Naval Campaigns User Manual

Introduction

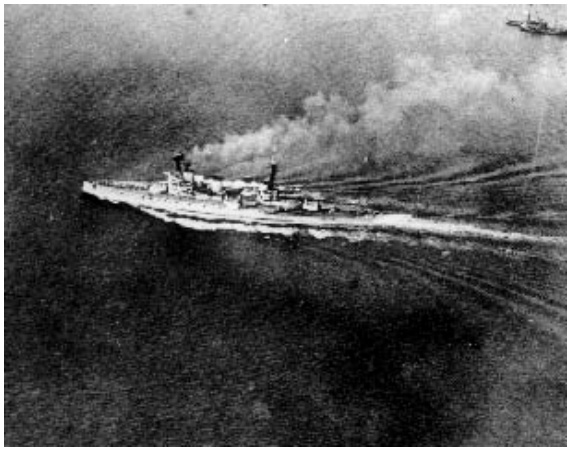
Naval Campaigns is a series of games covering modern naval actions including actions such as the World War I naval battle of Jutland. Each game consists of a series of scenarios based on the historical battle with hypothetical scenarios as well. The game can be played alone versus the computer, or against a human opponent using Network Play (over a Local Area Network or the Internet). The game is real-time with both sides playing simultaneously.

The documentation for Naval Campaigns is divided into several parts:

- The **Getting Started Help File** covering the basics of play. This Help File is tied to one of the scenarios in the game and will assist you in learning the basics of the game.
- This **User Manual** covering the game basics, main features and additional information such as Network Play, Tactics, and Troubleshooting.
- The **Main Program Help File** covering issues specific to the main game engine. Note: each menu, menu item, and dialog of the main program is discussed in detail in this Help File.
- The **Scenario Editor Help File** covering issues specific to the scenario editor.
- The **Order of Battle Editor Help File** covering issues specific to the Order of Battle editor.
- The **Parameter Data Editor Help File** covering issues specific to the Parameter Data Editor.

This manual last updated: January 7, 2011

The Interface



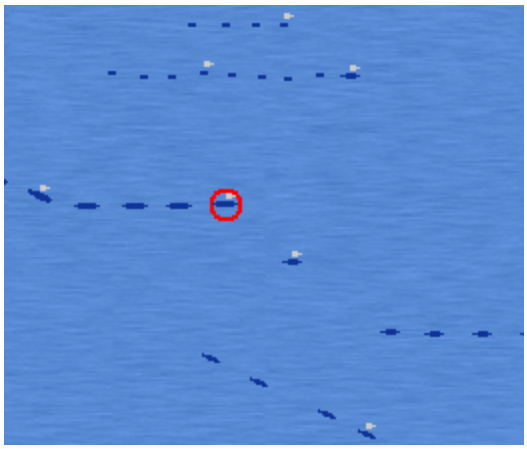
The interface of the main program is divided into three main areas and several other minor ones. The three main areas are: the Main Chart, the Jump Chart, and the Ship List areas. Each of these is described in detail below. You also use the various menus and Toolbar buttons to control the game, or you can sometimes use Hot Keys for common commands.

Running and Stopping the Game

The Naval Campaigns game runs in real-time. To control the speed of the game, there are four basic commands:

- Use the **Pause** button on the Toolbar or press the Space Bar Hot Key to stop the game at any time, or if stopped, to resume the game at normal speed.
- Use the **Normal** button on the Toolbar to run the game at actual real-time speed.
- Use the **Slower** button on the Toolbar to decrease the run speed of the game.
- Use the **Faster** button on the Toolbar to increase the run speed of the game. You can do this multiple times up to a 10x increase in the run speed of the game.

The Main Chart



The Main Chart shows the location of specific ships and aircraft and allows you to select these ships to issue commands. The ships and aircraft are displayed in two colors: blue for the first side and orange for the second. In addition, the ships are displayed in four primary classes: battleship, cruiser, destroyer (or torpedo boat), and aircraft carrier. If you click on a ship or aircraft with the left-mouse button, then it becomes **selected** and is shown in the Ship List (see below). On the Main Chart, the selected ship or aircraft is shown surrounded by a red circle.

The lead ship of a group, the **flagship**, is shown with a white or black flag. In general, you issue movement orders for a group by giving an order to the flagship.

When a ship that would normally be a flagship is attached to another group, then that is indicated with a "hollow" flag in Normal View.

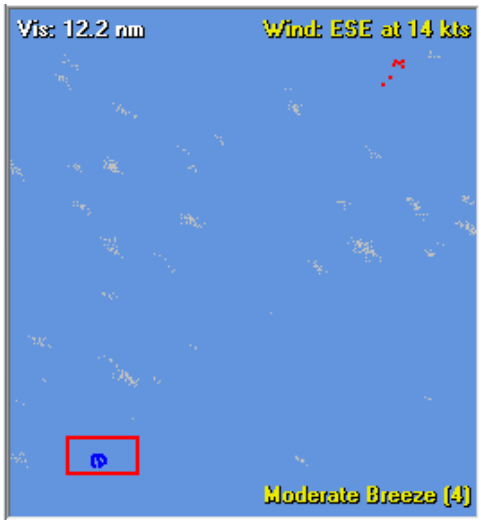
When you issue a turn command to a ship, a green turn arrow will appear on the Main Chart showing the new heading for the ship. Once the turn is completed, the turn arrow will disappear.

When a ship is selected and it has a target, then the target ship is shown highlighted.

The Main Chart has 4 zoom levels. These can be toggled by using the View Menu, the Toolbar zoom buttons, or through the use of hot keys. The Main Chart can be scrolled by moving the mouse to the edge of the screen. This will cause the Main Chart to scroll in the direction of the mouse.

In the lower right-hand corner of the Main Chart is the **Victory Bar**. When this bar has a blue area, then the first side has an advantage. When it is red, then the second side has the advantage. When the side's flag appears next to the Victory Bar, then that side has attained a Minor Victory. When the entire bar is colored for that side, then the side has a Major Victory.

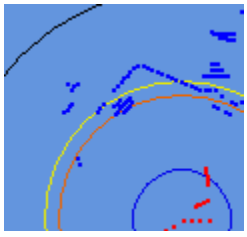
The Jump Chart



The Jump Chart is a smaller area in the lower left-hand corner of the screen that shows the entire battle area. Ships and aircraft of the first side are blue dots and ships and aircraft of the second side are red dots. The current viewing area is shown as a red rectangle in the Jump Chart. Clicking with the left mouse button in the Jump Chart will cause the Main Chart to scroll to that location.

The value in the upper left-hand corner of the Jump Chart is the current limit of visibility measured in yards or nautical miles. The wind speed and direction is shown in the upper right-hand corner. The Sea State both numerically and based on the Beaufort Scale is shown in the lower right-hand corner.

In the upper right-hand corner of the Jump Chart, the wind direction and strength is shown.



You can select the **Ship Range** option in one of two ways: by using the Ship Range option of the View Menu or by using the Ship Range Toolbar button.

When you select this option, there are up to 6 circles drawn on both the Jump Chart and the Main Chart associated with the currently selected ship:

- The **Blue** circle shows the maximum range for firing torpedoes, if the selected ship or aircraft is capable of firing torpedoes.

- The **Red** circle shows the maximum range of the **secondary armament** of the selected ship, if the ship has secondary armament. For aircraft, it shows the maximum range of the carried load, if any.
- The **Black** circle shows the maximum range of the **primary armament** of the selected ship. For aircraft it shows the maximum flying range of the aircraft and the half-maximum flying range of the aircraft.
- The **Yellow** circle shows the current maximum visibility.
- The **Magenta** circle shows the maximum range of any radar on the selected ship or Target. When this range extends past the horizon, then a second ring is drawn showing the distance to the horizon.
- The **Teal** circle shows the range of any AAA on the selected ship.

When you select the **Distances** option from the View Menu, then **White** circles are shown on the charts indicating the distance from the current Hot Spot in increments of 50 nautical miles.

The Ship List

The Ship List appears on the left-hand side of the screen and displays the last few ships or aircraft selected. In the list, if a ship or aircraft picture appears brighter, or highlighted, it indicates that the ship or aircraft is currently selected. The selected ship or aircraft will be shown on the Main Chart with a red circle around it. Clicking on a ship or aircraft in the Ship List will make that ship or aircraft become selected and will automatically scroll the Main Chart to the location of the ship or aircraft. Furthermore, by selecting the ship or aircraft in this way, the Main Chart will automatically scroll to follow the selected ship or aircraft as it moves.

There are several values shown in the Ship List display for each ship:

- The percentage number in the upper corner of the ship picture is the **Status** of the ship and is a percentage value between 0 and 100%.
- The direction shown in the lower corner of the ship picture is the current **Heading** of the ship. There are 16 possible headings for any given ship, each heading representing two naval points.
- The flag shown in the upper corner of the ship picture is the **Nationality** of the ship.
- The value shown in the lower corner of the ship is the **Speed** of the ship in knots.

The name of the ship is shown in the center of the picture. When the name is shown in yellow, it indicates that the ship is a Flagship. The hull type of the ship is shown before the name. Several common hull types are:

- **BB** – a New Battleship. These are the larger battleships built after the original Dreadnought.
- **B** – an Old Battleship. These are older battleships built before the Dreadnought.
- **BC** – a Battlecruiser. These are the larger cruisers built after the Dreadnought.
- **CA** – an Armored Cruiser. These are large cruisers, but without the armament of a Battlecruiser.
- **CL** – a Light Cruiser. These are smaller, faster cruisers which are used for scouting or to lead destroyers.
- **DD** – a Destroyer. These are small, fast ships typically armed with torpedoes.
- **TB** – a Torpedo Boat. These are very similar to Destroyers and are equipped with torpedoes intended to be used against Battleships.
- **CV** – an Aircraft Carrier. This ship is capable of launching and landing airplanes.
- **SS** – a Submarine. Capable of submerging beneath the water.

A fairly complete list of hull classifications as used in Naval Campaigns can be found in Standard Hull Classifications.

When the name is shown in green, it indicates that the ship is a flagship attached to another group.

When the word **Detached** appears at the top of the picture, it indicates that the ship is sailing independently of other ships and not part of a group of ships.

When the word **Attached** appears at the top of the picture, it indicates that the normal group of this ship has been attached to another group and the flagship of this other group will control the ship's normal group.

The Status value of a ship is color coded to represent various conditions associated with the ship:

- A **white** Status value indicates the ship is at 100% Status. Under Fog-of-War, this is reported as **No Damage**.
- A **green** Status value indicates the ship is between 76 and 99% Status. In this range, the speed of the ship is unaffected, but its firepower is reduced proportionally. Under Fog-of-War, this is reported as **Light Damage.**
- A **yellow** Status value indicates the ship is between 26 and 75% Status. In this range, the maximum speed of the ship is reduced, having full maximum speed at 75% to being unable to move at 25%. The firepower of the ship is again reduced proportionally to its Status. Under Fog-of-War, this is reported as **Medium Damage.**
- A **red** Status value indicates the ship is between 0 and 25% Status. In this range, the ship is **Disabled** and is unable to move or fire. Note however that a Disabled ship can still fire torpedoes if it is equipped with them. Under Fog-of-War, this is reported as **Heavy Damage.**

When a ship changes direction, its heading value shows two entries: one is the current direction of the ship in degrees, measured clockwise from 0 degrees equal to due north, and the second is the commanded direction of the ship. Once the ship reaches its commanded heading, the degree value disappears.

When a ship changes speed, its speed value shows two entries: the first is the actual speed of the ship in knots while the second is the commanded speed of the ship. Once the ship reaches its commanded speed, the first value disappears.

Certain ships carry loads in addition to any guns they may have. The active load is shown below the name of the ship and can be changed using the **Set Active Load** command. The number of that load is shown followed by the name of the load and finally the directions the load may be fired in.

There are several icons that may be displayed on the ship picture depending on its capabilities and situation.


A **Mine** icon indicates that the ship is capable of laying mines (see the section on Firing).

A **Torpedo** icon indicates that the ship is capable of firing torpedoes (see the section on Firing). If the ship has multiple torpedoes, then the number of torpedoes is shown over the icon.

 A **Smoke** icon indicates that the ship is capable of laying smoke (see the section on Maneuver).

A **Radar** icon indicates that the ship has radar or radar detection and that the device is functional. Next to the icon is a short descriptive name for the radar or the notation "XX" for ships equipped with radar detection.

 An **Active Sonar** icon indicates that the ship has active sonar and is capable of estimating both the direction and distance to submerged submarines.

 A **Passive Sonar** icon indicates that the ship has passive sonar and can estimate the direction to other ships, but not their distance.

A **Depth Charge** icon indicates that the ship is carrying depth charges (see the section on Firing). The number of depth charges is shown over the icon.

 When a ship is carrying aircraft or is an aircraft carrier, then an airplane icon is shown.

If a ship is currently not capable of having aircraft take-off or land on or next to it, then a red cross is drawn over the icon. A descriptive reason for this is shown next to the icon:

- **Wind** – the ship is not facing into the wind (for carriers).
- **Wait** – the ship is waiting for a previous operation (landing, take off, deck operation) to complete.
- **Burn** – the ship is on fire and burning.
- **Turn** – the ship is turning.
- **Cloud** – the ship is obscured by low-lying clouds.
- **Stat** – the status of the ship is below that required for air operations.
- **Sub** – the ship (submarine) is submerged.

When a ship has aircraft assigned to it, such as an aircraft or seaplane carrier, then there are counts displayed in the picture giving the distribution of aircraft on the ship:

- The two values following the **S** are the number of aircraft spotted for take off and the number of spotted aircraft moving to the Hangar.

- The two values following the **H** are the number of aircraft in the Hangar and the number of aircraft moving from the Hangar to be spotted.

When there are more aircraft on the flight deck than can be handled, then the spotted number turns to red indicating that no take offs or landings are possible.

Other icons indicate the status of the ship relative to the enemy.

Binoculars indicate that the ship can spot an enemy ship or aircraft.

When a cross is added to the binoculars, it indicates that the ship is firing on an enemy ship with its main armament.

If you click with the **right** mouse button in the Ship List and hold the mouse button down, then it will toggle the alternative ship display. This display shows additional information about the ship and its capabilities. On one side of this display will be the organizational hierarchy of the ship, starting with its hull type, followed by its class, and then a list showing where the ship appears in the overall Order of Battle. If one of the entries in the Order of Battle list is shown in yellow, then this organization is currently highlighted on the charts using the Highlight Organization feature of the View Menu or Toolbar. When the class is followed by three numbers (A/S/H), then these indicate the maximum number A of carrier planes, S of seaplanes, and H of helicopters that can be carried aboard the ship.

On the other side of the alternative display is shown a list of ship features:

- The **Crew** of the ship in men.
- The **Size** of the ship in tons.
- The **Belt** armor of the ship in inches.
- The **Deck** armor of the ship in inches.
- The **Range** of the main armament of the ship in yards.
- Whether the ship has **Secondary** armament.
- Whether the ship carries **Torpedoes**.
- Whether the ship is capable of laying **Mines** or **Smoke**.
- The number and type of guns making up the **Primary** armament of the ship.

Aircraft Values

Aircraft are represented in the game as **flights**. Each flight consists of one or more aircraft of the same type. Aircraft are rated as having a certain cruising speed, may have guns or cannons that they can use for dogfighting and strafing, and may carry loads such as bombs or rockets. Aircraft can be refueled and rearmed on aircraft carriers and at land airbases.

Aircraft have a maximum range that they can fly before needing land so they can be refueled. When the displayed range blinks, it indicates that the aircraft has only a 10% reserve range available to make it back to its home carrier or air base.

Aircraft have attributes which determine their capabilities and features. These include:

- **Airplane** and **Helicopters** – An aircraft may be classified as being an airplane (fixed wing) or a helicopter (rotary wing). This determines the ability of the aircraft to hover and to land off of a defined runway area.
- **Prop** and **Jet** – Airplanes are further classified as being propeller driven or jet powered, although this has mainly to do with sound effects in the game and has no functional difference.
- **Small** and **Large** – Each aircraft is classified as being small or large. This determines how much space they take up when parked and how long it takes to fuel and arm them.
- **Seaplane** and **Amphibious** – An airplane can be classified as being a seaplane, and thus able to land on the water, or amphibious and being able to land on both water and land.
- **Carrier** – An airplane capable of landing on an aircraft carrier.
- **Dive Bomber** – An airplane capable of conducting a dive bombing attack.

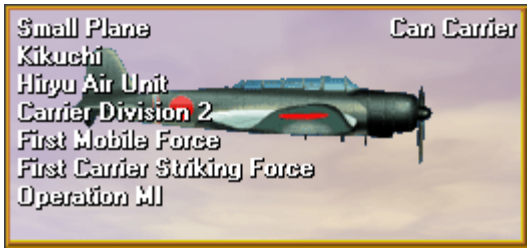
 An aircraft may have guns or cannons that they can use for dogfighting with other aircraft. They may also be able to use these for strafing ships and targets. A gun icon shows that the aircraft has guns or cannons and the number shown is the number of shots it has left.

An aircraft may carry a load such as bombs or rockets. When this is the case, the active load is shown below the name of the flight. The number of that load is shown followed by the name of the load.

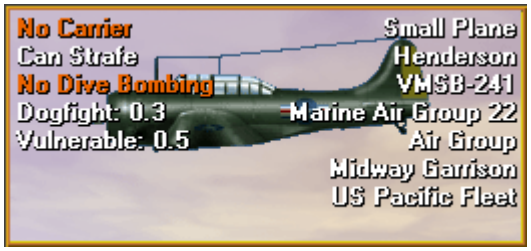
Other icons indicate the status of the ship relative to the enemy.

Binoculars indicate that the aircraft can spot an enemy ship or aircraft.

A cross icon indicates that the aircraft has **targeted** an enemy ship or target or is flying to land at a friendly ship or air base.



If you click with the **right** mouse button on the aircraft picture and hold the mouse button down, then it will toggle the alternative aircraft display. This display shows additional information about the aircraft and its capabilities. On one side of this display will be the organizational hierarchy of the aircraft, starting with its type, followed by a list showing where the aircraft appears in the overall Order of Battle. If one of the entries in the Order of Battle list is shown in yellow, then this organization is currently highlighted on the charts using the Highlight Organization feature of the View Menu or Toolbar.



Certain organizations are flagged as not having the training for carrier landings or dive bombing even when the aircraft they are flying are able to do this. When this happens the alternative display will show these limitations.

Objectives

Certain scenarios can have Objectives. There are two types of Objectives: **Line** and **Location**.

Line Objectives are displayed on the Main Chart and the Jump Chart as lines. Blue lines are used for Objectives for the first side and red lines are used for Objectives for the second side. When a scenario has a Line Objective for a particular side, then that side is awarded points when ships from that side cross the Objective line.

Location Objectives are displayed on the Main Chart and the Jump Chart as circles. When a scenario has a Location Objective for a particular side, then that side is awarded points when ships from that side enter the circle.

Objective Points are shown in the Victory Dialog.

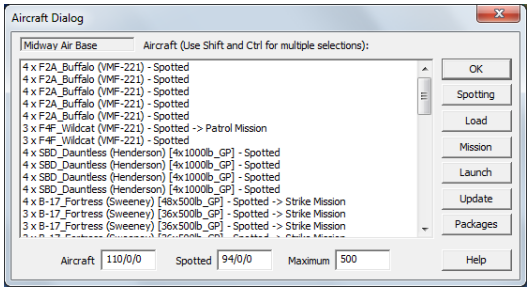
Targets

Depending on the scenario, there may be one or more Targets defined on the chart, usually on land. These can represent any number of entities, including air bases as described below. Enemy Targets may be attacked by ships and aircraft. A Target has a specified size and a protection value which affects how attacks against it are resolved. A Target may have a AAA value which is used to defend against air attacks and may have a radar ability which allows it to spot enemy ships and aircraft beyond visual range.

