Shortening or lengthening, pulling or pushing due to wind shifts

Tactical Sailing®

A Game Against the Wind

Introduction

Sailing - especially regatta sailing - is a fascinating sport that requires not only mental and physical training but also **basic geometric knowledge**. The central element in sailing is always the wind that moves the boat.

The wind, its direction and strength are an essential factor in **shortening** or **lengthening** the distance to be sailed to a destination.

A puller moves the boat closer to the windward buoy, thus shortening the distance.

A pusher moves the boat away from the windward buoy, thus extending the travel distance.

We have specially developed exercises that show how important it is to carefully observe the wind. In order to make this topic as understandable as possible for the youngest sailing enthusiasts, we chose the “Opti” with a boat length of 2.30m as the basis for calculation and measurement for the mathematical and graphical representation of various situations and decision-making options in changing winds. In the exercises, we make possible shortcuts or extensions of the route visible relatively easily - namely with Opti boat lengths - and thus illustrate the crucial role that wind shifts play on the regatta field.
In the following, sailing “against the wind” will be discussed specifically.

See the sketches and video clips below.

Summary

As a result of our analysis of **shortening** or **lengthening** the course, there are two main reasons.
Shortening or lengthening occurs, for example, due to:

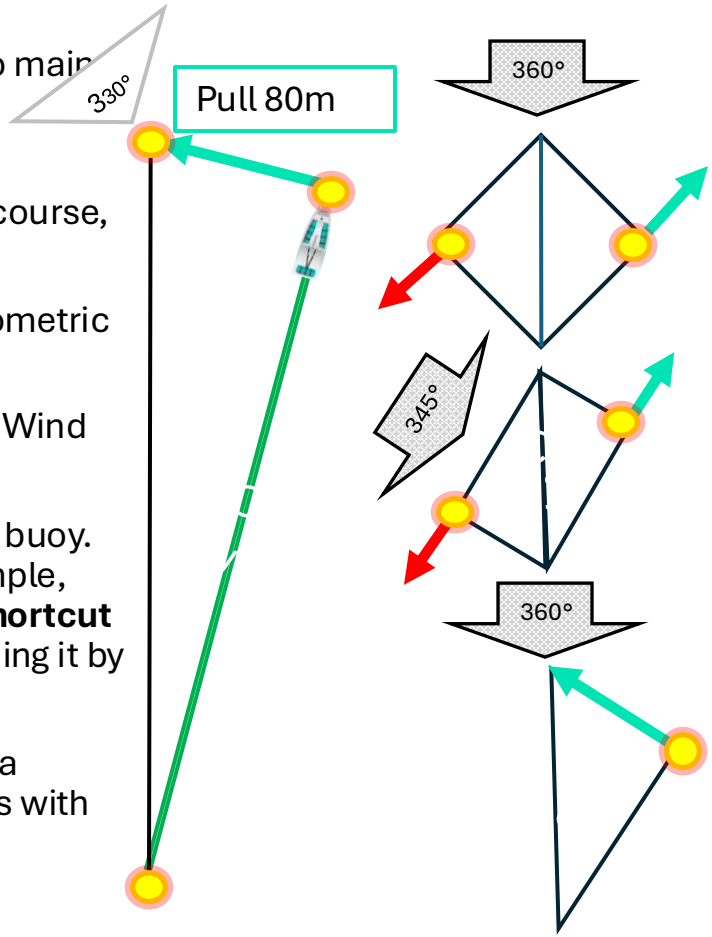
1. Wind shifts, such as from 360° to 330° or 345°, which shorten the course,
2. Missing turning points, thus lengthening the course.

The basis for our analysis of shortening or lengthening the course are familiar geometric shapes, namely a square, a rhombus, and a triangle, used in a regatta.

The square represents the longest course a boat must navigate against the wind. Wind shifts determine whether the square becomes a rhombus or a triangle.

For example, a square has a distance of 424 m from the leeward to the windward buoy. Then the two "legs" of the course in the square are 2 * 300 m = 600 m. As an example, let's take a "puller" with a shortened course from **600 m to 520 m, i.e., 80** m. A **shortcut** then means shortening the course by 80 m, or in the case of **lengthening**, extending it by 80 m.

The **boat length** – a new unit of measurement – is 2.30 m for an Optimist dinghy; a shortcut or lengthening of **80 m** results in **35 boats**! The exercises show examples with **21, 27, 28, and 35 boats**.



Shortening

Shortening or lengthening

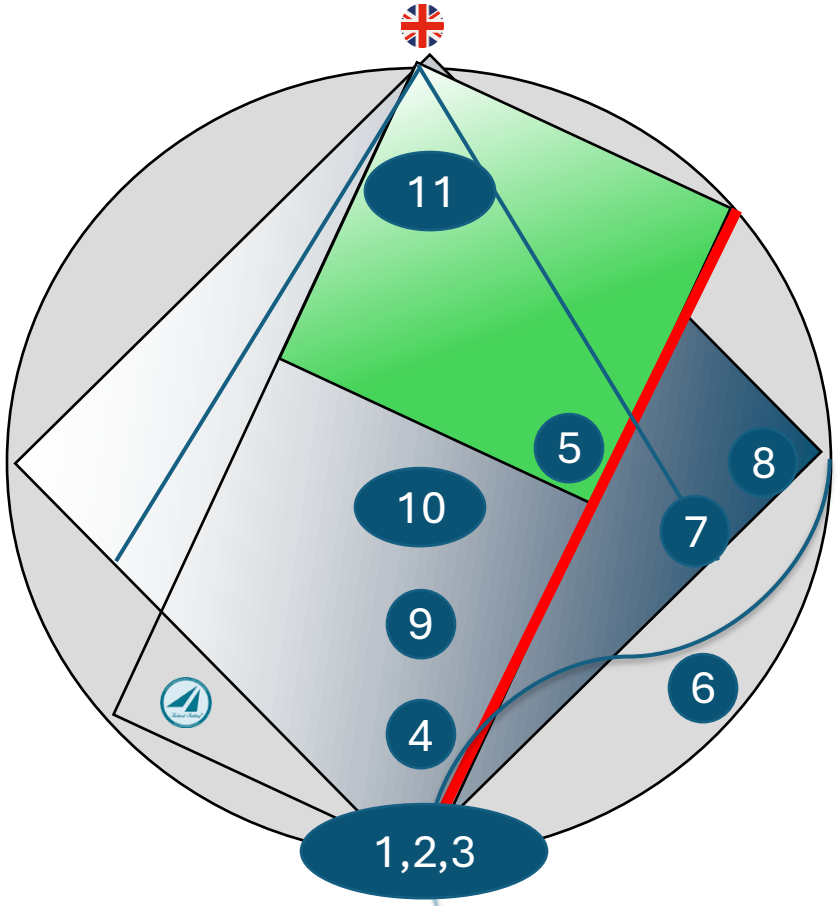
Basics about shortening and lengthening

The basis for **shortening and lengthening** is a geometric structure of **long leg and short leg**.
A well-known rule states:
"Starboard tack before port tack!"

The following geometric rules apply to the regatta course shapes **square**, **rhombus** and **triangle**:

a **puller** means an abbreviation on the short leg,
a **pusher** means an extension on the long leg.

Wind changes occur not only at the start line or the windward buoy, but also right in the middle at **every tactical point 1 to 11** on the regatta field.



Geometric regatta course shapes:
square, rhombus, and triangle.
Tactical decision points 1 to 11.

Gain in "boat lengths"

A wind shift of **-10° caused by a " pull** " and a transverse distance of **200** m creates an " **advantage",** for example at a starting line **.** The **resulting upwind advantage** of **35 m then corresponds to approximately 15 boats (red lines)** for an Optimist dinghy with a length of 2.30 m , i.e., a gain of approximately **17%** .

