Pacific Campaign and Torpedo Solution Reference (v1.1)

fSocko

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Contents

1 Introduction

The main purpose of this documentation is to record techniques and methods of early submarine attack techniques in a way which are simple to employ in computer programs (i.e. showing mathematical equations where possible), as well as acting as a reference for Submarine Simulators.

This document is a reference for Torpedo types and common conversion factors, as well as types of US Fleet Boats and Types of US Torpedoes. A brief recognition manual will be provided in an appendix. This document also aims to provide a brief overview of common torpedo solution methods.

2 Unit Conversion Factors

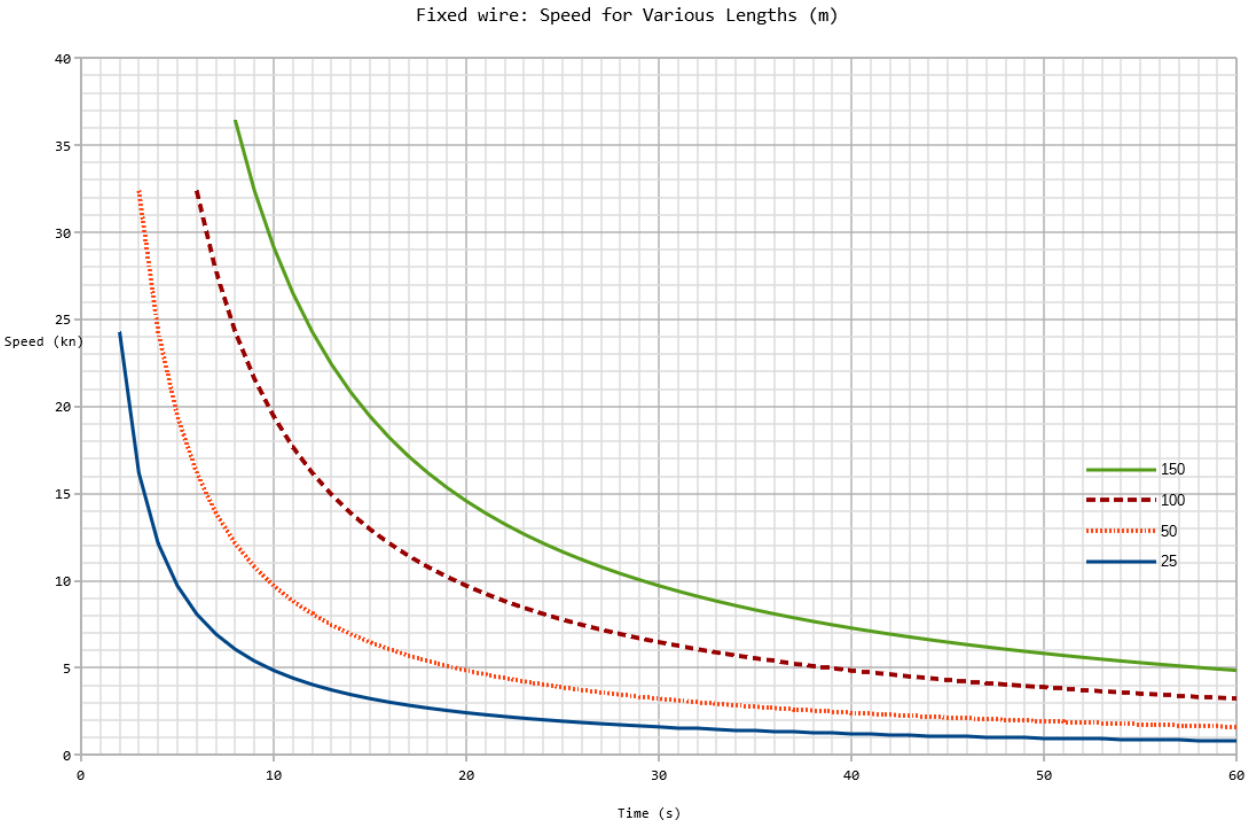
Length

NM	×1852.00	m
	×0.00054	
NM	×2025.37	yd
	×0.00049	
NM	×6076.12	ft
	×0.00016	
Mi	×1609.34	m
	×0.00062	
Mi	×1760	yd
	×0.00057	
m	×1.09361	yd
	×0.914	
m	×3.28084	ft
	×0.3048	

