Wind, water and waves direction and strength

Tactical Sailing

A Game Against the Wind

Summary – Wind, water and waves

Sailing – especially regatta sailing – is a fascinating sport that requires not only mental and physical training but also a solid understanding of physics. The central element in sailing is always the wind, its direction and strength – the kinetic energy that propels a boat.

With the wind coming from a 360° direction and at a maximum speed of force 8, a boat sailing downwind can reach up to 80% of its maximum speed in the 180° direction. Conversely, sailing upwind at 45° or 315°, a boat can only reach 59% of its maximum speed; see the geometric sketches and the polar diagram in the appendix.

The water – the current – moves the boat in a specific direction at a specific speed. The current – kinetic energy – pushes the boat forward in a 180° direction when sailing downwind, increasing its speed. Against the wind, however, the current slows the boat down in a 315°/45° direction. For example, with a current at 90°, the boat is pushed to leeward, creating a leeward drift (see geometric diagrams). Waves are created by friction between the wind and the water's surface; they transport energy. The water in a wave does not move; rather, the waves transfer their kinetic energy to the water's surface. Wave height depends on wind speed (see geometric diagrams). "A wind pattern is defined by the parameters of wind speed and wind direction over a spatial and temporal period," as described in "The Geometry of Regatta Sailing" by Tilo Schnekenburger. We have developed exercises specifically for this purpose, demonstrating the importance of carefully observing the wind. To make this topic as easy to understand as possible for even the youngest sailors, we have chosen the Optimist dinghy (2.30m) as the basis for calculations and the unit of measurement for the mathematical and graphical representation of various situations and decision-making options in changing winds. In the exercises, we make sensible tactical decisions regarding course direction relatively simple – namely, using Optimist boat lengths – and thus illustrate the crucial role that wind shifts play on the regatta course. The simulations in the Tactical Sailing program allow the helmsman to realistically depict the same situations on the water on the computer screen. The following section focuses specifically on sailing with different wind strengths and directions – namely, "**upwind**" and "**downwind**.“

See the following sketches and video clips.

Introduction - Wind, Water and Waves

As a result of our examination of wind, water, and waves, the following key insights emerge:

- Wind, water, and waves must be considered energy in physics and thus analyzed in terms of their effects.
- The kinetic energy of wind, water, and waves, in terms of direction and magnitude, can be observed as they move themselves—or objects. This kinetic energy is represented in geometric diagrams.

In our Tactical Sailing program, we use simulations and geometric diagrams to demonstrate the crucial role that wind, water, and waves play in sailing.

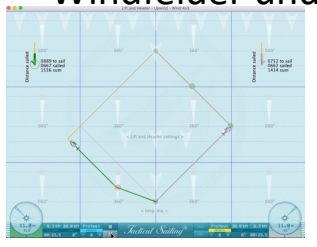
Wind with wind fields coming from different directions and of varying strength is simulated in various exercises within our Tactical Sailing program. For example, upwind conditions with wind shifts and gusts can be perfectly represented, as can turbo winds – oscillating randomly by 30°. Downwind conditions are also covered in the simulations; various decision-making options and situations are demonstrated, such as when encountering a pull, a push, or a leeward mark with a zone. In one simulation, two boats are steered by gybing, wind direction and strength are displayed, and the distances traveled by the two boats are compared. In our exercises, we can even simulate and analyze winds up to force 8 Beaufort. The simulations allow us to depict wind fields and gusts and realistically illustrate situations at the start and finish. Tactical Sailing also offers tactical tips on how to deal with water, wind, and waves, for example, choosing between the left or right side, or whether to pull or push, to find the optimal route to the destination.

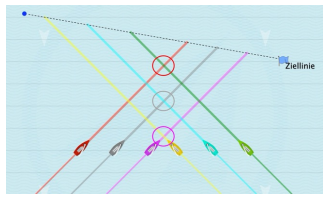
Water – the current – sailing 180° downwind makes the boat faster, allowing the helmsman to round the buoy to leeward more quickly. Sailing 315° / 45° upwind, the boat's speed is slowed, resulting in a leeward drift, as shown in the geometric diagrams.

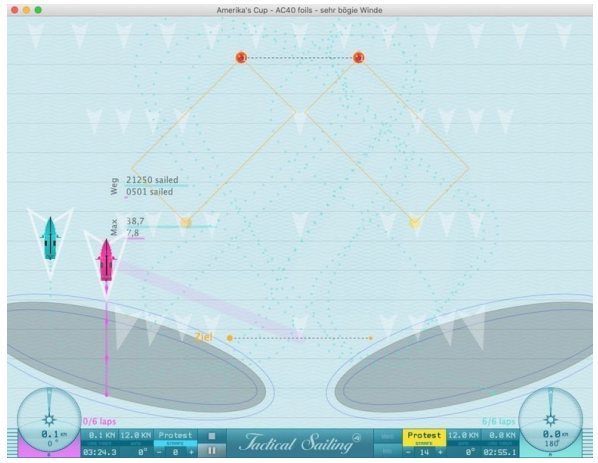
Waves: The water in a wave doesn't move; instead, the waves transfer their kinetic energy to the water's surface.