The so-called “ **10:17 rule** ”, described by Tilo Schnekenburger*, is an important calculation for shortening**.**

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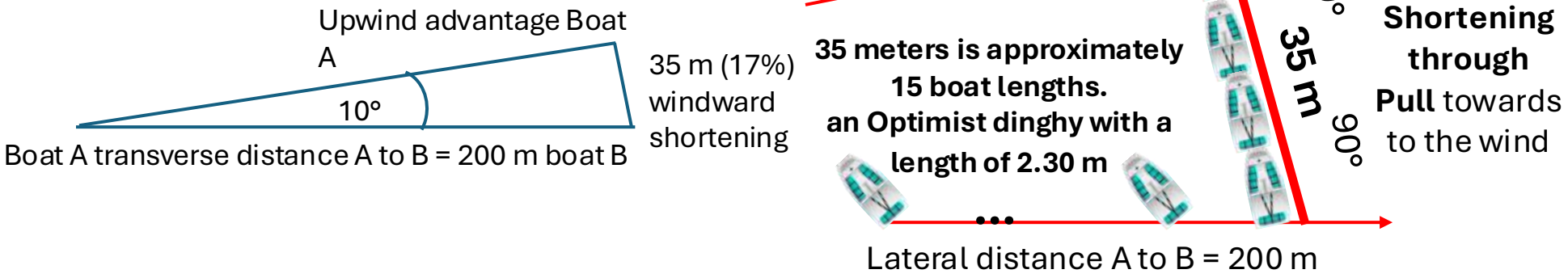
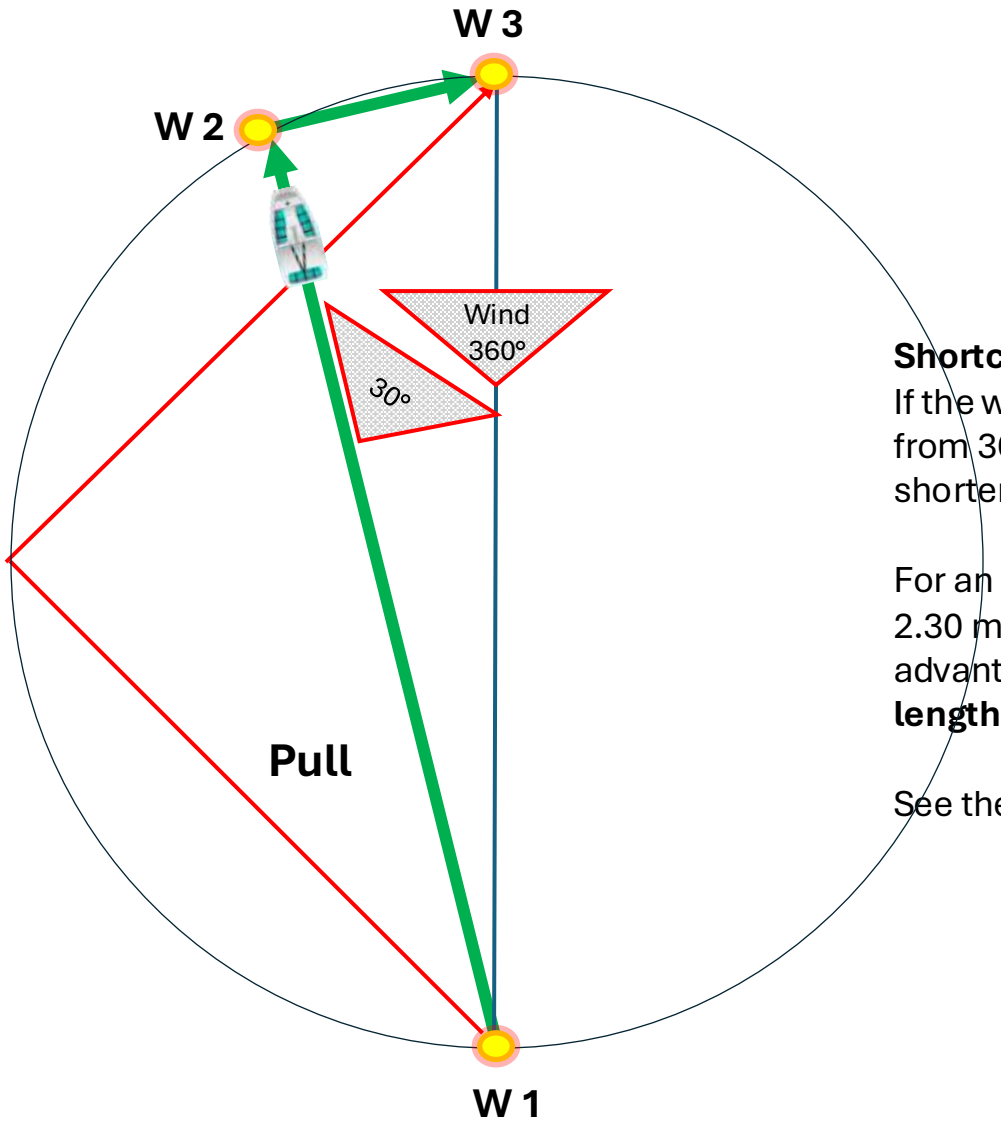


Pull - Shortcut through a pull at start – Long leg

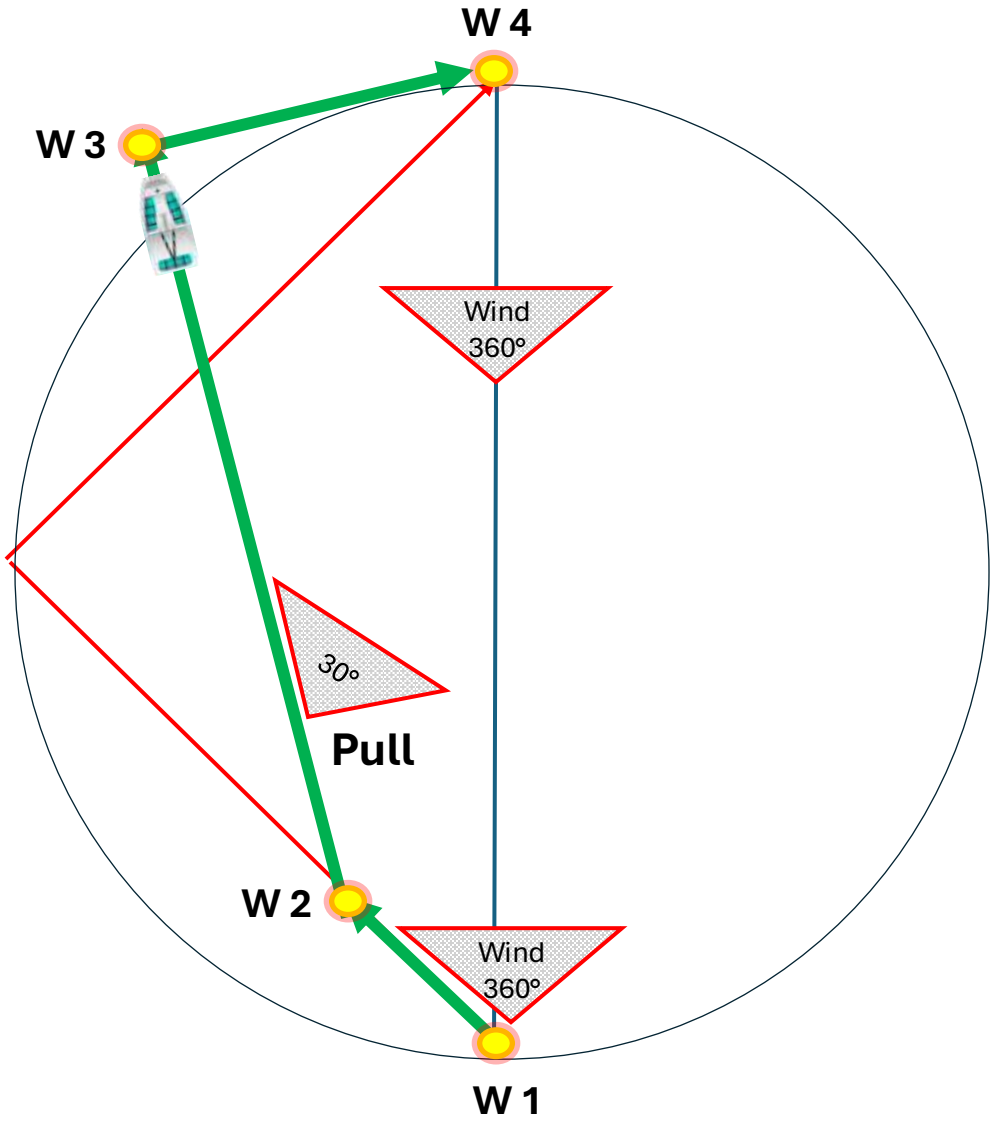


Shortcut
If the wind at turning point W1 shifts from 360° to 330°, this "**pull**" creates a shortening of **80 m**.

