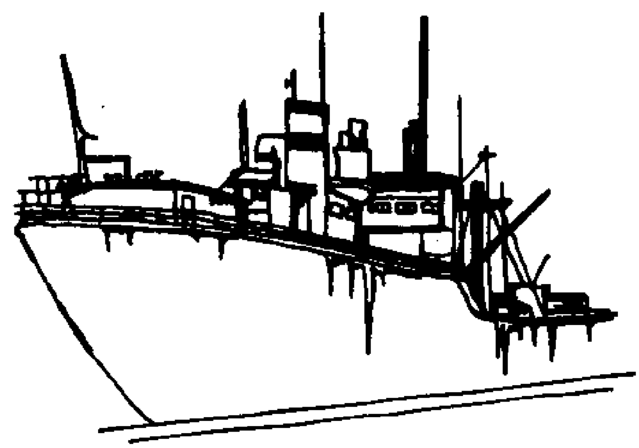
VESSEL TRAFFIC SYSTEMS:

an analysis of the design, implementation and legal implications in three west coast ports

Peter N. Swan



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Proceedings of a symposium which examined the legal implications of the growing interest in mariculture and focused discussion on the laws, new and old, that affect the establishment and operation of mariculture businesses.

THE FUTURE MANAGEMENT OF THE OREGON COAST: PROCEEDINGS OF A SYMPOSIUM HELD AT THE LAW CENTER, UNIVERSITY OF OREGON, OCTOBER 27, 1972. Publication No. W-74-001. (Price: $3.00) 167 pp.

Explores issues facing the Oregon Coastal Conservation and Development Commission. Sessions covered legal background for coastal zone management, zoning laws and the coastal zone, and the importance of planning for the Oregon coast. Panels discussed environmental considerations of estuary management, balancing the coastal zone interests, what level of government is appropriate for the coastal zone, and the future needs of the Oregon coastal economy.

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introduction

SCOPE

This paper will describe the vessel traffic systems in operation in Vancouver, British Columbia; Seattle, Washington; and San Francisco, California. Attention will be given to the geographic peculiarities of the locale of each system, as well as to the nature of the vessel traffic in the respective areas. A general outline of the administration of the systems, their day-to-day procedures, and the equipment they utilize will be attempted. Where appropriate, reference will be made to second-generation systems and to the perceptions and attitudes of the direct users of the systems, (*i.e.*, in the maritime industry). No effort was made in this study to contact or interview other interested parties such as pleasure boat owners, marine sportspersons or conservationists. Each system study concludes with a brief analysis and recommendations concerning the physical implementation of the system.

A general section at the end deals with the legal implications of recent federal legislation; coast guard regulations; the rights and liabilities of the system operators, system participants and equipment suppliers; modeling research; and possible international and intranational jurisdictional problems. The specific problem of pre-emption of state legislation and regulations by federal law is only discussed in passing in this paper.

LEGAL AUTHORITY FOR VESSEL TRAFFIC SYSTEMS

The Rules of the Road antedated vessel traffic systems by many decades, however they still provide the basic rules for vessel navigation and most systems are careful to state that compliance with the VTS does not relieve a vessel operator from its responsibilities under the Rules of the Road (*see, e.g.*, 33 C.F.R. § 161.105; Public Notice No. 12-55 operating procedures SFVTS Paragraph V, A 3; Canadian Ministry of Transport, Notice to Mariners No. 653 Paragraph 6). Just how literally these disavowals are to be taken is a subject of discussion herein.

The Fair Water Quality Act of 1970, (33 U.S.C.A. § 1321 [supp. 1975] as amended) calls for reporting of all spills of oil by the personnel of the vessel involved (Section [b][2] and [b][4]). The Act also confers authority upon the Coast Guard to promulgate regulations governing the inspections of tankers in order to reduce the likelihood of discharges of oil (Section [j][1][D]) and the Coast Guard has been charged with surveillance of the seas to detect and identify those responsible for oil spills (Section [b][5]).

