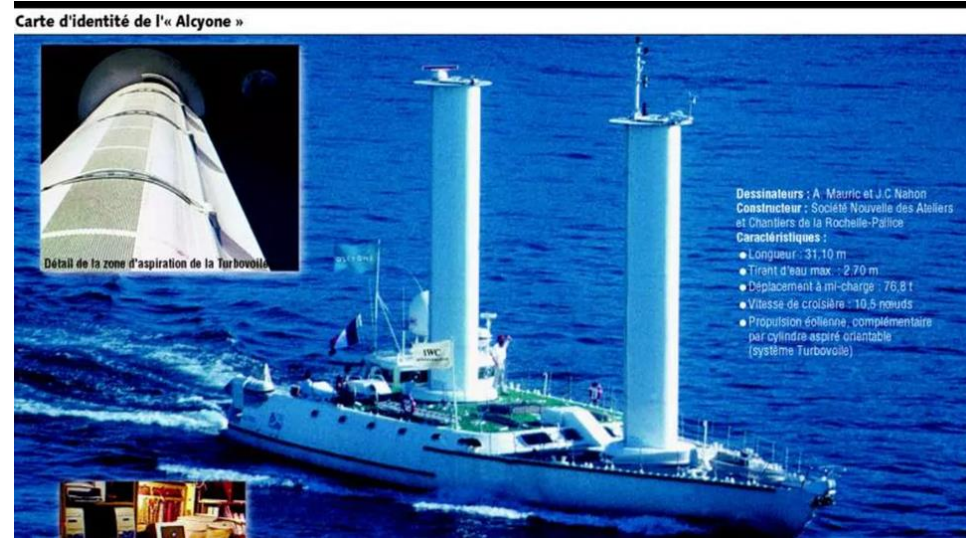
Source :

- Ecoulements tourbillonnaires d'une maquette de turbovoile, TH1 Chatillon, 1984, ONERA, <https://www.dailymotion.com/video/x16epb4>

Moulin a vent



Alcyone I



Source :

- Illustration Moulin A vent vessel <https://www.ina.fr/ina-eclaire-actu/video/rac03016753/catamaran-moulin-a-vent-de-jacques-yves-cousteau>
- Illustration Alcyone vessel, Source: <https://www.cousteau.org/know/vessels/alcyone/>
- <https://www.lesechos.fr/2003/11/la-mission-cousteau-retrouve-la-mer-rouge-677817>

Evolution of the concept: Ventifoil ECONOWIND

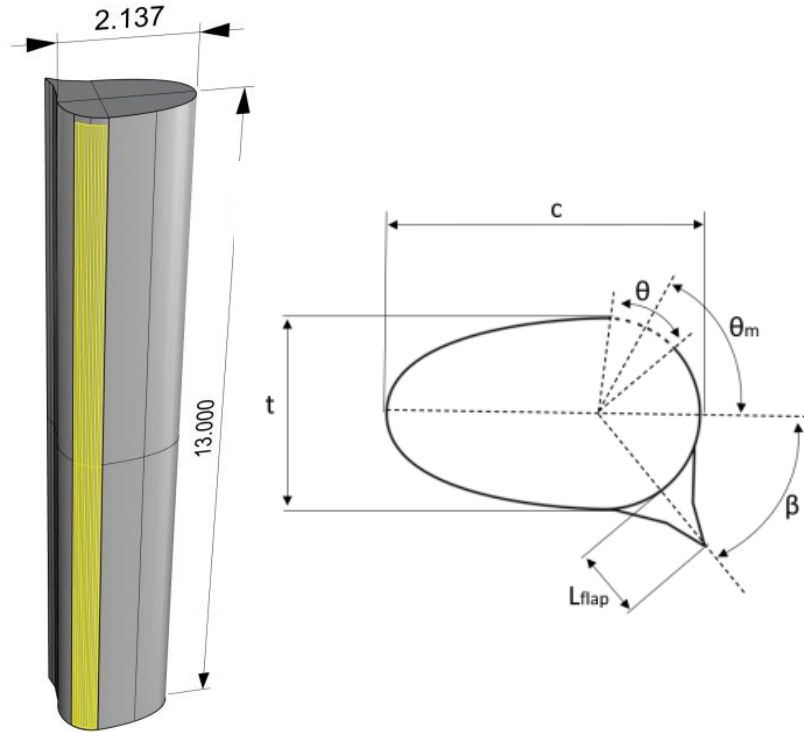


Figure 1.10: Measurements on the VentiFoil half scale model



Source :