Air Bases

Certain Targets are designated as **Air Bases**. When this is the case, then they are shown using the airport icon and aircraft can land and take off from them. An air base of size S can hold S/2 aircraft, with large aircraft being counted as 2 for this purpose.

An Air Base can be located on land or in the water. An Air Base located on land can be used by all aircraft except for non-amphibious seaplanes. That is, an Air Base located on land must be used by aircraft that has wheels. An Air Base located on the water is a Seaplane Base and can only be used by seaplanes.



To see the aircraft located at an Air Base and to see the number of aircraft that can be located there, double click on the Air Base icon. This will show the Aircraft Dialog and a list of the aircraft based there. More information on the Aircraft Dialog can be found in the section on Aircraft Carriers and in the Main Program Help File.

Mouse Selections

You can use the mouse to select and command ships and aircraft on the main chart:

- Clicking on a ship or aircraft with the left mouse button will show the ship or aircraft in the Ship List.
- Double-clicking on a ship that has aircraft assigned to it or an air base will display the Aircraft Dialog so that those aircraft can be selected and given commands.
- Double-clicking on an aircraft flight will highlight all of the flights that are in the same organization as the selected flight.
- Right clicking on a ship or target after selecting a ship will cause the ship to fire on that ship or target.
- Right clicking on the chart after selecting an aircraft flight or organization will cause the flight or organization to fly to that location and, if the location has a ship, flight, or Target, they will attack it.

More information on firing and attacking can be found in the following sections.

Main Features

Maneuver

You maneuver the ships and aircraft under your control by issuing commands which affect the heading and speed of the ships. A ship can either be **Detached** and sailing independent of other ships, or part of a group of ships under the control of a **Flagship.**

Turns

To turn an individual ship, you first select the ship and then issue a Clockwise (to Starboard) or Counterclockwise (to Port) turn command. This command can be issued using the Command Menu but is far easier to be issued using either the Toolbar or using Hot Keys.

If a ship is part of a group but not the flagship, then issuing a turn order to the ship will cause the ship to become Detached. Normally you turn a group of ships by issuing the turn command to the group's flagship. When you do this, the other ships in the group will automatically follow the flagship through the turn.

To turn a flight of aircraft, you first select the flight and then right click in the direction you want the flight to go in. The flight will continue in that direction until you issue another direction or target for it to fly to.

Group Turns

A normal turn involving a group of ships will first turn the flagship of the group and then each succeeding ship in the group will turn to follow the flagship through the turn to the new heading. However, it is possible

with some restrictions to cause the entire group of ships to turn simultaneously by using a Group Turn. To issue a Group Turn, you select the flagship of the group and then issue a Group Clockwise or Group Counterclockwise turn command. This will cause all ships in the group to turn simultaneously to the new heading.

Turn Abouts

Normally a flagship is in the van, or furthest forward, position of a group of ships. However, by using Group Turns, it is possible for a flagship to become placed in the rear of the group. Using Group Turns to place a flagship in the rear of the group is not necessarily possible for both sides in the game. This ability is determined by the **Can About Turn** Parameter Data value and can be viewed using the Parameter Data Dialog. When a given side is not capable of Turn Abouts, then it can use Group Turns to conduct a "flank turn" in which the ships of the group are sailing parallel to each other, but no further.

Flying Aircraft

To fly an aircraft in a certain direction, click on the aircraft to select it, and then **right click** in the direction you want the aircraft to fly. The aircraft will continue to fly in that direction until you change its direction.

To fly a group of aircraft in a certain direction, **double click** on one of the flights to highlight all of the aircraft in that group. Then as before, right click in the direction you want the aircraft to fly.

Speed Changes

To change the speed of a ship or aircraft, you select the ship or aircraft and then increase or decrease the speed of the ship using the Toolbar buttons or Hot Key commands. To change the speed of a group of ships, you normally issue the command to the flagship. Issuing a change speed command to a ship in a group which is not the flagship will cause the ship to become Detached. When you attempt to increase the speed of a group of ships, it will not be possible to command the ships to go any faster than the slowest ship in the group. If a ship in a group suffers damage which reduces its maximum speed, then the game will automatically reduce the speed of the other ships in the group to maintain the group formation. If this ship is subsequently sunk, then you will want to manually increase the speed of the group back to its maximum speed. You

may also want to Detached heavily damaged ships if they are degrading the maximum speed of the group.

Normally when you use the change speed buttons, the speed of the selected ship is modified in 1 knot increments or 10 knots for aircraft. If you hold down the **Alt** key when issuing the change speed command, then the speed will be modified in increments of 1/10 of a knot or 1 knot for aircraft, allowing much finer control over the speed of the ship or aircraft. Also, the Full Stop and Full Speed buttons and commands can be used to command the ship or a helicopter to stop, an airplane to fly at minimum speed or for a ship or aircraft to attain maximum speed.

Minimum airplane speeds are:

- 50 knots for a small prop airplane.
- 60 knots for a small jet airplane.
- 100 knots for a large prop airplane.
- 120 knots for a large jet airplane.

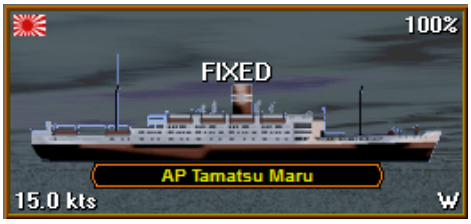
Attaching and Detaching

Normally each ship is part of a group of ships which typically is a Squadron, Division, or Flotilla. By selecting a ship and pressing the Detached toolbar button, it is possible to Detach a ship from a group so that it can be commanded individually. Selecting a Detached ship and pressing the Detached toolbar button will cause the ship to become part of its original group again, but you are responsible for first maneuvering the ship so that it takes its place in the group formation.

It is also possible to attach one group to another so that the flagship of the other group controls the group being attached. To attach one group to another, click on the flagship of the group to be attached on the Main Chart. Then, while holding down the mouse button, drag the mouse to the flagship of the group to attach to and release the mouse. This will attach the first group to the second. To later unattach the group, select any ship in the attached group and press the Detached toolbar button.

When a flagship is attached to another group, it is indicated with a "hollow" flag in Normal View.

Fixed Ships



In a given scenario, certain ships and aircraft may be designated as **Fixed**. A Fixed aircraft cannot take-off for the duration of the scenario. A Fixed ship which is not moving cannot move for the duration of the scenario.

A Fixed ship which is moving at the beginning of the scenario can only continue moving at the same speed and cannot turn until the enemy or an enemy shot is spotted. Once the enemy or an enemy shot is spotted, then all Fixed ships are freed to move and fire normally.

In Convoy Ships

Certain ships in a scenario may be designated as **In Convoy**. A ship that is In Convoy cannot be controlled by the player and will move according to the control of the game Artificial Intelligence.

A ship can be designated both Fixed and In Convoy. When this occurs, initially the ship is not under player control, but once the enemy or an enemy shot is spotted, then that ship is freed from both Fixed and Convoy restrictions and the player is free to move and fire using the ship normally.

Laying Smoke

Only certain ships are capable of laying a smoke screen. When this is possible, a smoke icon will appear in the ship picture in the Ship List. Each ship is only capable of laying a certain amount of smoke. This limit is determined by the Smoke Limit Parameter Data value. To toggle the laying of a smoke screen, select the ship and then press the Laying Smoke toolbar button. Pressing the Laying Smoke toolbar button a second time will terminate the smoke screen. The amount of time that the smoke screen will stay in effect is determined by the Smoke Time Parameter Data Value. Disabled ships cannot lay smoke.

Visibility and Sighting

In each scenario there is a maximum visibility value which determines the maximum range that opposing forces can be sighted. Depending on the scenario, this value may change during the course of the scenario.

Based on this maximum visibility value, there are specific sighting rules that determine whether a specific enemy ship or flight can be seen:

- Ships and Targets can spot enemy ships at the maximum visibility value.
- Ships and Targets can spot enemy flights at **1/2** the maximum visibility value with one exception. Enemy flights consisting of a single small airplane are spotted at **1/4** of the maximum visibility value.
- Aircraft can spot enemy ships at the maximum visibility value.
- Aircraft can spot enemy flights at **1/4** the maximum visibility value with one exception. Enemy flights consisting of a single small airplane are spotted at **1/8** of the maximum visibility value.

In addition, there are specialized sighting rules that only apply to submarines that can be found in the Submarine section of this manual.

Radar and Radar Detection

When a ship is designated as having radar, then a radar icon and a short nomenclature for the radar appears in the ship's unit picture. For the radar to be functional, the status of the ship must be at least 50%. The range of the radar depends on its type and the specific range value is determined by information found in the **Database Dialog** under the Help Menu.

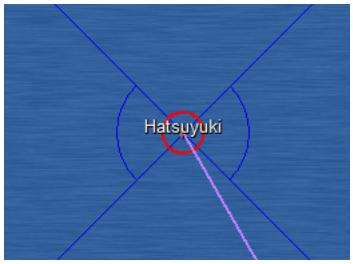
When a ship has functioning radar, it can detect enemy ships and aircraft beyond the normal visibility range. Enemy ships are spotted provided that the line to the enemy ship is not blocked by land or by any other ships and the enemy ship is not over the horizon. Radar can penetrate smoke screens.

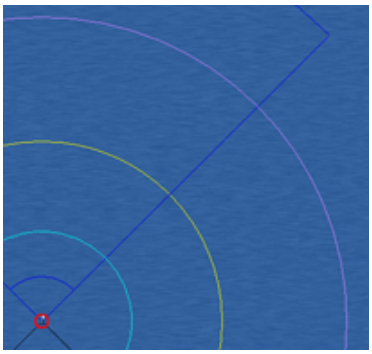
When an enemy flight is detected on radar, then it is shown as unknown as to type and number of aircraft until such time as the flight comes within visual range. Note that for a flight to become visible, it must be within **half** the current range of Visibility.

Ships can also be equipped with radar detection. This is signified by a radar icon with the "XX" designation. When a ship is equipped with radar detection, then it can detect enemy ships equipped with radar at a range equal to 150% of the range of the radar. Thus, ships equipped with radar detection can spot enemy ships with radar before those ships can spot them. The enemy ships must not be below the horizon however.

Some radar is **Air Only** can only be used to detect aircraft. Other radar is **Surface Only** and can only be used to detect ships. Some radar has the ability to be used when on a submarine at **Periscope** depth. All of these attributes are shown in the Database Dialog.

When a ship that has radar detection detects a ship with radar, then a magenta line is drawn in the direction of the detected ship. Note that this conveys no range information to the enemy ship.





Certain radar is **Range Only** and when it detects an enemy ship or airplane, can only convey the distance to the enemy ship or airplane but not its bearing. When this occurs, a magenta circle is drawn on the charts showing that range.

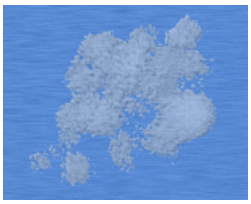
Single Aircraft Detection

As a special case in games such as **Midway** and **Guadalcanal**, the early radar used in this era often did not have the necessary fidelity to reliably detect a single aircraft. In these games, a single aircraft will only be detected on radar if it is within 25% of the nominal range of the radar.

Location Markers

Under Fog-of-War, it is possible to spot an enemy ship or aircraft momentarily and then lose it. To keep an idea of the general location where entities have been spotted, you can place a **Location Marker** at the current location of the red hot spot by pressing the **L** hot key. Once placed, Location Markers are permanent for the rest of the battle. Location Markers show up on the Jump Map as white squares.

Weather Effects



In certain scenarios, there is cloud cover which may be generated randomly throughout the battle area or in specified positions determined by the scenario designer. When Ships, Targets, or Aircraft are in the clouds, then certain effects occur as described below.

- Ships and Targets in clouds cannot fire AAA.
- Visibility between Ships and Targets and other Ships and Targets or Aircraft is reduced by 1/3.
- Visibility between Aircraft is blocked.
- Bombing attacks against Ships or Targets is reduced by the AAA Hit Modifier Parameter Data Value.

Certain effects are specific to Aircraft Carriers:

- Aircraft Carriers in clouds cannot take off or land Aircraft.
- When Aircraft Carriers are in clouds, it takes twice as long to spot Aircraft.
- Deck Operations are not possible in clouds.

Collisions

When one ship strikes another, a collision occurs and the speed of the first ship drops to zero until the collision is resolved by the second ship moving clear. If the **Collision Factor** Parameter Data value is nonzero, then it is used to determine the damage to the each ship according to the calculation:

Collision-Damage = Collision-Factor * Size-Other-Ship * Combined-Speed

where Size-Other-Ship is the size of the other ship involved in the collision and Combined-Speed is the sum of the individual speeds of the two ships. The damage to the ship being struck is also doubled.

Firing

There are several means that ships and aircraft have of firing or otherwise causing harm to enemy ships, aircraft, or targets. Each ship has **Primary** armament which can be fired at enemy ships and targets within its range and visible to the firing ship. The larger ships may also have **Secondary** armament which is used against Destroyers, Torpedo Boats, and enemy targets. Some ships and aircraft are capable of firing **Torpedoes**, which can cause great damage to a ship if they hit it. Some ships are capable of laying **Mines** which are motionless in the water, but can also do great damage to a ship which hits them. Finally, some ships carry **Depth Charges** which can be used against submerged submarines. Ships and aircraft can also carry loads that can be used to bomb or fire at enemy ships and targets. Aircraft may also carry guns or cannons that can be used to dogfight with enemy aircraft or possibly strafe enemy ships and targets.

Primary Armament

The primary armament of a ship is automatically fired whenever an enemy ship or target comes within range and is visible to the firing ship. There are a couple of restrictions on the use of the primary armament however:

- A ship with secondary armament will never use its primary armament against Destroyers and Torpedo Boats. Rather, its secondary armament is used for this.
- A Destroyer or Torpedo Boat never fires its primary armament against a Battle Cruiser or Battleship. If the Destroyer or Torpedo Boat has torpedoes or mines, then these can be used against Battle Cruisers and Battleships.

Once a ship selects a ship or target for its primary armament, then it will continue to fire at this ship or target until the ship or target goes out of range, is no longer visible to the firing ship, or in the case of a ship, is sunk. To manually change the firing target of one of the ships under your control, first select the firing ship, and then click using the **right** mouse button on the enemy ship or target.

Secondary Armament

Only certain ships have secondary armament which is indicated in the alternative ship display (see the section on The Interface). The secondary armament is automatically fired at Destroyers, Torpedo Boats, and enemy targets that come within range of the secondary armament and are visible to the firing ship. The rate of fire and the target ship are randomly determined each time the secondary armament fires and you have no control over this. The values which determine the reload time and range of secondary armament are part of the Parameter Data and can be viewed using the Parameter Data Dialog. The range of secondary armament is shown as a red circle when the Ship Range feature is enabled.

AAA

A ship or Target may have a AAA value which allows it to fire at enemy aircraft within a certain range. The control of AAA fire is automatic and does not require any user intervention. When the ship or Target is attacked or fired upon, then there is a certain probability that the AAA will become **suppressed** for a certain amount of time. When this happens, the AAA cannot fire until it becomes unsuppressed. Disrupted and Fixed ships cannot fire AAA, nor can submarines that are diving or submerged.

Ship Loads

In addition to the guns a ship might have, it can also carry **loads**. In general, these loads are used to represent a wide variety of ordnance including torpedoes and depth charges. The active load is displayed below the name of the ship in the ship picture. To change the active load, you use the **Set Active Load** menu item and toolbar button.

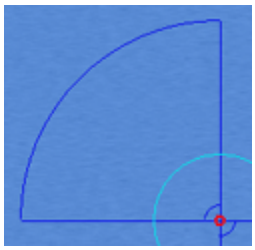
When you use the Range feature, then the range and direction the load can be fired will be displayed. To fire the load at a target within that region, how down the Control (**Ctrl**) key and click with the **right** mouse button in the region.

Note: if the active load cannot be fired where you have clicked, but the ship does carry another load that can fire at that point, then the active load will automatically be changed to that one and that load will be fired.

Firing Ship Torpedoes

Certain ships are capable of firing torpedoes. If this is possible for a ship, then a torpedo icon will appear in its picture in the Ship List (see the section on The Interface). This capability is determine in one of two ways:

- In older games in the series, torpedoes are represented abstractly and each ship that can fire torpedoes can do so one time. In this case, the torpedo icon does not show the number of torpedoes.
- In newer games in the series, torpedoes are represented as loads and shown below the name of the ship in the Ship List when the load is selected. In this case, the total number of remaining torpedoes is shown over the icon.



In the older approach, the range of the torpedo is determined by Parameter Data and can be viewed using the Parameter Data Dialog. In the newer approach, the speed and range of the torpedo is determined by the load data. In either case, when the Ship Range feature is enabled, then the range of torpedoes is shown as a blue circle. An inner circle shows the minimum range that the torpedo must run after firing before it will explode when hitting a ship.

To fire torpedoes at an enemy ship, you first select the ship to fire the torpedo. While holding down the Control (**Ctrl**) key, you then click on or near the enemy ship with the **right** mouse button. The torpedo will appear on the Main and Jump Charts as a white dot. When the torpedo is represented as a load, you must click within the firing sector defined by the torpedo.

In certain games using Enhanced Submarine Rules, submarines can carry external torpedoes that cannot be fired but can be used as reloads in a campaign game. If these external torpedoes exist, then they are shown following in parentheses.

Laying Mines

Certain ships are capable of laying mines. These mines are motionless in the water, but have the ability to damage ships which sail into them. If a ship can lay mines, then a mine icon will appear in its picture in the Ship List.

To lay mines, select the ship to lay the mines. Then while holding down the Control (**Ctrl**) key, right click **on** the ship using the **right** mouse button. The mines will appear on the charts as a black dot.

Mines are only visible within a certain distance. This distance is determined by Parameter Data and can be viewed using the Parameter Data Dialog.

Dropping Depth Charges

Certain ships and aircraft carry depth charges that can be used against submerged submarines. To drop depth charges, select the ship or aircraft. For ships, make sure that the depth charges are displayed below the name of this ship as the active load. Then while holding down the Control (**Ctrl**) key, right click behind the ship or aircraft, or for ships, in the direction indicated by the load, using the **right** mouse button. The depth charge will appear as a black dot. After a specified amount of time, the depth charge will explode, possibly causing damage to nearby submarines.

Burning Ships

Because of the aircraft fuel and ordnance that they carry, aircraft carriers are particularly susceptible to burning when they are hit. This burning will be the primary source for damage aboard an aircraft carrier and the ability of the crew to contain the damage is highly dependent on the training of the crew and the construction of the ship. Each side has **Damage Control** Parameter Data Values that determine the ability of that side to control burning aboard a ship. Once a ship starts to burn, damage control operations are assumed to automatically start and at some future time when the burning has come under control, the burning indication will cease in the ship picture. While an aircraft carrier is burning, it cannot launch or land airplanes.

Flooding Ships

When a ship is hit by a torpedo or mine, then it is subject to flooding. The amount of flooding is randomly calculated and its rate is determined by the Flooding Rate Parameter Data

Value. There is no user intervention possible for flooding as damage control is assumed to automatically start when it occurs.

