NAVIGATION

Juliet reads up on the International Date Line

60°, use 105 instead of 115 as the fixed number from which to subtract wind angle. If the WCA calculates to greater than 10°, then calculated GS should be reduced by a further 2% for a 10° WCA, 3%/15°, 6%/20°, 10%/25°, and 12%/30°. Note that when assessing the effect of a crosswind on travel over a distance, even a 90° crosswind creates a headwind component because of the need to crab towards the crosswind and away from the true heading.

RULE OF SIXTY: If you know how many miles you have travelled and how far the wind has taken you off your course at that point, the “Rule of Sixty” can help you determine how many degrees you have to adjust to get headed in the right direction and how many more degrees to adjust to intercept your original plotted course. This rule is sometimes referred to as the “One in Sixty” Rule. **EXAMPLE:** you have travelled 60 miles and find that you are 4 miles off course. Each mile off course at 60 miles is equal to one degree. A correction of 4º will get you headed in the correct direction. To intercept your original plotted course, you will have to adjust further. To intercept in another 60 miles you would adjust back by another 4º (closing angle) for a total of 8º. If you want to intercept more quickly, in 30 miles, you would adjust twice as much or a closing angle of 8º for a total of 12º. Once you intercept the course, you would subtract the 8º (closing angle) portion of the adjustment; retaining the 4º original track error adjustment to keep you on course, assuming that the wind remains the same.

To take another example; if you find that you are off course by 2 miles in the first 20 miles of travel, by extension, you would be off 6 miles if you went 60 miles, so you are off course by 6º. The same applies if you are off course by, say, 10 miles over a distance of 120 miles. Adjusting back from 120 miles to 60 miles you would have been off course by 5 miles or a 5º track error. The way the Rule of Sixty is derived is interesting. If you assume a circle of 360 degrees which is also 360 miles in circumference, then each mile equals one degree. The circumference of a circle is equal to 2 π radius. So, if a circle has a circumference of 360 miles, then the radius is about 60 miles (360 / (2 * 3.14) = 57.3 = roughly 60).

The chart below on the left, shows the conversion from the number of miles deviated off course (track error) during the miles travelled to the number of **degrees required to correct your course to the proper heading**. It also shows the additional number of **degrees** (the closing angle) to correct your heading to return to the original and planned track in a specified distance. The degrees in the chart are based on a radius of 57 miles.

TRACK ERROR & CLOSING ANGLE:

MILES TRAVELLED or MILES TO GO

MILES OFF TRACK	10	20	30	40	50	60	120	150	200
1	6	3	2	1	1	1	0	0	0
2	11	6	4	3	2	2	1	1	1
3	17	9	6	4	3	3	1	1	1
4	23	11	8	6	5	4	2	2	1
5	29	14	10	7	6	5	2	2	1
6		17	11	9	7	6	3	2	2
7		20	13	10	8	7	3	3	2
8		23	15	11	9	8	4	3	2
9		26	17	13	10	9	4	3	3
10		29	19	14	11	10	5	4	3
15			29	21	17	14	7	6	4
20				29	23	19	9	8	6

CORRECTION TO REGAIN THE PLANNED HEADING:

$$\frac{\text{Miles Off Course}}{\text{Miles Travelled}} = \frac{\text{Track Error (\%)}}{\mathbf{60}}$$

CORRECTION FROM THE PARALLEL COURSE TO INTERSECT PLANNED TRACK:

$$\frac{\text{Miles Off Course}}{\text{Miles Remaining}} = \frac{\text{Closing Angle (\%)}}{\mathbf{60}}$$

Another calculation is useful for departing from a plotted course to avoid or go around an obstacle such as a populated area or an area of raised terrain. The pilot will deviate from the course by a planned number of degrees, say 30º or 45º for a predetermined length of time or distance and then turn back twice the number of degrees (60º or 90º) for the same time or distance, thus intersecting the original course and continuing on as planned.

If you started at 6:00 AM sunrise in London, you would pass over each city at sunrise, the same time as you left London. To adjust to local sunrise time, you would set your watch back one hour every hour so that you would be at 6:00 AM local time as you tracked the sunrise over each city. When you arrived back in London, it would still be sunrise and your time and calendar date would be the same as when you left. Local time in London, however, would be 24 hours or one calendar day later. If you had stayed on Zulu time and not reset your watch, you would have traveled for 24 hours and would arrive one calendar day later and your calendar would agree with local time.

On an ocean voyage, sailors go much more slowly and change their own local time periodically, sometimes 15 minutes every evening, so that the sun is approximately overhead at Noon. Because they travel relatively slowly, they use local time not Zulu time. The effect is exactly the same as in the aircraft example. When Magellan's expedition returned to Spain in 1522 after a westward circumnavigation, the surviving crewmembers were convinced, based on their meticulous ships logs, that the correct day was 24 hours earlier than local calendar time. This is called the "circumnavigator's paradox" and the earliest historical reference to it is in the writings of a Syrian geographer and historian in about 1300. A circumnavigation to the east results in the recording of an extra day by the traveler, as happened to Phileas Fogg in "Around the World in Eighty Days."

The International Date Line (IDL) compensates for this paradox by arbitrarily changing the date so that the east side of the line is 24 hours later than the west side of the line. Thus local hourly time remains the same but the date is advanced by one day as you cross the line going east and set back one day as you travel west.

VOR: This stands for VHF Omnidirectional Range, a land based radio navigation system which provides a course to the transmitting equipment for each of the 360º compass points or radials extending away from the equipment. If you are flying to the East toward a VOR on the 270° radial, with the course selector set at 90°, the indication will show "To." Remember that if you reverse direction to fly to the West (270°) while staying in approximately the same location and leaving the selector set at 90°, the indication will remain "To". To use a VOR, tune it in and check the identifiers; then rotate the azimuth dial until the needle centers and the indication is "From" in order to identify the radial you are on (and where you are). Then rotate the azimuth dial until the indication is "To" and the needle is again centered. Turn the aircraft to the heading then shown on the VOR (which will be the reciprocal of the radial you have just identified) and begin tracking. If you drift off to one side or the other, correct by turning toward the needle to correct for the wind. Don't reset the course selector or you will keep drifting with the wind.

For example, the VOR illustrated to the left is set to the 254º radial, the needle is centered and the indication is "From." This indicates that the aircraft is on the 254º radial which is roughly west-southwest of the VOR station. It does not indicate what direction the aircraft is flying at the time. The aircraft could be flying north and just momentarily crossing the 254º radial. To fly towards the station on the 254º radial, turn the OBS (Omni Bearing Selector) dial until the indication is "To" and the needle is again centered. The new reading will be 74º. If you turn the aircraft to that heading (74º), you will be tracking roughly east north-east towards the VOR on the 254º radial.