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ELEMENTS OF NAVAL DOMAIN KNOWLEDGE. A FIRST STEP IN THE MANUAL --ETC(U)
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ELEMENTS OF NAVAL DOMAIN KNOWLEDGE

A first step in the manual knowledge acquisition process required by large artificial intelligence systems

RJ Bechtel

7 July 1981

Interim Report for Period 1 October 1980—30 April 1981

Prepared for
Naval Electronic Systems Command
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METRIC CONVERSION

To convert from	to	Multiply by
inches	mm	25.4
feet	m	$\sim 3.05 \times 10^{-1}$
yards	m	$\sim 9.14 \times 10^{-1}$
statute miles	km	~ 1.61
nautical miles (nmi)	km	~ 1.85
knots	m/s	$\sim 5.14 \times 10^{-1}$

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The collection of a large amount of information in and about the Navy domain. While directed at the particular problem of mission planning, this report generalizes to serve as a first step in the manual knowledge acquisition process for new workers in the domain. It contains examples that can be used in examining various existing and proposed knowledge representation systems. This report is intended as a living document, subject to update and correction.

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OBJECTIVE

Collect in one location a large amount of information in and about the Navy domain, directed at the particular problem of mission planning but general enough to serve as a first step in the manual knowledge acquisition process for new workers in the domain. Include domain examples to illustrate properties that a representation for naval knowledge must have.

RESULTS

1. A collection of static declarative knowledge is presented -- facts that do not change significantly over time.

2. An attempt was made to spell out the actions available in the domain and their effect on the state of the world. Such "procedural" knowledge is the weakest part of the report.

3. The attempt to describe naval knowledge in a way that is relatively independent of application and representation has perhaps interfered with the success of the effort more than was anticipated, since knowledge is difficult (if not impossible) to separate from use.

4. The report provides a base set of concepts that are required in the naval domain, to be used in the evaluation of various available knowledge representation systems.

RECOMMENDATIONS

1. Consider this report as a living document, subject to update and correction.

2. Use this report in evaluating various available knowledge representation systems.

3. Involve the designers and implementors of candidate representation systems in the evaluation process, since they are the true experts in the capabilities, strengths, and weaknesses of their own systems.

4. Solicit this involvement informally by providing copies of the report to system developers along with requests for evaluations of the appropriateness of their systems to the representation of the knowledge in the report.

CONTENTS

1. INTRODUCTION

Purpose

This is an effort to collect in one location a large amount of information in and about the Navy domain. It has become obvious that large artificial intelligence systems require considerable domain knowledge to perform interesting tasks competently. This has made the automated acquisition of knowledge an area of intense interest and research, since current techniques for collecting information form an enormous bottleneck. This report, while directed at the particular problem of mission planning, attempts to be general enough to serve as a first step in the manual knowledge acquisition process for new workers in the domain.

The immediate application of this information is as a collection of examples to be used in examining various existing and proposed knowledge representation systems. By attempting to embed the kinds of information in this report into particular knowledge representation systems, it is hoped that the strengths and weaknesses of those systems will be revealed. The intent was to include domain examples which would illustrate properties that a representation for naval knowledge must have and which (by their absence) would identify those representation issues which do not seem to arise in this domain. Because the report is not exhaustive, the examples are useful more in showing the properties that are necessary than those guaranteed to be unimportant.

Approach

The information in this report has been assembled by the "proxy expert" method. The author has consulted standard reference works, operational personnel, and planning experts to collect the information and to become an available "proxy" for the actual experts. The following important caveats attach to this approach:

- the knowledge is "book-learning," not based on actual experience

- the acquisition process has been somewhat hurried, leaving little time for thought about and discovery of subtleties

- the acquisition process is incomplete - there is much more to be learned.

Prior Biases

To an unknown extent, familiarity with some existing knowledge representation systems has flavored perception of the domain. For example, hierarchies are everywhere, though few of them are clean. There may be "primitive" actions. We are concerned about the dynamics of retrieval, update, and deletion as well as static properties of a representation. These preconceptions hopefully have not perverted the domain analysis, but readers are warned that they exist.

Organization

Everything in any interesting domain is deeply intertwined. An ideal way to present this information would be to embed it in some knowledge representation system, but that would defeat the attempt to remain representation independent. The printed page is all too linear, so some structure has been imposed on this report which may not be there in the domain. The categories chosen can be seen in the table of contents, but material is placed where discussion seems most natural, rather than (necessarily) in the "proper" place.

2. OBJECTS

2.1 Ships, Subs, and Aircraft

An interesting type of object is the CONVEYANCE, which is a physical object whose purpose is to move from place to place and to carry other objects (this term due to Ethan Scarl of MITRE, the specific definition my own). Anything on a conveyance goes wherever the conveyance goes. In the naval domain, some conveyances are of special interest, specifically SHIPS, SUBS, PLANES, and HELOS.

What's actually out there in the world are many instances (individuals) of these conveyances - however, they don't relate directly to CONVEYANCE. There are some subclasses of ship, organized along functional lines. These subclasses include:

- Passenger liners

- Aircraft carriers

- Patrol

- Fishing

- Cargo

- Ocean escort

- etc.

These subcategories may be further partitioned, still by function. For example, cargo ships could be container ships, tankers, conventional merchant craft, or something else. The two levels of functional partitioning may be distinguished or combined. The functional specification of a ship is its TYPE.

In the military realm, every ship is an instance of a CLASS, which is a subclass of a TYPE of ship, which is a subclass of SHIP, which is a subclass of CONVEYANCE, specialized for travel on the surface of water and larger than some arbitrary measure. A related subclass of conveyances, BOAT, is made up of SUBs and surface craft too small to be called ships.

Each individual (instantiated) ship has certain associated items or properties:

1. A commander

2. A name

3. A hull number

4. A weapons suite

5. A sensor suite

6. A communications suite

7. A current location

8. A current course

9. A current speed

10. A current fuel level

11. A class

12. An ID

13. A flag

14. A home port

15. A current readiness

16. A current ammunition store

17. A radio call sign

Additional properties are helpful when the ship is in transit (and some of the above are nonsensical or unimportant when not in transit):

1. A source, or starting point

2. A destination, or location goal

3. A speed goal (when changing speed)

4. A course goal (when changing course)

5. A track

Most (though not all) ships can also be located administratively, by identifying (the lowest of)

- Current fleet assignment

- Current task force assignment

- Current task group assignment

- Current task unit assignment

These follow "standard" subset membership - i.e. identifying the task unit identifies the task group, which identifies the task force, which identifies the fleet.

Most of the information about ships that is commonly considered interesting is associated with the ship classes. Ships in a class inherit these items (fields, slots, facets, properties) from their class, unless specifically overridden at the individual ship level:

1. Maximum speed
2. Cruise speed
3. Agility
4. Acceleration
5. Deceleration
6. Fuel capacity
7. Type
8. Length
9. Width (beam)
10. Draft
11. Height
12. Profile
13. Displacement (size)
14. ID amplification

As noted above, every class has a TYPE, which is the next step-up in a hierarchical organization (between class and ship). Little is stored at the type level, in terms of physical state knowledge. However, it is at the type level that missions and mission roles are stored (though the precise association mechanism is not clear). Thus, because a particular platform is an aircraft carrier, we expect to find it doing certain things and not doing other things which are associated with other types of craft.

SUBS are like ships - they have subclasses of TYPE, CLASS, and individual submarines. However, individual submarines have CURRENT DEPTH, which ships don't.

PLANES are like ships, except that they have an ALTITUDE, a PILOT, a SQUADRON, and a HOME SHIP. PLANES do not have DRAFT, DISPLACEMENT, or NAME. Planes also have types and classes, and have TAIL NUMBERS in place of HULL NUMBERS.

Ships have some size, usually expressed in terms of displacement (in tons). Being self-propelled, they have a particular kind of fuel (fuel oil, nuclear, gasoline??). Speed and fuel consumption rate are related. There is some optimal consumption/progress tradeoff point which is designated the cruise speed (this may also consider the effects of strain, etc.).

Ships carry weapons, sensors, provisions, and people. Being physical objects, they are subject to deterioration and destruction, the first being a slow process that is combatted by doing maintenance, the second a state that results from lack of maintenance over a long period of time or from application of (enemy) weapons. Repair may be possible in the case of destruction. Maintenance may include, in some cases, repair.

2.2 Suites

Strictly speaking, suites are not physical objects, but abstract objects which are collections of physical objects. Thus, one speaks of the sensor suite of a ship when talking about all of the sensors on that ship. Suites are commonly defined at the CLASS level, though individual ships (planes, subs) may not strictly inherit the class suite but may have additions, deletions, and replacements. The various SUITES are alike in having COMPONENTS and OWNERS. In fact, the only ways to distinguish one type of suite from another are to look at its components or at the role that the suite plays. Typically, however, the suites are distinguished by an associated label. The members of a sensor suite are sensors; of a weapons suite weapons; and of a communications suite, communications units.

