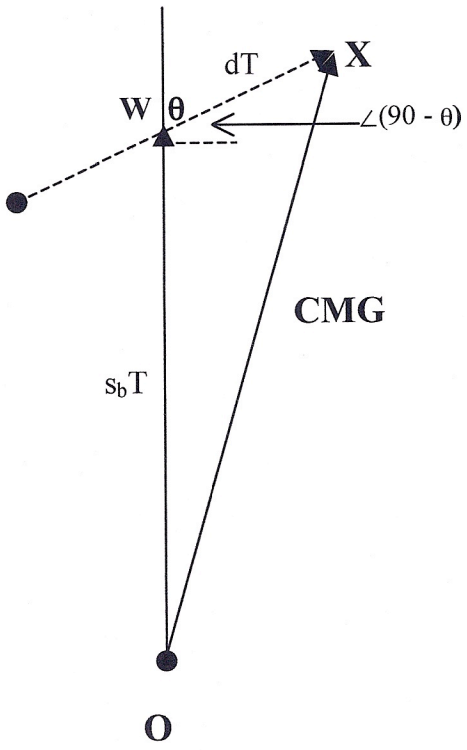
Set and Drift

Consider Figure 1, where we imagine vessel traveling at a boat speed (s_b) of 10 knots on a course for a waypoint 28 miles , or travel time (T) of 2.8 hours, away. The vector OW is the direct route to the waypoint (W). Its length (s_bT) is 28 miles or 2.8 hours in "boat speed units." The naïve navigator sets the course directly for WP and tells the helmsman to hold that course for 2 hours and 48 minutes.

But, unknown to the navigator, a current exists. It flows toward the starboard bow at a set of $+\theta°$; it comes from $(180 - \theta)°$ aft off the port bow; thus, if $\theta = 40°$ the current comes from -140° on the port quarter. The drift is d knots.

In 2.8 hours, when the navigator expects to be at the waypoint, the boat will actually be at point X; the course actually followed, called the Course Made Good (CMG), is OX because the current constantly pushes the boat $(90 - \theta)°$ greater than the intended course. X is dT miles from the waypoint. Thus,if $\theta = 40°$ and D = 1.3, X is 3.64 miles and 50° to the northeast of the waypoint. No big problem in the open ocean, but a big problem coming into a port in deep fog.

Figure 1
Current Set and Drift



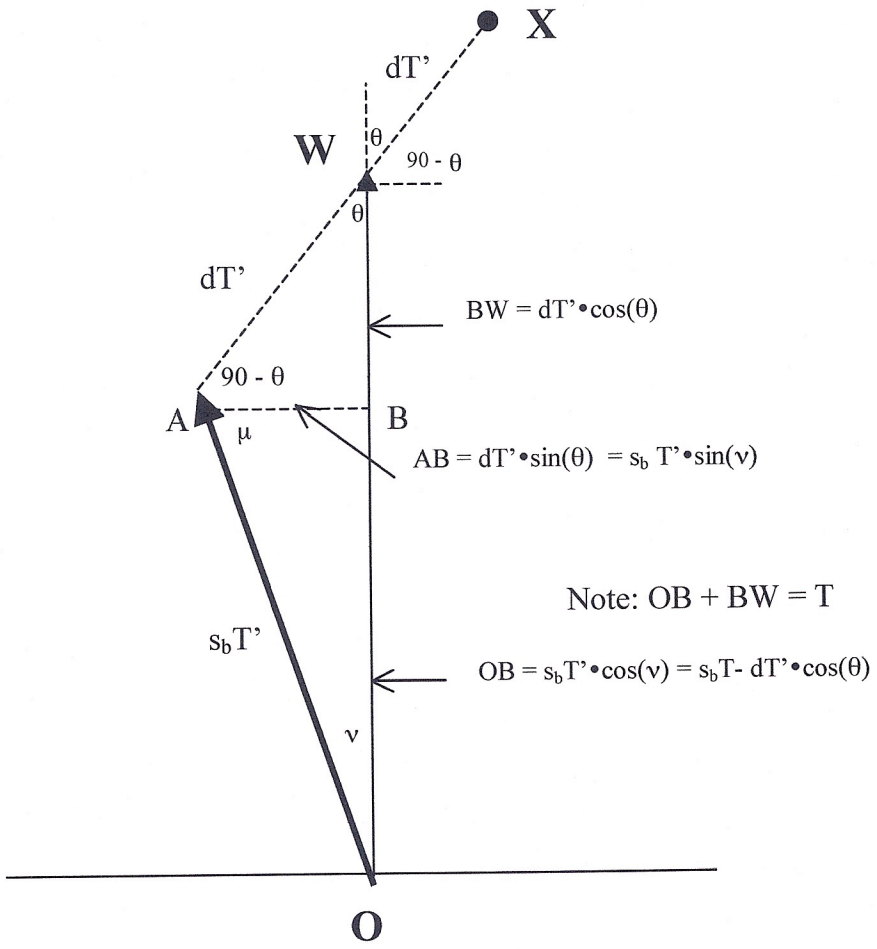
Of course, modern technology has reduced the mariner's need to calculate set and drift. GPS combined with autopilots will keep the vessel on the direct route. However, it creates inefficiency by keeping the rudder always at an angle to offset the current, thereby increasing the boat's drag and requiring higher rpms to maintain the boat speed. And if the equipment fails, knowledge of set and drift regains importance.