Aircraft Loads

Aircraft may carry a loads such as a bombs or torpedos. This can be used to attack enemy ships and Targets. To attack an enemy ship or Target with bombs, select the flight and then **right click** on the ship or Target. The ship or Target will become highlighted and the flight will automatically fly towards the target. When the aircraft flies over the target, the bombs will automatically be dropped.

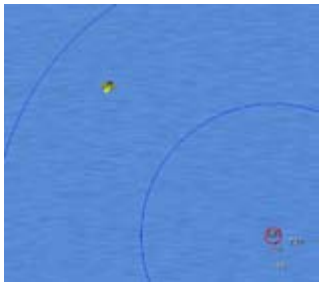
Firing Aircraft Torpedoes

There are two ways of firing torpedoes from aircraft at ships.

1. In the default mode, to fire a torpedo at a ship, fly in the direction of the ship and when you are in a suitable range, **right click** on the chart while holding down the Control (**Ctrl**) key. The torpedo will appear in the water as a white dot and travel in the direction you click.
2. Under the **Aircraft Torpedo Resolution** Optional Rule, you fly in the direction of the ship as before but once in range, you **right click** on the **target ship** while holding down the Control (**Ctrl**) key. The torpedo will travel towards the target ship and once there and if in range, a hit probability will be calculated and used to determine if the torpedo hits the ship or not.

In either method, be sure to use the **Range** menu item or toolbar button to display the range of the torpedo as an aid in firing.

Aircraft Torpedo Ranges



The rules for aircraft torpedo ranges are the same as those for ship torpedoes. That is, each torpedo has a minimum and maximum range displayed on the chart when the Range feature is enabled. In the case of aircraft torpedoes, the minimum range is modified by a **Torpedo Min Range Modifier** Parameter Data Value that is used to reflect the training of the pilots of the torpedo bombers for a given side. That modifier can cause the minimum range of the torpedo to be much greater compelling the torpedo to be fired at a much longer range.

Bomb and Torpedo Resolution

When you bomb an enemy ship, there are factors that influence the probability of hitting it:

- When the ship is turning when you drop the bombs, then a **Maneuver Hit Modifier**, determined by Parameter Data, is applied to the hit probability.
- When the ship has unsuppressed AAA when you drop the bombs, then a **AAA Hit Modifier**, determined by Parameter Data, is applied to the hit probability.

These modifiers mean that when your ships are attacked by enemy bombers, it is in your best interest to turn the ships during the bombing attack. Likewise, when you are bombing enemy ships, the ships will be most vulnerable when their AAA is suppressed.

When you attempt to hit an enemy ship under the default firing rule, then hits are determined by physical collisions between the torpedo and the ship (or any other ships). When you attempt to hit an enemy ship under the Aircraft Torpedo Resolution rule, then a Maneuver Torpedo Modifier is applied when the hit determination is made if the ship is turning at that time.

For more information about bomb and torpedo resolution, see the section on Firing Resolution.

Stuck Rudder Hits

When the **Stuck Rudder Prob** Parameter Data Value is nonzero, it represents the probability that a torpedo hit on a surface ship will result in a stuck rudder. This effect cannot be fixed and will remain in effect for the duration of the current scenario and campaign.

Strafing

 If you attack an enemy ship or Target and have no bombs that can be used against the target, then your aircraft will automatically strafe the target provided two things occur:

- The aircraft is flagged in the database as being able to strafe.
- The aircraft has a non-zero count associated with its guns/cannons.

Strafing can cause damage to the target, damage to aircraft stored at the target, and can also cause AAA suppression.

Critical Ships

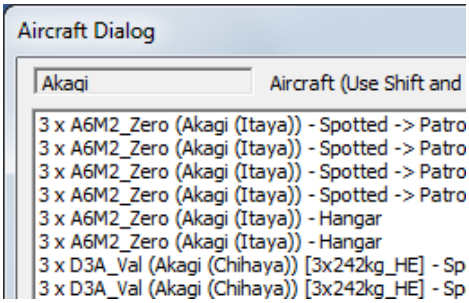
Depending on the scenario, there may be a ship that is defined as a **Critical Ship**. Such a ship is noted by an asterisk (*) following its name in the ship picture.

When a Critical Ship is sunk, the scenario will terminate immediately without waiting for the time period to expire and the victory results are immediately reported based on the status of the scenario at that point.

Aircraft Carriers

This section covers aircraft carrier operations as well as operations involving seaplanes carried aboard other ships. Aircraft carried aboard a ship can be in the Hangar, or spotted on a flight deck or a catapult and ready for take off. Ships can refuel and rearm aircraft on board the ship, with perhaps limitations described below on when that can happen.

The Aircraft Dialog



The Aircraft Dialog is the fundamental way of performing operations relative to aircraft carried aboard a ship. To display the Aircraft Dialog you can double-click on the ship icon on the Main Chart. This also works for air bases. Once displayed, you can make individual or multiple selections of the aircraft listed in the dialog. By holding down the Control (**Ctrl**) key, you can add or remove individual entries to the current selection. By holding down the Shift key you can add entire groups of entries to the current selection. Once you have selected the aircraft you wish to perform an operation on, you then click the corresponding button in the dialog.

Spotting Aircraft

Aircraft must be **spotted** before they can take off. For an aircraft carrier, spotting the aircraft means bringing it from the Hangar deck to the flight deck. For a seaplane carrier, spotting means placing the seaplane on a catapult for launching. For airbases, spotting means bringing the plane from the Hangar to the ramp area. The Aircraft Dialog has a **Spotting** button that toggles the state of the selected aircraft

between **In Hangar** and **Spotted**. The time that it takes aircraft to become spotted or return to the Hangar depends on Parameter Data.

When a carrier is turning, it takes twice as long to bring aircraft to the flight deck or back to the Hangar deck.

Overspotting

When there are more than half the capacity of an aircraft carrier on the flight deck (fractions rounded up), then the flight deck is **Overspotted**. This impacts operations in several ways:

- When the flight deck is overspotted, then more aircraft cannot be brought from the Hangar to the flight deck.
- When the flight deck is overspotted, airplanes cannot land on the carrier.

The color of the spotted number reflects that number of spotted aircraft as follows:

- A white number indicates no aircraft are spotted.
- A green number indicates 1/4 or less of the capacity of the carrier is spotted.
- A yellow number indicates 1/2 or less of the capacity of the carrier is spotted.
- A red number indicates the carrier flight deck is overspotted.

Vulnerability

The number of aircraft on a carrier and their fuel and ordnance state increases the chance of fire on the carrier when it is attacked. The color shown associated with the Hangar number reflects that vulnerability. For each aircraft **on board** the carrier (in the Hangar or on the flight deck), a value is associated with that aircraft between 0 and 1 as follows:

- Each aircraft that has ordnance either loaded or selected has 0.5 added to its value (Note this includes aircraft that have 0 ordnance loaded, but do have a load selected. That is the load selection for the aircraft must be blank before this value is 0).
- Each aircraft with a range of R and a maximum range of M has R/M added to its value. This reflects the fuel aboard the aircraft.

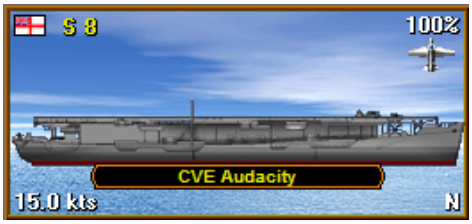
Large aircraft count double giving a value between 0 and 2.

Based on the total value of all aircraft on board, the Hangar number will reflect that vulnerability as follows:

- A white number indicates a total value of 0.
- A green number indicates a total value of less than 1/4 of the capacity of the carrier.
- A yellow number indicates a total value of less than 1/2 of the capacity of the carrier.
- A red number indicates a total value of 1/2 or more of the capacity of the carrier.

This vulnerability value is used in the burning calculation as described in the section on Firing Resolution. NOTE: all aircraft on board count in this calculation even though it is only indicated in the Hangar number. Moving aircraft to the flight deck from the Hangar does not lower the total value.

Carriers with No Hangar Decks



Very rarely it will be the case that a carrier has no Hangar, only a flight deck where all planes must reside. In this case, all planes are allowed to be on the flight deck without causing an Overspotting condition and the carrier never suffers from a Vulnerability issue.

Wind Indicators

To help the player align a carrier into the wind at the proper speed, there are two indicators that are used just with carriers. The first indicator will show the current heading in **yellow** when the carrier is not facing into the wind.

The second indicator appears when the carrier is facing into the wind and shows the **relative wind strength** in parentheses.

Launching Aircraft

Once aircraft are spotted, they are eligible to take off. To launch a flight, you select it and then **right click** on the Main Chart. This will cause the flight to become **Ready** for takeoff and when possible, it will automatically take off in

the direction that the ship is moving. Alternatively, there is a **Launch All** command in the Command Menu that will cause all eligible flights at the selected ship or air base to take off.

An aircraft carrier must be facing into the wind before it can launch aircraft and cannot be turning. A ship must also have a status of at least 75% before it can launch aircraft and cannot be Burning at the time. An airbase must have a status of at least 25% before aircraft can take off from it. After a flight has taken off, there will be delay before the next flight can take off determined by Parameter Data. Once a flight is airborne, you can control it normally. Note that submarines may also carry seaplanes and they must be on the surface in order to launch or recover the seaplanes.

When airplanes are taking off from carriers, the relative wind speed must be at least the minimum launch speed of the airplane but less than twice that speed, as determine by Parameter Data Values.

This typically means that for small prop airplanes, the relative wind speed must be at least **25** knots but less than **50** knots. For small jet airplanes, typically the relative wind speed must be at least **30** knots but less than **60** knots. When the relative wind speed does not allow the airplane to take off, either the message **Too Little Wind** or **Too Much Wind** appears.

Landing Aircraft

To land aircraft back at a ship or air base, first select the flight and then right click on the ship or air base you wish the flight to land at. When the flight reaches the ship or air base, it will automatically land there if possible. There are several factors that limit your ability to land a flight however. These include:

- An aircraft carrier must be facing into the wind before aircraft can land on it and cannot be turning.
- Before a ship can recover a seaplane, the ship must be dead in the water.

- After a flight lands or takes off, a certain amount of time must pass before the next flight can land or take off. The amount of time is determined by Parameter Data.
- A ship must have a status of at least 75% before it can land or take off aircraft and cannot be Burning at the time.
- An air base must have a status of at least 25% before it can land or take off aircraft.
- The aircraft attempting to land must not exceed the storage capability of the ship or air base for that type of aircraft.
- For aircraft carriers, the number of aircraft on the flight deck must not exceed 1/2 of the total storage capability of the carrier.

Refueling Aircraft

Once aircraft return to a ship or air base, they are automatically eligible for refueling and no user intervention is required to cause this to happen. When refueling will begin will depend on how many other aircraft are waiting for fuel. The time it takes to refuel an aircraft depends on Parameter Data and the size of the aircraft.

Large aircraft take 2 times as long to refuel as small aircraft. When the carrier is turning, the refueling rate is half that of normal.

Arming and Rearming Aircraft

Once aircraft return to a ship or air base, they are automatically eligible to become rearmed, subject to available stores on the ship or air base. If no user intervention occurs, then after a time that depends on how many aircraft are waiting for rearming, the aircraft will automatically become rearmed with whatever load they were carrying. If you wish to change the load that aircraft carry, you first select those aircraft using the Aircraft Dialog, and then using the **Load** button on the dialog, you can specify what load you wish the aircraft to carry. If the aircraft are already carrying some load, then this must first be unloaded before the new load can be loaded. When a flight has been ordered to rearm with a different load, then this will be indicated at the bottom of the aircraft picture with the old load shown first, and arrow (**=>**), and then the new load.

Large aircraft take 2 times as long to rearm as small aircraft. When the carrier is turning, the rearming rate is half that of normal.

Deck Operations

While an aircraft can be refueled and rearmed at an airbase in both the Hangar and on the ramp, being able to rearm and refuel aircraft while they are on the flight deck of an aircraft carrier is limited by settings in Parameter Data. If this setting does not allow Deck Operations, then the aircraft must be in the Hangar deck before it can be refueled or rearmed. When a carrier is in clouds, Deck Operations are not possible.

Maneuvering Carrier Groups

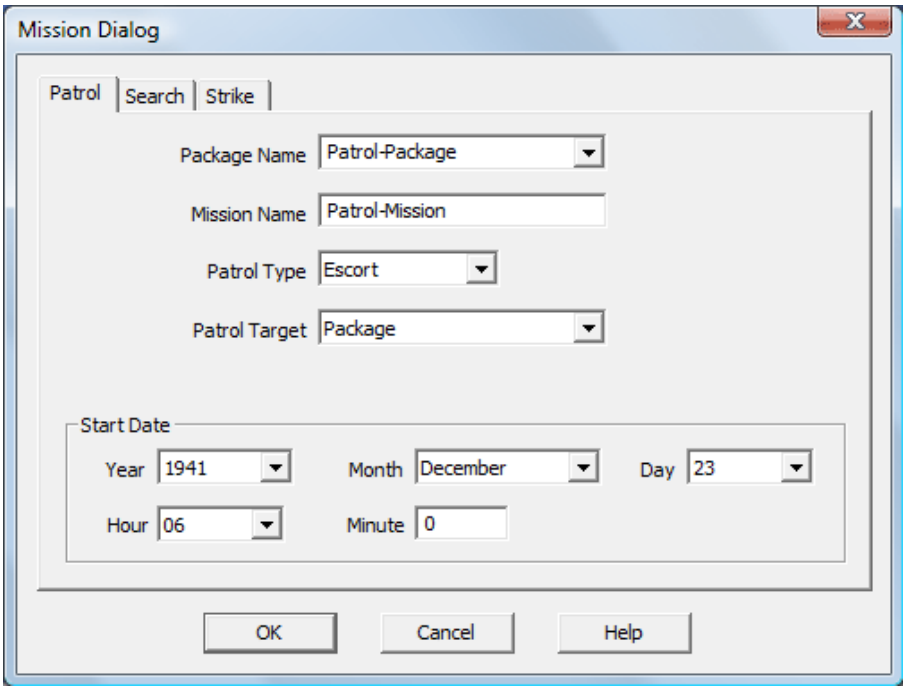
Carriers typically are part of a group of ships, with perhaps other carriers, and surrounded by a number of escort ships, destroyers, cruisers, and battleships, that provide both anti-air and anti-submarine protection to the carriers. In most scenarios, these groups will be organized so that one of the carriers is the flagship of the group and the other escort ships are attached to that flagship carrier. When this is the case, the best way to maneuver the carrier group is to issue **Group Turns** (see Maneuver) to the flagship carrier. When this is done, the entire carrier group will turn simultaneously and preserve the relative position of the ships.

Aircraft Missions

While it is possible to issue individual and group flying orders to aircraft, a more organized and efficient way of issuing aircraft orders is to use the Mission and Package feature of the interface. To start, display the Aircraft Dialog by double clicking on the aircraft carrier (or any ship that is carrying aircraft). Select one or more aircraft flights, and then click on the **Mission** button of the Aircraft Dialog to display the **Mission Dialog**.

There are three Missions that you can issue to a group of aircraft:

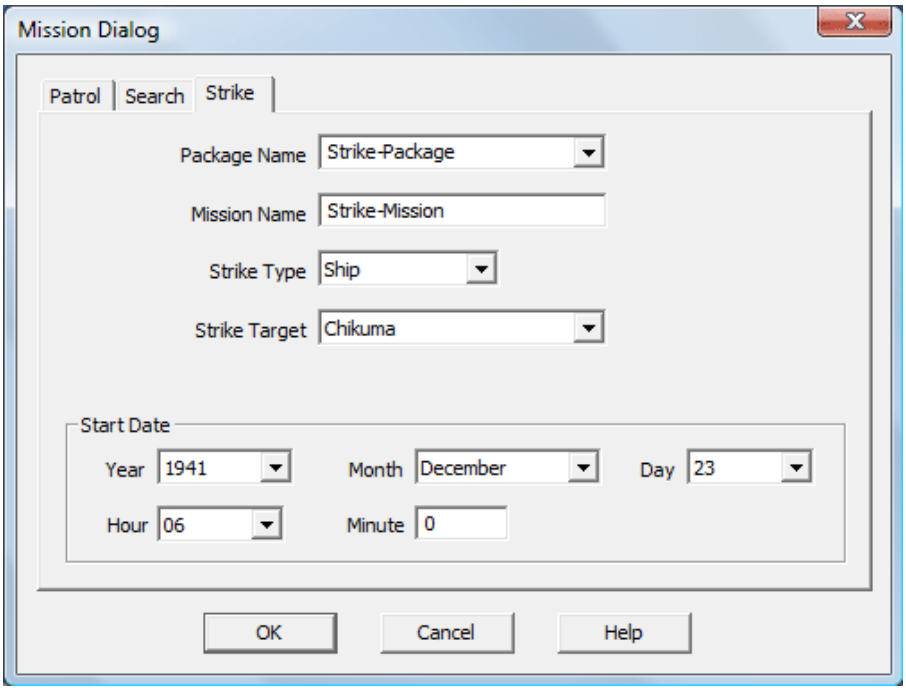
- **Patrol Mission** – Escort another mission or protect a ship or target from attack.
- **Search Mission** – Fly out in a predefined direction and distance and look for enemy ships.
- **Strike Mission** – Strike a specified ship or target, or fly to a specified location looking for enemy ships to strike.



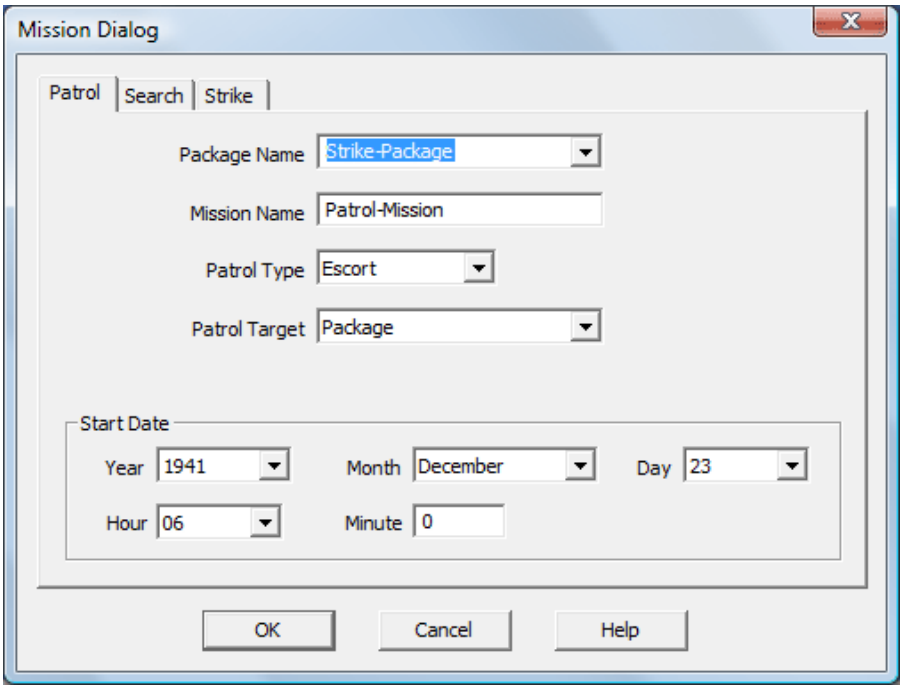
There are a few issues you should understand when issuing these orders:

- When you want a group of fighters to escort a Strike Mission, you must include the Patrol Mission of those fighters in the same Package as the Strike Mission. Start by creating the Strike Mission and then create the Patrol Mission by selecting the same Package from the drop-down list next to **Package Name**.
- When you create a Search Mission, you specify a **Minimum Course** and **Maximum Course**. The program will automatically distribute the flights in the group you are giving the order to so that they cover the "fan" defined by those two radials. It is important to understand that the distribution of flights is always done **clockwise** from the Minimum Course to the Maximum Course. So for example, if you want to conduct a search from 300 degrees to 45 degrees, you must specify 300 as the Minimum Course and 45 as the Maximum Course.

