

Calculations

3.2.1 Vector BS is determined by GPS (SOG) and Compass (Hdg) ????

SOG consist of STW + Tide-speed because both cause AWS.
Hdg reflects the point of sail and this is the bases for AWA.

$$\begin{aligned} \text{Vector BS} &: X_{BS} = \text{Cos} (90^\circ - \text{Hdg}) && * \text{SOG} \\ &: Y_{BS} = \text{Sin} (90^\circ - \text{Hdg}) && * \text{SOG} \end{aligned}$$

3.2.2 Vector Leeway

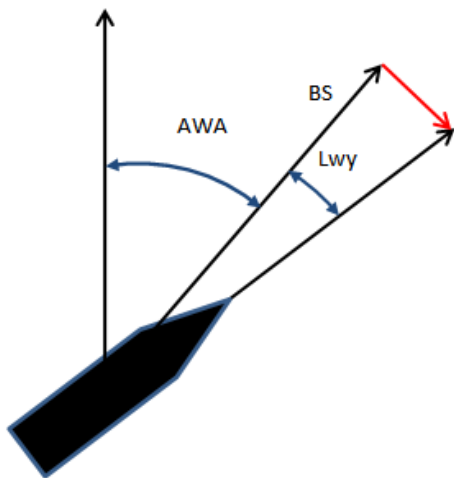
Leeway Angles (in degrees)	-----WIND STRENGTH & POINTS OF SAIL-----							
	3-10 knots		11-21 knots		22-33 knots		34-65 knots	
BOAT TYPE	beat	reach	beat	reach	beat	reach	beat	reach
Shallow-keel cruising sailboat	10	5	8	4	12	10	20	12
Deep-keel racer	6	4	4	2	6	4	12	6
Large cruising sailboat under power	4	2	6	4	10	8	20	12
Large cruising sailboat under sail	10	4	8	4	12	12	20	15
Dedicated parameters

Table I: Leeway Angles

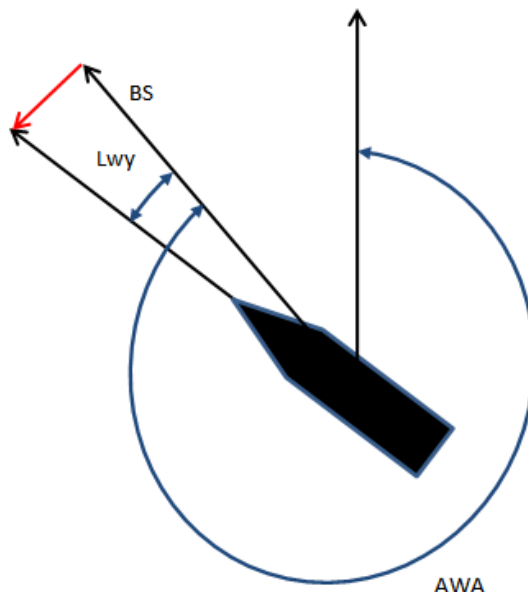
Source: <http://www.irbs.com/lists/navigation/9907/0052.html>

Two situations of Leeway are distinguished:

Wind over Starboard side ($0^\circ > \text{AWA} > 180^\circ$)



Wind over Port side ($180^\circ > \text{AWA} > 360^\circ$)



$$\begin{aligned} \text{Vector Lwy} &: \text{Starboard} &: \text{Lwy} &= \text{AWA} + 90^\circ && (0^\circ + \text{Lwy} < \text{AWA} < 180^\circ - \text{Lwy}) \\ &: \text{Port} &: \text{Lwy} &= \text{AWA} - 90^\circ && (180^\circ + \text{Lwy} < \text{AWA} < 360^\circ - \text{Lwy}) \\ &: X_{Lwy} &= \text{Cos} (90^\circ - \text{AWA} + \text{Lwy}) && * \text{Tan} (\text{Lwy}) * \text{SOG} \\ &: Y_{Lwy} &= \text{Sin} (90^\circ - \text{AWA} + \text{Lwy}) && * \text{Tan} (\text{Lwy}) * \text{SOG} \end{aligned}$$

