Route shortening or lengthening 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 **a solid foundation in geometry** . The central element in sailing is always the wind, which moves the boat. The following section will focus specifically on sailing "upwind".

The wind, its direction and strength, offer us the opportunity to **shorten** or **lengthen** (Gain or Loss) he route to a destination. Sailing "against the wind" will be discussed specifically below.

This illustrates to the skipper – graphically – the gains and losses as well as the "risk zones" by calculating "gained" and "lost" **boat lengths and demonstrate the importance of carefully observing wind shifts** .

As an example, we will use "Opti" boats with a length of **2.30 m** and a turning angle of **45°** .

See the sketches and video clips below.

Summary

Boat **length** is the new standard here.

As a **result** of our analysis of lost **opportunities** or **longer journey** , there are two main reasons.
The **reduction** or **lengthening of the journey** is caused by:

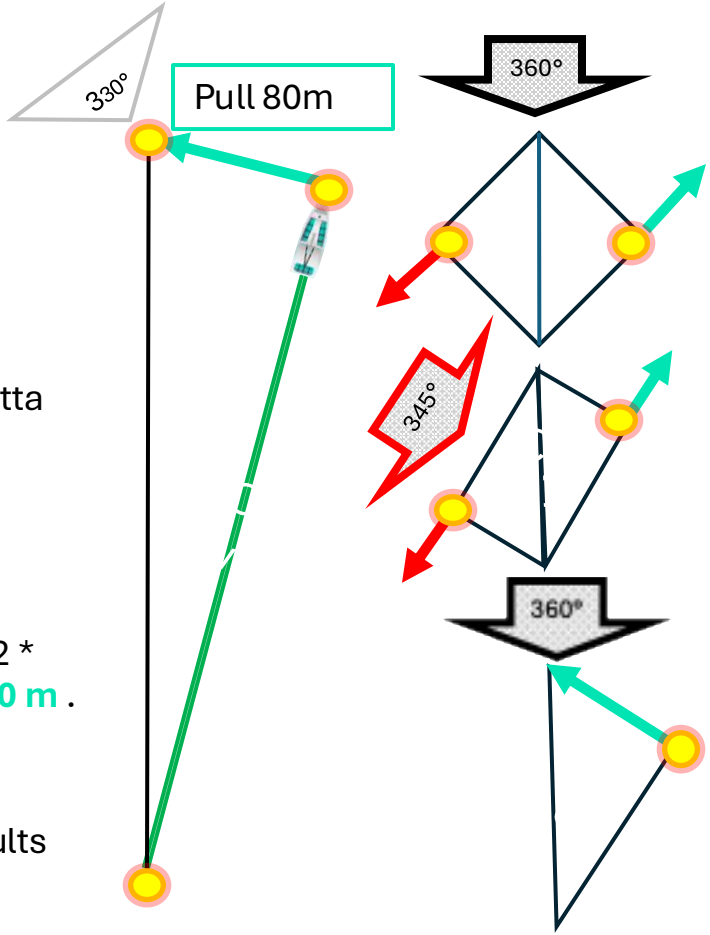
1. **Wind shifts,** such as from 360°, 330° or 345° , which shorten the journey,
2. **Turning points,** that we miss thus lengthening the journey.

The basis for our considerations about gain or loss are familiar geometric regatta field shapes, namely **square** , **rhombus** and **triangle** .

The square is the longest course a boat must navigate. Wind shifts cause the square to become a rhombus or a triangle.

A quadrilateral, for example, has a distance of 400 m from the leeward to the windward buoy. Then the two "legs" of the course within the quadrilateral are 2 * 280 m = 560 m. As an example, let's take a shortened/lengthened **course of 80 m** .
A **gain** then means shortening the course by 80 m, or in the case of **a loss** , lengthening the course by 80 m.

The **boat length** of an Optimist is 2.30 m**;** therefore, a gain or loss of **80 m** results in a difference of **34 boat lengths** !



Basics about shortening and lengthening

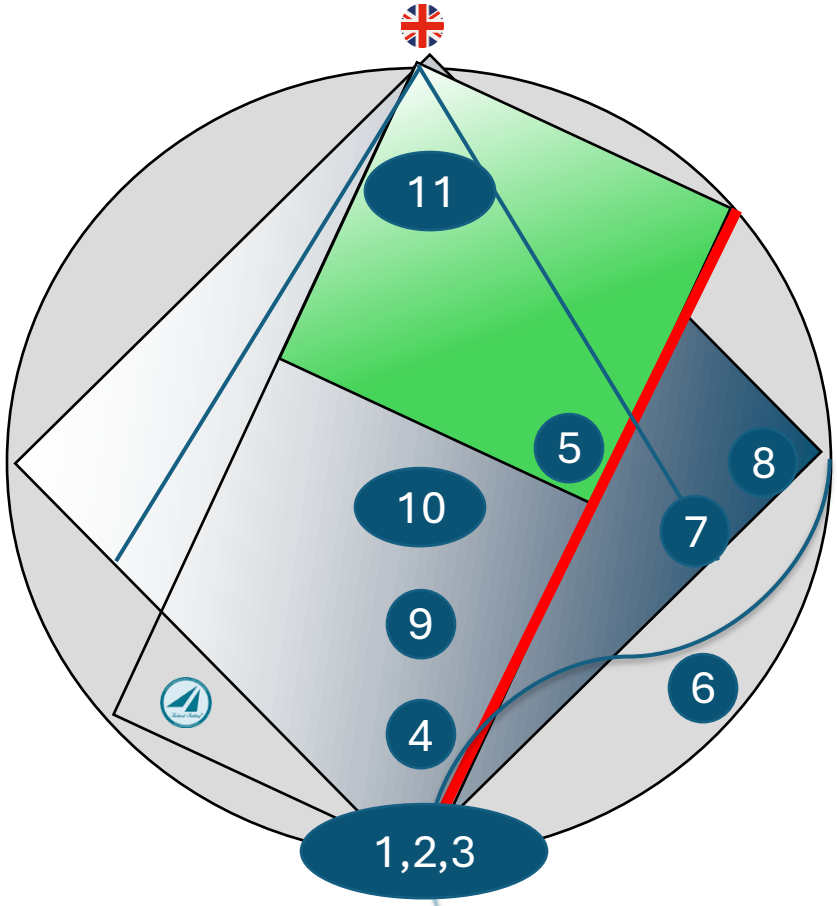
The basis for **shortening and lengthening** is a geometric structure of **long leg and short leg**.
A well-known rule states:
"Starboard tack before port tack!"

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

A **pull** is always a **win – long leg,**
A **push** always carries a **risk of loss – short leg**.

Wind changes don't only occur at the starting line or the leeward buoy, but also **at any point in the middle** of the racecourse. The so-called " **switch point** ," described by Tilo Schnekenburger*, is one such point for **tactical decisions 1 to 11**, for gain or loss.

* See notes on Tilo Schnekenburger in the appendix.