Strategy and tactics – wind, water and waves

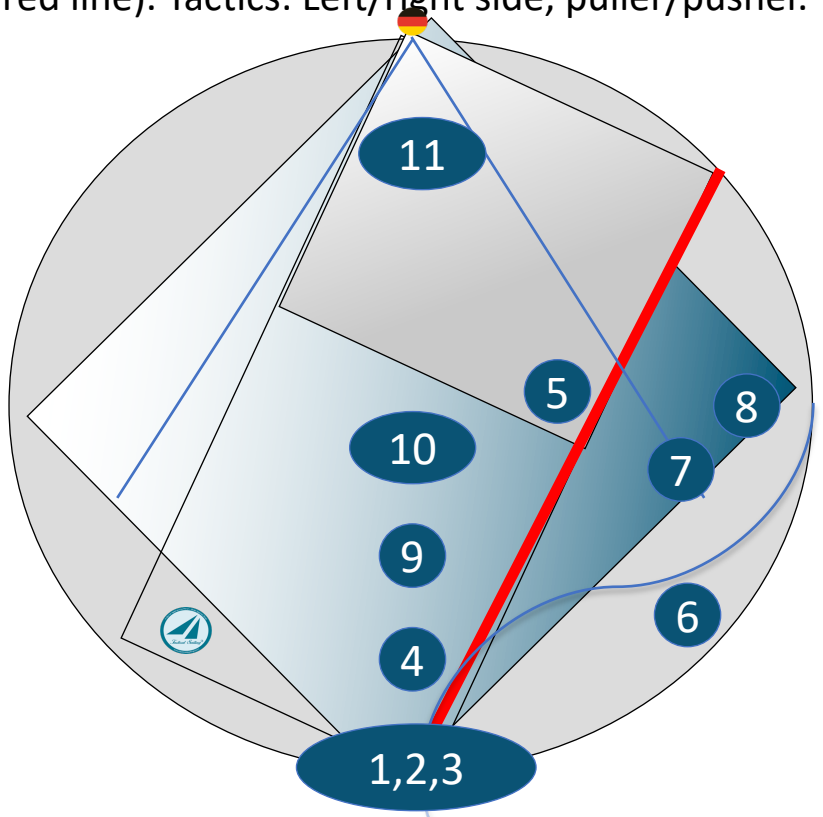
Simulation: using the Tactical Sailing program:







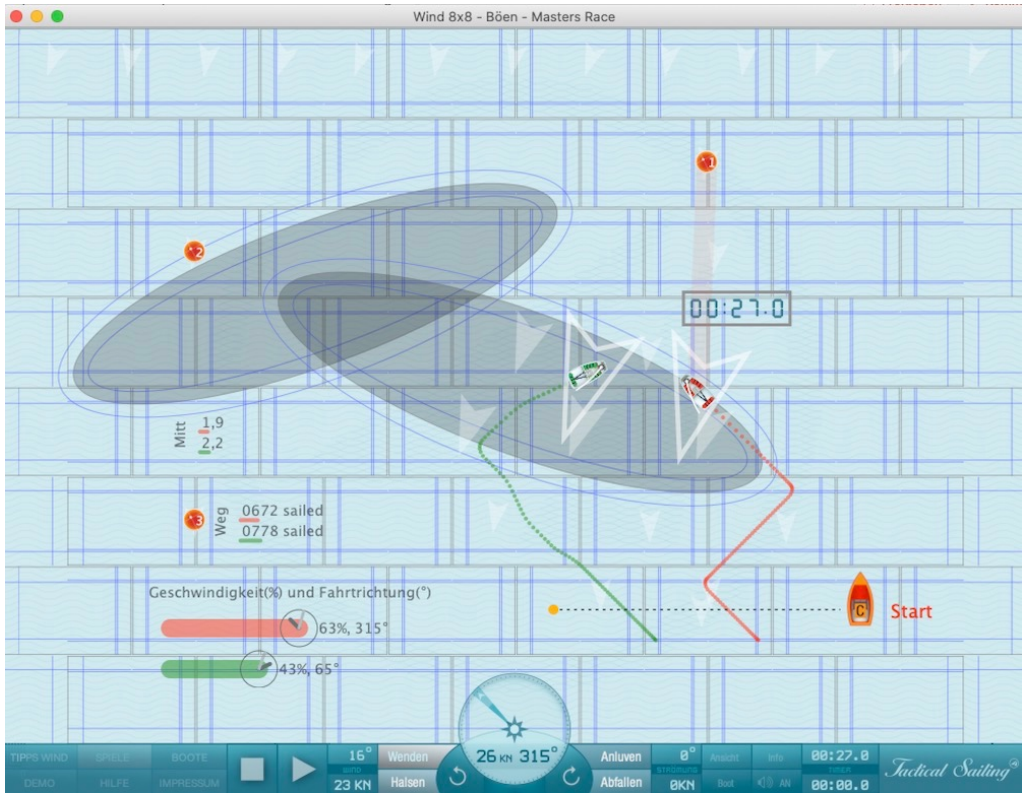
Geometric sketches: Wind direction 360° (geometric shape) a square. Wind direction 330° (geometric shape) a rectangle (red line). Tactics: Left/right side, puller/pusher.



