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MSC/Circ.999
11 June 2001

**ADOPTION OF AMENDMENTS TO THE INTERNATIONAL AERONAUTICAL AND MARITIME SEARCH AND RESCUE (IAMSAR) MANUAL**

1 The Maritime Safety Committee (MSC), at its seventy-fourth session, 30 May to 8 June 2001, having been informed that the International Civil Aviation Organization had approved amendments to the IAMSAR Manual, as prepared by the Joint ICAO/IMO Working Group on Harmonization of Aeronautical and Maritime Search and Rescue and endorsed by the Sub-Committee on Radiocommunications, Search and Rescue at its fifth session (11 to 15 December 2000) adopted the annexed amendments in accordance with the procedure laid down in resolution A.894(21).

2 MSC 74 decided that the amendments should enter into force on 1 July 2002.

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**ANNEX**

**Summary of amendments to the IAMSAR Manual**
**Search planning procedures**

The major changes being proposed involve the methods for estimating the drift and determining the optimal search area for search objects in the marine environment. Specifically, methods for dealing with search objects that tend to have leeway vectors diverging from the down wind direction to the right or left, have been added. An improved method for estimating the total probable drift error has been developed. Methods for optimally allocating effort to leeway divergence datums have also been added. New leeway data is proposed in the form of new graphs for leeway speed and values for leeway divergence angles and probable errors in leeway estimates. New sweep width tables and correction factors for aircraft searches are proposed to correct certain anomalies that have been observed when using the present values. Appendices K, L and N have the greatest volume of changes.

In addition to the changes just mentioned, a number of corrections are proposed. Most require only minor editing and many can be done with pen and ink if the cost of publishing corrected pages is considered prohibitive. However, most of these changes are also quite important if the reader is to gain a correct understanding of the material. The few remaining changes are generally minor grammatical corrections.

1 Several acronyms and terms associated with the proposed new methods are proposed for inclusion in the Abbreviations and Acronyms and Glossary sections.

2 A minimal number of changes are proposed for Chapter 4 to make the text and figures there consistent with the proposed new methods.

3 The **Datum Worksheet** and the worksheets supporting it have been modified to accommodate leeway divergence and the new method for estimating total probable drift error. A **Leeway Worksheet** was added. Appropriate modifications to all worksheet instructions are included.

4 The present **Effort Allocation Worksheet for Optimal Search Around a Datum Point or Datum Line** was divided approximately in half to form two separate worksheets – a **Total Available Search Effort Worksheet** and a new **Effort Allocation Worksheet for Optimal Search of Single Point, Leeway Divergence, and Line Datums**. Between these two worksheets is a **Widely Diverging Datums Worksheet**. Use of this worksheet is needed only when the divergence distance between leeway divergence datums is large in comparison to the total probable error of position – a situation that is expected to be relatively rare in practice. The new **Effort Allocation Worksheet for Optimal Search of Single Point, Leeway Divergence, and Line Datums** and corresponding instructions contain procedures for optimally allocating effort in situations involving leeway divergence as well as for single point and line datums. Procedures for extending line datums to account for probable position error around one or both end points and procedures for optimally allocating effort in these cases were added. The **Total Available Search Effort Worksheet** is consistent with the proposed replacement sweep width tables and correction factors.

5 Minor changes to other worksheets needed for correct referencing of the above worksheets are proposed. Some unrelated minor corrections are also proposed.

6 New leeway graphs and data based on the latest available experimental data and analyses are proposed as replacements for the present **Figures N-2** and **N-3**.

7 New tables of sweep widths for helicopters and fixed wing aircraft are proposed. These are based on the latest sweep width experiments and data analysis. The proposed replacements for **Tables N-5** and **N-6** have meteorological visibility as an entering argument, making them more consistent with the other two sweep width tables. New weather correction factors (**Table N-7**) are proposed that is also based on the latest sweep width experiments. Since the need for a visibility correction factor has been eliminated, it is proposed that **Table N-8** be replaced with a table of correction factors for search facility speed (velocity) that was also an outcome of the latest sweep width experiments and data analysis.

ANNEX

## AMENDMENTS TO THE IAMSAR MANUAL[1]

## VOLUME I

In page 2-9, paragraph 2.7.2 last line after "... organizations" **add**:
", including support for specialized functions such as developing a search plan"; and
after "other sources of data." **add:**
"Additional information may be found in paragraph 1.11 of Volume II, *Mission Co-ordination*."

## VOLUME II

### Abbreviations and Acronyms

| Page | Amendment |
|---|---|
| ix | **Add:** "ASW ..........................average surface wind" |
| | **Add:** "$ASW_e$ ................average surface wind error" |
| | **Add:** "$ASWDV_e$.. drift velocity error due to $ASW_e$" |
| | **Add:** "DD ................(leeway) divergence distance" |
| x | **Add:** "$DV_e$ ........................total drift velocity error" |
| | **Add:** "$f_v$.....search facility velocity correction factor |
| xi | **Add:** "$L_b$........................................ datum base line" |
| | **Add:** "$LW_e$ .........................................leeway error" |
| xii | **Add:** "$SC_e$ ................................... sea current error" |
| xiii | **Add:** "SR ....................................... separation ratio |
| | **Add:** "$TC_e$ ................................. tidal current error" |
| | **Add:** "$TWC_e$ .................... total water current error" |
| xiv | **Add:** "$WC_e$................................ wind current error" |
| | **Add:** "$Z_a$........................................ available effort" |
| | **Add:** "$Z_r$...........................................relative effort" |
| | **Add:** "$Z_{rc}$........................cumulative relative effort" |
| | **From** "$Z_t$" **to** "$Z_t$, $Z_{ta}$" |

[1] Contents and index for each volume should be checked and renumbered, if necessary.

## Glossary

| Page | Item | Amendment |
|---|---|---|
| xv | | **Add:** |
| “**Available effort ($Z_a$)** | | The amount of effort available for assignment to a particular datum” |
| xvi | | **Add:** |
| **“Datum base line** | | That portion of a datum line that is drawn between two specific locations, such as way points on a distressed or missing craft’s intended track line. May be extended to form a datum line that accounts for the probable error(s) of one or both locations. |
| xvi | **Datum marker buoy (DMB)** | **From** “actual sea current” **to** “actual total water current” |
| | | **Add:** |
| **“Divergence Distance** | | Distance between the left and right leeway divergence datums.” |
| | **Drift error ($D_e$)** | **From** “*Total drift error*” **to** “*Total probable drift error*” |
| | **Effort factor ($f_Z$)** | **From** “(1) For point datums” **to** “(1) For point and leeway divergence datums” |
| xvii | **Initial position error ($X$)** | **Replace** definition with:<br><br>“The estimated probable error of the initial position(s) at the beginning of a drift interval. For the first drift interval, this will be the probable error of the initially reported or estimated position of the SAR incident. For subsequent drift intervals, it will be the total probable error of the previous datum position(s).” |
| xviii | | **Add:** |
| “**Leeway Divergence Angle** | | The average angle between an object’s direction of leeway and the down wind direction. Leeway may diverge to either the right or the left of the down wind direction. Current evidence indicates that object’s with significant leeway divergence angles rarely jibe or tack down wind.” |
| xviii | | **Add:** |
| “**Leeway error ($LW_e$)** | | .............The probable error of the leeway estimate.” |
| **xx** | **Add:** | |
| “**Sea current error ($SC_e$)** | | The probable error of the sea current estimate.” |

| Page | Item | Amendment |
| --- | --- | --- |
| xxii | "**Separation Ratio (*SR*)** | **Add:** The ratio of the divergence distance (*DD*) between two leeway divergence datums to the total probable error of position (*E*). ($SR = DD/E$)" |
| xxiii | "**Tidal current (TC)** | **Add:** Near-shore currents caused by the rise and fall of the tides. |
| | **Tidal current error ($TC_e$)** | The probable error of the tidal current estimate." |
| | **Total drift error ($D_e$)** | **Replace** definition with: "Also total probable drift error. The total probable error in the datum position that is contributed by the total drift velocity error ($DV_e$). $D_e = DV_e \times t$ where $t$ is the length of the drift interval in hours." |
| xxiii | "**Total drift velocity error ($DV_e$)** | **Add:** Also total probable drift velocity error. The total probable error of the total drift velocity based on the probable errors contributed by the probable errors in the average surface wind, leeway, and total water current." |
| xxiii | "**Total water current error ($TWC_e$)** | **Add:** Also total probable water current error. The total probable error of the total water current based on either (a) the probable error of the measured total water current or (b) the probable errors of the wind current, tidal or sea current, and any other current that contributed to the total water current." |
| | "**Wind current error ($WC_e$)** | **Add:** The probable error of the wind current estimate." |

## Chapter 1

Page 1-15, paragraph 1.11.1 **add** at the end of the paragraph:

"This is not true for software that directly addresses the search planning problem. Developing such software requires specialized expertise in computer modelling, the application of search theory and the application of environmental sciences such as meteorology and oceanography to SAR. Paragraph 1.11.9 lists some of the functional characteristics that should be considered for search planning software."

Page 1-16, **add** new paragraph:

"1.11.9 *Computer-based Search Planning*. The use of computers to support the search planning process is growing as it offers the SAR Co-ordinator greater flexibility to calculate a refined search area. Although there may be a tendency to computerise the manual method, computerising this overly simplified pencil-and-paper technique should be avoided. Computers make much more sophisticated techniques feasible, such as making the best use of increasingly available detailed environmental data for modelling and predicting drift, creating and testing various scenarios, integrating and evaluating the impact of late-arriving information, and simulating changes in the search object's status and type, etc. Perhaps most importantly, such models can produce optimal search plans that maximise the probability of success. SAR Co-ordinators are cautioned that they should be familiar with the basic theories of each Search Planning element to fully take advantage of the search planning software. SAR Co-ordinators are also reminded that computers are only devices that provide support; they cannot make important decisions and the quality of their outputs can only be as good as the quality of the inputs. Further information may be found in Appendix P of this publication."

## Chapter 4

| Page | Section | Line | Amendment |
|---|---|---|---|
| 4-1 | | Footnote | **From** "a geographic point, line or area" **to** "a geographic point (or set of points), line or area" |
| 4-2 | 4.2.2 | 1-2 | **From** "The many diverse criteria … makes …" **to** "The many diverse criteria … make …" |
| 4-3 | 4.3.2 | 1 | **From** "A datum may be a point, line or area." **to** "A datum may be a point (or set of points), line or area." |
| | 4.3.3 | 4 | **From** "geometric figure covering" **to** "geometric figure or figures covering" |

| Page | Section | Line | Amendment |
|---|---|---|---|
| 4-6 | 4.4.3(a) | 4 | **From** "be somewhat off the downwind direction" **to** "diverge to the left or the right of the downwind direction. (The average angle between the search object's leeway direction and the downwind direction is known as the leeway divergence angle.) Whether the craft's leeway will diverge to the left or the right is unknown. This uncertainty requires that both possibilities be considered." |
| 4-6 | 4.4.3(a) | 7 | **From** "Leeway rates may be computed" **to** "Leeway rates and leeway directions may be computed" |
| | | 8 | **From** "procedures provided with the Datum Worksheet" **to** "procedures provided with the Leeway Worksheet" |
| 4-7 | 4.4.4 | 13 | **From** "*Only those designed to move with the upper one or two metres of the ocean are useful for search planning purposes.*" **to** "*Those that move with the upper one or two metres of the ocean measure total water current while those that are designed to move with deeper currents tend to measure only sea current.*" |
| 4-8 | 4.4.6 | 1 | **From** "the direction and rate of drift" **to** "the directions and rates of drift" |
| 4-8 | Figure 4-7 | | **Replace** Figure 4 -7 with the one shown below. |

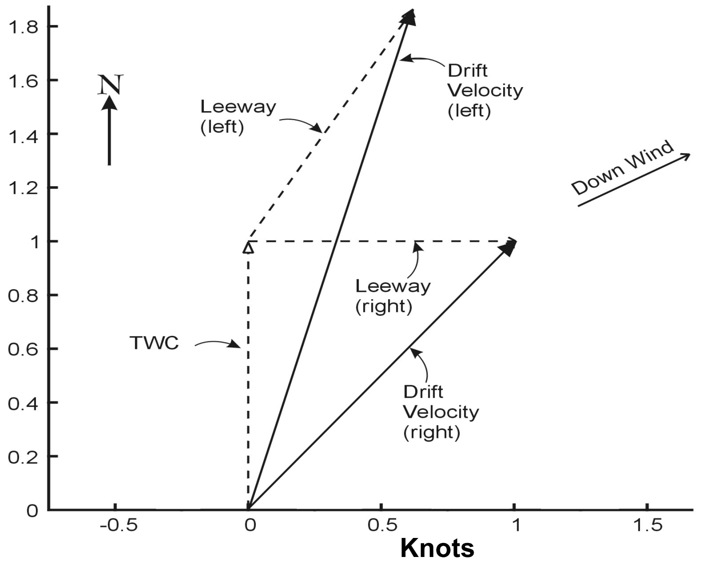


Figure 4-7 – *Computing drift speeds and directions from total water current and leeway*

| Page | Section | Line | Amendment |
|---|---|---|---|
| 4-9 | 4.4.7(a) | 1 | **From** "*Point Datums*" **to** *"Single Point and Leeway Divergence Datums*" |
| 4-9 | 4.4.7(a) | 3 | **Add:** "In a drift involving leeway, the first drift interval will produce two new datum points, one for each of the leeway vectors. Thereafter, it is assumed that the "left" datum will always use the leeway vector that is to the left of the down wind direction and the "right" datum will always use the leeway vector that is to the right of the down wind direction." |
| 4-9 | Figure 4-8 | | **Replace** Figure 4-8 with the one shown below. |

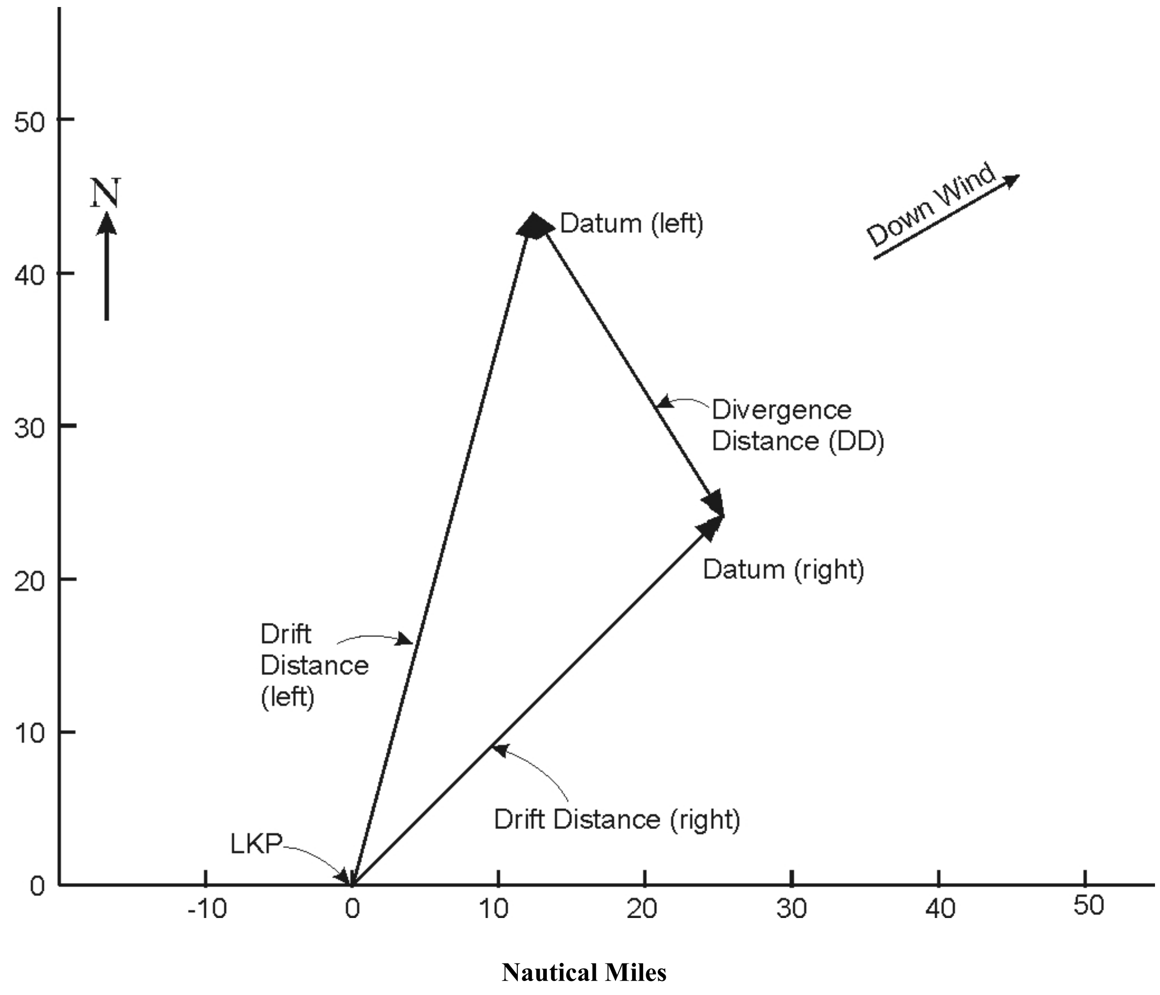


Figure 4-8 – *Determining new datums and divergence distance*
(*drift distance = drift speed × time adrift*)

| Page | Section | Line | Amendment |
|---|---|---|---|
| 4-10 | 4.4.8 | 1 | **From** "the computed drift velocity and the resulting drift distance" **to** "the computed drift velocities and the resulting drift distances" |

| Page | Section | Line | Amendment |
|---|---|---|---|
| 4-10 | 4.4.8(a) | 1 | **From** "a few types of craft" **to** "many types of craft" |
| | | 2 | **From** "Furthermore, most leeway studies have data only for light to moderate wind speeds. Estimates for higher" **to** "Furthermore, few leeway studies have data for high wind speeds. Therefore, estimates for high" |
| | | 5 | **From** "Some craft show a tendency to drift considerably off" **to** "Most craft show a tendency to have leeway off" |
| 4-10 | 4.4.8(c) | all | **Replace** this entire paragraph with the following: "The combined effects of the uncertainties in both environmental data and drift characteristics of the search object are taken into account by calculating the probable drift error rate (total probable drift velocity error) in knots. Multiplying the length of the drift interval in hours by this value gives the total probable drift position error ($D_e$). If uncertainty values are unavailable, a probable error rate of 0.3 knots is usually assumed for each component of the drift velocity. The greater the uncertainty about the object's drift characteristics or the winds and currents driving it, the greater the probable drift error rate estimate will be." |
| 4-11 | 4.6.1 | *Effort Factor* ($f_Z$) | **From** "(1) For point datums" **to** "For single point and leeway divergence datums" |
| | | 3 | **From** "length of the line (*L*)" **to** "length of the datum line (*L*)" |
| | | *Optimal Search Factor* ($f_s$) – 3 | **From** "rectangle (line datums)" **to** "rectangle (leeway divergence and line datums)" |
| 4-17 | 4.6.9(b) | 2 | **From** "line (L)" **to** "datum line (L)" |
| 4-18 | 4.6.11 | *Note* – 1 | **From** "around datum points or along datum lines" **to** "for single point, leeway divergence and line datums" |
| 4-18 | 4.6.12 | last | **From** "(for line datums)" **to** "(for leeway divergence and line datums)" |

| Page | Section | Line | Proposed Change |
|---|---|---|---|
| 4-19 | 4.6.14(b) | 2 | **From** “is as large, or larger than” **to** “is as large as, or larger than” |
| 4-21 | 4.6.17 | 3 | **From** “then the total POC for the two searches would be 75%” **to** “then the total POS for the two searches would be 75%” |
| | | Equation | **From** “+ … + $POC_n$” **to** “+ … + $POS_n$” |
| 4-23 | 4.7.4(b)(2) | last | **From** “search is about 82%” **to** “search is about 87%” |

| Page | Section | Line | Proposed Change |
|---|---|---|---|
| 4-23 | 4.7.4(c) | 5 | **Add:** "Probability maps are very useful when searching for stationary search objects even when the map probabilities must be updated by hand. Their use is always highly recommended for this type of search. However, when searching for moving objects, such as a boat or raft adrift on the ocean, maintaining probability maps by hand can prove to be very difficult. Updating of probability maps to account for **both** unsuccessful prior searching **and** increasingly uncertain search object drift is such a complex task that it is better left to computers programmed for the purpose." |
| 4-24 | 4.7.5(b)(2) | 8 | **From** "the optimal search factor … is 1.4" **to** "the optimal search factor … is 1.5" |
| | | 3rd equation | **From** "$= 1.4 \times 10 = 14$ NM" **to** "$= 1.5 \times 10 = 15$ NM" |
| | | 4th equation | **From** "$= 2 \times 14 \times 100 = 2800$ NM$^2$" **to** "$= 2 \times 15 \times 100 = 3000$ NM$^2$" |
| | | next line | **From** "which is a 28 NM" **to** "which is a 30 NM" |
| | | 5th equation | **From** "4000/2800 = 1.4" **to** "4000/3000 = 1.33" |
| | | next line | **From** "the POD for this search is about 92%" **to** "the POD for this search is about 74%" |
| 4-26 | 4.7.6(d) | last sentence | **From** "a sweep width of 5.0 nautical miles" **to** "a sweep width of 2.0 nautical miles" |
| | 4.7.6(e)(1) | 2 | **From** "$150 \times 4 \times 5 = 1200$" **to** "$150 \times 4 \times 2 = 1200$" |
| 4-27 | 4.7.6(e)(2) | 5 | **From** "POS of $2/3 \times 0.25$" **to** "a POC of $2/3 \times 0.25$" |
| 4-29 | 4.7.6(e)(3) | 5 | **From** "would be $0.8 \times 0.47$ or 38.6%" **to** "would be $0.8 \times 0.47$ or 37.6%" |
| | Figure 4-18 | Trial 2 | **From** "POS = 38.6%" **to** "POS = 37.6%" |
| 4-30 | 4.7.6(h)(2) | 3 | **From** "producing a POS of 23.40%" **to** "producing a POS of 23.70%" |
| 4-33 | 4.7.8 | 6 | **From** "necessary, but sometimes difficult, task. The first step" **to** "necessary, but often difficult, task if probability maps are to be used effectively in this situation. The generation and maintenance of probability maps for searches involving moving objects is best left to computers programmed for the purpose. To manually update a probability map for a drifting object, the first step" |

## Appendix K – Determining Datum

| Page | Item | Line | Amendment |
| --- | --- | --- | --- |
| K-i | | | **Modify** table of contents as needed to reflect changes outlined below. |
| K-2 | K.2.5 | 2 | **From** "paragraph K.1.2.3(a)" **to** "paragraph K.2.2(a)" |
| K-6 | B.4 | 2 | **From** "Table N-14" **to** "Table N-13" |
| | B.8 | 1 | **From** "($d_g = TAS_g \times t_d$)" **to** "($d_g = (TAS_g \times t_d)/60$)" |
| K-8 | B.8 | 1 | **From** "time of descent (**B.7**)" **to** "time of descent (**B.7**) and divide the result by 60 to get the glide distance in nautical miles" |
| K-9 | B.14 | 6 | **From** "enter the sum of" **to** "enter the larger of" |
| K-11 | 2 | title | **From** "Computing the Total Hours" **to** "Computing the Total Altitude Loss" |
| | 4 | 3 | **From** "in the drift interval" **to** "in the altitude loss" |
| | 5 | 1 | **From** "Go to **B.5**" **to** "Go to **line B.10**" |
| K-13 to K-25 | | | **Replace** all pages with the **attached Datum Worksheet**, **Datum Worksheet Instructions**, and supporting worksheets and instructions (attached pages K-13 to K-39). |