For some purposes, the various suites may be divided into "subsuites." For example, one may wish to refer to the RADAR SUITE of a particular ship or class of ships, or the ASW WEAPONS SUITE of a ship. This suggests that a suite is a dynamically created entity, formed when required by collecting its members (objects which satisfy its description). Suites are a form of derived information, recoverable from knowledge of what physical objects are carried on a conveyance.

Occasionally, the word "complement" is used instead of "suite," as in "sensor complement."

WEAPONS, SENSORS, and COMMUNICATION UNITS are alike in that they do not all have names but do have pointers to the (SENSOR, WEAPON, or COMMUNICATION-UNIT) class they are individual members of. They also have a back-pointer to the suite they are part of, and a slot that is filled with their status.

2.3 Weapons

WEAPON-CLASSes have

1. Type
2. Maximum range
3. Range at which there is a 50% probability of hitting
4. Probability of a hit at maximum range
5. Accuracy
6. Rate of fire (maximum - typically in rounds per unit time)
7. Ammunition (an ammunition type, which will be of some ammunition class)
8. Payload - the destructive capability of the ammunition
9. Name

There may be slots for ASSOCIATED SENSOR (as in a particular fire control radar - which would then need a similar pointer under the radar) and to indicate what kinds of targets the weapon is EFFECTIVE AGAINST. A weapon may be effective against more than one target. In some cases, the effective target classes will depend on the type of ammunition which is used in a particular firing.

2.4 Sensors

Sensors come in two varieties: active and passive. Most sensors work by detecting electromagnetic or acoustic (EMOA) events. Active sensors, in general, initiate the events that they detect. Active sensors have two advantages over passive sensors:

1. It is possible to detect objects which are not initiating EMOA events
2. The quality of information acquired can be much higher.

For these advantages there is a corresponding disadvantage which is that any object detected by active means, if properly equipped, can detect the user of the active sensor by using passive methods.

All sensors have parameters which describe their utility. These are (for all sensors):

- maximum range
- probability that an object at maximum range will be detected
- range at which there is a 50% probability of detecting an object.

Additionally, all sensors have some associated error factor which must be considered in evaluating the information they provide. Most sensors will occasionally give false reports and fail to report existing objects.

2.4.1 Radar

Radar units work by emitting microwave radiation and detecting the reflection of such emissions from objects. The emission is modulated in a way that makes it possible to determine the time lapse between transmission and reception. Since the speed of the emission is known, the time lapse can be converted to a distance (range). The direction of the object is also available. In some cases, it may be possible to infer (say from signal strength) the size of the detected object.

Every radar has certain characteristics associated with its emissions. These include

- carrier frequency
- pulse width
- pulse frequency
- pulse interval
- scan index (type)
- scan rate

Radars are also subject, on occasion, to a phenomenon known as "ducting," in which the detection range is greatly extended. Ordinarily, radar is limited to line of sight (LOS).

Particular radars are used for particular applications. Some radars are used for navigation, some for detection of aircraft, and some for fire control.

Information from a given radar is available on whatever carries it and to anyone to whom it is communicated.

2.4.2 Active Sonar

Active sonar is roughly the underwater acoustic equivalent of radar. Sound waves are generated, and the time between transmission and receipt of reflection gives distance. Direction is also available. Utility parameters are like those of radar. Emission characteristics are:

- carrier frequency
- pulse width

Information availability is like radar.

Since sonar relies on detecting possibly faint acoustic waves transmitted through water, performance of sonar degrades as the object carrying the sonar moves faster. The rate of degradation is an additional utility factor for sonar. Above some speed, sonar is worthless. The speed of sound in water also varies as a function of temperature, so sonar ranges can be affected by currents and thermoclines. Sonar can also be subject to ducting and interference from echoes from the bottom of the ocean.

2.4.3 Passive Sonar

Passive sonar is just the receiver portion of an active sonar. It can give direction information on receipt of a signal; but not knowing when the signal was sent, distance is unavailable. Some versions can also provide a description of the detected emission's characteristics. Since passive sonar detects direct emissions rather than reflections, it is effective over a longer range than active sonar. Passive sonar can also be affected by temperature gradients, particularly when they act as reflectors or sharp refractors.

2.4.4 ESM Receivers

Like passive sonar, an ESM receiver is the receiving side of a radar (though not necessary only that). It detects electromagnetic emissions in certain ranges of the spectrum and can give bearing and sometimes signal strength and other characteristics. As with passive sonar, its range is greater than that of its active counterpart, radar.

2.4.5 Infrared

Infrared sensors detect emissions in the electromagnetic spectrum just below those of visible light. Such emissions are typically associated with heat sources, such as jet or rocket engines or submarine power plants.

2.4.6 Vision

The human eye is an amazing sensor. While its range is limited to LOS and it is subject to environmental effects like fog, it remains a source of incredibly detailed information once a detection is possible. Range and bearing are available (though precision requires augmentation), and further information, such as class, flag, number, and the like, can also be acquired. As with all preceding sensors, this information is available on whatever is carrying the sensor, and to whomever it is communicated.

2.4.7 Other Sensors

The preceding sensors are all likely to be carried aboard ships, subs, and planes. Some other sensors are not carried on board (are not organic), and so their information is available only through communications links to be discussed later. However, though the information comes to most users through a communications link, the systems themselves are sensors and should be discussed here.

2.4.7.1 Satellites

Surveillance satellites detect a number of things, usually occurrences in the electromagnetic spectrum. Picture taking is another possibility. Satellite detections are available from ground stations, where the detections are usually processed before being passed on. Examples of satellite data are weather reports, identification of platforms, and flashes of light.

2.4.7.2 Intelligence Information

While not commonly considered a sensor, intelligence information performs that function - originating information. The range and complexity of intelligence information is too great to deal with here.

2.5 Communications Links

Every ship, plane, sub, and base (hereafter all called platforms) has a number of transmitters and receivers which are used to establish communications links with other platforms.

A communications link is of one of four types:

1. clear voice
2. secure voice
3. TTY
4. data

(TTY is a special format imposed which is different from DATA.) Additionally, every communications link has some required bandwidth. It may have a general spectrum allocation like UHF. These are properties of "disembodied" communications links. A communications link may be "embodied" by assigning a frequency and a transmitter/receiver pair to a disembodied link. All of the usual half-duplex problems exist in that transmitting on a frequency which is already in use (by someone else) results in garbage at all receivers tuned to that frequency. Strictly speaking, it is not necessary to have both a transmitter and receiver assigned at both ends of the link, but having only one transmitter and receiver implies one-way communication.

Transmitters have an upper and lower bound on the frequency which they can transmit. They also have a modulation method, which we may wish to ignore for current purposes. There is presumably some limit on the number of transmitters on any one platform and thus on the number of simultaneous active links, but this may also be ignored at present.

Receivers have upper and lower bounds and demodulation methods analogous to those of transmitters. Limits on the total number of receiver links also exist and may be ignored for now.

The observant reader will have noticed that sensors are a special case of communication links.

Once a communication link is embodied, information may be transmitted over it. What follows is an attempt to categorize the information that comes over links, and the links that that information traverses are listed with the information.

Communication links (and sensors) are sometimes categorized by their range. Equipment limited to a local horizon (usually because of frequency) is referred to as line of sight or LOS. Some equipment can communicate or detect beyond the local horizon, or beyond line of sight (BLOS). In the case of ducting, radar -- which is normally LOS -- can become BLOS. A third category includes systems which rely on methods like relays to extend the line of sight and thus are called ELOS.

2.5.1 Location and Other State Information

Location of objects is a critical form of information that is frequently passed along. Many US ships are equipped with a system called NTDS (Navy Tactical Data System), which allows participating ships to automatically share information about their own location and the location of objects detected by their organic sensors (especially air detections). The disembodied communication links necessary to support NTDS are called LINK 11. Similar but lower speed links called LINK 14 are also used to communicate this type of information. Aircraft can also access a version of NTDS through a disembodied link called LINK 4. Use of LINK 11 requires that some transmitter/receiver pair (called a node) be designated Net Control Station.

Location information can vary widely in quality. Precise location information (a single point in 3-space) is hard to come by. Even the best sensors, like on-board radar, have sufficient error that they are not completely precise. Passive sensors typically give bearing-only (direction) information, which only locates the detected object on some (possibly long) line. External sensors and processed detections are generally even worse, giving location as within an ellipse specified by major- and minor-axis length and major-axis bearing.

Along with location information, identification and status information can be passed. For example, a message might identify some previously unknown detected object as a hostile submarine. Another message might say that a piece of equipment is not working.

2.5.2 Other Information

In addition to the "state" type information described above, information about actions, intentions, missions, plans, and tactics may be sent over various communications links.