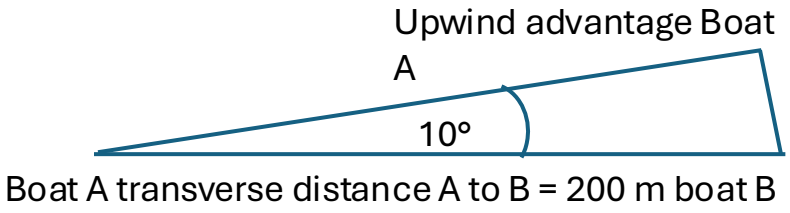
Geometric regatta course shapes:
square, rhombus, and triangle.
Tactical decision points 1 to 11.

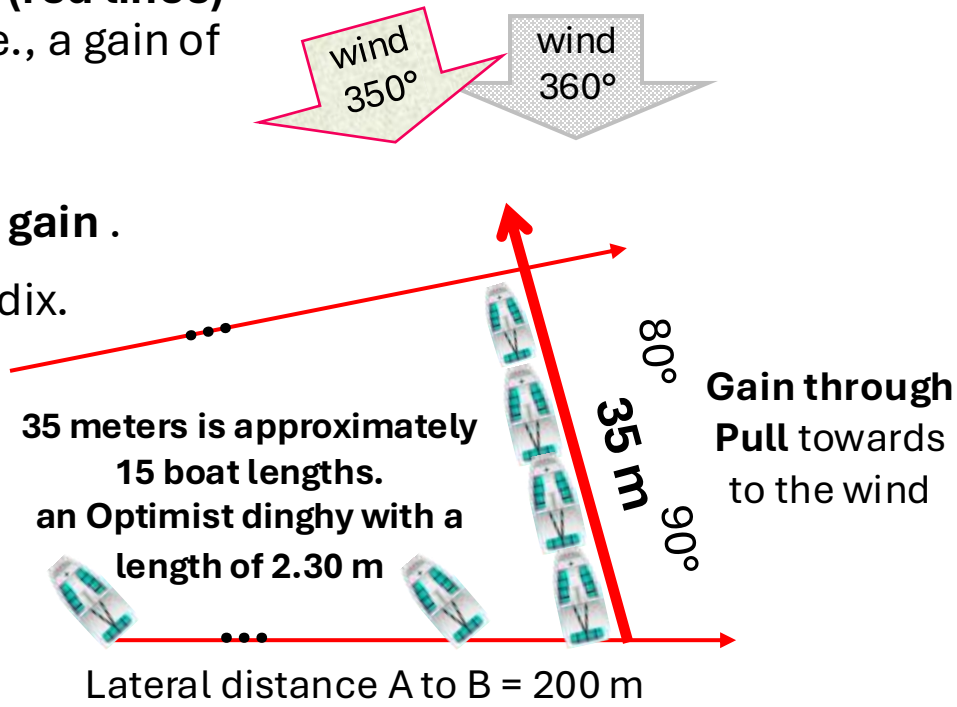
Gain in "boat lengths"

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 boat lengths (red lines)** for an Optimist dinghy with a length of 2.30 m , i.e., a gain of approximately **17%** .

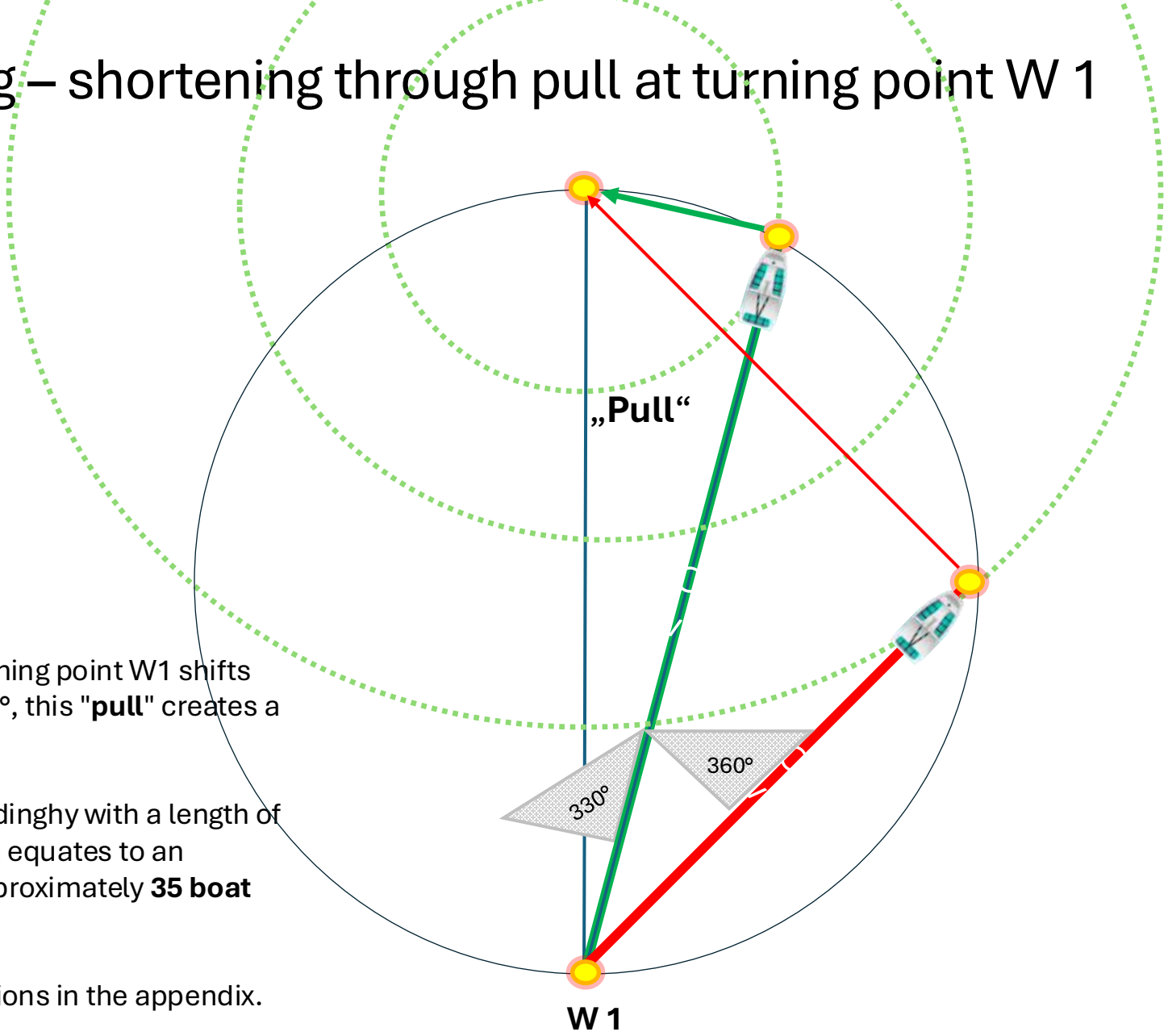
The so-called “ **10:17 rule** ”, described by Tilo Schnekenburger*, is an important calculation for **gain** .

* See notes on Tilo Schnekenburger in the appendix.