## Appendix L – Search Planning and Evaluation

| Page | Item | Line | Amendment |
|---|---|---|---|
| L-i | | | **Modify** table of contents as needed to reflect changes outlined below. |
| L-1 to L-4 | | | **Replace** these pages with the attached worksheets and instructions (attached pages L-1 to L-24). |
| L-17 | 13 | 4 | **Insert** the following sentence after "probability map.":<br><br>"Complete the new probability map by copying the POC values for the remaining (un-searched) cells from the previous probability map." |
| L-18 | 14 | "Total POC …" | **Replace** instructions with the following:<br><br>"Add the POC values from all cells on the new probability map to get the total probability of containment remaining after the latest search." |
| L-5 to L-18 | | | **Re-number** pages as needed (L-25 to L-38 if format of attached pages L-1 to L-24 is preserved). |

## Appendix M – Preparing Initial Probability Maps

| Page | Item | Line | Amendment |
|---|---|---|---|
| M-1 | Title | 2 | **From "For Point Datums" to "For Single Point Datums"** |
| | 2 | 2 | **From "line 25" to "line 14.b"** |
| M-2 | Title | 2 | **From "For Point Datums Instructions" to "For Single Point Datums Instructions"** |
| | 2 | 1 | **From "line 25" to "line 14.b"** |
| M-4 | 2 | 2 | **From "line 25" to "line 14.b"** |
| M-5 | 2 | 1 | **From "line 25" to "line 14.b"** |

## Appendix N – Tables and Graphs

| Page | Item | Line | Amendment |
|---|---|---|---|
| N-2 | Figure N-2 | | **Replace** with attached Figure N-2 for "Life Rafts, Survival Craft and Persons in the Water." |
| N-3 | Figure N-3 | | **Replace** with attached Figure N-3 for "Power Vessels, Sailing Vessels and Person-powered Craft." |
| N-4 | | 2 | **From** "of the distressed craft and the of the search facilities" **to** "of the distressed craft and of the search facilities" *i.e.*, delete the extra "the". |
| N-6 | Table N-5 | | **Replace** with attached "Table N-5 Sweep widths for helicopters (km (NM))." |
| N-7 | Table N-6 | | **Replace** with attached "Table N-6 Sweep widths for fixed-wing aircraft (km (NM))." |
| | Table N-7 | | **Replace** with attached "Table N-7 Weather correction factors for all types of search facilities." |
| | Table N-8 | | **Replace** with attached "Table N-8 Speed (velocity) correction factors for helicopter and fixed-wing aircraft search facilities." |
| N-9 | Table N-12 | 4000 | In the second column under **Distance in nautical miles**, change value from "**47**" to "**74**" |
| N-7 to N-20 | | | **Re-number** pages as needed to accommodate the larger sweep width tables. |

## New Pages to Appendix K

## Datum Worksheet
## For Computing Drift in the Marine Environment

Case Title: ______________________ Case Number: ______________ Date: ___________

Planner's Name: _________________ Datum Number: _____ Search Plan: A B C _______

Search Object: _________________________________________

**A. Starting Position for this Drift Interval**

1. Type of Position (Circle one)

| | | |
|---|---|---|
| | Last Known Position | LKP |
| | Estimated Incident Position | EIP |
| | Previous Datum | PD |

2. Position Date/Time __________________Z________

3. Latitude, Longitude of Position _____N/S _____W/E

**B. Datum Time**

1. Commence Search Date/Time __________________Z________

2. Drift Interval ___Hours

**C. Average Surface Wind (*ASW*)**
(Attach **Average Surface Wind (*ASW*) Worksheet**)

1. Average Surface Wind (*ASW*) ___°T _____KTS

2. Probable Error of Drift Velocity due to Probable Error of Average Surface Wind ($ASWDV_e$) _____KTS

**D. Total Water Current (*TWC*)**
(Attach **Total Water Current (*TWC*) Worksheet**)

1. Total Water Current (*TWC*) ___°T _____KTS

2. Probable Total Water Current Error ($TWC_e$) _____KTS

**E. Leeway (*LW*)**
(Attach **Leeway (*LW*) Worksheet**)

1. Left of down wind ___________°T _____________KTS

2. Right of down wind ___________°T _____________KTS

3. Probable Leeway Error ($LW_e$) _____________KTS

**F. Total Surface Drift**
Use a Manoeuvring Board or Calculator to add Total Water Current and Leeway vectors. (See **Figure K-1a**.)

| | (left of down wind) | (right of down wind) |
|---|---|---|
| 1. Drift Directions | __________°T | _____________°T |
| 2. Drift Speeds | __________KTS | _____________KTS |
| 3. Drift Distances (**line F.2 × line B.2**) | __________NM | _____________NM |
| 4. Total Probable Drift Velocity Error ($DV_e$) $\left(DV_e = \sqrt{ASWDV_e^2 + TWC_e^2 + LW_e^2}\right)$ | | _____________KTS |

**G. Datum Positions and Divergence Distance**
Using a Chart, Universal Plotting Sheet or Calculator, determine the datum positions and divergence distance (*DD*) (See **Figure K-1b**.)

1. Latitude, Longitude (left of down wind) _______________N/S _______________W/E

2. Latitude, Longitude (right of down wind) _______________N/S _______________W/E

3. Divergence Distance (*DD*) _______________NM

**H. Total Probable Error of Position (*E*) and Separation Ratio (*SR*)**
(Attach **Total Probable Error of Position (*E*) Worksheet**)

1. Total Probable Error of Position Squared ($E^2$) _______________$NM^2$

2. Total Probable Error of Position (*E*) _______________NM

3. Separation Ratio (*SR* = *DD*/*E*) _______________

4. Go to the **Total Available Search Effort Worksheet**.

## Datum Worksheet (Marine Environment) Instructions

**Introduction.** The **Datum Worksheet** is used to compile information from other worksheets and compute a new Datum Position. A **Datum Worksheet** should be completed for each initial datum point.

Complete the information at the top of the page, then go to **Part A**.

### A. Starting Position for this Drift Interval

1. Type of Position — Circle the appropriate source of information about the starting position for this drift interval. If the initial position is the last known position (as clearly and accurately reported by the distressed vessel, an eyewitness, or a remote sensor), circle "LKP." If the initial position was estimated by dead reckoning or determined by remote sensing with a large probable error or as ambiguous positions (e.g. pairs of positions sometimes reported by COSPAS/SARSAT), circle "EIP." If the initial position for this drift interval was a datum position computed for a previous drift interval, circle "PD."

2. Position Date/Time — Enter the date time group (DTG) of the starting position. Example: 231200Z FEB 99.

3. Latitude, Longitude of Position — Enter the latitude and longitude of the starting position for this drift interval.

### B. Datum Time

1. Commence Search Date/Time — Enter the date and time when the next search will begin in date time group (DTG) format. This will be the time for which the next datum position is computed.

2. Drift Interval — Subtract the starting position date and time (**line A.2**) from the commence search date and time (**line B.1**). If necessary, convert the result from days and hours to get the number of hours between the two date time groups.

### C. Average Surface Wind (*ASW*)

If the search object has no leeway and wind current is not a factor, leave **Part C** blank and go to **Part D**. Otherwise, go to the **Average Surface Wind (ASW) Worksheet** and compute the average surface wind for this drift interval.

1. Average Surface Wind (*ASW*) — Enter the average surface wind direction in degrees true and the average surface wind speed in knots from **line A.2** of the **Average Surface Wind (*ASW*) Worksheet**.

2. Probable Error of Drift Velocity due to $ASW_e$ ($ASWDV_e$) — Enter the estimated probable error of the drift velocity that will be caused by the probable error of the average surface wind from **line B.2** of the **Average Surface Wind (*ASW*) Worksheet**.

**D. Total Water Current (*TWC*)**

1. Total Water Current (*TWC*) — Enter the total water current direction in degrees true and the total water current speed in knots **from line A.2** or **line B.5** of the **Total Water Current (*TWC*) Worksheet**, as appropriate.

2. Probable Total Water Current Error ($TWC_e$) — Enter the estimated/computed probable error of the total water current from **line A.3** or **line B.6** of the **Total Water Current (*TWC*) Worksheet**, as appropriate.

**E. Leeway (LW)**

1. Left of down wind — Enter the leeway direction to the left of the down wind direction in degrees true and the leeway speed in knots from **line 6.a** of the **Leeway (*LW*) Worksheet**.

2. Right of down wind — Enter the leeway direction to the right of the down wind direction in degrees true and the leeway speed in knots from **line 6.b** of the **Leeway (*LW*) Worksheet**.

3. Probable Leeway Error ($LW_e$) — Enter the estimated probable leeway error from **line 7** of the **Leeway (*LW*) Worksheet**.

**F. Total Surface Drift** — The total surface drift velocities are the vector sum of the total water current velocity from **line D.1** and each of the leeway velocities from **lines E.1** and **E.2**. Multiplying each of the total surface drift speeds by the drift interval produces the total surface drift distances.

1. Drift Directions — Using a manoeuvring board or calculator, add the total water current vector from **line D.1** to each of the leeway vectors from **lines E.1** and **E.2** to compute two resultant surface drift velocity vectors. **Figure K-1a** is an example of how the two drift velocity vectors might appear. Enter the direction of each resultant surface drift velocity vector.

2. Drift Speeds — Enter the magnitude of each resultant surface drift velocity vector.

3. Drift Distances — Multiply the drift speeds (**line F.2**) by the drift interval (**line B.2**) and enter the results.

4. Total Probable Drift Velocity Error ($DV_e$) — Compute the probable error of the surface drift velocity vectors by taking the square root of the sum of the squared errors from **lines C.2, D.2**, and **E.3**.

$$\left( DV_e = \sqrt{ASWDV_e^2 + TWC_e^2 + LW_e^2} \right)$$

**G. Datum Positions and Divergence Distance** — Determine and plot the datum positions and determine the distance between them. (See **Figure K-1b**.)

1. Latitude, Longitude (left of down wind) — Using a chart, universal plotting sheet, or a calculator, determine the latitude and longitude of the datum position based on the total drift direction (**line F.1**) and distance (**line F.3**) from the starting position (**line A.3**) for the datum that lies to the **left** of the down wind direction. Plot the position.

2. Latitude, Longitude (right of down wind) — Using a chart, universal plotting sheet, or a calculator, determine the latitude and longitude of the datum position based on the total drift direction (**line F.1**) and distance (**line F.3**) from the starting position (**line A.3**) for the datum that lies to the **right** of the down wind direction. Plot the position.

3. Divergence Distance (*DD*) — Using a chart, universal plotting sheet, or a calculator, determine the divergence distance between the two datums. (See **Figure K-1b**.)

**H. Total Probable Error of Position (*E*) and Separation Ratio (*SR*)**

1. Total Probable Error of Position Squared ($E^2$) — Enter the square of the total probable error of position from **line D.1** of the **Total Probable Error of Position Worksheet**. This value will be used later with the **Effort Allocation Worksheet**.

2. Total Probable Error of Position (*E*) — Enter the total probable error of position from **line D.2** of the **Total Probable Error of Position Worksheet**. This value will also be used with the **Effort Allocation Worksheet**.

3. Separation Ratio (*SR*) — Divide the divergence distance (*DD*) on **line G.3** by the total probable error of position on **line H.2** and enter the result. Stated as a formula, *SR* = *DD*/*E*. This value will also be used with the **Effort Allocation Worksheet**.

4. Go to the **Total Available Search Effort Worksheet** — Proceed to the **Total Available Search Effort Worksheet** to continue planning the search.

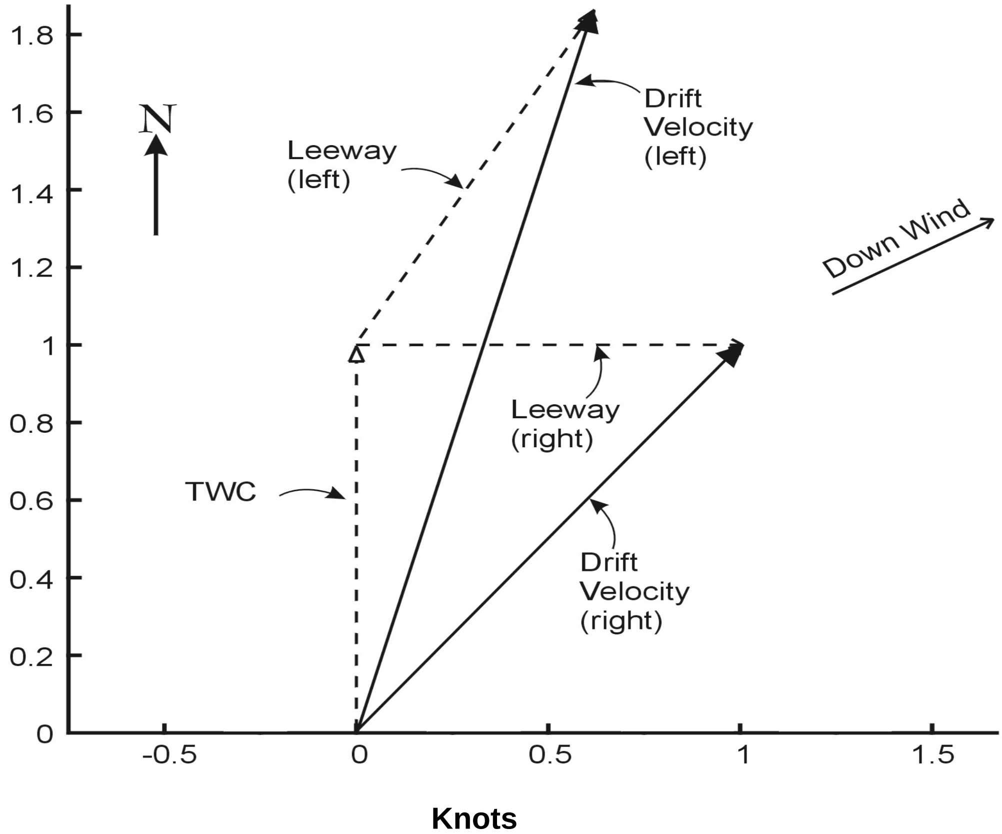


**Figure K-1a**. **–** Drift Velocity Vectors With Leeway Divergence

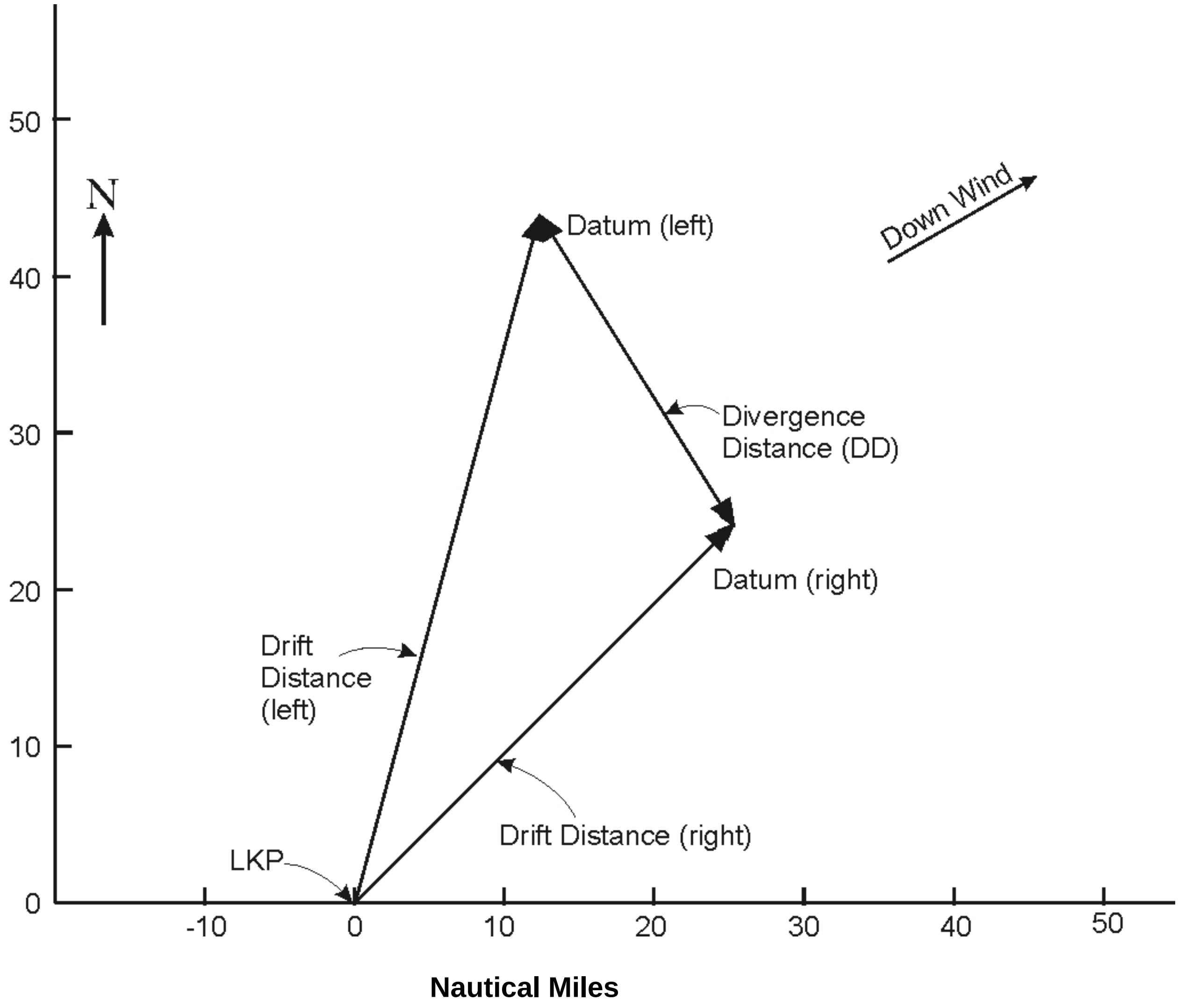


Figure K-1b – Drift Distances and Divergence Distance

**Average Surface Wind (*ASW*) Worksheet**

Case Title: ______________________ Case Number: ______________ Date: __________

Planner's Name: _________________ Datum Number: _____ Search Plan: A B C _______

**A. Average Surface Wind**

1. Surface Wind Data

| Time of Observation | Time Interval | Number of Hours (A) | Wind Direction (B) | Wind Speed (C) | Contribution (A × C) |
|---|---|---|---|---|---|
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| _________ | ______-______ | ________ | ________°T | ________KTS | ________NM |
| | Total Hours | ________ (D) | Vector Sum of Contributions | ________°T (E) | ________NM (F) |

2. Average Surface Wind (*ASW*) [(E)°T (F/D) KTS] __________°T __________KTS

**B. Probable Error**

1. Probable Error of the Average Surface Wind ($ASW_e$) __________KTS

2. Probable Error of Drift Velocity due to
   Probable Error of the Average Surface Wind ($ASWDV_e$) __________KTS

Go to **Part C** on the **Datum Worksheet**.

# Average Surface Wind (*ASW*) Worksheet Instructions

**Introduction.** The purpose of this worksheet is to compute a weighted average of wind velocity vectors over some period of time, usually a drift interval. Average surface wind is used to estimate wind current and leeway. The contribution of each wind observation or estimate is weighted according to the amount of time it was in effect. For example, a wind that has been in effect for twelve hours will have twice as much influence on the average wind as one that was in effect for only six hours. In general, wind averages should not be used for intervals exceeding 24 hours in length.

Wind observations and estimates are not exact and forecast wind data is even less accurate. Furthermore, the winds experienced by the search object can never be known precisely. Therefore, it is necessary to estimate the probable error of the average surface wind acting on the search object and the amount of probable error this will introduce into the drift computations. This amount will be used to compute the total probable error of position.

## A. Average Surface Wind (ASW)

1. Surface Wind Data

For each available wind value in this drift interval, enter the time of the observation, the starting and ending times of the time interval during which that wind value was in effect, the number of hours in the interval (ending time minus starting time), the wind direction, the wind speed, and the wind contribution for that interval (wind speed times the number of hours in the interval).

2. Average Surface Wind

Add the hours in the "Number of Hours" column to get the "Total Hours" (D). (The total hours should equal the number of hours in the drift interval from **line B.2** of the **Datum Worksheet**. If this is not the case, the difference should be explained.) Use a manoeuvring board or a calculator to compute the direction (E) and speed (F) of the vector sum of all the wind contribution vectors. Copy the direction of this vector sum (E) to the average surface wind direction on **line A.2** of this worksheet. Divide the speed of the vector sum (F) by the total hours (D) and enter the result as the average surface wind speed on **line A.2** of this worksheet. Copy the average surface wind direction and speed to **line C.1** of the **Datum Worksheet**.

**B. Probable Error**

1. Probable Error of *ASW* — Estimate the probable error of the average surface wind. If no value is available, enter 5 knots for observed winds, 8 knots for forecast winds.

2. Probable Error of Drift Velocity due to Probable Error of the Average Surface Wind ($ASWDV_e$) — Estimate the probable error of the drift velocity that will be caused by the probable error of the average surface wind. If no better estimate is available, enter **0.3** knots for observed winds that are either relatively steady or change gradually in speed or direction. Enter **0.5** knots for forecast winds and highly variable observed winds such as winds that suddenly shift during the passage of storms or weather fronts. Copy this value to **line C.2** of the **Datum Worksheet**. See note below for more information.

Note: The probable error of the average surface wind ($ASW_e$) contributes to the total probable drift velocity error ($DV_e$) in two ways. The $ASW_e$ increases the total probable wind current error and the total probable leeway error. The value recorded on **line B.2** of the **Average Surface Wind (*ASW*) Worksheet** is an estimate of the combined effects of the increased probable errors in wind current and leeway due to the probable error in the average surface wind. ***Caution:*** The probable wind current error ($WC_e$) entered on **line 7** of the **Wind Current (*WC*) Worksheet** represents **only** the probable error in the wind current estimate that still exists even when the average surface wind is precisely known. It does **not** include any error due to uncertainty about the average surface wind value used to estimate the wind current. Similarly, the probable leeway error ($LW_e$) entered on **line 7** of the **Leeway (*LW*) Worksheet** represents **only** the probable error in the leeway estimate that still exists even when the average surface wind is precisely known. It also does **not** include any error due to uncertainty about the average surface wind value used to estimate the leeway.

**Total Water Current (*TWC*) Worksheet**

Case Title: ________________________ Case Number: ________________ Date: ____________

Planner's Name: ___________________ Datum Number: ______ Search Plan: A B C ________

**A. Observed Total Water Current (*TWC*)**

1. Source (datum marker buoy (DMB), debris, oil) _________________________________

2. Observed Set/Drift _____________°T _____________KTS

3. Probable Error of Observation ($TWC_e$) _____________KTS

4. Go to **Part D** on the **Datum Worksheet.**

**B. Computed Total Water Current**

1. Tidal Current (*TC*)

   a. Source (tidal current tables, local knowledge) _________________________________

   b. Tidal Current (*TC*) Set/Drift _____________°T _____________KTS
   (Attach any tidal current computations)

   c. Probable Error of Tidal Current ($TC_e$) _____________KTS

2. Sea Current (*SC*)

   a. Source (Atlas, Pilot Chart, etc.) _________________________________

   b. Sea Current (*SC*) Set/Drift _____________°T _____________KTS

   c. Probable Error of Sea Current ($SC_e$) _____________KTS

3. Wind Current (*WC*)
   (Attach **Wind Current Worksheet**)

   a. Wind Current (*WC*) Set/Drift _____________°T _____________KTS

   b. Probable Error of Wind Current ($WC_e$) _____________KTS

4. Other Water Current (*OWC*)

   a. Source (local knowledge, previous drifts, etc.) ______________________________

   b. Other Water Current (*OWC*) Set/Drift ____________°T ____________KTS

   c. Probable Error of Other Water Current ($OWC_e$) ____________KTS

5. Computed Total Water Current (*TWC*) Set/Drift ____________°T ____________KTS

6. Computed Probable Total Water Current Error ($TWC_e$) ____________KTS

$$\left(TWC_e = \sqrt{TC_e^2 + SC_e^2 + WC_e^2 + OWC_e^2}\right)$$

7. Go to **Part D** on the **Datum Worksheet**.

## Total Water Current (*TWC*) Worksheet Instructions

**Introduction.** Total water current may be determined by observing the drift of objects that have little or no leeway. Total water current may also be determined or estimated using data from tidal current tables, sea current atlases, a wind current graph or computational procedure, and other sources. Often the Total Water Current will be the vector sum of two or more of these values.

