Pacific Campaign and Torpedo Solution Reference (v0.5.1)

fSocko

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Contents

1 Introduction

The 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), and/or slide-rules. 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

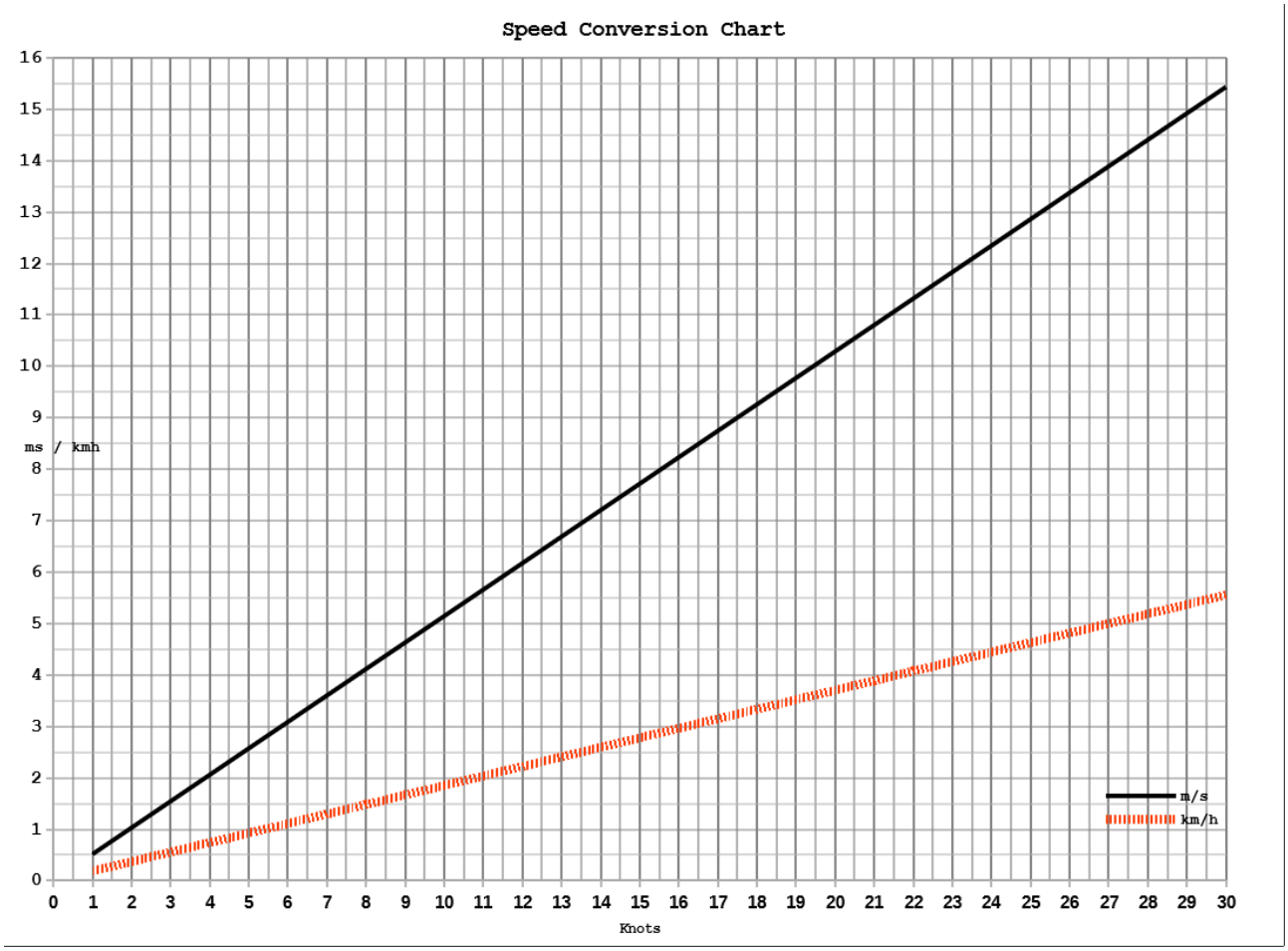
Length

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	

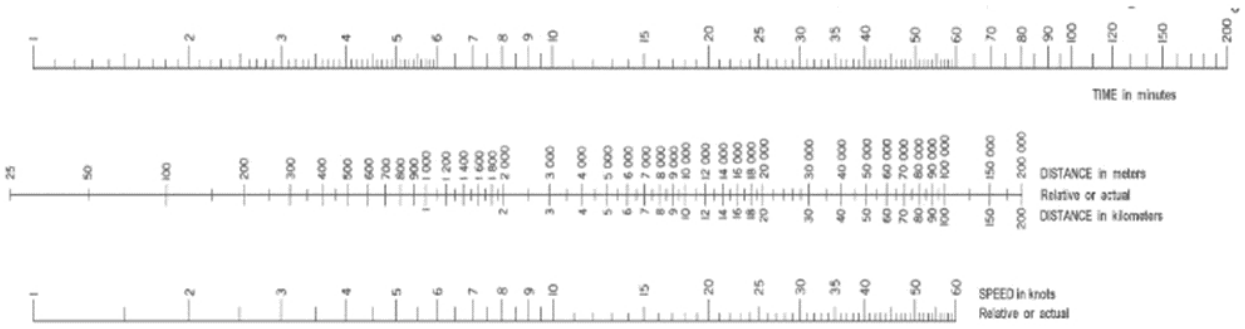
Speed

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 Speed Nomogram (Metric)



3 Torpedo Data - US

The following is torpedo for American torpedo types as used predominantly in the Pacific theatre. Slow and Fast speeds shown as appropriate. Torpedo data adapted from [6].

3.0.1 Mark 10

Available from:	Always
Range(m):	3200
Speed(kt):	36
Warhead:	80-160 radius 3-6m
Depth keeping:	70% chance of deviating $\pm 0.8m - \pm 1.2m$
Dud Chance (at AOB):	1% (0°-70°) 25% (70°-90°)
Renown cost:	0

Notes: Default torpedo for the S-Class. Slower and with a shorter range than the Mk. 14, but extremely reliable.

3.0.2 Mark 14

Available from:	Always
Range(Slow)(m):	8200
Range(Fast)(m):	4100
Speed(Slow)(kt):	31
Speed(Fast)(kt):	46
Warhead:	100-170 radius 3-7m
Depth keeping:	70% chance of deviating $\pm 1.5m - \pm 3.3m$
Dud Chance (at AOB):	1% (0°-35°); 34% (35°-70°); 99% (70°-90°)