Under the Bridge-to-Bridge Radiotelephone Act of 1972, (33 U.S.C.A. §§ 1201-1208 [Supp. 1975]) the requirement was imposed that vessels navigating in inland waters have inter-bridge communications capability and that they constantly monitor a VHF frequency (156.65 MHz) to facilitate meeting arrangements. Bridge-to-bridge communications obviously play an important role in marine casualty avoidance and in vessel traffic systems. Whether or not bridge-to-bridge communications and VTS communications and monitoring are compatible on the same frequency is a question which is explored in the paper.

The Ports and Waterways Safety Act of 1972, (33 USC §§ 1221-27 [Supp. 1974]; 46 USC § 391a [Supp. 1974]) confers authority on the Secretary of Transportation to establish, operate and compel compliance with vessel traffic systems in congested waters; to control vessel movements in hazardous circumstances; to restrict traffic on the basis of size, speed, and operating characteristics of the vessel; and to require pilots (33 USC § 1221). The Coast Guard is authorized to formulate requirements for hull structure (46 USC § 391a [3][7]). It is under this general authority that equipment requirements, construction requirements and the implementation of vessel traffic systems are authorized.

THE AIR TRAFFIC CONTROL MODEL

The Air Traffic Control Systems of the Federal Aviation Administration offer valuable references for comparison. These systems, operating with high-speed traffic in a three-dimensional medium, represent the state of the art and exemplify the capabilities that a vessel traffic control system could have if they were proved to be needed. The authority of the Air Traffic Controllers is more extensive than that of any existing vessel traffic system operators. Air controllers, in addition to offering information and advice, can order pilots to fly specified routes (can vector aircraft). Vessel traffic systems, on the other hand, hold themselves out as purely advisory. In the Canadian system, the operators are informally referred to as "communicators" rather than "controllers". It is clear, however, that the Coast Guard Captain of the Port has authority to order ships into specified anchorages, to stay clear of the port, to immediately depart the port, to procede only with an escort vessel, or to procede only with oil spill collection booms, or the like. Clearly, vessel traffic systems are offering "advice" and in some cases are "clearing" vessels to proceed in certain areas. Whether these are tantamount to orders will be discussed in this paper as will the question of whether VTS operators should be asserting themselves with regard to navigational decision-making.

The air traffic control system studied was the En Route Traffic Control Center at Auburn, Washington. The Seattle (Auburn) Center has jurisdiction over air travel in the Pacific Northwest corner of the United States. It acquires its radar echoes from four antennas located at Klamath Falls, Oregon; Dallas, Oregon; Seattle, Washington; and Spokane, Washington. Each such radar set has a range of 200 miles. Digitized data is then sent to a battery of four IBM 360 computers which, utilizing the national airspace system computer program (NAS), processes the data for generation of the synthetic display in the plan view display (PVD) seen by the controller and his supervisor. This synthetic display, in addition to recreating the radar echoes, permits several additions of information useful to the controllers. Sector boundaries, airport locations, restricted zone boundaries and other map overlays can be displayed directly on the screen. Second, a data block can be displayed adjacent to the symbol representing the echo. This data block typically contains a flight identification number, the aircraft's cruising altitude as indicated by flight plan (or by controller correction to flight plan), the aircraft's actual altitude (assuming it is equipped with a mode C radar transponder which can transmit the plane's altitude) and emergency notations, if any, among other items. Based on the intensity of the echo, the computer can also display the relative size of the target. Special symbols are used to indicate whether or not the echo is identified and being tracked by the computer according to a flight plan, and whether or not the aircraft transponder is signaling. Aircraft equipped with transponders can identify themselves by "setting in" a designated identification code ("squawking the code"). An aircraft without this capability can identify its echo on the computer display once it is in radio communication with the controller by hitting its identification button on the transponder. This will cause an "identified" symbol to appear on the display in the location of that particular echo.

The computer also has the capability to display a continuously adjusted "vector" for a predetermined future period of time (*e.g.*, one to five minutes) indicating where the plane will be if it continues its course and speed for the designated number of minutes. This has obvious collision-avoidance benefits. See Appendix-1 for PVD depiction.