None of the values will be exact and each will have at least some probable error. It is necessary to estimate the sizes of these probable errors. If two or more current vectors are added to determine the total water current, then the probable error of the total water current must be computed from the probable errors of the individual currents. This value will then be used to compute the total probable error of position.

If available, observed total water current at or near the scene is preferable to computed or estimated values. If total water current observations are available, complete **Part A** of this worksheet and record the result in **Part D** of the **Datum Worksheet**. If total water current observations are not available, complete the applicable sections of **Part B** of this worksheet and record the result in **Part D** of the **Datum Worksheet**

**A. Observed Total Water Current** — Datum marker buoys (DMBs) and debris with little freeboard tend to drift with the surface current. Early observations derived from relocating identifiable objects may be questionable due to navigational error. Self-locating DMBs are generally very accurate although the data returned may require some processing to be useful.

1. Source — Enter the type of object whose drift was observed to determine the total water current.

2. Observed Set/Drift — Enter the true direction and drift of the observed object.

3. Probable Error of Observation ($TWC_e$) — Enter the estimated probable error of the observed total water current as it relates to the search object's probable starting position. Factors to consider include the probable position errors of the observations, the distance between the observations and the search object's probable starting position, the amount of time since the last observation, and the amount of variability of the currents in the area of interest. If the observations are considered to be of good to excellent quality and representative of the current at the search object's (unknown) location, enter **0.1** knots. Otherwise, enter **0.2** knots.

4. Go to **Part D** of the **Datum Worksheet** — Enter the true direction and speed (**line A.2**) on **line D.1** of the **Datum Worksheet**. Enter the probable error (**line A.3**) on **line D.2** of the **Datum Worksheet**.

| | |
|---|---|
| **B. Computed Total Water Current** | Enter values only for those currents that are present at the search object's location. For any current that is not present, leave the set, drift, and probable error blank. |
| 1. Tidal Current (*TC*) | General Rule: In coastal waters, tidal currents will usually be important. To compute tidal current, search planners should consult published Tidal Current Tables, if available, for the vicinity of the datum position. Local knowledge is also often of great value in dealing with drift due to tidal currents. |
| a. Source | Enter the source of the tidal current information. |
| b. Tidal Current (*TC*) Set/Drift | Enter the true direction and speed of the average, or net, tidal current for the drift interval. |
| c. Probable Error of Tidal Current ($TC_e$) | Enter the estimated probable error of the computed or estimated tidal current as it relates to the search object's approximate location. Factors to consider include the distance between the reference location shown in the tidal current tables and the search object's probable starting position and the amount of variability of the currents in the area of interest. If no better estimate is available, enter **0.3** knots. |
| 2. Sea Current (*SC*) | General Rule: Sea currents derived from long-term seasonal averages taken over a wide area (*e.g.*, currents taken from a pilot chart or atlas of surface currents) are most useful in areas that are well off shore. Currents from these sources generally should not be used when computing total water current in coastal waters, especially when the distance from the shore of a large land mass is less than 25 miles **and** the water depth is less than 300 feet (100 metres, 50 fathoms). If local and regional data on short-term coastal surface currents are available, or if such data is available from a validated computerized circulation model, these values should be used. If not, sea current should be ignored and *TWC* should be calculated using only the wind current (*WC*) and tidal current (*TC*). |
| a. Source | Enter the source of the sea current information. |
| b. Sea Current (*SC*) Set/Drift | Enter the true direction and speed of the sea current from the information source. |
| c. Probable Error of Sea Current ($SC_e$) | Enter the estimated probable error of the sea current as it relates to the search object's approximate location. Consider the amount of variability of the currents in the area of interest. If no better estimate is available, enter **0.3** knots. |

| | |
|---|---|
| 3. Wind Current (*WC*) | Go to the **Wind Current Worksheet**, compute the wind current, and attach the worksheet. |
| a. Wind Current (*WC*) Set/Drift | Enter the true direction and speed of the wind current from **line 6** of the **Wind Current Worksheet**. |
| b. Probable Error of Wind Current ($WC_e$)from | Enter the estimated probable error of the wind current **line 7** of the **Wind Current Worksheet**. |
| 4. Other Water Current (*OWC*) | General Rule: Other Water Current is current that does not fall into one of the other categories. For example, the discharge of large rivers into the sea can affect the currents many miles from shore. |
| a. Source | Enter the source of this current information. |
| b. Other Water Current (*OWC*) Set/Drift | Enter the true direction and speed of this current from the information source. |
| c. Probable Error of Other Water Current ($OWC_e$) | Enter the estimated probable error of this current as it relates to the search object's approximate location. Consider the amount of variability of the currents in the area of interest. If no better estimate is available, enter **0.3** knots. |
| 5. Computed Total Water Current Set/Drift | Using a manoeuvring board or calculator, compute the vector sum of all the above water currents. Enter the resultant direction (set) and speed (drift) in the spaces provided. |
| 6. Computed Total Probable Water Current Error ($TWC_e$) | Compute the probable error of the total water current by taking the square root of the sum of all the squared water current errors. Stated as a general formula,<br>$$TWC_e = \sqrt{TC_e^2 + SC_e^2 + WC_e^2 + OWC_e^2}$$<br>Usually only some of these terms will be used. For example, if the object is well out to sea beyond tidal influence, then the term $TC_e$ is removed from the formula above. |
| 7. Go to **Part D** of the **Datum Worksheet** | Enter the computed total water current true direction and speed (**line B.5**) on **line D.1** of the **Datum Worksheet**. Enter the probable total water current error (**line B.6**) on **line D.2** of the **Datum Worksheet**. |

## Wind Current (*WC*) Worksheet

Case Title: ______________________ Case Number: _______________ Date: ___________

Planner's Name: __________________ Datum Number: _____ Search Plan: A B C ________

**Wind Current (*WC*)**

1. Average Surface Wind (*ASW*) ____________°T _______________KTS
   (from **Datum Worksheet**, **line C.1**)

2. Down Wind Direction (ASW direction ± 180°) _______________°T

3. Wind Current Drift _______________KTS
   (from **Figure N-1**)

4. Divergence of Wind Current ± _______________°
   (from **Figure N-1**)

5. Wind Current Set _______________°T
   (Down wind direction ± Divergence of Wind Current)
   (Add Divergence in northern hemisphere, subtract in southern hemisphere.)

6. Wind Current (*WC*) Set/Drift _____°T_____________KTS

7. Probable Error of Wind Current ($WC_e$) _______________KTS

8. Go to **line B.3** on the **Total Water Current (*TWC*) Worksheet**.

## Wind Current (*WC*) Worksheet Instructions

**Introduction.** Local wind blowing over the ocean's surface generates a current in the water. Usually this current is in addition to the average sea current found in atlases and on pilot charts. Therefore, it is necessary to estimate this current and the probable error of the estimated value.

**Wind Current (*WC*)**

Caution: In areas where the wind is nearly constant over long periods, like the trade winds, it may not be appropriate to add wind current to the average sea current. Also, the sea current values estimated by some computer models include the local wind current. Search planners should not compute and add wind current to this type of data.

1. Average Surface Wind (*ASW*)

   Enter the computed average surface wind from the **Datum Worksheet** (**line C.1**).

2. Down Wind Direction

   Add (or subtract) 180° to (from) the average surface wind direction to get the down wind direction.

3. Wind Current Drift

   Go to **Figure N-1**, **Local Wind Current Graph and Table**, find the wind current that corresponds to the speed of the average surface wind on **line 1**.

4. Divergence of Wind Current

   Go to **Figure N-1** and find the appropriate value for the divergence of the wind current from the down wind direction based on the approximate latitude of the search object.

5. Wind Current Set

   In the northern hemisphere, add the divergence from **line 4** to the down wind direction from **line 2**. If the result is greater than 360°, subtract 360°. In the southern hemisphere, subtract the divergence on **line 4** from the down wind direction on **line 2**. If the result is less than zero, add 360°.

6. Wind Current (*WC*) Set/Drift

   Enter the set from **line 5** and the drift from **line 3**.

7. Probable Wind Current Error ($WC_e$)

   Enter the estimated probable error of the wind current. Factors to consider include the distance between the wind observations and the search object's probable starting position, the amount of time since the last wind observation, and the amount of variability of the winds in the area of interest during the drift interval. Wind current estimates based on the average of highly variable winds tend to have larger probable errors than those based on steady winds. If no better estimate is available, enter 0.3 knots. See note below for more information.

8. Go to **line B.3** on the **Total Water Current (*TWC*) Worksheet**

Enter the wind current set and drift (**line 6)** on **line B.3.a** of the **Total Water Current (*TWC*) Worksheet**. Enter the probable error of the wind current (**line 7)** on **line B.3.b** of the **Total Water Current (*TWC*) Worksheet**.

Note: The relationship between wind and wind current is not precisely understood, especially when there is significant variation in the wind over the interval of interest. For this reason the wind current estimate has some probable error that is independent of the probable error in the average surface wind. The probable wind current error ($WC_e$) entered on **line 7** of the **Wind Current (*WC*) Worksheet** represents **only** the probable error in the wind current estimate that is still present even when the average surface wind is precisely known. It does **not** include any error due to uncertainty about the average surface wind value used to estimate the wind current. The additional error due to uncertainty about the average surface wind is included in the **Probable Error of Drift Velocity due to Probable Error of the Average Surface Wind ($ASWDV_e$)** entered on **line B.2** of the **Average Surface Wind (ASW) Worksheet** and **line C.2** of the **Datum Worksheet**.

## **Leeway (*LW*) Worksheet**

Case Title: ________________________ Case Number: ________________ Date: ____________

Planner's Name: ___________________ Datum Number: ______ Search Plan: A B C ________

Search Object: ____________________________________________

1. Average Surface Wind (*ASW*) _____°T_____________KTS
   (from **Datum Worksheet**, **line C.1**)

2. Down Wind Direction (ASW direction ± 180°) _______________°T

3. Leeway Speed _______________KTS
   (from **Figure N-2** or **N-3**)

4. Leeway Divergence Angle ± _______________°
   (from **Figure N-2** or **N-3**)

5. Leeway Directions

   a. Left of down wind (**line 2 – line 4**) _______________°T

   b. Right of down wind (**line 2** + **line 4**) _______________°T

6. Leeway (*LW*)

   a. Left of down wind __________°T _____________KTS

   b. Right of down wind __________°T _____________KTS

7. Probable Leeway Error ($LW_e$) _____________KTS
   (from **Figure N-2** or **N-3**)

8. Go to **Part E** on the **Datum Worksheet**.

**Leeway (*LW*)Worksheet Instructions**

**Introduction.** Leeway is the movement of an object through the water due to wind and waves acting on the object. Leeway speeds for various types of objects may be estimated by using the graphs in **Figures N-2** and **N-3**. Estimating leeway direction is more difficult. Lack of symmetry in the search object's shape either above or below the waterline may cause it to have leeway in a direction that is not directly down wind. The leeway divergence angles given in **Figures N-2** and **N-3** are the average differences between the object's direction of leeway and the down wind direction. For example, an object with a leeway divergence of ± 45° has a leeway that is, on average, either 45° to the left of the down wind direction or 45° to the right of the down wind direction. Since the leeway of objects that tend to diverge from the down wind direction is equally likely to be to the left or right of the down wind direction, it is necessary to account for both possibilities. It is also necessary to account for the probable error of the leeway estimate.

The leeway values obtained from **Figures N-2** and **N-3** are not exact. They are average values for the types of objects shown. All the values have at least some probable error. It is necessary to estimate the size of this probable error so the total probable drift error may be computed.

| | |
|---|---|
| 1. Average Surface Wind (*ASW*) | Enter the value for the average surface wind direction and speed from the **Datum Worksheet line C.1**. |
| 2. Down Wind Direction | Add (or subtract) 180° to (from) the average surface wind direction to get the down wind direction. |
| 3. Leeway Speed | Find the description in **Figure N-2** or **N-3** that most closely corresponds to the search object. Use the corresponding line on the graph and the average surface wind speed (**line 1**) to find the leeway speed. Enter this value in the blank provided. |
| 4. Leeway Divergence Angle | Use the same description as the one used for **line 3** to find the search object's leeway divergence angle on **Figure N-2** or **N-3**. Enter the leeway divergence angle that appears in parentheses ( ) next to the search object's description. |
| 5. Leeway Directions | |
| a. Left of Down Wind | Subtract the leeway divergence angle (**line 4**) from the down wind direction (**line 2**). If the result is less than zero, add 360°. |
| b. Right of Down Wind | Add the leeway divergence angle (**line 4**) to the down wind direction (**line 2**). If the result is greater than 360°, subtract 360°. |
| 6. Leeway (*LW*) | |
| a. Left of Down Wind | Enter the direction from **line 5.a** and the speed from **line 3.** |
| b. Right of Down Wind | Enter the direction from **line 5.b** and the speed from **line 3.** |

| | |
|---|---|
| 7. Probable Leeway Error | Using the same description as the one used for **line 3**, find the probable error of the search object's leeway estimate on **Figure N-2** or **N-3**. Enter the probable leeway error that appears in brackets [ ] next to the search object's description. Copy this value to **line E.3** of the Datum Worksheet. See note below for more information. |
| 8. Go to **line E** on the **Datum Worksheet** | Enter the "left" direction and speed from **line 6.a** on **line E.1** of the **Datum Worksheet**. Enter the "right" direction and speed from **line 6.b** on **line E.2** of the **Datum Worksheet**. Enter the probable leeway error from **line 7** on **line E.3** of the **Datum Worksheet**. |

Note: **Figures N-2** and **N-3** are based on the best and latest information from leeway experiments. However, the values obtained from the graphs are not exact and are still subject to some probable error. The probable leeway error ($LW_e$) entered on **line 7** of the **Leeway (*LW*) Worksheet** represents **only** the probable error in the leeway estimate that still exists even when the average surface wind is precisely known. It does **not** include any error due to uncertainty about the average surface wind value used to estimate the leeway. The additional error due to uncertainty about the average surface wind is included in the **Probable Error of Drift Velocity Due to Probable Error of the Average Surface Wind ($ASWDV_e$)** entered on **line B.2** of the **Average Surface Wind (ASW) Worksheet** and **line C.2** of the **Datum Worksheet**.

**Total Probable Error of Position (*E*) Worksheet**
**For Land and Marine Environments**

Case Title: ________________________ Case Number: ________________ Date: ____________

Planner's Name: ___________________ Datum Number: ______ Search Plan: A B C ________

**A. Probable Distress Incident/Initial Position Error (*X*)**
(Go to **line 1** to compute probable error of the distress incident position. Go to **line 6** if the starting position for this drift interval is a previous datum.)

1. Navigational Fix Error ______________ NM
   (from **Table N-1** or **N-2**)

2. Dead Reckoning (DR) Error Rate ______________ %
   (from **Table N-3**)

3. DR Distance Since Last Fix ______________ NM

4. DR Navigational Error (**line A.2** × **line A.3**) ______________ NM

5. Glide Distance (if aircraft/parachute descent heading is unknown) ______________ NM

6. Probable Initial Position Error (*X*) ______________ NM
   (*X* = **line A.1** + **line A.4** + **line A.5**) or
   (*X* = Total Probable Error of Position from **line H.2** of previous **Datum Worksheet**.)

**B. Total Probable Drift Error ($D_e$)**

1. Drift Interval ______________Hours
   (from **line B.2** of the **Datum Worksheet**)

2. Probable Drift Velocity Error ($DV_e$) ________________KTS
   (from **line F.4** of the **Datum Worksheet**)

3. Total Probable Drift Error ($D_e$) ________________ NM
   ($D_e$ = **line B.1** × **line B.2**)

**C. Probable Search Facility Position Error (*Y*)**

1. Navigational Fix Error (from **Table N-1** or **N-2**) ________________ NM

2. Dead Reckoning (DR) Error Rate (from **Table N-3**) ________________ %

3. DR Distance Since Last Fix ________________ NM

4. DR Navigational Error (**line C.2** × **line C.3**) ________________ NM

5. Probable Search Facility Position Error (*Y*) ($Y$ = **line C.1** + **line C.4**) ________________ NM

**D. Total Probable Error of Position (*E*)**

1. Sum of Squared Errors ($E^2 = X^2 + D_e^2 + Y^2$) ________________ $NM^2$

2. Total Probable Error of Position ________________ NM

$$\left(E = \sqrt{X^2 + D_e^2 + Y^2}\right)$$

## Total Probable Error of Position (*E*) Worksheet Instructions

**Introduction.** The total probable error of position is a measure of the uncertainty about the search object's location and the ability of the search facilities to locate their assigned search areas accurately. Total probable error of position is used to determine the size of the optimal area to search with the available search effort. The new datum position and total probable error of position data are carried forward to the **Effort Allocation Worksheet**.

**A. Probable Distress Incident/Initial Position Error (*X*)**

If this is the first **Total Probable Error of Position Worksheet** for this case, complete **lines A.1** through **A.6**. Otherwise, go directly to **line A.6** and enter the total probable error of position (*E*) from **line H.2** of the previous **Datum Worksheet.**

1. Navigational Fix Error

Enter the probable fix error based on the navigational capability of the distressed craft. **Tables N-1** and **N-2** provide estimates of probable navigational fix error based on the type of navigation and size of the distressed craft. These values may be used when more accurate information is not available.

2. Dead Reckoning (DR) Error Rate

Enter the probable error in DR position as a percentage of the distance travelled since the last navigational fix. **Table N-3** provides estimates of DR error rates based on the type and size of the distressed craft. These values may be used when more accurate information is not available.

3. DR Distance Since Last Fix

Enter the estimated distance travelled by the distressed craft since its last navigational fix.

4. DR Navigational Error

Convert the percentage on **line A.2** to a decimal fraction and multiply it by the value on **line A.3** to get the DR Navigational Error.

5. Glide Distance (aircraft/parachute)

If the incident involves an aircraft and the descent heading is unknown for either the aircraft, a parachute with a non-zero glide ratio or both, enter the maximum estimated glide distance (aircraft glide or parachute glide as appropriate). Otherwise, enter zero.

6. Probable Initial Position Error (X)

If **lines A.1** through **A.5** were completed, compute the Probable Initial Position Error as the sum of **lines A.1**, **A.4**, and **A.5**. Otherwise, enter the total probable error of position from **line H.2** of the previous **Datum Worksheet**.

**B. Total Probable Drift Error ($D_e$)**

| | | |
|---|---|---|
| 1. | Drift Interval | Enter the drift interval in hours from **line B.2** of the **Datum Worksheet**. |
| 2. | Probable Drift Velocity Error ($DV_e$) | Enter the probable drift velocity error **from line F.4** of the **Datum Worksheet**. |
| 3. | Total Probable Drift Error ($D_e$) | Multiply the drift interval on **line B.1** by the probable drift velocity error on **line B.2** to get the total probable drift error. |

**C. Probable Search Facility Position Error ($Y$)**

| | | |
|---|---|---|
| 1. | Navigational Fix Error | Enter the probable fix error based on the navigational capability of the search facility. **Tables N-1** and **N-2** provide estimates of probable navigational fix error based on the type of navigation and size of the search facility. These values may be used when more accurate information is not available. |
| 2. | Dead Reckoning (DR) Error Rate | Enter the probable error in DR position as a percentage of the distance travelled by the search facility between navigational fixes. **Table N-3** provides estimates of DR error rates based on the type and size of the search facility. These values may be used when more accurate information is not available. |
| 3. | DR Distance Since Last Fix | Enter the estimated distance travelled by the search facility between navigational fixes. |
| 4. | DR Navigational Error | Convert the percentage on **line C.2** to a decimal fraction and multiply it by the value on **line C.3** to get the DR Navigational Error. |
| 5. | Probable Search Facility Position Error ($Y$) | Compute the Probable Search Facility Position Error as the sum of **lines C.1** and **C.4**. |

**D. Total Probable Error of Position ($E$)**

| | | |
|---|---|---|
| 1. | Sum of Squared Errors ($E^2$) | Square the values on **lines A.6**, **B.3**, and **C.5**. Add the squared values together to get the sum of the squared errors ($E^2$). This value will be used in the **Effort Allocation Worksheet**. |
| 2. | Total Probable Error of Position ($E$) | Compute the square root of the value on **line D.1** to get the total probable error of position ($E$). This value will be used for search effort allocation and as the probable initial position error for the next drift interval. |

## New Pages to Appendix L

Total Available Search Effort ($Z_{ta}$) Worksheet

Case Title: ______________________ Case Number: _______________ Date: _____________

Planner's Name: __________________ Datum Number: _____ Search Plan: A B C _________

Datum _________________ _________________ Datum _________________ _________________

(left) Latitude Longitude (right) Latitude Longitude

Search Object: __________________________________________ Date/Time __________________

Total Available Effort Computations

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Search Sub-area Designation | _______ | _______ | _______ | _______ | _______ |
| 2. Search Facility Assigned | _______ | _______ | _______ | _______ | _______ |
| 3. Search Facility Speed (*V*) | _______ | _______ | _______ | _______ | _______ |
| 4. On Scene Endurance | _______ | _______ | _______ | _______ | _______ |
| 5. Daylight Hours Remaining | _______ | _______ | _______ | _______ | _______ |
| 6. Search Endurance (*T*) <br> (*T* = 85% of lesser of **line 4** or **5** above.) | _______ | _______ | _______ | _______ | _______ |
| 7. Search Altitude | _______ | _______ | _______ | _______ | _______ |
| 8. Uncorrected Sweep Width | _______ | _______ | _______ | _______ | _______ |
| 9. Weather, Terrain Correction Factor ($f_w$, $f_t$) | _______ | _______ | _______ | _______ | _______ |
| 10. Velocity Correction Factor ($f_v$) <br> (aircraft only) | _______ | _______ | _______ | _______ | _______ |
| 11. Fatigue Correction Factor ($f_f$) | _______ | _______ | _______ | _______ | _______ |
| 12. Corrected Sweep Width (*W*) | _______ | _______ | _______ | _______ | _______ |
| 13. Available Search Effort ($Z = V \times T \times W$) | _______ | _______ | _______ | _______ | _______ |

14. Total Available Search Effort ($Z_{ta} = Z_{a1} + Z_{a2} + Z_{a3} + \ldots$) _______________$NM^2$

15. Separation Ratio (*SR*) (leeway divergence datums only) _______________
(from **line H.3** of the **Datum Worksheet**.)

16. If the separation ratio (*SR*) on **line 15** is greater than four ($SR > 4$), go to the **Widely Diverging Datums Worksheet**. Otherwise, go to the **Effort Allocation Worksheet**.

## Total Available Search Effort ($Z_{ta}$) Worksheet Instructions

**Introduction.** This **Total Available Search Effort Worksheet** is used to determine the total amount of search effort that will be available on scene. This worksheet is based on a DAYLIGHT VISUAL SEARCH.