Renown cost:	0

Notes: Default torpedo for all modern fleet boats. Faster and with a longer range than the Mk. 10, it packs a roughly 20% stronger punch but is much less reliable.

3.0.3 Mark 16

Available from:	1945-01-01
Range(m):	12500
Speed(kt):	46
Warhead:	180-250 radius 3.5-8m
Depth keeping:	70% chance of deviating $\pm 1.5m - \pm 3.3m$
Dud Chance (at AOB):	4% (0°-35°); 45% (35°-70°); 100% (70°-90°)
Renown cost:	400

Notes: Fast torpedo with an exceptionally long range, but also terribly unreliable.

3.0.4 Mark 18

Available from:	1943-07-12
Range(m):	3650
Speed(kt):	29
Warhead:	120-180 radius 3-7
Depth Keeping:	55% chance of deviating $\pm 1.2m - \pm 2.8m$
Dud Chance (at AOB):	1% (0°-35°); 34% (35°-70°); 99% (70°-90°)
Renown cost:	500 (200 from 1944-01-16; 0 from 1944-09-01)

Notes: Slower, 10% more powerful, with a shorter range and much more reliable than the Mk. 14.

3.0.5 Mark 23

Available from:	1943-01-01
Range(m):	4100
Speed(kt):	46
Warhead:	120-180 radius 3-7m
Depth Keeping:	70% chance of deviating $\pm 1.5m - \pm 3.3m$
Dud Chance (at AOB):	1% (0°- 35°); 34% (35°- 70°); 99% (70°- 90°)
Renown cost:	100 (0 from 16-01-1944)

Notes: Same range, speed and reliability than the Mk. 14 but roughly 10% more powerful. Definitely replaces the Mk. 10 as the "standard" torpedo from 16-01-1944.

