Shortening or lengthening, lift or header due to wind shifts

Tactical Sailing®

A Game Against the Wind

Summary - geometric fundamentals

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

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

We have developed specific exercises to demonstrate the importance of carefully observing the wind. To make this topic as accessible as possible to even the youngest sailors, we have chosen the Optimist dinghy (2.30m) as the basis for calculations and measurements for the mathematical and graphical representation of various situations and decision-making options in changing winds. In the exercises, we use Optimist boat lengths to illustrate potential shortcuts or lengthening of the route, thus highlighting the crucial role that wind shifts play on the regatta course. The simulations in the Tactical Sailing program allow the helmsman to realistically experience the same situations on the water on the computer screen. The following section focuses specifically on sailing "upwind".

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:

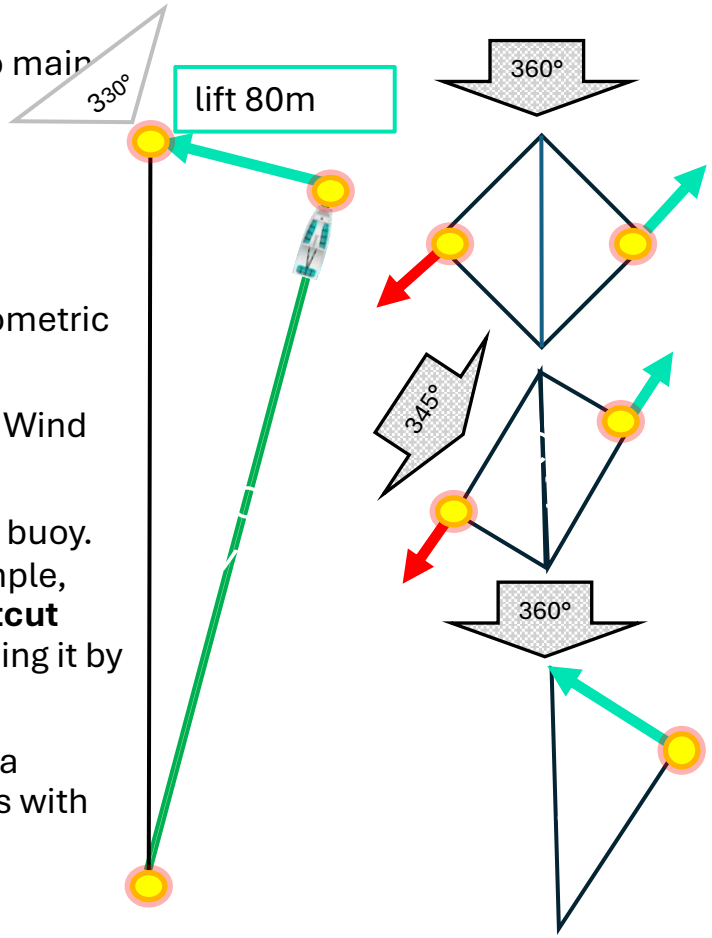
1. Wind shifts, such as from 360° to 330° or 345°, which shorten the course,
2. Missing turning points, thus lengthening the course.

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 "lift" 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

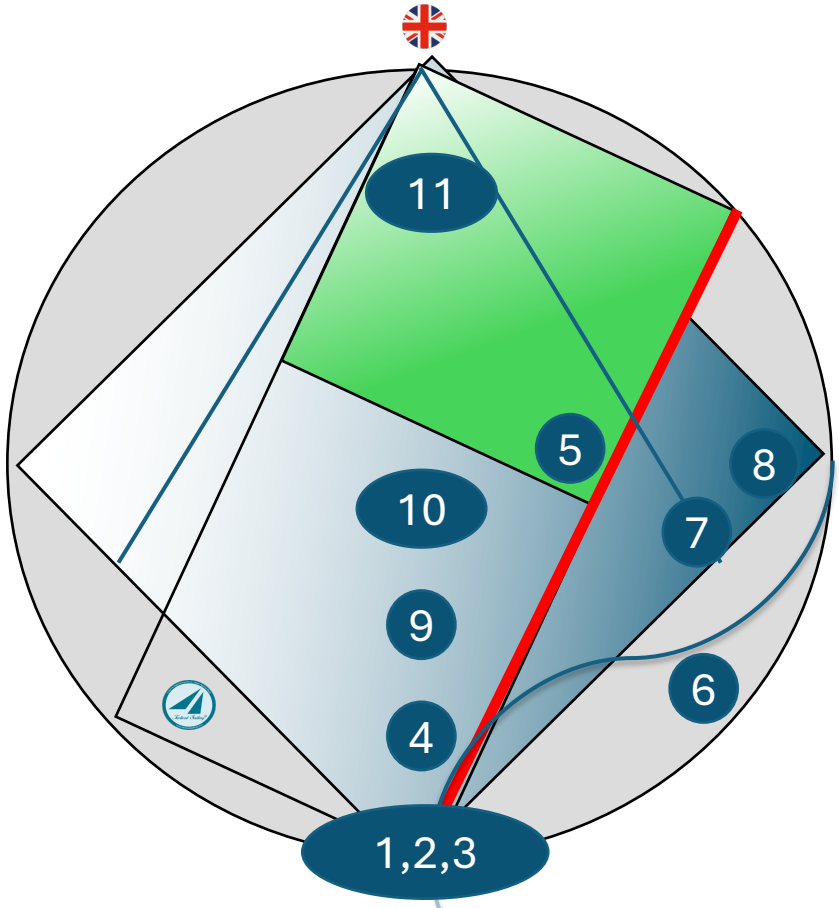
Basics about shortening and lengthening

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 **lift** means an abbreviation on the short leg,
a **header** 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.



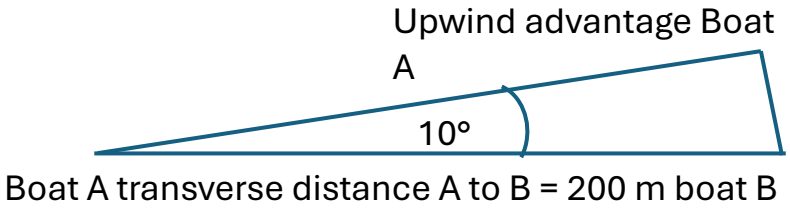
Geometric regatta course shapes:
square, rhombus, and triangle.
Tactical decision points 1 to 11.

Gain in "boat lengths"

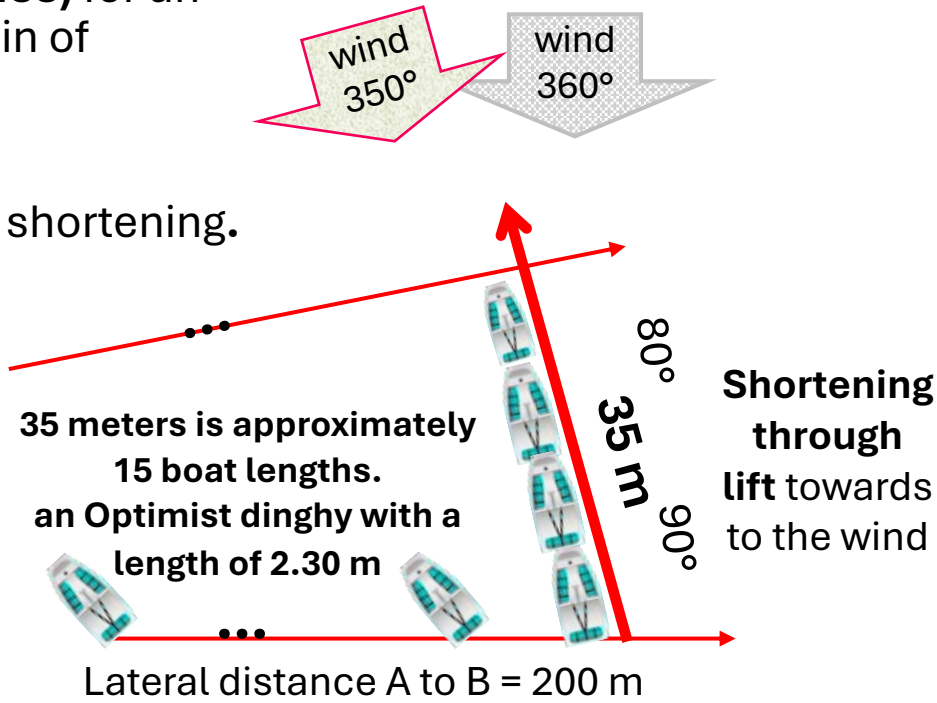
A wind shift of **-10liftused by a "lift**" and a transverse distance of **200** m creates an " **advantage",** for example at a starting line **.** The **resulting upwind advantage** of **35 m then corresponds to approximately 15 boats (red lines)** for an Optimist dinghy with a length of 2.30 m , i.e.,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

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

.