For an Optimist dinghy with a length of 2.30 m, this **shortcut** equates to an advantage of approximately **35 boat lengths**!

See the calculations in the appendix.

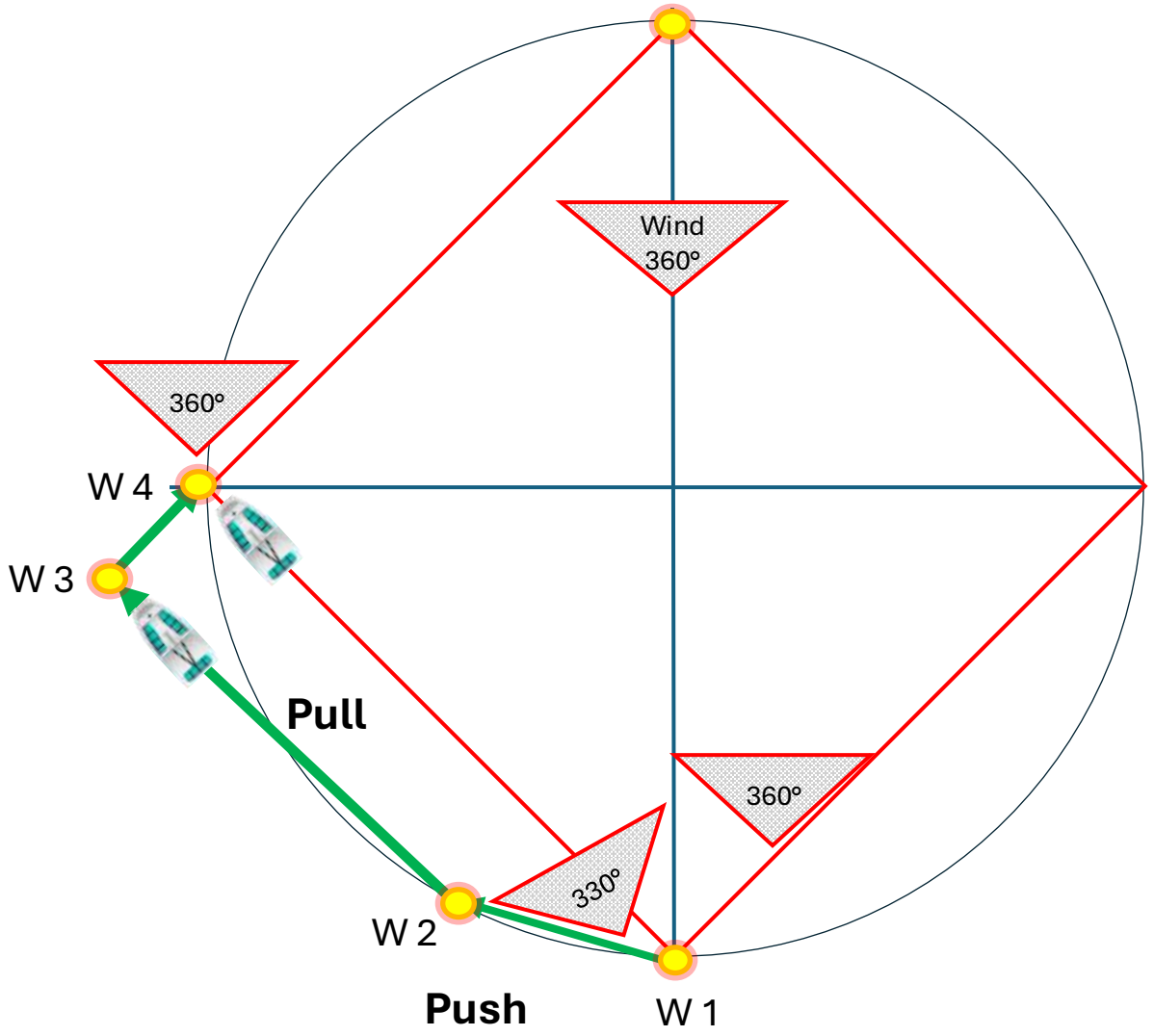
Pull - Shortcut on the way after the start – Long leg



Shortcut
If the wind turns from 360° to 30° at the turning point W 2, this "pull" creates an abbreviation of W 1-2-3-4, so from 600-55= **49 m**.

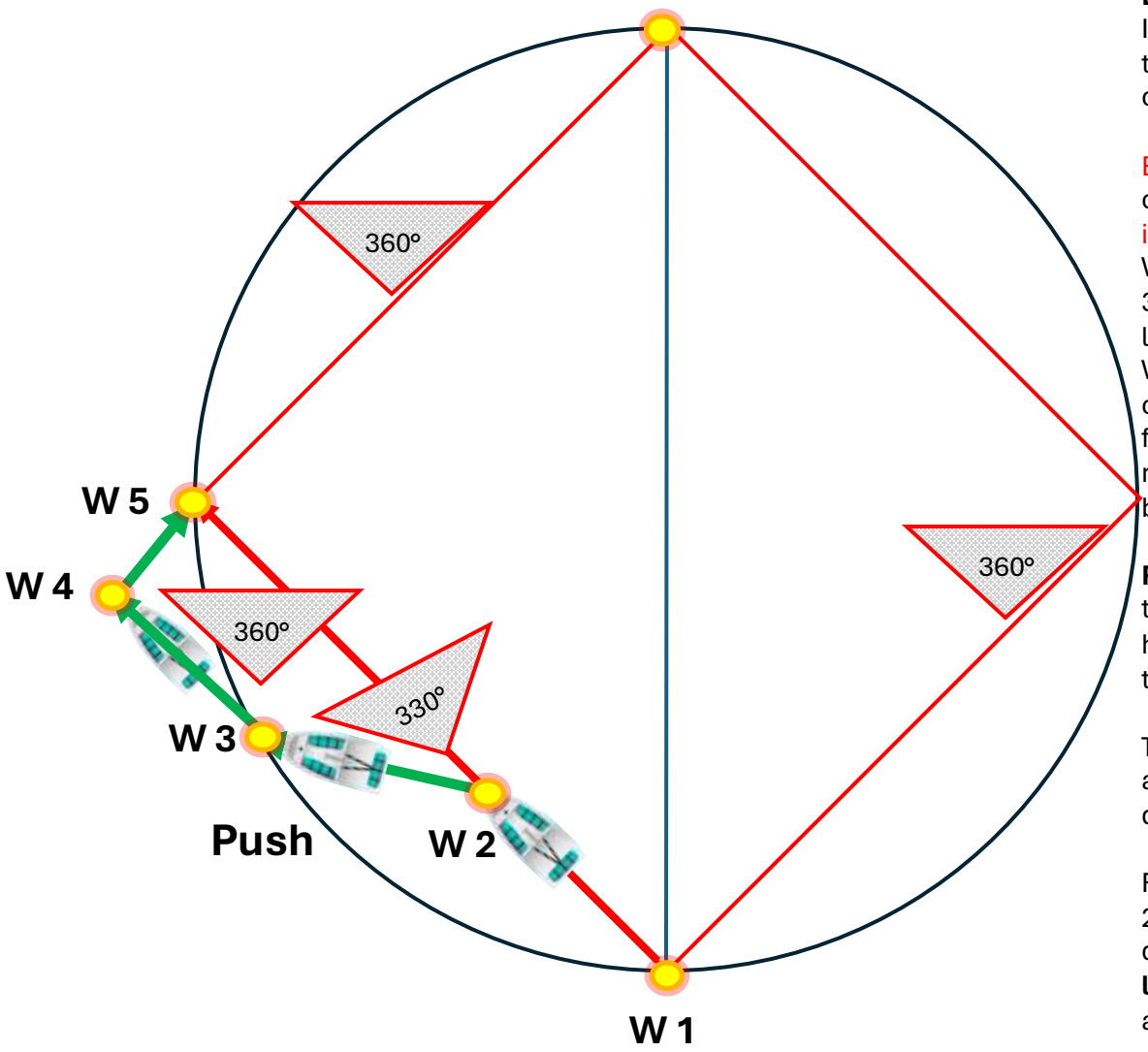
The **shortcut** then corresponds to an advantage of approx. **21 boat lengths** for an Opti with a length of 2.30 m! See the calculations in the attachment.