Enter the case title, case number, planner's name, datum number, search designator, datum latitudes, longitudes and time, and the primary search object in the spaces provided. All of this information may be found on the **Datum Worksheet** except possibly the planner's name. The name that appears on this worksheet should be that of the person responsible for completing this worksheet, who may be different from the person who completed the **Datum Worksheet**.

### Total Available Search Effort Computations

| | |
|---|---|
| 1. Search Sub-Area Designation | Use standard sub-area designators, such as A-1, B-3, etc. |
| 2. Search Facility Assigned | Enter name, hull or tail number, or other identifier that uniquely identifies the search facility assigned to the corresponding search sub-area. |
| 3. Search Facility Speed (*V*) | Enter the average speed made good over the ground for each search facility while searching. For aircraft, the True Airspeed (TAS) while searching is usually a satisfactory approximation. |
| 4. On Scene Endurance | Enter the total amount of time the search facility can provide on scene. Do not include the transit time to and from the area. |
| 5. Daylight Hours Remaining | Enter the number of hours between the search facility's estimated time of arrival on scene (start of searching) and sunset. |
| 6. Search Endurance (*T*) | Compute 85% of the value on **line 4** or **line 5**, whichever is smaller. This figure represents the "productive" search time. It provides a 15% allowance for investigating sightings and navigating turns at the ends of search legs. |
| 7. Search Altitude | Determine the search altitude options available (See *Note* below) and enter a preliminary altitude assignment. |

*Note: Recommended guidelines for determining search altitude options:*

*a. Stay at least 150 m (500 ft) below cloud bases.*
*b. Stay at least 60 m (200 ft) above the water or ground.*
*c. Use at least 150 m (500 ft) of vertical separation between aircraft that share a common search sub-area boundary.*
*d. In most cases, use altitudes in increments of 150 m (500 ft).*
*e. Additional guidance is provided in **Table N-11**.*

| | |
|---|---|
| 8. Uncorrected Sweep Width | Enter the appropriate value from the Sweep Width Tables in Appendix N. Based on the type of search facility, use **Table N-4**, **N-5**, or **N-6** for maritime searches. Use **Table N-9** for searches over land. |
| 9. Weather, Terrain Correction Factor ($f_w$, $f_t$) | For maritime searches, enter the appropriate value ($f_w$) from **Table N-7**. For searches over land, enter the appropriate value ($f_t$) from **Table N-10**. |
| 10. Velocity Correction Factor ($f_v$) | For searches conducted by aircraft over water, enter the appropriate velocity correction factor ($f_v$) from **Table N-8**. For searches conducted by vessels and for searches over land, enter **1.0**. |
| 11. Fatigue Correction Factor ($f_f$) | If there are indications that the search facility crew is or will be suffering significantly from fatigue during the search, enter **0.9**. If crew fatigue is not considered a significant factor for the assigned search facility, enter **1.0**. |
| 12. Corrected Sweep Width ($W$) | Multiply the values in each column on **lines 8**, **9**, **10**, and **11** (uncorrected sweep width, weather/ terrain correction factor, velocity correction factor and fatigue correction factor) to get the corrected sweep width. |
| 13. Available Search Effort ($Z$) | Multiply the search facility's speed (**line 3**) by the search facility's endurance (**line 6**) and multiply the result by the corrected sweep width (**line 12**), or use **Figure N-4**. |
| 14. Total Available Search Effort ($Z_{ta}$) | Add the individual Available Search Effort values listed on **line 13** and enter the total. |
| 15. Separation Ratio ($SR$) | Enter the separation ratio ($SR$) from **line H.3** of the **Datum Worksheet**. |

16. In most cases, the separation ratio (*SR*) will be less than or equal to four (*SR* ≤ 4) and the search planner may go directly to the **Effort Allocation Worksheet**. However, if the separation ratio (*SR*) entered on **line 15** is greater than four (*SR* > 4), an initial effort allocation decision must be made between the following two choices:

- The two datums may be treated as separate single point datums, each with its own search area. Two separate search areas with no overlap will be the usual result.

- A line may be drawn between the two datums and treated as the base line portion of a datum line. In this case a single search area centred on the datum line will be the result.

The **Widely Diverging Datums Worksheet Instructions** provide guidance to help the search planner decide which alternative to use. The **Widely Diverging Datums Worksheet** helps the search planner make the necessary preparations for entering the **Effort Allocation Worksheet(s)**.

The following conditions can lead to leeway divergence datums becoming so widely separated in comparison to their total probable errors of position that separate search areas should be considered:

- The leeway divergence angle is large (> 30°).
- The leeway rate is moderate to large (> 1 knot).
- The time adrift is significant (> 12 hours).
- The probable errors of the initial and search facility positions are small (< 1 NM).
- The probable errors of the factors affecting drift (winds, currents, leeway) are all small (< 0.3 knot).
- The cumulative relative search effort is small to moderate (< 10).

Usually all of these conditions must be met before the separation ratio will become greater than four (*SR*>4) and the divergence distance (*DD*) will be large enough to justify dividing the available search effort into two portions assigned to separate, non-contiguous search areas. Only rarely will enough of these conditions be met to create such a situation.

# Widely Diverging Datums Worksheet

Case Title: ________________________ Case Number: ________________ Date: ______________

Planner's Name: ___________________ Datum Number: ______ Search Plan: A B C __________

Datum (left) ___________________ Latitude ___________________ Longitude

Datum (right) ___________________ Latitude ___________________ Longitude

Search Object: _____________________________________________ Date/Time ___________________

1. Total Available Search Effort ($Z_{ta}$) _______________ $NM^2$
   (from **line 14** of the **Total Available Search Effort Worksheet**)

2. Divergence Distance (*DD*) _______________NM
   (from **line G.3** of the **Datum Worksheet**)

3. Total Probable Error of Position (*E*) _______________NM
   (from **line H.2** of the **Datum Worksheet**)

4. Type of Datum to use for Planning this Search (Circle one)

   a. Two Separate Point Datums (Go to **line 5**.)

   b. A Line Datum between Two Point Datums (Go to **line 6**.)

5. Two Separate Point Datums

   a. Search Effort Available for the Left Datum ($Z_{a(left)}$) _______________ $NM^2$

   b. Search Effort Available for the Right Datum ($Z_{a(right)}$) _______________ $NM^2$

   c. Total Available Search Effort ($Z_{ta} = Z_{a(left)} + Z_{a(right)}$) _______________ $NM^2$
      (must equal value on **line 1**)

   d. Go to the **Effort Allocation Sheets** (one for each datum) and follow the instructions for single point datums.

6. A Line Datum between Two Point Datums

   a. Length of the Datum Line [$L = DD + (2 \times E)$] _______________NM

   b. Go to the **Effort Allocation Sheet** and follow the instructions for a line datum.

## Widely Diverging Datums Worksheet Instructions

**Introduction:** It is possible for objects that have leeway divergence to have two widely separated datums whose associated probability density distributions have little or no overlap. When the distance between the datums is large in comparison to the probable error of each datum position, the search planner must decide whether they should be treated as two separate single point datums or as the end points of the base line portion of a datum line.

Experimental evidence indicates that once an object starts to have a leeway to the left of the down wind direction it tends to remain on that tack indefinitely. The same is true if the object starts to have a leeway to the right of the down wind direction. If the initial and search facility probable position errors are small, the leeway divergence angle is large (> 30°), the probable errors of the winds, currents and leeway are all small (each contributing less than 0.3 knot to the drift velocity error), etc., the divergence distance (*DD*) may become greater than four times the probable error of position (*E*). This is an unlikely situation. However, if it occurs, the search planner should seriously consider applying a portion of the available search effort to each datum rather than applying the total available search effort to a single large area that includes both datums and the area between them. Objects that have large divergence angles will tend toward locations on the line connecting the left and right datums only if they jibe or tack down wind. There has been very little evidence of jibing behaviour in the leeway experiments done to date. This means that when the probable errors are small and the divergence angle is large, there is very little chance of the search object being halfway between the left and right datums. If this is the case, then the area that is near the midpoint of the line connecting the left and right datums will not be a very productive area to search.

If the search planner decides to treat the two datums separately, then it is necessary to divide the total available search effort into two portions and plan two single point datum searches. Unless there is some reason to favour one datum over the other, the total available search effort should be divided into two equal portions. One example of a situation where one datum should be favoured over the other is the following: Suppose a drifting search object was located by an aircraft and observed long enough to determine its leeway was to the right of the down wind direction, but then contact was lost before a homing beacon could be deployed or a rescue facility could arrive on scene. In this case, the datum for the next search that was to the right of the down wind direction probably should be assigned most of the total available search effort. Whenever search effort is to be allocated separately to two datums, an **Effort Allocation Worksheet** should be completed for each datum, using the instructions for a single point datum.

In situations where the wind has shown large and sudden changes in direction, when the sea is confused, etc., the search planner may decide that the probability of the search object jibing or tacking down wind is larger than usual. The search planner may have other reasons for covering all of the area between the left and right datums. In these cases, the search planner should consider drawing a line between the left and right datums and using it as the base line portion of a datum line. When the total available search effort is to be allocated in this fashion, a single **Effort Allocation Worksheet** should be completed following the instructions for a datum line.

| | |
|---|---|
| 1. Total Available Search Effort ($Z_{ta}$) | Enter the total available search effort ($Z_{ta}$) from **line 14** of the **Total Available Search Effort Worksheet**. |
| 2. Divergence Distance (*DD*) | Enter the divergence distance (*DD*) from **line G.3** of the **Datum Worksheet**. |
| 3. Total Probable Error of Position (*E*) | Enter the total probable error of position from **line H.2** of the **Datum Worksheet**. (Note: The value of *DD* on **line 2** should be more than four times the value of *E* on this line ($DD > 4 \times E$). If this is **not** true, discard this worksheet and go directly to the **Effort Allocation Worksheet**.) |
| 4. Type of Datum | Decide whether to plan the next search around two separate datums or along a datum line that passes through the left and right datums. Circle "a" or "b" as appropriate. If "a" is circled, go to **line 5**. If "b" is circled, go to **line 6**. |
| 5. Two Separate Point Datums | In this case, the total available search effort is to be divided into two parts. One part will be applied to a search area centred on one of the datums while the other part will be applied to a search area centred on the other datum. |
| a. Search Effort Available for the Left Datum ($Z_{a(left)}$) | Enter the amount of search effort that will be applied to the left datum. This amount must be between zero and the total available search effort ($0 \le Z_{a(left)} \le Z_{ta}$). |
| b. Search Effort Available for the Right Datum ($Z_{a(right)}$) | Enter the amount of search effort that will be applied to the right datum. This amount must be between zero and the total available search effort ($0 \le Z_{a(right)} \le Z_{ta}$). |
| c. Total Available Search Effort ($Z_{ta} = Z_{a(left)} + Z_{a(right)}$) | Add the search effort available for the left datum **(line 5.a)** to the search effort available for the right datum **(line 5.b)**. The result should equal the total available search effort **(line 1)**. If this is not true, adjust the efforts for the left and right datums so their sum equals the total available search effort **(line 1)**. |
| d. Go to **Effort Allocation Worksheets** | Complete an **Effort Allocation Worksheet** for each datum. Enter the search effort available for the left datum ($Z_{a(left)}$) on **line 1** of the **Effort Allocation Worksheet** for the left datum. On a second **Effort Allocation Worksheet,** enter the search effort available for the right datum ($Z_{a(right)}$) on **line 1**. |

| | |
|---|---|
| 6. A Line Datum between Two Point Datums | In this case, a single search area is to be centred on the line connecting the left and right datums. |
| a. Length of the Datum Line (*L*) | Compute the length of the datum line by adding twice the total probable error of position (*E*) from **line 3** to the divergence distance (*DD*) from **line 2**. Stated as a formula, L = $DD + (2 \times E)$. |
| b. Go to the **Effort Allocation Worksheet.** | Go to the **Effort Allocation Worksheet**. Enter the total available search effort ($Z_{ta}$) from **line 1** of this worksheet as the available search effort ($Z_a$) on **line 1** of the **Effort Allocation Worksheet**. Enter the length of the datum line (*L*) from **line 6.a** as the length of the datum line (*L*) on **line 2.b** of the **Effort Allocation Worksheet**. Follow the effort allocation instructions for line datums. |

## Effort Allocation Worksheet

### For Optimal Search of Single Point, Leeway Divergence, or Line Datums

Case Title: ________________________ Case Number: ________________ Date: _____________

Planner's Name: __________________ Datum Number: _____ Search Plan: A B C _________

Datum (left) __________________ Latitude __________________ Longitude

Datum (right) __________________ Latitude __________________ Longitude

Datum ____________ Date/Time ____________________________ Search Object

**Effort Allocation Computations**

1. Available Search Effort ($Z_a$) _______________$NM^2$
   (from **line 14** of **Total Available Search Effort Worksheet** or **line 5.a** or **line 5.b** of the **Widely Diverging Datums Worksheet**)

2. Effort Factor ($f_Z$)

   a. Total Probable Error of Position ($E$) _________________NM

   b. Length of Datum Line ($L$) _________________NM

   c. Effort Factor ($f_Z$) ($f_{Zp} = E^2$ or $f_{Zl} = E \times L$) _________________$NM^2$

3. Relative Effort ($Z_r = Z_a/f_Z$) _________________

4. Cumulative Relative Effort ($Z_{rc}$ = Previous $Z_{rc} + Z_r$) _________________

5. Optimal Search Factor ($f_s$) Ideal______ Poor______ ($f_s$) ____________

6. Optimal Search Radius ($R_o = f_s \times E$) _______________NM

7. Optimal Search Area ($A_o$) _______________$NM^2$
   a. Single Point Datum ($A_o = 4 \times R_o^2$)
   b. Leeway Divergence Datums [$A_o = (4 \times R_o^2) + (2 \times R_o \times DD)$]
   c. Line Datum ($A_o = 2 \times R_o \times L$)

8. Optimal Coverage Factor ($C_o = Z_a/A_o$) _________________

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 9. Optimal Track Spacing ($S_o = W/C_o$) | _______ | _______ | _______ | _______ | _______ |
| 10. Nearest Assignable Track Spacing ($S$) (within limits of search facility navigational capability) | _______ | _______ | _______ | _______ | _______ |
| 11. Adjusted Search Areas ($A = V \times T \times S$) | _______ | _______ | _______ | _______ | _______ |

12. Total Adjusted Search Area ($A_t = A_1 + A_2 + A_3 + \ldots$) ____________NM$^2$

13. Adjusted Search Radius ($R$) ____________NM

a. Single Point Datum $R = \frac{\sqrt{A_t}}{2}$

b. Leeway Divergence Datums $R = \frac{\sqrt{DD^2 + (4 \times A_t)} - DD}{4}$

c. Line Datum $R = \frac{A_t}{2 \times L}$

14. Adjusted Search Area Dimensions

a. Length — Length ______________NM

i.) Single Point Datum *Length* = $2 \times R$

ii.) Leeway Divergence Datums *Length* = $(2 \times R) + DD$

iii.) Line Datum Length of the Base Line ($L_b$) _____________NM

a.) No Extensions *Length* = $L_b$

b.) One Extension *Length* = $R + L_b$

c.) Two Extensions *Length* = $(2 \times R) + L_b$

b. Width = $2 \times R$ — Width _____________NM

15. Plot the adjusted search area on a suitable chart (Check when done)______

16. Divide the adjusted search area in to search sub-areas according to the values on **line 11**. (Check when done)______

17. Go to the **Search Action Plan Worksheet**.

## Effort Allocation Worksheet Instructions

## For Optimal Search of Single Point, Leeway Divergence, or Line Datums

**Introduction.** This **Effort Allocation Worksheet** is used to determine the optimal way to allocate the available search effort around a single datum point, over two divergent datum points or along a datum line. It considers the search effort that several dissimilar search facilities can provide. The worksheet also aids in computing the optimal area to search and the optimum uniform coverage factor. Finally, the worksheet provides guidance for determining the actual search sub-area dimensions for each available search facility. This worksheet is based on a DAYLIGHT VISUAL SEARCH.

Enter the case title, case number, datum number, search designator, datum latitude, longitude and time, and the primary search object from the **Datum Worksheet**. In the space labelled "Planner's Name," enter the name of the person responsible for completing this worksheet.

### Effort Allocation Computations

1. Available Search Effort ($Z_a$) — Enter the total available search effort ($Z_{ta}$) from **line 14** of the **Total Available Search Effort Worksheet** unless the left and right datums are to be treated as separate searches. In that case, two **Effort Allocation Worksheets** will be required. Enter the available effort for the left datum ($Z_{a(left)}$) on one worksheet and the available effort for the right datum ($Z_{a(right)}$) on the other worksheet.

2. Effort Factor ($f_Z$) — The effort factor ($f_Z$) provides a standard method for characterizing the size of the area where the search object is probably located. Although the effort factor has units of *area*, its value is only a fraction of the area where the search object may be located.

   (a) Total Probable Error of Position ($E$) — Enter the total probable error of position ($E$) from **line H.2** of the **Datum Worksheet**.

   (b) Length of Datum Line ($L$) — **For line datums only:** Measure or compute the length of the base line ($L_b$) connecting two points, such as the last known position of a vessel or aircraft and the next point at which a report was expected but not received. When appropriate, extend the base line in one or both directions by an amount equal to $E$ to form the datum line ($L$). Examples:

   (i) A vessel's intended track lies between two ports, the LKP was the port of departure and the vessel is overdue at its destination. The base line is not extended over land in either direction and $L = L_b$.

(ii) A vessel's intended track lies between its last reported position at sea and its next port of call, where it is overdue. In this situation, the seaward end of the base line is extended by $E$ and $L = L_b + E$.

(iii) Both the last reported position and the next position where the vessel or aircraft was expected to report might be in error. In this situation, both ends of the base line are extended by $E$ and $L = L_b + 2 \times E$. **Figure L-4** depicts this situation.

(iv) The length of the datum line was computed on **line 6.a** of the **Widely Diverging Datums Worksheet**. In this situation, the divergence distance ($DD$) was used as the length of the base line ($L_b$) that was then extended in both directions to form the datum line, as shown in **Figure L-4**.

Enter the value of $L$ on **line 2.b** if this effort allocation is for a datum line. Otherwise, leave blank.

(c) Effort Factor ($f_Z$)

For single and diverging point datums, enter the total probable error of position squared ($E^2$) from **line H.1** of the **Datum Worksheet** or square the total probable error of position ($E$) from **line 2.a**. Stated as a formula, $f_{Zp} = E^2$. For line datums, multiply the total probable error of position ($E$) from **line 2.a** by the length of the datum line ($L$) from **line 2.b**. Stated as a formula, $f_{Zl} = E \times L$.

3. Relative Effort ($Z_r$)

The relative effort ($Z_r$) shows the relationship between the available search effort ($Z_a$) and the size of the area where the search object may be located. The relative effort ($Z_r$) is computed as the ratio of the available effort ($Z_a$) to the effort factor ($f_Z$). Divide the available effort ($Z_a$) from **line 1** by the effort factor ($f_Z$) from **line 2.c**.

4. Cumulative Relative Effort ($Z_{rc}$)

Add the relative effort ($Z_r$) on **line 3** to the cumulative relative effort ($Z_{rc}$) from **line 4** of the previous **Effort Allocation Worksheet**. If this is the first search, enter the value of $Z_r$ from **line 3** above. If this is the first time two leeway divergence datums are being treated separately, assume one half of the relative effort ($Z_{rc}$) from **line 4** of the previous **Effort Allocation Worksheet** was applied to each datum.

5. Optimal Search Factor ($f_s$)

Check "Ideal" or "Poor" search conditions, as appropriate. If any of the correction factors on **lines 9**, **10** or **11** of the **Total Available Search Effort Worksheet** are less than **1.0**, or if any probable search facility position error exceeds the corresponding corrected sweep width, check "Poor" search conditions. Otherwise, check "Ideal" search conditions. Enter the optimal search factor ($f_s$) from the appropriate graph and curve in **Appendix N** (**Figure N-5** or **N-6** for single point and leeway divergence datums, **Figure N-7** or **N-8** for line datums).

| | |
|---|---|
| 6. Optimal Search Radius ($R_o$) | Multiply the optimal search factor ($f_s$) from **line 5** by the total probable error of position ($E$) from **line 2.a**. |
| 7. Optimal Search Area ($A_o$) | The optimal search area depends on whether the type of datum is (a) a single point datum, (b) two leeway divergence datums, or (c) a line datum. |
| a. Single Point Datum | For a single point datum, square the optimal search radius ($R_o$) from **line 6** and multiply by four. Stated as a formula, $A_o = 4 \times R_o^2$. |
| b. Leeway Divergence Datums | For two leeway divergence datums, copy the divergence distance ($DD$) between the two datums from **line G.3** of the **Datum Worksheet** to **line 7.b** of this worksheet. Compute the optimal search area ($A_o$) using the following formula: $A_o = (4 \times R_o^2) + (2 \times R_o \times DD)$. |
| c. Line Datum | For a line datum, multiply twice the optimal search radius ($R_o$) from **line 6** by the length of the datum line ($L$) from **line 2.b**. Stated as a formula, $A_o = 2 \times R_o \times L$. |
| 8. Optimal Coverage Factor ($C_o$) | Divide the available search effort ($Z_a$) from **line 1** by the optimal search area ($A_o$) from **line 7**. |
| 9. Optimal Track Spacing ($S_o$) | Divide the corrected sweep widths ($W$) from **line 12** of the **Total Available Search Effort Worksheet** by the optimal coverage factor ($C_o$) from **line 8**. |
| 10. Nearest Assignable Track Spacing ($S$) | Round the optimal track spacing ($S_o$) from **line 9** to a value that the corresponding search facility can navigate safely and accurately. |
| 11. Adjusted Search Areas ($A$) | Multiply the search facility's speed from **line 3** of the **Total Available Search Effort Worksheet** by the search facility's endurance from **line 6** of the **Total Available Search Effort Worksheet** and multiply the result by the nearest assignable track spacing from **line 10** of this worksheet. Stated as a formula, $A = V \times T \times S$. **Figure N-9** may also be used to find the adjusted search areas. |
| 12. Total Adjusted Search Area ($A_t$) | Add the individual Adjusted Search Area alues listed on **line 11** and enter the total. |
| 13. Adjusted Search Radius | The adjusted search radius ($R$) depends on whether the type of datum is (a) a single point datum, (b) two leeway divergence datums, or (c) a line datum. |

a. Single Point Datum

For single point datums, the adjusted search radius ($R$) is one-half the square root of the total adjusted search area ($A_t$) from **line 12.** Stated as a formula,

$$R = \frac{\sqrt{A_t}}{2}$$

b. Leeway Divergence Datums

For two diverging point datums, the search planner must adjust the search radius so the area of the actual search rectangle equals the total adjusted search area ($A_t$) from **line 12**. The following formula is used to compute an adjusted search radius ($R$) for the circles around each datum.

$$R = \frac{\sqrt{DD^2 + (4 \times A_t)} - DD}{4},$$

c. Line Datum

For a line datum, divide the total adjusted search area ($A_t$) from **line 12** by twice the length of the datum line ($L$) from **line 2.a** to get the adjusted search radius. Stated as a formula,

$$R = \frac{A_t}{2 \times L}$$

14. Adjusted Search Area Dimensions

Choose the correct type of datum below, compute the length of the adjusted search area on **line 14.a** and the width of the adjusted search area on **line 14.b** using the formulas provided.

a. Length

The formula used to find the length of the adjusted search area depends on whether the type of datum is (i) a single point datum, (ii) two leeway divergence datums, or (iii) a line datum.

i. Single Point Datum

The adjusted search area is a square with its length equal to twice the adjusted search radius from **line 13**. Stated as a formula,

$$Length = 2 \times R$$

ii. Leeway Divergence Datums

The length of the adjusted search area is found by adding twice the adjusted search radius ($R$) from **line 13** to the divergence distance ($DD$). Stated as a formula,

$$Length = (2 \times R) + DD$$

iii. Line Datum

Enter the length of the base line portion ($L_b$) of the datum line. The length of the adjusted search area depends on whether the datum line was formed with zero, one, or two extensions as described in the instructions for **line 2.b**.

a.) No Extensions

If the base line was not extended in either direction to form the datum line, then the length of the adjusted search area is the same as the length of the base line ($L_b$).

$$Length = L_b$$

b.) One Extension

If only one end of the base line was extended to form the datum line, then the length of the adjusted search area is the adjusted search radius ($R$) plus the length of the base line ($L_b$).

$$Length = R + L_b$$

c.) Two Extensions

If the base line was extended in both directions to form the datum line, then the length of the adjusted search area is twice the adjusted search radius ($R$) plus the length of the base line ($L_b$).

$$Length = (2 \times R) + L_b$$

b. Width

The formula used to find the width of the adjusted search area is the same in all cases. The width is always equal to twice the adjusted search radius ($R$). Stated as a formula,

$$Width = 2 \times R$$

15. Plot the adjusted search area on a suitable chart

Using a suitable chart, plot the adjusted search square(s) or rectangle centred on the datum(s).

a. Single Point Datum

Using the datum position as the centre, draw a circle with its radius equal to the adjusted search radius ($R$) from **line 13**. Estimate the direction of search object drift during the search. Circumscribe a square around the circle and orient the square so the search legs will be parallel to the predicted direction of drift during the search. In **Figure L-1** it is assumed the direction of drift during the search will be the same as the average direction of drift from the last known position.

b. Leeway Divergence Datums

Using each of the datum positions as a centre, draw a circle around each datum with its radius equal to the adjusted search radius ($R$) from **line 13**. Based on the distance separating the circles, decide whether to use a single rectangle as shown in **Figure L-2** or two squares as shown in **Figure L-3**. Estimate the directions of search object drift during the search. Orient the search sub-areas so the search legs are as nearly parallel as possible to the predicted directions of search object drift during the search. However, do not compromise safety of search facility navigation in adjacent search sub-areas.

c. Line Datum

Instructions for plotting the adjusted search area depend on whether the datum line was formed with zero, one, or two extensions as described in the instructions for **line 2.b**.

i.) No Extensions

If the base line was not extended in either direction to form the datum line, draw lines perpendicular to the base line at each end. On each of these perpendicular lines, use a compass or dividers to measure a distance equal to the adjusted search radius (*R*) in each direction from the datum line. Using these four points as the corner points, plot the rectangular adjusted search area. (See **Figure L-5**.)

ii.) One Extension

If the base line was extended in only one direction to form the datum line, draw a line perpendicular to the base line at the end that was **not** extended. Measure a distance equal to the adjusted search radius (*R*) in each direction from the datum line along the perpendicular line. These two points will be two of the corner points of the rectangular adjusted search area. Using the other end of the **base line** as the centre, draw a circle with its radius equal to the adjusted search radius (*R*). Draw a rectangle that includes the previous two corner points and the circle. (See **Figure L-6**.)

iii.) Two Extensions

If the base line was extended in both directions to form the datum line, draw a circle with a radius equal to the adjusted search radius (*R*) around each end point of the **base line**. Be certain to use the end points of the **base line** as the centres of the circles, not the end points of the datum line. Circumscribe a single rectangle around both circles. (See **Figure L-7**.)