Here is an example of how to package a Strike. You start by selecting certain flights to be the Strike aircraft and assigning them a Strike Mission:

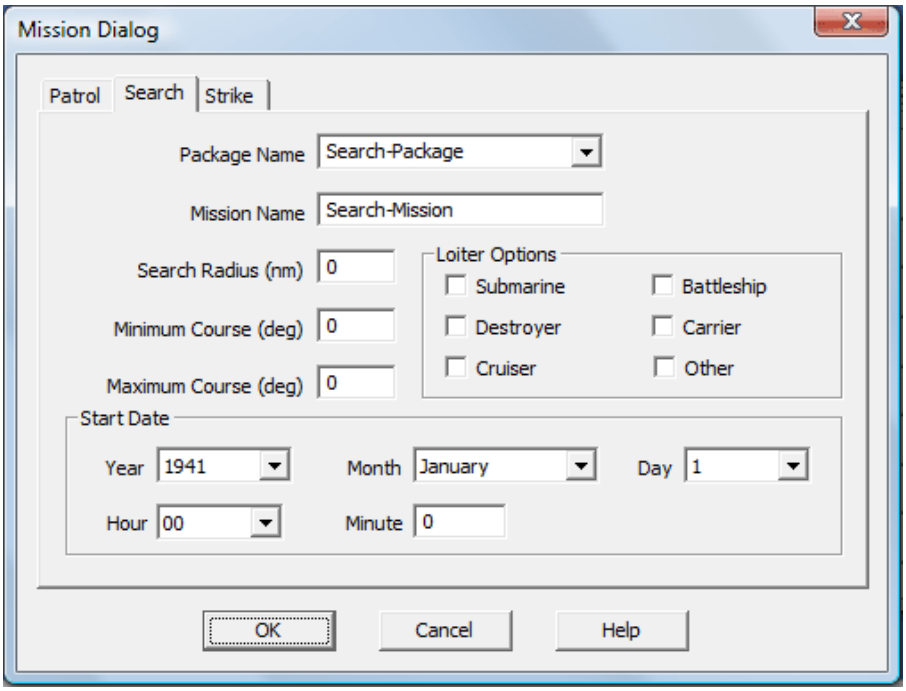


Next, you selected certain flights to escort the Strike aircraft and assign them a Patrol Mission:



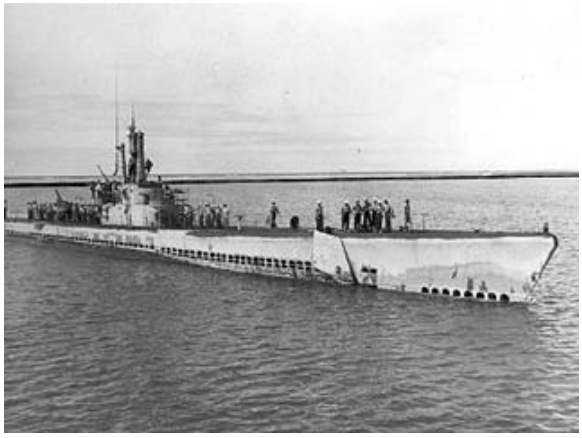
Notice that the Package Name here is the same as the Package name assigned to the Strike Mission.

When you construct the Package in this way, the Strike aircraft will take off, form up with the Patrol aircraft, and the Package will fly together to the Strike target.



When you construct a Search Mission, you can select which types of enemy ships the search planes will loiter when they find them. For example, if you want the search planes to loiter when they find submarines, then check the Submarine box. If you want them to ignore submarines, but continue until they possibly find carriers, then check the Carrier box. You can check one or more of the boxes or leave them all blank, in which case the planes will always flight out to the limit of their search radius.

Submarines



This section covers submarine operations as well as anti-submarine operations. Submarines are able to submerge to either periscope depth or deep depth. On the surface or at periscope depth, submarines are able to fire torpedoes. The main deterrent to submerged submarines is the use of depth charges, dropped from ships and aircraft, since they are otherwise not vulnerable to normal weapons. Active sonar can be used to detect submerged submarines while passive sonar can be used by submarines to avoid the enemy.

This section describes the standard submarine rules that apply to all Naval Campaign games. The following section describes enhanced submarine rules that only apply to games which focus on submarine actions.

Diving and Rising

There are three levels available to a submarine: surface, periscope depth, and deep depth. The **To Surface**, **To Periscope Depth**, and **To Deep Depth** commands and toolbar buttons can be used to command a submarine to these levels. The process of diving or rising takes a certain amount of time as given in the **Submarine Dive/Rise Intervals** Parameter Data.

Firing Torpedoes

While on the surface or at periscope depth, a submarine can fire torpedoes, either forward or in some cases, to the rear. To fire a torpedo, select the submarine and then while holding down the Control (**Ctrl**) key, right click in the direction you wish to fire the torpedo. Submarines may carry a certain amount of torpedo reloads. These are indicated in the load description at the bottom of the image as the second number as in:

Number for firing/Number for reloads x Torpedo name – Firing direction

The time it takes to reload a torpedo tube is given in the Database Data Dialog. A submarine that is diving or rising cannot fire torpedoes.

When reloading, the information shown at the bottom of the screen changes to display the number of seconds remaining to reload:

Number for firing/Number for reloads/Reload time x Torpedo name – Firing direction

Submarine Visibility and Detection

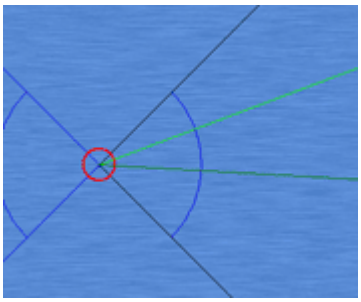
A submarine on the surface can only be detected at **1/2** the normal radar range of another ship.

When a submarine is submerged at periscope depth, there are two modifications to the normal visibility rules:

- A submarine at periscope depth can only see half as far as a normal ship.
- A submarine at periscope depth can only be seen if it is within the Periscope Visibility Parameter Data value.

Sonar

Sonar can either be **passive** (indicated with a blue icon) or **active** (indicated with a yellow icon). Active sonar uses transmitted sound ("pings") and echoes to estimate both direction and distance while passive sonar simply uses listening to estimate direction.



When sonar detects another ship, a green line will be drawn from the ship with the sonar in the approximate direction of the detected ship. A dark green line indicates a detection made using passive sonar while a bright green line indicates a detection either made using active sonar or made by passive sonar hearing the pings of a target with active sonar.

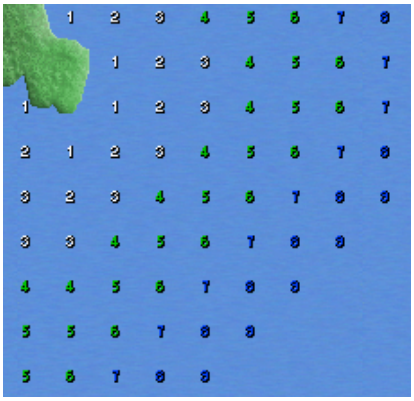
In the case of a detection made using active sonar, the length of the line will also estimate the distance to the detected ship. In the case of a detection using passive sonar, the line will be drawn out to the maximum detection range and the detected ship can be anywhere along that line. In all cases, there is a

minimum and maximum range that sonar is effective, give in the Parameter Data.

When a target is using active sonar, it can be detected by other sonar at twice the normal effective range.

Depth Soundings

Using the **Depth Soundings** option of the View Menu or toolbar button, depth sounding values can be displayed on the Main Chart.



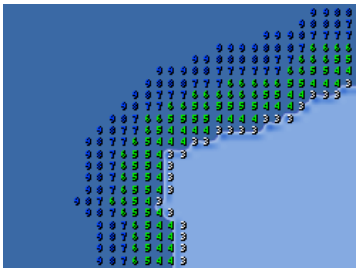
These sounds will affect submarine operations in the following ways:

- A non-midget submarine cannot be submerged in **Shallow Depth** areas (A sounding value of 3 or less, shown in white).
- A non-midget submarine cannot be submerged below periscope depth in **Intermediate Depth** areas (A sounding value of 6 or less, shown in green).
- A midget submarine (SSM) cannot be submerged below periscope depth in **Shallow Depth** areas but is not restricted in **Intermediate Depth** areas.
- A submarine submerged in **Shallow** or **Intermediate Depth** areas cannot be detected by sonar.

No maneuver effects or restrictions apply to submarines in **Deep Depth** areas (A sounding value of 7 or more, shown in blue).

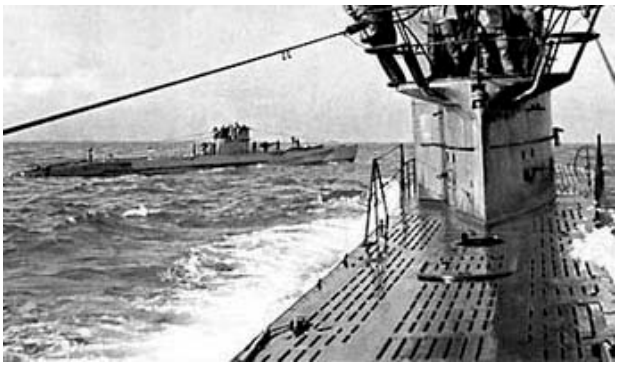
Shallow Banks

In certain scenarios, there may be banks of shallow water. These are shown on the main chart and jump chart as solid light blue areas. When depth



soundings are displayed, then the inner most depth sounding value will be the depth of the water over the bank. This depth value applies to the entire area of the bank and will affect submarine operations according to the rules applying to shallow water.

Enhanced Submarine Rules



This section covers enhanced submarine rules that only apply to certain Naval Campaign games which focus on submarine actions such as **Wolfpack**. Games which are primarily surface action games such as **Jutland** only use the standard submarine rules described in the previous section.

Reduced Night Spotting

Submarines attacked a lot at night because their reduced above-surface size meant that they were very hard to visually detect at night. In addition to the standard submarine spotting rules given in the previous section, an additional rule applies in games with enhanced submarine rules:

- At night, the maximum spotting distance to see a submarine on the surface is halved .

This means that at night, a submarine can see another surface ship at the standard visibility range while not being visible to that ship.

Battery Performance

Most submarines rely on batteries to provide power while submerged (modern nuclear submarines being an exception). In all cases, these batteries have a certain limited power and when this power is exhausted, the submarine is forced to surface. The time that the batteries can last is determined primarily by how fast the submarine is going. That is, by how much power the submarine is drawing from the batteries. For batteries of a certain rating, this rate of usage is a non-linear function of the speed the submarine is going.

Each submarine that uses batteries is rated according to a single letter code 'A', 'B', etc. The power attributes associated with those letters are described in the Database Data using three values:

- The maximum amount of time the submarine can cruise submerged at minimum speed.
- The minimum speed that the submarine can travel while submerged (some speed being required to maintain a level depth).

- The number of hours it takes to recharge the batteries once back on the surface.

For example, a battery might be rated 'A' with three values 48 hours, 2.0 knots, and 8 hours meaning that the submarine can run for 48 hours submerged at 2.0 knots, its minimum speed submerged, and that it takes 8 hours to full recharge the batteries on the surface if they were totally discharged.

In the upper-left hand corner of the submarines picture in the Unit List will appear two values. The first is the standard status value of the submarine, common to all ships. The second value in parentheses is the **battery status** of the submarine. When this value is 100%, the batteries are fully charged. When this value becomes 0%, the batteries are exhausted and the submarine must surface.

The batteries will discharge while the submarine is submerged based on the current speed of the submarine according to the equation:

Endurance = Max-Endurance * (Min-Speed / Speed) ^ 2.5

For example, suppose a submarine is traveling submerged and it has a maximum endurance of 48 hours, a minimum speed of 3 knots, and it is currently traveling at its maximum submerged speed of 9 knots. Its endurance at this speed is given by :

Endurance = 48 * (2 / 9) ^ 2.5 = 1.1 hours

Notice that the equation indicates that "modest" submerged speeds will balance the speed of the submarine with its endurance while using maximum submerged speed will very quickly exhaust the batteries.

Snorkels

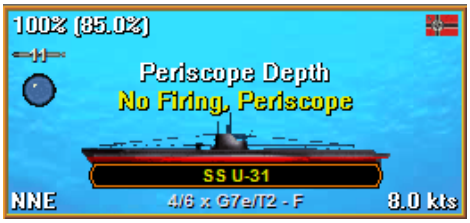
Snorkels were developed for submarines so that they could run their air-breathing engines while submerged and thus not have to rely on battery power as well as having the ability to recharge those batteries. Only certain submarines are designed to have snorkels. Submarines equipped with snorkels will show a snorkel icon in their picture in the Unit List. By default, when the submarine is at periscope depth, the snorkel will be deployed and the batteries can be recharged. However use of a snorkel prevents the sub from using passive sonar since the engines are running and for the same reason

allows the submarine to be detected at twice the passive sonar range as normal. See below for how to control the deployment of the snorkel.

Inhibiting Default Actions

The default firing behavior of ships in the Naval Campaign series is appropriate for surface actions but not always when submarines are involved. Likewise, given the need for stealth, several features work against that and there is a need to be able to inhibit these. The following options are available both in the scenario editor and main program to toggle certain features:

- **No Firing** - Inhibit the default firing of guns. This is useful for submarines when they don't want to give their location away by firing their guns.
- **No Radar** - When radar is used it can be detected by the enemy and so this option inhibits the use of radar on the selected ship. A ship without range-only radar that inhibits the use of radar can still detect radar from other ships.
- **No Active Sonar** - The use of active sonar produces "pings" that can be heard at long distances. This option is useful for both surface ships that wish to avoid detection as well as submarines equipped with active sonar. When active sonar is inhibited, it is still possible to use passive sonar.
- **No Snorkel** - Snorkels must protrude at the surface and thus make a submerged submarine easier to detect. This option inhibits the use of the snorkel and thus makes the submarine harder to detect.
- **No Periscope** - Likewise a periscope can be spotted by surface ships and so this option inhibits the use of the periscope when the submarine wishes to reduce its chance of being detected.



When Firing or Periscope is inhibited, then this is reported in the unit picture with the words "No Firing" and/or "No Periscope".

When Radar, Active Sonar, or Snorkel is inhibited, then this is shown in the unit picture by having a red cross over the icon for that function.

Sonar Speed Limitations

Ships moving through water produce disturbances which limit their ability to detect other ships using sonar. The maximum speed at which sonar is useful is determined by Parameter Data and typically would be something like 24 to 30 knots. Based on the current speed of the ship, the maximum range at which their sonar is useful is given by the equation:

Maximum Sonar Range Modifier = 1 - (Speed / Max-Sonar-Speed)^2

For example, if the maximum sonar speed is 30 knots and a ship is travelling at 15 knots, then its maximum sonar range is modified by:

Modifier = 1 - (15 / 30)^2 = 75%

and thus is only 75% of what it would be if the ship was motionless.

Passive Sonar Range Modifier

The maximum range that a ship can be detected using passive sonar is modified by the size and speed of the ship according to this calculation:

Noise-Modifier = CubeRoot (Size) * Speed / Noise-Mod

where Size is the size of the ship in tons, Speed is the speed of the ship in knots, and Noise-Mod is the Noise Modifier value given by Parameter Data. Submerged ships have 3 times the Noise-Modifier that ships on the surface have to account for the fact that they are in a much quieter environment than a ship on the surface.

Example 1. With a Noise Modifier value of 180, a destroyer of 1700 tons moving at 15 knots would have a noise modifier of CubeRoot (1700) * 15 / 180 = 0.99.

Example 2. A battleship of 40,000 tons moving at 15 knots would have a modifier of CubeRoot(40000) * 15 / 180 = 2.8 and thus would be detected by passive sonar at almost 3 times the distance of the destroyer.

Example 3. A submerged submarine of 750 tons moving at 6 knots would have a modifier of 3 * CubeRoot (750) * 6 / 180 = 0.91.

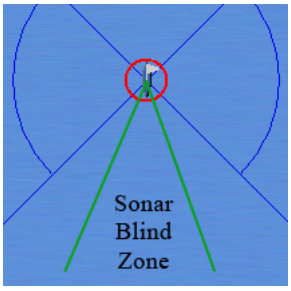
Thermoclines

A thermocline is a layer of water in which the temperature changes rapidly as compared with the water above and below it. When this happens, sound from above which strikes the layer at a shallow angle will be reflected by the layer.

Each scenario is assigned a percentage chance from 0 to 100 that the water associated with the scenario has a thermocline. When the scenario is played, this percentage is applied to determine if the thermocline exists or not.

When a submarine is submerged in deep water (a Depth Soundings value of 9) and the thermocline exists, then this appears in the unit picture for that submarine. Active sonar from the surface will only have half its normal range for detecting the submarine. Likewise, both passive and active sonar from the submarine will have half range for detecting ships above the layer.

Sonar Blind Zones



Each ship surfaced or submerged has a sonar blind zone measured from the stern of the ship based on the Sonar Blind Zone parameter data angle. This angle determines the size of the blind zone. Any other ship within half that angle from the stern of the ship cannot be detected by sonar by that ship.

Torpedo Data Computer (TDC)

In the standard submarine rules, torpedo shots must be fired manually. But in most cases, submarines were equipped with computers that provided a firing solution based on input target data. In the enhanced submarine rules, there is a Torpedo Data Computer (TDC) feature that can be used to generate firing solutions.

To invoke the TDC feature, you select the submarine to fire the torpedo and then hold the cursor over the target ship while holding down the Control (Ctrl) key. This will generate an approximate firing solution shown on the main chart as a blue line as shown here. You can then fire your torpedoes however you see fit with respect to this firing solution to achieve what you consider to be the optimal torpedo spread. Note however that there is always some error associated with the firing solution mainly associated with the historical training and experience level of the submarine crew. This error is reported per side as the Torpedo Data Computer Error in the Parameter Data.

When a torpedo is fired using the Torpedo Data Computer, then the running time of the torpedo to reach the calculated hit location will be automatically shown on the ship icon in the format minutes:seconds.

Torpedo Reliability

Early on in World War II, American and German torpedoes were horribly unreliable with "dud" rates of around 30%. After a while, the torpedo problems were identified and solved, but this failure rate greatly diminished the success of the early submarine missions. Each side has a Torpedo Failure Rate expressed as a percentage that is used to determine how many torpedo hits do not result in an explosion and damage to the target ship.

Depth Charge Hit Probabilities

Under the standard submarine rules, Depth Charges are assumed to have damaged the submarine provided they explode vertically aligned with the submarine. In the enhanced rules, this is modified to be more realistic and to reflect the skill of the surface ship. Associated with each side, there is a Depth Charge Hit Probability value in Parameter Data. This probability value is applied in addition to the alignment requirement to determine if the submarine is damaged by the DC.