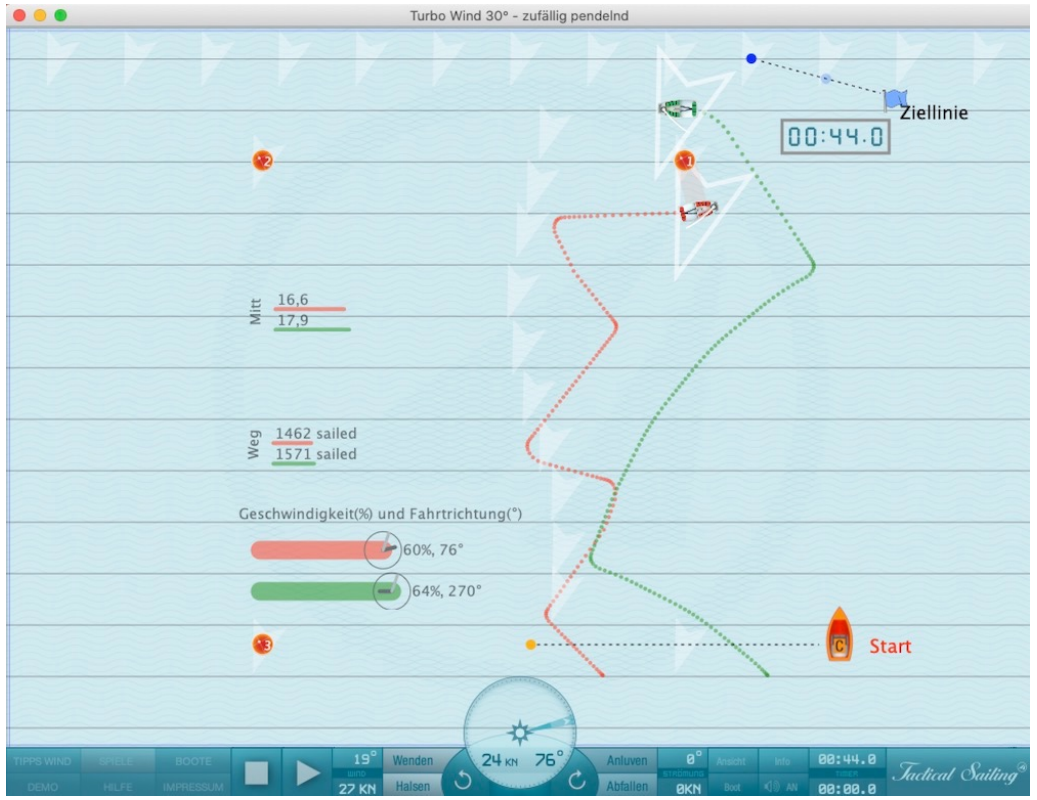
Tactical decision points 1 to 11.

Tactical Sailing – Simulations “Against the Wind”

Exercise: Sailing against the wind – wind shifts – gusts (ellipse)
Compare direction (tacking), strength, and distance
Result: The optimal route to the destination.
Distance sailed: 778 – 672 = 106 (46 boat lengths of an Optimist dinghy)

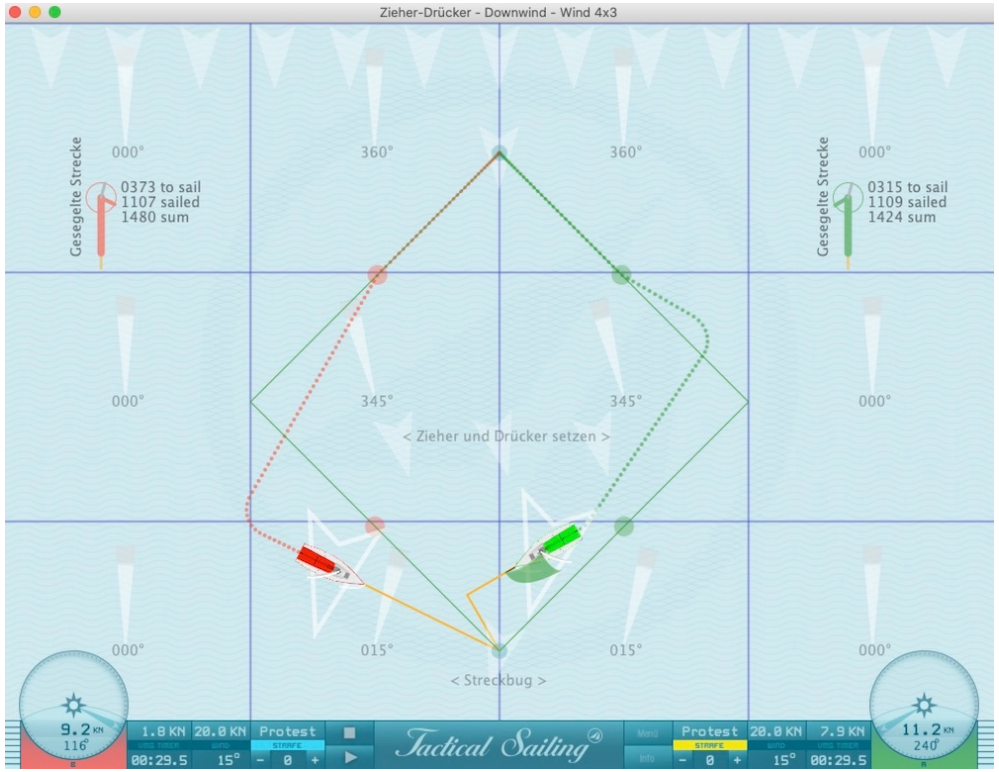


Übung: Turbo Wind - zufällig um 30° pendelnd,
Gegen den Wind – Richtung, Stärke und Wegstrecke vergleichen,
Ergebnis: Der optimale Weg zum Ziel.
Weg gesegelt: 1571 - 1462 = 109 (47 Bootslängen eines Opti)