Long leg – shortening through pull at turning point W 1

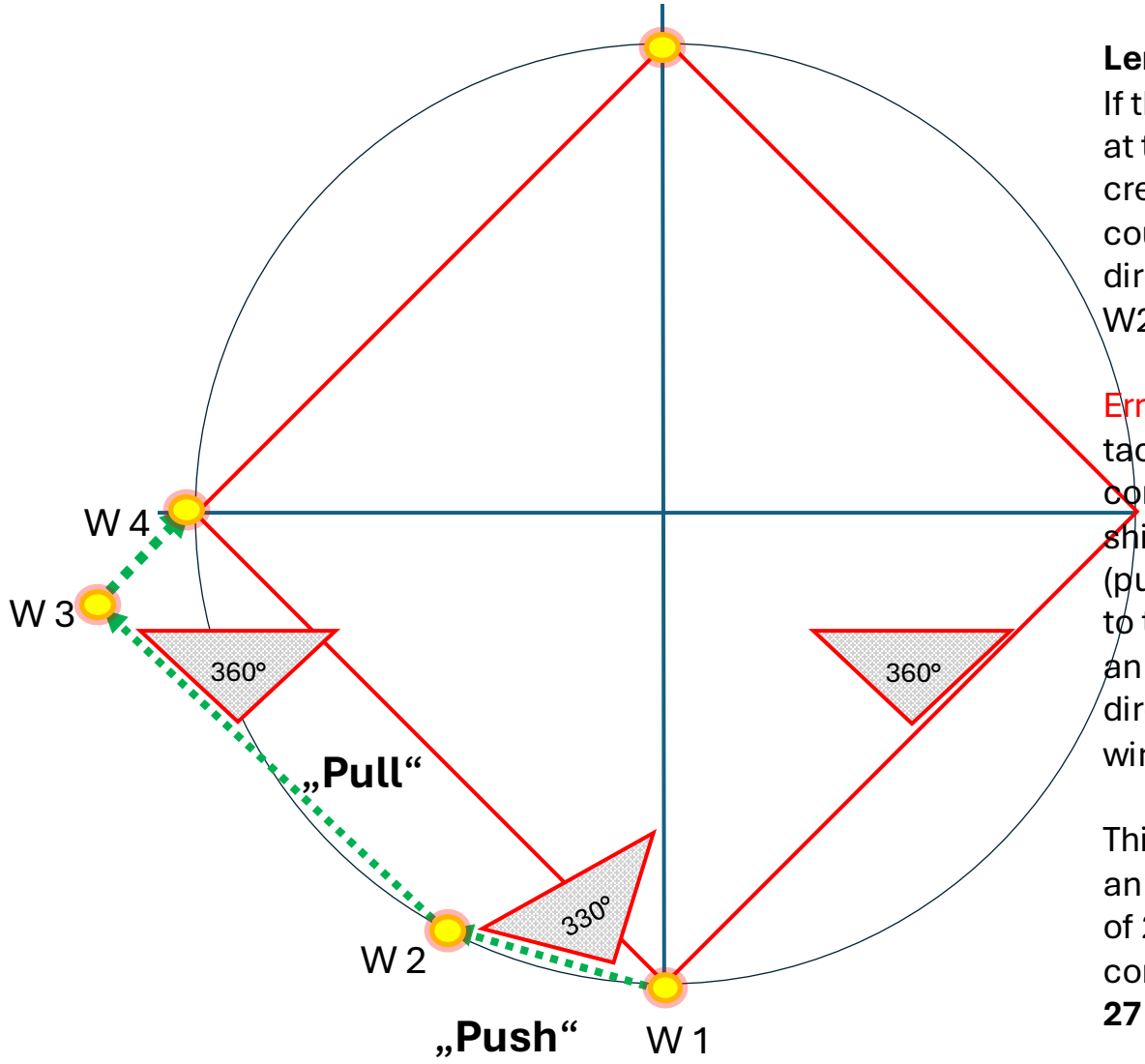


Shortening
If the wind at turning point W1 shifts from 360° to 330°, this "**pull**" creates a gain of **80 m**.

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

See the calculations in the appendix.

Short leg (1) -Lengthening, error and risk due to “pushers”



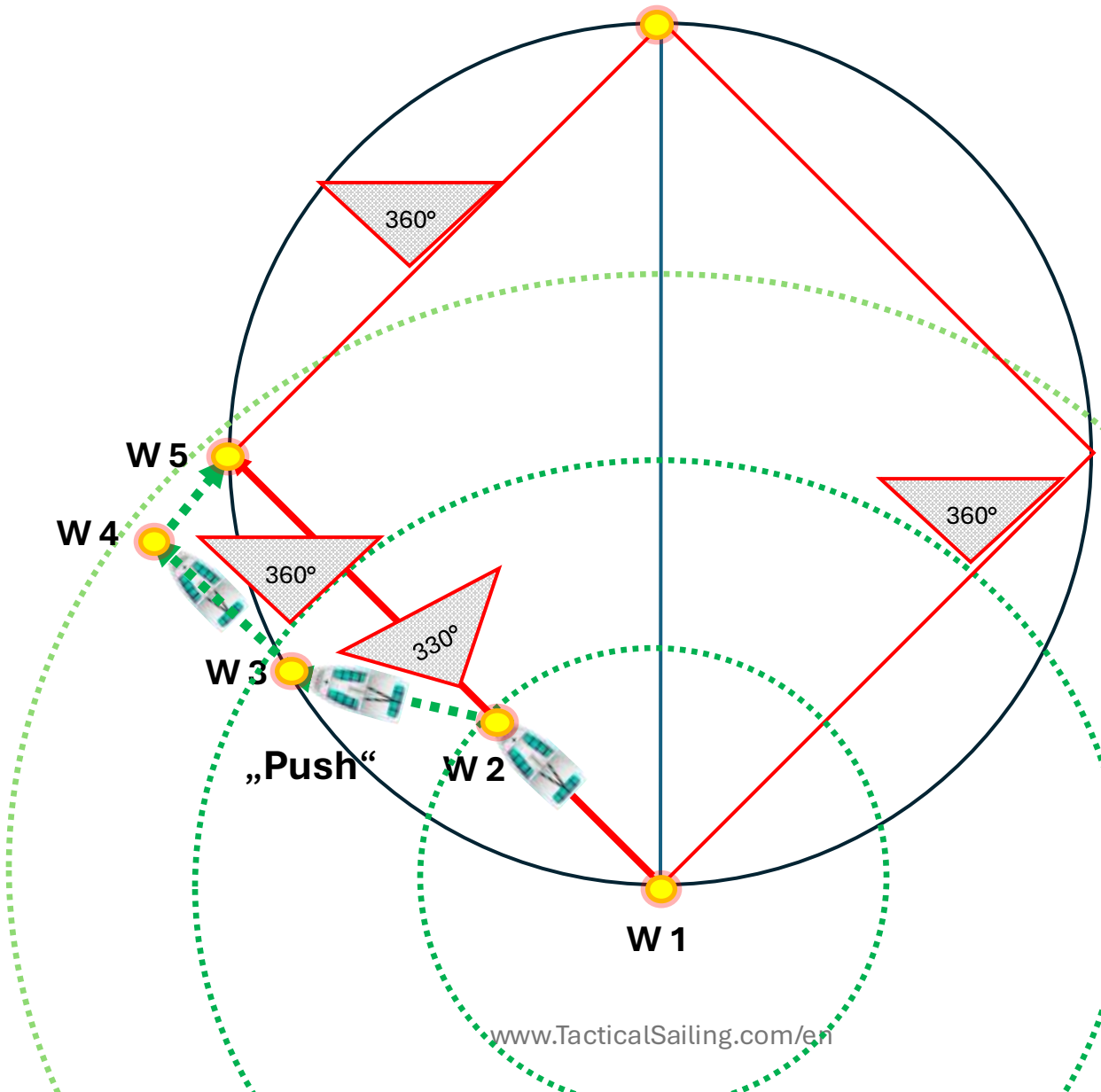
Lengthening
If the wind shifts from 360° to 330° at turning point W1, this "pull" creates a risk of “lengthening." The course then runs from W1 in the direction of 285° to turning point W2.