16. Adjust the locations, lengths and widths of the search sub-areas so they fill the total adjusted search area as nearly as possible. The following guidelines may be used:

a) The width of each search sub-area must equal a whole number of track spacings. Some adjustment of track spacings may be made, but care must be taken to ensure all track spacings remain within the usable limits of the assigned search facility's navigational capability.

b) The search legs should be parallel to the search object's anticipated direction of movement during the search.

c) For fixed-wing aircraft, a flying time of about 30 minutes per search leg is recommended. For rotary wing aircraft, a flying time of about 20 minutes is recommended.

*Note 1:* *POS values tend to be very stable near the point of perfectly optimal effort allocation. This allows search planners the freedom needed to adapt the optimal allocation of effort to account for practical considerations imposed by the environment and the capabilities of the search facilities. Normally, small changes from the optimal values indicated in lines 10-14 that are needed to make the search plan practical will not have a large impact on search effectiveness (POS).*

*Note 2:* *Do not use the POS graphs (**Figures N-11 and N-12**) for searches of leeway divergence datums. The variations in the relationship between divergence distance and the probable error of position create a situation that is too complex to represent on a graph. For the same reason, no templates for constructing probability maps for two leeway divergence datums are provided in Appendix M.*

17. Go to the **Search Action Plan Worksheet** where the plotted search sub-areas of **line 16** will be specified in one of the standard formats (methods) such as the corner-point method. The search action plan will also provide all necessary co-ordination instructions such as assigning specific search facilities to specific search sub-areas, search patterns, altitudes to each aircraft, commence search points, direction of creep (for parallel sweep and creeping line search patterns), etc.

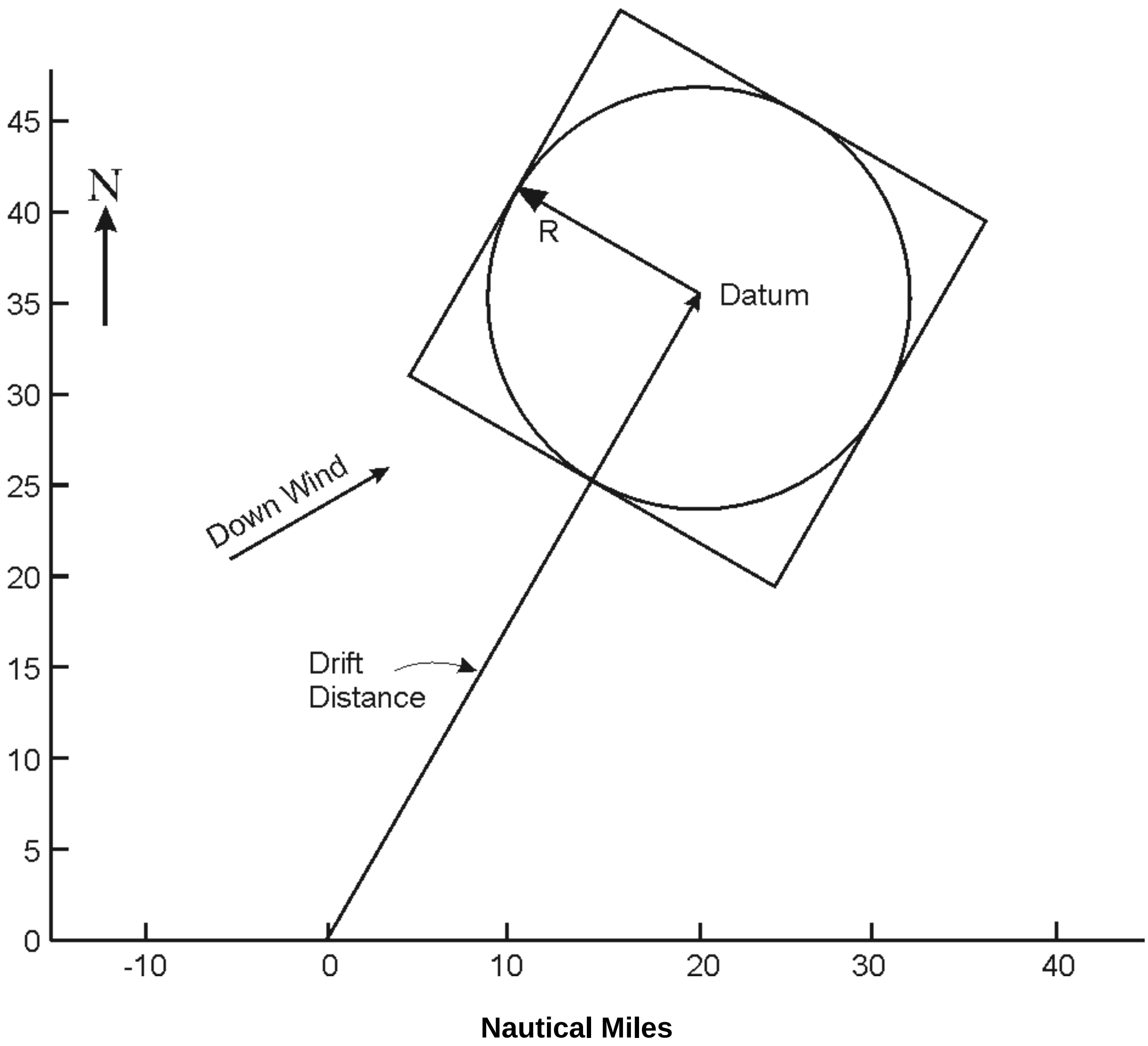


Figure L-1 – Search Area for a Single Point Datum

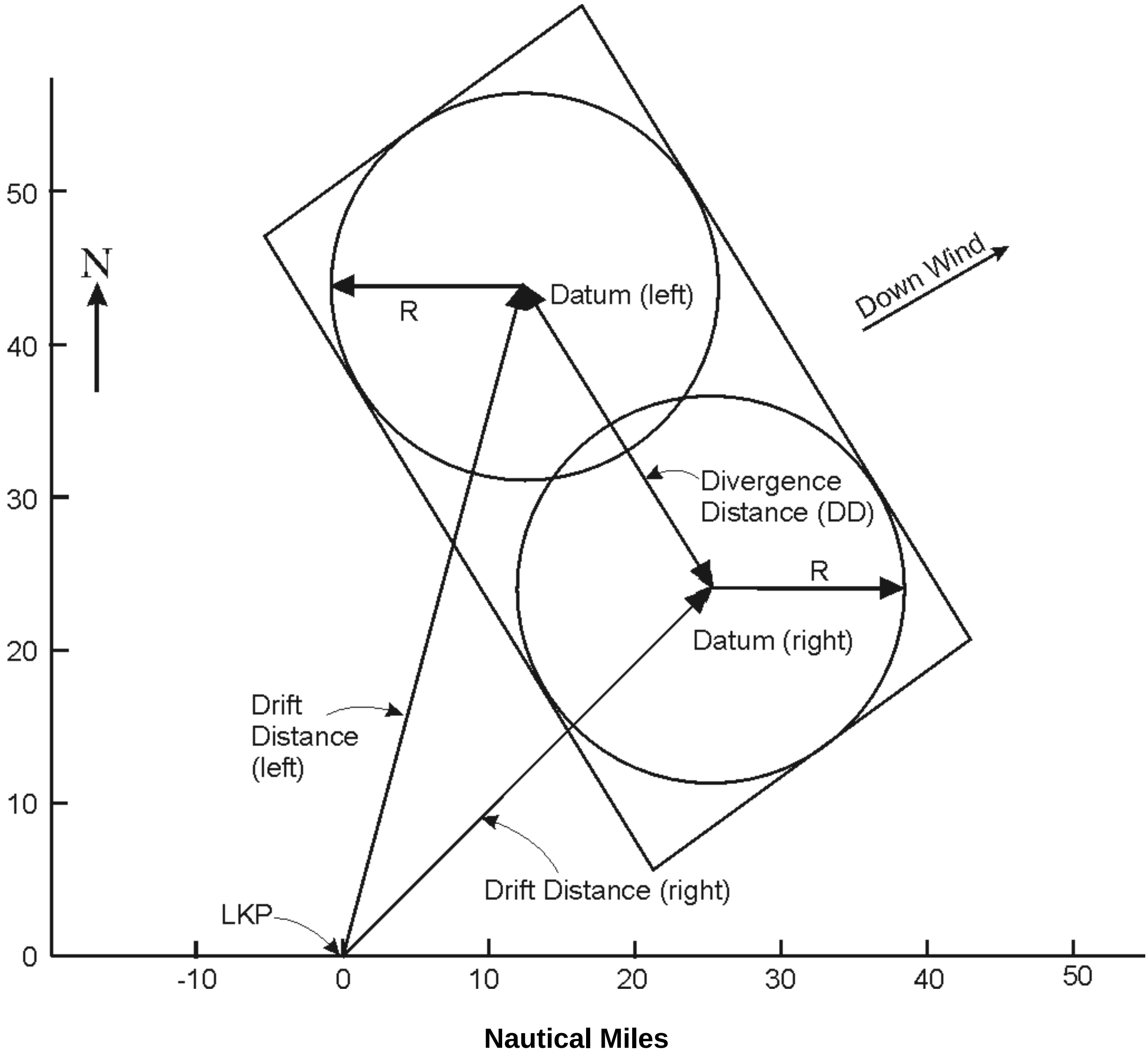


Figure L-2 – Search Area for Two Leeway Divergence Datums
When the Leeway Divergence Distance (*DD*) Is Less Than $4 \times E$.

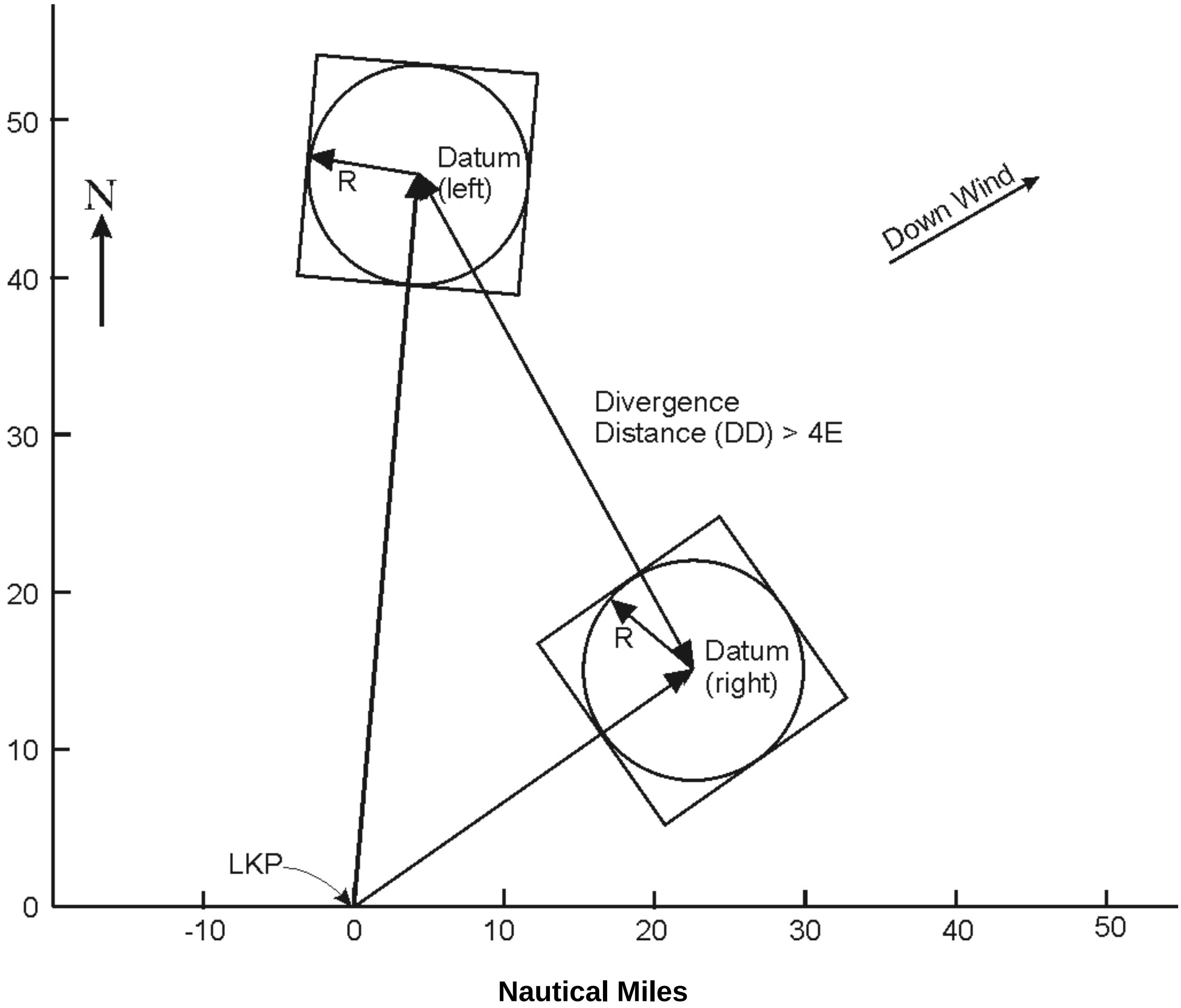


Figure L-3 – Search Areas for Two Leeway Divergence Datums
When the Leeway Divergence Distance (*DD*) is Greater Than $4 \times E$.

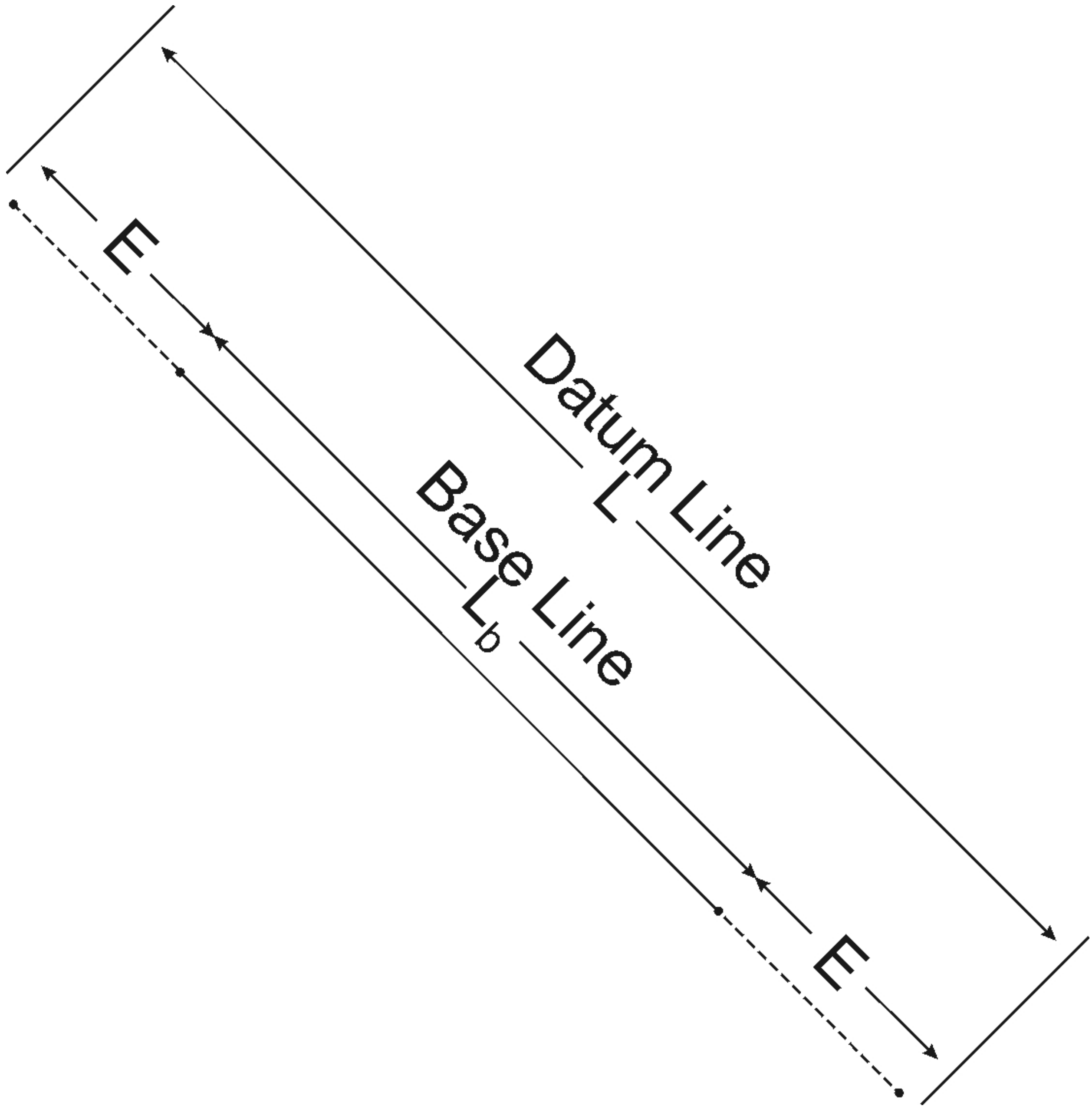


Figure L-4 – Forming a Datum Line from a Base Line

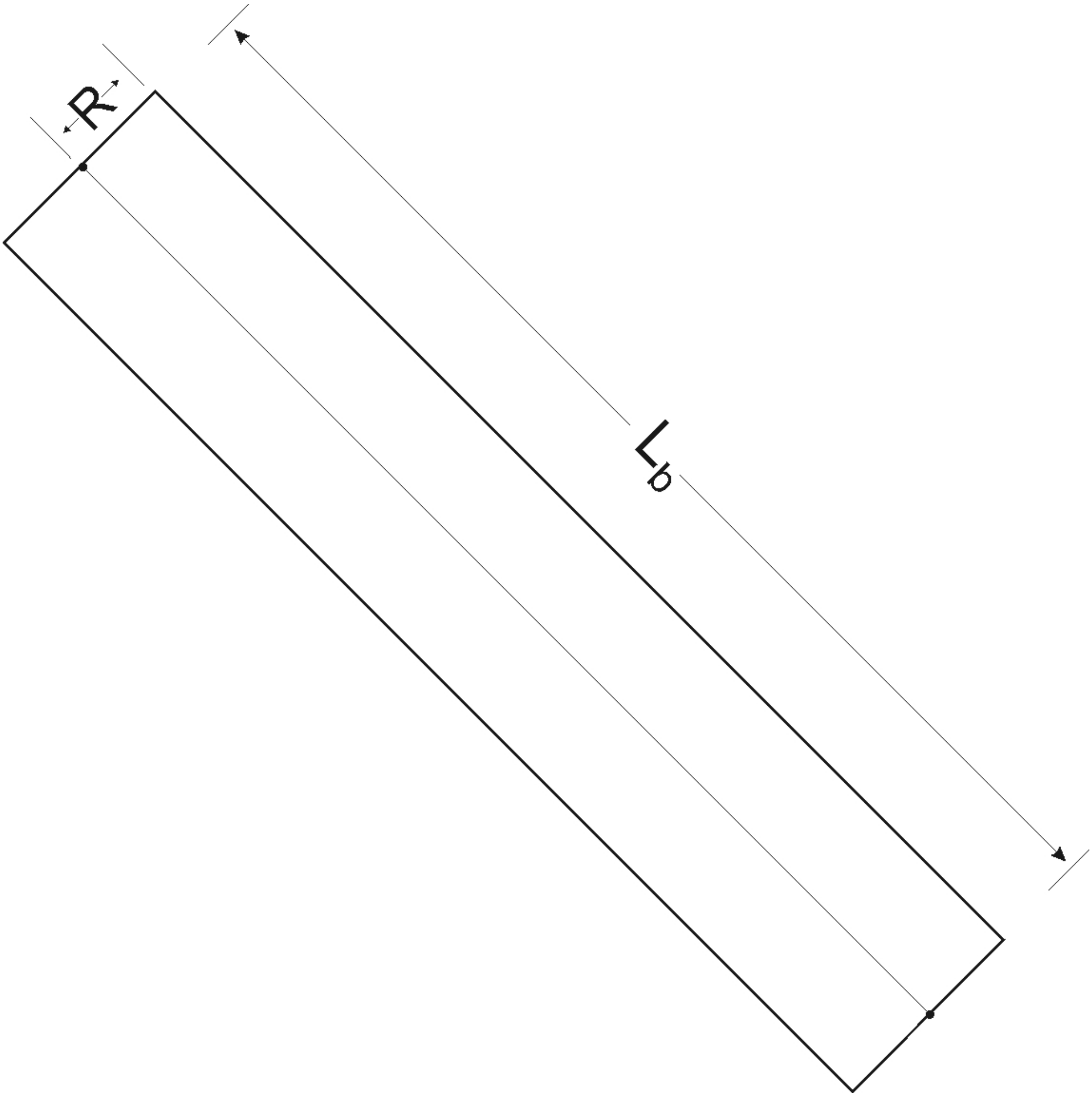


Figure L-5 – Search Area for a Line Datum (Neither End Extended)