In the area of casualty reconstruction, the computer has the capability under the data log plot program of generating a graphic presentation (hard copy) related to a set of computer coordinates which will indicate the path of a tracked aircraft. This program, along with the legal analysis data recording program (LADRE), works in conjunction with the data retrieval program which takes all computer operations off of a magnetic tape record known as the SAR tapes. With the aid of a further program or an experienced systems analyst, the graphics can be further decoded to relate to map coordinates. Additionally, all verbal communications are constantly recorded on magnetic tape. Also, on command, a piece of equipment known as an FR1800 can record the digital data from the radar on tape, but this is not routinely done.

The images produced by the four radar sets are further subdivided by the computer into sectors. Each sector is then manned by two controllers. One who primarily does the radio communications and the other who monitors the PVD and accesses the computer. In addition to geographic boundaries, some sectors are further layered by altitude. The progress of an aircraft from one sector to another presents obvious problems in control and tracking. The process of transference of control is known as a "hand off". These hand offs may be done automatically if the computerized data satisfies certain non-ambiguity tests. The essential purpose of these tests is to make sure that there is no mistake in the identity of the displayed echo for purposes of computations by the computer and display of the data bloc. All such hand offs are logged in the computer records. Non-automatic hand offs must be accomplished by communications between the sector controllers. The sector controllers also keep written records in the form of flight progress strips on which salient pieces of information and non-routine occurrances are logged.

In virtually every case of commercial flights and in many cases of private flights the aircraft are "Flat Tracked". This means that the computer is displaying flight-plan-assisted tracking. That is to say that the flight plan of the aircraft is stored in the computer memory and simply updated for takeoff time. Thereafter the computer is capable of extrapolating to estimate the location of the aircraft by computations based on its speed over the ground and course heading. The software in the computer then constantly compares echoes actually received from tracked aircraft with their computed and expected positions to confirm that the display is presenting the correct data bloc with the proper aircraft symbol. In addition to authenticating the position displayed on the controllers' PVD, this has obvious utility for search and rescue operations. Vessels do not file anything equivalent to flight plans although they do occasionally report their location. Since vessels move much more slowly than aircraft, there is less reason for confusion and ambiguity as to the echo displayed and less likelihood of an erroneous data block. Thus this complex search-and-verify software is probably not necessary. There is at least one occasion, however, when such a capability could be needed. If two vessels are overtaking in such a manner that they may pass under a bridge and a third vessel is in a meeting or crossing situation, it is possible that the blips on the radar will disappear momentarily as the vessels pass under the bridge. This is especially true if they are close abeam of each other. As the blips re-emerge on the far side of the bridge it is possible for the computer to transpose the data block. Though it is unlikely that shoreside controllers would be giving passing instructions to the vessels involved, if they were to give an advisory based on the assumed identification of the displayed echoes, it is conceiveable that the transpostiton of data blocks could lead to highly confusing, if not detrimental, advice being given.

The software can be programmed to give "blinks", a form of visual alert whereby a tracked plane echo is visually called to the attention of the controller. Each controller's console has an accurate time display, as do all of the recordings on the magnetic communications tape and the SAR tapes. All of these are synchronized to and adjusted from station WWV Fort Collins, Colorado, which in turn reads out in Coordinated Universal Time (Greenwich mean time).

In addition to the magnetic tape record of the communications between controller and pilot, the controller will annotate his flight progress slips with any verbal command or routing suggestion. If for any reason a pilot disregards or rejects the controller's suggestion, this is noted on the slip and other aircraft in the vicinity are notified of the apparent intentions of the non-complying aircraft. If an aircraft loses radio contact with the control center, an input from the controller's console will result in the letters "NORDO" being displayed in the E field of the data block. This is the emergency field and the symbol indicates no radio.

Resolution for display purposes with the radar on the 100 mile range is 1/8th of a nautical mile. This is also the resolution of the coordinates which can be obtained from the computer memory by means of the data log plot (DPCT) program. If the radar range were shortened to six miles by the controller the display resolution would be even better, though the computer coordinates would not improve in their geographic discrimination.