Error: Full risk if the boat doesn't tack at turning point W2 but continues onward. 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 of the course in the direction of W3, W4, and the windward buoy.

This results in a loss of **62 m**. For an Optimist dinghy with a length of 2.30 meters, this loss corresponds to a disadvantage of **27 boat lengths**!

See the calculations in the appendix.

Short leg (2) - Lengthening, error and risk due to “pushers”



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 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**.

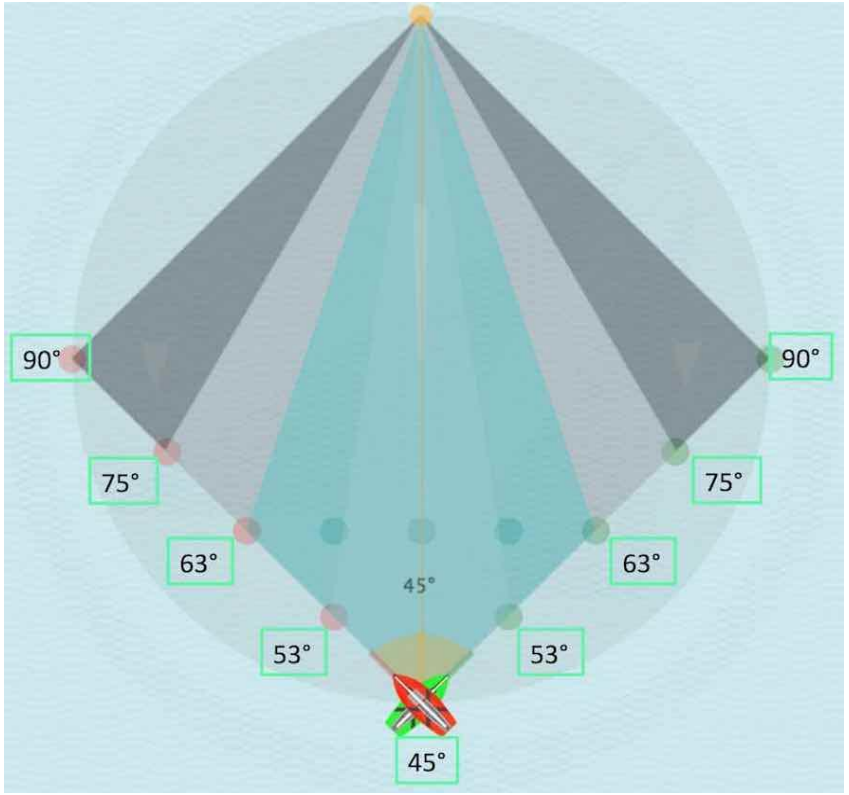
For an Optimist dinghy with a length of 2.30 m, this loss equates to a disadvantage of approximately **28 boat lengths**! See the calculations in the attachment.

Missed opportunities

Risk and Opportunity Zones

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.



Simulations with the Tactical Sailing (TS) program. See video clips on YouTube.

- Risk at the turning point – the “Switch Point”
  https://www.youtube.com/watch?v=u2tRKjDODGc
- Advantage of the 10:17 rule
  https://www.youtube.com/watch?v=5Sn4d4e7LQ4
- Pull and push winds in a migrating gust
  https://www.youtube.com/watch?v=QAzmLElzZic
- Boat to boat - leverage with risk
  https://www.youtube.com/watch?v=Rr3wW-sgqoE
- Starting line with decision for left or right side
  https://www.youtube.com/watch?v=u2tRKjDODGc
- Avoid risk zones
  https://www.youtube.com/watch?v=4PdM06uuaCw

Gain through "pulling" in the direction of travel 15° (yellow) is simulated by the Tactical Sailing program.

➢ Download the **Tactical Sailing program with Coach’s Toolbox** from the TS website:
https://www.tacticalsailing.com/en/coachs-toolbox

Wind shifts across the entire regatta course

Wind shifts can occur in small increments 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 at any point on the racecourse. The so-called "switch point," described by Tilo Schnekenburger*, is one such point for tactical decisions, for gain or loss.

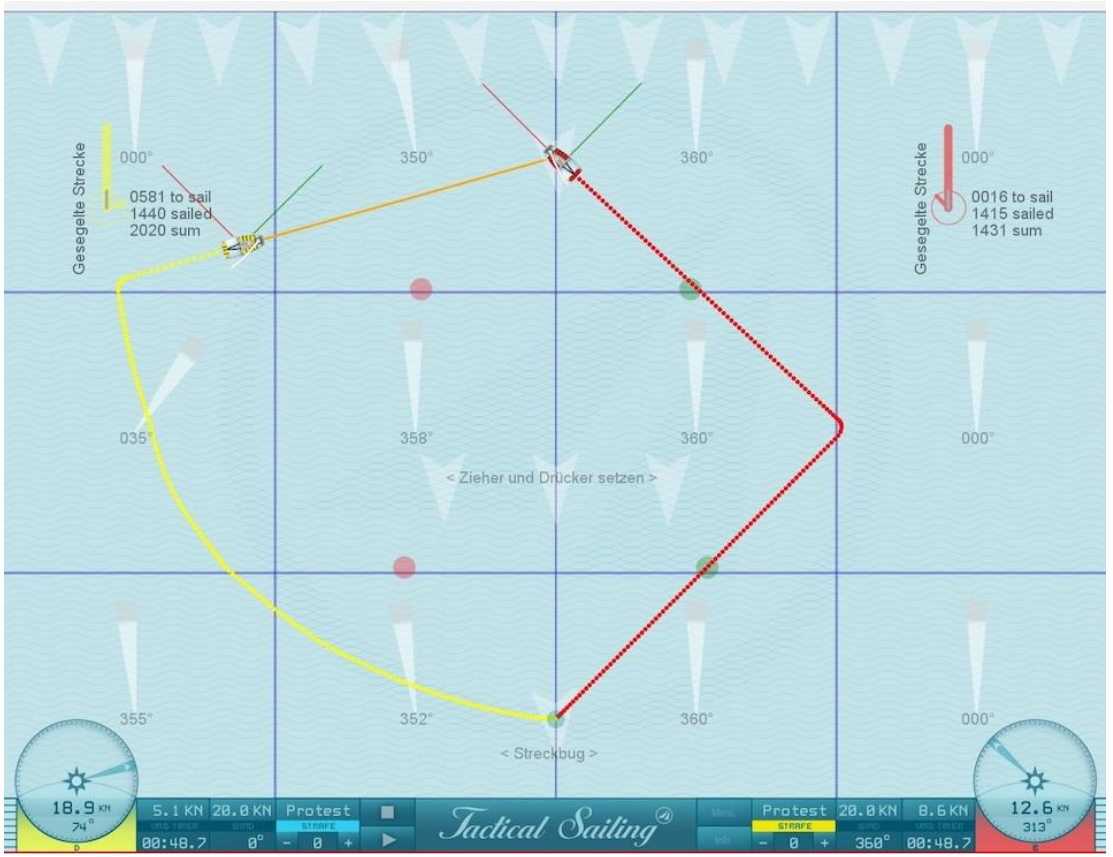
The Tactical Sailing program simulates a racecourse with wind conditions in 12 zones that change in both direction and wind speed. These zones can be constant or follow rhythmic lines**.