2.6 Countermeasures

Countermeasures are steps taken to interfere with the enemy's ability to detect, locate, and identify our forces. Since the enemy capabilities rest on sensors and communication links, countermeasures focus on reducing their utility.

Broadly speaking, there are four categories of countermeasures:

1. Preventing detectable emissions or reflections.
2. Raising the noise level of the environment to match or exceed the signal level.
3. Creating decoys which either emit or reflect as a true target would.
4. Modifying emissions or reflections to be those characteristic of something else.

The simplest (conceptually) of these is preventing emissions and reflections. Passive sensors rely on the detection of energy in some portion of the spectrum. By reducing or eliminating such detectable emissions, an object can remain undetected. This leads to standard doctrine like emissions control (EMCON), radio silence, and even design criteria like the reduction of noise created by nuclear power plants. This "nonradiating" countermeasure is obviously a passive measure and, as such, is less effective against active sensors which detect reflected energy. Passive countermeasures can be used here as well, as in coatings which absorb energy in certain bands, but imposition of a countermeasure is not as dynamic a tool as, for example, EMCON. The nonradiating method is useless against enemy communication links.

Raising the noise level of the environment is the method used in the most familiar countermeasures: jamming and chaff. The utility of a particular sensor depends on its ability to distinguish "interesting" or significant signals from a background of noise. By raising the noise level either actively, by jamming on a sensor's frequency, or passively, by uniformly reflecting an active sensor's emission, it is possible to "hide" an object in an area where the sensor is blind. The effect is like blinding a person by shining a bright light in his eyes. Jamming, since it is an active technique, can also be used to disrupt communication links.

Using decoys decreases the utility of sensors by reducing the uniqueness of "interesting" detections. Often, the intent is to overload the enemy response capability by forcing the commitment of resources to deal with decoys as though they were real threats. Decoys in communication include artificially enhanced message traffic, which can create an illusion of real activity.

Modifying distinguishing characteristics is a technique as old as the wolf in sheep's clothing. The basic ploy is to appear to be something other than what you really are. (Obviously, decoys must have their distinguishing characteristics modified to be successful.) Steps to accomplish this vary from painting out a hull number to broadcasting with captured enemy equipment.

All countermeasures, like all other actions, have both advantages and disadvantages. The advantages are (hopefully) a decrease in enemy capabilities. The disadvantages depend on the technique used but can range from an inability to communicate (in EMCON) to accidental destruction by own forces when a disguise is too successful.

2.7 Weather

Weather can play a major role in naval operations. The primary considerations are the effects that poor weather has on ordinary actions. When the sea state (a measure of "roughness") rises, it is more difficult to move in certain directions. Heavy seas can also place extreme stress on ships, threatening to damage or destroy them. Violent movement of a ship can incapacitate personnel, making it impossible for them to carry out assigned duties. Objects not securely fastened down (including people) can be swept off the deck.

Above the surface, cloud cover and precipitation can reduce the effective range of sensors, can ground aircraft, and can interfere with communications.

The benefit of being in an area of bad weather is the reduced likelihood of detection. Balanced against this must be the additional burden of insuring ship safety and survival in a hostile environment. For this reason, most planning will avoid all but the mildest of storms wherever possible.

Weather reports and predictions are available from land-based stations, but the accuracy of predictions decreases with their extent, just as on land.

3. ABSTRACT OBJECTS

3.1 Measurements and Units

Speed is expressed (as always) as distance per time. The Navy has a special name for the unit equivalent to one nautical mile per hour: this is the "knot."

Time is the usual hours, minutes, and seconds, and may be either elapsed or absolute with respect to some specified time zone (e.g. Greenwich). Days are possibly dropped, possibly included. Days also may be counted in elapsed time from some distinguishing point. Standard calendar notation is also used.

Distance is in yards and nautical miles. A nautical mile is (by definition) one minute of arc at the earth's surface. Thus, the earth (being 360 degrees around, and each degree having 60 minutes) is 21600 nautical miles in circumference. Further, for working purposes, each nautical mile is 2000 yards. A nautical mile is actually 6076.1 feet, or 1.15 statute miles.

Acceleration and deceleration are speed changes per time.

Position is indicated in spherical latitude/longitude coordinates. Latitude 0 is the equator, and latitudes increase going toward the poles, reaching 90 at the poles. The distance between two latitudes is constant. Longitude lines run north and south, intersecting both poles (and all other longitude lines). Lines of longitude are great circles, while lines of latitude are not. Longitude is measured with respect to an arbitrary point, which, for the US Navy, is Greenwich, England.

Latitude and longitude are labelled with some flexible conventions. Latitude is usually expressed in terms of north and south, as in 35N, 67S. Occasionally (especially in computer applications) a sign is used in some conventional way. North latitudes are positive, and south negative. Thus the earlier examples would become 35 and -67. Longitude could be expressed as 0 through 360, but is more often divided into two 180-degree segments. These are labelled east and west, as in 35E and 52W. As with latitude, sign may be used in place of the letter label. Notice that this creates an anomaly at 180. 179 and -179 are only 2 degrees apart, not 358. Elaborate testing is sometimes required to allow for this. (Similar testing may be needed for paths crossing the poles where latitude is concerned.) Conventionally, east is positive and west negative (remember this is all with respect to Greenwich).

Since lines of longitude intersect at the poles, they are obviously not a constant distance apart. The "one degree equals 60 miles" rule is only strictly true for longitude at the equator, though the fact that the change is as the cosine makes the estimation relatively good for a fair distance on either side.

When written together, position values appear in the order latitude, longitude, usually separated by a comma.

While latitude and longitude are given in degrees, there are (at least) two ways to give fractions of a degree. The traditional method is minutes and seconds, where one minute is one-sixtieth of a degree, and one second is one-sixtieth of a minute (one thirty-six-hundredth of a degree). However, the fractional parts of degrees may also be expressed in decimal notation as tenths, hundredths, etc. One convention that I'm familiar with uses a decimal point to separate the parts when using decimal notation, and a dash when using minutes and seconds.

Direction is also indicated in degrees, ranging from 0 to 360 (overlap), and is measured clockwise from due north. Occasionally, course (direction) will be indicated in degrees with a letter appended, as in 143T. The possible letters and their meanings are:

- T - true (with respect to true north)
- M - magnetic (with respect to the magnetic pole)
- R - relative to some fixed point (which must be given)

Now that there are some standards for direction, we can give some units to the maneuverability property mentioned earlier. Maneuverability is measured in degrees (change in course) per time.

For surface ships, altitude and depth are not a real problem - everything is at sea level. However, airplanes are concerned with altitude, which is expressed in feet (or thousands of feet). Depth, a concern for subs, is also expressed in feet, though there is also the fathom, which is six feet.

Now that we've described some of the nautical measurements, let's give some examples and typical values. A nautical mile is (roughly) 1.15 statute (land) miles.

Cruising speeds for ships range from around 10 knots (for merchants and fishing vessels) to about 20 knots for combatants.

Maximum speeds run from 10-15 to above 30 knots for ships. An interesting problem in configuring ship groups for cruising is that different ships (typically by class) have different optimal cruise speeds, and what may be optimal for one ship is wasteful for another, and vice versa.

We assume that ships are all located at some lat-lon pair at any given time. Further, ships can change their position over time (assuming that some constraints, like fuel and working engines, are met). We may know how quickly these changes can occur and, further, how quickly changes in the changes (maneuvers, speed changes) can take place.

3.2 Organizational Structure

For the most part, organization in the Navy is hierarchical. Operational units (of surface ships) are structured in FLEETS. Every surface ship is part of (is assigned to) some fleet. Fleets have responsibility for designated parts of the world. For example, the U.S. Sixth Fleet operates in the Mediterranean. Every fleet has a commander. Fleets are enormous entities, and are not usually operated as a single unit.

Below the fleet in the operational hierarchy is the TASK FORCE, a subset of the fleet assigned to carry out a particular mission. Task forces and lower levels of organization are dynamically allocated as opposed to fleets, which are essentially static entities. (The makeup of a fleet may change, as ships are added and subtracted, but the fleet itself continues to exist.) Upon creation of a task force for a particular mission, the fleet commander assigns certain ships to the force, names a commander of the force, and assigns a force name. Force names are created by concatenating a unique numeric identifier to the fleet number. Thus, the Seventh Fleet could have task forces 71, 72, 75, and so forth. (These would be referred to as TF71, TF72, and TF75.) The commander of a task force is referred to as CTF, as in CTF72. While the fleet commander is still technically in command of the force, operational command is assumed by the task force commander, acting in accordance with the orders he received that placed him in command of the force.