In the water navigation context there is no need for altitude information. Arguably, it would be convenient to have a precise identification of the radar echo, such as the squawk code used by pilots on their transponder. But with the slower moving targets and the current adequacy of VHF voice communications, this presently does not seem necessary. The separate question of the usefulness and need for identifying the individual in command of a particular ship is discussed later in this paper.

the British Columbia vessel traffic system

GEOGRAPHY AND NATURE OF TRAFFIC

The Canadian VTS is presently operative as a shore-based system only in the southern portion of British Columbia coastline, notably from the northern tip of Vancouver Island southward to the Strait of San Juan de Fuca. With the exception of Port Alberni, a deep water inlet off of Barkley Sound on the western coast of Vancouver Island, most of the involvement of the Canadian system is with inland waterway traffic (for the administration of the Straits of Juan de Fuca and Haro Strait, see p. 40, Jurisdictional Problems *infra*). This is not to say that the waterways are rivers or bays. Indeed, "inlets" are excluded from the VTS coverage because of relatively low traffic density and of the need to reduce communication congestion. The inland waterway parallels the east coastline of Vancouver Island and constitutes the principal waterway for tug-and-barge traffic headed to the upper British Columbia coast and to Alaska originating in Puget Sound. It is also the principal waterway for coastal cargo vessels. VTS officials report over 42,000 commercial vessels (excluding fishing boats) entered or departed Vancouver Harbour during the last five months of 1974! The most salient geographic features of this area are the Canadian San Juan Islands, the seaport of Vancouver (Burrard Inlet), and nearby Howe Sound. These points lie easterly across the Strait of Georgia from Vancouver Island. Further north, the waterway narrows drastically through Discovery Passage and Seymour Narrows, thence through Johnstone Strait and Queen Charlotte Strait and Gordon Channel to the northern end of Vancouver Island.

The southern portion of the VTS area has the inherent management problem of considerable cross-traffic and multi-directional courses as craft of various sizes wend their ways between the various islands. There is also a feature of cross-strait ferry traffic. The northern reaches on the other hand, involve vessels virtually always operating on parallel or recriprocal courses, though in places, particularly Seymour Narrows and the northern end of Johnstone Strait, the maneuvering area can be quite restricted.

Deepwater vessels call frequently at Vancouver, B.C., in addition to pulp and lumber ports on the mainland and on Vancouver Island. Many of these ships also call (either before or after calling at Canadian ports) at Puget Sound ports (usually Tacoma or Seattle). Additionally, a great deal of the Cook Inlet and Valdez tug and barge traffic originates in Puget Sound and moves northward through the inland waterway.

The geographic boundaries of the system are legally defined as Canadian coastal waters from the entrance to the Strait of Juan de Fuca to the northern end of Vancouver Island (Notice to Mariners No. 653 as amended by Notice to Mariners No. 749-11/74), from Vancouver Island north to the Alaska-British Columbia border (Notice to Mariners No. 633, 7/75), and Canadian waters west of Vancouver Island (Notice to Mariners No. 281-3/24/75). Although the latter two areas were incorporated into the system as of August 1, 1975 and April 1, 1975, respectively, the description herein will be confined to the inland waters portion of the system, referred to hereinafter as the "Vancouver Traffic Zone". (The western coast of Vancouver Island area is known as the "Tofino Traffic Zone". The northernmost zone is known as the "Prince Rupert Traffic Zone". The latter has no shore stations at the present time.) The Vancouver traffic zone is subdivided into three sectors. Sector I is the Straits of Juan de Fuca from its seaward mouth (Carmanah Point to Tatoosh Island) to its landward entrance (Race Rocks to Ediz Hook) (see p. 40, Jurisdictional Problems, for a further explanation of the VTS administration in the Strait of Juan de Fuca). Sector III is Howe Sound and Burrard Inlet (Vancouver) and the immediate offshore waters. Sector II is the entire residue of the Vancouver Traffic Zone area. See Appendix-2.