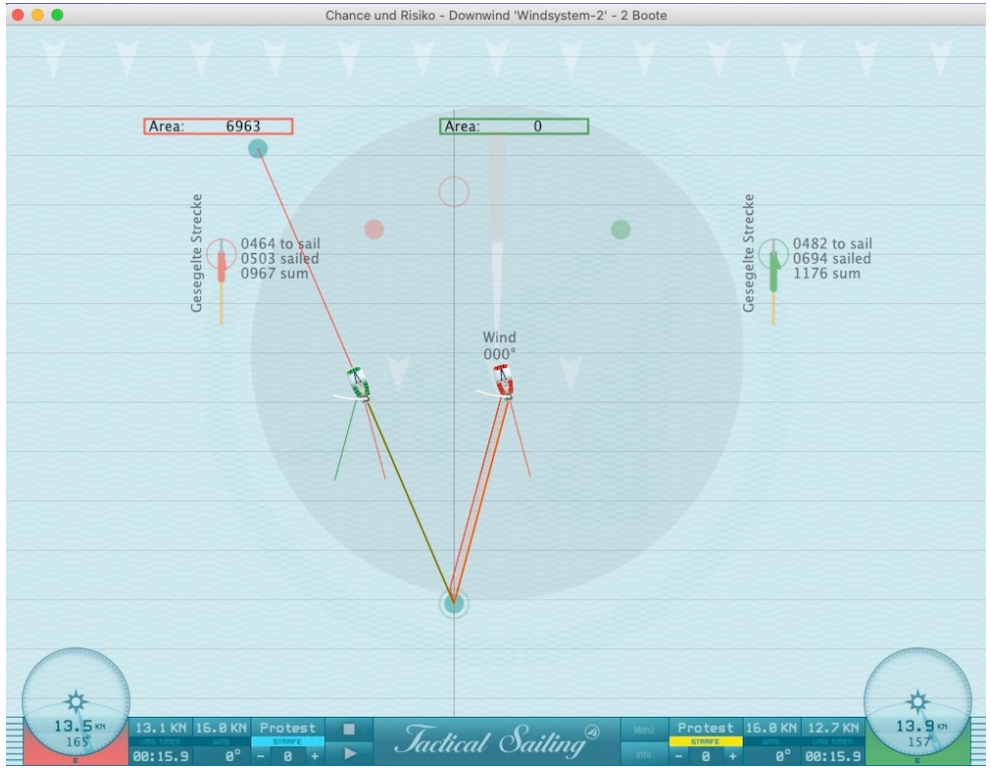


Tactical Sailing – Simulations “Downwind”

Exercise: "Downwind" – Pull/Push
Steer 2 boats by "gybing" (buttons: "Red" and "Green")
Result: The optimal route to the leeward buoy
Distance sailed: 1480 – 1107 = 56 (24 boat lengths of an Optimist)

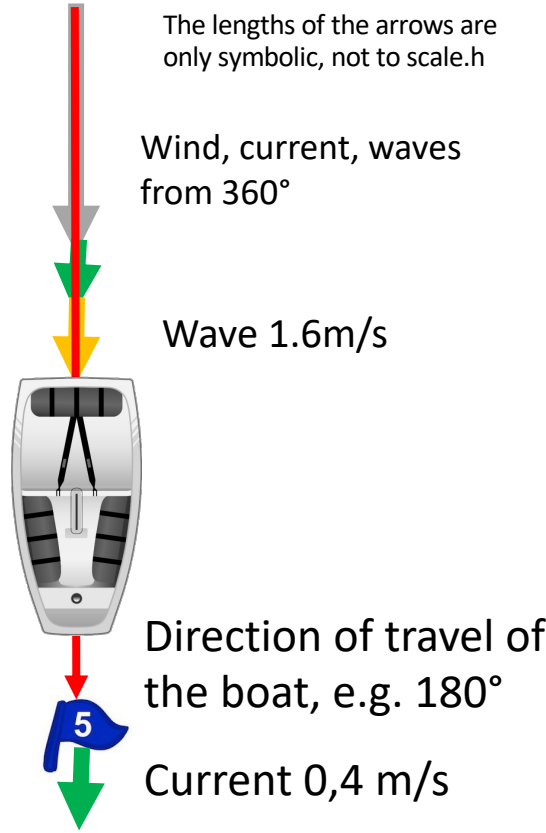


Exercise: "Downwind" "Lawn Buoy" Zone
Steer 2 boats by "gybing" (keys: "Red" and "Green")
Result: The optimal route to the lee buoy
Distance sailed: 694 - 503 = 191 (83 boat lengths of an Optimist dinghy)**)**



Geometric sketch: Direction of travel "downwind" from 360°

The three elements (wind, current, wave) act as an accelerating force on a sailboat when they come from the same direction (red), e.g., 360°. In our example, the boat's direction of travel "downwind" in the direction of 180° is the red line. The initial force is the wind (gray), its "kinetic energy" is faster than a current (green), and it is superimposed by waves (orange).



Geometric sketches: direction of travel "downwind" plus currents

If the three elements (wind, current, waves) do not come from the same direction, the direction of travel will vary.

The direction of travel for boats 1 and 2 is initially downwind, with the wind coming from 360°.

A current can influence the direction of travel as a drift, flowing abeam in a direction of 225° or 270°.

The direction of the waves comes from 360° and is determined by the wind direction.

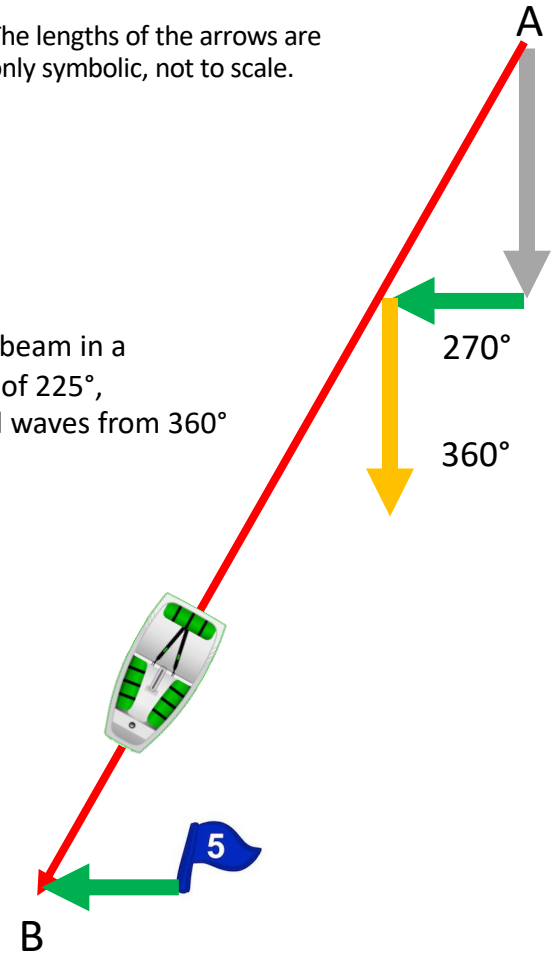
The sum of the three directions determines the direction of travel for boats 1 and 2 from A to B (red):
Boat 1: 190°
Boat 2: 215°

The drift caused by the current results in different directions of travel for boats 1 and 2 when approaching buoy (5). This situation requires the helmsman to consider tactically how to approach buoy 5 downwind in order to round it while taking the current into account.