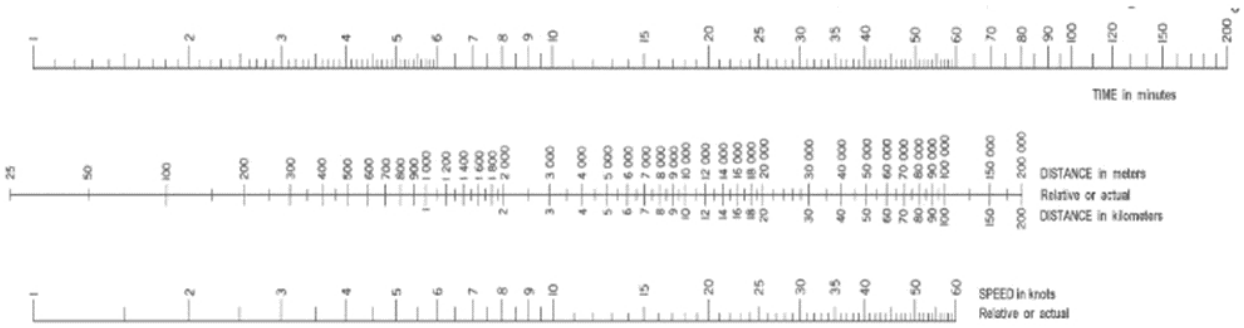
Speed

NM/h	×1	kt
	×1	
m/s	×1.94384	kt
	×0.514444	
yd/s	×1.77745	kt
	×0.562603	
ft/s	×0.592484	kt
	×1.68781	

2.1 Speed



2.2 Nomogram (Metric)



3 Torpedo Data

The following is torpedo data for German torpedo types as used in the European Theatre of Operations. Slow and Fast speeds and ranges removed as appropriate.

3.0.1 T1 (G7a)

Available from:	Always
Range(Slow):	12.5km
Range(Medium):	7.5km
Range(Fast):	6km
Speed(Slow):	30kt
Speed(Medium):	40kt
Speed(Fast):	44kt

Notes:

3.0.2 T2 (G7e)

Available from:	Always
Powerplant:	Electric
Range(Slow):	5km
Speed(Slow):	30kt

Notes:

3.0.3 T3a (G7e)

Available from:	June 1942
Powerplant:	Electric
Range(Slow):	7.5km
Speed(Slow):	30kt

Notes:

3.0.4 T4 (G7es) Falke

Available from:	July 1943
Powerplant:	Electric
Range(Slow):	7.5km
Speed(Slow):	20kt

Notes:
Acoustic homing torpedo. Tracking speed: SH3-5-40kt, Historical: 7-13kt

3.0.5 T5 (G7es) Zaunkönig I

Available from:	October 1943
Powerplant:	Electric
Range(Slow):	5.7km
Speed(Slow):	24kt

Notes:
Acoustic homing torpedo. Acoustic homing starts at 400m. Tracking speed: SH3-5-40kt, Historical: 10-18kt

3.0.6 T11 (G7es) Zaunkönig II

Available from:	July 1944
Powerplant:	Electric
Range(Slow):	5.7km
Speed(Slow):	24kt

Notes:
Acoustic homing torpedo. Acoustic homing starts at 400m. Tracking speed: SH3-5-40kt, Historical: 8-19kt

4 Calculating AOB Based on Aspect Ratio

AOB can be determined given the following data:

- Observed Mast Height
- Observed Ship Length
- Reference Aspect Ratio (i.e. $\frac{ReferenceLength}{ReferenceMastHeight}$)

4.1 Determine an observed *aspect ratio.*

$$AR\_observed = \frac{ObservedLength}{ObservedMastHeight}$$

As the required figure is a ratio, it does not matter in what units the figures are given. For example, this could be the number of degrees Length and Mast Heigh subtend, the number of periscope graduations subtended or angular length in metres. It only matters that units for Observed Mast Height and Observed Length are the same.