ADMINISTRATION AND AUTHORITY TO ACT

The 1972 amendments to the Shipping Act confer authority upon the Governor in Council to make regulations "establishing compulsory traffic routes and other shipping traffic controls considered necessary for safe navigation . . . ." (Ch. 27 [2d Supp.] § 730 [o].) The Ministry of Transport is the operating agency of the Canadian government. Civilian personnel of this ministry operate this system. Unlike the United States Coast Guard, the Canadian Coast Guard restricts itself to search and rescue missions and to maintainence and establishment of navigational aids. The Canadian Coast Guard apparently does not involve itself in enforcement of fisheries, customs or navigation laws; in documentation matters; in vessel inspection matters; or in marine casualty investigations, all of which are handled directly by the Ministry of Transport. Although some of the MOT personnel operating VTS have nautical experience, this is not a prerequisite. Notices to mariners are sent out over the Ministry of Transport's radio network and are disseminated in printed form by the Ministry of Transport.

There are no Inland Rules of the Road for the British Columbia coastlines. The International Rules of the Road cover the navigation of vessels at all relevant times. Manadatory pilotage is required inward from the pilot boarding station at Brotchie Ledge, south of the city of Victoria, although there is an exemption for coasting vessels and for American registry traffic originating in San Francisco or northward and destined for ports in Alaska.

The Vancouver Vessel Traffic Management system which is presently on a voluntary basis, is anticipated to become mandatory by mid-1976. In its present configuration the system is confined to a radio call-in system utilizing VHF channels 11 and 12. The radio reporting requirements are presently applied to all vessels over 20 meters in length and towing vessels over 8 meters in length or having a total bow-of-tug-to-stern-of-tow length of 30 meters or more. The personnel with responsibility for advising the ships and monitoring the respective VHF channels are referred to as "vessel traffic regulators". Their immediate superior is a shift supervisor but they have a wide range of discretion in making their advisories directly without prior approval of the shift supervisor.

The Vessel Traffic Regulators have been designated Pollution Prevention Officers by the Minister of Transport persuant to the Oil Spill Prevention Amendments to the Canada Shipping Act (ch. 27, § 731). As such they may issue orders regarding speed, anchorage, pilotage, routes, or even total exclusion, if they feel a ship has not complied with requirements under the Act or otherwise, due to weather conditions or deficiencies of hull or equipment, presents a risk of discharge of pollutant.

EQUIPMENT AND PROCEDURES

The system is principally a radio reporting system (VHF) utilizing various calling-in points (CIP's) although it is presently radar assisted in Sector III (Vancouver and environs). The communications net utilizes remote transmitter-receivers at Alert Bay;

Chatham Point; on Cape Lazo; on Sea Island, in West Vancouver; on Mt. Newton, near Sydney; and at Sooke (App.-2). (The Tofino zone will also have remote transmitter-receivers at Ucluelet Inlet and at Tatchu Point on the western coast of Vancouver Island.) All transmitter-receivers have complete redundancy in case of equipment failure and they transmit to the Vancouver Vessel Traffic Management Centre by leased voice grade phone lines.

Communications in Sectors I and II proceed on channel 11, while communications in Sector III are to be made on channel 12. In its present configuration the VTM system is dependent upon the ships calling in to give their location and progress (except in the Vancouver area where radar is operative). Vessels must maintain a continuous listening watch on the appropriate channel and must request an initial clearance when proceeding to or leaving berths within Sector II or the deepwater berths at Tsawwassen or Roberts Bank; when proceeding after a stranding or collision; or after suffering any disabling defect in navigational equipment or maneuvering machinery. Additionally, obstructions to navigation, sudden deteriorations in weather conditions, and casualties subject to the Candian Casualty Reporting Regulations should also be reported over the VTM system frequency.

A request for initial clearance to enter the Vancouver traffic zone should be terse but must nonetheless contain the following information: the name of the ship, position, its estimated time of arrival at the zone boundary; its last port, and immediate destination; its deadweight tonnage and draft; any deficiencies in shipboard navigation equipment, pollution prevention equipment, or steering machinery, or in charts and navigational publications; and confirmation that the vessel has VHF capabilities on channel 11, 12, 13, 14 and 16. Additionally, if the ship is a non-Canadian tanker over 500 tons, it must confirm that it carries a certificate of compliance with the Canadian pollution laws (Canada Shipping Act, Ch. 27 [2d Supp.] § 730 [2] and regulations thereunder (*see, e.g.*, SOR/71-495 and SOR/73-500). Ships must also give a description and weight of pollutants they carry and must report any actual or potential leakage of such pollutants (Notice to Mariners, No. 653, Paragraph 13). After initial clearance vessels are required to call in at the designated calling-in points giving their names, the relevant CIP, and their estimated time of arrival at the next CIP. Additionally, if they are approaching a Sector boundary, they should make a radio report when the vessel is three miles from the boundary line.