Current abeam in a direction of 225°,
Wind and waves from 360°

Direction of travel of boat 1 e.g. 190°

The lengths of the arrows are only symbolic, not to scale.



Current beam in a direction of 225°,
Wind and waves from 360°

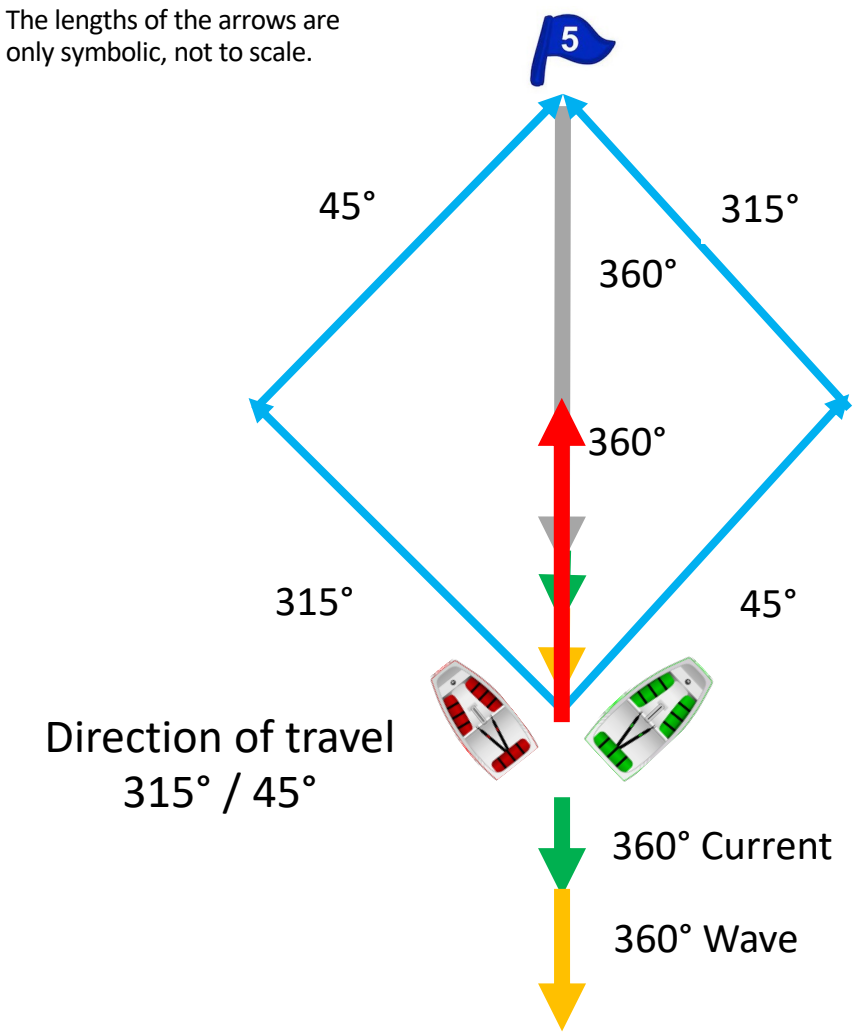
Direction of travel of boat 2 e.g. 215°

Geometric sketch: Direction of travel "against the wind" from 360°

The wind acts as a driving force on a sailboat in the direction of +315° / 45° to approach a buoy (5), for example, when it comes from the direction of 360° (gray). However, on a course "upwind," current and waves, also coming from 360°, act as "pushers" on the boat in our example, pushing it faster to leeward.

While the boats' directions of travel are essentially "upwind" from the direction of 360° (red line), the blue lines (laylines) indicate the directions of travel in the direction of 315° / 45°.

The "acceleration forces" are the wind direction and wind speed; they act on the sails like a "flow" along the curved sail surface and "pull" the boat to windward. The other two forces—current and waves—"push" and "shove" the boat to leeward in the direction of 180°.