Visual half scale model: L.P.Lagendijk <https://repository.tudelft.nl/record/uuid:fea305b0-209b-4c06-bd85-e780b8309b27>

Visual MV Ankie L.P.Lagendijk <https://repository.tudelft.nl/record/uuid:fea305b0-209b-4c06-bd85-e780b8309b27>

Visual profile Ventifoil: M.Borren <https://repository.tudelft.nl/record/uuid:ca679aed-9a6a-489b-9d5f-0b480f7183d5>

Evolution of the concept: Ventofoil ECONOWIND



Ventofoil on the Chemical Challenger



- Ventofoil concept:

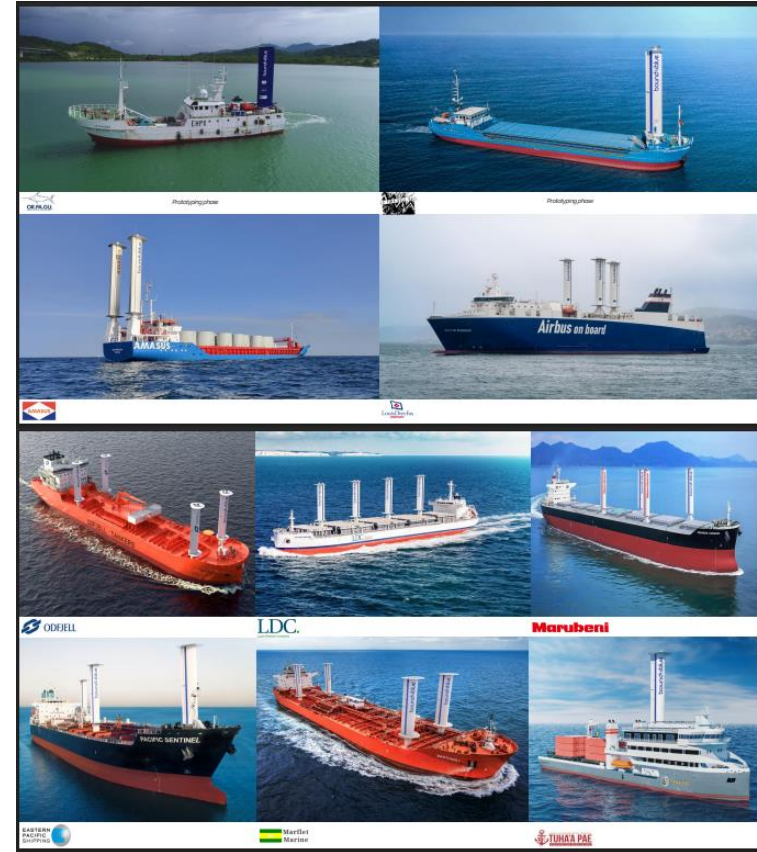
- Different profile (symmetric) without flap
- Suction at about mid-chord
- No flap

Source :

Ventofoil <https://econowind.nl/wp-content/uploads/2025/02/100th-VentoFoil-unit-sold.jpg>

Ventofoil on Chemical Challenger: Source AFP and <https://swzmaritime.nl/news/2024/02/19/chemship-fits-tanker-with-econowinds-ventofoils/>

Evolution of the concept: eSAIL® Bound4Blue



Source :

eSAIL® system <https://bound4blue.com/esail/>

eSAIL® details and existing installations <https://rina.org.uk/publications/the-naval-architect/wind-propulsion-2024-advancements-in-sails/> and RINA wind propulsion Bound4Blue presentation 2024