3.0.6 Mark 27 "Cutie"

Available From:	1944-01-01
Range(m):	4570
Speed(kt):	12
Warhead:	50-100 radius 1.5-5
Depth Keeping:	NA
Dud Chance (at AOB):	1% (0°-25°)
Renown cost:	500

Notes: Slow acoustic homing torpedo with a small warhead primarily used for defence against destroyers.

3.0.7 Torpedo minimum arming distance

arming_distance is set across all torpedoes to 220m except the Mk. 27, which is 150 meters.

3.0.8 Torpedo max dive angle

max_dive_angle is set to 20 degrees for all torpedo types.

3.0.9 Torpedo maximum turn angle

max_turn_angle is 135°for all torpedoes except the Mk. 27, which is 180°.

3.0.10 Magnetic detonation range

mag_detonation_range is 2m for all torpedoes except for the Mk. 27, which is 1m.

3.0.11 Circular runner torpedos

circle_runner_chance is 0.5% for all torpedoes except for the Mk. 27, which is 0%.

3.0.12 Gyro problems

The chance of having gyro problems is 0.3% at the introduction time of all torpedoes and drops to 0.2% in later periods for all torpedoes except for the Mk. 16. The *max_deviation* when having gyro problems is always 50°. This does not apply to the Mk. 27.

3.0.13 Homing torpedos

The Mk. 27 will run straight for 200m before homing.

4 Torpedo Data - German

4.0.1 G7a T1

Available from:	Always
Range(Slow)(m):	14000
Range(Med)(m):	8000
Range(Fast)(m):	6000
Speed(Slow)(kt):	30
Speed(Med)(kt):	40
Speed(Fast)(kt):	44

Notes: The pre-war issue torpedo, it had the disadvantage of leaving a visible trail of bubbles on the surface on its way to the target. [10]

4.0.2 G7e T2

Available from:	Always
Range(Slow)(m):	5000
Speed(Slow)(kt):	30

Notes: The standard electric torpedo of the war. It suffered from early problems with its internal depth-keeping equipment, and its firing pistol, but these were solved after the Norwegian Campaign. [10]

4.0.3 G7e T3

Available from:	1942
Range(Slow)(m):	5000
Speed(Slow)(kt):	30

Notes: As for T2 but fitted with an influence fuse. [10]

4.0.4 G7e T4 "Falke"

Available from:	March 1943
Range(Slow)(m):	7500
Speed(Slow)(kt):	24

Notes: Falke, the first homing torpedo, was fitted with a passive acoustic homing device. [10]

4.0.5 G7es T5 "Zaunkonig"

Available from:	Autumn 1943
Range(Slow)(m):	5700
Speed(Slow)(kt):	24

Notes: The Zaunkonig (Wren) came into service during the autumn of 1943. Intended to be an escort-killer. [10]

5 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. $\frac{ReferenceLength}{ReferenceMastHeight}$)

AOB is required for a number of formulas such as the intercept lead angle.

5.1 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.

5.1.1 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*).

5.2 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.

6 Target Interception Formulas

Formulas used in the initial interception of target, prior to calculating any torpedo solutions.

6.1 Determine Interception Lead Angle given known Target Speed, known Own Speed and known AOB

Determine the intercept lead angle ahead of the targetBearing (leadAngle) given a known target speed, own speed, and AOB. Data adapted from Cpt_Geschraub, 2005[9] and Kylania 2010 [8].

$$interceptLeadAngle = sin^{-}1(TargetSpeed * sin(AOB)/OwnSpeed)$$

6.1.1 Determine Minimum speed for interception

Above formula rearranged for speed, given a set intercept angle.

$$minOwnSpeed = interceptLeadAngle\left(Sin^{-}1(TargetSpeed * Sin(AOB))\right)$$

6.2 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)

$$DistancetoTrack = Range * (sin(AOB))$$

7 Determine the lead angle for a perpendicular attack with 0°gyro angle (AKA OKane 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.