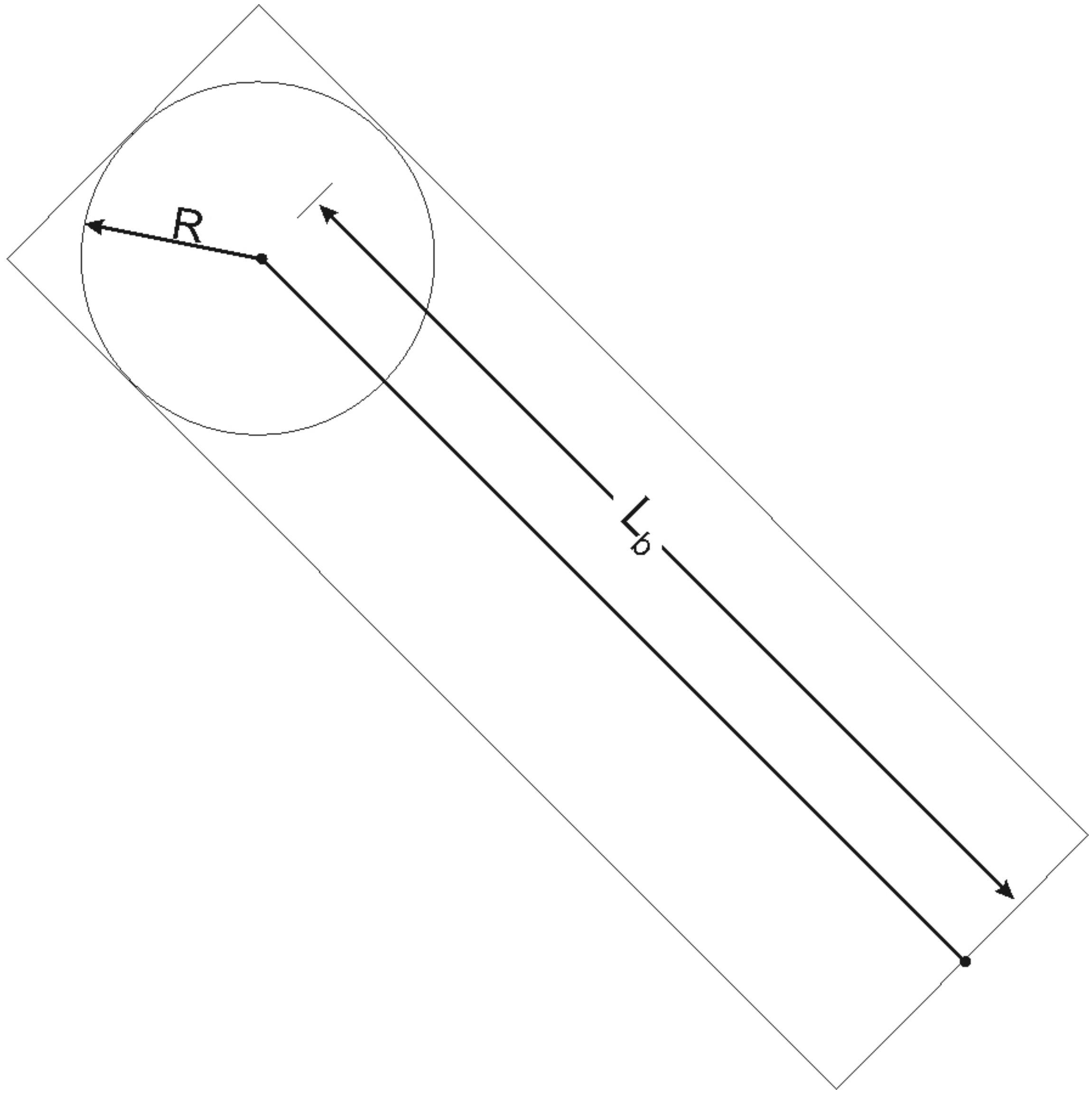


Figure L-6 – Search Area for a Line Datum (One End Extended)

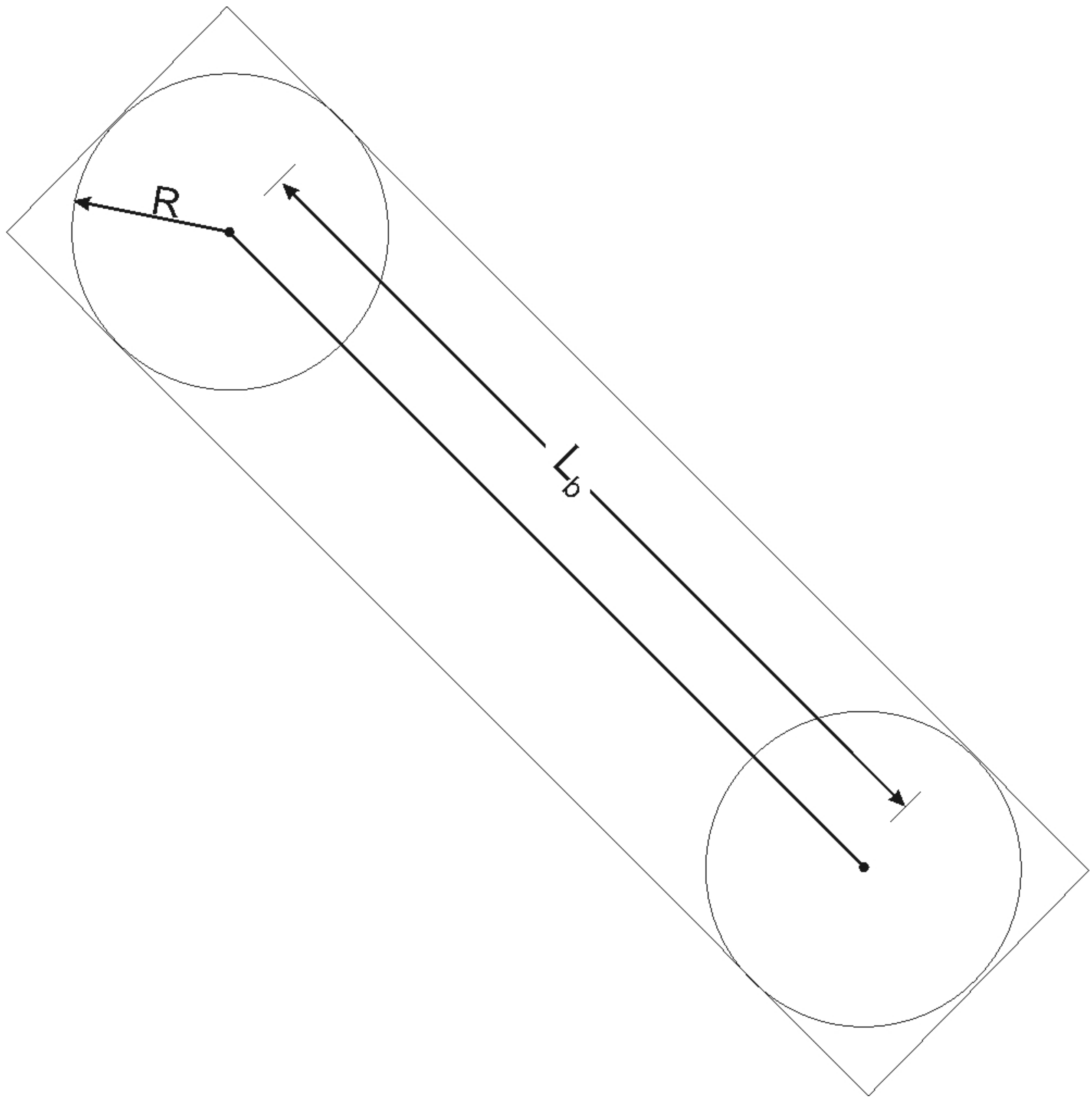


Figure L-7 – Search Area for a Line Datum (Both Ends Extended)

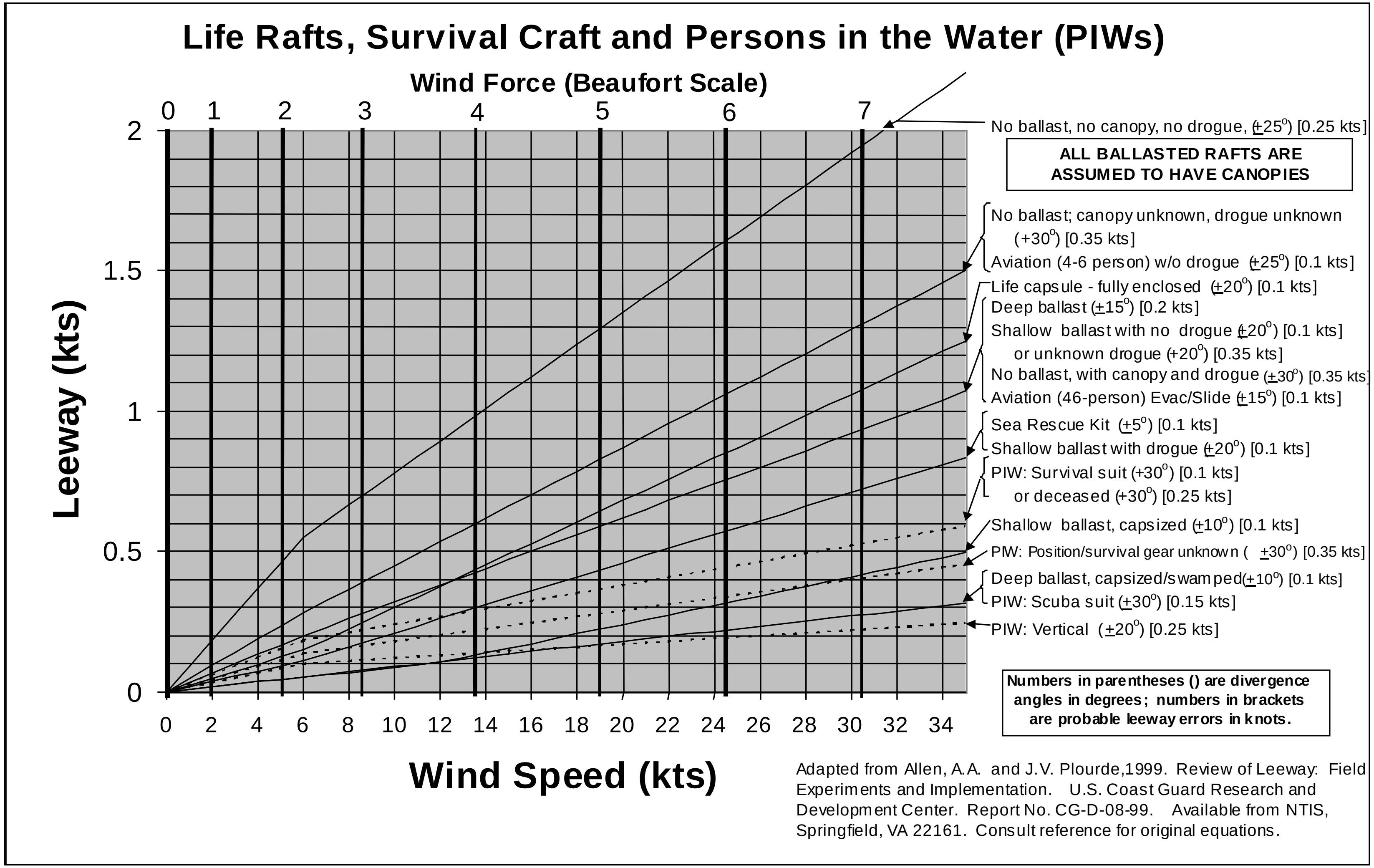


Figure N-2 – Leeway of Life Rafts, Survival Craft and Persons in the Water (PIWs)

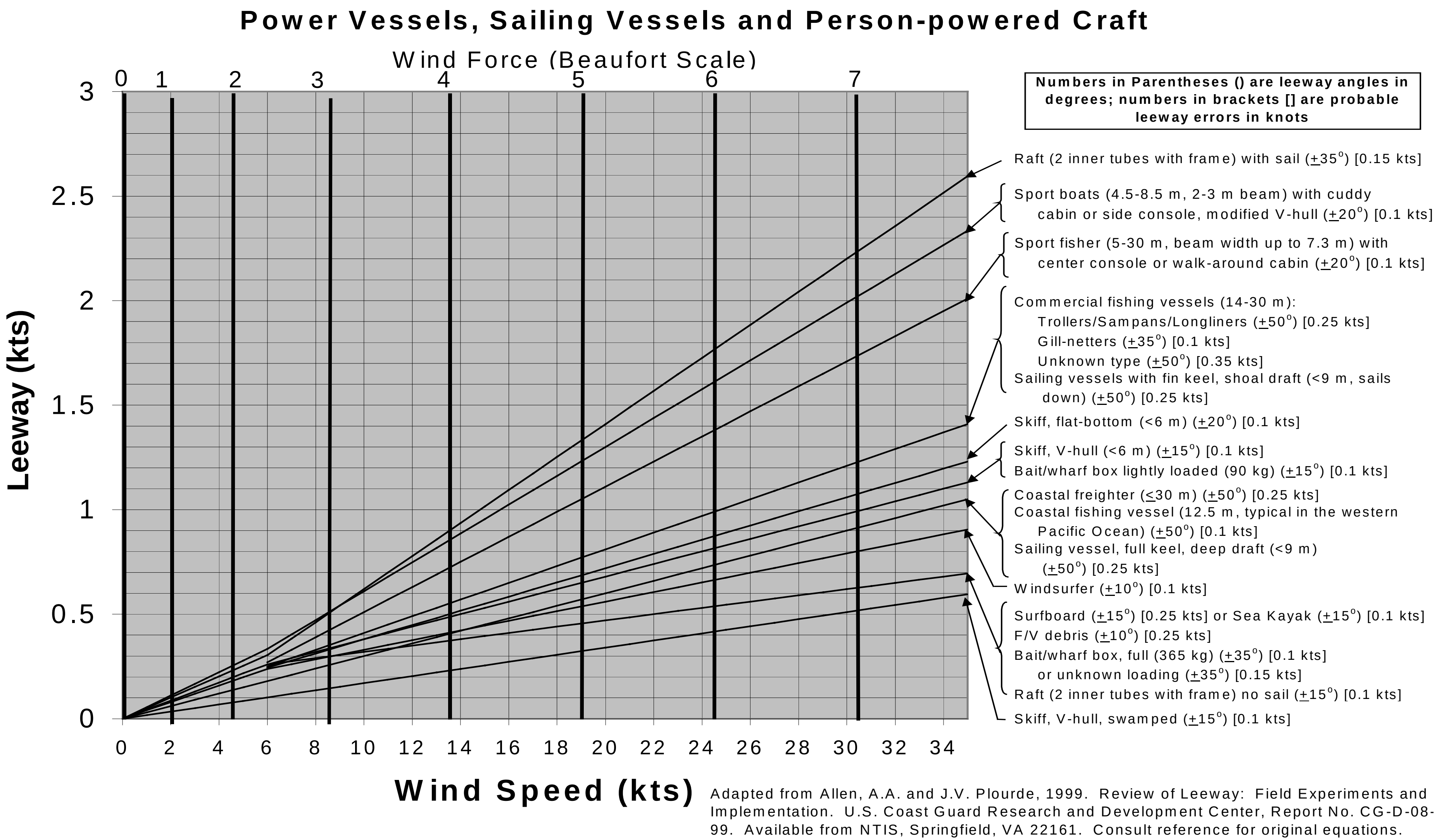


Figure N-3 – Leeway for Power Vessels, Sailing Vessels and Person-powered Craft

| *Search Object* (metres (feet)) | *Altitude 150 metres (500 feet) Visibility (km (NM))* | | | | | | *Altitude 300 metres (1000 feet) Visibility (km (NM))* | | | | | | *Altitude 600 metres (2000 feet) Visibility (km (NM))* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* |
| Person in Water* | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.2 (0.1) |
| Raft 1 person | 0.7 (0.4) | 1.7 (0.9) | 2.2 (1.2) | 3.0 (1.6) | 3.3 (1.8) | 3.3 (1.8) | 0.7 (0.4) | 1.7 (0.9) | 2.2 (1.2) | 3.0 (1.6) | 3.3 (1.8) | 3.3 (1.8) | 0.4 (0.2) | 1.5 (0.8) | 2.2 (1.2) | 3.0 (1.6) | 3.3 (1.8) | 3.3 (1.8) |
| Raft 4 person | 0.9 (0.5) | 2.2 (1.2) | 3.0 (1.6) | 4.1 (2.2) | 4.8 (2.6) | 5.2 (2.8) | 0.9 (0.5) | 2.2 (1.2) | 3.1 (1.7) | 4.3 (2.3) | 4.8 (2.6) | 5.4 (2.9) | 0.6 (0.3) | 2.2 (1.2) | 3.1 (1.7) | 4.3 (2.3) | 5.0 (2.7) | 5.6 (3.0) |
| Raft 6 person | 0.9 (0.5) | 2.6 (1.4) | 3.5 (1.9) | 5.0 (2.7) | 5.9 (3.2) | 6.5 (3.5) | 0.9 (0.5) | 2.6 (1.4) | 3.7 (2.0) | 5.2 (2.8) | 5.9 (3.2) | 6.5 (3.5) | 0.6 (0.3) | 2.6 (1.4) | 3.7 (2.0) | 5.2 (2.8) | 6.1 (3.3) | 6.7 (3.6) |
| Raft 8 person | 1.1 (0.6) | 2.8 (1.5) | 3.7 (2.0) | 5.2 (2.8) | 6.1 (3.3) | 6.9 (3.7) | 0.9 (0.5) | 2.8 (1.5) | 3.9 (2.1) | 5.4 (2.9) | 6.3 (3.4) | 7.0 (3.8) | 0.6 (0.3) | 2.8 (1.5) | 3.9 (2.1) | 5.6 (3.0) | 6.7 (3.6) | 7.2 (3.9) |
| Raft 10 person | 1.1 (0.6) | 3.0 (1.6) | 4.1 (2.2) | 5.7 (3.1) | 6.7 (3.6) | 7.4 (4.0) | 0.9 (0.5) | 3.0 (1.6) | 4.1 (2.2) | 5.9 (3.2) | 6.9 (3.7) | 7.6 (4.1) | 0.6 (0.3) | 3.0 (1.6) | 4.3 (2.3) | 6.1 (3.3) | 7.2 (3.9) | 7.8 (4.2) |
| Raft 15 person | 1.1 (0.6) | 3.1 (1.7) | 4.3 (2.3) | 6.1 (3.3) | 7.4 (4.0) | 8.1 (4.4) | 1.1 (0.6) | 3.1 (1.7) | 4.4 (2.4) | 6.5 (3.5) | 7.6 (4.1) | 8.3 (4.5) | 0.6 (0.3) | 3.1 (1.7) | 4.6 (2.5) | 6.7 (3.6) | 8.0 (4.3) | 8.7 (4.7) |
| Raft 20 person | 1.1 (0.6) | 3.3 (1.8) | 4.8 (2.6) | 7.0 (3.8) | 8.5 (4.6) | 9.4 (5.1) | 1.1 (0.6) | 3.3 (1.8) | 5.0 (2.7) | 7.2 (3.9) | 8.7 (4.7) | 9.6 (5.2) | 0.7 (0.4) | 3.3 (1.8) | 5.0 (2.7) | 7.4 (4.0) | 9.1 (4.9) | 10.0 (5.4) |
| Raft 25 person | 1.1 (0.6) | 3.5 (1.9) | 5.0 (2.7) | 7.6 (4.1) | 9.3 (5.0) | 10.4 (5.6) | 1.1 (0.6) | 3.5 (1.9) | 5.2 (2.8) | 7.8 (4.2) | 9.4 (5.1) | 10.6 (5.7) | 0.7 (0.4) | 3.5 (1.9) | 5.4 (2.9) | 8.0 (4.3) | 9.8 (5.3) | 10.9 (5.9) |
| Power Boat < 5 (15) | 0.9 (0.5) | 2.2 (1.2) | 2.8 (1.5) | 3.5 (1.9) | 4.1 (2.2) | 4.3 (2.3) | 0.9 (0.5) | 2.2 (1.2) | 3.0 (1.6) | 3.9 (2.1) | 4.3 (2.3) | 4.6 (2.5) | 0.6 (0.3) | 2.4 (1.3) | 3.1 (1.7) | 4.3 (2.3) | 4.8 (2.6) | 5.0 (2.7) |
| Power Boat 6 (20) | 1.3 (0.7) | 3.7 (2.0) | 5.4 (2.9) | 8.0 (4.3) | 9.6 (5.2) | 10.7 (5.8) | 1.3 (0.7) | 3.9 (2.1) | 5.6 (3.0) | 8.1 (4.4) | 9.8 (5.3) | 10.9 (5.9) | 0.7 (0.4) | 3.9 (2.1) | 5.6 (3.0) | 8.3 (4.5) | 10.2 (5.5) | 11.3 (6.1) |
| Power Boat 10 (33) | 1.5 (0.8) | 4.6 (2.5) | 7.2 (3.9) | 11.5 (6.2) | 14.4 (7.8) | 16.7 (9.0) | 1.3 (0.7) | 4.8 (2.6) | 7.2 (3.9) | 11.7 (6.3) | 14.6 (7.9) | 16.9 (9.1) | 0.9 (0.5) | 4.8 (2.6) | 7.4 (4.0) | 11.9 (6.4) | 14.8 (8.0) | 17.2 (9.3) |
| Power Boat 16 (53) | 1.5 (0.8) | 5.7 (3.1) | 9.4 (5.1) | 17.0 (9.2) | 22.8 (12.3) | 27.2 (14.7) | 1.3 (0.7) | 5.7 (3.1) | 9.6 (5.2) | 17.0 (9.2) | 22.8 (12.3) | 27.4 (14.8) | 0.9 (0.5) | 5.6 (3.0) | 9.6 (5.2) | 17.2 (9.3) | 23.0 (12.4) | 27.6 (14.9) |
| Power Boat 24 (78) | 1.5 (0.8) | 6.1 (3.3) | 10.6 (5.7) | 20.0 (10.8) | 27.8 (15.0) | 34.1 (18.4) | 1.5 (0.8) | 6.1 (3.3) | 10.6 (5.7) | 20.2 (10.9) | 27.8 (15.0) | 34.3 (18.5) | 0.9 (0.5) | 5.9 (3.2) | 10.6 (5.7) | 20.2 (10.9) | 28.0 (15.1) | 34.3 (18.5) |
| Sail Boat 5 (15) | 1.3 (0.7) | 3.5 (1.9) | 5.0 (2.7) | 7.2 (3.9) | 8.7 (4.7) | 9.6 (5.2) | 1.1 (0.6) | 3.5 (1.9) | 5.2 (2.8) | 7.4 (4.0) | 8.9 (4.8) | 10.0 (5.4) | 0.7 (0.4) | 3.5 (1.9) | 5.2 (2.8) | 7.8 (4.2) | 9.3 (5.0) | 10.4 (5.6) |
| Sail Boat 8 (26) | 1.5 (0.8) | 4.4 (2.4) | 6.9 (3.7) | 10.6 (5.7) | 13.1 (7.1) | 15.2 (8.2) | 1.3 (0.7) | 4.6 (2.5) | 6.9 (3.7) | 10.7 (5.8) | 13.5 (7.3) | 15.4 (8.3) | 0.9 (0.5) | 4.6 (2.5) | 7.0 (3.8) | 11.1 (6.0) | 13.9 (7.5) | 15.9 (8.6) |
| Sail Boat 12 (39) | 1.5 (0.8) | 5.6 (3.0) | 9.1 (4.9) | 15.4 (8.3) | 20.9 (11.3) | 25.0 (13.5) | 1.3 (0.7) | 5.6 (3.0) | 9.1 (4.9) | 15.9 (8.6) | 21.1 (11.4) | 25.0 (13.5) | 0.9 (0.5) | 5.6 (3.0) | 9.1 (4.9) | 16.1 (8.7) | 21.1 (11.4) | 25.2 (13.6) |
| Sail Boat 15 (49) | 1.5 (0.8) | 5.7 (3.1) | 9.6 (5.2) | 17.6 (9.5) | 23.5 (12.7) | 28.3 (15.3) | 1.3 (0.7) | 5.7 (3.1) | 9.8 (5.3) | 17.6 (9.5) | 23.7 (12.8) | 28.5 (15.4) | 0.9 (0.5) | 5.7 (3.1) | 9.8 (5.3) | 17.8 (9.6) | 23.9 (12.9) | 28.7 (15.5) |
| Sail Boat 21 (69) | 1.5 (0.8) | 5.9 (3.2) | 10.2 (5.5) | 19.3 (10.4) | 26.1 (14.1) | 32.0 (17.3) | 1.5 (0.8) | 5.9 (3.2) | 10.4 (5.6) | 19.3 (10.4) | 26.3 (14.2) | 32.0 (17.3) | 0.9 (0.5) | 5.9 (3.2) | 10.4 (5.6) | 19.4 (10.5) | 26.5 (14.3) | 32.2 (17.4) |
| Sail Boat 25 (83) | 1.5 (0.8) | 6.1 (3.3) | 10.6 (5.7) | 20.4 (11.0) | 28.2 (15.2) | 34.6 (18.7) | 1.5 (0.8) | 6.1 (3.3) | 10.6 (5.7) | 20.4 (11.0) | 28.3 (15.3) | 34.8 (18.8) | 0.9 (0.5) | 5.9 (3.2) | 10.6 (5.7) | 20.6 (11.1) | 28.5 (15.4) | 35.0 (18.9) |
| Ship 27-46 (90-150) | 1.5 (0.8) | 6.3 (3.4) | 11.1 (6.0) | 22.6 (12.2) | 32.2 (17.4) | 40.6 (21.9) | 1.5 (0.8) | 6.3 (3.4) | 11.1 (6.0) | 22.6 (12.2) | 32.2 (17.4) | 40.6 (21.9) | 0.9 (0.5) | 6.1 (3.3) | 11.1 (6.0) | 22.6 (12.2) | 32.4 (17.5) | 40.7 (22.0) |
| Ship 46-91 (150-300) | 1.5 (0.8) | 6.3 (3.4) | 11.7 (6.3) | 25.2 (13.6) | 37.8 (20.4) | 49.3 (26.6) | 1.5 (0.8) | 6.3 (3.4) | 11.7 (6.3) | 25.2 (13.6) | 37.8 (20.4) | 49.3 (26.6) | 0.9 (0.5) | 6.3 (3.4) | 11.7 (6.3) | 25.2 (13.6) | 37.8 (20.4) | 49.3 (26.6) |
| Ship > 91 (300) | 1.5 (0.8) | 6.5 (3.5) | 11.9 (6.4) | 26.5 (14.3) | 40.9 (22.1) | 55.2 (29.8) | 1.5 (0.8) | 6.5 (3.5) | 11.9 (6.4) | 26.5 (14.3) | 41.1 (22.2) | 55.2 (29.8) | 1.1 (0.6) | 6.3 (3.4) | 11.9 (6.4) | 26.5 (14.3) | 41.1 (22.2) | 55.2 (29.8) |