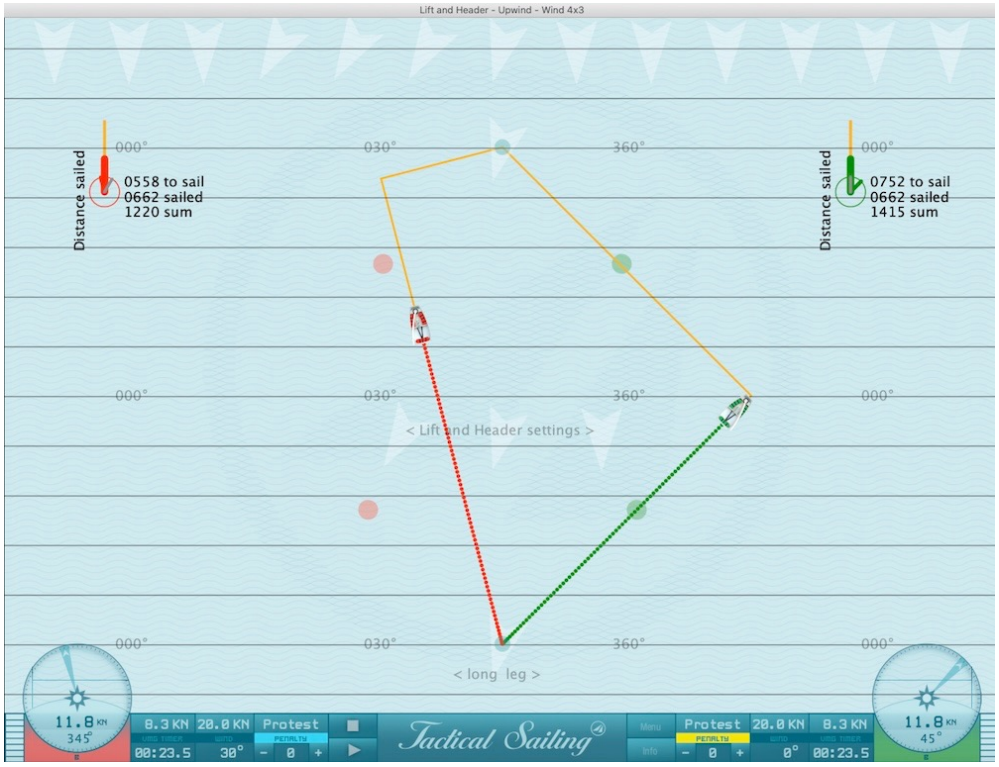
35 m (17%) windward shortening



Shortening through lift towards to the wind

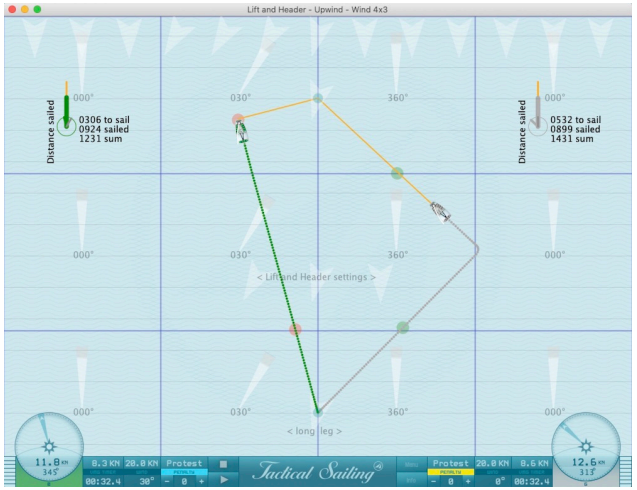
Regatta simulation with the Tactical Sailing program

- The simulations in the Tactical Sailing program allow the helmsman to realistically experience the same situations on the water on his PC screen.
- The simulation in the Tactical Sailing program can, for example, display his own position compared to other Optimist dinghies. There is a horizontal windward indicator that shows his boat alongside another Optimist—both underway and at the windward mark.
- Just like in a regatta on the water, the helmsman observes his position relative to other boats along the course. At the starting line, everyone is side by side at the same distance from the finish. This changes, however, on the way to the windward mark, thanks to the skillful use of wind shifts. The helmsman then continues to observe the other sailors: are they alongside him, ahead, or behind? The simulation calculates his lead or the distance he has gained along the course based on the number of boat lengths.
- Further examples are shown in the following scenes.

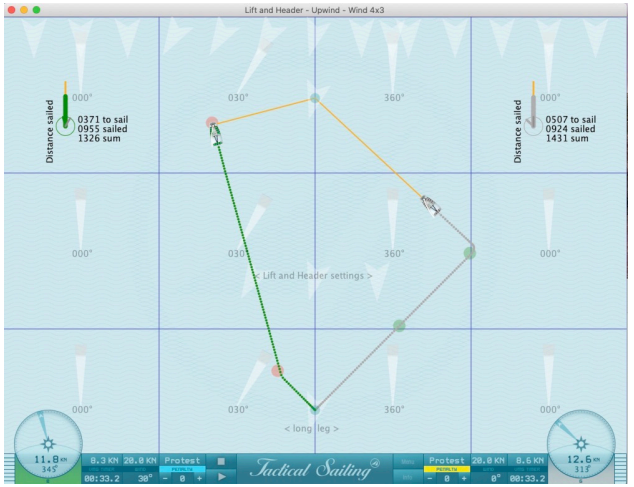


Up wind ladder en route

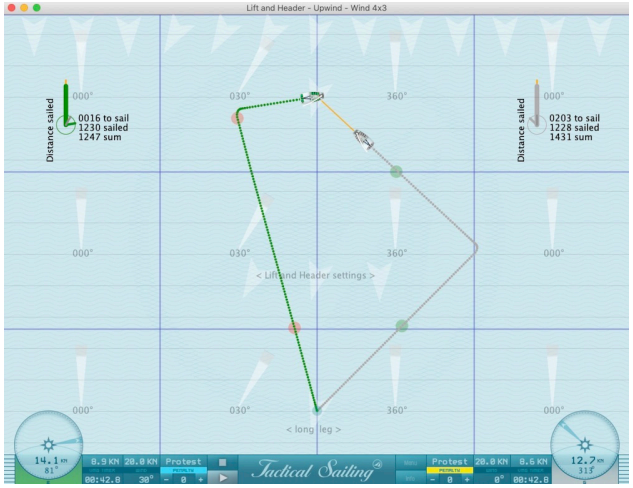
Examples with scenes from the Tactical Sailing program, see YouTube video clips, click here.