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

8 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).

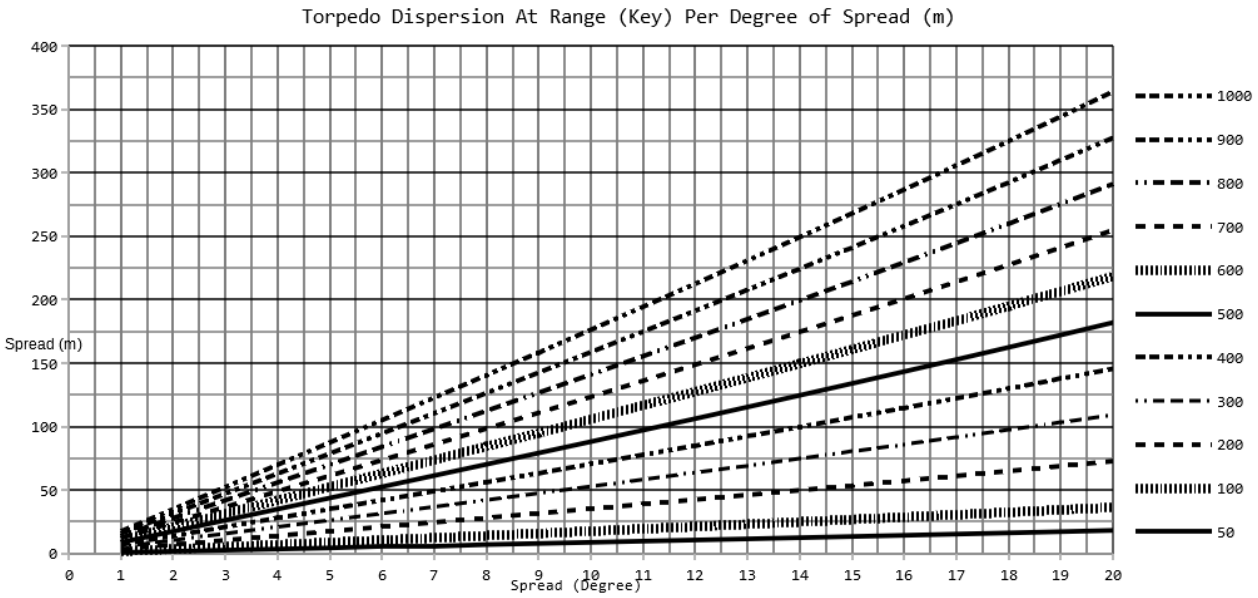
$$sin(leadangle)/sin(AOB) = (targetspeed)/(torpedospeed)$$