- CoFlowJet Lift: cylinder with suction
- CRAIN technology: SW270 suction wing



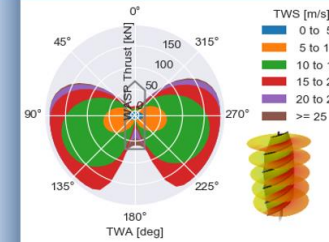
Evolution of the concept: wind-ship database

Ship Name	Type	DWT	GT	Length	Technology Installed	Installation Year	Installation Type
Ankie	General Cargo	3,638	2,528	90	2 x 13m hinged suction wings	2020	retrofit
Frisian Sea	General Cargo	6,477	4,298	118	2 x 11m flat-rack/hinged suction wings	2021	retrofit
Naumon	General Cargo/Theatre Vessel	1,006	1,057	59	1 x 17m fixed suction sail	2021	retrofit
Marfret Niolon	Ro-Ro	5,282	7,395	123	2 x 12m hinged/container suction wings	2022	retrofit
Anna	General Cargo	5,097	2,993	90	2 x 16m hinged suction wings	2022	retrofit
EEMS Traveller	General Cargo	2,850	2,137	90	2 x 17m fixed suction sails	2023	retrofit
Sunnanvik	Cement Carrier	9,060	7,454	124	2 x 16m suction wings	2023	retrofit
Chemical Challenger	Tanker	16,111	9,155	134	4 x 16m suction wings	2024	retrofit
Odda Marie	General Cargo	5,000	3,998	100	2 x 12m suction wings	2024	retrofit
Ville de Bordeaux	Ro-Ro	5,200	21,528	154	3 x 22m suction sails	2024	retrofit
Kalamazoo	Container	12,593	9,743	143	2 x 2 x 12m containerised retractable suction wings	2024	retrofit
NBA Magritte	Bulk Carrier	82,099	43,013	229	2 x 10m flat-rack/hinged suction wings	2024	retrofit

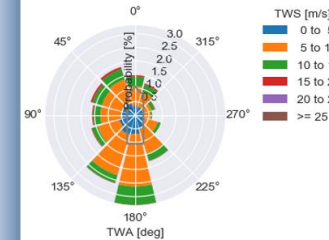
31 installations listed (more installations may not be in the database yet)

- Prediction:
 - CFD – wind tunnel tests
 - PPP/VPP – voyage simulations
- Verification
 - Sea trial following ITTC 7.5-04-01-02
 - -> calibration PPP/VPP predictions
 - Monitoring campaign

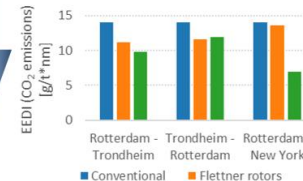
1 Performance (Thrust & Power)