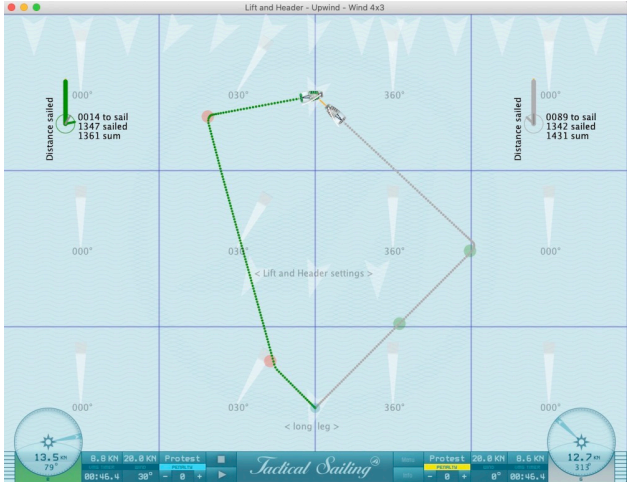
lift at start leeward



lift on the way after the start

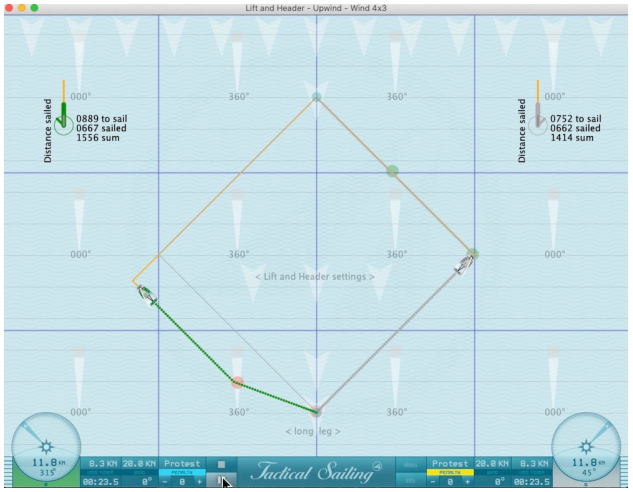


lift - shortcut to the finish to windward

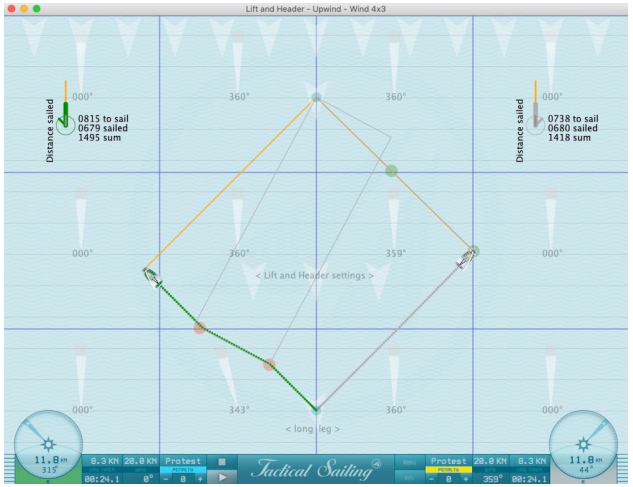


lift on the way to the finish to windward

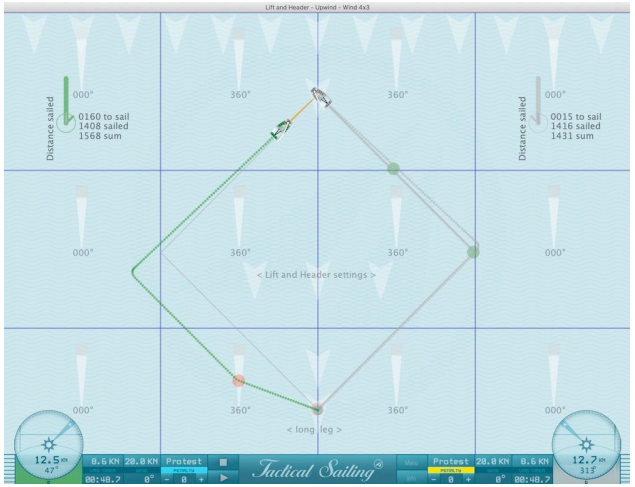
Header with scenes from the Tactical Sailing program, see YouTube video clips, click here



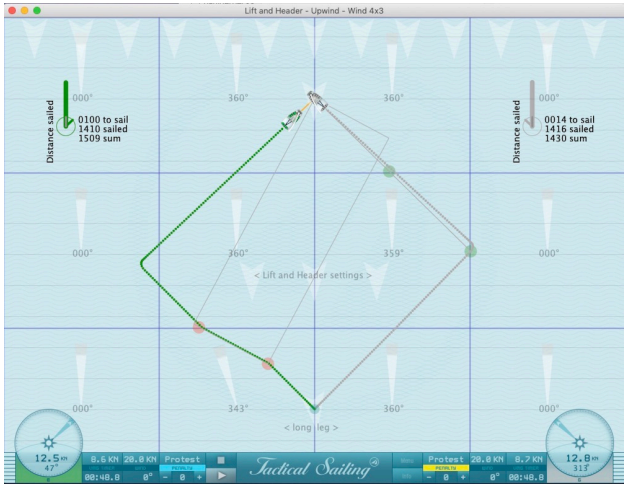
header start leeward



header on the way after the start



header - shortcut to the finish to windward



header 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°.

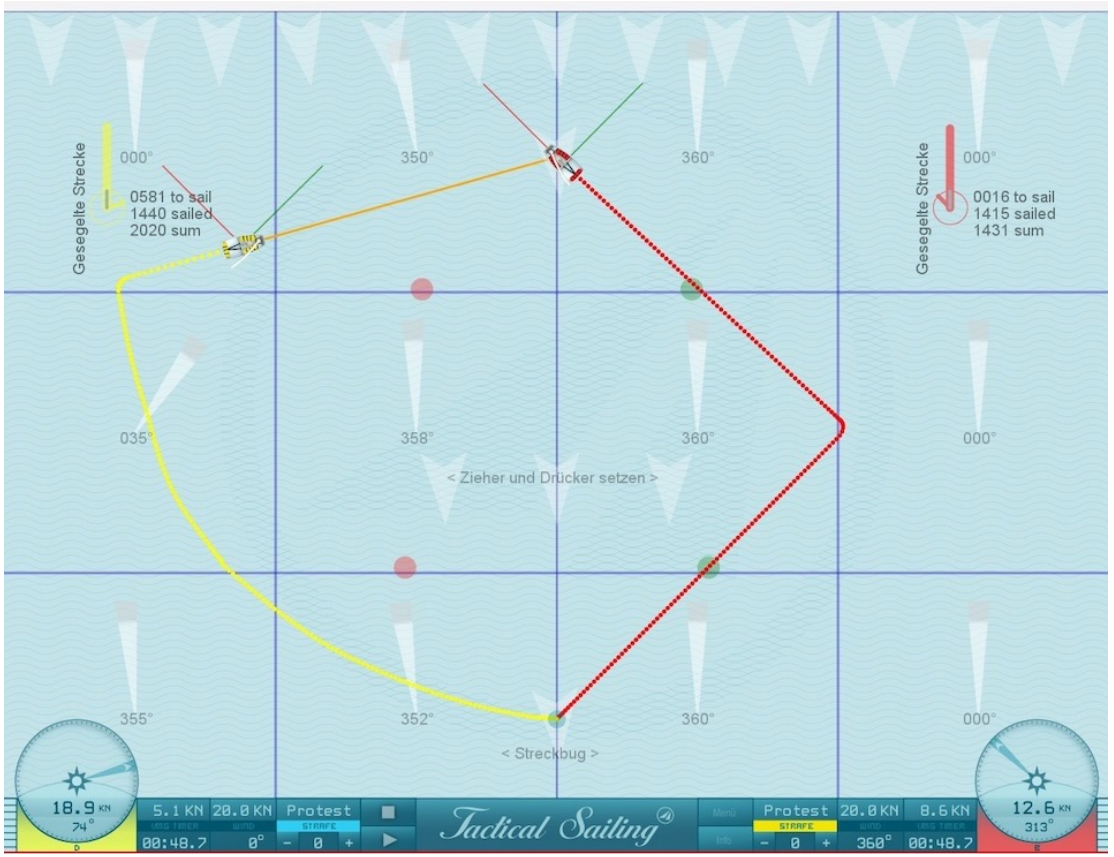
However, wind changes don't only occur at the starting line or the leeward mark, but also a**t any point** on the racecourse. The so-called "switch point," described by Tilo Schnekenburger, is one such point for **tactical decisions.**

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 .