Correcting for Set and Drift

So what is a navigator to do? The answer is simple: set a course and a travel time such that the combination of course and current will carry the boat to the waypoint. But how to do that, knowing only the set (θ) and the drift (d).

Figure 2 shows the correction for the current shown in Figure 1. The navigator sets a course at angle ν relative to the desired course. This course will be held for T' hours at the boat's chosen speed. At the end of T' the boat will have drifted for dT' miles at angle θ. The boat will be at W!

Figure 2
Set and Drift Corection



The navigator's task is to determine ν and T' using his knowledge of T (time to W on direct course), and the drift and set (d, θ).

The oblique triangle OAW can be split into two right triangles OAB and BAW. From BAW the segment AB can be computed as $dT' \cdot \sin(\theta)$; this is equal to $s_b T' \cdot \sin(\nu)$ from OAB. Thus, $\sin(\nu) = AB/OA = d' \cdot \sin(\theta)$, where $d' = (d/s_b)$ is drift in boat speed units; a 1.3 knot drift at a 10 knot boat speed is $d' = 0.13$. We easily obtain the correction angle as

$$(1a) \qquad \nu = \sin^{-1}[d' \cdot \sin(\theta)]$$

Note that It's sign will be the opposite of the sign of θ: If current is flowing toward the starboard (port), ν should be subtracted from (added to) the bearing direct to the waypoint.

From the segment OB (derived from triangles OAB and BAW) we also have $T'\cos(\nu) = T - d'T'\cos(\theta)$, yielding

$$(1b) \qquad T'/T = 1/[\cos(\nu) + d' \cdot \cos(\theta)]$$

The navigator need only calculate these results from information on d' and θ.

Returning to our original example, let $s_b = 10$ knots, T = 2.8 hours, $\theta = +40°$, and d =1.3 knots. The course correction angle will be $\nu = -4.79°$ and $(T'/T) = 0.91$. The boat should set a course 4.79° less than the bearing to the waypoint, and it should stay on that course for 25.5 hours.

So the following steps correct for current:

- Calculate the original travel time, T, as distance to waypoint divided by boat speed
- Determine the set and drift. Set will be degrees off bow relative to forward motion
- Use equations (1a) and (1b) to calculate ν and T'/T
- Correct the course by deducting ν from the bearing for the direct route
- Correct the travel time by multiplying T by (T'/T

Course Correction Tables

If drift is calculated relative to boat speed, i.e. as $d' = (d/s_b)$, the correction equations can be written as (1a) and (1b) above. Thus, tables for course correction can be computed without reference to boat speed (with the exception of defining drift in units of boat speed). Correction tables are attached