At the Vessel Traffic Management Centre at West Vancouver, written annotations are made by the Regulators on small strips closely resembling air traffic control flight progress slips. Actual time is compared with estimated time of arrival for each check point and recorded on the slips along with the name of the vessel and its speed. (*See* example in Appendix-4.) All voice (VHF) communications are recorded on magnetic tape with a channel for time synchronization. The progress slips are retained in a hand-copy file by date. These slips are fastened to plastic counters which in turn are stored in a vertical racking system. Permanent counters or dividers are used to designate various calling-in points. The communicators manually move the slips from position to position past the counters symbolizing calling-in points to create a schematic depiction of the progress of the ships and to give an indication of the traffic in the vicinity. Direction of travel is indicated by a color coding system. White refers to ships that are north bound or east bound and buff refers to ships that are south or west bound. Obviously, the ships will seldom be on precise north-south-east-west headings, so the slips are generally used to indicate whether vessels are inbound or outbound from Vancouver. Thus in the southern area of the zone, vessels in Haro Strait, Boundary Passage and the Strait of Georgia would all have a white color code so long as they were proceeding toward Vancouver (App.-2). Ironically vessels heading westerly (*i.e.*, outbound) in Johnstone Strait would still have a white color coding even though they were technically heading west. Conversely the buff color indicates a vessel inbound in the northern area of the zone and outbound south of Vancouver. Ferry boats with regular crossings are indicated by a blue colored strip and a horizontal arrow (if the arrow is pointing toward the left it indicates a westerly crossing and if it is pointing to the right it indicates an easterly crossing). Temporary dangerous conditions, *e.g.*, fog banks, logs broken loose from a raft, etc., are marked on white slips with a red grease pencil and the slips are placed on counters which remain stationary (vis-a-vis the counters representing ships in transit). Despite the rudimentary nature of this system for depicting vessel movements, the Vessel Traffic Regulators feel that it works well, especially with regard to slow moving tug-and-barge traffic.

A total of forty calling-in points are utilized in the Vancouver Traffic Zone.

CIP's are numerous largely because of the extreme length of the inland passage. Some calling-in points, however, are simply opposite sides of heavily trafficked narrow passages, *e.g.*, CIP's 15 and 16 are on the east and west entrances respectively of Porlier Pass. Centre officials estimate that 98 per cent of deep-water vessels have been complying with the VHF reporting requirements even during the voluntary phase of the system. They estimate 85 per cent of other commercial traffic is complying. Navigating Appliances Regulations under the Canada Shipping Act (SOR/73-53 paragraph 20) require that all vessels over 100 tons should have in the wheelhouse VHF capabilities on channel 6, 14 and 16 and also channel 11 and 12 (Schedule F, items 17 and 18). Canadian military vessels are also reported to be fully cooperating with the reporting requirements.

The traffic management system presently utilizes a traffic separation scheme only from the boarding station at Victoria to the south end of Haro Strait and in Georgia Strait south from the first narrows at the entrance to Vancouver Harbour. The American TSS controls the Strait of Juan de Fuca; most of the balance of the inland waterway is deemed to be a narrow channel under the International Rules. When the shipment of Alaskan oil to the continental United States begins it is possible that offshore (*i.e.*, off the west coast of Vancouver Island) traffic lanes will be instituted by international agreement.