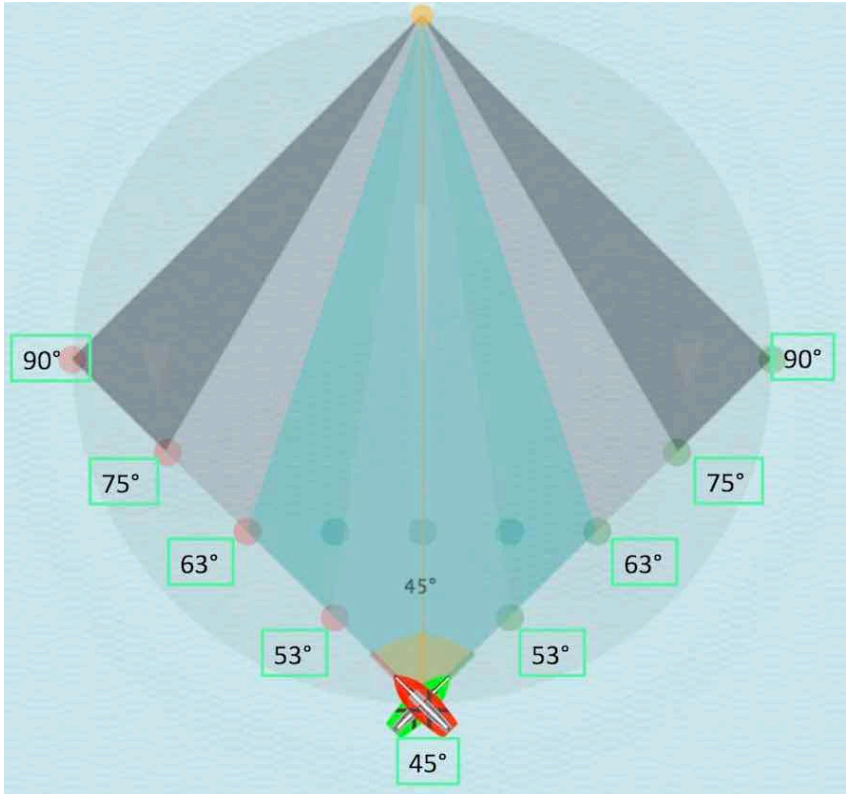


The yellow route becomes a so-called "banana "

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.

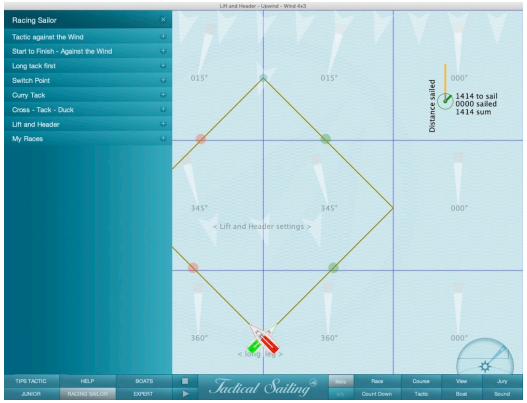


Attachments

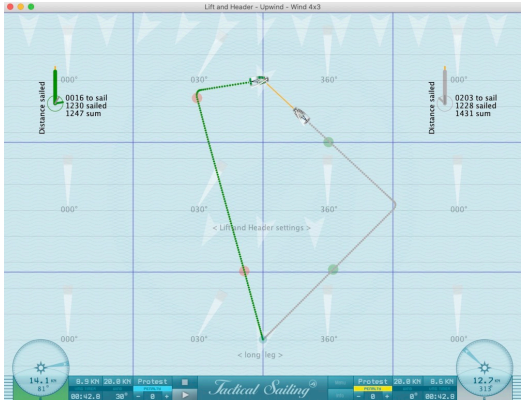
- Create your own exercise with the Tactical Sailing Program
- List of links to video clips (YouTube), documentation and literature references
- Geometric representation of shortening and lengthening
- Exercises in the Tactical Sailing Program
- Table of calculations for shortening and lengthening
- Sources

Create your own exercise - Start and menu selection

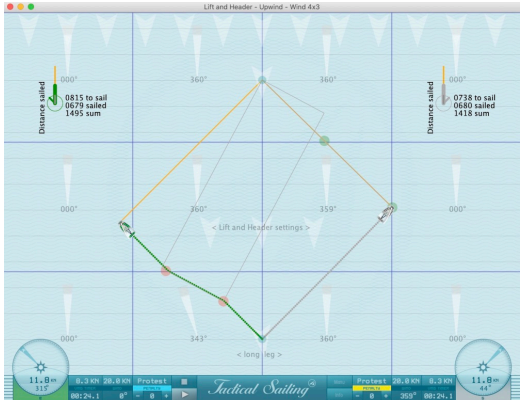
- Download the program from http://www.tacticalsailing.com/en
- Start Tactical Sailing (TS) – Coachs' Toolbox – Click Menu
- Select your boat type and colour: Menu/Boats/Select your boat/Opti - Colour
- Select the exercise: Menu/Racing Sailor/Lift and Header/Upwind – Wind 4x3
- Select options: Menu/Tactic - 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
  - lift or header