TABLE 1

COURSE BEARING CORRECTION
FOR CURRENT SET AND DRIFT

SET	*(° Off Bow)*	*DRIFT (Current Speed Relative to Boat Speed)*									
Current TO	*Current FROM*	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
0	180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	170	0.50	0.99	1.49	1.99	2.49	2.99	3.48	3.98	4.48	4.98
20	160	0.98	1.96	2.94	3.92	4.91	5.89	6.88	7.86	8.85	9.85
30	150	1.43	2.87	4.30	5.74	7.18	8.63	10.08	11.54	13.00	14.48
40	140	1.84	3.69	5.53	7.39	9.25	11.12	13.00	14.90	16.81	18.75
50	130	2.20	4.39	6.60	8.81	11.04	13.29	15.55	17.84	20.16	22.52
60	120	2.48	4.97	7.46	9.97	12.50	15.06	17.64	20.27	22.94	25.66
70	110	2.69	5.39	8.10	10.83	13.59	16.37	19.20	22.08	25.02	28.02
80	100	2.82	5.65	8.49	11.36	14.25	17.18	20.16	23.20	26.31	29.50
90	90	2.87	5.74	8.63	11.54	14.48	17.46	20.49	23.58	26.74	30.00
100	80	2.82	5.65	8.49	11.36	14.25	17.18	20.16	23.20	26.31	29.50
110	70	2.69	5.39	8.10	10.83	13.59	16.37	19.20	22.08	25.02	28.02
120	60	2.48	4.97	7.46	9.97	12.50	15.06	17.64	20.27	22.94	25.66
130	50	2.20	4.39	6.60	8.81	11.04	13.29	15.55	17.84	20.16	22.52
140	40	1.84	3.69	5.53	7.39	9.25	11.12	13.00	14.90	16.81	18.75
150	30	1.43	2.87	4.30	5.74	7.18	8.63	10.08	11.54	13.00	14.48
160	20	0.98	1.96	2.94	3.92	4.91	5.89	6.88	7.86	8.85	9.85
170	10	0.50	0.99	1.49	1.99	2.49	2.99	3.48	3.98	4.48	4.98
180	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: If Current is from Port to Starboard SUBTRACT correction angle to bearing to waypoint obtain Course to Steer
If Current is from Starboard to Port ADD correction angle to bearing to waypoint obtain Course to Steer

Definitions:

- **SET is the direction in which the current is flowing relative to the bow. If the bearing to waypoint is 280° and the current is flowing northeasterly at 30° relative to the bow at drift = 0.4 boat speed units, the course to steer is 268.5° (= 2**
- **DRIFT is the speed at which the current is flowing relative to boat speed. If the boat speed over ground is 15 knots and the current is flowing at 3 knots, the DRIFT is 0.20 (=3/15).**

TABLE 2

TRAVEL TIME CORRECTION

		DRIFT (Current Speed Relative to Boat Speed)									
SET Current TO	*(° Off Bow) Current FROM*	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
0	180	0.95	0.91	0.87	0.83	0.80	0.77	0.74	0.71	0.69	0.67
10	170	0.95	0.91	0.87	0.84	0.80	0.77	0.74	0.72	0.69	0.67
20	160	0.96	0.91	0.88	0.84	0.81	0.78	0.75	0.73	0.70	0.68
30	150	0.96	0.92	0.89	0.85	0.82	0.79	0.77	0.74	0.72	0.70
40	140	0.96	0.93	0.90	0.87	0.84	0.81	0.79	0.77	0.74	0.72
50	130	0.97	0.94	0.91	0.89	0.86	0.84	0.82	0.80	0.78	0.76
60	120	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.83	0.82	0.80
70	110	0.98	0.97	0.95	0.94	0.92	0.91	0.89	0.88	0.87	0.85
80	100	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.94	0.93	0.92
90	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	80	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
110	70	1.02	1.04	1.06	1.07	1.09	1.12	1.14	1.16	1.18	1.21
120	60	1.03	1.05	1.08	1.11	1.14	1.18	1.21	1.25	1.29	1.34
130	50	1.03	1.07	1.11	1.15	1.19	1.24	1.29	1.35	1.41	1.48
140	40	1.04	1.08	1.13	1.18	1.24	1.30	1.37	1.44	1.53	1.62
150	30	1.05	1.10	1.15	1.21	1.28	1.35	1.44	1.53	1.64	1.76
160	20	1.05	1.10	1.16	1.23	1.31	1.39	1.49	1.60	1.73	1.89
170	10	1.05	1.11	1.17	1.25	1.33	1.42	1.53	1.65	1.80	1.97
180	0	1.05	1.11	1.18	1.25	1.33	1.43	1.54	1.67	1.82	2.00