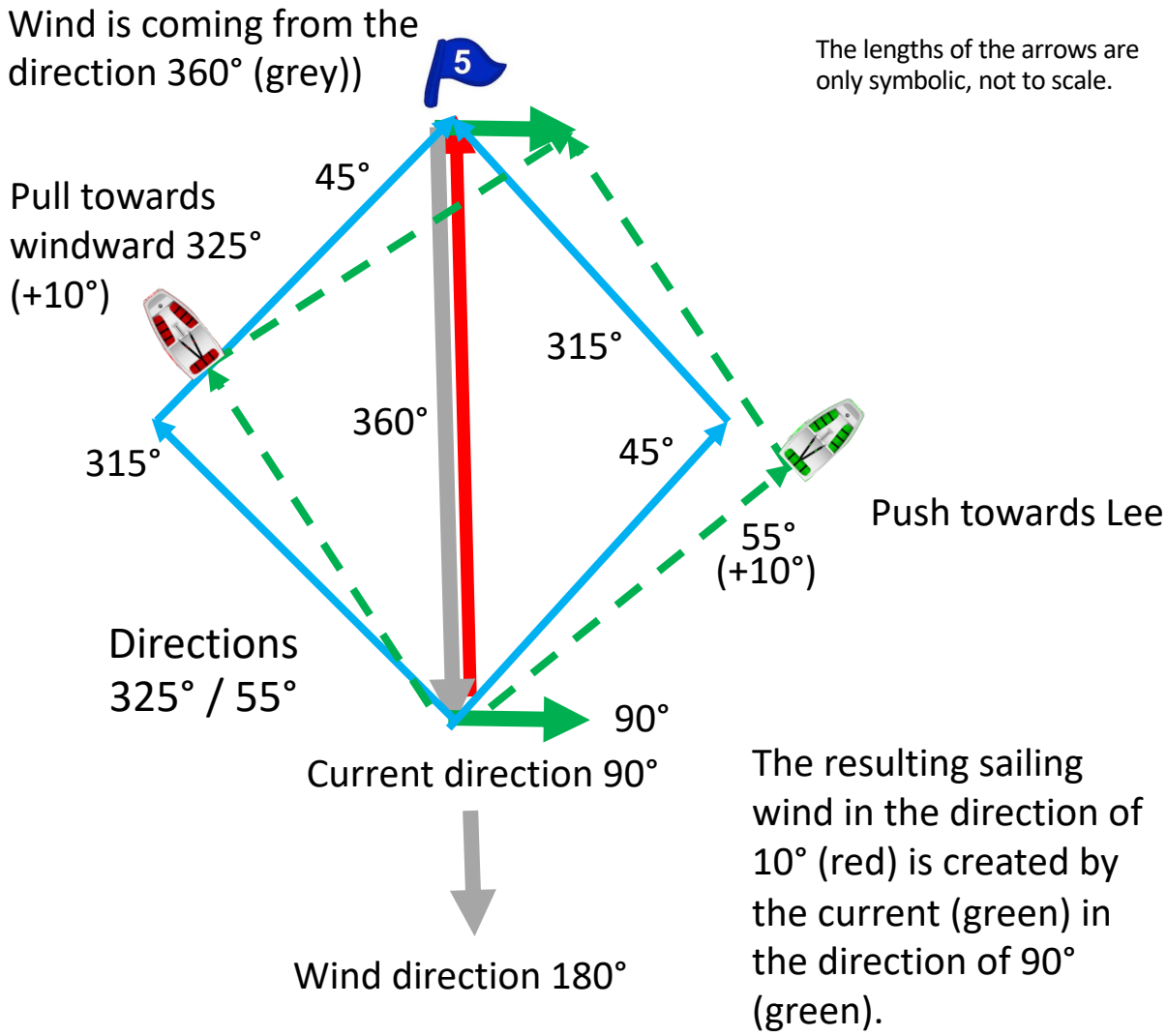


Geometric sketch: Direction of travel "against the wind" from 360° with a flow direction at 90°.

The current (thick green) in our example flows in a direction of 90° and pushes the green boat downwind (55°). The red boat, on the other hand, is pulled upwind (325°), from which it might even gain an advantage due to the current.

The direction of travel is essentially "against the wind" in a direction of 360° (red line), with the blue laylines (315°/45°) showing the directions of travel without current, and the dashed green laylines (+10°) showing the directions of travel with current.

The wind (grey) blows in a direction of 180°, the current (green) in a direction of 90°.



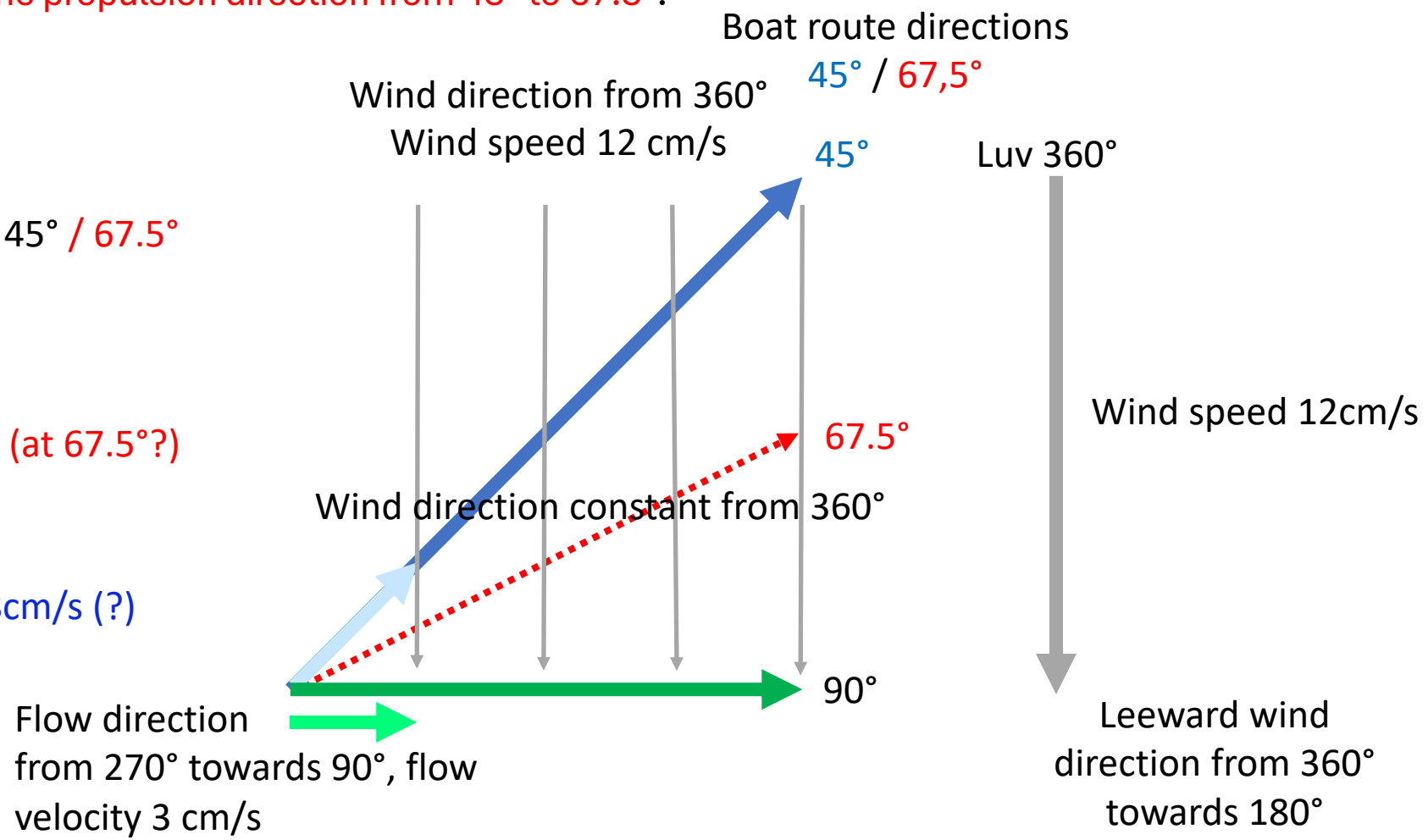
For experts: Geometric sketch of the drive directions 45° and 90°