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.

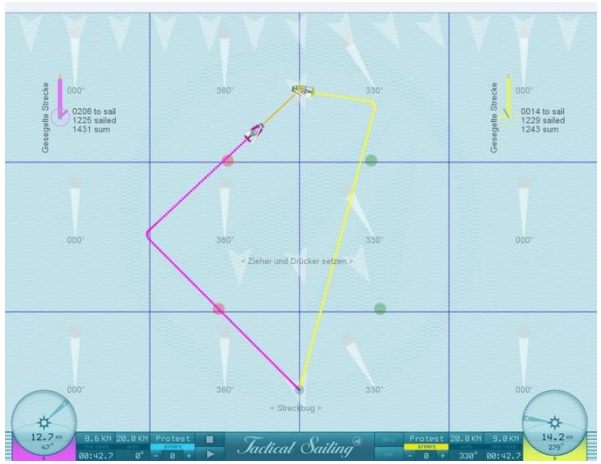
* See notes on Tilo Schnekenburger in the appendix.

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

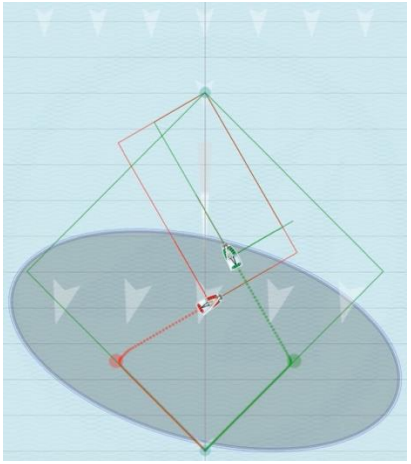


The yellow route becomes a so-called "banana"

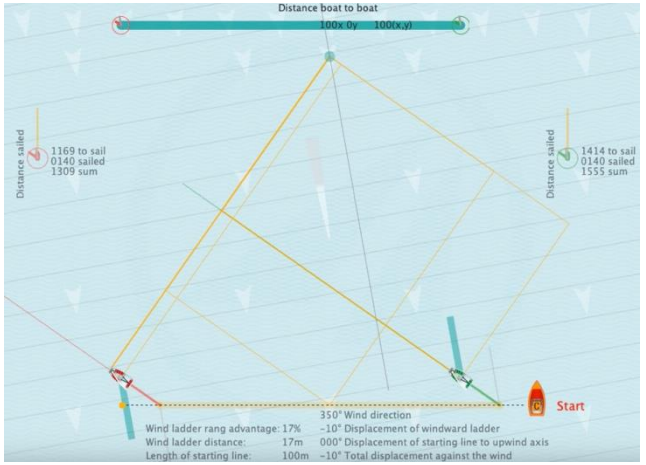
Attachment: Examples of Tactical Sailing Program Scenes



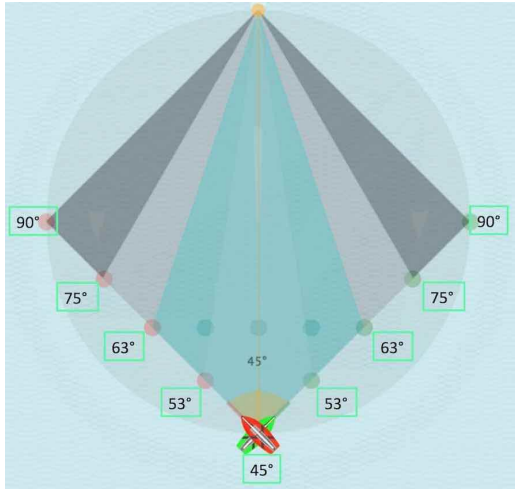
12 wind zones, lift (yellow)



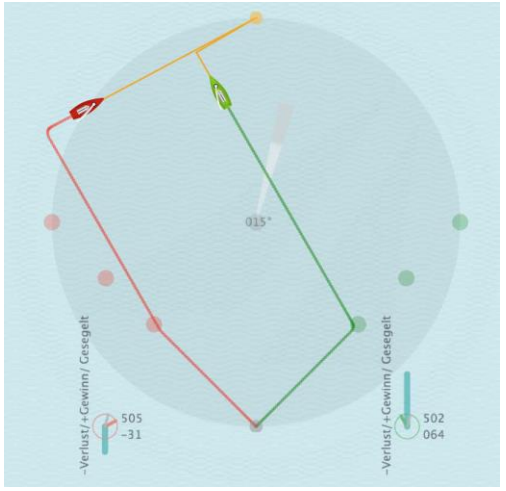
Wind gust (grey)