$$gyroAngle = targetBearing - leadAngle$$

9 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°

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



11 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

12 Recognition Manual (Short, Metric)

Name	Speed (kn)	Length (m)	Mast (m)	Draft (m)	Aspect
Auxilary Subchaser	17.00	63.00	11.40	4.20	5.5263
Agano Light Cruiser	35.00	175.00	23.60	5.70	7.4153
Akikaze Destroyer	34.00	102.50	21.80	2.90	4.7018
Akita Maru	13.50	105.00	16.00	7.30	6.5625
Akitsu Escort Carrier	20.00	143.75	35.70	7.84	4.0266
Akizuki Destroyer	33.00	135.00	22.80	3.80	5.9211
Armed Merchant Cruiser	17.50	155.00	26.80	8.70	5.7836
Armed Trawler	12.00	62.00	13.50	4.20	4.5926
Asashio Destroyer	35.00	118.00	27.00	3.40	4.3704
Atami Gunboat	20.00	45.00	7.80	1.10	5.7692
Attacker Escort Carrier	18.00	152.00	33.80	8.20	4.4970
Baltimore Heavy Cruiser	33.00	205.00	30.60	6.50	6.6993
Biyo Maru	12.00	120.00	20.10	7.50	5.9701
Black Swan Sloop	19.50	91.30	27.20	3.50	3.3566
Bogue Escort Carrier	18.00	152.00	11.30	8.20	13.4513
British Medium Old Tanker	10.00	91.50	11.00	4.50	8.3182
Brooklyn Light Cruiser	32.50	185.00	32.30	7.00	5.7276
Buckley Destroyer Escort	24.00	93.20	21.10	3.40	4.4171
Buzyun Maru	11.00	103.00	9.80	6.40	10.5102
Casablanca Escort Carrier	19.00	156.00	13.90	6.30	11.2230
Chitose Seaplane Tender	28.90	192.50	32.60	7.50	5.9049
Clemson Destroyer	35.00	95.00	28.80	3.10	3.2986
Cleveland Light Cruiser	32.50	185.00	36.20	6.60	5.1105
Coastal Composite Freighter	13.00	80.77	17.90	5.48	4.5123
Colorado Battleship	21.00	190.20	43.90	9.10	4.3326
Conte Verde Liner	21.00	173.74	28.60	7.50	6.0748
Dido Light Cruiser	32.00	156.00	36.50	6.30	4.2740
Elco Torpedo Boat	44.00	24.70	5.30	1.20	4.6604
Elite Black Swan Sloop	19.50	91.30	27.20	3.50	3.3566
Etorofu Escort	19.70	66.00	17.90	2.93	3.6872
Evarts Destroyer Escort	19.00	89.50	27.70	3.40	3.2310
Fiji Light Cruiser	32.00	169.00	43.90	5.00	3.8497
Fishing boat	10.00	38.00	18.70	1.80	2.0321
Fishing boat	10.00	38.00	18.70	1.80	2.0321
Fishing Boat	8.00	34.00	7.90	2.40	4.3038
Fishing Trawler	12.00	62.00	13.50	4.20	4.5926
Fleet Carrier	32.50	250.00	54.40	6.80	4.5956
Fletcher Destroyer	35.00	115.00	28.00	4.90	4.1071
Flower Corvette	16.00	60.60	19.70	3.50	3.0761
Fubuki Destroyer	38.00	118.50	22.60	3.50	5.2434
Furutaka Heavy Cruiser	33.00	188.00	25.90	5.20	7.2587
Fuso Battleship	24.70	212.00	48.30	9.50	4.3892
Hakusika Maru	12.00	135.00	20.30	8.70	6.6502
Haruna Maru	11.00	76.00	19.70	4.60	3.8579
Heito Maru	17.00	103.60	16.60	6.50	6.2410
Hira Gunboat	20.00	55.00	10.10	1.10	5.4455
Hiryu Fleet Carrier	34.30	223.30	37.20	7.50	6.0027
Horai Maru	17.00	137.46	25.60	8.53	5.3695
Iowa Battleship	33.00	270.40	44.30	11.00	6.1038
Ise Battleship	25.60	220.00	44.50	9.50	4.9438
Ise Battleship (Late War)	25.60	220.00	49.20	9.50	4.4715
J Class Destroyer	36.00	108.50	28.00	4.60	3.8750
JC Butler Destroyer Escort	24.00	93.30	28.10	2.80	3.3203
Junk	10.00	19.60	17.70	1.20	1.1073
Kasagisan Maru	12.50	86.80	18.10	6.10	4.7956