Task forces may be further divided, at the option of the force commander, into task groups. Task groups are created to carry out an aspect of the task force mission. For example, in many operations there may be logistics ships which are part of the task force but which are collected into a distinct logistics support group to perform the logistics support function. Task groups have member ships, a commander (CTG), and a number formed by appending a period and unique numeral to the task force designator. The term "task group" is abbreviated TG, so a typical designator would be TG75.1. Traditionally, the task group which performs the "central" task of a mission is given the ".1" designator.

If necessary, there is a further subdivision available, called a task unit. Task units are numbered by appending a period and unique numeral to the task group identifier. Like all other organizational units, task units have a commander, some component craft, and a designator. Task units (TUs) will usually consist of one to three ships.

Generally, organizational entities have a lifetime related to their position in the hierarchy. Fleets, being at the top, are effectively immortal. Task forces will often remain organizationally intact for long periods of time, though like fleets, their components may change. Task groups will vary from mission to mission, and task units can be created and deactivated very quickly, as in a TU formed to investigate a possible submarine contact, which dissolves when the investigation is over.

Organizational entities can be specified for future creation. Many orders describe task groups and units with the proviso "when formed." This is a technique which allows the mechanisms of subgroup command to be established in advance so that time need not be lost nor confusion created when a new entity is formed.

Determining who is assigned as commander of what organizational entity is a complex problem. I won't deal with it here, but I am investigating and may include the information in a future supplement.

Submarines operate under somewhat different rules. Unlike surface craft, they are not assigned directly to task forces. Instead, they are controlled by the Submarine Operating Authority. If a force commander wishes to include submarines as a part of his organizational structure, he must submit his planned use of those subs to the SubOpAuth for approval. Alternatively, he can request coordinated action by SubOpAuth, but this places the submarines outside the CTF's chain of command.

Aircraft (both planes and helicopters) also have different organizational structures. For our present purposes, we will assume that aircraft are under the command of the ship that carries them, though there may be other considerations.

3.3 Navy Missions

On the largest scale, the US Navy has four defined missions:

1. Strategic deterrence
2. Sea control
3. Projection of power
4. Naval presence

Each of these missions has tactics which can be used in accomplishing the mission. The tactics themselves are fairly high-level but provide the basis for missions that are assigned to operational forces.

3.3.1 Strategic Deterrence

The strategic deterrence mission of the Navy is handled primarily through the use of ballistic-missile-equipped submarines. The known capabilities of these submarines coupled with the inability of other countries to pinpoint their location serve to implement the four tactics for achievement of the strategic deterrence mission:

- Assured second strike
- Controlled response
- Deterrence of third powers
- Maintenance of a balance of power image

3.3.2 Sea Control

The sea control mission (control of a limited portion of the sea for a limited time) is typically accomplished by utilizing one or more of the following tactics:

- Sortie control - preventing enemy forces from leaving a designated area, usually a harbor. The traditional method is a blockade.
- Chokepoint control - preventing enemy forces from passing through a specified area, such as a strait.

- Open area operations - seeking out and neutralizing enemy threats, usually at a distance in the open ocean. One consideration that dictates this tactic is a lack of current contact with the enemy.

- Local engagement - closing to within weapons range before attempting engagement. Often this will be further constrained so that the enemy is on the offensive, with own forces hopefully controlling the circumstances of engagement and being prepared for defense.

Deception and intimidation are also possible tactics for use in the sea control mission. To realize these tactics, it is necessary to assign more specific missions to operational commands. For example, to implement the chokepoint control tactic for achieving control over an area of ocean, it is necessary to assign the mission of preventing passage through the chokepoints.

Each of these tactics, when particularized and assigned as a mission to some command, has recognized methods for its implementation. The commander's selection among the available methods will vary with circumstances and may include methods that are commonly considered part of other mission areas. For example, in carrying out a chokepoint control mission, amphibious forces may be used to establish control of land areas around the chokepoint to assist in preventing passage through the chokepoint. Even though amphibious assault is a tactic for projecting power ashore, in this case it serves the goal of sea control.

Selecting forces for the sea control mission will be affected by the tactic chosen and the type of forces expected in opposition. The following table summarizes the utility of various types of forces in the available sea control tactics:

Force	Sortie Control	Chokepoint Control	Open Area Operations	Local Engagement
Submarines	X	X	X	X
ASW Aircraft		X	X	X
Fighter Aircraft		X		X
Attack Aircraft	X	X		
Mines	X	X		
Escort Ships	X	X	X	X

(Table taken from [1])

Information taken from the table must be tempered with knowledge of the opposition forces. For example, both attack and fighter aircraft can be quite useful in chokepoint operations, but their utility is primarily against surface and air craft and less against submarines. Similarly, submarines are generally useful but not against air threats.

3.3.3 Projection of Power

Projection of power involves delivery of force to on-shore positions. There are three common tactics:

1. Amphibious assault
2. Tactical air projection
3. Naval bombardment

Each of these tactics is useful for achieving particular objectives. Amphibious assault can be used to secure land from which a land or air campaign can be launched, to secure territory or facilities to prevent enemy use, or to destroy facilities and divert enemy efforts. Combinations of objectives are also possible. Tactical air projection can destroy portions of an enemy's warmaking potential and can provide support to a ground campaign either directly or by interdicting enemy support to engaged areas. Naval bombardment can provide direct support to ground troops, interdict enemy movements along coasts, and harass enemy operations in coastal areas.

3.3.4 Naval Presence

The naval presence mission can also be described as the use of naval forces short of war to achieve political objectives. The existence and location of a presence force can threaten a nation with one or more of five possible actions --

1. Amphibious assault

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[1] Missions of the U.S. Navy, by S. Turner, in To Use the Sea (Supplement 1975), Naval Institute Press.

2. Air attack

3. Bombardment

4. Blockade

5. Exposure through reconnaissance

depending, of course, on the composition of the presence force. The tactic which supports the naval presence mission is deployment of forces in some location or area of interest. Such deployment can be either preventive, in anticipation of possible future events (in hopes of influencing those events), or reactive, in response to events that have already occurred. Many times deployment of presence forces will be both reactive and preventive, having been triggered by some occurrence and intended to affect future occurrences.

There are, loosely speaking, two variables in the assignment of a presence mission. The first is the area in which the presence is to be established, and the second is the makeup of the presence force.

In most cases, selecting an area for the presence mission is relatively straightforward. Particularly when the deployment is reactive, an area in which the presence is desired is known when the mission is formulated. For example, in the case of a show of force intended to demonstrate willingness to use force to guarantee freedom of the seas, the naval presence must be established in the area under dispute. The type of threat which the presence force will be used to establish may also dictate location. It makes little sense to assign a presence force consisting of amphibious assault platforms to a location which is not vulnerable to amphibious assault. Similarly, an attempt to establish an air attack threat will not be credible if the carriers are stationed out of range of possible targets. Reconnaissance threats must be positioned to collect meaningful information.

The composition of the presence force is a somewhat more complex problem but is driven by the same considerations as location selection. A force containing no carriers cannot establish an air attack threat. On the other hand, if the presence is intended to establish a reconnaissance threat, it would be inappropriate to include amphibious forces. In selecting a presence force, a commander must consider the problem (the occurrence being reacted to or prevented), the desired outcome of the presence mission, and the threat, if any, to be established by the presence force to effect the desired outcome. Thus, a force to demonstrate freedom of the seas must be capable of defending itself against anticipated challenges, to insure successful completion of the presence mission; but it need not (and should not) pose an overwhelming offensive threat as well.

3.3.5 Implicit Missions

Though not stated as explicit missions, there are a number of goals that strongly affect the methods used for carrying out assigned missions. The most obvious of these implicit goals or missions is the preservation of forces. While the successful accomplishment of an assigned mission is paramount, tactics which preserve forces for future use are to be preferred to tactics which involve the loss of forces. A regard for preservation of forces places upon the commander a requirement that he assess the possible threats faced by his forces and provide defenses against those threats whenever such defense does not compromise his assigned mission. In general, there are three threat categories:

1. Air threats
2. Surface threats
3. Submarine threats

Not surprisingly, there are three missions that arise from these threats: an antiair mission, a surface warfare mission, and an antisubmarine mission. As the commander weighs the likelihood of each threat, he may choose to configure his forces in a way that optimizes his ability to react against one type of threat at the expense of another. Typically, since optimal resource allocations for any one type of threat leave a force dangerously weak against other threats, the configuration chosen is not optimized for any single threat but rather tries to strike a reasonable balance without leaving significant weaknesses.

Successful achievement of the three "defensive" missions requires the ability to detect, pinpoint, identify, and destroy any threat. In a purely defensive mode, tactics for the defensive missions may also include measures like avoidance, evasion, and deception.