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



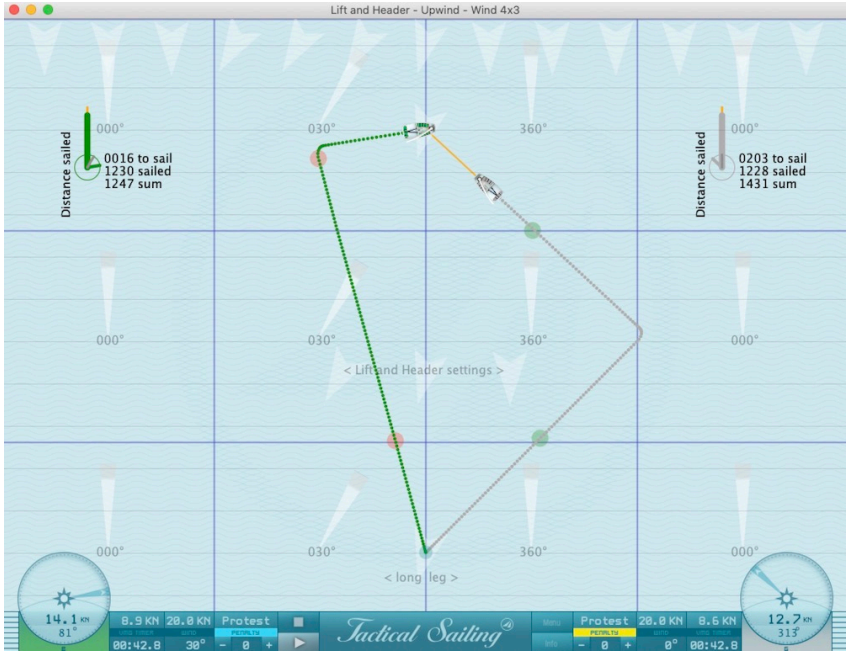
Exercise lift **030° finish**



Practice header on the **go 315/285°**

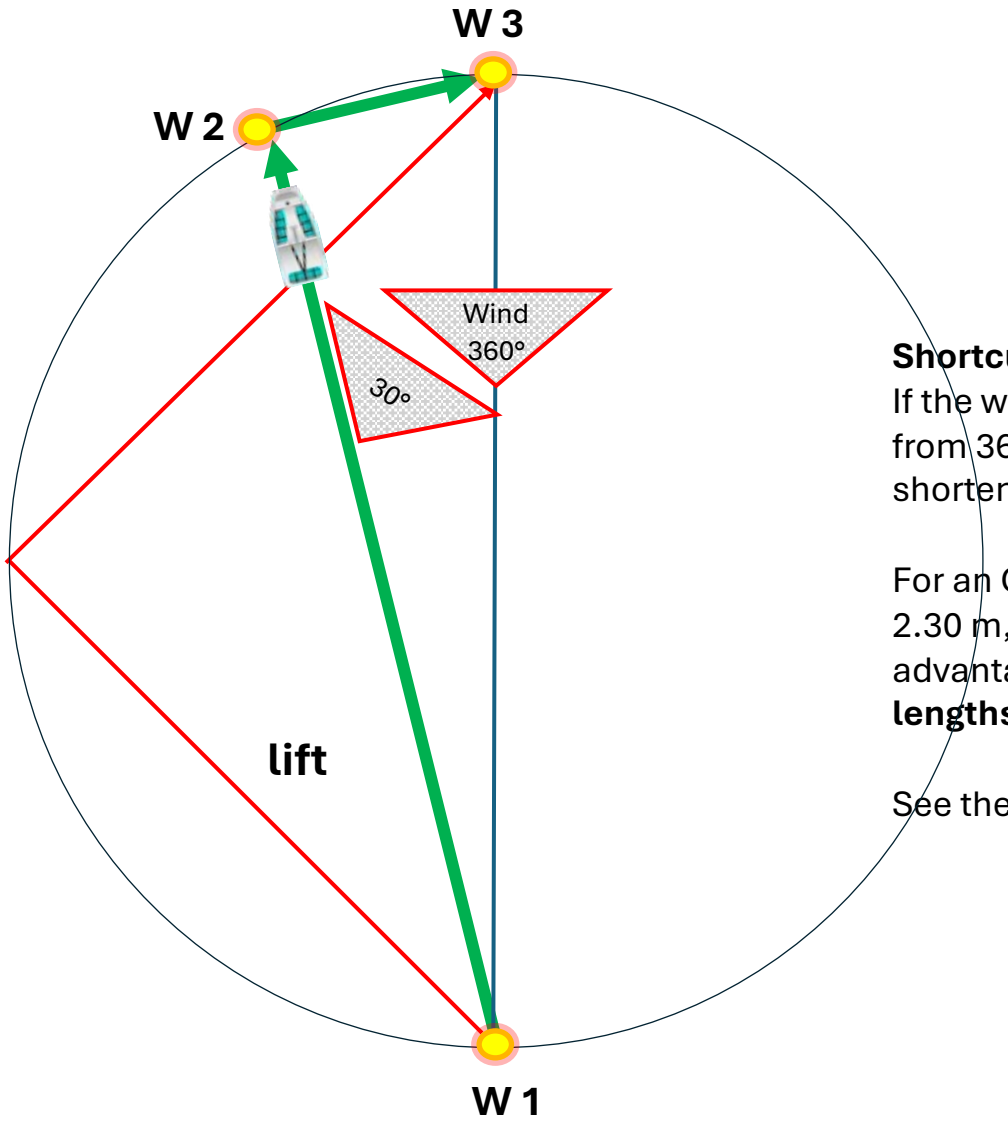
List of free video clips (YouTube), information on Tactical Sailing (TS) – documentation and literature

- List of youTube Video Clips: Play List click here .
- Tactical Sailing Documentation:
  - lift or header
  - Coach's Toolbox
- Download the Tactical Sailing Program with Coach's Toolbox on the TS website: click here.
- "Switch Point" – TS-Risk at the turning point: 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



Sketch "Shortcut" from the Tactical Sailing Program

Geometry lift - Shortcut through a lift at start – Long leg

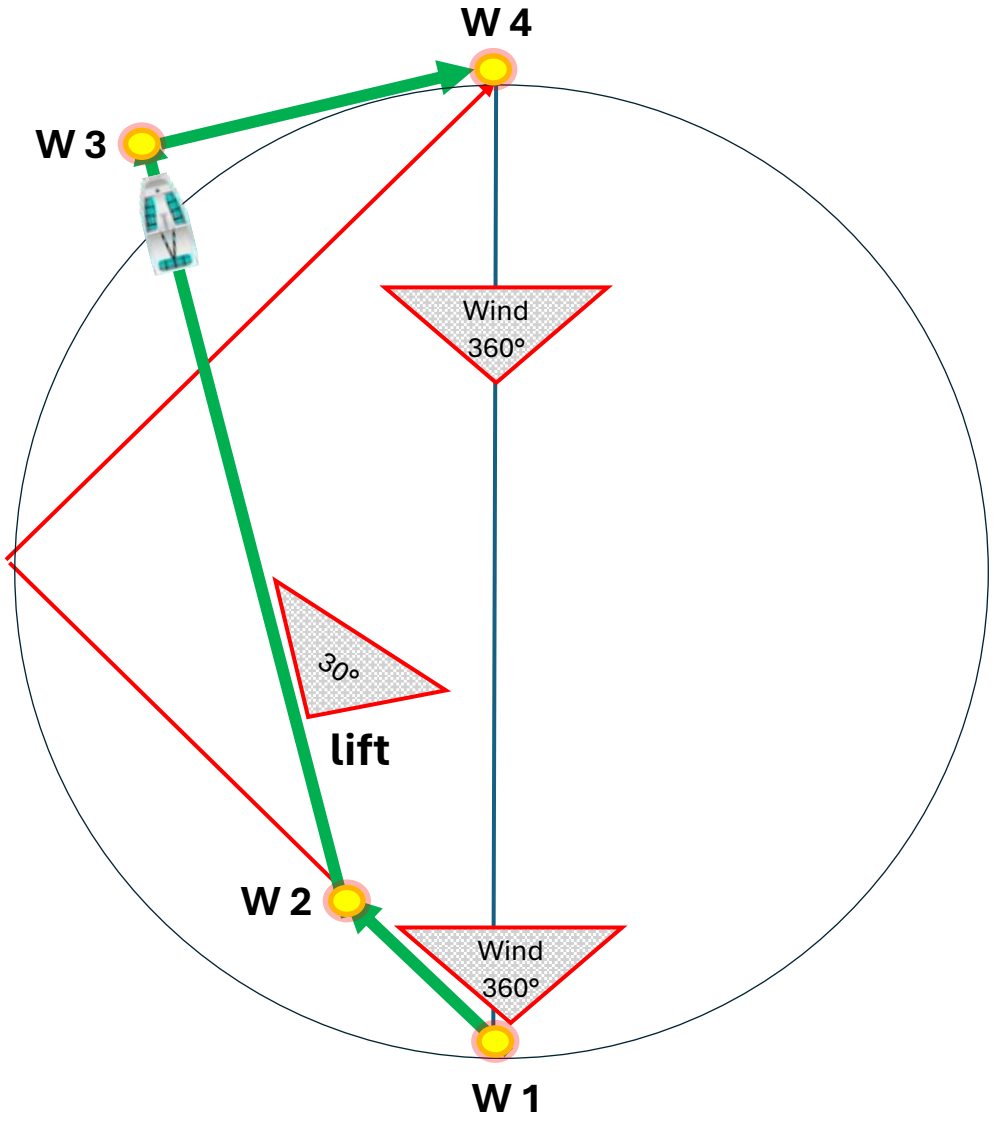


Shortcut
If the wind at turning point W1 shifts from 360° to 330°, this "**lift**" creates a shortening of **80 m**.

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.

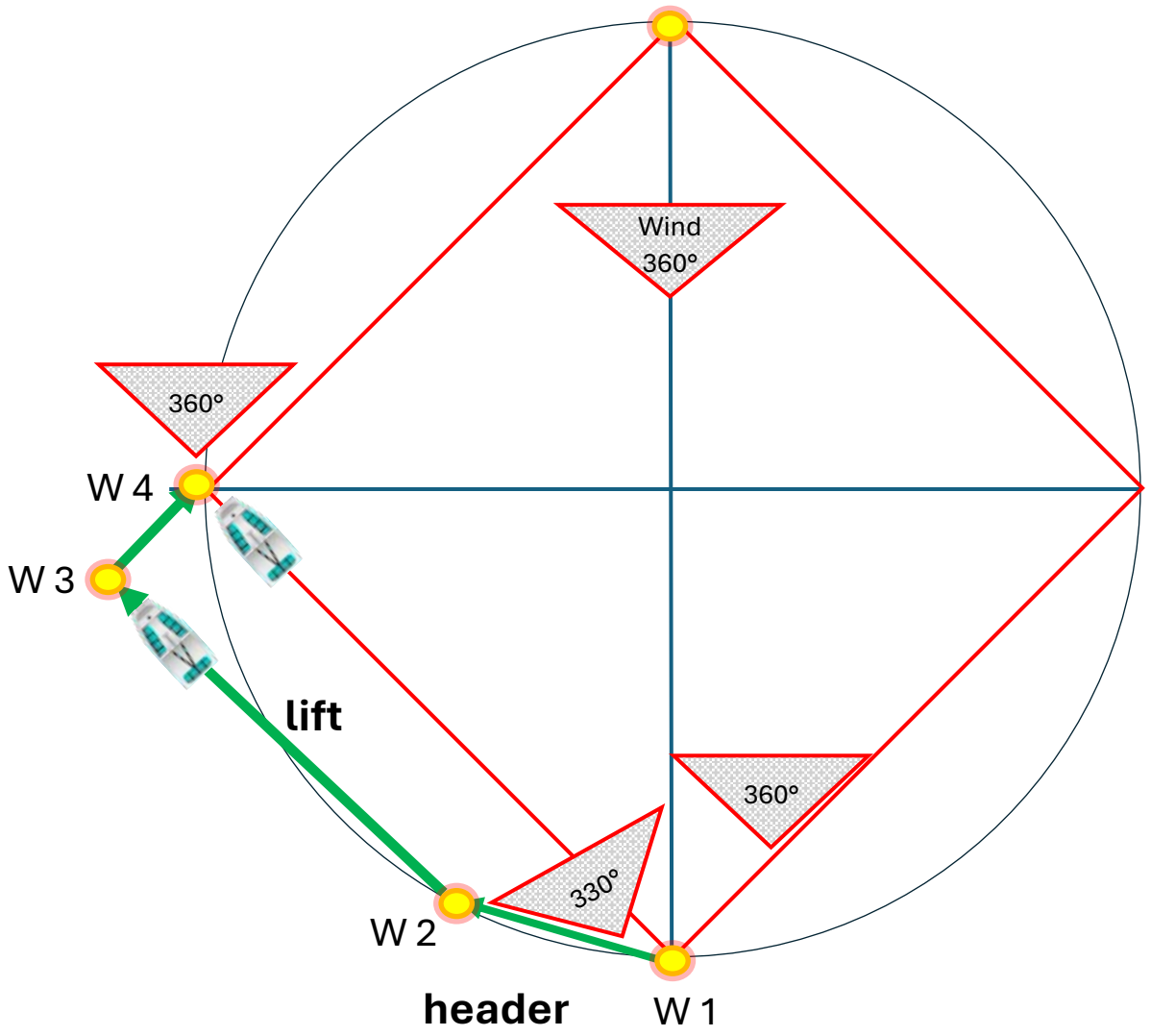
Geometry lift - Shortcut on the way after the start – Long leg