4.1.1 Determine the Reference Aspect Ratio

Identify the target and find the Length and Mast Height as given in the recognition manual (if possible) or calculate these figures using the SubSkipper ship parser. Proceed as for the observed aspect ratio to get the Reference Aspect Ratio ($ARreference$).

4.2 AOB calculation

$$AOB = arcSin\frac{AR\_observed}{AR\_reference}$$

- Note: This method is less accurate as AOB approaches 0. Using this method with a sample size of 16 at various AOBs, the average error was 9.1°and the median error 6.88°. The optimum range for collecting data seems to be around 2000m.
- Note: This method does not compute whether the AOB is on the port or starboard side.
- Note: "The AOB can only go up to 90, and gives no indication of starboard or port side showing. You have to determine that visually.
- AOB (Relative to Target) for each Quadrant:
  - 0°- 90°: Use AOB result as is.
  - 90°- 180°: Subtract AOB result from 180.
  - 180°- 270°: Subtract AOB result from 180.
  - 270°- 360°: Subtract AOB result from 360.

5 Determine the distance to the track of a target

As you manoeuvre into a firing position, it is useful to know your distance to the track of your target. Knowing the range and AOB of the target:

Track: intersection point between Submarine course and the current target course.

$$DistancetoTrack = Range\,(sin(AOB))$$

6 Determine the lead angle for a perpendicular attack with 0°gyro angle (AKA OḰane Solution)

Once you are turned onto a perpendicular intercept course, this method calculates when to fire. The lead angle is simply the target bearing at the moment you fire. The range is irrelevant to the calculation although it is best to plan the attack within 500-1000m.

$$leadangle = tan^{-1}([targetspeed/torpedospeed])$$

7 Determine the torpedo gyro angle

This example will show how to calculate the required gyro angle for a firing solution. This method is somewhat simplified and is best for smaller gyro angles (<30°) and shorter ranges (<1000 metres).

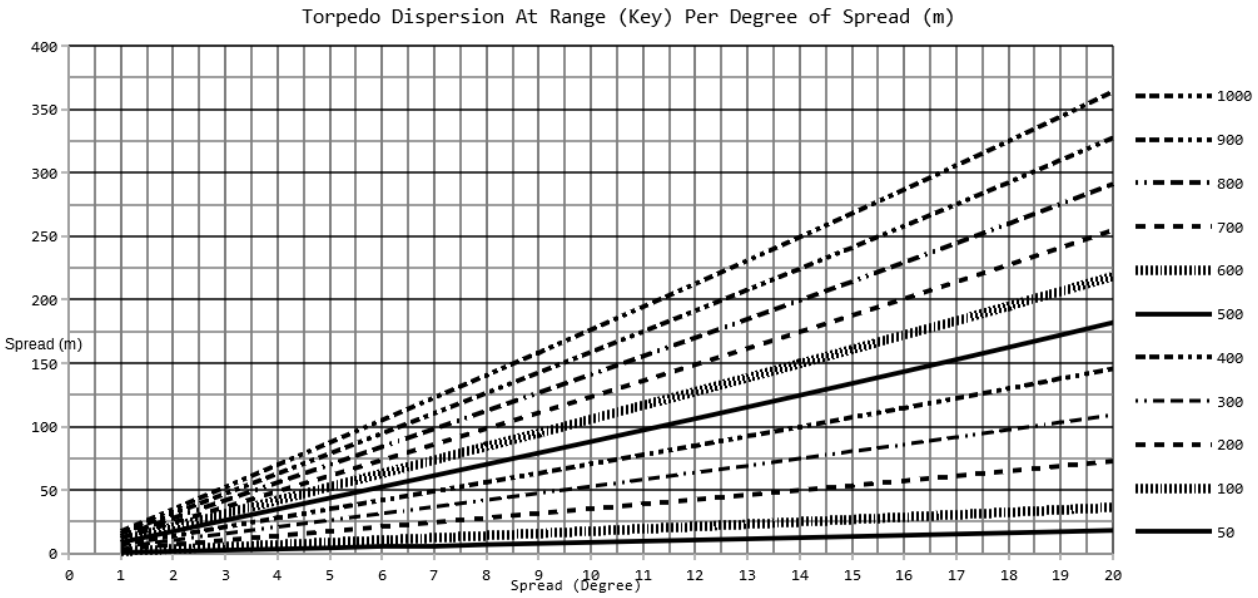
$$sin(leadangle)/sin(AOB) = (targetspeed)/(torpedospeed)$$