The average of the propulsion directions (45° + 90°) = 135° : 2 = 67.5° results in a mean propulsion direction of 67.5°.
Note: The current direction of 90° does NOT change the wind direction (360°, gray). However, it does affect the boat's direction of travel, changing the propulsion direction from 45° to 67.5°.

Directions (°):
Wind direction 360°,
Current direction 90°
Boat travel directions 45° / 67.5°

Speeds (cm/s):
Wind 12 cm/s,
Current 3 cm/s,
Boat speed 7.08 cm/s (at 67.5°?)

Boat speed diagonal
12cm/s° * 59% = 7,08cm/s (?)



Facilities

Create your own exercise with the Tactical Sailing program

List of links to video clips (YouTube),

Download the TS program with Trainer Toolbox,

Operation of the Tactical Sailing (TS) program,

Literature on the "Geometry of Regatta Sailing"

Sources

Create your own exercise - Program start and menu selection (German)

Download des Programms www.TacticalSailing.com/de

Übung: Gegen den Wind – Winddrehungen – Böen (Ellipse)
Start: Tactical Sailing / Spiel gegen den Wind; Start: Tactical Sailing / Spiel gegen den Wind; Menü: Boote/Wähle Dein Boot/Optimist-Farbe; Menü: Spiele/Spiel gegen den Wind/Wind – 8x8 – Böen – Masters Race; Kommando: Play/Pause/Stop - Wenden

Übung: Turbo Wind - zufällig um 30° pendelnd
Start: Tactical Sailing / Spiel gegen den Wind; Menü: Boote/Wähle Dein Boot/Optimist- Farbe;
Menü: Spiele/Turbulente Winde – 30° 40° 50°/Turbo Wind 30° - zufällig pendelnd, Kommando:
Play/Pause/Stop - Wenden

Übung: Downwind „vor dem Wind“ – Zieher Drücker
Start: Tactical Sailing / Trainer Toolbox; Menü: Boote/Wähle Dein Boot/ J70 – Farben; Menü: Regattasegler/Zieher und Drücker/Zieher-Drücker – Downwind - Wind 4x3; Spielfelder: Ändere die Windrichtungen in den Wind-Regionen und erzeuge Zieher und Drücker; Kommando:
Play/Pause/Stop – Steuere 2 Boote: Tasten „G und R“

Übung: Downwind „vor dem Wind“ „Leeboje“ – Zone
Start: Tactical Sailing / Trainer Toolbox; Menü: Boote/Wähle Dein Boot/ 2 Optis – Farben; Menü: Experte/Chance und Risiko - Downwind - 2 Boote; Spielfeld: Ändere die Windrichtung und –stärke; Kommando:
Play/Pause/Stop – Steuere 2 Boote: Tasten „G und R“

Siehe ggf. die ausführliche Hilfe im Programm und in der TS-Dokumentation „Trainer Toolbox“

Trainer Toolbox
Wind-Wasser-Wellen

Programmstart Tactical Sailing

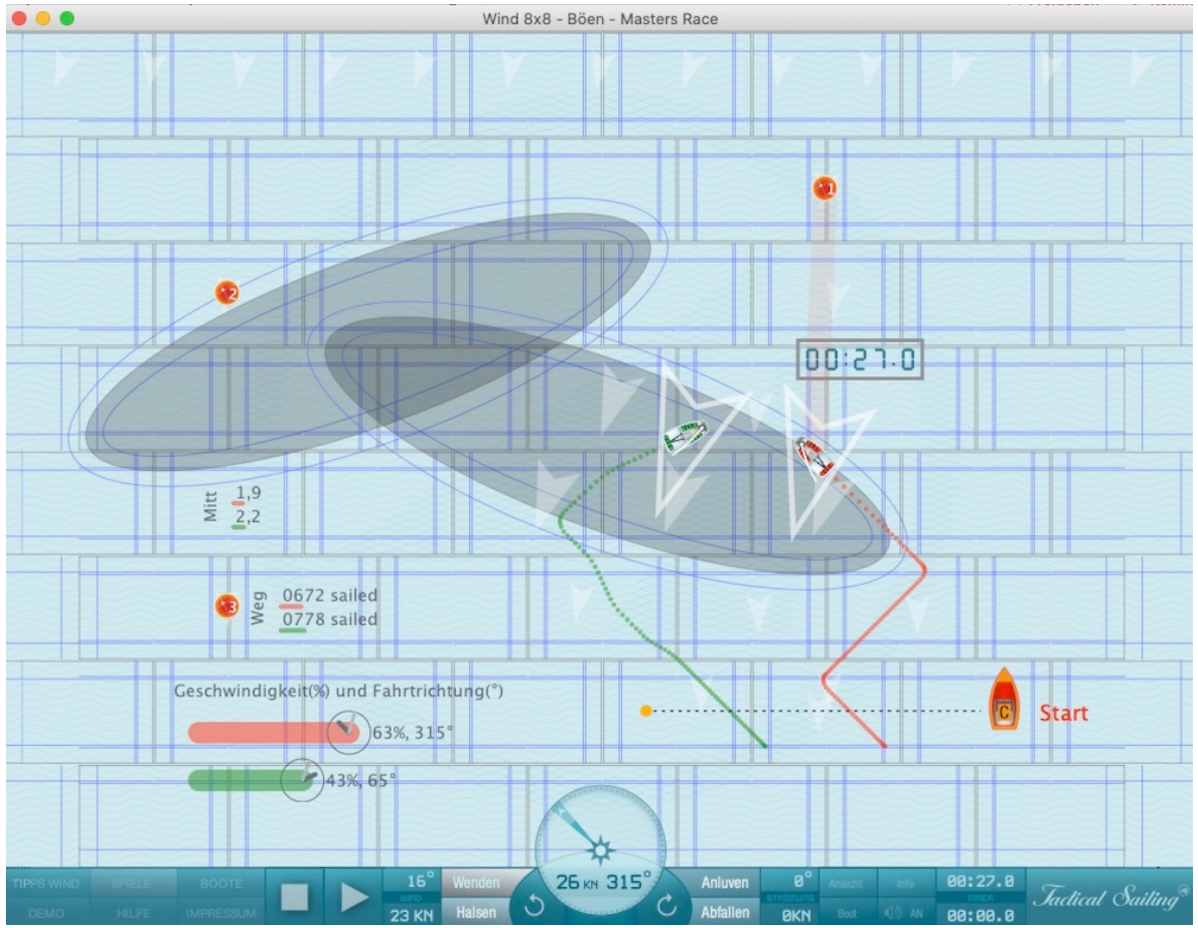
List of free video clips on YouTube, documentation on Tactical Sailing (TS), and literature on the geometry of regatta sailing.