Shortcut
If the wind turns from 360° to 30° at the turning point W 2, this “lift” 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.

Geometry header – Extension at the start in Leeward – Short leg

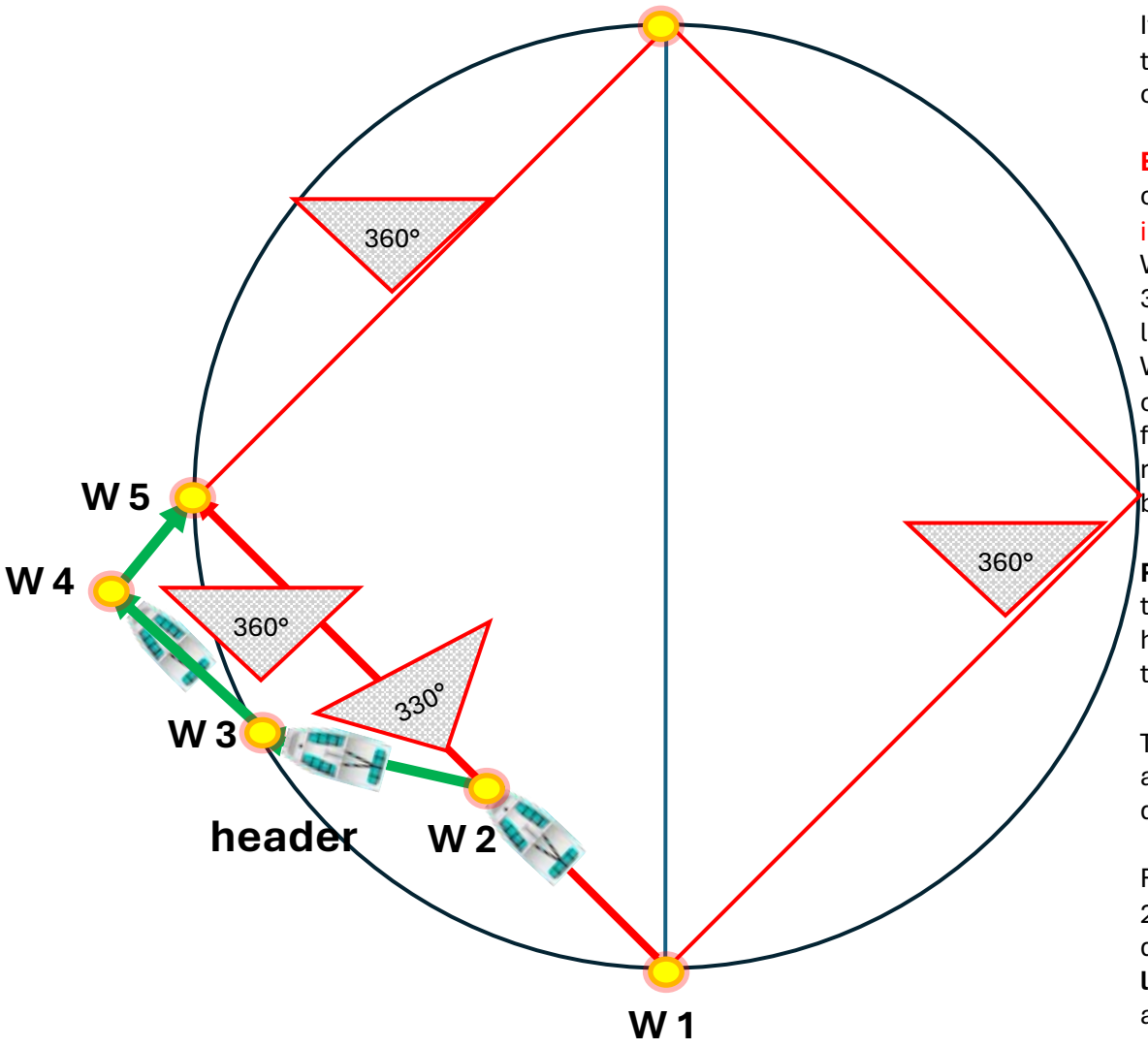


Extension

If the wind turns from 360° to 330° at the turning point W 1, **this "header" 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 tack at the turning point W 2 but continues sailing. But then the wind turns from 330° back to 360° (lift). 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.

Geometry header – 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.

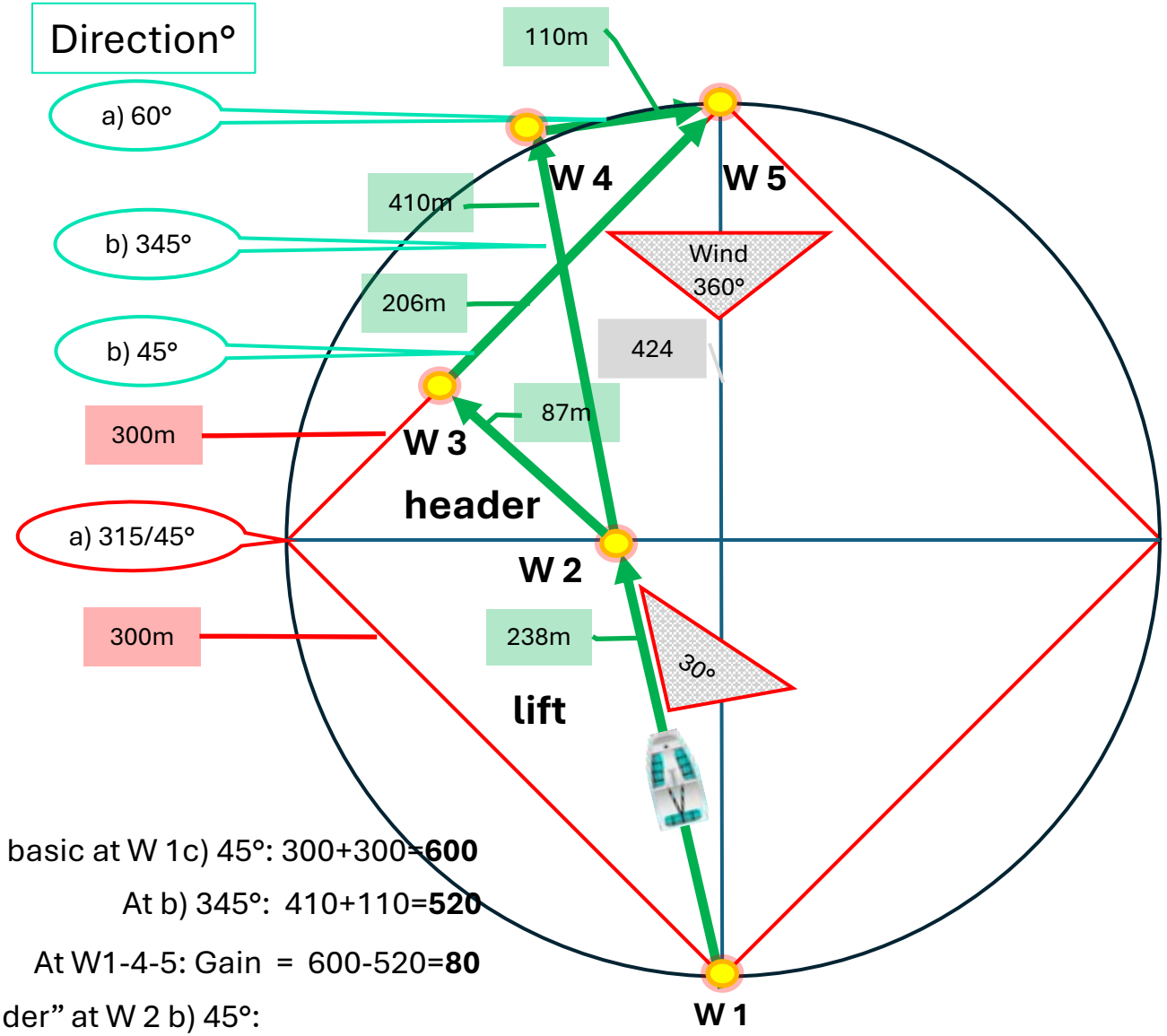
Error: Don't tack at turning point W2 but continue to turning point W3. This increases the distance traveled towards W3. If the wind even shifts back from 330° to 360° at turning point W3, the next loss of distance occurs to turning point W4. A tack at turning point W4 and continuing to turning point 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.