$$gyroAngle = targetBearing - leadAngle$$

8 O'Kane Table of Values

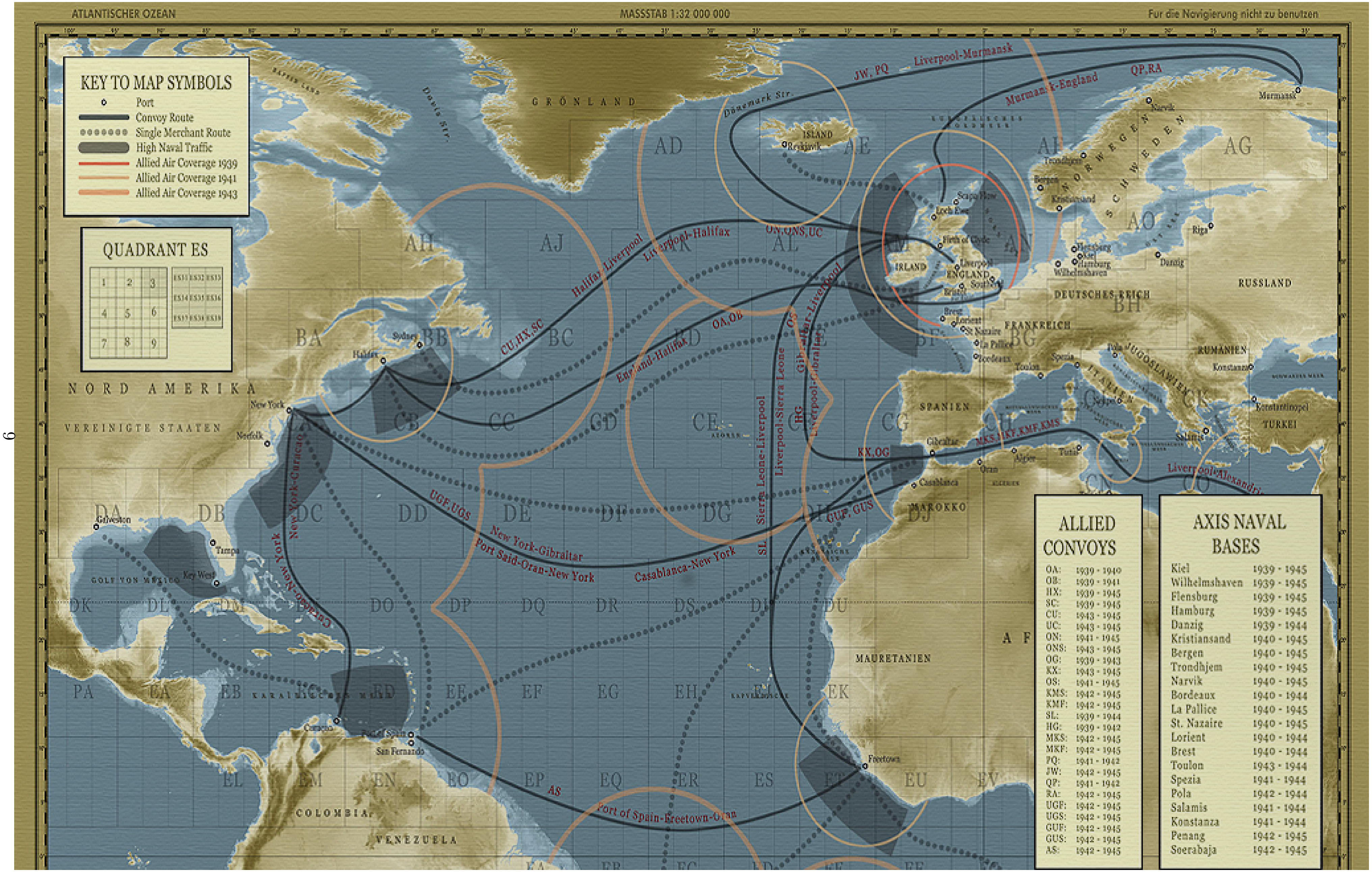
Ship Speed In Knots	Torpedo Speed Slow	Fast
1	2 °	1 °
2	4 °	2.5 °
3	5.5 °	3 °
4	7 °	5 °
5	9 °	6 °
6	11 °	7.5 °
7	13 °	8.5 °
8	14.5 °	9 °
9	16 °	11 °
10	18 °	12 °
11	19.5 °	13.5 °
12	21 °	14.5 °
13	23 °	16 °
14	24 °	17 °
15	25 °	18 °
16	27 °	19 °
17	29 °	20 °
18	30 °	21 °
19	31.5 °	22.5 °
20	33 °	23.5°