Electric Torpedoes

Some torpedo designs used batteries for propulsion which meant they did not produce any air bubbles on the surface when fired. These torpedoes were extremely hard to see underwater and can only be seen at half the standard torpedo spotting distance.

Depth Bombs

While true Depth Charges that exploded at deep depths were dropped by airplanes, it was more common that they dropped what can be called Depth Bombs at submarines. These Depth Bombs could either strike the submarine on the surface and explode, or if they missed, they were designed to explode at a shallow depth which would damage the submarine both on the surface and at shallow depths.

To manually drop a Depth Bomb, you should first make it the active load on the aircraft (See the **Set Active Load** option in the Command Menu or toolbar button). While holding down the **Control** (Ctrl) key, right click on the aircraft icon on the main chart. This will drop 2 depth bombs at the current location of the aircraft. Depth Bombs are also automatically dropped if the aircraft is targeting a ship or submarine that it is overflying.

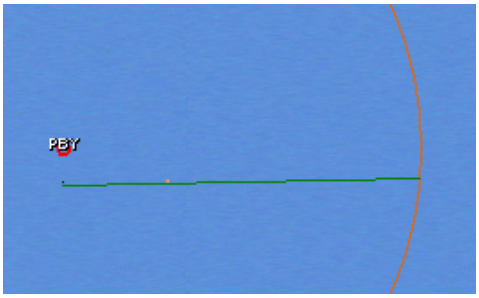
Sonobuoys

There are four types of sonobuoys represented in the game. They can be **active** or **passive** and they can be **directional** or **nondirectional**. Once dropped, sonobuoys remain active for the duration of the scenario.

To deploy a sonobuoy, it should be the active load on the aircraft (See **Set Active Load** option in Command Menu or toolbar button).

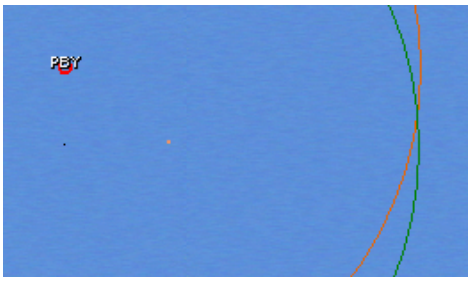
To deploy a single sonobuoy, hold down the **Control** (Ctrl) key while right-clicking on the aircraft icon on the main chart. The sonobuoy will appear on the main chart as a black dot.

A directional sonobuoy will show the general direction to the sonar contact using a green line.



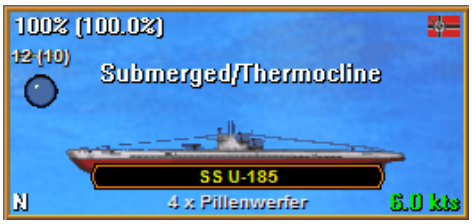
In the case of active sonobuoys, this line also shows the range to the contact whereas for passive sonobuoys, the line is always drawn out to the maximum range of the sonobuoy.

A non-directional sonobuoy will only show that a sonar contact has been made using a green circle.



In the case of active sonobuoys, this circle also shows the range to the contact whereas for passive sonobuoys, the circle is always drawn at the maximum range of the sonobuoy.

Submarine Decoys



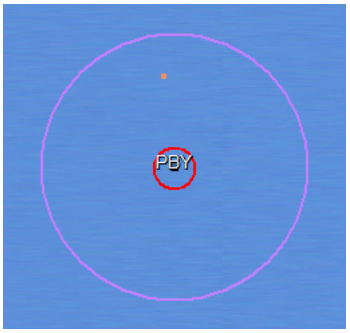
Certain loads are classified as **Submarine Decoys** and may be carried on some submarines. To deploy a Submarine Decoy, you must first select the load as the active load. Having done this, you then "fire" the decoy using the standard Ctrl-Right-Click action.

A deployed Submarine Decoy will appear to the enemy as a submarine on sonar. This will affect both detections by surface ships as well as sonobuoys and homing torpedoes.

Some Submarine Decoys have a speed of 0 and will remain active as long as the duration specified in the Reload field of the load database. Other Submarine Decoys will have a range and speed and will travel in the direction they are "fired" at that speed for that range.

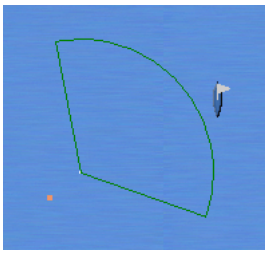
Magnetic Anomaly Detection (MAD)

Certain aircraft in a scenario may be identified as having a Magnetic Anomaly Detection (MAD) capability. This allows the aircraft to detect ships, particularly submarines, based on their disturbance of the earth's magnetic field. This detection applies to all ships, including those on the surface, those submerged, both friendly and enemy ships, and those that have been sunk. The distance a ship can be detected using MAD is determined by the MAD Range Parameter Data Value. An aircraft with the MAD capability is identified with a compass icon in its picture.



When an aircraft equipped with MAD detects a ship, a magenta colored circle is shown on the main chart. Note that the detected ship can be anywhere within this circle and the radius of the circle only shows the maximum detection range of the MAD capability.

Homing Torpedoes



Certain torpedoes in the database are classified as homing using passive acoustic homing. When fired from a ship, they must travel the minimum torpedo range distance, determined by Parameter Data, before they can begin homing. Each homing torpedo has an acquisition range and angle that determines which ships it will home on. This is shown on the main chart using a green arc. When the torpedo acquires a target, then the arc turns bright green and its size

indicates the maximum range it can home on the current target based on the size and speed of the target. The acquisition range of the torpedo is modified for any given potential target based on the Noise Modifier of the target as previously described.

Each homing torpedo is classified as surface ship homing, submerged submarine homing, or both. When there are ships of the appropriate type in the torpedoes homing cone, then it will pick the noisiest one to home on. The noise factor is based on the size of the ship, its speed, and its range from the torpedo as follows:

Noise-Factor = CubeRoot (Size) * Speed / Range

The maximum detection range is also modified according to the depth of the water that the ship is in (see Depth Soundings) according to the calculation:

Depth-Factor = Water-Depth / Max-Water-Depth

where Max-Water-Depth has the value 9. For example, a ship in water that has a Depth Sounding value of 3 would have 1/3 the detection range compared with the same ship in deep water.

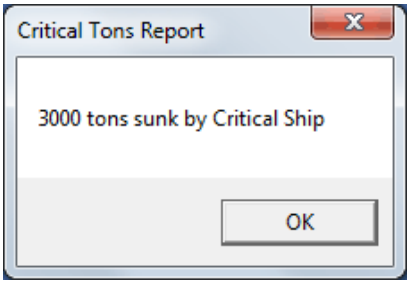
If the torpedo then strikes a target, there is a hit probability value that is used to determine if the strike is a success. This probability is normalized based on the size and speed of the target ship as described in the section on Optional Torpedo Hit Resolution. The resulting probability determines the probability of a successful hit on the target.

When homing torpedoes are fired from an aircraft, they begin by travelling in a circle until they acquire a suitable target. Then they home on the target as previously described and the hit resolution is as before. There is no minimum travel distance for such torpedoes.

Contact Hit Only Loads

Certain anti-submarine weapons such as Hedgehogs and the Limbo mortar are designed to only explode on hitting their target, as opposed to a standard depth charge which is set to explode at a given depth. When a weapon is classified as Contact Hit Only then it won't produce an explosion unless it hits a target.

Tonnage Sunk



The tons of enemy ships sunk by a Critical Ship is reported whenever the Victory Dialog is displayed and used in the Campaign Game to track the performance of the Critical Ship.

Missile Enhancements

This section covers enhancements to the basic rules of Naval Campaigns needed to cover combat in the missile age. The primary enhancements are those associated with guided missiles and defenses against them.

Anti-Ship Missile Hit Probability

The basic probability that an anti-ship missile fired at a ship will hit is given by:

Hit-Prob = discrete (Nominal-Hit-Prob, Norm-Size)

where:

- Nominal-Hit-Prob is the nominal hit probability for the missile.
- Norm-Size is the normalized size of the target ship. This value equals (size / 1000.0)^1/3 where 'size' is the size of the target ship in tons. The value is designed to vary proportional to the freeboard of the ship with ships of 1000 tons normalized to 1.

and:

discrete (prob, mod) = 1 - (1 - prob)^mod

This probability is the hit probability calculated prior to the modification of any counter-measures.

Missile Hit Examples

These examples are taken from the Naval Postgraduate Thesis by John Schulte, thesis advisor Wayne Hughes. In each case, the nominal hit probability of the missile is assumed to 0.7. Each example is for a ship with no anti-ship missile defenses, or a ship that didn't use its defenses.

Example 1. Sinking of the Eilat (1967)

The Eliat was an Israeli destroyer of 1,710 tons. This results in a hit probability of 0.76. If 4 missiles were fired at it, an average of 3 would hit (Actual 3 hits).

Example 2. Sinking of the Orit (1970)

The Orit was an Israeli fishing vessel assumed to be 10 tons. This results in a hit probability of 0.23. If 4 missiles were fired at it, an average of 0.92 would hit (Actual 1 near miss).

Example 3. Arab-Israeli War: Battle of Latakia (1973)

A Komar-class missile boat is 66 tons. This results in a hit probability of 0.38. An Osa-class missile boat is 172 tons. This results in a hit probability of 0.49. If 11 missiles were fired at them, an average of between 4.2 and 5.4 would hit (Actual 6 hits).

Example 4. Arab-Israeli War: The Battle of Baltim (1973)

If 12 missiles were fired against Osa-class missile boats, an average of 5.9 would hit (Actual 6 hits).

Example 5. Arab-Israeli War: Second Battle of Latakia (1973)

If 6 missiles were fired at Osa-class missile boats, an average of 2.9 would hit (Actual 3 hits). If a merchant ship had a size of 5,000 tons, the hit probability against it would be 0.83. If 2 missiles were fired at it, an average of 1.66 would hit (Actual 2 hits).

Example 6. Arab-Israeli War: Battle of Tartus (1973)

If 6 missiles were fired at Osa-class missile boats, an average of 2.9 would hit (Actual 4 hits). If a merchant ship with a size of 5,000 tons was fired at by 2 missiles, an average of 1.7 would hit (Actual 2 hits).

Example 7. Iran-Iraq War (1980-1987)

An oil tanker of 100,000 tons would have a hit probability of 0.99. If 53 missiles were fired against them, an average of 52.5 would hit (Actual 52 hits).

Example 8. Falklands War: Attacks on Argentine Patrol Boats (1982)

The Alferez Sobral has a size of 835 tons and thus a hit probability of 0.68. If 2 missiles were fired against it, an average of 1.36 would hit (Actual 2 hits). Likewise, if two missiles were fired against the Somellera of size 835 tons, then 1.36 would hit (Actual 2 hits).

Example 9. Falklands War: Attack on HMS Sheffield (1982)

The HMS Sheffield had a size of 4,820 tons which gives a hit probability of 0.87. If 1 missile was fired against it, there would be an average of 0.87 hits (Actual 1 hit).

Example 10. Falklands War: Sinking of the Atlantic Conveyor (1982)

The Atlantic Conveyor had a size of 14,950 and thus a hit probability of 0.95. If 2 missiles were fired against it, an average of 1.9 would hit (Actual 2 hits).

Example 11. Battle of Sidra (1986)

The Libyan Combattante II patrol boat has a size of 560 tons giving a hit probability of 0.63. If 6 missiles were fired against them, an average of 3.8 would hit (Actual 3 hits).

Example 12. USS Stark Incident (1987)

The USS Stark has a size of 4,100 giving a hit probability of 0.85. If 2 missiles were fired at it, an average of 1.7 would hit (Actual 2 hits).

Example 13. Persian Gulf War: The Battle of Bubyian Island (1991)

A small combatant with size 200 tons would have a hit probability of 0.51. If 14 missiles were fired against them, an average of 7.1 would hit (Actual 8 hits).

Example 14 (Post Schulte Study). Israeli Hanit (2006)

On July 14, 2006, Hezbollah fighters fired two missiles, a C-802 and possibly a C-701, at the Israeli corvette Hanit. The Hanit has a size of 1,075 giving a hit probability of 0.71. If two missiles were fired at it, an average of 1.4 would hit (Actual 1 hit). Note: the Hanit is designed for a reduced RCS and this should be taken into account in this example, except that the hanger crane was deployed at the time of the attack, which reduced the otherwise stealthy design of the ship and in fact this crane may have been the impact point for the missile.

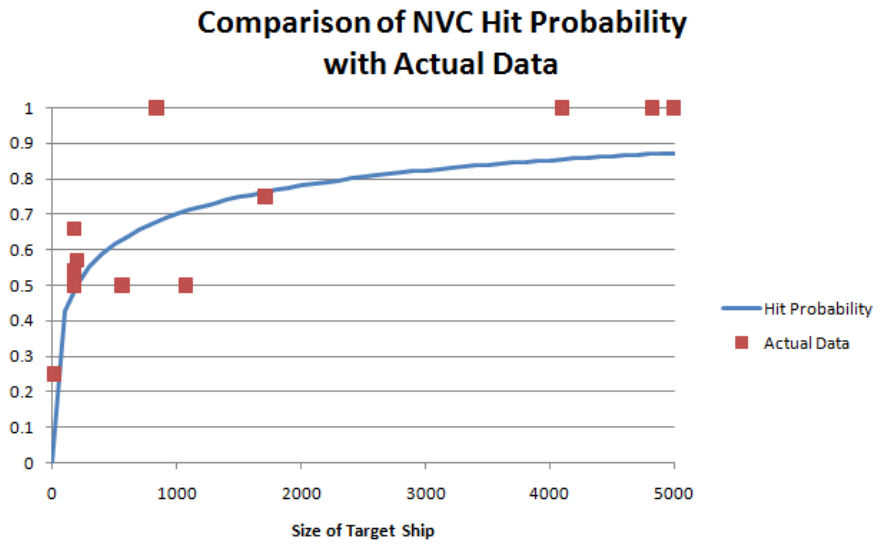
Summary. In his thesis, Schulte summarizes the results up to 1982 by saying that the hit probability against a "Defendable Target", usually a warship that was not using defenses, is 0.684. Against a "Defenseless Target", usually a larger commercial ship, the hit probability is 0.913. Using a nominal hit probability of 0.7 and working backwards to size, this gives:

Ship size (warship) giving 0.684 hit probability = 876 tons

Ship size (commercial ship) giving 0.913 hit probability = 8,342 tons

In his book, "Fleet Tactics and Coastal Combat", Second Edition, page 276, Wayne Hughes states that one certain reason why a defenseless merchant ship had a higher hit probability than a defendable warship is that the merchant ships were larger and easier to hit than the warships.

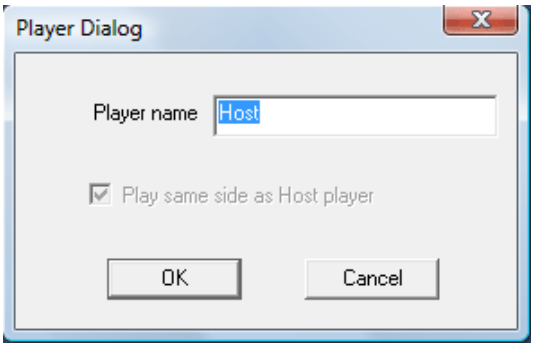
This hit data is plotted below and compared with the hit probability function defined here.



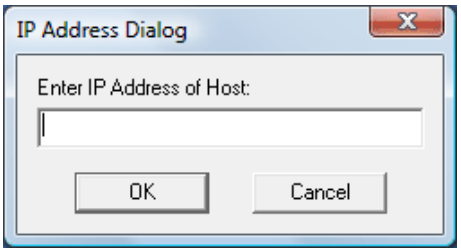
Other Features

Network Play

This section describes the details associated with multi-player **Network Play**. Microsoft's Direct Play is used for this purpose. The TCP/IP protocol is used to connect the computers being used. If you are using a firewall to connect to the Internet, you must configure it before you can connect using Direct Play. Information on how to do this can be found in this Microsoft technical article: DirectX: Ports Required to Play on a Network.



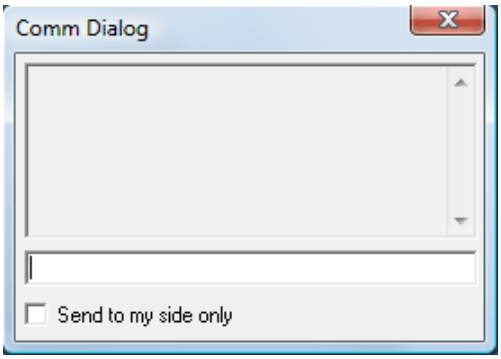
The Player Dialog is displayed so that each player can specify their name and to specify if they want to be on the same side as the Host player or the opposing side.



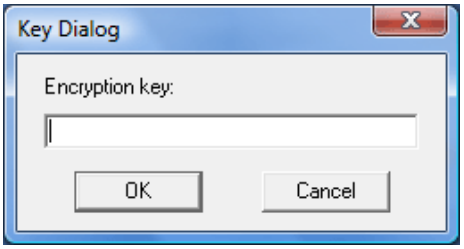
The Caller will be prompted to enter the IP Address of the Host computer. The Host player must determine their IP Address and communicate this to the other players.

One way for the Host player to determine their IP Address is to perform the following steps:

- Click on **Start**, then **Run**, and enter **cmd**.
- In the window that opens, enter **ipconfig**.



Once a connection has been established, the Comm Dialog will appear and allow both players to communicate with each other. You can type messages in the area at the bottom of the Comm Dialog and press Return to send them. All messages are displayed in the top area of the Comm Dialog prefaced by the name of the player sending the message. In Multi-Player Network Play games, you can limit the sending of the message to players of your side, by selecting the option at the bottom of the Comm Dialog.

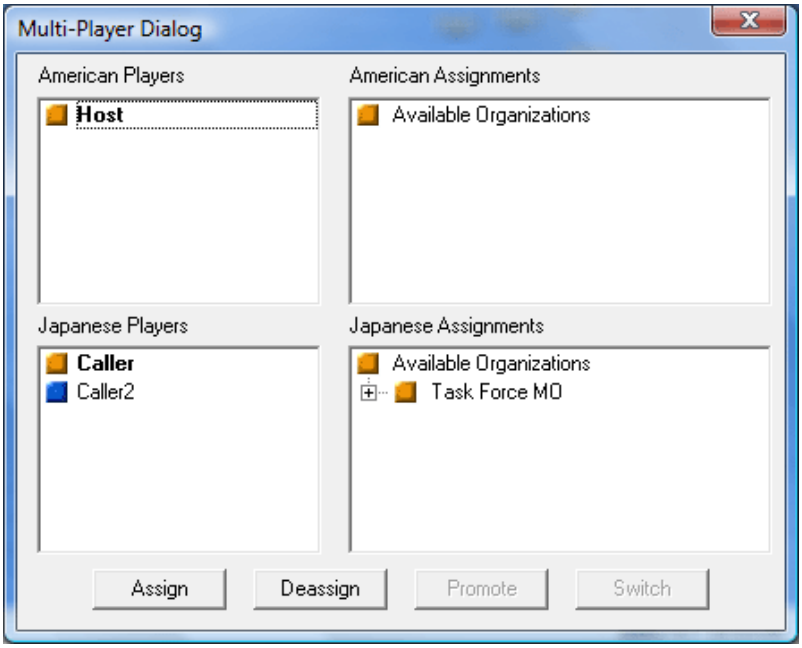


If you are the first Caller of the opposing side, you will be prompted to specify an Encryption Key to be used to encrypt the battle file on the Host computer. This encryption will prevent your opponent from trying to access the battle file in your absence. Be sure to remember your Encryption Key and specify it exactly the next time you open an existing battle or else a read error will occur. If you trust your opponent, it is OK to leave the Encryption Key blank.