Push – Extension at the start in Leeward – Short leg



Extension
If the wind turns from 360° to 330° at the turning point W 1, **this "push" creates a risk of "extension".** The direction of travel is then from W 1 from direction 285° to the turning point W 2.
Error: **Full risk** if the boat does not luff at the turning point W 2 but continues sailing. But then the wind turns from 330° back to 360° (pull). New direction of travel is then 315° to the turning point W 3. This creates an **extension** in the direction of W 3, W 4 and to the windward buoy of **62m**, which then corresponds to a disadvantage of **27 boat lengths** for an Opti with a length of 2.30 m!
See the calculations in the attachment.

Push – Extension on the way after the start – Short leg



Extension
If the wind shifts from 360° to 330° at turning point W2, this sudden change can result in a loss of distance.

Error: Don't tack at turning point W2, but continue to turning point W3. This increases the distance traveled towards W3. If the wind even shifts back from 330° to 360° at turning point W3, the next loss of distance occurs to turning point W4. A tack at turning point W4 and continuing to turning point W5 results in further distance loss, and the boat reaches the mooring line to the windward buoy.

Recommendation: In these cases, a timely tack should be made on the holebow, e.g., at turning point W2, when the sudden change begins!

The distances traveled from W2, W3, W4, and W5 create a loop that increases the distance from W2 to W5 by **65 meters**.

For an Optimist dinghy with a length of 2.30 m, this loss equates to a disadvantage of approximately **28 boat lengths**! See the calculations in the attachment.

Pull - Shortcut for wind shifter,

examples with scenes from the Tactical Sailing program, see YouTube video clips, click here.

Puller at start leeward

Puller on the way after the start

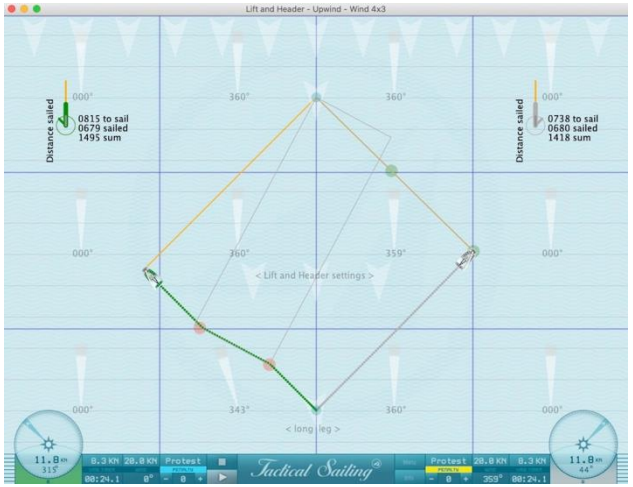
Puller - shortcut to the finish to windward

Puller on the way to the finish to windward

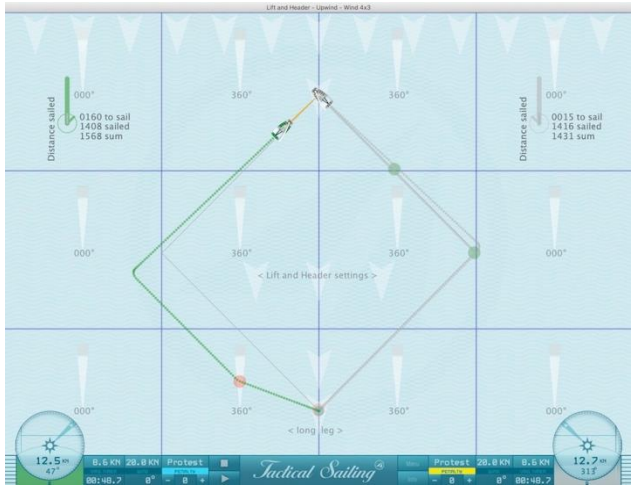
Push - Shortcut for wind shifter,

examples with scenes from the Tactical Sailing program, see YouTube video clips, click here.

Pusher at start leeward



Pusher on the way after the start



Puller - shortcut to the finish to windward

Puller on the way to the finish to windward

Wind shifts across the entire regatta course - so-called ”banana”

Wind shifts can occur in **small increm**ents on the racecourse, e.g., +/- 5° as the boat approaches the shore. A **sudden change** in wind direction can be caused by a gust, e.g., +/- 15°.

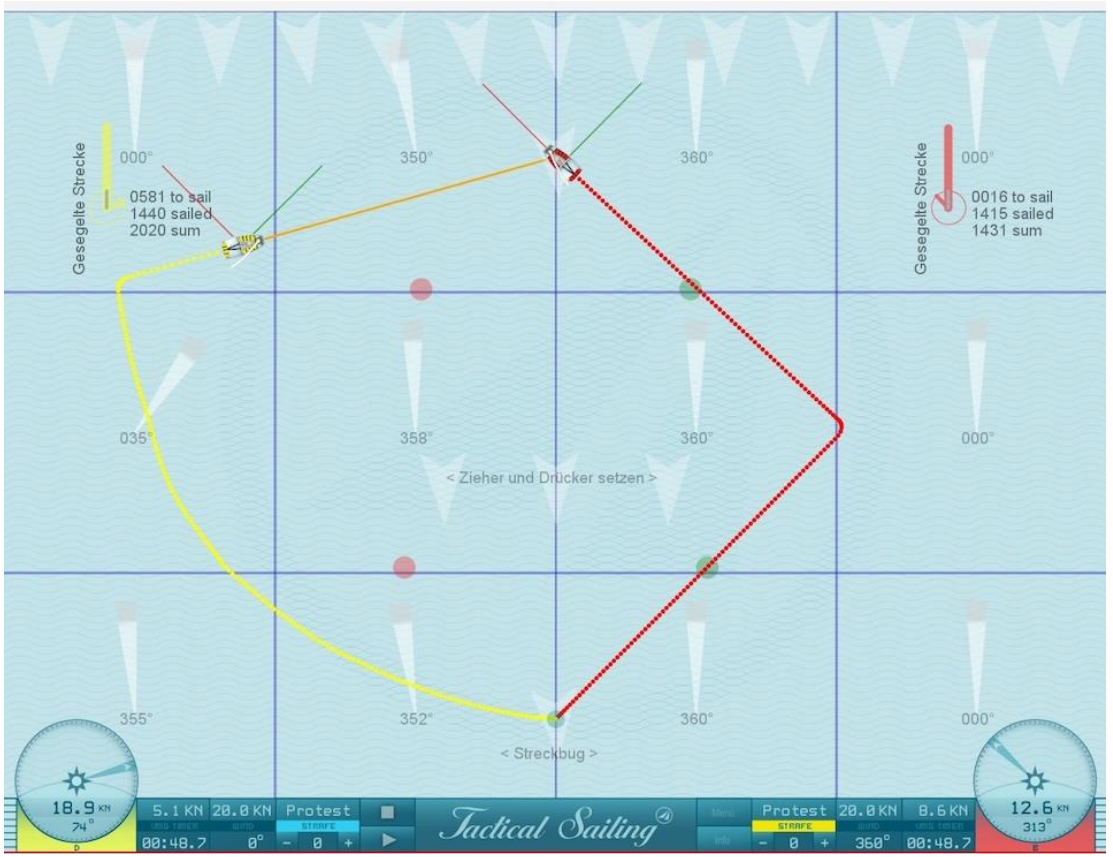
However, wind changes don't only occur at the starting line or the leeward mark, but also a**t any point** on the racecourse. The so-called "switch point," described by Tilo Schnekenburger, is one such point for **tactical decisions.**

The Tactical Sailing program simulates a racecourse with wind conditions in 12 zones that change in both **direction and wind speed**. These zones can be constant or follow rhythmic lines*.

The geometric analysis of these situations **is very complex** when one also considers any position of the boats (port/right, top/bottom) and their lateral distance on the racecourse.

If the wind shifts beyond 360°, the sailing route can easily become a so-called "banana," resulting in a significant loss of time and distance.

* See the PC simulations with the Tactical Sailing program on YouTube, click here .