Exercise in the Tactical Sailing Program - the lift at the start in Lee - abbreviation



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

At b) 345°: 410+110=**520**

At W1-4-5: Gain = 600-520=**80**

With a “header” at W 2 b) 45°:

206+87+238=**531** Gain reduced : 600-531= **69**

Abbreviation

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

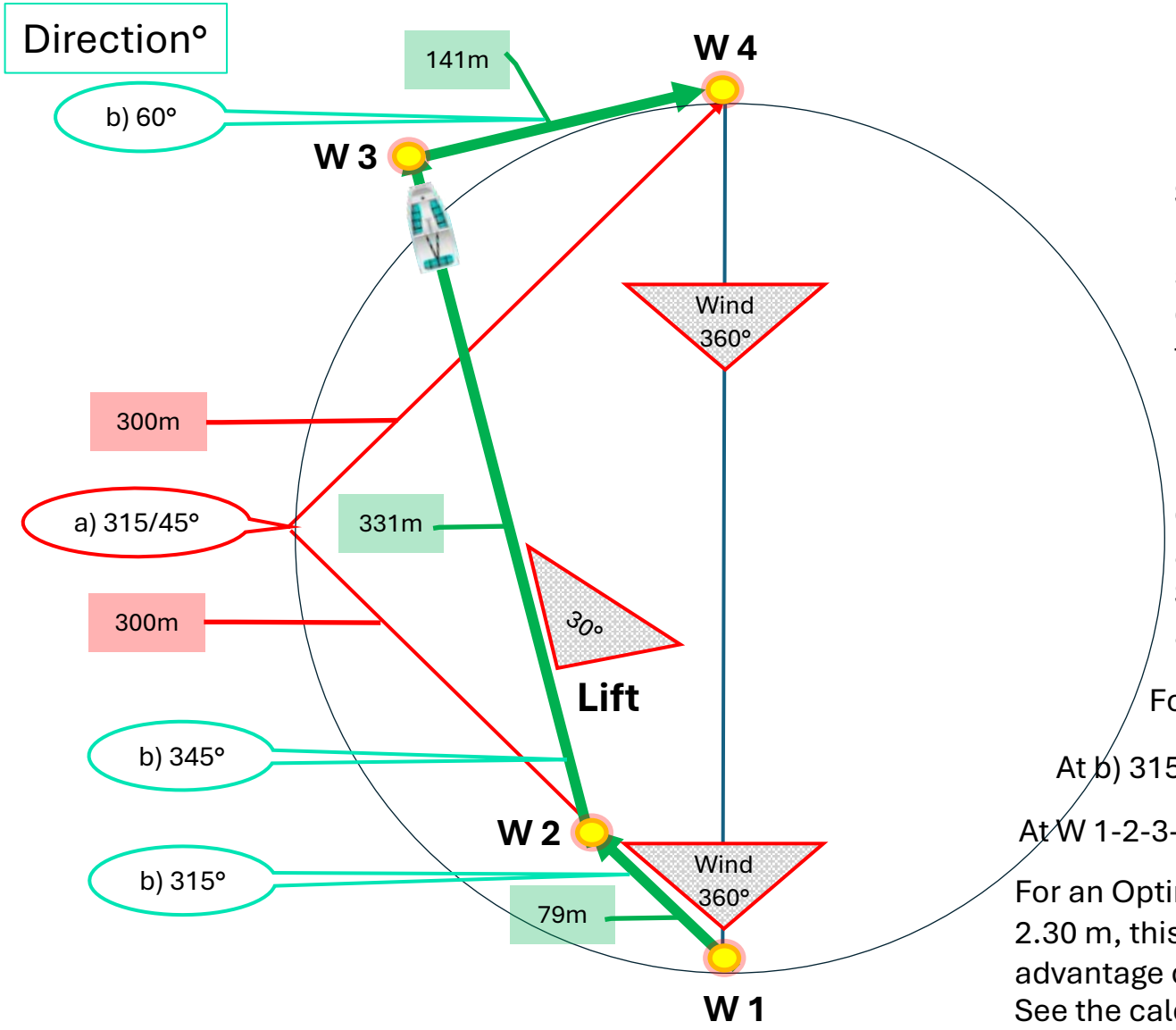
Is there a risk if the wind oscillates? Can a wind shift back from 330° to 360° cause damage?

NO: the ”header" 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.

Exercise in the Tactical Sailing Program - the lift "on the way" after the start - shortcut



Shortcut
If the wind at turning point W2 shifts from 360° to 30°, this "lift" 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.