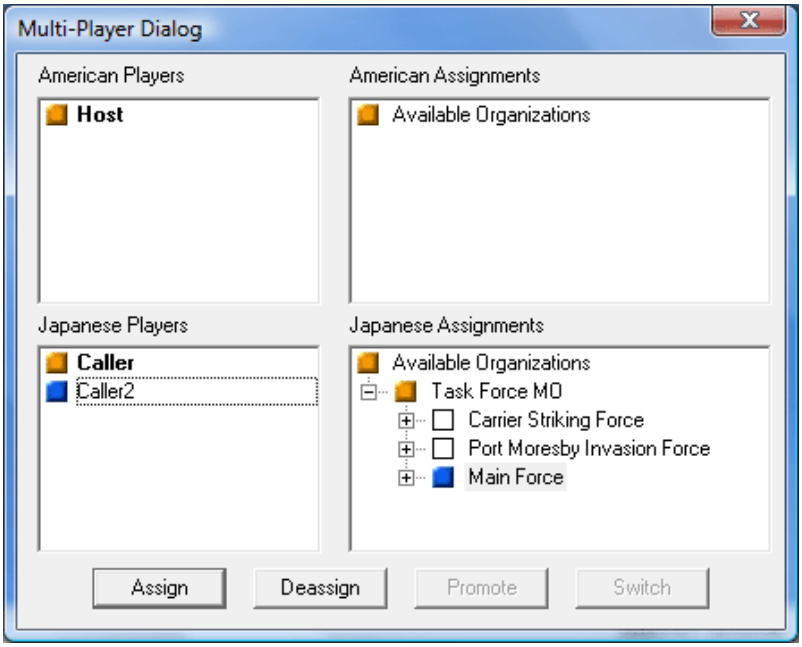
Multi-Player

In general, both sides of a Network game can have more than one person assigned to them. The Host player and the first player to connect playing the opposing side, will be the **Commander** for their respective sides. By default, the Commanders control all units for their side. Additional players on each side can be assigned commands by the Commander. Each player can only

command ships under their control. The Multi-Player Dialog is used by the Commanders to assign commands to their subordinates.



The Multi-Player Dialog displays the players for both sides and allows the commanders of those sides to assign commands to their subordinates.

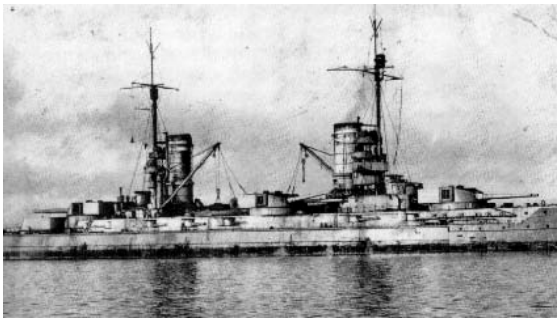


To assign a subordinate player a command, you open the organization tree on the right hand side and select the organization to give the subordinate. You also select the subordinate in the list of players on the left-hand side. Finally, you click the **Assign** button to assign that player the selected command. A

single player can be assigned multiple commands. If you want to drop an organization from the command of a subordinate, you select the organization on the right-hand side and click the **Deassign** button.

The **Promote** and **Switch** functions of the Multi-Player Dialog can only be used by the Host player. If you want to change the Commander for each side, you select that player and press the Promote button. The selected player will become the Commander for that side. If you want to switch a player from one side to the other, select the player and press the Switch button. The player will change sides in the game.

Firing Resolution



This section describes the internal calculations that are used to determine firing, torpedo, mine, and bomb resolution. With respect to ships, there is ship to ship firing, ship to Target firing, and ship to aircraft firing (AAA for example). With respect to aircraft, there is bombing and firing at a distance on ships, as well as for Targets. Likewise, there is aircraft to aircraft combat (dogfighting). Finally, with respect to Targets, there is firing on ships and aircraft. Each of these is covered in the following section.

In the examples given below on aircraft attacks in World War II in the Pacific, there are three primary time periods covered:

- Early War – Pearl Harbor, Coral Sea, Midway
- Middle War – Eastern Solomons, Santa Cruz
- Late War – Philippines Sea

Basic Firing Resolution

The resolution of fire from primary and secondary armament follows the same basic resolution. This resolution consists of two parts: if the shot hits the target ship and if so, then what the damage to the target ship is.

The probability that a given shot will hit the target ship is based on the following calculation:

Hit Prob = Basic-Hit-Prob * Norm-Size * Norm-Range^2 * Norm-Speed

where:

- Basic-Hit-Prob is the basic hit probability for the side of the firing ship. This value is part of the Parameter Data values and can be found in the Parameter Data Dialog.
- Norm-Size is the normalized size of the target ship. This value equals Sqrt (size) / 100.0 where ‘size’ is the size of the target ship in tons and ‘Sqrt’ is the square-root function.
- Norm-Range is the normalized range to the target ship. This value is equal to 15000 / range where ‘range’ is the range in yards. This value is squared in the hit probability equation.

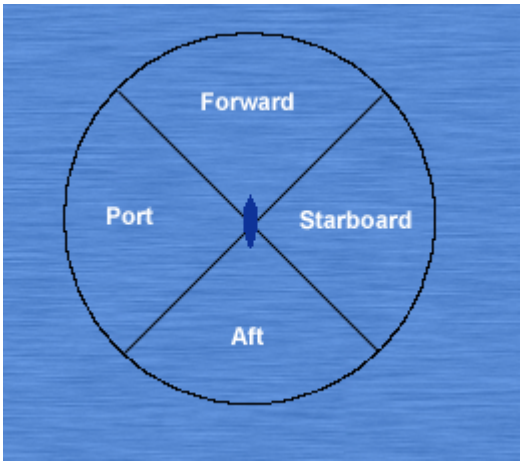
- Norm-Speed is the normalized speed of the target ship. This value is equal to 25 / (speed + 5) where 'speed' is the speed of the target ship in knots. Note: The minimum value of speed used in this calculation is 5 knots. This results in normalized speed values that range from near zero for fast ships to 2.5 as a maximum value.

Example. Suppose one ship fires on another at a range of 20,000 yards, where the target ship is 10,000 tons and is traveling at 25 knots. Suppose the basic hit probability of the firing ship is 2%. The normalized size of the target ship is equal to Sqrt (10000) / 100 = 100 / 100 = 1.0. The normalized range is equal to 15000 / 20000 = 0.75. The normalized speed of the target ship is equal to 25 / (25 + 5) = 25 / 30 = 0.83. Finally, the hit probability equals

Hit Prob = 0.02 * 1.0 * 0.75^2 * 0.83 = 0.0093375

Or less than 1%.

If a shot hits, then the following calculation is used to determine the damage to the target ship. First a fire value is calculated. If the fire is from the secondary armament of the firing ship, then the Secondary Fire Value in the Parameter Data values is used as the firepower. Otherwise a determination is made which guns of the firing ship are able to fire in the direction of the target ship.



Each gun of a ship is assigned a number of facings that it is allowed to fire in the direction of. These facings are listed in the Database Dialog and can consist of the values F (for can fire forward), A (for can fire aft), P (for can fire in the port direction), and S (for can fire in the starboard direction). The forward direction includes all ships that are within 45 degrees of the direction the firing ship is facing. The aft direction consists of all ships that are within 45 degrees of the opposite direction the firing ship is facing. The port direction includes all ships that are within 45 degrees of the port direction of the firing ship and the starboard direction includes all ships that are within 45 degrees of the starboard direction of the firing ship.

If a gun can fire on the target ship, then the basic firepower of that gun is given by:

Firepower = firevalue^2 * status / 100

where ‘firevalue’ is the firepower value of the gun, which is squared, and status is the percentage status value of the firing ship.

Next a determination is made of the effective armor of the target ship. A ship has two armor values: a belt armor and a deck armor value. Based on the range from the firing ship to the target ship, the effective armor when fired upon by primary armament is equal to:

((max-range – range) * belt + range * average) / max-range

where ‘max-range’ is the maximum range of the firing ship and ‘average’ is the average of the belt and deck armor. When firing with secondary armament, the belt armor value is always used.

Examples: Suppose a ship is firing primary armament at maximum range at a target ship. The effective armor of the target ship is equal to the average of its belt and deck armor values. If the ship is firing at very close range, then the effective armor of the target ship is very close to the belt armor value.

Finally then the maximum damage to the target ship is calculated as:

Max-Damage = SVS * firepower / effective-armor

where SVS is the **Ship vs Ship Fire** Parameter Data Value. The damage value is given in tons. The actual damage is taken randomly between the maximum damage value and 0.

Ship vs Target Resolution

When a ship fires its guns against a Target, the same basic resolution is used in terms of hit probability and damage resolution.

The probability that a given shot will hit the Target is based on the following calculation:

Hit Prob = Basic-Hit-Prob * Norm-Size * Norm-Range^2

where:

- Basic-Hit-Prob is the basic hit probability for the side of the firing ship. This value is part of the Parameter Data values and can be found in the Parameter Data Dialog.
- Norm-Size is the normalized size of the Target. This value equals size / 100.0 where ‘size’ is the size of the Target.
- Norm-Range is the normalized range to the Target. This value is equal to 15000 / range where ‘range’ is the range in yards. This value is squared in the hit probability equation.

If a shot hits, then the following calculation is used to determine the damage to the Target. First the firepower of the ship is calculated as described previously. The maximum damage is given by:

Max-Damage = SVT * firepower / protection

where SVT is the **Ship-vs-Target Fire** Parameter Data Value, and protection is the protection of the target (values less than 1 are taken to be 1). The actual damage is taken randomly between the maximum damage value and 0.

The damage value is used to determine a change in the Status of the Target according to the following calculation:

Effect = (100 * Damage) / Size^2

where Effect is the percentage change in the Status of the Target, and Size is the size of the Target.

Critical Hits

Under certain conditions, it is possible that when a target ship is hit, then it can suffer a Critical Hit. This represents a catastrophic explosion within the ship that results in the immediate sinking of the ship as a result. The probability that a hit on a given ship will be a Critical Hit is determined by the Critical Hit probability in the Parameter Data values. There are restrictions on when this is applied:

- Neither the firing ship nor the target ship can be a Destroyer.
- If the firing ship is a Light Cruiser (CL), then the target ship must also be a Light Cruiser.

Damage Effects

As a ship takes damage, its status will decrease from 100% to 0%. When a ship's status reaches 0%, it is sunk. As the ship takes damage, there are two effects on the ship in terms of its ability to fire and maneuver.

- When the status of a ship is 75% or more, there is no effect on maneuver.
- When the status of a ship reaches 25%, it is Disabled and unable to maneuver.
- As the status of a ship goes from 75% to 25%, its maximum speed decreases from 100% of its rated speed to 0%.
- The firing value of a ship varies proportional to its status until the status reaches 25% or lower at which point the ship cannot fire.

- When the status of a ship is below 50%, then any radar that the ship has becomes non-functional.
- A ship whose status is below 75% cannot land or launch aircraft.

Ship Load Hit

The hit probability of a load fired from a ship is the same calculation as that for a gun shot (In this version, all load shots are assumed to be unguided). The damage resolution for a load shot is described below.

Aircraft Load Hit

Each aircraft type of a given side has a basic bombing probability given by parameter data according to the following:

- Dive Bombers use the **Dive Bombing Probability** for their side.
- Other Small Bombers use the **Low Level Bombing Probability** for their side.
- Large Bombers use the **High Level Bombing Probability** for their side.

When a bomb is dropped from an aircraft on a ship, the calculation of the hit probability is:

Hit-Prob = Bombing-Prob * Norm-Size * Norm-Speed

where Bombing-Prob is the basic bombing probability for the aircraft, Norm-Size is the normalized size of the ship as described above, and Norm-Speed is the normalized speed of a ship as described above.

When a bomb is dropped from an aircraft on a Target, the calculation of the hit probability is:

Hit-Prob = Bombing-Prob * Norm-Size

where Bombing-Prob is the basic bombing probability for the aircraft and Norm-Size is the normalized size of the Target as described above.

When a load with non-zero Range is fired at a ship, the calculation of the hit probability is:

Hit-Prob = Low-Level-Bomb-Prob * Norm-Size * Norm-Range^2 * Norm-Speed

where Low-Level-Bomb-Prob is the **Low Level Bombing Probability** Parameter Data Value for the aircraft side, and:

Norm-Range = 1000 / Range

for ranges of 1000 yds or greater, or 1 for ranges within 1000 yards. Likewise the hit probability against a Target is:

Hit-Prob = Low-Level-Bomb-Prob * Norm-Size * Norm-Range^2

When a bomb is dropped on a ship that is turning, then there is a modifier to the hit probability given by the **Maneuver Hit Modifier** Parameter Data Value.

When a load is fired or dropped at a ship from an aircraft within range of that AAA of the ship and the AAA of that ship is not suppressed, then there is a modifier to the hit probability given by the **AAA Hit Modifier** Parameter Data Value.

The damage resolution for a load shot is described below.

Dive Bombing Examples

Example 1. (Midway) Suppose a D3A Val with a Dive Bombing Probability of 0.5 drops a bomb on the CV Yorktown whose size is 25,500, which is maneuvering at 24 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.5 * 1.6 * 0.86 = 68.8%

where 1.6 is the normalized size and 0.86 is the normalized speed of the Yorktown. Since the Yorktown is firing AAA and maneuvering, the resulting hit probability is:

Hit-Prob = 0.688 * 0.75 * 0.75 = 38.7%

assuming a Maneuvering Hit Mod and a AAA Hit Mod of 0.75. If there were 7 Val's attacking, this would result in an average of 2.7 hits (Actual 3 hits).

Example 2. (Midway) Suppose an SBU Dauntless with a Dive Bombing Probability of 0.25 drops a bomb on the CV Kaga whose size is 42,450, which is maneuvering at 28 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 2.06 * 0.75 = 38.6%

where 2.06 is the normalized size and 0.75 is the normalized speed of the Kaga. Since the Kaga is firing AAA and maneuvering, the resulting hit probability is:

Hit-Prob = 0.386 * 0.75 * 0.75 = 21.7%

assuming a Maneuvering Hit Mod and a AAA Hit Mod of 0.75. If there were between 12 and 25 Dauntless' attacking, this would result in between 2.6 and 5.4 hits, for an average of 4.0 (Actual 4 hits).

Example 3. (Midway) Suppose the same SBU Dauntless drops a bomb on the CV Akagi, whose size is 41,300, maneuvering at 28 knots with AAA. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 2.03 * 0.75 = 38.1%

The resulting hit probability is 21.4%. If there were 5 Dauntless' attacking, this would result in an average of 1.1 hits (Actual 1 hit).

Example 4. (Midway) Suppose an SBD Dauntless with a Dive Bombing Probability of 0.25 drops a bomb on the CV Hiryu whose size is 20,250, which is maneuvering at 24 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 1.42 * 0.86 = 30.5%

where 1.42 is the normalized size and 0.86 is the normalized speed of the Hiryu. Since the Hiryu is firing AAA and maneuvering, the resulting hit probability is:

Hit-Prob = 0.305 * 0.75 * 0.75 = 17.2%

assuming a Maneuvering Hit Mod and a AAA Hit Mod of 0.75. If there were 24 Dauntless' attacking, this would result in an average of 4.1 hits (Actual 4 hits).

Example 5. (Coral Sea) Suppose an SBD Dauntless with a Dive Bombing Probability of 0.25 drops a bomb on the CV Shokaku whose size is 29,800, which is maneuvering at 34 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 1.72 * 0.64 = 27%

where 1.72 is the normalized size and 0.64 is the normalized speed of the Shokaku. Since the resulting hit probability is 15.5%. If there are 22 SBD's attacking, then this would result in an average of 3.4 hits (Actual 2 hits).

Example 6. (Eastern Solomons) Suppose a D3A Val with a Dive Bombing Probability 0.4 of drops a bomb on the CV Enterprise whose size is 25,500, which is maneuvering at 30 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.4 * 1.6 * 0.71 = 45%

where 1.6 is the normalized size and 0.71 is the normalized speed of the Enterprise. The resulting hit probability is 25.6%. If there are 11 Val's attacking, then this would result in an average of 2.8 hits (Actual 3 hits).

Example 7. (Santa Cruz) Suppose an SBD Dauntless with a Dive Bombing Probability of 0.4 drops a bomb on the CV Shokaku whose size is 29,800, which is maneuvering at 30 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.4 * 1.72 * 0.71 = 49%

where 1.72 is the normalized size and 0.71 is the normalized speed of the Shokaku. The resulting hit probability is 27.4%. If there are 11 SBD's attacking, then this would result in an average of 3.0 hits (Actual 3 hits).

Example 8. (Coral Sea) Suppose an SBD Dauntless with a Dive Bombing Probability of 0.25 drops a bomb on the CV Shoho whose size is 14,200, which is maneuvering at 28 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 1.19 * 0.75 = 22.3%

The resulting hit probability is 12.5%. If there are 18 SBD's attacking, then this would result in an average of 2.25 hits (Actual 2 hits).

Example 9. (Coral Sea) Suppose in a subsequent attack, an SBD Dauntless drops a bomb on the CV Shoho, which is drifting and unable to maneuver but is firing AAA. The nominal hit probability is:

Nominal-Hit-Prob = 0.25 * 1.19 * 2.5 = 74.4%

The resulting hit probability is 55.8%. Assuming there are 25 SBD's attacking, there would be an average of 14 hits (Actual 11 hits).

Example 10. (Coral Sea) Suppose a D3A Val with a Dive Bombing Probability of 0.5 drops a bomb on the Oiler Neosho whose size is 7,470, which is maneuvering at 18 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.5 * 0.86 * 1.08 = 46.4%

The resulting hit probability is 26.1%. If there were 32 Val's attacking, this would result in an average of 8.3 hits (Actual 7 hits).

Example 11. (Pearl Harbor) Suppose a D3A Val drops a bomb on the Battleship Nevada, whose size is 27,500, maneuvering at 12 knots with AAA firing. The nominal hit probability for one bomb is:

Nominal-Hit-Prob = 0.5 * 1.66 * 1.47 = 122%

The resulting hit probability is 68%. If there are 23 Val's attacking, the average number of bomb hits would be 15.7 (Actual 15 hits).

Example 12. (Philippine Sea) Suppose an SB2C Helldiver with a Dive Bombing Probability of 0.4 drops a bomb on the CV Zuikaka, whose size is 29,800, maneuvering at 34 knots with AAA firing. The nominal hit probability is:

Nominal-Hit Prob = 0.4 * 1.72 * 0.64 = 44%

The resulting hit probability is 24.8%. If there are 8 Helldivers attacking, the average number of bomb hits would be 1.98 (Actual 2 hits).

Example 13. (Eastern Solomons) Suppose an SBD Dauntless with a Dive Bombing Probability of 0.4 drops a bomb on the CVL Ryujo, whose size is 12,732, maneuvering at 29 knots with AAA firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.4 * 1.13 * 0.071 = 31.9%

The resulting hit probability is 17.9%. If there are 5 SBD's attacking, the average number of bomb hits would be 0.9 (Actual 1 hit).