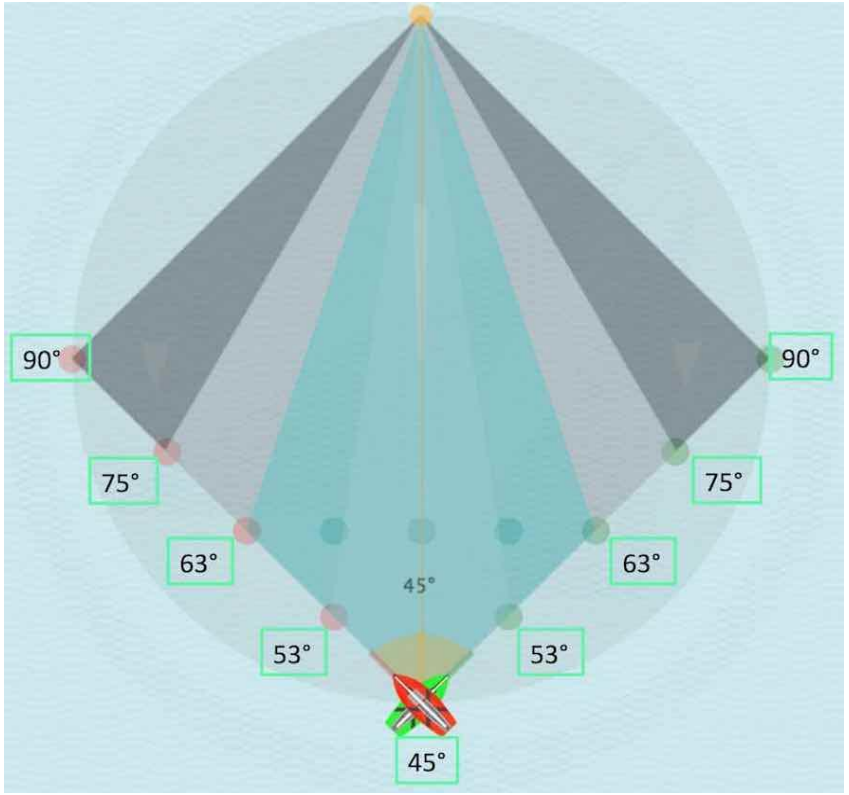


The yellow route becomes a so-called "banana "

The Risk and Opportunity Zones - Tactical Decision Points

The color-coded "Risk and Opportunity Zones" in the diagram represent **tactical decision areas** whose boundaries should not be crossed or should be observed on the port and starboard sides. These zones depend on the turning angle of a boat. For practical reasons, the diagrams assume a boat with a 90° turning angle (e.g., Optimist, 470) and a 360° **wind direction**. The sailing distance indicates the zones with the "viewing direction" from the boat to the windward buoy at 45°, 53°, 63°, 75°, and 90°.

The different segments and boundaries are distinguished by different colors:
- dark gray areas indicate the **absolute loss zone** at a distance of 75° to 90° from the centerline,
- light gray areas indicate the **high risk zone** and simultaneously the high opportunity zone at a distance of 63° to 75° from the centerline.
- Turquoise areas mark the zone with **medium risk** and/or **medium chance** at a distance of 53° to 63° from the center line.
- Light turquoise areas mark the zone with **minimal risk** and/or **minimal chance** at a distance of 45° to 53° from the center line.

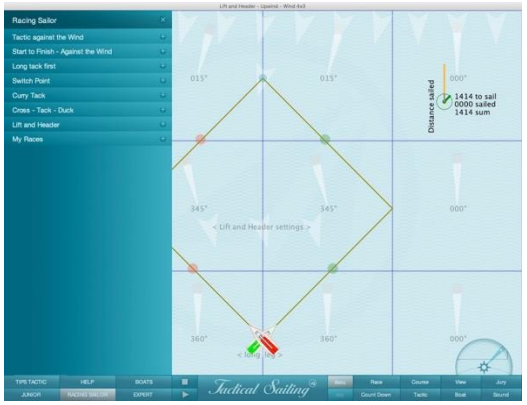


Attachments

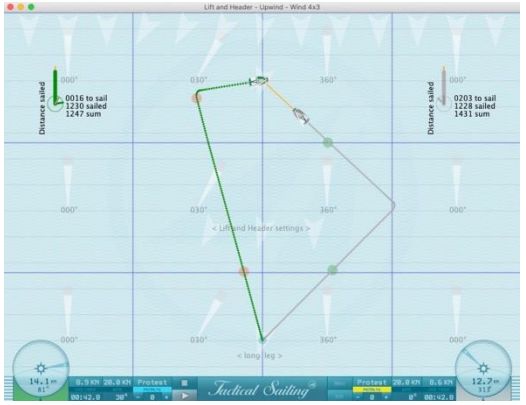
- Create your own exercise with the Tactical Sailing program
- List of links to video clips (YouTube), documentation and literature references
- Geometric fundamentals for experts
- Sketches for shortening and lengthening
- Calculations for shortening and lengthening
- Sources for editing

Create your own exercise - Start and menu selection

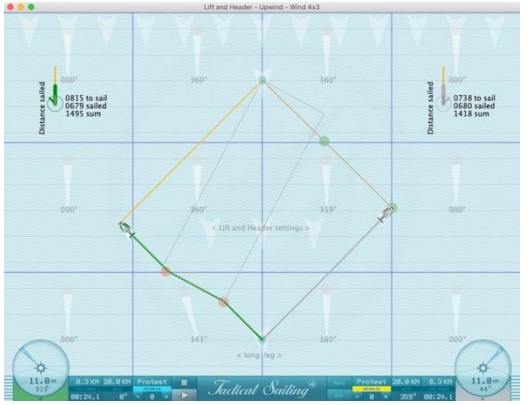
- Download the program from http://www.tacticalsailing.com/en
- Start Tactical Sailing (TS) – Coachs' Toolbox – Click Menu
- Select your boat type and colour: Menu/Boats/Select your boat/Opti - Colour
- Select the exercise: Menu/Racing Sailor/Lift and Header/Upwind – Wind 4x3
- Select options: Menu/Tactic - Distance Sailed (on), all others (off)
- Set wind direction 000 – 360° in the 4x3 wind fields
- Click "Play / Pause". See the detailed help in the TS documentation if needed:
  - Coach' Toolbox
  - Pull or Push



Exercise from the start of the exercise **Wind 4x3**



Exercise Puller **030° finish**



Practice push on the go 315/345°

List of free video clips (YouTube), information on Tactical Sailing (TS) – documentation and literature

- YouTube Video Clips: Play List click here .
- Pull at the start in lee: click here.
- Pull underway after the start: click here.
- Push at the start in lee: click here.
- Push underway after the start: click here.
- "Switch Point" - Risk at the turning point: click here.
- Tactical Sailing Documentation:
  - Pull or Push
  - Coach's Toolbox

Sketch "Shortcut" from the Tactical Sailing Program

- Download the Tactical Sailing Program with Coach's Toolbox on the TS website: click here.