3.2.4 Vector AWS

$$\begin{aligned} \text{Vector AWS} &: X_{AWS} = \text{Cos} (90^\circ - \text{Hdg} + \text{AWA} + 180^\circ) && * \text{AWS} \\ &: Y_{AWS} = \text{Sin} (90^\circ - \text{Hdg} + \text{AWA} + 180^\circ) && * \text{AWS} \end{aligned}$$

(+ 180 because the force is opposite of the wind direction)

3.2.5 **Vector TWS = vector AWS + vector BS + Vector Lwy**

$$TWS = ((X_{AWS} + X_{BS} + X_{Lwy})^2 + (Y_{AWS} + Y_{BS} + Y_{Lwy})^2)^{1/2}$$

$$TWA = \text{Tan} ((Y_{AWS} + Y_{BS} + Y_{Lwy}) / (X_{AWS} + X_{BS} + X_{Lwy}))$$

TWA + 180 because the force is opposite of the wind direction ?????

Convert TWA magnetic to TWA True see attachment V: Conversion.

3.2.6 **Vector Tide = vector GPS (COG, SOG) - vector LOG (Hdg, STW)**

$$\begin{aligned} \text{Vector GPS} &: X_{GPS} = \text{Cos} (90^\circ - \text{COG}) \quad * \text{SOG} \\ &: Y_{GPS} = \text{Sin} (90^\circ - \text{COG}) \quad * \text{SOG} \end{aligned}$$

Convert HDG magnetic to HDG True see attachment V: Conversion.

$$\begin{aligned} \text{Vector LOG} &: X_{LOG} = -\text{Cos} (90^\circ - \text{Hdg}) \quad * \text{STW} \\ &: Y_{LOG} = -\text{Sin} (90^\circ - \text{Hdg}) \quad * \text{STW} \end{aligned}$$

$$\text{Tide-speed} = ((X_{GPS} + X_{LOG})^2 + (Y_{GPS} + Y_{LOG})^2)^{1/2}$$

$$\text{Tide-angle} = \text{Tan} ((Y_{GPS} + Y_{LOG}) / (X_{GPS} + X_{LOG}))$$

For non-tidal waters (Tide = 0) GWS = True wind Speed and GWA = True wind Angle.
This could lead to back calculate Leeway. Based at the experiences reported in the article of "Compusail performance sailing services" this does not seem to be an option.

3.2.7 **Vector GWS = vector TWS – vector Tide**

$$\begin{aligned} \text{Vector TWS} &: X_{TWS} = \text{Cos} (90^\circ - \text{TWA}_{\text{True North}}) \quad * \text{TWS} \\ &: Y_{TWS} = \text{Sin} (90^\circ - \text{TWA}_{\text{True North}}) \quad * \text{TWS} \end{aligned}$$

$$\begin{aligned} \text{Vector Tide} &: X_{Tide} = \text{Cos} (90^\circ - \text{Tide-angle}_{\text{True North}}) \quad * \text{Tide-speed} \\ &: Y_{Tide} = \text{Sin} (90^\circ - \text{Tide-angle}_{\text{True North}}) \quad * \text{Tide-speed} \end{aligned}$$

$$\text{GWS-speed} = ((X_{TWS} + X_{Tide})^2 + (Y_{TWS} + Y_{Tide})^2)^{1/2}$$

$$\text{GWS-angle} = \text{Tan} ((Y_{TWS} + Y_{Tide}) / (X_{TWS} + X_{Tide}))$$

If TWA and Tide-angle are base at True North then GWS-angle is also based at True North

3.2.8 **VMG**

$$\text{VMG} = \text{cos}(TWA) \times \text{BS}$$

Boat speed is determined by:

- S.O.G Boat performance including tidal effects and Leeway.
- STW Boat performance only.