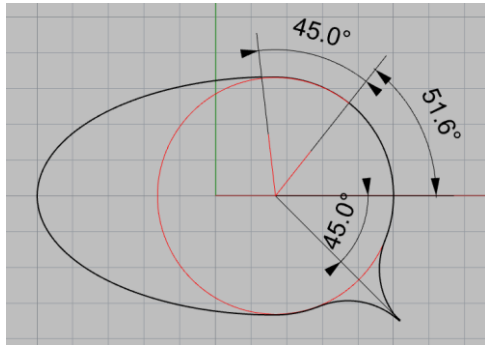


2 Wind statistics

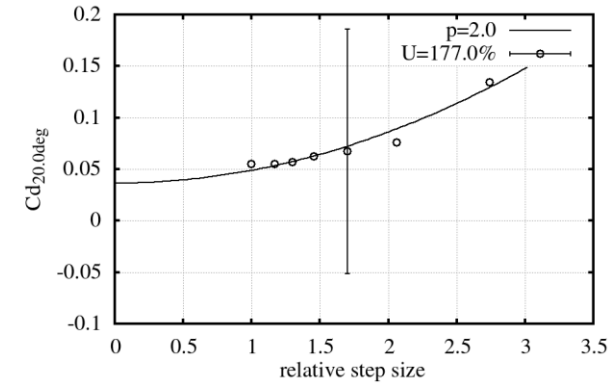
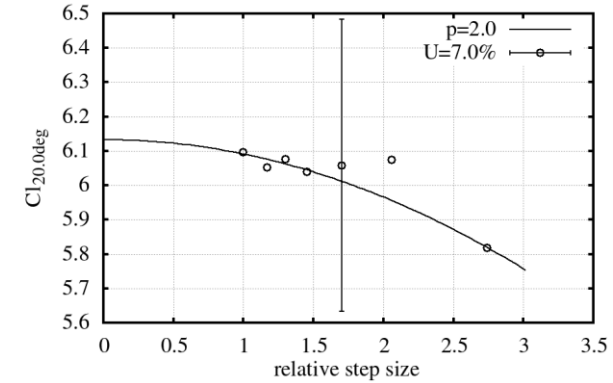
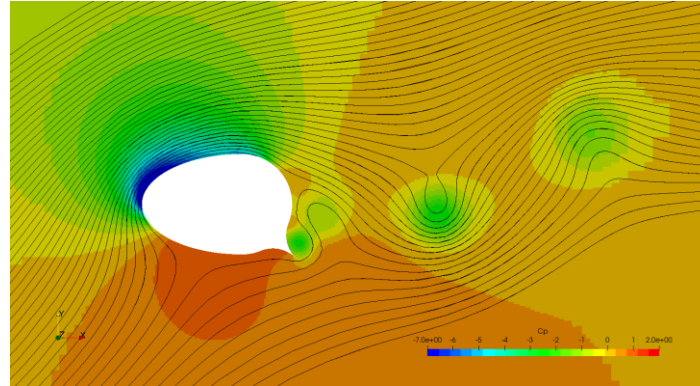