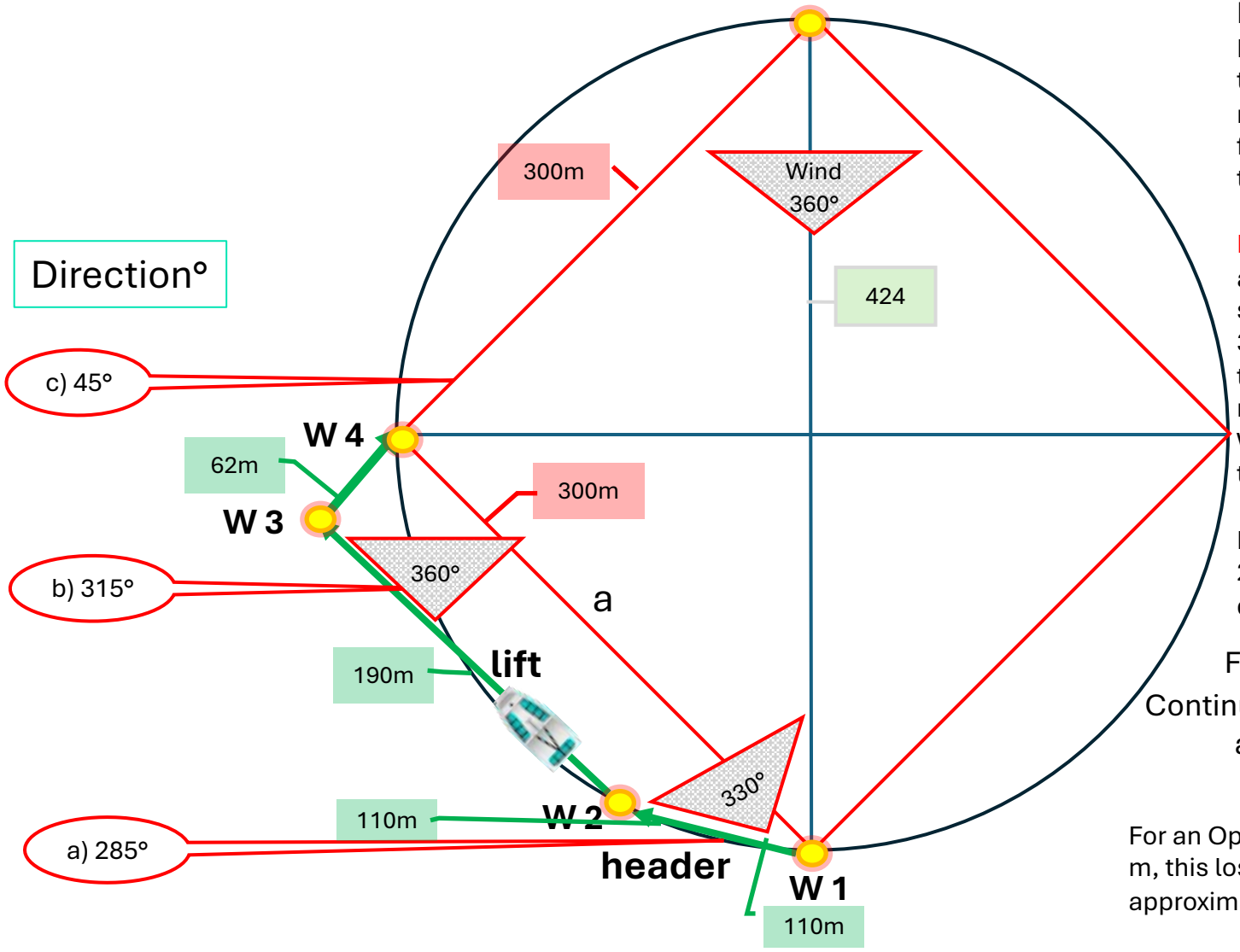
For base a) 315°: 300+300=**600m**

At b) 315, 345, 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.

Exercise in the Tactical Sailing Program - the header at the start in Lee - extension



Extention

If the wind shifts from 360° to 330° at turning point W1, this "lift" 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° (lift). 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**!

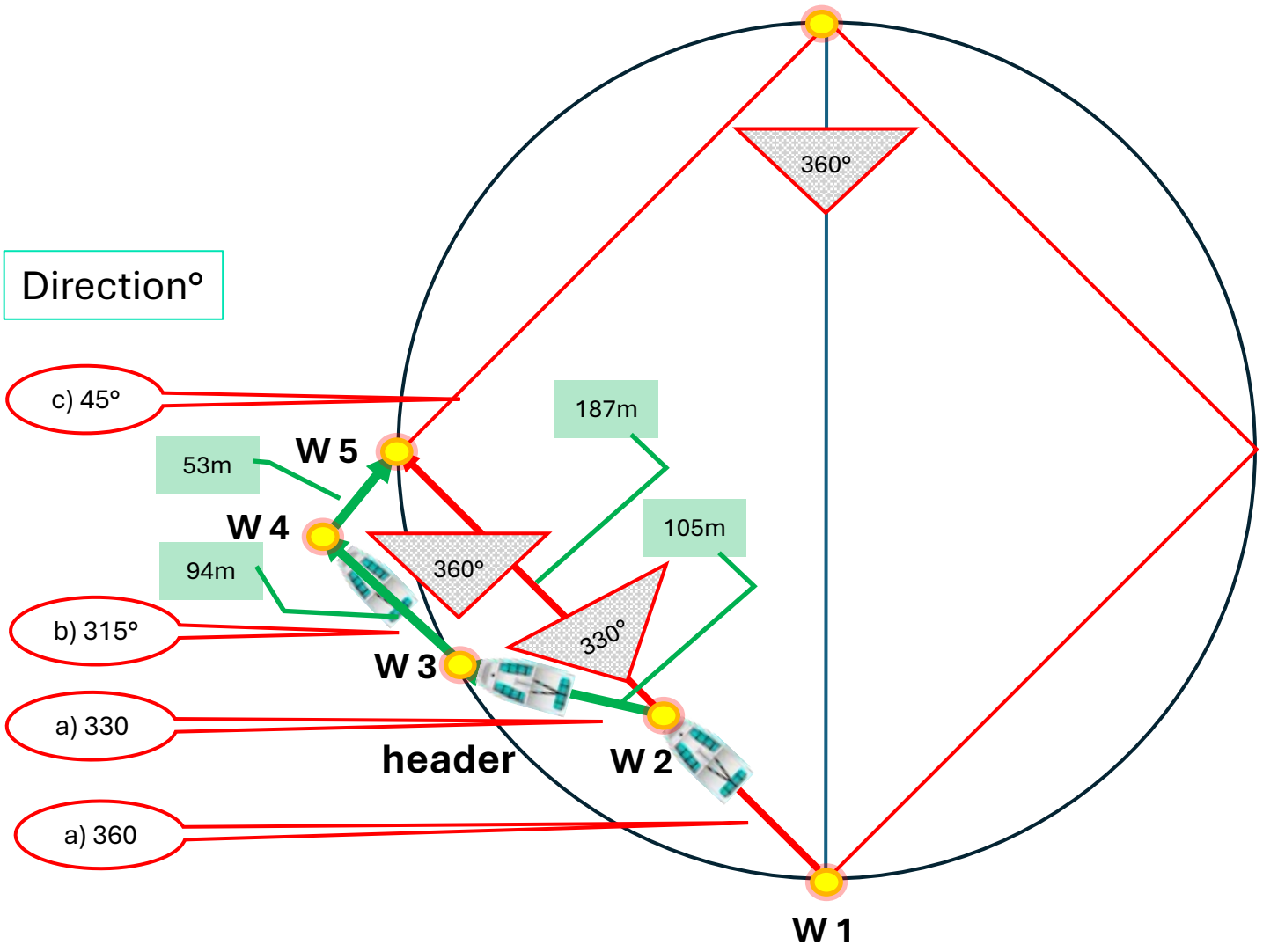
For base c) 315°/45°: 300=**300**

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!**

Exercise in the Tactical Sailing Program - the trigger "en route" after the start - extension



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 fall off and 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

Table of calculations: Abbreviation and extension

Shorting – lift

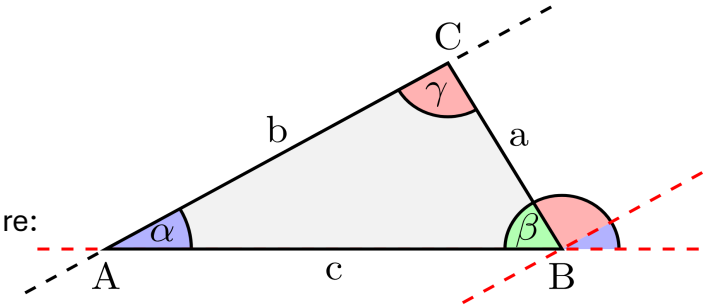
Wind direction°	Triangle sides (m)			Sailboat direction°	Distance to sail(m)	Won(m)	Number of boats winning
	a	b	c	α °			2,3
360°	300	300	424	**45**	600	0	0
15°	212	367	424	**30**	579	21	9
30°	110	410	424	**15**	520	80	35
30°/360°	206	325	424	**15/45**	531	69	30
360/30/30	142	410	424	**315/345/60**	551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

Lengthening - header

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"							

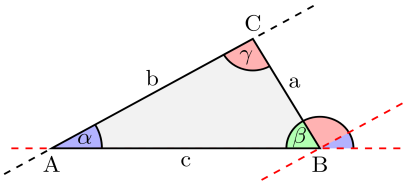
The basis for the calculations in the right-angled triangle are:
- the diameter of the circle, the side "c" (leeward to windward) is 400m,
- the formula of the "Pythagoras": $a^2 = b^2 + c^2$, and the "sine rule":
- a : b : c = sin (alpha) : sin (beta) : sin (gamma).

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, lifts and headers, 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 .