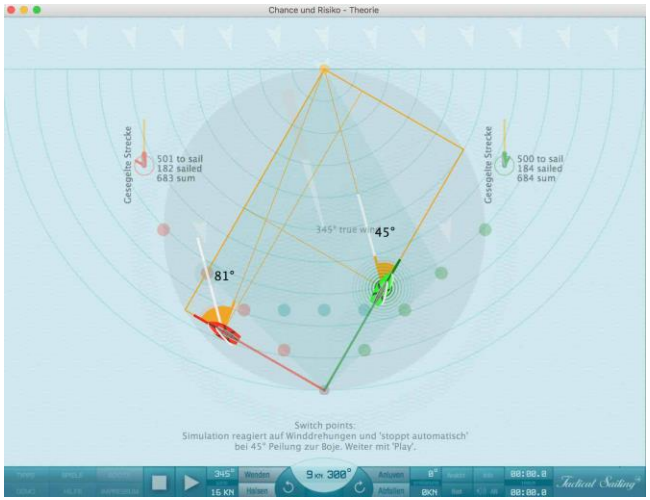
10:17 rule



Risk zones

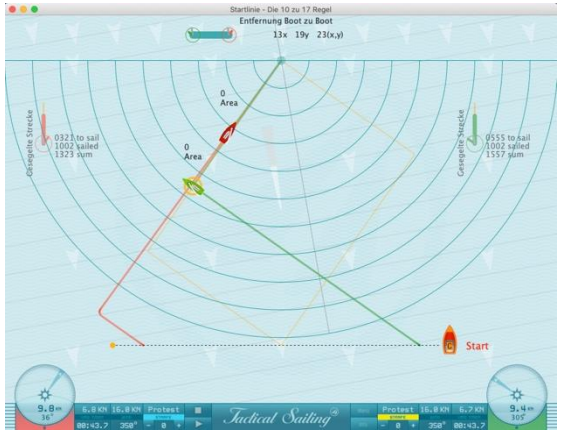


Gain/Loss Calculation

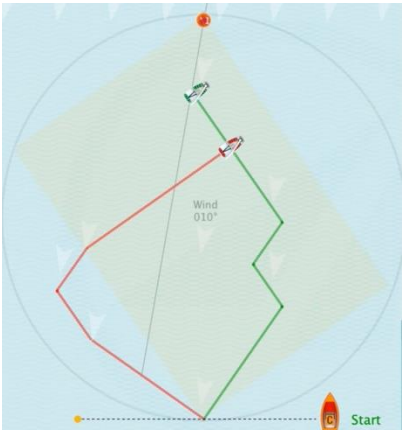


Switch Point

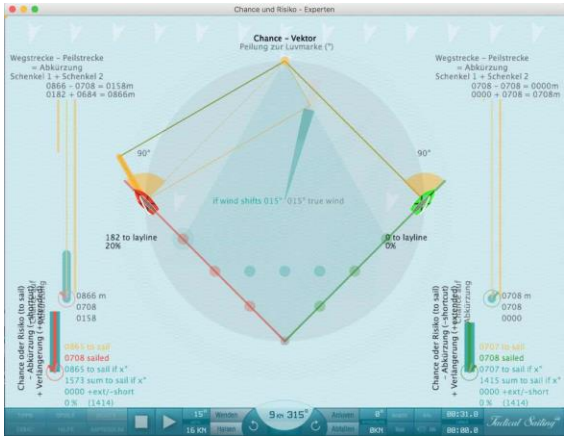
Attachment: Examples of Tactical Sailing Program Scenes



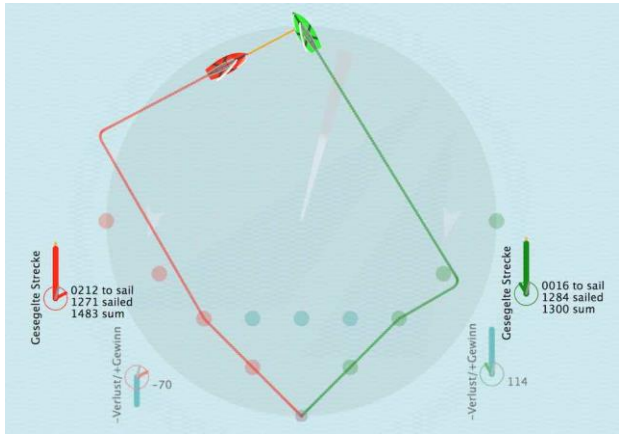
Distance circles - boat to boat



Diamond: gain - Loss



Values of the calculations



Display of gain and loss

My regatta; 4 boats, 16 wind fields

2 gusts in 16 wind fields

Attachments

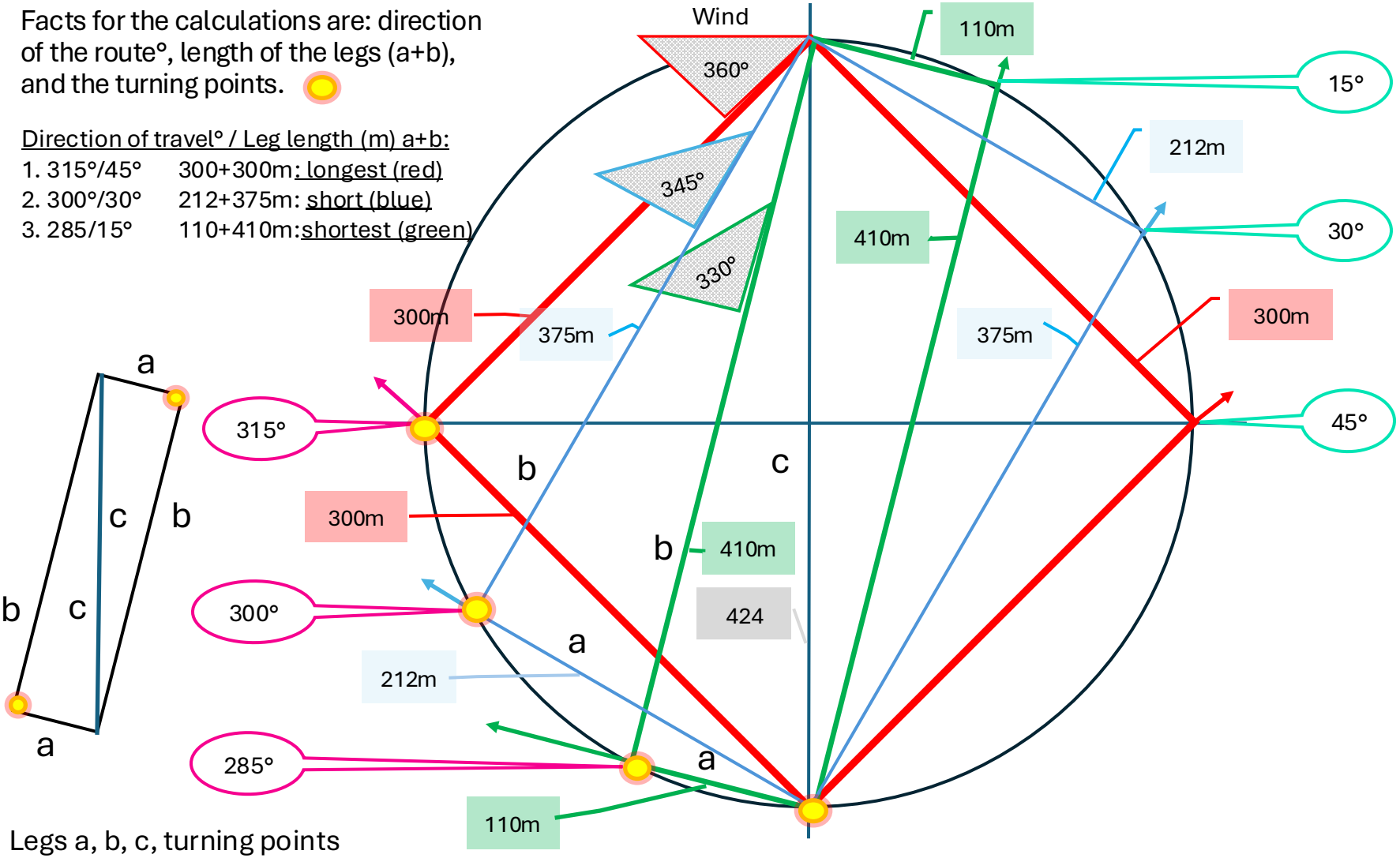
- Geometric principles
- Tactical decision points
- Geometric sketches for long leg and short leg
- Calculations
- Sources used in the editing process