3 Overall fuel/emission performance

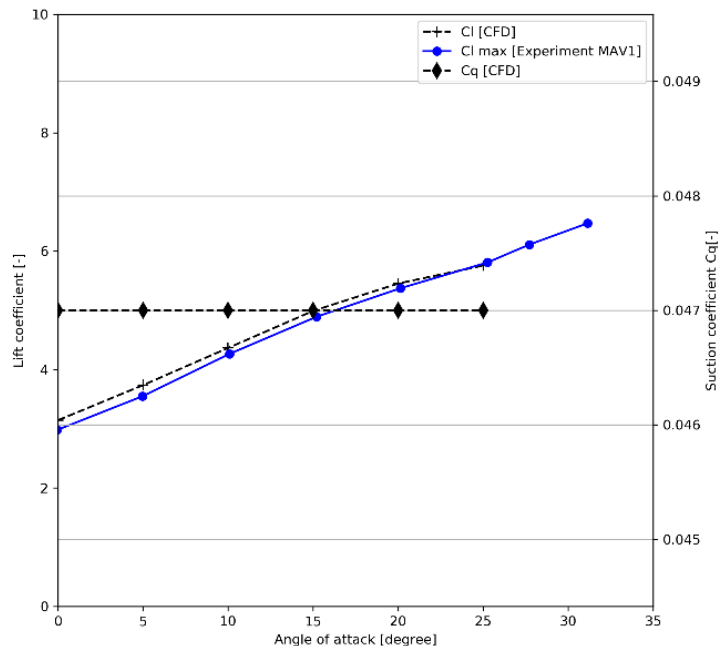




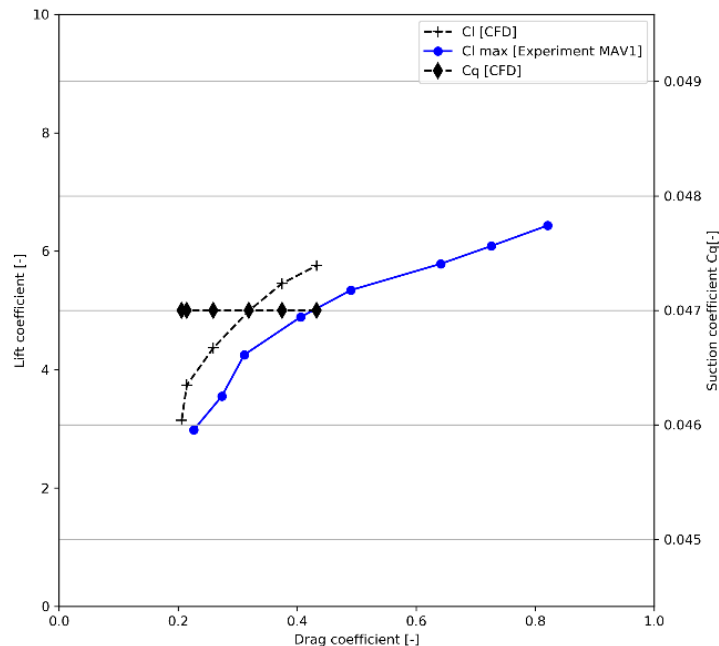
Approximation of MAV I profile



Relatively good agreement in terms of Lift



Under prediction in terms of drag

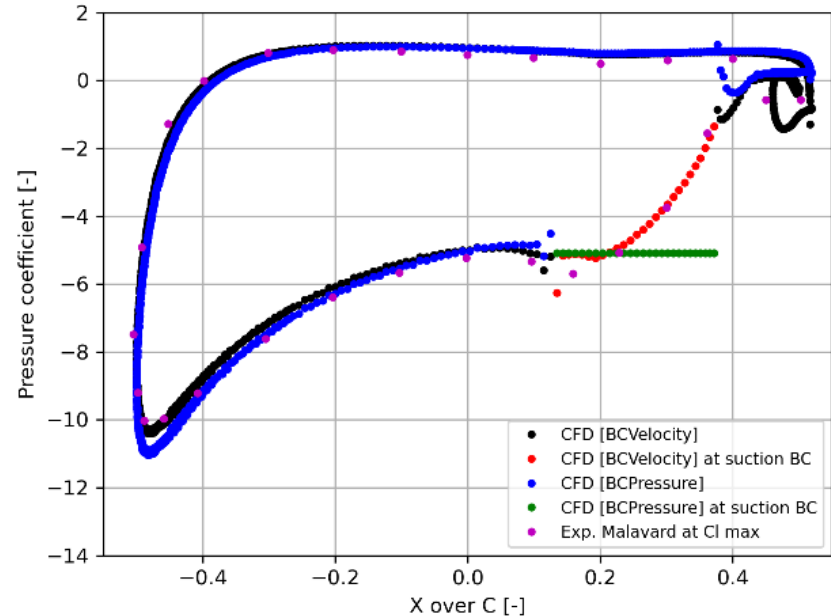
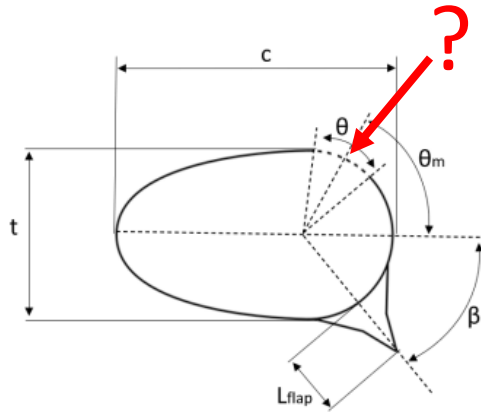


Disclaimers/challenges:

- Profile description in paper from 1984 is unclear. Suction coefficient is not specified in paper. Are the experiments really in 2D? The Reynolds number is also not clearly indicated.