9 Torpedo spread at range (m) per angle of spread (°)



10 Knot to Km Travelled Conversion Chart

Kt / Hr	1	2	3	4	5	6	7	8	9	10
1	1.85	3.70	5.56	7.41	9.26	11.11	12.96	14.82	16.67	18.52
2	3.70	7.41	11.11	14.82	18.52	22.22	25.93	29.63	33.34	37.04
3	5.56	11.11	16.67	22.22	27.78	33.34	38.89	44.45	50.00	55.56
4	7.41	14.82	22.22	29.63	37.04	44.45	51.86	59.26	66.67	74.08
5	9.26	18.52	27.78	37.04	46.30	55.56	64.82	74.08	83.34	92.60
6	11.11	22.22	33.34	44.45	55.56	66.67	77.78	88.90	100.01	111.12
7	12.96	25.93	38.89	51.86	64.82	77.78	90.75	103.71	116.68	129.64
8	14.82	29.63	44.45	59.26	74.08	88.90	103.71	118.53	133.34	148.16
9	16.67	33.34	50.00	66.67	83.34	100.01	116.68	133.34	150.01	166.68
10	18.52	37.04	55.56	74.08	92.60	111.12	129.64	148.16	166.68	185.20
11	20.37	40.74	61.12	81.49	101.86	122.23	142.60	162.98	183.35	203.72
12	22.22	44.45	66.67	88.90	111.12	133.34	155.57	177.79	200.02	222.24
13	24.08	48.15	72.23	96.30	120.38	144.46	168.53	192.61	216.68	240.76
14	25.93	51.86	77.78	103.71	129.64	155.57	181.50	207.42	233.35	259.28
15	27.78	55.56	83.34	111.12	138.90	166.68	194.46	222.24	250.02	277.80
16	29.63	59.26	88.90	118.53	148.16	177.79	207.42	237.06	266.69	296.32
17	31.48	62.97	94.45	125.94	157.42	188.90	220.39	251.87	283.36	314.84
18	33.34	66.67	100.01	133.34	166.68	200.02	233.35	266.69	300.02	333.36
19	35.19	70.38	105.56	140.75	175.94	211.13	246.32	281.50	316.69	351.88
20	37.04	74.08	111.12	148.16	185.20	222.24	259.28	296.32	333.36	370.40
21	38.89	77.78	116.68	155.57	194.46	233.35	272.24	311.14	350.03	388.92
22	40.74	81.49	122.23	162.98	203.72	244.46	285.21	325.95	366.70	407.44
23	42.60	85.19	127.79	170.38	212.98	255.58	298.17	340.77	383.36	425.96
24	44.45	88.90	133.34	177.79	222.24	266.69	311.14	355.58	400.03	444.48
25	46.30	92.60	138.90	185.20	231.50	277.80	324.10	370.40	416.70	463.00
26	48.15	96.30	144.46	192.61	240.76	288.91	337.06	385.22	433.37	481.52
27	50.00	100.01	150.01	200.02	250.02	300.02	350.03	400.03	450.04	500.04
28	51.86	103.71	155.57	207.42	259.28	311.14	362.99	414.85	466.70	518.56
29	53.71	107.42	161.12	214.83	268.54	322.25	375.96	429.66	483.37	537.08
30	55.56	111.12	166.68	222.24	277.80	333.36	388.92	444.48	500.04	555.60