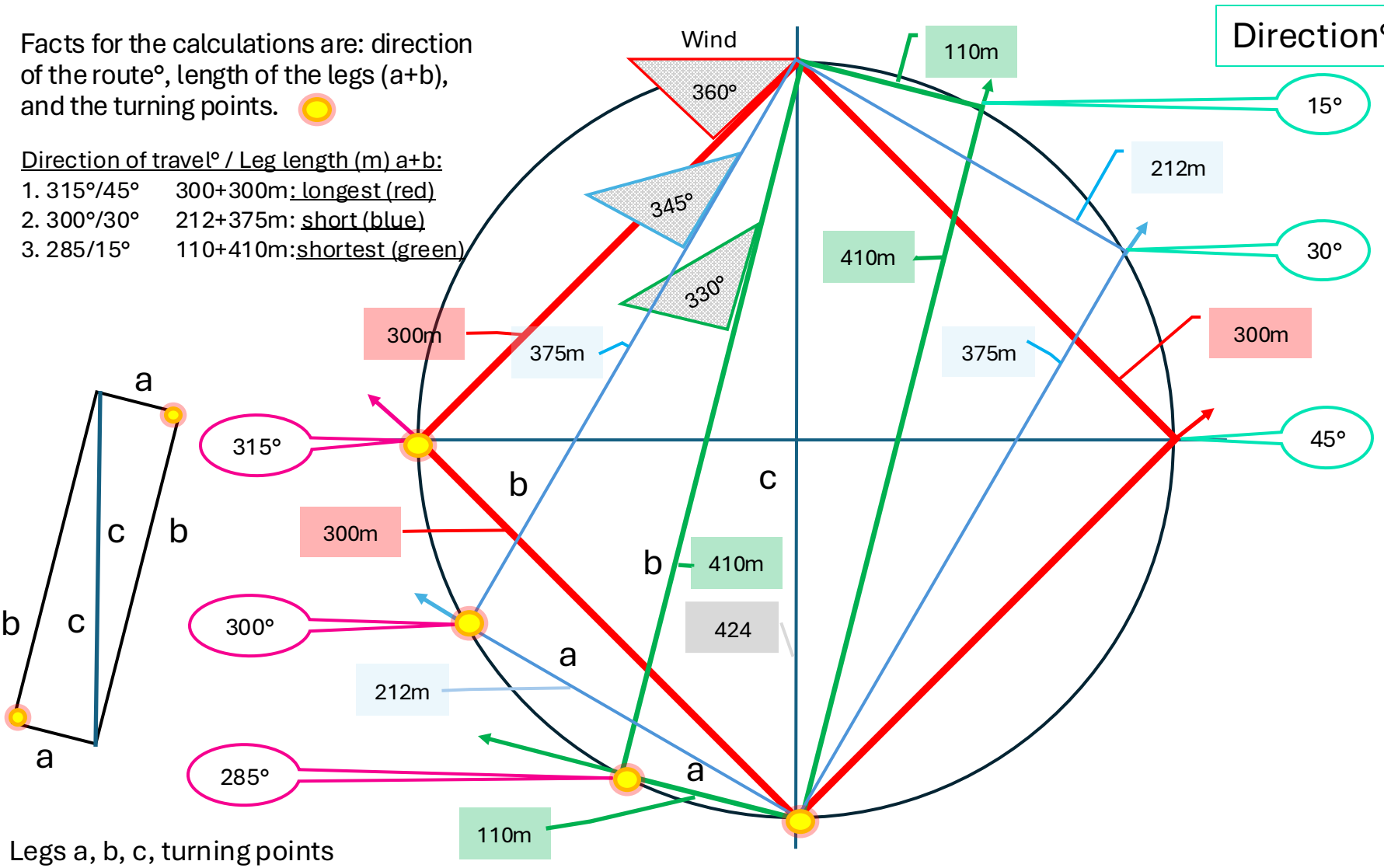
- Literatur: Autor Tilo Schnekenburger, „Die Geometrie des Regattasegelns" (German language), Geometrische Tools für Strategie und Taktik beim Regattasegeln. ISBN: 97 83 75 83 70 700.
  See his webseite (German):
  www.schnekenburger.click

Geometric principles for experts

Facts for the calculations are: direction of the route°, length of the legs (a+b), and the turning points.

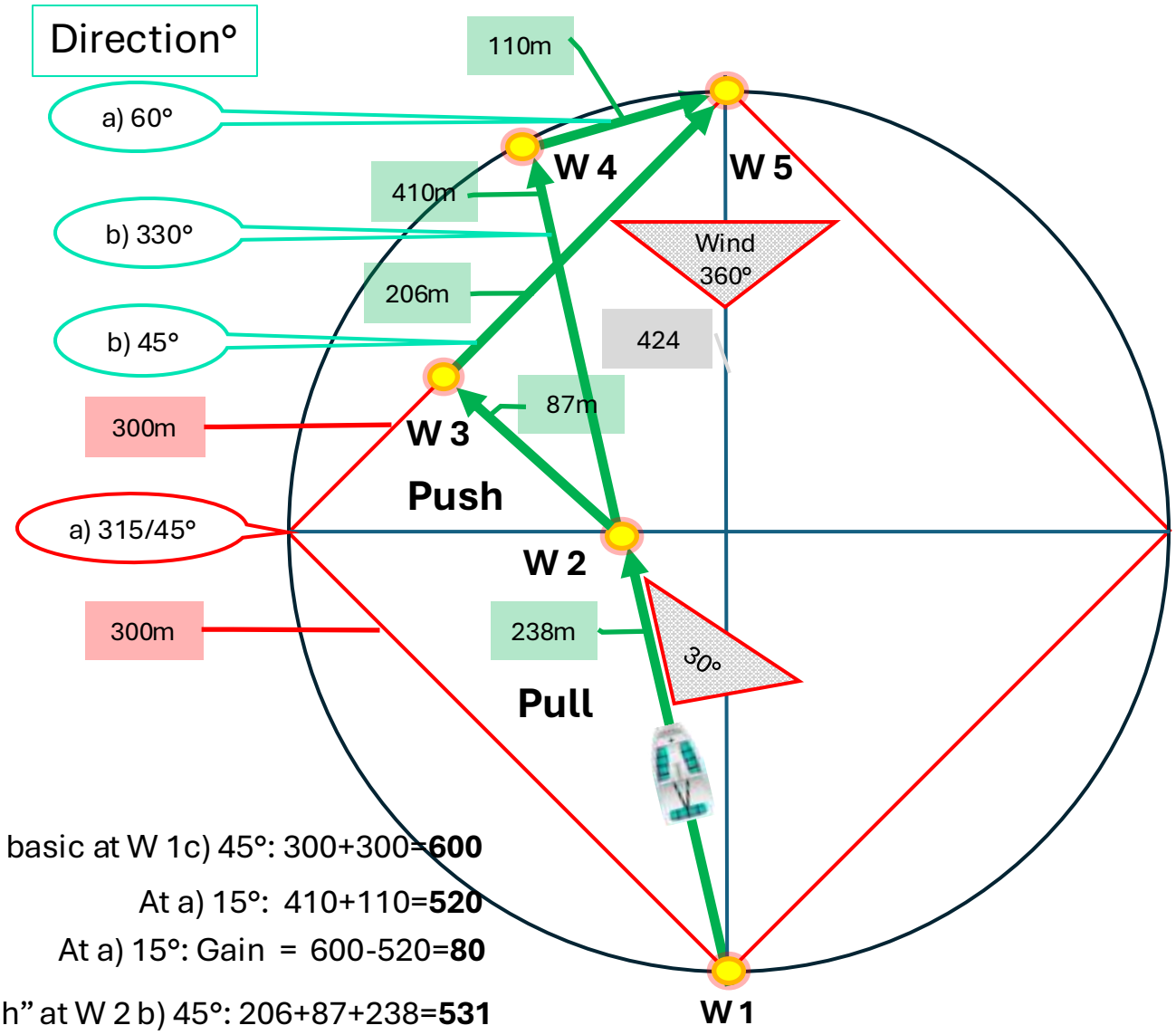
Direction of travel° / Leg length (m) a+b:

1. 315°/45° 300+300m: longest (red)
2. 300°/30° 212+375m: short (blue)
3. 285/15° 110+410m:shortest (green)



Legs a, b, c, turning points

Puller at the start in Lee - shortcut



The basic at W 1c) 45°: 300+300=**600**

At a) 15°: 410+110=**520**

At a) 15°: Gain = 600-520=**80**

With a “Push” at W 2 b) 45°: 206+87+238=**531**

Gain reduced : 600-531= **69**

Shortening
If the wind at turning point W1 shifts from 360° to 330°, this "**pull**" creates a gain of 600-520m = **80m** over a 15° angle to W 4.