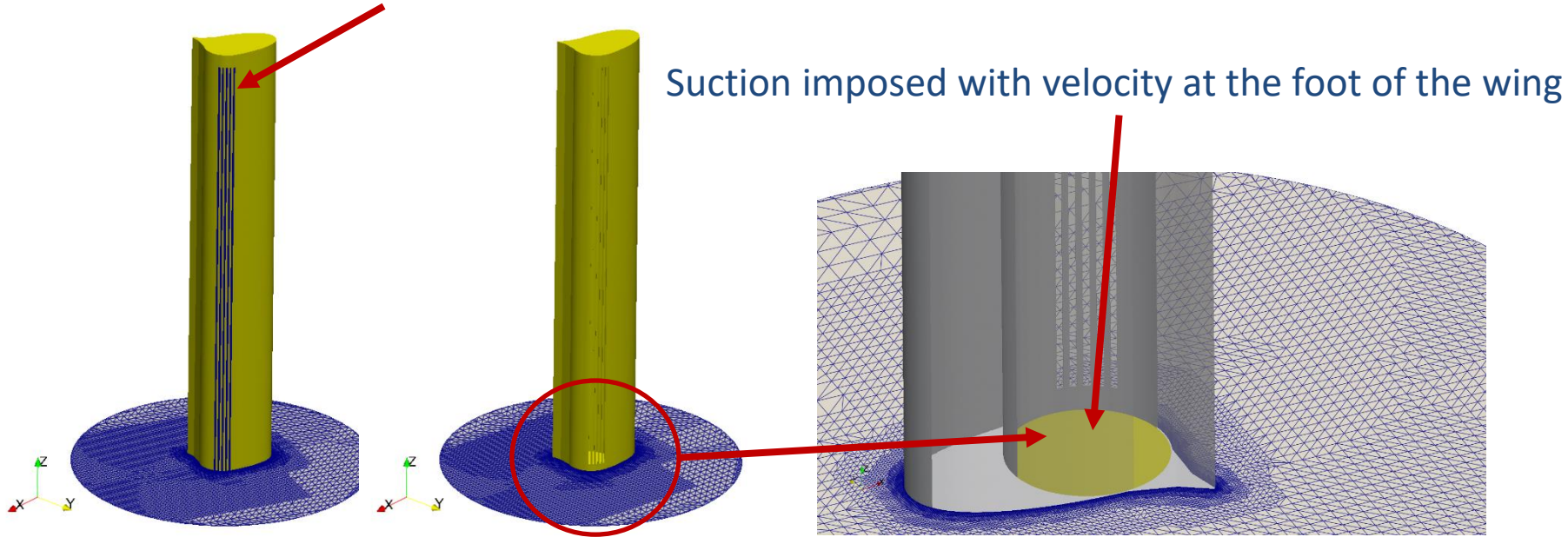
Three options:

- Imposed constant pressure
- Imposed normal suction velocity
- Model the inner part of the suction wing