3.3.6 Supporting Missions

To carry out the "official" and "implicit" missions may require some assistance or support which does not fall directly into one of the categories discussed above. While a naval presence mission involves movement of forces, the providing of fuel that makes the movement possible is not directly a presence mission but rather is a mission in support of the presence mission. In the operational context, there are two basic support missions:

1. Logistics - insuring the supply of personnel and material to support the execution of other missions

2. Intelligence - collecting, organizing, and analyzing information to support the execution of other missions.

These support missions are sufficiently important and distinct that they are typically handled by specialists. Organizationally, supporting forces may be incorporated into a group tasked with a particular mission or they may remain under separate command, with suitable coordination procedures established.

Avoiding detection may be a goal of some platform. Methods of accomplishing this usually focus on restricting emissions that can be detected. Such restrictions may be spelled out in an EMCON (emission control) plan, which may contain instructions for actions ranging from prohibition of all emissions to restriction of emissions to certain times and frequencies. A related goal (often pursued when avoidance has not succeeded) is to minimize information gained by the detector. Plans in support of this goal include

1. restricting emissions to those which are not unique to the emitting platform, its class, its category (combatant, non-combatant, etc), its side, or its size

2. moving as rapidly as possible, when detection has been made, from the area where detection remains possible

3. turning on particular emitters in an attempt to interfere with the transmission and (more correctly) the reception of signals by the detector (jamming and countermeasures).

3.4 Actions

There are only a few distinct actions available in the naval domain. The most obvious of these concern movement of platforms (ships, aircraft, and submarines) from place to place. Other actions include emitting electromagnetic energy (transmitting), preparing to receive electromagnetic energy (turning on receivers), transferring information (communicating), and releasing other conveyances (launching planes, etc.).

Interestingly, the primitive ACTS of conceptual dependency [2] may form a reasonable basis for describing platform behavior. Certainly some of the primitive acts are close analogues of naval domain actions.

3.4.1 Movement

The simplest description of movement includes a starting and ending point and either a speed to be used between those points or starting and ending times. In orders, this is what is usually given. However, there may be a variety of paths between points. Merchant shipping, for example, tends to travel in well-defined "merchant lanes" which are standard paths between points. Many of these standard paths are configured to require minimal adjustments to course and speed throughout the voyage. A path that never changes in heading is referred to as a rhumb line. Great circle routes, while the shortest distance between points, require occasional correction of heading, and so are somewhat more complex.

Another common practice in merchant shipping is the use of "junction points." A junction point is a place where a number of merchant lanes either cross or come very close together. The Strait of Gibraltar is an excellent example of a junction point. Many times, a ship bound for a port to which there is no widely accepted merchant lane will follow a lane to a junction point and will change course at that point to follow another lane to its destination. For example, there is a major junction point in the North Atlantic which lies roughly on the great circle route to Gibraltar. Ships bound for Northern European and British ports will follow the route to Gibraltar until reaching the junction point, then will change course and head north.

On heavily travelled routes there will be different merchant lanes, and thus courses of choice, for eastbound and westbound traffic. In general, though not always, westbound traffic will follow a more northerly route.

Merchant shipping may be strongly affected by weather. While large ships (like supertankers) may choose to ride out storms, many ships, if given sufficient warning, will choose courses that avoid at least the worst parts of a storm. Those ships choosing to ride out a storm or accidentally caught in a storm may be far off course when the storm has passed, due to the need to steam in a particular direction to avoid foundering.

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[2] <u>Scripts, Plans, Goals, and Understanding</u>, by R. Schank and R. Abelson. Lawrence Erlbaum Associates, 1977.

Some of the same considerations apply to combatants, but in a reduced sense. While military ships do not necessarily avoid storms, high sea states (big waves) can force them to alter course. In forces composed of many different types of ships, some ships may be excused from formation steaming during heavy weather so that they may better cope with the problems of staying afloat.

Merchant lanes do not dictate to military ships as they do to merchant shipping. Combatants may travel in merchant lanes for convenience and as a means of deception, but they are not bound by lane restrictions.

Generally, the ships of an organizational unit (task force or below) will move as a unit, in a defined formation. In this case, it is enough to specify the movement of the group as a whole (perhaps by indicating the movement of the commander's ship) and the formation of the group, in terms of relative positions. Each ship will be assigned a position and is to maintain that position relative to the formation until relieved or released.

Submarines have the advantage of being able to dive below the surface effects of heavy weather, so their paths can be more regular.

Aircraft are somewhat more interesting. It is almost always the case that aircraft missions begin and end at the same place, aboard the ship that carries the aircraft. The ship may have moved somewhat, but relative to the distance traveled by the aircraft, this movement is usually minimal. Thus, a starting point and end point description of flights is very uninformative.

Flights can be broadly divided into two categories: those with a specific "destination," as in attack sorties and VERTREPs, and those with area coverage requirements, as in ASW flights and combat air patrol. In either case, a good description of the movement of the aircraft should include a description of the destination or coverage area, respectively.

Like aircraft, submarines may have an area coverage assignment. A description of the area then becomes an important part of a movement description for that submarine.

3.4.2 Emissions, Detections, and Communications

In using the emitters it carries on board, a platform may cause electromagnetic energy to be emitted. Describing the action involves describing the time at which the emission occurred and the characteristics of the emission. There may also be information about the continuity of the emission. Platforms may also cause the emission of acoustic energy, whether intended or not. This action can be described the same way as electromagnetic emissions. The action is closely analogous to the SPEAK primitive of Conceptual Dependency [2].

On the other hand, a platform cannot arbitrarily decide to receive an emission, either electromagnetic or acoustic. This is because such an emission must exist to be received, and the detecting platform generally has no control of the emissions of others. The best that can be done is to take an action that guarantees that any emissions meeting certain criteria will be detected. A description of the action must include the time of the action and the criteria for detection. As emitting was analogous to SPEAK in conceptual dependency, so preparation for detection is analogous to ATTEND.

Information may be transferred or shared among platforms by encoding it in an emission which is detected by the receiving platforms. The emission and detection actions can be described as above. The information transfer action must include a description of the information, the originator, and the intended recipient.

3.4.3 Releasing Objects

Conveyances were defined some time ago as objects which move and which carry other objects. The carried objects may themselves be conveyances. Such carried conveyances may require assistance from their carrier in beginning independent movement. The most intuitive example is of aircraft launched from the deck of a carrier. Without assistance on the part of the carrier (in terms of course into the wind and catapult), the aircraft could not begin independent movement successfully.

The same principle can be applied in the case of weapons. A shell or missile can be considered a conveyance carrying a payload. Assistance from the platform carrying the shell or missile is needed to begin independent movement.

A description of the launching action includes the object launched and a description of its initial (launch-imparted) trajectory.

4. CONCLUSIONS

Not surprisingly, the naval domain is complex, incredibly detailed, and wide ranging. This report has barely scratched the surface, despite being oriented toward a specific application -- mission planning. Much more remains to be done, and to that end this report is intended as a living document, subject to update and correction.

What has been described here is primarily static declarative knowledge, a collection of facts which do not change significantly over time. While an attempt has been made to spell out the actions available in the domain and their effect on the state of the world, such "procedural" knowledge is the weakest part of the report. The attempt to describe naval knowledge in a way that is relatively independent of application and representation has perhaps interfered with the success of the effort more than was anticipated, since knowledge is difficult (if not impossible) to separate from use.

5. RECOMMENDATIONS

The report was written to provide a base set of concepts that are required in the naval domain to be used in the evaluation of various available knowledge representation systems. While the author and others in the Navy research setting can and will use the report in doing such evaluations, it is also recommended that the designers and implementors of candidate representation systems be involved in the evaluation process, since they are the true experts in the capabilities, strengths, and weaknesses of their own systems. This involvement should be solicited informally, by providing copies of the report to system developers along with requests for evaluations of the appropriateness of their systems to the representation of the knowledge in the report. The author of this report will be available to try to provide additional information wherever possible.

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APPENDIX A. EXAMPLES

Information about ships, weapons, and sensors is taken from Jane's [4], and is not guaranteed to be accurate. The purpose of this section is to provide some values that can be plugged into trial systems.

A.1 Ships

Surface military combatant ships include:

Aircraft Carriers
Battleships
Cruisers
Destroyers
Frigates
Corvettes

There are also other "military combatants" which are employed in very specific missions types, such as amphibious support craft of the following types:

Amphibious command ships
Amphibious assault ships
Amphibious transport docks
Dock landing ships
Tank landing ships
Amphibious transport
Amphibious cargo ships

Amphibious operations also will call for landing craft.

Military noncombatant (support) ship types include:

Ammunition ships
Store ships
Oilers
Combination ships
Destroyer tenders
Repair ships
Barracks ships
Salvage ships
Cable ships
Submarine tenders

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[4] Jane's Fighting Ships, 1976-1977, edited by J. Moore. Franklin Watts, Inc., 1976.

Submarine rescue ships
Military cargo ships
Minesweepers
Icebreakers

For the purpose of providing examples, we'll concentrate on US and Russian military combatants, giving details on a few of the many ships that exist.