The present VTS system has a radar antenna atop the 12 story Centre Building in West Vancouver. This radar offers a display of vessel traffic moving into Burrard Inlet through the first narrows under Lions Gate Bridge and as far as the bridge at the second narrows. A video camera takes a continuous picture of the PPI and displays it as a television picture at a Vessel Traffic Regulator's console both in the traditional green tones and in black and white. The radar display has full offset capabilities. In periods of good visibility the twelfth-story location of the Centre also affords an excellent view of Burrard Inlet as far as the first narrows. A video tape recorder can be command actuated to make a record of what appears on the PPI should that be deemed desirable. There is also a low light-level TV camera mounted under the Lions Gate Bridge. This camera has remote aiming and focusing capability controlled from the Centre. It affords Vessle Traffic Regulators a view of the otherwise unseen berths on the north shore just inside of Lions Gate Bridge.

SECOND GENERATION CONCEPTS AND EQUIPMENT

Bids are presently being solicited for hardware and software to implement the second-generation system both in the Vancouver Traffic Zone and in the Tofino Traffic Zone. The Tofino system will have radar with sixty mile range which will reach down as far as the seaward entrance of the Strait of Juan de Fuca. It will be located at Mount Ozzard (near Tofino). Plans for the Vancouver Traffic Zone call for the installation of radar antennas at Gonzales Shell (Victoria), Mount Newton (Vancouver Island), Mount Parke (Mayne Island) and Bowen Island (in Howe Sound) (App.-2). Analog data from these antennas will be sent by microwave link from the remote sites back to the Centre in West Vancouver.

The radar must be able, in good weather conditions, to detect a 20 meter steel-hulled vessel with an average freeboard height of 1.2 meters at a distance of thirty nautical miles and must be able to detect a wooden-hulled vessel 14 meters long with an average freeboard of one meter at a distance of 15 nautical miles. A 1974 amendment to the Canadian Collision Prevention Regulations requires radar reflectors on certain non-metal vessels under 20 meters in length. On January 1, 1977 this same requirement will be extended to commercial fishing boats. On January 1, 1978 it will be extended to pleasure boats. These radar reflectors are designed to give response in a three centimeter wave band and the above-quoted minimum detection requirements contemplate the test vessels being so equipped. Additionally the radar should be able to identify a 2.9 meter (9.5 foot) standard navigation buoy fitted with an X-band racon at 16 nautical miles in good weather with a maximum 1.2 meter swell and should identify a 1.4 meter (4.5 foot) buoy with a radar reflector at six nautical miles under similar circumstances.

At the indicated antenna positions officials believe the radar will give 99 per cent coverage of the area from Victoria to Vancouver, through the southern end of the Vancouver Traffic Zone. The radar will be equipped with moving target indicators which will filter out undesired land masses but will be designed not to filter out bridges or buoys. The radar-computer system will have the capability for video-map overlays to allow the presentation of shore outlines, islands, anchorages, sector limits, underwater shoal contours, etc.

The radar data processing computer is to provide a system of target identification (by track number and by an alphanumeric tag six to eight digits long). The software and memory must be able to keep track of 160 targets simultaneously on the four radars together (excluding the one in West Vancouver), and it must be able to compute the closest point of approach (CPA), and ETCPA, and display these on a digital display panel. It must also be equipped to provide automatic collision or grounding hazard warnings.

Targets of interest will be manually "acquired" by the Vessel Traffic Regulator by using a track ball which can be positioned by a joy stick on the console. A small bloc of up to six alphanumeric characters may be associated with all acquired targets and displayed on the plan view display (PVD). When a tracked vessel moves out of one radar coverage sector and into an adjacent sector the target and its alphanumeric label will automatically transfer to the new sector's display. Similarly, any stored data with regard to a tracked vessel can be called up on command by the Regulator at any sector. The Regulator has the capability of requesting CPA calculations for two or more selected targets or one or more selected targets and one or more selected fixed points. If more than one CPA results the different CPA's will be listed in order of decreasing priority. In addition the system shall continuously internally make CPA calculations for all the vessels which are on converging courses and shall signal an alert to the Regulator if these CPA's are less than a predetermined minimum distance or will occur in less than a predetermined time (to be specified by the Vessel Traffic Regulator). Similarly the computer, upon command of the Regulator, shall generate a meeting/passing report which will list, in decreasing priority, all ships which a ship selected by the Regulator will meet or pass in a constrained channel within any time frame specified by the Regulator.