ATLANTISCHER OZEAN
MASSSTAB 1:32 000 000
Fur die Navigierung nicht zu benutzen
KEY TO MAP SYMBOLS
Port
Convoy Route
Single Merchant Route
High Naval Traffic
Allied Air Coverage 1939
Allied Air Coverage 1941
Allied Air Coverage 1943
QUADRANT ES
ALLIED CONVOYS
OA: 1939 - 1940
OB: 1939 - 1941
HX: 1939 - 1945
SC: 1939 - 1945
CU: 1943 - 1945
UC: 1943 - 1945
ON: 1941 - 1945
ONS: 1943 - 1945
OG: 1939 - 1943
KX: 1943 - 1945
OS: 1941 - 1945
KMS: 1942 - 1945
KMF: 1942 - 1945
SL: 1939 - 1944
HG: 1939 - 1942
MKS: 1942 - 1945
MKF: 1942 - 1945
PQ: 1941 - 1942
JW: 1942 - 1945
QP: 1941 - 1942
RA: 1942 - 1945
UGF: 1942 - 1945
UGS: 1942 - 1945
GUF: 1942 - 1945
GUS: 1942 - 1945
AS: 1942 - 1945
AXIS NAVAL BASES
Kiel 1939 - 1945
Wilhelmshaven 1939 - 1945
Flensburg 1939 - 1945
Hamburg 1939 - 1945
Danzig 1939 - 1944
Kristiansand 1940 - 1945
Bergen 1940 - 1945
Trondhjem 1940 - 1945
Narvik 1940 - 1945
Bordeaux 1940 - 1944
La Pallice 1940 - 1945
St. Nazaire 1940 - 1945
Lorient 1940 - 1944
Brest 1940 - 1944
Toulon 1943 - 1944
Spezia 1941 - 1944
Pola 1942 - 1944
Salamis 1941 - 1944
Konstanza 1941 - 1944
Penang 1942 - 1945
Soerabaja 1942 - 1945
GRÖNLAND
NORD AMERIKA
VEREINIGTE STAATEN
NORWEGEN
SCHWEDEN
RUSSLAND
DEUTSCHES REICH
FRANKREICH
SPANIEN
ITALIEN
JUGOSLAWIEN
RUMÄNIEN
TURKEI
MAROKKO
MAURETANIEN
COLOMBIA
VENEZUELA
ISLAND
IRLAND
ENGLAND
Davis Str.
Dänemark Str.