The US identifies several classes of cruisers, which are further subdivided by propulsion (nuclear or fossil fuel). The cruiser classes and their members, weapons, and sensors are as follows:

California (nuclear)

California	CGN 36
South Carolina	CGN 37

Weapons
- 2 Tartar-D surface-to-air missile launchers
- 2 5-inch Mk 45 guns
- 4 Mk 32 torpedo tubes
- 1 8-tube ASROC launcher

Sensors
- NTDS
- SQS-26CX sonar
- SPS-48 radar
- SPS-10 radar
- SPS-40 radar
- various weapons control radars

Truxtun (nuclear)

Truxtun	.GN 35

Weapons
- 1 twin ER/ASROC launcher
- 1 5-inch Mk 42 gun
- 2 3-inch Mk 34 antiaircraft guns
- 4 Mk 32 torpedo tubes
- helicopter facilities

Sensors
- NTDS
- SQS-26 sonar
- SPS-48 radar
- SPS-10 radar
- SPS-40 radar
- various weapons control radars

Belknap

Belknap	CG 26
Josephus Daniels	CG 27
Wainwright	CG 28
Jouett	CG 29
Horne	CG 30
Sterett	CG 31
William H. Standley	CG 32
Fox	CG 33
Biddle	CG 34

Weapons
- LAMPS Helicopter
- 1 ER/ASROC missile launcher
- 1 5-inch Mk 42 gun
- 2 3-inch Mk 34 guns
- 2 triple Mk 32 torpedo tubes

Sensors
- NTDS
- SQS-26 sonar
- SPS-48 radar
- SPS-10 radar
- SPS-37 radar (first three ships)
- SPS-40 radar (remaining ships)
- TACAN
- various weapons control radars

Bainbridge (nuclear)

Bainbridge	CGN 25

Weapons
- 2 twin ER missile launchers
- 4 3-inch Mk 33 antiaircraft guns
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes

Sensors
- SQS-23 sonar
- SPS-52 radar
- SPS-10 radar
- SPS-37 radar
- various weapons control radars

Leahy

Leahy	CG 16
Harry E. Yarnell	CG 17
Worden	CG 18
Dale	CG 19

Richmond K. Turner	CG 20
Gridley	CG 21
England	CG 22
Halsey	CG 23
Reeves	CG 24

Weapons
- 2 twin ER launchers
- 4 3-inch Mk33 guns
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes

Sensors
- NTDS
- SQS-23 sonar
- SPS-10 radar
- SPS-48 radar
- SPS-37 radar

Long Beach (nuclear)

Long Beach	CGN 9

Weapons
- 1 twin Talos (surface-to-air) launcher
- 2 twin ER launchers
- 2 5-inch Mk 30 guns
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes

Sensors
- NTDS
- SQS-23 sonar
- SPS-32 radar
- SPS-33 radar
- SPS-12 radar
- SPS-10 radar
- various weapons control radars

US destroyers:

Coontz class

Farragut	DDG 37
Luce	DDG 38
McDonough	DDG 39
Coontz	DDG 40
King	DDG 41
Mahan	DDG 42
Dahlgren	DDG 43
Wm V Pratt	DDG 44
Dewey	DDG 45
Preble	DDG 46

Weapons
- 1 twin Terrier launcher
- 1 5-inch Mk 42 gun
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes
- helicopter landing area

Sensors
- NTDS
- SQS-23 sonar
- SPS-10 radar
- SPS-52 radar (King and Pratt)
- SPS-48 radar (all others)
- TACAN
- various weapons control radars

Converted Forrest Sherman class

Decatur	DDG 31
John Paul Jones	DDG 32
Parsons	DDG 33
Somers	DDG 34

Weapons
- 1 single Tartar launcher
- 1 5-inch Mk 42 gun
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes

Sensors
- SQS-23 sonar
- SPS-10 radar
- SPS-37 radar (except Somers)
- SPS-40 radar (Somers only)
- SPS-48 radar
- various weapons control systems

Charles F. Adams class

Charles F. Adams	DDG 2
John King	DDG 3
Lawrence	DDG 4
Claude V. Ricketts	DDG 5
Barney	DDG 6
Henry B. Wilson	DDG 7
Lynde McCormick	DDG 8
Towers	DDG 9
Sampson	DDG 10
Sellers	DDG 11
Robison	DDG 12

Hoel	DDG 13
Buchanan	DDG 14
Berkeley	DDG 15
Joseph Strauss	DDG 16
Conyngham	DDG 17
Semmes	DDG 18
Tattnall	DDG 19
Goldsborough	DDG 20
Cochrane	DDG 21
Benjamin Stoddert	DDG 22
Richard E. Byrd	DDG 23
Waddell	DDG 24

Weapons
- 1 twin Tartar launcher (Adams through Buchanan)
- 1 single Tartar launcher (Berkeley through Waddell)
- 1 Chaparral launcher (Lawrence and Hoel only)
- 2 5-inch Mk 42 guns
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes

Sensors
- SQS-23 sonar
- SPS-10 radar
- SPS-37 radar (Adams through Buchanan)
- SPS-40 radar (Berkeley through Waddell)
- SPS-39 radar
- various weapons control systems

Forrest Sherman class

Forrest Sherman	DD 931
Bigelow	DD 942
Mullinnix	DD 944
Hull	DD 945
Edson	DD 946
Turner Joy	DD 951

(The following have special antisubmarine modernization:)

Barry	DD 933
Davis	DD 937
Jonas Ingram	DD 938
Manley	DD 940
Du Pont	DD 941
Blandy	DD 943
Morton	DD 948
Richard S. Edwards	DD 950

Weapons

Antisub mod.
- 2 5-inch Mk 42 guns

1 ASROC 8-tube launcher
2 triple Mk 32 torpedo tubes

Unmodified

3 5-inch Mk 42 guns (except Hull)
2 5-inch Mk 42 guns (Hull only)
1 8-inch Mk 71 gun (Hull only)
2 triple Mk 32 torpedo tubes

Sensors

SQS-23 sonar
SPS-10 radar
SPS-40 radar

US frigates:

Brooke class

Brooke	FFG 1
Ramsey	FFG 2
Schofield	FFG 3
Talbot	FFG 4
Richard L. Page	FFG 5
Julius A. Furer	FFG 6

Weapons

1 Tartar launcher
1 5-inch Mk 30 gun
1 ASROC 8-tube launcher
2 triple Mk 32 torpedo tubes
1 LAMPS helicopter

Sensors

SQS-26AX sonar
SPS-52 radar
SPS-10 radar
various weapons control systems

Knox class

Knox	FF 1052
Roark	FF 1053
Gray	FF 1054
Hepburn	FF 1055
Connole	FF 1056
Rathburne	FF 1057
Meyerkord	FF 1058
W.S. Sims	FF 1059
Lang	FF 1060
Patterson	FF 1061
Whipple	FF 1062
Reasoner	FF 1063
Lockwood	FF 1064

Stein	FF 1065
Marvin Shields	FF 1066
Francis Hammond	FF 1067
Vreeland	FF 1068
Bagley	FF 1069
Downes	FF 1070
Badger	FF 1071
Blakely	FF 1072
Robert E. Peary	FF 1073
Harold E. Holt	FF 1074
Trippe	FF 1075
Fanning	FF 1076
Ouellet	FF 1077
Joseph Hewes	FF 1078
Bowen	FF 1079
Paul	FF 1080
Aylwin	FF 1081
Elmer Montgomery	FF 1082
Cook	FF 1083
McCandless	FF 1084
Donald B. Beary	FF 1085
Brewton	FF 1086
Kirk	FF 1087
Barbey	FF 1088
Jesse L. Brown	FF 1089
Ainsworth	FF 1090
Miller	FF 1091
Thomas C. Hart	FF 1092
Capodanno	FF 1093
Pharris	FF 1094
Truett	FF 1095
Valdez	FF 1096
Moinester	FF 1097

Weapons
- 1 5-inch Mk 42 gun
- 1 ASROC 8-tube launcher
- 4 Mk 32 torpedo tubes
- Sea Sparrow launcher (in Knox through Cook)
- LAMPS Helicopter

Sensors
- SQS-26CX sonar
- SQS-35 sonar (except in Roark through Hepburn, Rathburne through Whipple, Blakely, and Ouellet)
- SPS-10 radar
- SPS-40 radar

Garcia class

Garcia	FF 1040
Bradley	FF 1041

Edward McDonnell	FF 1043
Brumby	FF 1044
Davidson	FF 1045
Voge	FF 1047
Sample	FF 1048
Koelsch	FF 1049
Albert David	FF 1050
O'Callahan	FF 1051

Weapons
- 2 5-inch Mk 30 guns
- 1 ASROC 8-tube launcher
- 2 triple Mk 32 torpedo tubes
- LAMPS Helicopter