* For search altitudes of 150 metres (500 feet) only, the sweep width values for a person in water may be multiplied by 4, if it is known that the person is wearing a personal flotation device.

**Table N-5 – Sweep widths for helicopters (km (NM))**

| *Search Object* (metres (feet)) | *Altitude 150 metres (500 feet) Visibility (km (NM))* | | | | | | *Altitude 300 metres (1000 feet) Visibility (km (NM))* | | | | | | *Altitude 600 metres (2000 feet) Visibility (km (NM))* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* | *1.9 (1)* | *5.6 (3)* | *9.3 (5)* | *18.5 (10)* | *27.8 (15)* | *>37.0 (>20)* |
| Person in Water* | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.2 (0.1) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| Raft 1 person | 0.6 (0.3) | 1.3 (0.7) | 1.7 (0.9) | 2.2 (1.2) | 2.6 (1.4) | 2.6 (1.4) | 0.6 (0.3) | 1.3 (0.7) | 1.7 (0.9) | 2.2 (1.2) | 2.6 (1.4) | 2.6 (1.4) | 0.2 (0.1) | 1.1 (0.6) | 1.7 (0.9) | 2.2 (1.2) | 2.6 (1.4) | 2.6 (1.4) |
| Raft 4 person | 0.7 (0.4) | 1.9 (1.0) | 2.4 (1.3) | 3.3 (1.8) | 3.7 (2.0) | 4.1 (2.2) | 0.6 (0.3) | 1.9 (1.0) | 2.4 (1.3) | 3.3 (1.8) | 3.9 (2.1) | 4.3 (2.3) | 0.4 (0.2) | 1.7 (0.9) | 2.4 (1.3) | 3.5 (1.9) | 4.1 (2.2) | 4.3 (2.3) |
| Raft 6 person | 0.7 (0.4) | 2.0 (1.1) | 2.8 (1.5) | 4.1 (2.2) | 4.6 (2.5) | 5.2 (2.8) | 0.7 (0.4) | 2.0 (1.1) | 3.0 (1.6) | 4.1 (2.2) | 4.8 (2.6) | 5.2 (2.8) | 0.4 (0.2) | 2.0 (1.1) | 3.0 (1.6) | 4.3 (2.3) | 5.0 (2.7) | 5.4 (2.9) |
| Raft 8 person | 0.7 (0.4) | 2.2 (1.2) | 3.0 (1.6) | 4.3 (2.3) | 5.0 (2.7) | 5.4 (2.9) | 0.7 (0.4) | 2.2 (1.2) | 3.1 (1.7) | 4.4 (2.4) | 5.2 (2.8) | 5.6 (3.0) | 0.4 (0.2) | 2.2 (1.2) | 3.1 (1.7) | 4.6 (2.5) | 5.4 (2.9) | 5.9 (3.2) |
| Raft 10 person | 0.7 (0.4) | 2.2 (1.2) | 3.1 (1.7) | 4.6 (2.5) | 5.4 (2.9) | 5.9 (3.2) | 0.7 (0.4) | 2.4 (1.3) | 3.3 (1.8) | 4.8 (2.6) | 5.6 (3.0) | 6.1 (3.3) | 0.4 (0.2) | 2.2 (1.2) | 3.3 (1.8) | 5.0 (2.7) | 5.7 (3.1) | 6.5 (3.5) |
| Raft 15 person | 0.9 (0.5) | 2.4 (1.3) | 3.5 (1.9) | 5.0 (2.7) | 6.1 (3.3) | 6.7 (3.6) | 0.7 (0.4) | 2.6 (1.4) | 3.7 (2.0) | 5.2 (2.8) | 6.3 (3.4) | 6.9 (3.7) | 0.4 (0.2) | 2.6 (1.4) | 3.7 (2.0) | 5.6 (3.0) | 6.5 (3.5) | 7.2 (3.9) |
| Raft 20 person | 0.9 (0.5) | 2.8 (1.5) | 3.9 (2.1) | 5.9 (3.2) | 7.0 (3.8) | 7.8 (4.2) | 0.7 (0.4) | 2.8 (1.5) | 4.1 (2.2) | 5.9 (3.2) | 7.2 (3.9) | 8.0 (4.3) | 0.7 (0.4) | 2.8 (1.5) | 4.1 (2.2) | 6.3 (3.4) | 7.4 (4.0) | 8.3 (4.5) |
| Raft 25 person | 0.9 (0.5) | 3.0 (1.6) | 4.3 (2.3) | 6.3 (3.4) | 7.6 (4.1) | 8.5 (4.6) | 0.7 (0.4) | 3.0 (1.6) | 4.3 (2.3) | 6.5 (3.5) | 7.8 (4.2) | 8.7 (4.7) | 0.6 (0.3) | 3.0 (1.6) | 4.4 (2.4) | 6.7 (3.6) | 8.1 (4.4) | 9.1 (4.9) |
| Power Boat < 5 (15) | 0.7 (0.4) | 1.7 (0.9) | 2.2 (1.2) | 2.8 (1.5) | 3.1 (1.7) | 3.3 (1.8) | 0.7 (0.4) | 1.9 (1.0) | 2.4 (1.3) | 3.1 (1.7) | 3.3 (1.8) | 3.7 (2.0) | 0.4 (0.2) | 1.9 (1.0) | 2.4 (1.3) | 3.3 (1.8) | 3.7 (2.0) | 4.1 (2.2) |
| Power Boat 6 (20) | 0.9 (0.5) | 3.1 (1.7) | 4.4 (2.4) | 6.7 (3.6) | 8.0 (4.3) | 8.9 (4.8) | 0.9 (0.5) | 3.1 (1.7) | 4.6 (2.5) | 6.9 (3.7) | 8.1 (4.4) | 9.3 (5.0) | 0.6 (0.3) | 3.1 (1.7) | 4.6 (2.5) | 7.0 (3.8) | 8.5 (4.6) | 9.4 (5.1) |
| Power Boat 10 (33) | 1.1 (0.6) | 3.9 (2.1) | 6.1 (3.3) | 9.8 (5.3) | 12.4 (6.7) | 14.3 (7.7) | 0.9 (0.5) | 4.1 (2.2) | 6.3 (3.4) | 10.0 (5.4) | 12.6 (6.8) | 14.4 (7.8) | 0.6 (0.3) | 4.1 (2.2) | 6.3 (3.4) | 10.2 (5.5) | 12.8 (6.9) | 14.8 (8.0) |
| Power Boat 16 (53) | 1.1 (0.6) | 5.0 (2.7) | 8.3 (4.5) | 15.0 (8.1) | 20.2 (10.9) | 24.3 (13.1) | 1.1 (0.6) | 5.0 (2.7) | 8.3 (4.5) | 15.2 (8.2) | 20.2 (10.9) | 24.3 (13.1) | 0.7 (0.4) | 4.8 (2.6) | 8.3 (4.5) | 15.4 (8.3) | 20.4 (11.0) | 24.6 (13.3) |
| Power Boat 24 (78) | 1.1 (0.6) | 5.2 (2.8) | 9.3 (5.0) | 18.1 (9.8) | 25.0 (13.5) | 30.9 (16.7) | 1.1 (0.6) | 5.2 (2.8) | 9.4 (5.1) | 18.1 (9.8) | 25.2 (13.6) | 30.9 (16.7) | 0.7 (0.4) | 5.2 (2.8) | 9.3 (5.0) | 18.1 (9.8) | 25.2 (13.6) | 31.1 (16.8) |
| Sail Boat 5 (15) | 0.9 (0.5) | 3.0 (1.6) | 4.1 (2.2) | 5.9 (3.2) | 7.2 (3.9) | 8.0 (4.3) | 0.9 (0.5) | 3.0 (1.6) | 4.3 (2.3) | 6.1 (3.3) | 7.4 (4.0) | 8.1 (4.4) | 0.6 (0.3) | 3.0 (1.6) | 4.3 (2.3) | 6.5 (3.5) | 7.6 (4.1) | 8.3 (4.5) |
| Sail Boat 8 (26) | 1.1 (0.6) | 3.7 (2.0) | 5.7 (3.1) | 9.1 (4.9) | 11.3 (6.1) | 13.0 (7.0) | 0.9 (0.5) | 3.9 (2.1) | 5.9 (3.2) | 9.3 (5.0) | 11.5 (6.2) | 13.1 (7.1) | 0.6 (0.3) | 3.9 (2.1) | 6.1 (3.3) | 9.6 (5.2) | 11.9 (6.4) | 13.5 (7.3) |
| Sail Boat 12 (39) | 1.1 (0.6) | 4.8 (2.6) | 8.0 (4.3) | 14.1 (7.6) | 18.5 (10.0) | 22.0 (11.9) | 1.1 (0.6) | 4.8 (2.6) | 8.0 (4.3) | 14.1 (7.6) | 20.2 (10.9) | 22.2 (12.0) | 0.7 (0.4) | 4.6 (2.5) | 8.0 (4.3) | 14.3 (7.7) | 18.7 (10.1) | 22.4 (12.1) |
| Sail Boat 15 (49) | 1.1 (0.6) | 5.0 (2.7) | 8.5 (4.6) | 15.6 (8.4) | 20.9 (11.3) | 25.4 (13.7) | 1.1 (0.6) | 5.0 (2.7) | 8.5 (4.6) | 15.7 (8.5) | 21.1 (11.4) | 25.4 (13.7) | 0.7 (0.4) | 5.0 (2.7) | 8.5 (4.6) | 15.9 (8.6) | 21.3 (11.5) | 25.7 (13.9) |
| Sail Boat 21 (69) | 1.1 (0.6) | 5.2 (2.8) | 9.1 (4.9) | 17.2 (9.3) | 23.5 (12.7) | 28.7 (15.5) | 1.1 (0.6) | 5.2 (2.8) | 9.1 (4.9) | 17.2 (9.3) | 23.7 (12.8) | 28.9 (15.6) | 0.7 (0.4) | 5.0 (2.7) | 9.1 (4.9) | 17.4 (9.4) | 23.9 (12.9) | 29.1 (15.7) |
| Sail Boat 25 (83) | 1.1 (0.6) | 5.2 (2.8) | 9.4 (5.1) | 18.3 (9.9) | 25.4 (13.7) | 31.5 (17.0) | 1.1 (0.6) | 5.2 (2.8) | 9.4 (5.1) | 18.3 (9.9) | 25.6 (13.8) | 31.5 (17.0) | 0.7 (0.4) | 5.2 (2.8) | 9.4 (5.1) | 18.5 (10.0) | 25.7 (13.9) | 31.7 (17.1) |
| Ship 27-46 (90-150) | 1.1 (0.6) | 5.4 (2.9) | 10.0 (5.4) | 20.6 (11.1) | 29.4 (15.9) | 37.2 (20.1) | 1.1 (0.6) | 5.4 (2.9) | 10.0 (5.4) | 20.6 (11.1) | 29.4 (15.9) | 37.2 (20.1) | 0.7 (0.4) | 5.4 (2.9) | 10.0 (5.4) | 20.6 (11.1) | 29.6 (16.0) | 37.2 (20.1) |
| Ship 46-91 (150-300) | 1.1 (0.6) | 5.6 (3.0) | 10.6 (5.7) | 23.2 (12.5) | 35.0 (18.9) | 45.7 (24.7) | 1.1 (0.6) | 5.6 (3.0) | 10.6 (5.7) | 23.2 (12.5) | 35.0 (18.9) | 45.7 (24.7) | 0.7 (0.4) | 5.6 (3.0) | 10.6 (5.7) | 23.2 (12.5) | 35.0 (18.9) | 45.7 (24.7) |
| Ship > 91 (300) | 1.3 (0.7) | 5.6 (3.0) | 10.7 (5.8) | 24.4 (13.2) | 38.2 (20.6) | 51.7 (27.9) | 1.1 (0.6) | 5.6 (3.0) | 10.7 (5.8) | 24.4 (13.2) | 38.2 (20.6) | 51.7 (27.9) | 0.9 (0.5) | 5.6 (3.0) | 10.7 (5.8) | 24.4 (13.2) | 38.3 (20.7) | 51.7 (27.9) |

* For search altitudes of 150 metres (500 feet only), the sweep width values for a person in water may be multiplied by 4, if it is known that the person is wearing a personal flotation device.

**Table N-6 – Sweep widths for fixed-wing aircraft (km (NM))**

| | Search Object | |
|---|---|---|
| **Weather: Winds km/h (kt) or seas m (ft)** | **Person in water, raft or boat < 10 m (33 ft)** | **Other search objects** |
| Winds 0-28 km/h (0-15 kt) or seas 0-1 m (0-3ft) | 1.0 | 1.0 |
| Winds 28-46 km/h (15-25 kt) or seas 1-1.5 m (3-5ft) | 0.5 | 0.9 |
| Winds > 46 km/h (> 25 kt) or seas > 1.5 m (> 5 ft) | 0.25 | 0.9 |

Table N-7 Weather correction factors for all types of search facilities

| Search Object | Fixed Wing Speed km/h (kts) | | | Helicopter Speed km/h (kts) | | | |
|---|---|---|---|---|---|---|---|
| | **≤ 275 (≤ 150)** | **330 (180)** | **385 (210)** | **≤ 110 (≤ 60)** | **165 (90)** | **220 (120)** | **255 (140)** |
| Person in Water | 1.2 | 1.0 | 0.9 | 1.5 | 1.0 | 0.8 | 0.7 |
| Raft - 1-4 Person | 1.1 | 1.0 | 0.9 | 1.3 | 1.0 | 0.9 | 0.8 |
| Raft - 6-25 Person | 1.1 | 1.0 | 0.9 | 1.2 | 1.0 | 0.9 | 0.8 |
| Power Boat - < 8 m (< 25 ft) | 1.1 | 1.0 | 0.9 | 1.2 | 1.0 | 0.9 | 0.8 |
| Power Boat - 10 m (33 ft) | 1.1 | 1.0 | 0.9 | 1.1 | 1.0 | 0.9 | 0.9 |
| Power Boat - 16 m (53 ft) | 1.1 | 1.0 | 1.0 | 1.1 | 1.0 | 0.9 | 0.9 |
| Power Boat - 24 m (78 ft) | 1.1 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 0.9 |
| Sail Boat - < 8 m (< 25 ft) | 1.1 | 1.0 | 0.9 | 1.2 | 1.0 | 0.9 | 0.9 |
| Sail Boat - 12 m (39 ft) | 1.1 | 1.0 | 1.0 | 1.1 | 1.0 | 0.9 | 0.9 |
| Sail Boat - 25 m (83 ft) | 1.1 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 0.9 |
| Ship - > 27 m (> 90 ft) | 1.0 | 1.0 | 1.0 | 1.1 | 1.0 | 1.0 | 0.9 |

Table N-8 – Speed (velocity) correction factors for helicopter and fixed wing aircraft search facilities

## Appendix P (to Volume II)

## Functional Characteristics to Consider with Computer-based Search Planning Aids

### Overview

The computer software, hereinafter referred to as the search planning model, should be designed to accept all inputs that the SAR Co-ordinator can reasonably be expected to use in search planning and present the calculated results to the Co-ordinator as useable information in the form of an optimal search plan, useful statistics and values important to the search planning process. It should not simply produce a mass of data outputs. The desirable functional characteristics of the search planning model should include, but should not be limited to those in the following list. The model should perform the following functions:

- Accept and integrate various environmental data from multiple sources, together with their estimated error and variability patterns;
- Simulate the effects of the environment on search object status and motion, sensor performance and the survivors.
- Use appropriate sampling techniques for simulating possible search object movements (e.g. drift), and determining the area of containment;
- Have the flexibility to develop updated search plans based on new information or assumptions made by the search planner;
- Have the ability to allow for time uncertainty and/or position uncertainty of the initial distress location;
- Simulate hazards, possible encounters between the missing craft and the hazards, and the probabilities that such encounters would result in a distress incident;
- Have the ability to generate initial probability density distributions using the previous two features together;
- Be capable of simulating post-distress changes (state changes) in the status of distressed persons such as abandoning a vessel into a life raft;
- Be capable of predicting the survivability of distressed persons based on selectable scenarios and when computing optimal effort allocations;
- Generate valid probability density distributions of possible search object locations based on post-distress search object trajectories using low to high resolution[2] environmental data, as available (high resolution data is always preferred);
- Be capable of handling multiple scenarios simultaneously which includes the ability to compare the scenarios and assign weighting factors to them;
- Produce an operationally feasible search plan that maximises the probability of finding the distressed persons alive with the available search facilities – i.e., produce an optimal search plan for the situation at hand. Factors to consider are the possible (weighted) scenarios, the dynamic probability density distribution of search object locations, survivor state changes, survival times, environmental parameters, search facility characteristics (number, type, location, endurance, sensors, etc.), previous search results, etc. Both tactical (myopic, day-to-day or sortie-to-sortie) and strategic optimisation (when resource availability can be predicted with reasonable certainty) should be available;

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[2] High resolution data is data on a small spatial (e.g. 0.1 x 0.1 degree or 6 NM x 6 NM at the equator) and temporal (*e.g.* every 3 hours) grid. Low resolution data would be on larger grids (e.g., 1 x 1 degree x 24 hours or greater).

- Be able to properly evaluate search results (in the computational sense), including both positive (e.g., debris sightings) and negative (no sightings of search object) aspects. It should perform detailed updates of the dynamic probability density distributions of the possible search object locations based on actual sortie tracks and reports of sensor performance;
- Make proper use of previous search results when computing optimal plans for subsequent searches;
- Correctly simulate the effects of the relative motion between moving search objects and moving search facilities;
- Compute and display estimates of search effectiveness in the form of POS values for sorties and the cumulative POS value for all searching done to date;
- Be capable of processing and re-evaluating new (including late-arriving) information such as update of last known position and/or distress time to produce an updated optimal search plan;
- Consideration should be given to the man-machine interface so that the information generated by the computer-based tool and database would be useful to the search planner. The model should also be capable of displaying large volumes of information in ways that promote rapid assimilation. The model should contain or be integrated with appropriate geographical displays and useful tools for describing search sub-areas, generating search patterns, communicating search plans to search facilities, etc.; and,
- Finally, the software of such a model must be developed using sound software engineering principles to keep life-cycle costs down, maximise reliability, provide for ease of making future improvements, and have it operate with as many hardware platforms and operating systems as possible.

**Appendix Q (to Volume II)**
**Sample Problem**

**F/V Sample – Alpha Search**

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**Alpha Search Scenario**

1 On 25 January 2000 at 2145Z, the F/V Sample broadcast a distress radio call. The captain reported the vessel's engines were inoperable and the vessel was taking on water, but the vessel was not in immediate danger of sinking. However, the captain requested assistance. The vessel's reported DR position at 2145 Z was given as 37-10N, 065-45W. This DR position was based on a celestial fix at 250100Z JAN 00 in position 38-57N, 068-54W. Communications were lost after this initial call for assistance.

2 A British Airways flight transiting the area while en route to Bermuda at 261100Z JAN 00 failed to sight the F/V Sample. Based on enquiries about resource availability, the earliest time at which a search can commence is 261630Z JAN 00. A search is to be planned for this commence search time.