GOLF VON MEXICO
KARAIBISCHES MEER
JW, PQ
Liverpool-Murmansk
QP,RA
Murmansk-England
Liverpool-Halifax
Halifax-Liverpool
ON,ONS,UC
CU,HX,SC
OA,OB
England-Halifax
OG
Gibraltar-Liverpool
HG
Liverpool-Gibraltar
SL
Sierra Leone-Liverpool
Liverpool-Sierra Leone
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UGF,UGS
New York-Gibraltar
Port Said-Oran-New York
Casablanca-New York
GUF, GUS
New York-Curacao
Curacao-New York
AS
Port of Spain-Freetown-Oran
New York
Norfolk
Halifax
Sydney
Galveston
Tampa
Key West
Curacao
Port of Spain
San Fernando
Freetown
Casablanca
Gibraltar
Oran
Algier
Tunis
Reykjavik
Scapa Flow
Loch Ewe
Firth of Clyde
Liverpool
Bristol
Brest
Lorient
St. Nazaire
La Pallice
Bordeaux
Toulon
Spezia
Pola
Salamis
Konstantinopel
Konstanza
Wilhelmshaven
Hamburg
Kiel
Flensburg
Danzig
Riga
Bergen
Trondhjem
Kristiansand
Narvik
Murmansk
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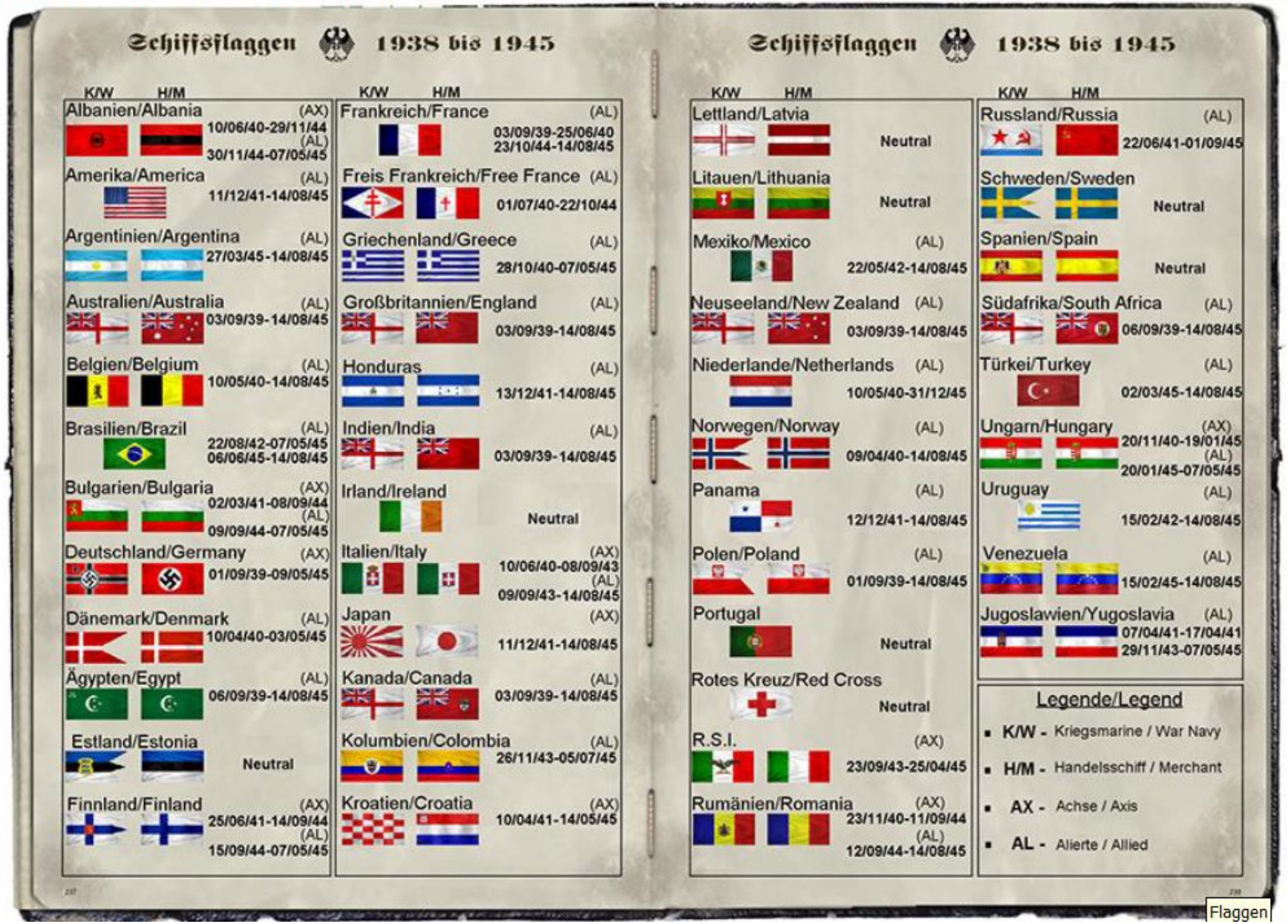
Flag recognition ("*Schiffsflaggen*") quick reference sheet



References

[1] Karl Hahl, Kriegsmarine Angriffscheibe Handbuch, p. 15, 2008.

[2] http://www.tvre.org/en/acquiring-torpedo-firing-data, Acquiring torpedo firing data, 2015.

[3] Corey "Gutted" Hardwell, Silent Hunter IV 90°- AOB Firing Angles, circ. 2008(?).

[4] http://www.subsim.com

[5] MathOnWeb, The arcsin function, Accessed 17.08.2015,