Sensors
- SQS-26 sonar
- SPS-10 radar
- SPS-40 radar
- Specialized NTDS (in Voge and Koelsch)
- Weapon control radars

Ammunition ships:

Kilauea class

Kilauea	AE 26
Butte	AE 27
Santa Barbara	AE 28
Mount Hood	AE 29
Flint	AE 32
Shasta	AE 33
Mount Baker	AE 34
Kiska	AE 35

Weapons
- 8 3-inch Mk 33 antiaircraft guns

Sensors
- Fire control radar

Miscellaneous
- 2 Sea Knight helicopters for VERTREP

Combat stores ships:

Mars class

Mars	AFS 1
Sylvania	AFS 2
Niagara Falls	AFS 3
White Plains	AFS 4

Concord	AFS 5
San Diego	AFS 6
San Jose	AFS 7

Weapons
8 3-inch Mk 33 guns

Sensors
TACAN

Miscellaneous
2 Sea Knight helicopters for VERTREP

Oilers:

Neosho class

Neosho	AO 143
Hassayampa	AO 145
Kawishiwi	AO 146
Truckee	AO 147
Ponchatoula	AO 148

Weapons
12 3-inch AA guns

Miscellaneous
Neosho and Truckee have helicopter platforms

Replenishment oilers:

These ships are unusual in that they can carry all commonly needed forms of supplies - fuel, ammunition, and (in limited quantities) dry stores like food.

Wichita class

Wichita	AOR 1
Milwaukee	AOR 2
Kansas City	AOR 3
Savannah	AOR 4
Wabash	AOR 5
Kalamazoo	AOR 6
Roanoke	AOR 7

Weapons
4 3-inch Mk 33 guns, except Roanoke, hangar equipped ships
1 Sea Sparrow launcher (Roanoke only)

Miscellaneous
All have helicopter landing area, some have hangars.

Hangar-equipped ships can carry 2 Sea Knights.

Soviet combatants are as follows:

Cruisers:

Kara class

Nikolayev
Kerch
Ochakov
Azov

Weapons
1 Hormone helicopter
8 SSN-10 missile tubes
4 SAN-4 missile tubes
4 SAN-3 missile tubes
4 76-mm guns
4 30-mm guns
2 12-barreled MBU2500A launchers
10 21-inch torpedo tubes

Sensors
Topsail
Headnet C
various weapons control radars
variable depth sonar

Kresta II class

Admiral Isachenkov
Admiral Isakov
Admiral Makarov
Admiral Nakhimov
Admiral Oktyabrsky
Kronstadt
Marshal Timoshenko
Marshal Voroshilov

Weapons
1 Hormone helicopter
2 quadruple SSN-10 missile tubes
2 twin SAN-3 missile tubes
4 57-mm guns
8 30-mm guns
2 12-barreled MBU2500A launchers
10 21-inch torpedo tubes

Sensors
Topsail

Headnet C
various weapon control radars

Kynda class

Admiral Fokin
Admiral Golovko
Grozny
Varyag

Weapons
2 quad SSN-3 missile tubes
1 twin SAN-1 missile tube
4 3-inch guns
2 12-barreled MBU2500A launchers
6 21-inch torpedo tubes

Sensors
Headnet A
various weapon control radars

Destroyers:

Krivak class

Bditelny
Bodry
Doblestny
Dostoyny
Drozny
Razumny
Razyashchy
Silny
Storozhevoy
Svirepy
Zharki

Weapons
4 SSN-10 missile tubes
4 SAN-4 missile tubes
4 3-inch guns
4 30-mm guns
2 12-barreled MBU2500A launchers
8 21-inch torpedo tubes

Sensors
Headnet C
various weapon control radars

Kanin class

Boyky
Derzky
Gnevny
Gordy
Gremyashchyi
Uporny
Zhguchy
Zorky

Weapons
1 twin SAN-1
8 57-mm guns
8 30-mm guns
3 12-barreled MBU2500A launchers
10 21-inch torpedo tubes

Sensors
Headnet A or Headnet C
various fire control radars

Frigates:

Mirka I and II class

20 ships - names not given in Jane's

Weapons
4 3-inch guns
4 MBU2500A (Mirka I)
2 MBU2500A (Mirka II)
5 16-inch torpedo tubes (Mirka I)
10 16-inch torpedo tubes (Mirka II)

Sensors
Slimnet
Hawk Screech fire control radar

Riga class

Barsuk
Bujvol
Byk
Gepard
Giena
Kobchik
Lisa
Medved
Pantera
Sakal
Turman
Volk

Weapons
3 100-mm guns
4 37-mm guns
4 30-mm guns in some
2 MBU2500 (in some)
3 21-inch torpedo tubes

Sensors
Slimnet

Service ships:

Boris Chilikin class (replenishment oilers)

Boris Chilikin
Dnestr
Ivan Subnov
Vladimir Kolechitsky

Weapons
4 57-mm guns (except Ivan Subnov)

Sensors
Don-2 radar

Kazbek class (replenishment tankers)

Alatyr
Desna
Volkhov

Sensors
Don-2 radar

A.2 Submarines

Ballistic missile submarines will not be included in this survey, since their mission is solely strategic deterrence and they play little part in most mission planning. Information is available on these subs in Jane's, for the curious.

US submarines:

Sturgeon class

Sturgeon	SSN 637
Whale	SSN 638
Tautog	SSN 639
Grayling	SSN 646
Pogy	SSN 647
Aspro	SSN 648

Sunfish	SSN 649
Pargo	SSN 650
Queenfish	SSN 651
Puffer	SSN 652
Ray	SSN 653
Sand Lance	SSN 660
Lapon	SSN 661
Gurnard	SSN 662
Hammerhead	SSN 663
Sea Devil	SSN 664
Guitarro	SSN 665
Hawkbill	SSN 666
Bergall	SSN 667
Spadefish	SSN 668
Seahorse	SSN 669
Finback	SSN 670
Pintado	SSN 672
Flying Fish	SSN 673
Trepang	SSN 674
Bluefish	SSN 675
Billfish	SSN 676
Drum	SSN 677
Archerfish	SSN 678
Silversides	SSN 679
William H. Bates	SSN 680
Batfish	SSN 681
Tunny	SSN 682
Parche	SSN 683
Cavalla	SSN 684
L. Mendel Rivers	SSN 686
Richard B. Russell	SSN 687

Weapons
- 4 21-inch torpedo tubes
- SUBROC
- A/S torpedoes

Sensors
- BQQ-2 sonar
  - BQS-6 active sonar
  - BQR-7 passive sonar
- BQS-8 sonar
- BQS-12 sonar (Sturgeon through Sea Devil)
- BQS-13 sonar (remaining units)
- BPS-14 radar

Permit class

Permit	SSN 594
Plunger	SSN 595
Barb	SSN 596
Pollack	SSN 603

Haddo	SSN 604
Jack	SSN 605
Tinosa	SSN 606
Dace	SSN 607
Guardfish	SSN 612
Flasher	SSN 613
Greenling	SSN 614
Gato	SSN 615
Haddock	SSN 621

Weapons
SUBROC
A/S torpedoes
4 21-inch torpedo tubes

Sensors
BQQ-2 sonar

Soviet submarines:

Victor class

18 subs

Weapons
8 21-inch torpedo tubes

November Class

13 subs

Weapons
6 21-inch torpedo tubes

Juliet class

16 subs

Weapons
4 SSN-3 missile tubes
6 21-inch torpedo tubes
4 16-inch torpedo tubes

Echo II class

27 subs

Weapons
8 SSN-3 missile tubes
6 21-inch torpedo tubes
4 16-inch torpedo tubes

Charlie class

12 subs

Weapons
8 SSN-7 missile tubes
8 21-inch torpedo tubes

A.3 Sensors

The detailed characteristics of these sensors are not guaranteed to be correct, but rather are given as plausible values for tutorial purposes.