Geometric principles

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

Long Leg – Shortening through puller at the turning point W 1, W 2

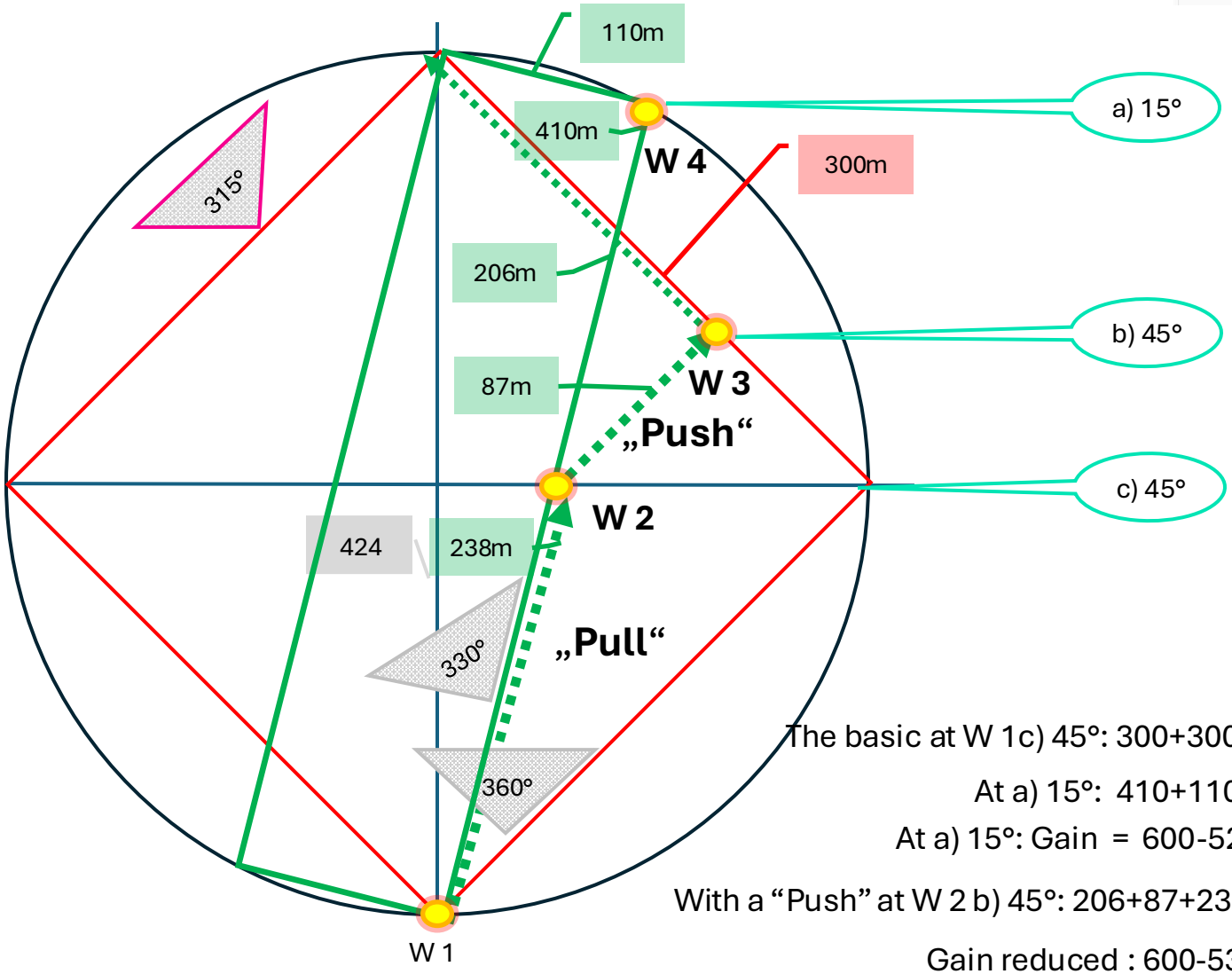
Shortening
If the wind at turning point W1 shifts from 360° to 330°, this "**pull**" creates a gain of 600-520m = **80m** over a 15° angle to W 4.

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.



The basic at W 1c) 45°: 300+300=600

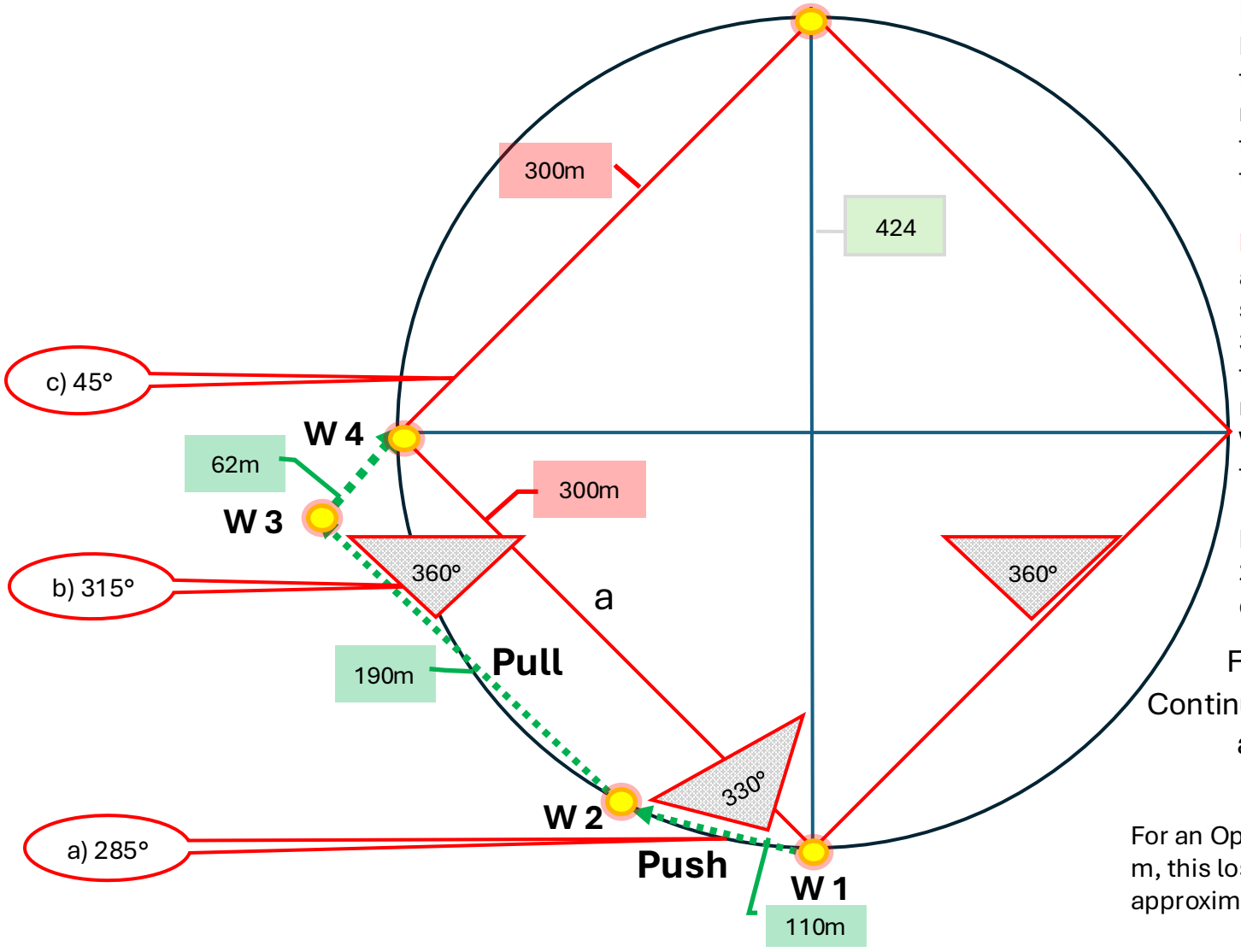
At a) 15°: 410+110=520

At a) 15°: Gain = 600-520=80

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

Gain reduced : 600-531= 69

Short leg (1) - Lengthening, error and risk due to “pushers”



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**!