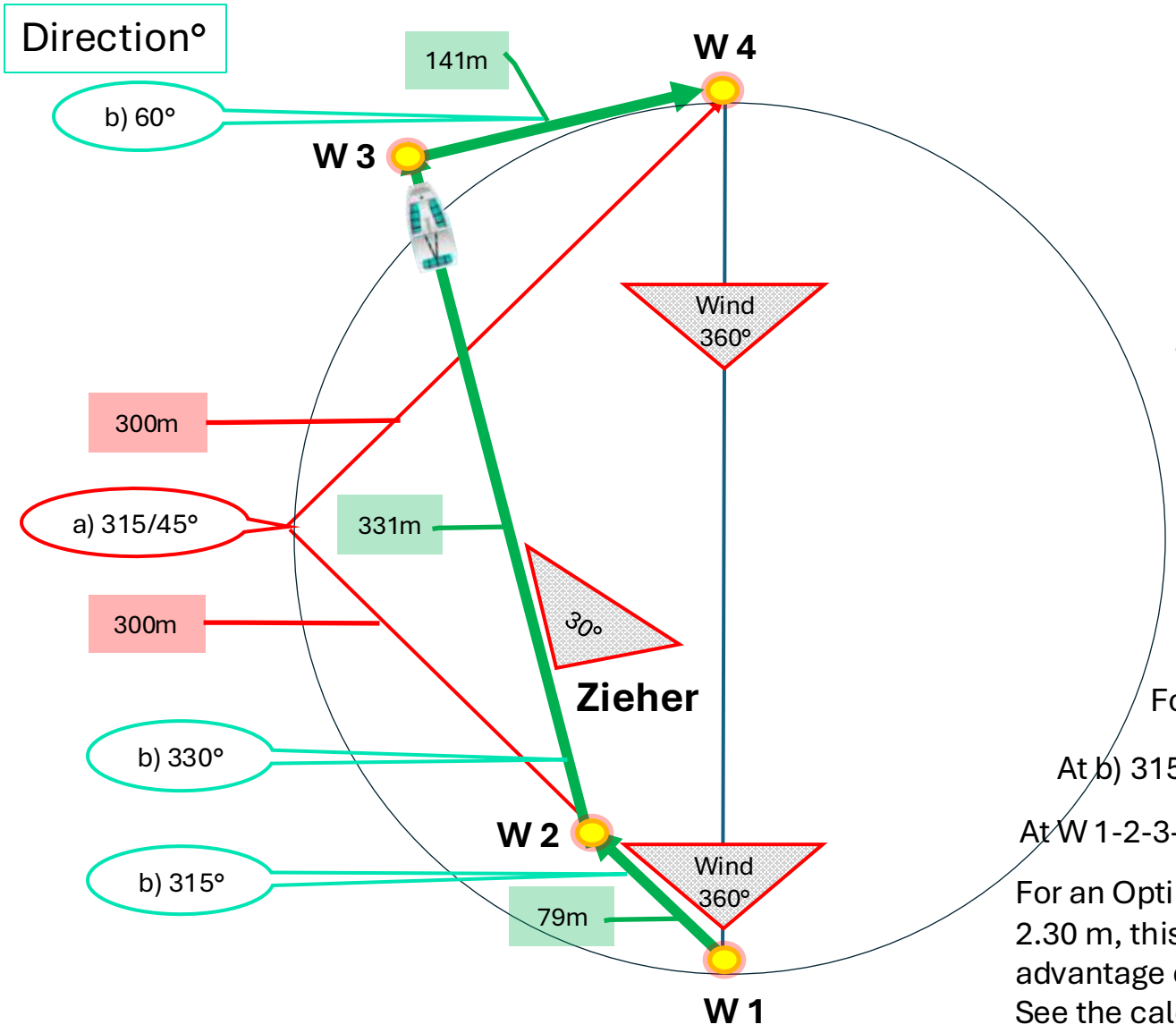
Is there a risk if the wind oscillates? Can a wind shift back from 330° to 360° cause damage?

NO: the ”push" at turning point W2 is not a "loss"; the "gain" is simply **reduced** from **80m** to 600-531 = **69m at W 3**

For an Optimist dinghy with a length of 2.30m, this gain corresponds to an **advantage of approximately 35** or **30 boat** lengths!

See the calculations in the appendix.

Puller on the way after the start - shortcut



Shortcut
If the wind at turning point W2 shifts from 360° to 30°, this "pull" creates a shortcut of W1-2-3-4, that is, 600-551 = **49 m**.

For an Optimist dinghy with a length of 2.30 m, this shortcut corresponds to an advantage of approximately **21 boat lengths**! See the calculations in the appendix.

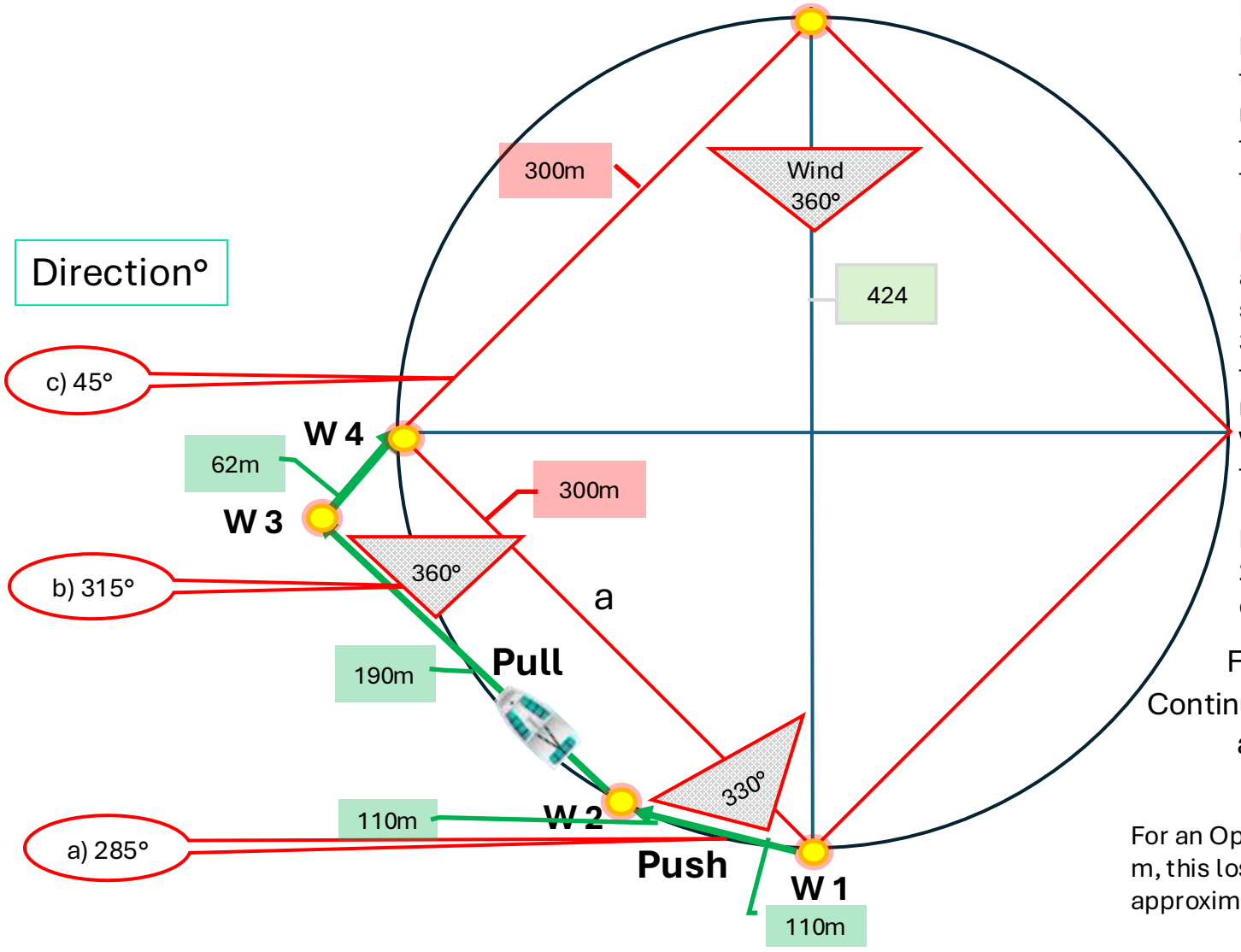
For base a) 315°: 300+300=**600m**

At b) 315, 330, 60°: 79+331+141=**551m**

At W 1-2-3-4: shortcut = 600-551=**49m**

For an Optimist dinghy with a length of 2.30 m, this **shortcut** equates to an advantage of **21 boat lengths**!
See the calculations in the appendix.

Push at the start in Lee - lengthening



Lengthening

If the wind shifts from 360° to 330° at turning point W1, this "pull" creates a risk of "loss." The course then runs from W1 in the direction of 285° to turning point W2.

Error: Full risk if the boat doesn't tack at turning point W2 but **continues** sailing. The wind then **shifts back** from 330° to 360° (pull). The new course is then 315° to turning point W3. This results in an extension towards W3, W4, and buoy. This leads to a loss of the windward **62m**.

For an Optimist dinghy with a length of 2.30m, this loss corresponds to a disadvantage of **27 boat lengths**!