Radars:

BPS-14
- Maximum range: 30 nmi
- Probability of detection at maximum range: 5%
- 50% probability range: 12 nmi
- Signal signature
  - Carrier frequency: 7.5 GHz
  - Pulse interval: 1.3072 ms
  - Pulse frequency: 765 Hz
  - Pulse width: 0.7 μs
  - Scan rate: 9.85 s
  - Scan type: A
- Range error: 1%
- Angle error: 1%
- Signal quality: 50 (out of 100)

Don-2
- Maximum range: 47 nmi
- Probability of detection at maximum range: 40%
- 50% probability range: 25 nmi
- Signal signature
  - Carrier frequency: 6.5 GHz
  - Pulse interval: 1.5748 ms
  - Pulse frequency: 635 Hz
  - Pulse width: 3.2 μs
  - Scan rate: 9.25 s
  - Scan type: A
- Range error: 1%
- Angle error: 1%
- Signal quality: 90

Headnet A

- Maximum range: 250 nmi
- Probability of detection at maximum range: 40%
- 50% probability range: 190 nmi
- Signal signature
  - Carrier frequency: 2.5 GHz
  - Pulse interval: 3.5088 ms
  - Pulse frequency: 285 Hz
  - Pulse width: 8.3 μs
  - Scan rate: 7.75 s
  - Scan type: A
- Range error: 1%
- Angle error: 1%
- Signal quality: 65

Headnet C

- Maximum range: 290 nmi
- Probability of detection at maximum range: 25%
- 50% probability range: 240 nmi
- Signal signature
  - Carrier frequency: 2.5 GHz
  - Pulse interval: 4.2553 ms
  - Pulse frequency: 235 Hz
  - Pulse width: 9.4 μs
  - Scan rate: 7.25 s
  - Scan type: A
- Range error: 1%
- Angle error: 1%
- Signal quality: 85

Slim Net

- Maximum range: 240 nmi
- Probability of detection at maximum range: 20%
- 50% probability range: 150 nmi
- Signal signature
  - Carrier frequency: 2.5 GHz
  - Pulse interval: 3.5088 ms
  - Pulse frequency: 285 Hz
  - Pulse width: 8.1 μs
  - Scan rate: 7.75 s
  - Scan type: A
- Range error: 1%
- Angle error: 1%
- Signal quality: 60

SPS-10

- Maximum range: 35 nmi
- Probability of detection at maximum range: 15%
- 50% probability range: 30 nmi

Signal signature
Carrier frequency: 7.5 GHz
Pulse interval: 1.3986 ms
Pulse frequency: 715 Hz
Pulse width: 1.6 μs
Scan rate: 9.75 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 85

SPS-12
Maximum range: 200 nmi
Probability of detection at maximum range: 30%
50% probability range: 110 nmi
Signal signature
Carrier frequency: 1.75 GHz
Pulse interval: 4.7685 ms
Pulse frequency: 127.5 Hz
Pulse width: 14 μs
Scan rate: 7.5 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 65

SPS-32
Maximum range: 310 nmi
Probability of detection at maximum range: 35%
50% probability range: 165 nmi
Signal signature
Carrier frequency: 2.5 GHz
Pulse interval: 4.6512 ms
Pulse frequency: 215 Hz
Pulse width: 9.6 μs
Scan rate: 7.25 s
Scan type: D
Range error: 1%
Angle error: 1%
Signal quality: 50

SPS-33
Maximum range: 320 nmi
Probability of detection at maximum range: 30%
50% probability range: 175 nmi
Signal signature
Carrier frequency: 1.5 GHz
Pulse interval: 6.0606 ms
Pulse frequency: 165 Hz

Pulse width: 12 μs
Scan rate: 6.5 s
Scan type: D
Range error: 1%
Angle error: 1%
Signal quality: 50

SPS-37
Maximum range: 225 nmi
Probability of detection at maximum range: 10%
50% probability range: 180 nmi
Signal signature
Carrier frequency: 3.5 GHz
Pulse interval: 3.0769 ms
Pulse frequency: 325 Hz
Pulse width: 7.4 μs
Scan rate: 8.0 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 75

SPS-39
Maximum range: 200 nmi
Probability of detection at maximum range: 25%
50% probability range: 120 nmi
Signal signature
Carrier frequency: 3.5 GHz
Pulse interval: 2.5794 ms
Pulse frequency: 385 Hz
Pulse width: 6.7 μs
Scan rate: 8.5 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 50

SPS-40
Maximum range: 225 nmi
Probability of detection at maximum range: 15%
50% probability range: 180 nmi
Signal signature
Carrier frequency: 3.5 GHz
Pulse interval: 2.5641 ms
Pulse frequency: 390 Hz
Pulse width: 7.6 μs
Scan rate: 8.0 s
Scan type: A
Range error: 1%

Angle error: 1%
Signal quality: 50

SPS-48
Maximum range: 200 nmi
Probability of detection at maximum range: 10%
50% probability range: 180 nmi
Signal signature
Carrier frequency: 3.5 GHz
Pulse interval: 2.4096 ms
Pulse frequency: 415 Hz
Pulse width: 6.3 us
Scan rate: 8.5 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 60

SPS-52
Maximum range: 350 nmi
Probability of detection at maximum range: 8%
50% probability range: 190 nmi
Signal signature
Carrier frequency: 0.3125 GHz
Pulse interval: 1.5314 ms
Pulse frequency: 653 Hz
Pulse width: 25.0 μs
Scan rate: 8.75 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 80

Topsail
Maximum range: 260 nmi
Probability of detection at maximum range: 10%
50% probability range: 190 nmi
Signal signature
Carrier frequency: 2.5 GHz
Pulse interval: 4.2553 ms
Pulse frequency: 235 Hz
Pulse width: 9.2 μs
Scan rate: 7.75 s
Scan type: A
Range error: 1%
Angle error: 1%
Signal quality: 75

Sonars:

BQS-6
  Maximum range: 25 nmi
  Prob. at max range: 5%
  50% prob. range: 12 nmi
  Signal characteristics
    Carrier frequency: 11.5 kHz
    Pulse width: 11.2 ms
  Range error: 1%
  Angle error: 2%
  Signal quality: 80

BQR-7
  Maximum range: 38 nmi
  Prob. at max range: 38%
  50% prob. range: 35 nmi
  Signal characteristics
    Carrier frequency: 15.7 kHz
    Pulse width: 15.0 ms
  Range error: 1%
  Angle error: 2%
  Signal quality: 80

BQS-13
  Maximum range: 80 nmi
  Prob. at max range: 15%
  50% prob. range: 40 nmi
  Signal characteristics
    Carrier frequency: 3.5 kHz
    Pulse width: 1.5 ms
  Range error: 1%
  Angle error: 2%
  Signal quality: 50

SQS-26
  Maximum range: 40 nmi
  Prob. at max range: 2%
  50% prob. range: 15 nmi
  Signal characteristics
    Carrier frequency: 5.5 kHz
    Pulse width: 43.0 ms
  Range error: 1%
  Angle error: 2%
  Signal quality: 75

SQS-35
  Maximum range: 20 nmi
  Prob. at max range: 5%
  50% prob. range: 10 nmi
  Signal characteristics
    Carrier frequency: 15.5 kHz
    Pulse width: 15.6 ms

Range error: 1%
Angle error: 2%
Signal quality: 75

A.4 Weapons

Surface-to-air missiles:

Name	Range
Standard MR	12 nmi*
Standard ER	32 nmi*
Sea Sparrow	12 nmi*
Talos	65 nmi
Terrier	20 nmi
Tartar	14 nmi
SAN-1	17 nmi
SAN-3 (Goblet)	20 nmi
SAN-4 (Goa)	20 nmi

* Indicates surface-to-surface capability

Surface-to-surface missiles:

SSN-3 (Shaddock)	150-250 nmi
SSN-7	30 nmi
SSN-10	30 nmi

Surface-to-subsurface missiles:

ASROC	1-5 nmi

Submarine-to-subsurface missiles:

SUBROC	30 nmi

Guns:

Name	Range	Rate of Fire
USSR		
30-mm	3-4 km	500 rounds/min
37-mm	4 km	130
57-mm	12 km	120
76-mm	15 km	60
100-mm	18 km	20

USA			
Mk33	3-in	13 km	45
Mk34	3-in	13 km	45
Mk42	5-in	24 km	40
Mk45	5-in	24 km	20
Mk71	8-in	>24 km	12

A.5 Places

Some locations throughout the world, just to give a feeling for latitude and longitude.

Papeete, Tahiti	17-32S	149-34W
Strait of Gibraltar	35-57N	5-45W
Port Said, Egypt	31-16N	32-19E
San Francisco, CA	37-48-30N	122-24W
San Diego, CA	32-43N	117-10-30W
Seattle, WA	47-36N	122-22W
New York, NY	40-42N	74-01W
Boston, MA	42-22N	71-03W
St. John's, Canada	47-34N	52-42W
Galveston, TX	29-19N	94-47W
Panama Canal	8-53N	79-31W
Honolulu, HI	21-18-30N	157-52-15W
Murmansk, USSR	68-58-30N	33-03E
Yokohama, Japan	35-27N	139-39E
Sydney, Australia	33-51-30S	151-13E
Singapore	1-16N	103-50E
Shanghai, PRC	31-14N	121-29-30E
Hong Kong	22-17N	114-10E
Vladivostok	43-06-30N	131-53E
Buenos Aires	34-35S	58-22W
Rio de Janeiro	22-53-30S	43-11W
Cape Town, S. Africa	33-54S	18-26E
Bombay, India	18-56N	72-51E
Lisbon, Portugal	38-42N	9-08W
Marseille, France	43-19-10N	5-21-17E
Adaban, Iran	30-19-48N	48-16-30E
Osaka, Japan	34-38N	135-26E