Example 14. (Santa Cruz) Suppose a D3A Val with a Dive Bombing Probability of 0.4 drops a bomb on the CV Hornet, whose size is 25,500, maneuvering at 34 knots with AAA Firing. The nominal hit probability is:

Nominal-Hit-Prob = 0.4 * 1.60 * 0.64 = 41%

The resulting hit probability is 23%. If there are 3 Val's attacking, the average number of bomb hits would be 0.7 (Actual 1 hit).

Low Level Bombing Examples

Example 1. (Santa Cruz) Suppose a TBF Avenger with a Low Level Bombing Probability of 0.08 drops four 500 lb bombs on the Cruiser Chikuma, whose size is 15,200, which is maneuvering at 35 knots with AAA firing. The nominal hit probability for one bomb is:

Nominal-Hit-Prob = 0.08 * 1.23 * 0.625 = 6.2%

The resulting single bomb hit probability is 3.5%. If there are 8 Avengers dropping a total of 32 bombs, then there would be an average of 1.1 hits (Actual 1 hit).

Example 2. (Pearl Harbor) Suppose a B5N2 Kate with a Low Level Bombing Probability of 0.1 drops an 800kg AP bomb on the Battleship Arizona, whose size is 31,400, fixed in harbor with no active AAA. The hit probability is:

Hit-Prob = 0.1 * 1.77 * 2.5 = 44%

If there are 3 Kates attacking, then there would be an average of 1.3 hits (Actual 1 hit).

Example 3. (Midway) Suppose an SBD Dauntless flown by a pilot without dive bombing training with a Low Level Bombing Probability of 0.05 drops a bomb on the CV Hiryu, whose size is 20,250, maneuvering at 34 knots with AAA firing. The nominal hit probability for one bomb is:

Nominal-Hit-Prob = 0.05 * 1.42 * 0.64 = 4.5%

The resulting hit probability is 2.5%. If there are 10 SBD's in Henderson's group that drop bombs, the average number of hits would be 0.25 (Actual 0 hits).

Example 4. (Philippine Sea) Suppose an F6F Hellcat with a Low Level Bombing Probability of 0.08 drops a bomb on the CV Ryuho, whose size is 12,732, maneuvering at 29 knots with AAA firing. The nominal hit probability is:

Nominal-Hit Prob = 0.08 * 1.12 * 0.74 = 6.6%

The resulting hit probability is 3.7%. If there are 14 Hellcats attacking, the average number of bomb hits would be 0.5 (Actual 0 hits).

Example 5. (Santa Cruz) Suppose a B5N2 Kate with a Low Level Bombing Probability of 0.08 drops an 800kg HE bomb on the CV Hornet, whose size is 25,500, which is drifting with no control but is firing AAA. The hit probability is:

Nominal-Hit-Prob = 0.08 * 1.6 * 2.5 = 32%

The resulting hit probability is 24%. If there are 6 Kate's attacking, then there would be an average of 1.4 hits (Actual 1).

High Level Bombing Examples

Example 1. (Midway) Suppose a B-17 Flying Fortress with a High Level Bombing Probability of 0.01 drops 12 bombs on the CV Hiryu, whose size is 20,250, maneuvering at 34 knows with AAA firing. The nominal hit probability for one bomb is:

Nominal-Hit-Prob = 0.01 * 1.42 * 0.64 = 0.91%

The resulting single bomb hit probability is 0.5%. If 72 bombs are dropped by 6 B-17's, then there would be an average of 0.36 hits (Actual 0 hits).

Example 2. (Eastern Solomons) Suppose a B-17 Flying Fortress with a High Level Bombing Probability of 0.016 drops 11 bombs on the Destroyer Mutsuki, whose size is 1,772, which is motionless in the water with no AAA firing. The hit probability for one bomb is:

Hit-Prob = 0.016 * 0.42 * 2.5 = 1.7%

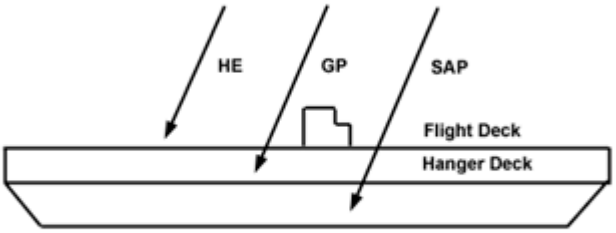
If there are 4 B-17 each dropping 11 bombs, the average number of hits would be 0.74 (Actual 1 hit).

Note on Ship Size Calculation

The flight deck of the Hiryu was 62,568 sq feet (= 711x88) while the flight deck of the Kaga was 81,500 sq feet (=815x100). The flight deck ratio Kaga/Hiryu = 1.30 while the normalized size ratio Kaga/Hiryu = 1.45, agreeing within 10% of each other.

Note on Bomb Penetration

The diagram below shows the typical penetration of Japanese HE and SAP bombs on a carrier as well as the typical penetration of an American GP bomb.



Carrier Bomb Penetration

While British carriers used flight deck armor, the armor on Japanese and American carriers was between the Hangar deck and belowdecks. The HE bombs were fused to explode on contact with the wooden flight deck while the fusing of the GP bomb caused it to typically explode in the Hangar deck. The SAP bomb usually penetrated to belowdecks before exploding. When Hangar decks were full of aircraft, the GP bomb would have the greatest tendency to start a fire, while with carriers that were lightly loaded, the SAP bomb would cause the greatest damage. The penetration values used for Japanese and American bombs thus agrees well with their actual penetration of the carriers and their damage and burning characteristics are representative of their actual effects.

Load Damage Resolution

The resolution of damage for loads is the same regardless of whether they are fired or dropped from ships or aircraft. The firepower of a load shot is equal to its Explosive value as given by the database. The calculation of damage to the ship or Target is then the same using this firepower value with modifications to the effective armor and protection of the target.

A load which is shot from a non-zero range is assumed to hit the belt and deck armor of a ship with equal probability. A load which is shot from a zero range (i.e, a bomb), is assumed to hit the deck armor of a ship. For a load with a given Penetration value and a ship with a given Armor value (belt or deck):

Penetration-Effect = Penetration / Armor if Penetration < Armor, else 1.

and

Max-Damage = AVS * firepower * Penetration-Effect

where AVS is the **Air vs Ship Fire** Parameter Data Value.

Likewise, for a Target with a Protection value:

Penetration-Effect = Penetration / Protect if Penetration < Protect, else 1.

and

Max-Damage = AVT * firepower * Penetration-Effect

where AVT is the **Air vs Target Fire** Parameter Data Value.

When a shot consists of N of a given load, then the preceding calculation of hits and damage is calculated for the N loads individually and the resulting damage is the sum of the individual damages. It is possible depending on the load and the size of the ship that a hit by a load can cause a critical hit on the ship.

Example 1. (Midway) Suppose a D3A Val drops a 250kg SAP bomb on the CV Yorktown and hits. The Penetration Value of the 250kg SAP is 2.0 and the deck armor value of the Yorktown is 2.0. Thus:

Penetration-Effect = 1

The calculation of damage gives:

Max-Damage = 8 * 412 * 1 = 3296

where 8 is the Air vs. Ship Fire Parameter Data Value and 412 is the Explosive value of the 250kg SAP bomb. The average damage would be 1648. Since the Yorktown has a size of 25,500, then the average damage would be:

Average-Damage = 1648 / 25500 = 6.5%

Example 2. (Midway) Suppose a SBD Dauntless drops a 1000lb GP bomb on the CV Akagi and hits. The Penetration Value of the 1000lb GP bomb is 2.0 and the deck armor of the Akagi is 3. Thus:

Penetration-Effect = 0.667

The calculation of damage gives:

Max-Damage = 8 * 900 * 0.667 = 4802

where 8 is the Air vs. Ship Fire Parameter Data Value. The average damage would be 2401. Since the Akagi has a size of 41,300, the average damage would be:

Average-Damage = 2401 / 41300 = 5.8%

Example 3. (Midway) If the same 1000lb GP bomb hits the CV Hiryu with a size of 20,250 and deck armor of 1, then the Penetration-Effect is 1 and

Max-Damage = 8 * 900 * 1 = 7,200

This gives an average damage of 3,600 or 18%.

Example 4. (Coral Sea) If the same 1000lb GP bomb hits the CV Shokaku with a size of 29,800 and deck armor of 2, then the Penetration-Effect is 1 and

Max-Damage = 8 * 900 * 1 = 7,200

This gives an average damage of 3,600 or 12%

Example 5. (Midway) Suppose a D3A Val drops a 242kg HE bomb on the CV Yorktown and hits. The Penetration Value of the 250kg SAP is 0.5 and the deck armor value of the Yorktown is 2.0. Thus:

Penetration-Effect = 0.25

The calculation of damage gives:

Max-Damage = 8 * 532 * 0.25 = 1064

where 8 is the Air vs. Ship Fire Parameter Data Value and 532 is the Explosive value of the 242kg HE bomb. The average damage would be 532. Since the Yorktown has a size of 25500, then the average damage would be 2%.

Example 6. (Eastern Solomons) Suppose a B-17 Flying Fortress drops a 500lb GP bomb on the Destroyer Mutsuki and hits. The Penetration Value of the 500lb GP bomb is 1.5 and the deck armor of the Mutsuki is 1, so the Penetration Effect is 1.0. The calculation of damage gives:

Max-Damage = 8 * 450 * 1.0 = 3,600

The average damage would be 1,800. Since the Mutsuki has a size of 1,772, then the bomb sinks the ship.

Optional Torpedo Hit Resolution

Under the **Aircraft Torpedo Resolution** Optional Rule, the determination of torpedo hits is done using a probability calculation rather than physical collision of the torpedo and the ship. In this way, historical hit probabilities can be achieved. The probability that a torpedo fired from an aircraft will hit a ship that is within range is given by:

Hit-Prob = Torpedo-Prob * Torp-Size * Norm-Speed

where Torpedo-Prob is the **Torpedo Hit Probability** Parameter Data Value for the side of the aircraft, Norm-Speed is the normalized speed of the ship, and

Torp-Size = CubeRoot (Size) / 30

where ‘CubeRoot’ is the cube-root function applied to the size of the ship. When the target ship is maneuvering, then this hit probability is multiplied by the **Maneuvering Torpedo Modifier**.

Example 1. (Midway) If a B5N2 Kate with a Torpedo Hit Probability of 0.6 fires a torpedo at the Yorktown, whose size is 25,500, maneuvering at 25 knots, then the basic hit probability is given by:

Norm-Prob = 0.6 * 0.98 * 0.83 = 49%

where 0.98 is the Torpedo Size of the Yorktown and 0.83 is its Normalized Speed. Assuming a Maneuvering Torpedo Modifier of 0.5, the final probability is:

Hit-Prob = 0.5 * 0.49 = 24%

If there are 7 torpedoes fired, there would be an average of 1.7 hits (Actual 2).

Example 2. (Coral Sea) If a B5N2 Kate with a Torpedo Hit Probability of 0.6 fires a torpedo at the Lexington, whose size is 38,760, maneuvering at 34 knots, then the basic hit probability is given by:

Norm-Prob = 0.6 * 1.13 * 0.64 = 43.4%

where 1.13 is the Torpedo Size of the Lexington and 0.64 is its Normalized Speed. Assuming a Maneuvering Torpedo Modifier of 0.5, the final probability is:

Hit-Prob = 0.5 * 0.43 = 22%

If there are 11 torpedoes fired, there would be an average of 2.2 hits (Actual 2).

Example 3. (Coral Sea) If a B5N2 Kate with a Torpedo Hit Probability of 0.6 fires a torpedo at the Yorktown, whose size is 25,500, maneuvering at 34 knots, then the basic hit probability is given by:

Norm-Prob = 0.6 * 0.98 * 0.64 = 37.6%

Assuming a Maneuvering Torpedo Modifier of 0.5, the final probability is:

Hit-Prob = 0.5 * 0.376 = 19%

If there are 3 torpedoes fired, there would be an average of 0.6 hits (Actual 0).

Example 4. (Santa Cruz) If a TBF Avenger with a Torpedo Hit Probability of 0.4 fires a torpedo at the Cruiser Suzuya, whose size is 13,440, maneuvering at 35 knots, then the basic hit probability is given by:

Norm-Prob = 0.4 * 0.79 * 0.63 = 19.8%

The final probability is 10%. If there are 3 torpedoes fired, there would be an average of 0.3 hits (Actual 0).

Example 5. (Santa Cruz) If a TBF Avenger with a Torpedo Hit Probability of 0.4 fires a torpedo at the Cruiser Tone, whose size is 15,200, maneuvering at 35 knots, then the basic hit probability is given by:

Norm-Prob = 0.4 * 0.82 * 0.63 = 20%

The final probability is 10%. If there are 6 torpedoes fired, there would be an average of 0.6 hits (Actual 0).

Example 6. (Eastern Solomons) If a TBF Avenger with a Torpedo Hit Probability of 0.4 fires a torpedo at the CVL Ryujo, whose size is 12,732, maneuvering at 29 knots, then the basic hit probability is given by:

Norm-Prob = 0.4 * 0.78 * 0.74 = 23%

The final probability is 11.5%. If there are 7 torpedoes fired, there would be an average of 0.81 hits (Actual 1).

Example 7. (Coral Sea) If a TBD Devastator with a Torpedo Hit Probability of 0.2 drops a torpedo at the CVL Shoho, whose size is 14,200, which is moving at 24 knots but not maneuvering, the hit probability is:

Hit-Prob = 0.2 * 0.81 * 0.86 = 14%

If there are 12 Devastators attacking, there would be an average of 1.7 hits (Actual 2).

Example 8. (Coral Sea) If a TBD Devastator with a Torpedo Hit Probability of 0.2 drops a torpedo at the CV Shokaku, whose size is 29,800, which is maneuvering at 34 knots, the basic hit probability is given by:

Norm-Prob = 0.2 * 1.03 * 0.64 = 13.2%

The final probability is 6.6%. If there are 9 Devastators attacking, there would be an average of 0.6 hits (Actual 0). With 11 Devastators attacking, there would be an average of 0.7 hits (Actual 0).

Example 9. (Pearl Harbor) If a B5N2 Kate with a Torpedo Hit Probability of 0.6 drops a torpedo at the Battleship Oklahoma, whose size is 27,500, which is fixed in harbor with no AAA active, then the hit probability is:

Hit-Prob = 0.6 * 1.00 * 2.5 > 1

It is certain that the torpedo will hit (Actual 9 torpedo hits on the Oklahoma during the attack).

Example 10. (Midway) If a TBD Devastator with a Torpedo Hit Probability of 0.2 drops a torpedo at the CV Hiryu, whose size is 20,250, which is maneuvering at 34 knots, then the basic hit probability is given by:

Norm-Prob = 0.2 * 0.91 * 0.64 = 11.7%

The final probability is 8.8%. If there are 5 torpedoes launched, there would be an average of 0.4 hits (Actual 0).

Example 11. (Santa Cruz) If a B5N2 Kate with a Torpedo Hit Probability of 0.4 drops a torpedo at the CV Hornet, whose size is 25,500, which is maneuvering at 34 knots, then the basic hit probability is given by:

Norm-Prob = 0.4 * 0.98 * 0.64 = 25%

The resulting probability is 19%. If there are 8 torpedoes launches, there would be an average of 1.5 hits (Actual 2).

Torpedo Resolution

When a torpedo strikes a ship, calculations are performed to determine the amount of damage caused by the torpedo explosion and the amount of damage caused by flooding in the ship. For a torpedo with a certain explosive value, the maximum damage is calculated as:

Max-Damage = Explosive * Torpedo-Damage-Parameter

where Explosive is the explosive value of the torpedo and Torpedo-Damage-Parameter is the Torpedo Damage Parameter Data Value. The actual damage is randomly calculated between 0 and this maximum value.

A second calculation is performed to determine the amount of flooding the torpedo causes. Given an amount of Damage to the ship, the flooding damage is calculated randomly between:

Low-Flooding = Flooding-Damage-Parameter * Damage / 2

High-Flooding = Flooding-Damage-Parameter * 3 * Damage / 2

where Flooding-Damage-Parameter is the Damage Flooding Parameter Data Value. Thus the average flooding damage is this Parameter Data Value times the amount of original damage.

Example 1. (Midway) Suppose the CV Yorktown, whose size is 25,500, is hit by a Japanese Type 91 torpedo, whose explosive value is 452, dropped from a Kate. Given a Torpedo Damage Parameter Value of 5, the average resulting damage to the Yorktown is 1130, or about 4.4%. The flooding damage is this value times the Flooding Damage Parameter Value, which if given as 5, results in an additional 22% of damage. The average total damage to the Yorktown is then 26.4%. Two hits would result in an average damage of 52.8%.

Example 2. (Midway) Suppose then that the Yorktown is hit by a Japanese Type 95 torpedo, whose explosive value is 893, fired from a submarine. The average resulting damage to the Yorktown is 2232 or about 8.7%. The average flooding damage would be 43.7%. Total average damage would be 52.4%.

Example 3. (Coral Sea) Suppose that the CV Lexington, whose size is 38,746, is hit by a Japanese Type 91 torpedo. Given a Torpedo Damage Parameter Value of 5, the average resulting damage to the Lexington is 2.9%. The flooding damage, using a Flooding Damage Parameter Value of 5, would be an additional 14.5%. Total damage would be 17.4%. Three hits would result in an average of 52.2% damage.

Example 4. (Eastern Solomons) Suppose that the CVL Ryujo, whose size is 12,732, is hit by a Mark 13 torpedo, whose explosive value is 600. Given a Torpedo Damage Parameter Value of 5, the average resulting damage to the Ryujo is 1500, or about 11.8%. The flooding damage, using a Flooding Damage Parameter Value of 5, would be an additional 59%, resulting in a total damage of about 71%.

Mine Resolution

The resolution of mine strikes is the same as that for torpedo hits using an explosive value of 1000.

Depth Charge Resolution

A depth charge is set to explode after a certain amount of time specified as the Reload time in the Load database. When it explodes, if there is a submerged submarine nearby (calculated as a lateral distance between the position of the depth charge and the position of the submarine), then damage to the submarine can occur. The maximum damage is calculated as:

Max-Damage = Depth-Charge-Parameter * Explosive

where Explosive is the explosive value of the depth charge and Depth-Charge-Parameter is a Damage Resolution Parameter Data Value. The actual damage is randomly calculated between 0 and this maximum value. This damage is applied to the submarine. However, if this damage is greater than 25% of the size of the submarine, the submarine is assumed to have sunk.

AAA Resolution

AAA shots are determined randomly about every 6 seconds by the program whenever enemy aircraft appear within range of the AAA. For a given ship or Target firing AAA at an enemy aircraft, the probability of a hit is given by:

Hit-Prob = logistical (AAA-Effect, Modifier)

where AAA-Effect is the AAA Effectiveness for the side of the firing entity

Modifier = AAA-Value * AAA-Fire * Status / 100

where AAA-Value is AAA value of the firing entity, Status is the percentage status value of the entity, AAA-Fire is a Parameter Value, and

logistical (prob, mod) = prob * mod / (prob * (mod – 1) + 1)

For large aircraft, the Modifier value is multiplied by 2. For High Flying aircraft, the Hit-Prob is divided by 10.

A AAA hit automatically causes a loss of one aircraft.