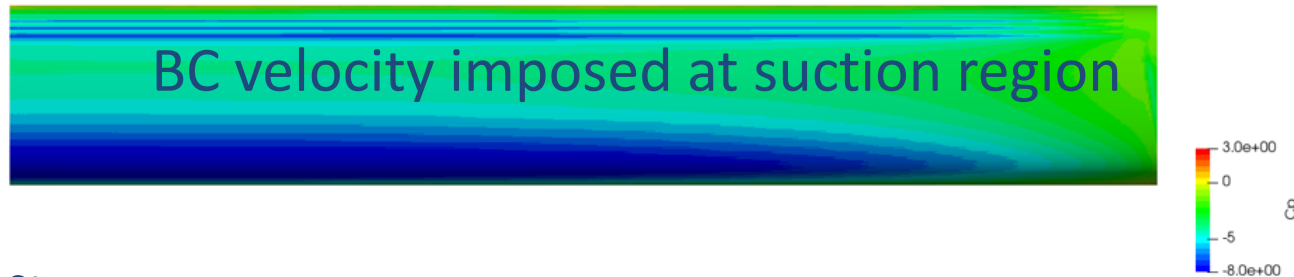
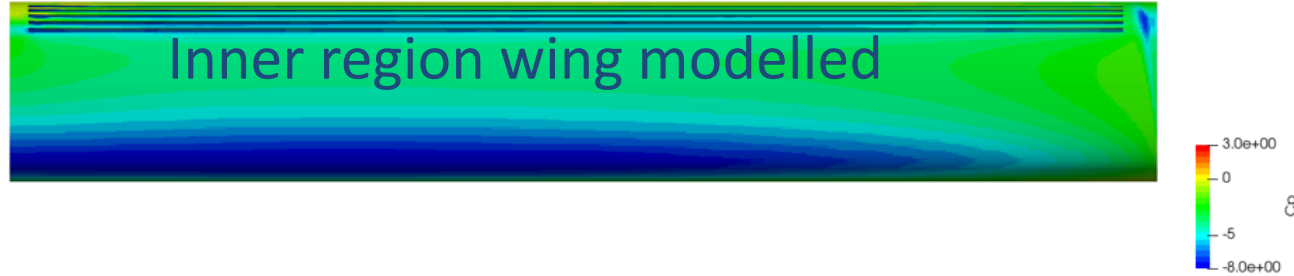
Observation: Normal suction velocity shows best agreement with experiment

Suction imposed with velocity boundary condition



Source :

Profile inspired by VentiFoil geometry available in M.Borren <https://repository.tudelft.nl/record/uuid:ca679aed-9a6a-489b-9d5f-0b480f7183d5>

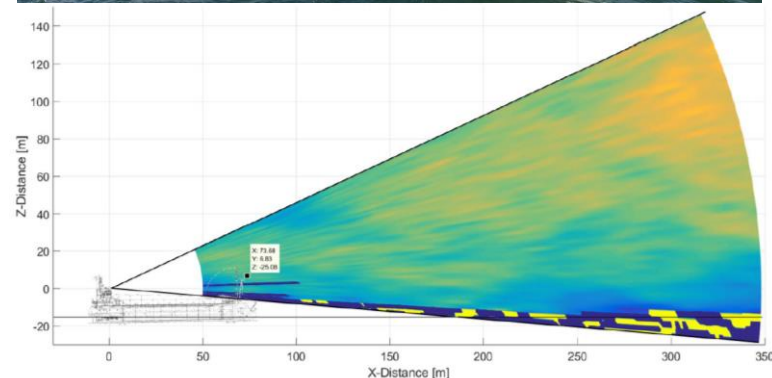


Observations:

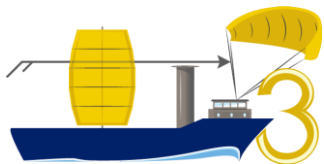
- Comparable pressure distribution obtained along the wing
- Lift is slightly reduced with inner region of wing modelled
- Drag is increased

General speed-power trial/monitoring, but ...

- Wind required (so preferably no “calm environment”)
- Contribution of wind propulsion established by regularly enabling/disabling wind propulsion (ITTC 7.5-04-01-02)
- Preferably force measurement and wind scan (LIDAR) in addition to common measurements
- Experience on multiple ships including MV Ankie and Canopee.



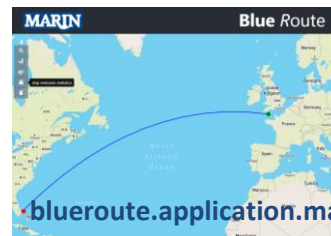
<https://www.marin.nl/en/publications/measuring-3d-wind-fields-at-the-speed-of-light>



<https://www.marin.nl/en/jips/wisp-3>



<https://www.optiwise-project.eu/>



blueroute.application.marin.nl



<https://blueforum.org/>
7-11 April 2025

Blue Forum Seminars



Much more to talk about (but limited time), feel free to contact:

r.eggerts@marin.nl ; m.garenaux@marin.nl ; j.j.a.schot@marin.nl