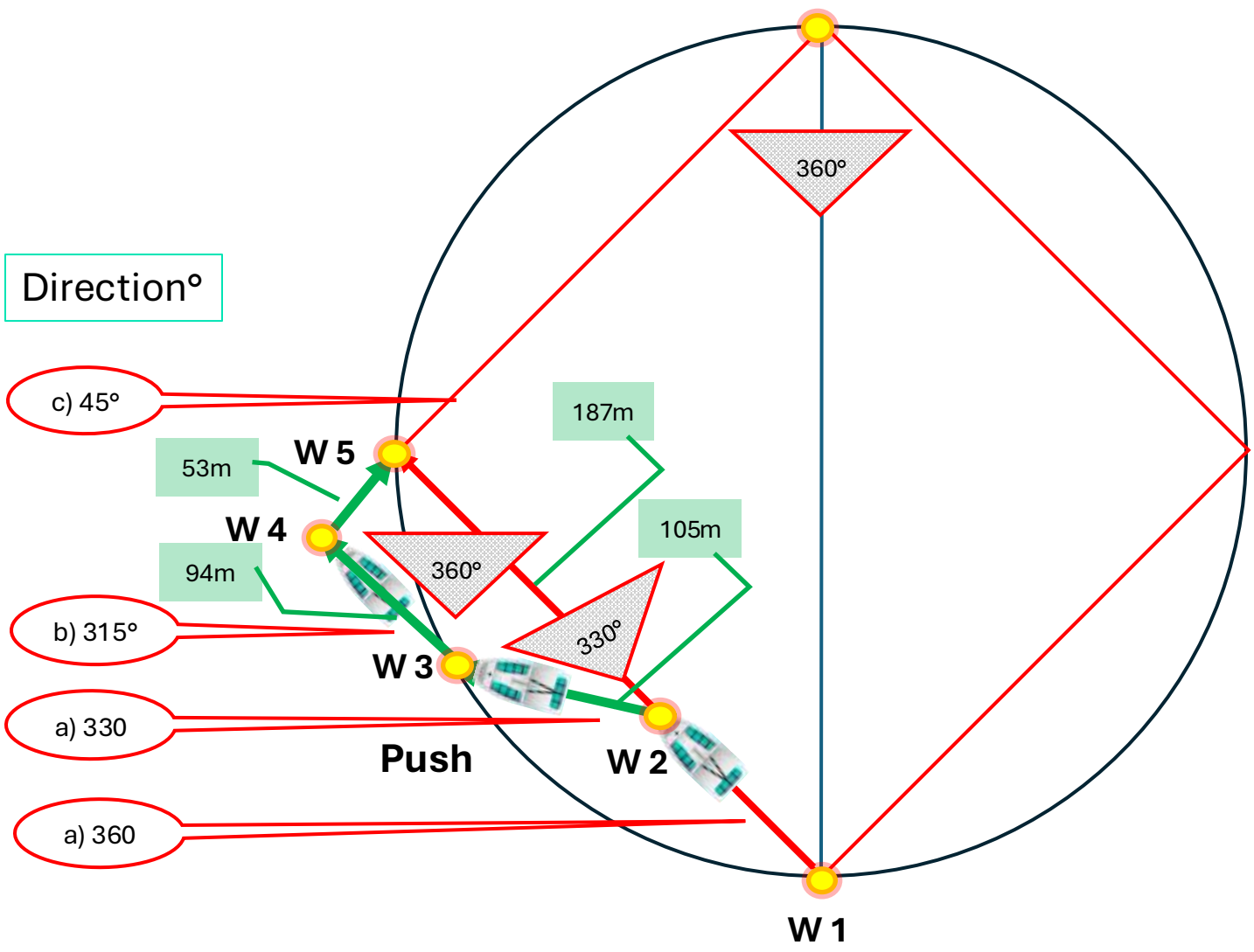
For base c) 315°/45°: 300=**300**

Continue with "proceed" to W 3, W 4 at 315°/45°: 110+190+62=**362**

Loss: 362-300= **62**

For an Optimist dinghy with a length of 2.30 m, this loss corresponds to a disadvantage of approximately **27 boat lengths!**

Push on the go after the start - lengthening



Lengthening
If the wind shifts from 360° to 330° at turning point W2, this sudden change can result in a loss of distance.

Error: Don't tack at turning point W2, but continue sailing to turning point W3. This increases the distance sailed towards W3. If the wind even shifts back from 330° to 360° at turning point W3, the next loss of distance to turning point W4 occurs. Tacking at turning point W4 and continuing to turning point W5 results in further **distance loss**, and the boat reaches the mooring line to the windward buoy.

Recommendation: In these cases, a timely tack should be made on the holebow, e.g., at turning point W2, when the sudden change in wind begins!

With the course from W 2, 3, 4, 5, the boat travels an arc of 252 m compared to the 187 m section. The distance from W 2 to W 5 is therefore 252 - 187 = **65 m**.

For an Optimist dinghy with a length of 2.30 m, this loss corresponds to a disadvantage of approximately **28 boat lengths!**

Loss: 362 - 300 = 62

Attachment: Shortening and lengthening Calculations

Shorting – Pull

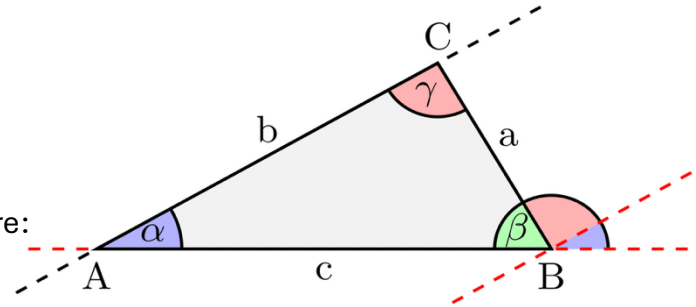
Wind direction°	Triangle sides (m)			Sailboat direction°	Distance to sail(m)	Won(m)	Number of boats winning
	a	b	c	α °			2,3
360°	300	300	424	**45**	600	0	0
345°	212	367	424	**30**	579	21	9
330°	110	410	424	**15**	520	80	35
330/360	206	325	424	**15/45**	531	69	30
360/30/30	142	410	424	**315/345/60**	551	49	21

Lengthening - Push

Wind direction°	Triangle sides (m)			Sailboat direction°	Distance to sail(m)	Lost(m)	Number of boats lost
	a	b	c	α °			2,3
360	300	300	424	**315**	600	0	0
345	212	367	424	**300**	579	21	9
330°	110	410	424	**285**	520	80	35
360/330	**300**	**62**	424	285/315	362	62	27
Push	110+190+62			Pull		Line a=300m	
360/330/360/45	**105**	**252**	187	330/360	252	65	28
Push	**105**	**105+94+53**	"Bow" W 3,4,5	330/360	"Bow" W 3,4,5		
Changes in all values marked "red"							

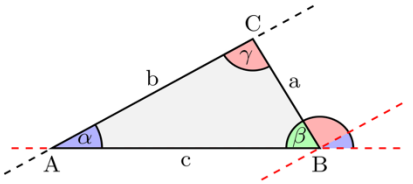
The basis for the calculations in the right-angled triangle are:
- the diameter of the circle, the side "c" (leeward to windward) is 400m,
- the formula of the "Pythagoras": $a^2 = b^2 + c^2$, and the "sine rule":
- a : b : c = sin (alpha) : sin (beta) : sin (gamma).

See the article in the topic area. "Rule of Three Calculator" – www.Smart-Rechner.de
Recommendation: **A very good, flexible tool** for calculating triangles can be found here:
https://www.smart-rechner.de/dreieck/rechner.php
Publisher: Expert on calculating triangles, see: Michael Mühl



Attachments: Sources

Calculations:
The calculated distances in meters (boat lengths) are only exemplary values to illustrate th geometric relationships. The following principles apply:
- Calculations are performed within a right-angled triangle,
- the distance from leeward to windward, side "c", is set to 424 m for the calculations,
- constant boat and wind speeds are assumed,
- Optimist dinghies with a length of 2.30 m and a turning angle of 45° are used.



Literature: "Die Geometrie des Regattasegelns" (German language, 3rd edition 2024).
Autor Tilo Schnekenburger.
(German language, 3rd edition 2024). ISBN: 97 83 75 83 70 700.
Geometric tools for strategy and tactics in regatta sailing. See the website:
www.schnekenburger.click .
Contact: schnekenburger@segelverband-bw.de

The "Tactical Sailing Program (TS)"
simulates wind shifts and gusts, including gains and losses, lift and pushes, wind speed changes, and gusts. Equipped with a "Coach' Toolbox," the TS offers flexible learning and training options for optimally utilizing wind shifts.
Parameters such as wind speed changes, tacking points, boat selection speeds, and the display of calculated routes can be customized.
To order the program for Windows and Mac PCs, please visit the following website: click here.
A detailed description of the **"Coach Toolbox"** can be found in the documentation: click here.

See video clips on YouTube: Play List click here .
Contact: office@TacticalSailing .de .