AAA Suppression

When an aircraft attacks a ship, there is a probability that the AAA, if any, on the ship will become suppressed for a variable amount of time. Given a load with a Penetration-Effect as described above and an Explosive value, the probably of suppression is given by:

Suppression-Prob = (1 – Penetration-Effect) * Supp * Explosive / 100

where Supp is the Bomb AAA Suppression Parameter Data Value. Thus high explosive loads with a lower penetration have a higher probability of causing suppression than armor piercing loads.

Example 1. (Midway) Suppose the CV Yorktown is hit by a 242kg HE bomb with an Explosive value of 532 and a Penetration Value of 0.5. The Penetration Effect is:

Penetration-Effect = 0.5 / 2 = 0.25

where 2 is the deck armor of the Yorktown. Thus the Suppression Prob is:

Suppression-Prob = 0.75 * 0.2 * 532 / 100 = 80%

Thus there would be an 80% chance of this bomb hit causing AAA Suppression.

Example 2. (Midway) A 250kg SAP bomb hitting the Yorktown with an Explosive value of 330 and a Penetration Value of 2.0 would result in:

Suppression-Prob = 0 * 0.2 * 330 / 100 = 0

and thus would have no AAA Suppression effect.

Dogfight Resolution

Two flights in the same location can engage in a dogfight resulting in damage to either flight. A dogfight resolution of one aircraft type T1 engaging a second aircraft type T2 is a symmetric calculation resulting in a probability of damage

to one flight or the other. It flight T1 has shots left, then the probability of the flight T2 being hit is given by:

Dogfight * Vulnerable * Training-Modifier

where Dogfight is the dogfight value of T1, Vulnerable is the vulnerable value of T2, both taken from the aircraft database, while Training-Modifier is given as:

Training-Modifier = Dogfight-Side-1 / Dogfight-Side-2

where Dogfight-Side-1 and Dogfight-Side-2 are the Dogfight Parameter Data Values of the respective sides. Each dogfight hit results in a loss of one aircraft to that flight.

Example 1 (Early War). Suppose an equal number of AGM2 Zeros with Dogfight Value of 0.5, Vulnerable Value of 0.4, and Dogfight Parameter Data of 1.0 and F4F Wildcats with Dogfight Value of 0.5, Vulnerable Value of 0.4, and Dogfight Parameter Data of 0.75 engage in a dogfight. In each iteration, the probability that a Zero will shoot down a Wildcat is:

Zero-Kill-Prob = 0.5 * 0.4 * 1.333 = 0.2666

The probability of a Wildcat shooting down a Zero is:

Wildcat-Kill-Prob = 0.5 * 0.4 * 0.75 = 0.15

Thus the kill ratio is 1 to 1.777 Zeros to Wildcats.

Example 2 (Middle War). Suppose an equal number of Wildcats with Dogfight Parameter Data of 1.0 attack a group of D3A Vals with Dogfight Value of 0.3, Vulnerable Value of 0.5, and Dogfight Parameter Data of 0.8. The probability that a Val will shoot down a Wildcat is:

Val-Kill-Prob = 0.3 * 0.4 * 0.8 = 0.096

The probability of a Wildcat shooting down a Val is:

Wildcat-Kill-Prob = 0.5 * 0.5 * 1.25 = 0.3125

Thus the kill ratio is 1 to 3.255 Wildcats to Vals.

Example 3 (Middle War). Suppose an equal number of Wildcats with values as before attack a group of B5N2 Kates with Dogfight Value of 0.2, Vulnerable Value of 0.6, and Dogfight Parameter Data of 0.8. The probability that a Kate will shoot down a Wildcat is:

Kate-Kill-Prob = 0.2 * 0.4 * 0.8 = 0.064

The probability of a Wildcat shooting down a Kate is:

Wildcat-Kill-Prob = 0.5 * 0.6 * 1.25 = 0.375

Thus the kill ratio is 1 to 5.86 Wildcats to Kates.

Example 4 (Late War). Suppose an equal number of AGM3 Zeros with Dogfight Value of 0.5, Vulnerable Value of 0.4, and Dogfight Parameter Data of 0.5 and F6F Hellcats with Dogfight Value of 0.6, Vulnerable Value of 0.4, and Dogfight Parameter Data of 1.0 engage in a dogfight. The probability that a Zero will shoot down a Hellcat is:

Zero-Kill-Prob = 0.5 * 0.4 * 0.5 = 0.1

The probability of a Hellcat shooting down a Zero is:

Hellcat-Kill-Prob = 0.6 * 0.4 * 2.0 = 0.48

Thus the kill ratio is 1 to 4.8 Hellcats to Zeros.

Strafing Resolution

When an aircraft attacks a ship or Target and has no load that can be used to attack the target but it does have non-zero Shots left and it has a Strafing capability, then it can strafe the target with the possibility of causing damage to it, causing damage to aircraft stored there, and possibly suppressing the AAA, in the case of a ship.

The damage that strafing causes is given by the **Strafing Damage** Parameter Data Value times the number of aircraft in the attacking flight. For large aircraft, the damage is halved. For strafing against submarines, semi-submersibles, and boats that are awash, the damage is halved.

When strafing a ship (or aircraft carrier) carrying aircraft or an air base, then there is a probability that the Spotted aircraft will be damaged by the strafing. The basic probability of strafing hitting an aircraft which is Spotted is given by the **Strafing Hit Probability** associated with the side of the attacking aircraft. This probability is applied to each Spotted aircraft for each attacking aircraft to determine if it is hit.

The probability that strafing will cause AAA suppression is given by the **Strafe AAA Suppress** Parameter Data Value. This probability is applied once for each aircraft in the attacking flight.

Example 1. A flight of 4 F4F Wildcats strafes the Japanese Destroyer Ushio with a Strafing Damage value of 5. The damage caused will be:

Damage = 4 * 5 = 20

Given a tonnage of 2090 for the Ushio this will result in a damage result of:

Effect = 20 / 2090 = 1%.

Example 2. A flight of 3 A6M2 Zeros strafes an American Target with a Strafing Damage value of 5. The damage caused will be:

Damage = 3 * 5 = 15

Given a size of 100 for the target, this will result in damage of:

Effect = 15 / 100^2 = 0.15%

Burning Resolution

The initiation and resolution of burning of aircraft carriers consists of two steps: initiation and continuation. A carrier has a Vulnerability Value V based on the total value of all aircraft on board the carrier as described in the section on Aircraft Carriers. Based on this value, a Vulnerability Factor is calculation according to the following:

- If V > 0.5, F = 1.0.
- If V < 0.25, F = 0.5.
- Otherwise, F = 3 * V – 0.25

Thus a Vulnerability Factor will range from 0.5 to 1 and vary linearly in the range 0.25 < V < 0.5. Note that when V < 0.25, the Hangar number of the carrier is green, when V > 0.5, the Hangar number is red, and that when 0.25 < V < 0.5, then the Hangar number is yellow.

When an aircraft carrier is attacked and suffers damage, there is a chance that burning will begin on the carrier. Given a carrier having suffered damage of D% and having a Vulnerability Factor of F, the probability that burning will be initiated is:

Prob = F * (D – 1) / 5

Once burning is deemed to begin, then a second calculation is made that determines how much damage the burning will eventually cause. Given a damage control value of C for the carrier with a damaged status value of S%, the burning damage is randomly calculated as being uniformly between the values:

High-Burning = (1 – C) * S * F * 1.5

Low-Burning = (1 – C) * S * F * 0.5

Thus the average burning damage is (1 – C) * S * F.

Burning proceeds using the Burning Rate Parameter Data Value until the status of the ship reaches that determined by the burning damage at which point the burning terminates.

Example 1. (Midway) Suppose the CV Akagi at 100% with a Vulnerability Factor of 1 is hit by a 1000lb GP bomb resulting in damage of 6%. The probability that burning will be initiated is:

Burning-Prob = 1 * 5 / 5 = 1

and thus the carrier will start burning. Using a Damage Control value of 0.2 (=20%), the burning damage calculations would be:

High-Burning = 0.8 * 94 * 1 * 1.5 = 112%

Low-Burning = 0.8 * 94 * 1 * 0.5 = 38%

Thus the average burning damage to Akagi is 75%. Using a Burning Parameter Data Value of 6 hours, the Akagi will burn from 94% to 19% over the next 4 ½ hours.

Example 2. (Midway) Suppose the CV Yorktown at 100% with a Vulnerability Factor of 0.50 is hit by a 250kg SAP bomb resulting in damage of 6%. The probability that burning will be initiated is:

Burning-Prob = 0.50 * 5 / 5 = 50%

and thus there is a 50% chance the carrier will start burning as a result of this hit. Using a Damage Control value of 0.8 (=80%), the burning damage calculation would be:

High-Burning = 0.2 * 94 * 0.50 * 1.5 = 14%

Low-Burning = 0.2 * 94 * 0.50 * 0.5 = 4.7%

Thus the average burning damage to the Yorktown is 9%. The Yorktown will burn from 94% to 85% over the next 30 minutes.

Example 3. (Midway) Suppose the CV Hiryu at 100% with a Vulnerability Factor of 0.5 is hit by three 1000lb GP bombs resulting in 54% damage. The probability that burning will be initiated from the hit is:

Burning-Prob = 0.5 * 53 / 5 > 1

and thus the carrier will start burning. Using a Damage Control value of 0.2 (=20%), the burning damage calculations would be:

High-Burning = 0.8 * 46 * 0.5 * 1.5 = 28%

Low-Burning = 0.8 * 46 * 0.5 * 0.5 = 9%

Thus the average burning damage to Hiryu is 18%. Using a Burning Parameter Data Value of 6 hours, the Hiryu will burn from 46% to 28% over the next 1 hour.

Example 4. (Coral Sea) Suppose the CV Shokaku at 100% with a Vulnerability Factor of 0.5 is hit by three 1000lb GP bombs resulting in 36% damage. The probability that burning will be initiated from the hit is:

Burning-Prob = 0.5 * 35 / 5 > 1

and thus the carrier will start burning. Using a Damage Control value of 0.2 (=20%), the burning damage calculations would be:

High-Burning = 0.8 * 64 * 0.5 * 1.5 = 38%

Low-Burning = 0.8 * 64 * 0.5 * 0.5 = 13%

Thus the average burning damage to Shokaku is 22%. Using a Burning Parameter Data Value of 6 hours, the Shokaku will burn from 64% to 42% over the next 1 ½ hours.

Summary Example 1. (Midway) In the attack by seven Val dive bombers on the CV Yorktown, there are hits by two 250kg SAP bombs and one 242kg HE bomb. The total average bomb damage would be 14% (=6+6+2) and the calculations show that burning is likely to occur resulting in another 9% of damage. At the conclusion of the burning, the status of the Yorktown would be 77%. Subsequent to this, there is an attack by seven Kate torpedo bombers resulting in two hits by Type 91 torpedoes, giving a total damage of 52% leaving the Yorktown at a status of 25%. Finally, the Yorktown is hit by two Type 95 torpedoes from the I-168 submarine, causing a total of 16% of torpedo damage with flooding resulting in the sinking of the Yorktown.

In the ratio 2 SAP bombs to 1 HE bomb and with the assumption that burning occurs, nominal bomb damage to the Yorktown will be an average of about 8% each bomb. Nominal torpedo damage from Type 91 torpedoes will be 26%, or about 3 times as damaging per hit. If the Yorktown is carrying airplanes with fuel and bombs, its vulnerability to bombing greatly increases because of the doubled burning damage. At these average damage values, it would take 4 torpedoes or 12 bombs to sink the Yorktown.

Summary Example 2. (Coral Sea) The CV Lexington is hit by perhaps three Type 91 torpedoes and four bombs. The average damage with flooding from the three torpedoes would be 52% and the damage with burning from the four bombs can be estimated as 22%, resulting in a final status value for the Lexington of 26%.

Summary Example 3. (Santa Cruz) The CV Hornet is hit by two 250kg SAP bombs and one 242kg HE Bomb dropped by Val dive bombers. Similar to the calculation for the Yorktown, this would result in a total of 14% damage leaving a status of 86%. During the same attack, the Hornet was hit by 2 Type 91 torpedoes resulting in an average of 52% damage. This would leave the Hornet at an average status of 34%. A later hit by another Type 91 torpedo

would cause an additional 26% damage leaving the Hornet at 8% status. With 9% burning caused by the bombs, the Hornet would sink.

Correlation with *Midway Inquest*

In the book *Midway Inquest*, by Dallas Isom, a War Game Exercise is given in Appendix D. The rules presented in that section include the following.

- In dogfights, one Zero would be lost for every one and one-half Wildcats shot down. In the previous Early War dogfight example, the ratio is 1 Zero to every 1.777 Wildcat.
- One-third of all bombs dropped by Val dive bombers on carriers are assumed to hit. In the Midway Yorktown bombing example given previously, the hit probability is 38%.
- One-fifth of all torpedoes fired by Kate torpedo bombers at carriers are assumed to hit. In the Yorktown torpedo hit examples given previously, the average value is 21%.
- A 250kg bomb dropped on a carrier is stated to cause 1 damage point. Assuming that the carriers in the book war game have a total of 10 damage points, not explicitly stated in the rules, this would translate into 10% damage. In the Yorktown bombing example given previously, the result is 8% on average.
- A torpedo hit on a carrier is stated to cause 3 damage points, or 30% damage again based on the assumption of 10 total damage points. In the Yorktown torpedo example previously given, the result is 26%.

Correlation with Naval War College Game Rules

In 1939, the Naval War College published hit and lethality numbers relative to submarine-fired torpedoes for use in their wargames. These values were revised with respect to hit probability and published in the 1944 editor of *Current Submarine Doctrine*. Using a Torpedo Damage Parameter of 4 (versus the value of 5 used in previous examples), the following correlation between the torpedo damage values and the Naval War College values can be determined based on the Mark 14 torpedo with a 643lb warhead. The tonnage values associated with each type of ship is not included in the Naval War College data but for this study, the following values are used: Battleship = 50,000, large carrier = 40,000, small carrier = 20,000, large cruiser = 13,000, medium cruiser = 10,000, small cruiser = 7,000, destroyer = 2,000, submarine = 1,500. Note: very similar results can be obtained by using the original 507lb warhead of the Mark 14 together with a Torpedo Damage Parameter of 5.

Hits Required to Sink the Ship

Type of Ship	1939 Naval War College	Naval Campaigns
Battleship	7.0	6.5
Large carrier	5.0	5.2
Small carrier	2.7	2.6
Large cruiser	1.5	1.7
Medium cruiser	1.3	1.3
Small cruiser	1.0	0.9
Destroyer	0.5	0.3
Submarine	0.3	0.2

Correlation with Humphrey

In 1992, Richard Humphrey published a study of ordnance required to sink ships of various tonnage. The results were for a 3,000 ton ship, a 15,000 ton ship, and a 45,000 ton ship using 1000lb bombs and 21in torpedoes. In this comparison, a 1000lb bomb is assumed to cause an average of 3600 tons of damage using an Air vs Ship Fire Parameter value of 8 and each result is normalized using the normalized size calculation used in the hit probability calculation above. For example, for the 3,000 ton ship the calculation is:

3000/3600 * (45000/3000)^0.5 = 3.2

1,000 lb Bomb Ordnance to Sink a Warship

Displacement	Humphrey	Naval Campaigns
3,000	4.0	3.2 (80%)
15,000	9.0	7.2 (80%)
45,000	15.5	12.5 (81%)

Note that there would be exact agreement if an Air vs. Ship Fire parameter value of 10 was used.

In the next set of calculations, torpedo damage is calculated using a 21in torpedo with a warhead of 507lb and a Torpedo Damage Parameter of 5. This results in an average damage per hit of 6337 tons. The results are normalized using the cube root size and normalized speed hit probability calculations above. For example, for the 3,000 ton ship moving at 30 kts (normalized relative to a 20 kt ship), the calculation is:

3000/6337 * (45000/3000)^0.333 * (35/25) = 1.7

21in Torpedo Ordnance to Sink a Warship

Displacement	Humphrey	Naval Campaigns
3,000	1.6	1.7
15,000	3.5	4.0
45,000	6.1	7.1

Standard Hull Classifications

Below is a fairly complete list of the standard hull classifications as used in Naval Campaigns:

- **ACM** - Auxiliary Minelayer.
- **AD** - Destroyer Tender.
- **AE** - Ammunition Ship.
- **AG** - Misc Auxilliary.
- **AGS** - Surveying Ship.
- **AH** - Hospital Ship.
- **AK** - Cargo Ship.
- **AKL** - Light Cargo Ship.
- **AKS** - Stores Issue Ship.
- **AM** - Minesweeper.
- **AMC** - Coastal Minesweeper.
- **AN** - Net Layer.
- **AO** - Fleet Oiler.
- **AOG** - Gasoline Tanker.
- **AP** - Transport.
- **AR** - Repair Ship.
- **ARC** - Cable Repair Ship.
- **AS** - Submarine Tender.
- **ASR** - Submarine Rescue Ship.
- **AT** - Ocean Tug.
- **AV** - Seaplane Tender.
- **AVD** - Seaplane Tender (DD).
- **AVP** - Small Seaplane Tender.
- **AVT** - Auxiliary Aircraft Transport.
- **AW** - Distilling Ship.
- **B** – Old Battleship.
- **BB** – Battleship.
- **BC** – Battlecruiser
- **CA** – Armored Cruiser.

- **CGC** - Coast Guard Cutter.
- **CL** – Light Cruiser.
- **CLAA** - Antiaircraft Cruiser.
- **CM** - Minelayer.
- **CMC** - Coastal Minelayer.
- **CMN** - Mine and Net Layer.
- **CV** – Aircraft Carrier.
- **CVL** - Light Carrier.
- **CVE** - Escort Aircraft Carrier.
- **CX** - Armed Merchant Ship.
- **D** - Old Destroyer
- **DD** – Destroyer.
- **DE** - Destroyer Escort.
- **DM** - Destroyer Minelayer.
- **DMS** - Destroyer Minesweeper.
- **FC** - Fast Attack Boat.
- **FF** - Frigate.
- **K** - Corvette.
- **MT** - Manned Torpedo.
- **MV** - Merchant Carrier.
- **PB** - Patrol Boat.
- **PC** - Submarine Chaser or Patrol Craft.
- **PF** - Patrol Frigate.
- **PG** - Patrol Gunboat.
- **PGM** - Gunboat Minelayer.
- **S** - Old Submarine.
- **SL** - Sloop.
- **SS** – Submarine.
- **SSC** - Coastal Submarine.
- **SSM** - Midget Submarine.
- **SSV** - Special Service Vessel
- **TB** – Torpedo Boat.
- **YTB** - Ferry.

Credits

Developer: John Tiller

Artist: Joseph Amoral

Additional Graphics: Julia Tiller

Music: Thomas Hook

Additional A/I Programming: Dr. John Rushing and Dr. Cara Gall, University of Alabama-Huntsville

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Midway

Game Coordinator: Rich Hamilton

Scenario Designers: Gary McClellan, John Tiller, Pat Covich

Playtesters: Mike Cox, Dennis Suttman, George Miller, Mark Brien, Craig Forrest.

Guadalcanal Naval Battles

Research and Scenario Design: John Tiller

Overview Document: Robert Mayer

Playtesters: Lee Elmendorf, Mark Adams, Kevin Campbell, Robert Mayer, Greg Smith.

Tsushima

Research and Scenario Design: John Tiller

Playtesters: Robert Mayer, Mark Adams, Greg Smith, and Kevin Campbell.

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Jutland

Research and Scenario Design: John Tiller

Playtesters: Robert Mayer, Mark Adams, Greg Smith, and Kevin Campbell.

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