Liste bei youTube mit Video Clips: Play List Klick hier .

Download des **Tactical Sailing Programms incl. Trainer Box** auf der TS-Webseite: **klick hier** .

Programmbedienung, klick hier Tactical Sailing

Literatur: Autor Tilo Schnekenburger,
„Die Geometrie des Regattasegelns“,
Geometrische Tools für Strategie und Taktik beim Regattasegeln. ISBN: 97 83 75 83 70 700.
Siehe die Webseite:
www.schnekenburger.click

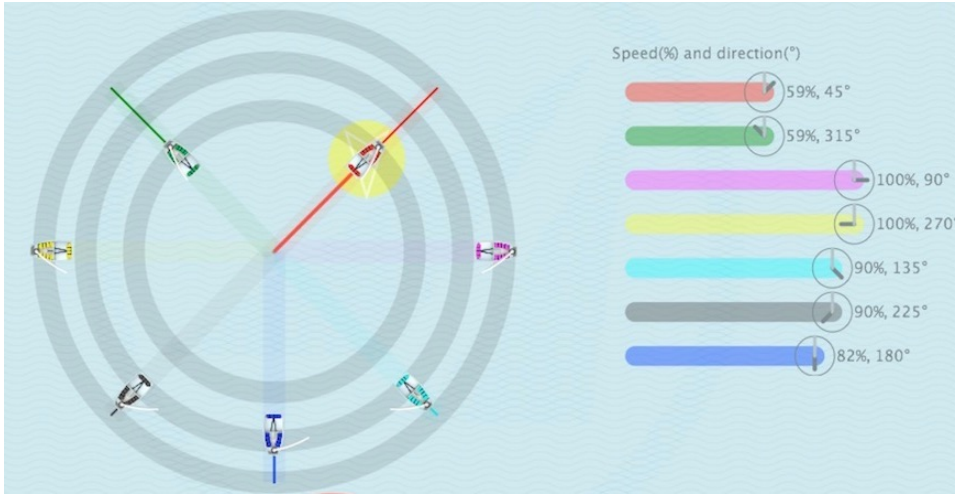


Übung: Gegen den Wind – Winddrehungen – Böen (Ellipse)

Sources

Polardiagramm der Geschwindigkeiten des Optis im 360° Kreis:

Gegen den Wind 315/45°	59 %
Raumschots 270/90°	100 %
Halber Wind 225/135°	90 %
Vor dem Wind 180°	80 %



Berechnungen bei ChatGPT Fahr* recherchiert:

Physikalische Fakten zu Wind, Wasser, Strömung und Wellen, Boot z.B.:

- Wind 11 m/s (40 km/h, 6 Bft)
- Wasser 2 m/s (7,2 km/h, 2 Bft)
- Strömung 0,4 m/s (1,5 km/h, Wirbel)
- Welle 1,6 m/s (6 km/h, kleine Welle)
- Bootslänge eines Opti 2,30 m

Fotos Tactical Sailing von Jollen Meisterschaften
SailGP – Regatta und Team Fotos von Felix van den Hövel

Literatur: „Die Geometrie des Regattasegelns“
Autor Tilo Schnekenburger.
Geometrische Tools für Strategie und Taktik beim Regattasegeln. ISBN: 97 83 75 83 70 700.
3. Auflage 2024. Siehe die Webseite:
www.schnekenburger.click
Kontakt: schnekenburger@segelverband-bw.de

Programm: „Tactical Sailing - Toolbox (TS)“
Eine Simulation von Wind, Windgeschwindigkeit -dreher und Böen zeigen die Szenen im Tactical Sailing Programm (TS). Das TS-Programm mit einer „Trainer Toolbox“ ausgestattet bietet flexible Möglichkeiten zum Erlernen und Trainieren, um den Wind optimal zu nutzen.
Die Parameter Windgeschwindigkeit -dreher, Wendepunkte, Bootswahl und Geschwindigkeiten, sowie das Anzeigen der Berechnungen der Fahrwege können individual gewählt werden.
Wähle zur **Bestellung** des Programms für **Windows- und Mac PCs** folgende Webseite, klick hier.
Eine ausführliche Beschreibung der „**Trainer Toolbox**“ steht in der Dokumentation, klick hier .
Siehe Video-Clips auf youTube: Playlist klick hier .
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