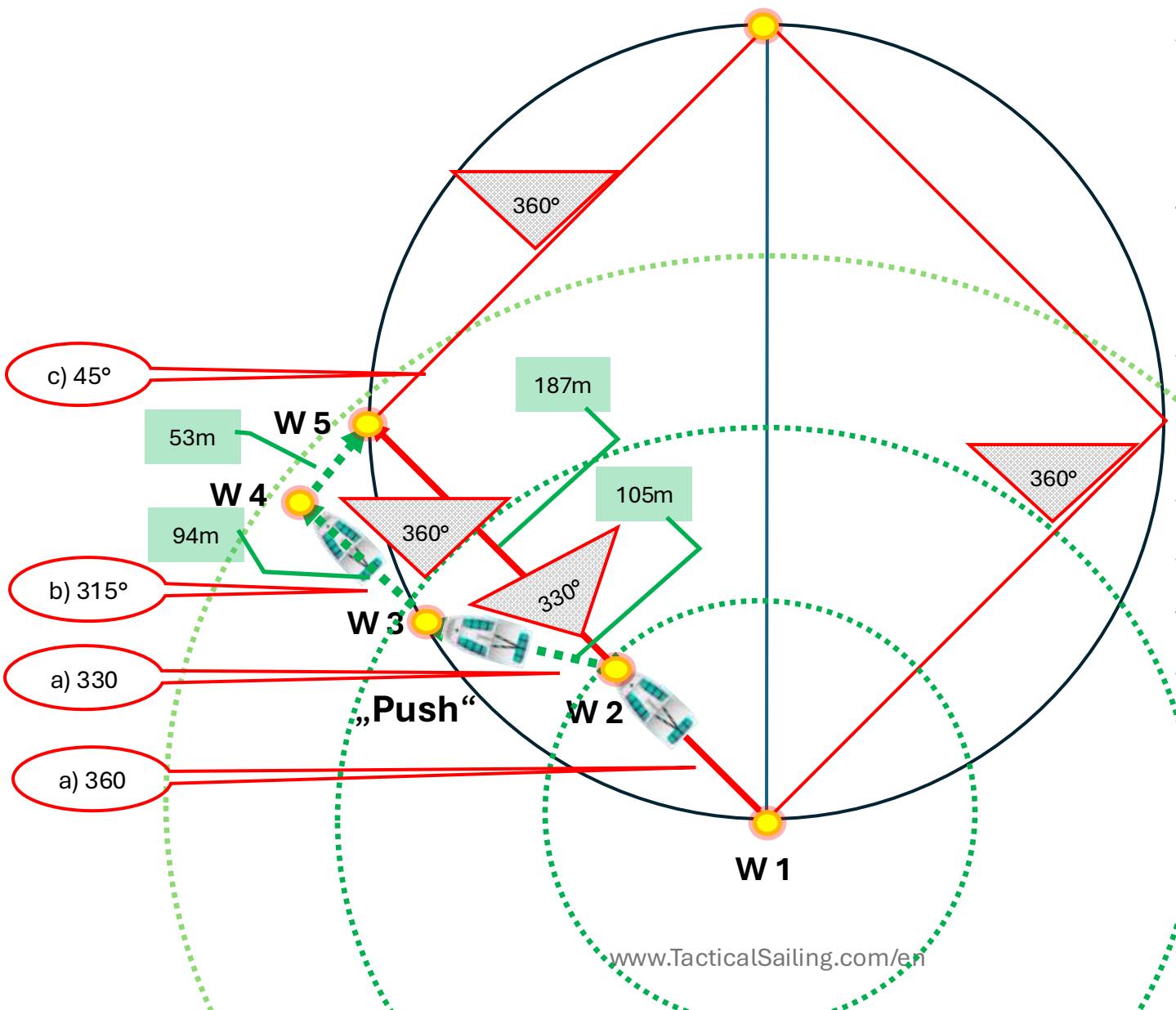
For base c) 315°/45°: 300=**300**

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!**

Short leg (2) - Lengthening, error and risk due to “pushers”



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

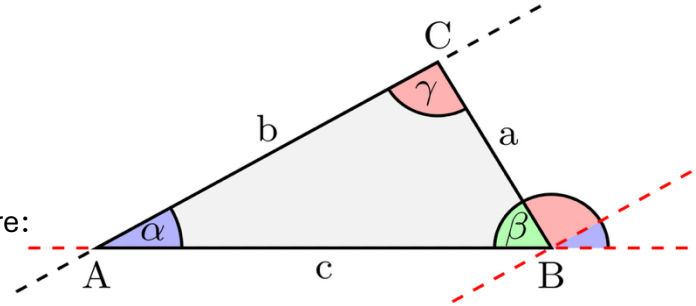
Wind direction°	Triangle sides (m)			Sailboat direction°	Distance to sail(m)	Won(m)	Number of boats winning
	a	b	c	α °			2,3
360°	300	300	424	**45**	600	0	0
345°	212	367	424	**30**	579	21	9
330°	110	410	424	**15**	520	80	35
330/360	**206**	**325**	424	**15/45**	531	69	30
Pull	87+238			Push			
Changes in all values marked "red"							

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"							

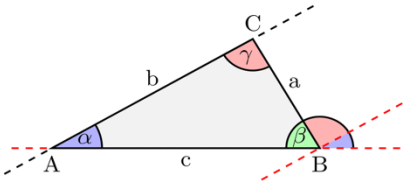
The basis for the calculations in the right-angled triangle are:
- the diameter of the circle, the side "c" (leeward to windward) is 400m,
- the formula of the "Pythagoras": $a^2 = b^2 + c^2$, and the "sine rule":
- a : b : c = sin (alpha) : sin (beta) : sin (gamma).

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.



"The Geometry of Regatta Sailing"
„Die Geometrie des Regattasegelns" (German language, 3rd edition 2024). Geometric tools for strategy and tactics in regatta sailing. ISBN: 97 83 75 83 70 700. 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.
Download the program from:
http://www.tacticalsailing.com/en. A detailed description is available in the documentation:
"Coach' Toolbox": https://www.tacticalsailing.com/en/downloads/documentation/coachs-toolbox,
Documentation:
https://www.tacticalsailing.com/fileadmin/files/downloads/documents/en/TS_Toolbox_en.pdf
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