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**Wind Information**

3 **Observed and forecast wind data:**

| **Date** | **Time** | **°T/KTS** | **Date** | **Time** | **°T/KTS** |
|---|---|---|---|---|---|
| 26 JAN | 0000Z | 175/32 | 27 JAN | 0000Z | 200/32 |
| | 0600Z | 190/30 | | 0600Z | 195/30 |
| | 1200Z | 210/35 | | 1200Z | 195/30 |
| | 1800Z | 205/37 | | 1800Z | 200/28 |

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**Vessel Description**

4 The F/V Sample is a 75-foot eastern rigged side trawler, with a black steel hull and a white superstructure.

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**Search Facilities**

5 Two four-engine fixed wing aircraft search facilities are available with GPS navigation systems.

| **Aircraft Type** | **Speed** | **On Scene Endurance** | **Crew Fatigue** |
|---|---|---|---|
| C-130 Hercules | 180 knots | 3.00 hours | Normal |
| P-3 Orion | 200 knots | 4.00 hours | Normal |

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**Search Conditions**

6 On scene weather for 26 January 2000:

| | | | |
|---|---|---|---|
| Meteorological Visibility | 5 NM | Ceiling | 1500 feet |
| Winds | 210°T/35 knots | Seas | 3-5 feet |
| Sunrise | 1100Z | Sunset | 2200Z |

**Datum Worksheet**
**For Computing Drift in the Marine Environment**

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

Search Object: **Medium displacement fishing vessel**

A. Starting Position for this Drift Interval

1. Type of Position (Circle one)

| | |
|---|---|
| Last Known Position | LKP |
| Estimated Incident Position | ***EIP*** |
| Previous Datum | PD |

2. Position Date/Time **252145Z JAN 2000**

3. Latitude, Longitude of Position **37-10 *N***/S **065-45 *W***/E

**B. Datum Time**

1. Commence Search Date/Time **261630Z JAN 2000**

2. Drift Interval **18.75** Hours

**C. Average Surface Wind (*ASW*)**
(Attach **Average Surface Wind (*ASW*) Worksheet**)

1. Average Surface Wind (*ASW*) **194** °T **31.72** KTS

2. Probable Error of Drift Velocity due to Probable Error of Average Surface Wind ($ASWDV_e$) **0.3** KTS

**D. Total Water Current (*TWC*)**
(Attach **Total Water Current (*TWC*) Worksheet**)

1. Total Water Current (*TWC*) **057** °T **1.86** KTS

2. Probable Total Water Current Error ($TWC_e$) **0.42** KTS

**E. Leeway (*LW*)**
(Attach **Leeway (*LW*) Worksheet**)

| | | | | | |
|---|---|---|---|---|---|
| 1. | Left of down wind | **324** | °T | **1.3** | KTS |
| 2. | Right of down wind | **064** | °T | **1.3** | KTS |
| 3. | Probable Leeway Error ($LW_e$) | | | **0.3** | KTS |

**F. Total Surface Drift**
Use a Manoeuvring Board or Calculator to add Total Water Current and Leeway vectors. (See **Figure K-1a**.)

| | | (left of down wind) | | (right of down wind) | |
|---|---|---|---|---|---|
| 1. | Drift Directions | **021** | °T | **060** | °T |
| 2. | Drift Speeds | **2.21** | KTS | **3.15** | KTS |
| 3. | Drift Distances (**line F.2** × **line B.2**) | **41.49** | NM | **59.14** | NM |
| 4. | Total Probable Drift Velocity Error ($DV_e$) | | | **0.60** | KTS |

$$\left(DV_e = \sqrt{ASWDV_e^2 + TWC_e^2 + LW_e^2}\right)$$

**G. Datum Positions and Divergence Distance**
Using a Chart, Universal Plotting Sheet or Calculator, determine the datum positions and divergence distance (*DD*) (See **Figure K-1b**.)

| | | | |
|---|---|---|---|
| 1. | Latitude, Longitude (left of down wind) | **37-48.7** ***N***/S | **065-26.3** ***W***/E |
| 2. | Latitude, Longitude (right of down wind) | **37-39.6** ***N***/S | **064-40.5** ***W***/E |
| 3. | Divergence Distance (*DD*) | | **37.5** NM |

**H. Total Probable Error of Position (*E*) and Separation Ratio (*SR*)**
(Attach **Total Probable Error of Position (*E*) Worksheet**)

| | | |
|---|---|---|
| 1. | Total Probable Error of Position Squared ($E^2$) | **1,002.7** $NM^2$ |
| 2. | Total Probable Error of Position (*E*) | **31.67** NM |
| 3. | Separation Ratio ($SR = DD/E$) | **1.18** |

4. Go to the **Total Available Search Effort Worksheet**.

## Average Surface Wind (*ASW*) Worksheet

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

### A. Average Surface Wind

1. Surface Wind Data

| Time of Observation | Time Interval | Number of Hours (A) | Wind Direction (B) | Wind Speed (C) | Contribution (A × C) |
|---|---|---|---|---|---|
| **260000Z** | **2145** - **0300** | **5.25** | **175** °T | **32** KTS | **168** NM |
| **260600Z** | **0300** - **0900** | **6.00** | **190** °T | **30** KTS | **180** NM |
| **261200Z** | **0900** - **1500** | **6.00** | **210** °T | **35** KTS | **210** NM |
| **261800Z** | **1500** - **1630** | **1.50** | **205** °T | **37** KTS | **55.5** NM |
| | - | | °T | KTS | NM |
| | - | | °T | KTS | NM |
| | - | | °T | KTS | NM |
| | - | | °T | KTS | NM |

Total Hours **18.75** (D) Vector Sum of Contributions **194** °T (E) **594.76** NM (F)

2. Average Surface Wind (*ASW*) [(E)°T (F/D) KTS] **194** °T **31.72** KTS

### B. Probable Error

1. Probable Error of the Average Surface Wind ($ASW_e$) **5.0** KTS

2. Probable Error of Drift Velocity due to Probable Error of the Average Surface Wind ($ASWDV_e$) **0.3** KTS

Go to **Part C** on the **Datum Worksheet**.

## Total Water Current (*TWC*) Worksheet

Case Title: **F/V SAMPLE**____________ Case Number: __**00-001**______ Date:**26 JAN 2000**_

Planner's Name: **SAR SCHOOL**____ Datum Number: _**1**___ Search Plan: A B C _**A**_____

**A. Observed Total Water Current (*TWC*)**

1. Source (datum marker buoy (DMB), debris, oil) ______________________________

2. Observed Set/Drift ______________°T ______________KTS

3. Probable Error of Observation ($TWC_e$) ______________KTS

4. Go to **Part D** on the **Datum Worksheet.**

**B. Computed Total Water Current**

1. Tidal Current (*TC*)

   a. Source (tidal current tables, local knowledge) ______________________________

   b. Tidal Current (*TC*) Set/Drift ____________________°T ________________KTS
   (Attach any tidal current computations)

   c. Probable Error of Tidal Current ($TC_e$) ______________KTS

2. Sea Current (*SC*)

   a. Source (Atlas, Pilot Chart, etc.) ______________**NOOSP NA6 1400**______________

   b. Sea Current (*SC*) Set/Drift _____________**075**______°T _______**0.8**____KTS

   c. Probable Error of Sea Current ($SC_e$) _______**0.3**____KTS

3. Wind Current (*WC*)
   (Attach **Wind Current Worksheet**)

   a. Wind Current (*WC*) Set/Drift _____________**044**______°T _______**1.13**___KTS

   b. Probable Error of Wind Current ($WC_e$) _______**0.3**____KTS

4. Other Water Current (*OWC*)

   a. Source (local knowledge, previous drifts, etc.) ________________________________

   b. Other Water Current (*OWC*) Set/Drift _____________°T _____________KTS

   c. Probable Error of Other Water Current ($OWC_e$) _____________KTS

5. Computed Total Water Current (*TWC*) Set/Drift **057** °T **1.86** KTS

6. Computed Probable Total Water Current Error ($TWC_e$) **0.42** KTS

   $\left(TWC_e = \sqrt{TC_e^2 + SC_e^2 + WC_e^2 + OWC_e^2}\right)$

7. Go to **Part D** on the **Datum Worksheet**.

## Wind Current (*WC*) Worksheet

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

**Wind Current (*WC*)**

1. Average Surface Wind (*ASW*) **194** °T **31.72** KTS
   (from **Datum Worksheet**, **line C.1**)

2. Down Wind Direction (ASW direction ± 180°) **014** °T

3. Wind Current Drift **1.13** KTS
   (from **Figure N-1**)

4. Divergence of Wind Current ± **+30**°
   (from **Figure N-1**)

5. Wind Current Set **044** °T
   (Down wind direction ± Divergence of Wind Current)
   (Add Divergence in northern hemisphere, subtract in southern hemisphere.)

6. Wind Current (*WC*) Set/Drift **044** °T **1.13** KTS

7. Probable Error of Wind Current ($WC_e$) **0.3** KTS

8. Go to **line B.3** on the **Total Water Current (*TWC*) Worksheet**.

## Leeway (*LW*) Worksheet

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

Search Object: **Medium displacement fishing vessel**

1. Average Surface Wind (*ASW*) (from **Datum Worksheet**, **line C.1**) — **194** °T **31.72** KTS
2. Down Wind Direction (ASW direction ± 180°) — **014** °T
3. Leeway Speed (from **Figure N-2** or **N-3**) — **1.3** KTS
4. Leeway Divergence Angle (from **Figure N-2** or **N-3**) — ± **50** °
5. Leeway Directions
   a. Left of down wind (**line 2 – line 4**) — **324** °T
   b. Right of down wind (**line 2** + **line 4**) — **064** °T
6. Leeway (*LW*)
   a. Left of down wind — **324** °T **1.3** KTS
   b. Right of down wind — **064** °T **1.3** KTS
7. Probable Leeway Error ($LW_e$) (from **Figure N-2** or **N-3**) — **0.3** KTS
8. Go to **Part E** on the **Datum Worksheet**.

**Total Probable Error of Position (*E*) Worksheet**
**For Land and Marine Environments**

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

**A. Probable Distress Incident/Initial Position Error (*X*)**
(Go to **line 1** to compute probable error of the distress incident position. Go to **line 6** if the starting position for this drift interval is a previous datum.)

1. Navigational Fix Error (from **Table N-1** or **N-2**) — **2.0** NM
2. Dead Reckoning (DR) Error Rate (from **Table N-3**) — **15** %
3. DR Distance Since Last Fix — **184** NM
4. DR Navigational Error (**line A.2** × **line A.3**) — **27.6** NM
5. Glide Distance (if aircraft/parachute descent heading is unknown) — ____________ NM
6. Probable Initial Position Error (*X*) — **29.6** NM
(*X* = **line A.1** + **line A.4** + **line A.5**) or
(*X* = Total Probable Error of Position from **line H.2** of previous **Datum Worksheet**.)

**B. Total Probable Drift Error ($D_e$)**

1. Drift Interval (from **line B.2** of the **Datum Worksheet**) — **18.75** Hours
2. Probable Drift Velocity Error ($DV_e$) (from **line F.4** of the **Datum Worksheet**) — **0.6** KTS
3. Total Probable Drift Error ($D_e$) — **11.25** NM
($D_e$ = **line B.1** × **line B.2**)

**C. Probable Search Facility Position Error (*Y*)**

1. Navigational Fix Error (from **Table N-1** or **N-2**) ____**0.1**____ NM

2. Dead Reckoning (DR) Error Rate (from **Table N-3**) __________ %

3. DR Distance Since Last Fix __________ NM

4. DR Navigational Error (**line C.2** × **line C.3**) __________ NM

5. Probable Search Facility Position Error (*Y*) ($Y$ = **line C.1** + **line C.4**) ____**0.1**____ NM

**D. Total Probable Error of Position (*E*)**

1. Sum of Squared Errors ($E^2 = X^2 + D_e^2 + Y^2$) ____**1002.7**____ $NM^2$

2. Total Probable Error of Position $\left(E = \sqrt{X^2 + D_e^2 + Y^2}\right)$ ____**31.67**____ NM

**Total Available Search Effort Worksheet**

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

| | Latitude | Longitude | | Latitude | Longitude |
|---|---|---|---|---|---|
| Datum (left) | **37-48.7 N** | **065-26.3 W** | Datum (right) | **37-39.6 N** | **064-40.5 W** |

Search Object: **Medium displacement fishing vessel** Date/Time **261630Z JAN 2000**

Total Available Effort Computations

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Search Sub-area Designation | **A-1** | **A-2** | | | |
| 2. Search Facility Assigned | **C-130** | **P-3** | | | |
| 3. Search Facility Speed (*V*) | **180** | **200** | | | |
| 4. On Scene Endurance | **3.0** | **4.0** | | | |
| 5. Daylight Hours Remaining | **7.5** | **7.5** | | | |
| 6. Search Endurance (*T*) (*T* = 85% of lesser of **line 4** or **5** above.) | **2.55** | **3.40** | | | |
| 7. Search Altitude | **500** | **1000** | | | |
| 8. Uncorrected Sweep Width | **5.0** | **5.1** | | | |
| 9. Weather, Terrain Correction Factor ($f_w$,$f_t$) | **0.9** | **0.9** | | | |
| 10. Velocity Correction Factor ($f_v$) (aircraft only) | **1.0** | **1.0** | | | |
| 11. Fatigue Correction Factor ($f_f$) | **1.0** | **1.0** | | | |
| 12. Corrected Sweep Width (*W*) | **4.5** | **4.6** | | | |
| 13. Available Search Effort ($Z = V \times T \times W$) | **2,065.5** | **3,128** | | | |

14. Total Available Search Effort ($Z_{ta} = Z_{a1} + Z_{a2} + Z_{a3} + \ldots$) **5,193.5** $NM^2$

15. Separation Ratio (*SR*) (leeway divergence datums only) (from **line H.3** of the **Datum Worksheet**.) **1.18**

16. If the separation ratio (*SR*) on **line 15** is greater than four ($SR > 4$), go to the **Widely Diverging Datums Worksheet**. Otherwise, go to the **Effort Allocation Worksheet**.

**Effort Allocation Worksheet**
**For Optimal Search of Single Point, Leeway Divergence, or Line Datums**

Case Title: **F/V SAMPLE** Case Number: **00-001** Date: **26 JAN 2000**

Planner's Name: **SAR SCHOOL** Datum Number: **1** Search Plan: A B C **A**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Datum (left) | **37-48.7 N** Latitude | **065-26.3 W** Longitude | | Datum (right) | **37-39.6 N** Latitude | **064-40.5 W** Longitude | |

Search Object: **Medium displacement fishing vessel** Date/Time **261630Z JAN 2000**

**Effort Allocation Computations**

1. Available Search Effort ($Z_a$) **5,193.5** $NM^2$
   (from **line 13** of **Total Available Search Effort Worksheet** or **line 5.a** or **line 5.b** of the **Widely Diverging Datums Worksheet**)

2. Effort Factor ($f_Z$)

   a. Total Probable Error of Position ($E$) **31.66** NM

   b. Length of Datum Line ($L$) ______ NM

   c. Effort Factor ($f_Z$) ($f_{Zp} = E^2$ or $f_{Zl} = E \times L$) **1,002.7** $NM^2$

3. Relative Effort ($Z_r = Z_a/f_Z$) **5.18**

4. Cumulative Relative Effort ($Z_{rc}$ = Previous $Z_{rc} + Z_r$) **5.18**

5. Optimal Search Factor ($f_s$) Ideal______ Poor **X** ($f_s$) **1.1**

6. Optimal Search Radius ($R_o = f_s \times E$) **34.83** NM

7. Optimal Search Area ($A_o$) **7,464** $NM^2$
   a. Single Point Datum ($A_o = 4 \times R_o^2$)
   b. Leeway Divergence Datums [$A_o = (4 \times R_o^2) + (2 \times R_o \times DD)$]
   c. Line Datum ($A_o = 2 \times R_o \times L$)

8. Optimal Coverage Factor ($C_o = Z_a/A_o$) **0.70**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 9. Optimal Track Spacing ($S_o = W/C_o$) | **6.45** | **6.45** | | | |
| 10. Nearest Assignable Track Spacing ($S$) (within limits of search facility navigational capability) | **6.5** | **6.5** | | | |
| 11. Adjusted Search Areas ($A = V \times T \times S$) | **2983.5** | **4420** | | | |

12. Total Adjusted Search Area ($A_t = A_1 + A_2 + A_3 + \ldots$) **7,403.5** $NM^2$

13. Adjusted Search Radius ($R$) **34.7** NM

a. Single Point Datum
$$R = \frac{\sqrt{A_t}}{2}$$

b. Leeway Divergence Datums
$$R = \frac{\sqrt{DD^2 + (4 \times A_t)} - DD}{4}$$

c. Line Datum
$$R = \frac{A_t}{2 \times L}$$

14. Adjusted Search Area Dimensions

a. Length — Length **107** NM

i.) Single Point Datum — *Length* = $2 \times R$

ii.) Leeway Divergence Datums — *Length* = $(2 \times R) + DD$

iii.) Line Datum — Length of the Base Line ($L_b$) ____________ NM

a.) No Extensions — *Length* = $L_b$

b.) One Extension — *Length* = $R + L_b$

c.) Two Extensions — *Length* = $(2 \times R) + L_b$

b. Width = $2 \times R$ — Width **69** NM

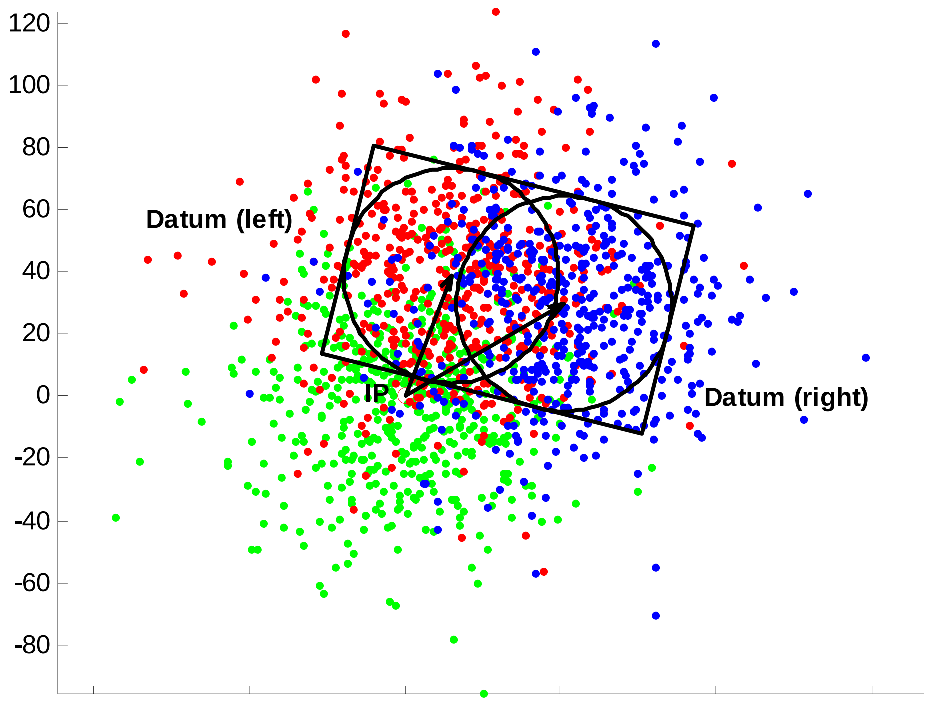
15. Plot the adjusted search area on a suitable chart (Check when done)______

16. Divide the adjusted search area in to search sub-areas according to the values on **line 11**. (Check when done)______

17. Go to the **Search Action Plan Worksheet**.

***See results of simulation on next page.***

**Results of a Monte Carlo Simulation
Using the F/V Sample Data for the Alpha Search**




Monte Carlo Simulation of F/V Sample – Alpha Search

| Area | POC | Coverage | POD | POS |
|---|---|---|---|---|
| 7,343 $NM^2$ | 70.8% | 0.70 | 50.2% | 35.6% |

Green/light grey dots represent some of the possible initial search object locations. Blue/black and red/dark grey dots (nearly indistinguishable if printed in black-and-white) represent some of the possible search object locations at the commence search time. There are 500 dots of each colour. Only the blue and red dots inside the search rectangle were counted and used to estimate the probability of the search object being in the search area at the commence search time.

**VOLUME III**

**Insert** following paragraphs in page 2-21, before "**Helicopter Operations**":

*"Hi-Line Technique*

In certain circumstances, typically, poor weather, obstructed vision or confined winching area, it may not be possible to lower the helicopter crewman or lifting harness to the deck from directly above the vessel. In such cases the Hi-Line technique may be used.

- A weighted line, attached to the aircraft's hook by a weak link, is lowered to the vessel. It may be illuminated by cyaline lightsticks. The transfer area should give unobstructed access to the deck edge.

- The line should be handled by one member of the vessel's crew.

- **ONLY WHEN INSTRUCTED BY THE HELICOPTER CREW** the slack should be hauled in (it is advisable to wear gloves)

- **THE LINE MUST NOT BE MADE FAST.**

- The helicopter will pay out the line and descend to one side of the vessel while the crewman continues to take in the slack. A second crewmember should coil the spare line into a container, clear of obstructions.

- When the helicopter crewman or lifting harness reaches deck height the line must be hauled in to bring the winch hook on board (considerable effort may be required).

- The static discharge line must touch the vessel before contact with the hook is made.

- At any time the helicopter may discontinue the operation, in which case the line must be paid out immediately, clear of obstructions.

- When prepared for winching the helicopter crewman, if present, or a member of the vessel's crew, should indicate to the helicopter by hand signals.

- The helicopter will climb and winch in the cable. The line must be paid out maintaining sufficient force to prevent a swing.

If multiple transfers are required to be made the line should be retained. On the final lift the end of the line should be released over the side of the vessel."

**Replace** Tables in page 3-19 with the following tables;

**Sweep widths for helicopters (km (NM))**

| | **Meteorological Visibility** | | |
|---|---|---|---|
| **Search Object** | **1.9 (1)** | **9.3 (5)** | **>37 (>20)** |
| Person in water | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) |
| 4-person life raft | 0.9 (0.5) | 3.1 (1.7) | 5.4 (2.9) |
| 8-person life raft | 0.9 (0.5) | 3.9 (2.1) | 7.0 (3.8) |
| 15-person life raft | 1.1 (0.6) | 4.4 (2.4) | 8.3 (4.5) |
| 25-person life raft | 1.1 (0.6) | 5.2 (2.8) | 10.6 (5.7) |
| Boat < 5m (17 ft) | 0.9 (0.5) | 3.0 (1.6) | 4.6 (2.5) |
| Boat 6 m (20 ft) | 1.3 (0.7) | 5.6 (3.0) | 10.9 (5.9) |
| Boat 10 m (33 ft) | 1.3 (0.7) | 7.2 (3.9) | 16.9 (9.1) |
| Boat 24 m (82 ft) | 1.5 (0.8) | 10.6 (5.7) | 34.3 (18.5) |

**Sweep widths for fixed-wing aircraft (km (NM))**

| | **Meteorological Visibility** | | |
|---|---|---|---|
| **Search Object** | **1.9 (1)** | **9.3 (5)** | **>37 (>20)** |
| Person in water | 0.0 (0.0) | 0.2 (0.1) | 0.2 (0.1) |
| 4-person life raft | 0.6 (0.3) | 2.4 (1.3) | 4.3 (2.3) |
| 8-person life raft | 0.7 (0.4) | 3.1 (1.7) | 5.6 (3.0) |
| 15-person life raft | 0.7 (0.4) | 3.7 (2.0) | 6.9 (3.7) |
| 25-person life raft | 0.7 (0.4) | 4.3 (2.3) | 8.7 (4.7) |
| Boat < 5m (17 ft) | 0.7 (0.4) | 2.4 (1.3) | 3.7 (2.0) |
| Boat 6 m (20 ft) | 0.9 (0.5) | 4.6 (2.5) | 9.3 (5.0) |
| Boat 10 m (33 ft) | 0.9 (0.5) | 6.3 (3.4) | 14.4 (7.8) |
| Boat 24 m (82 ft) | 1.1 (0.6) | 9.4 (5.1) | 30.9 (16.7) |

___________