Name	Speed (kn)	Length (m)	Mast (m)	Draft (m)	Aspect
Kent Heavy Cruiser	31.50	183.00	21.80	5.00	8.3945
King George V Battleship	27.00	244.00	53.90	9.10	4.5269
Kinposan Maru	14.50	108.00	18.50	6.60	5.8378
Kisaragi Destroyer	37.00	102.00	11.20	3.00	9.1071
Kiturin Maru	18.50	130.00	25.70	8.60	5.0584
Kongo Battleship	30.50	220.00	42.50	8.50	5.1765
Kuma Light Cruiser	36.00	163.00	35.60	6.10	4.5787
Landing Ship Tank	10.80	98.70	25.20	3.30	3.9167
Large German Tanker	18.00	190.00	24.20	10.70	7.8512
Large Sampan	10.00	35.00	26.90	2.20	1.3011
Liberty Cargo	13.00	147.00	21.00	5.80	7.0000
Maya Heavy Cruiser	34.00	204.00	33.50	5.90	6.0896
Medium Modern Passenger/Freighter	16.00	105.00	27.40	7.30	3.8321
Minekaze Destroyer	39.00	102.60	21.80	2.90	4.7064
Mogami Heavy Cruiser	35.00	200.00	35.00	6.70	5.7143
Momi Destroyer	18.00	102.60	11.10	2.93	9.2432
Momoyama Maru	11.00	120.00	16.00	4.70	7.5000
Momoyama Maru	11.00	120.00	16.00	4.70	7.5000
Mutsuki Destroyer	37.00	102.00	11.20	3.00	9.1071
Nagara Maru	19.00	137.00	20.50	7.50	6.6829
Naka Light Cruiser	35.25	162.00	31.30	5.10	5.1757
Nevada Battleship	20.50	190.20	43.90	9.10	4.3326
New Mexico Battleship	22.00	190.00	42.00	10.00	4.5238
Nippon Maru	20.00	150.00	16.70	8.60	8.9820
North Carolina Battleship	27.00	220.00	33.40	9.00	6.5868
Northampton Heavy Cruiser	32.70	183.00	49.00	7.00	3.7347
Okinoshima Minelayer	20.00	123.40	28.50	4.80	4.3298
Old Raked Bow Split Merchant	11.00	120.00	17.30	4.70	6.9364
Omaha Light Cruiser	35.00	168.00	19.50	4.50	8.6154
Patrol Boat 102	35.00	95.00	28.70	3.10	3.3101
Pennsylvania Battleship	21.00	190.20	43.90	9.10	4.3326
Pocket Battleship	28.50	183.00	37.90	7.00	4.8285
River class Frigate	20.00	91.50	25.90	4.00	3.5328
Sampan	10.00	19.50	16.50	1.20	1.1818
Schnellboat	44.00	24.70	5.30	1.20	4.6604
Shimushu Escort	20.00	70.00	24.50	2.93	2.8571
Shiratsuyu Destroyer	34.00	108.00	22.00	3.00	4.9091
Shokaku Fleet Carrier	34.50	250.00	32.40	8.70	7.7160
Small Old Split Freighter	17.00	80.50	17.90	3.70	4.4972
Small Split Freighter	12.50	86.87	18.10	6.10	4.7994
Somers Destroyer	37.00	116.00	31.50	4.20	3.6825
Submarine Tender	18.00	201.00	22.40	9.40	8.9732
T3 Tanker	18.00	190.00	25.50	10.70	7.4510
Taiho Fleet Carrier	33.30	253.70	46.20	9.50	5.4913
Taihosan Maru	13.00	80.50	17.90	3.70	4.4972
Taiyo Escort Carrier	21.00	180.10	15.10	7.50	11.9272
Takao Heavy Cruiser	36.50	204.00	35.30	6.00	5.7790
Tennessee Battleship	20.50	190.00	42.00	10.00	4.5238
Tennessee Battleship	20.50	190.20	43.90	9.10	4.3326
Tribal Destroyer	36.50	115.00	15.40	4.00	7.4675
Troop Transport	16.00	152.00	23.20	8.50	6.5517
Tug Boat	15.00	63.00	11.50	4.20	5.4783
Tyohei Maru	13.00	79.00	14.30	4.60	5.5245
Type C Escort	19.00	89.50	27.70	3.40	3.2310
Type D Escort	19.00	89.50	27.70	3.40	3.2310

Name	Speed (kn)	Length (m)	Mast (m)	Draft (m)	Aspect
V.W Destroyer	34.00	95.00	21.00	3.20	4.5238
Victory Cargo	17.00	139.60	21.80	7.30	6.4037
Wakatake Patrol Boat	18.00	102.60	21.70	2.93	4.7281
West Virginia Battleship	21.00	190.00	42.00	10.00	4.5238
Yamato Battleship	27.40	263.00	39.20	10.80	6.7092
Yugumo Destroyer	35.00	118.00	11.50	3.40	10.2609
Z Class Destroyer	38.00	118.50	22.60	3.50	5.2434
Zinbu Maru	10.00	120.00	18.60	4.70	6.4516

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