Contractors may also be asked to submit optional features pertaining to certain classes of information that can be entered into a data base such as vessel characteristics, a vessel's course and speed before entering the area of radar coverage, instantaneous course and speed of a vessel that is being tracked by the radar and computer and location coordinates for fixed points.

Automatic data logging, which is especially useful for casualty reconstruction purposes, will be accomplished by the following means: a hard copy data log will be generated by a serial impact printer. This logging system will periodically record the position of each tracked target. The record period can be selected by the shift supervisor, but will not be oftener than once per minute. If this logging is done on magnetic tape recorders, more frequent updating can be utilized. The logging system must record all warnings which the system directs to the Regulator.

One of the systems analysts in Vancouver has conceptualized a third generation system which is not directly involved in the present design competition except in so far as the optional data base capability is concerned. The idea is to interface the radar-computer system with a general purpose computer which in turn could draw on disc or tape files containing individual vessel data, notices to shipping, location coordinates for aids to navigation, tide tables, meteorological data and the "snap shots" which are made by the data logger at periodic intervals. Not only could the Regulators draw upon these files to enhance their own decision-making and advisory capability, but the Marine Information Center and casualty reconstruction experts could (at least as to tracked vessels) utilize the data so generated and updated. Additionally, the radar could detect when a buoy had broken loose or had been dislodged and could automatically send notices to the personnel responsible for maintainence of nav-aids and could generate a master notice to shipping (*see* Appendix-3 for schematic of this concept).

It is unclear whether the second generation software could display a "history" in the manner of the air traffic control NAS program or the shipboard device known as the Marconi Predictor. Apparently the PVD will not have the capability of producing a velocity vector based on instantaneous course and speed for preselected intervals into the future. This device has proved useful for air traffic controllers, but does not appear to be part of the second-generation specifications.

Range and bearing determination can be made by means of a cursor controlled at the Regulator's console. This will give a range readout in a digital display in nautical miles correct to two decimal places (the range being from the particular antenna in question) and will give a bearing readout accurate to the nearest degree.

A video tape recorder will also be utilized to record what is seen on the PVD. Additional channels will also be available for sychronizing time pulses and azimuth data pulses which can be visually displayed at the same time as the video tape. This VTR will work directly off of a read-write tube rather than having to photograph the actual PVD. The date will also be recorded on the basis of a three digit message indicating the days of the year from 001 to 365. The VTR shall also record all voice communications on command. Additionally, as in the present system, they will be routinely recorded on magnetic tape.

The software is divided into categories: application software (divided into functional modules which control such things as radar driver, display driver and keyboard functions); the operational control program (a core-resident program to allocate CPU time to the various tasks awaiting execution on a prioritized basis); support software (compilers, assemblers, text editors, linkages, memory dump routines, etc.); and diagnostic programs (for maintainance, test and debugging purposes).

ANALYSIS

At the present time the VHF communications system within the Vancouver Traffic Zone is seldom operated on a sectorized basis. Consequently the Regulator may be listening to someone in the northern end of the zone by using a remote transmitter-receiver in that vicinity while a vessel in the southern end of the zone, unable to hear the conversation from the north, may be calling the Centre, resulting in an overlay of incoming messages. This problem would be eliminated by sectorization. Regulators have suggested the need for sectorization even when the workload is not heavy, simply to provide a rotation and create a relief period to break the possible fatigue resulting from the requirement of unbroken periods of concentration.

The two-color directional code seems insufficiently discriminatory with regard to traffic in the Canadian San Juans which may be travelling on unconventional courses. Regulators have reported good cooperation from tug skippers who are *passing*, but not crossing, a calling-in point (CIP). For example, tugs *crossing* the entrance to Porlier Pass, but not transiting the Pass itself are not obliged to call in. Nevertheless they have been responsible about doing so. This type of information is obviously relevant to any ship which is emerging from the pass in the vicinity of the crossing vessel.

Regulators have not been asking for the speed of vessels, although they gain a sense of this by having the vessel call in its ETA at the next CIP. It would seem advisible that the reports at least initially also advise the Centre of the expected routing of the vessel, *i.e.*, which pass it will use through the San Juans, etc. Regulators indicate that they will ask the approximate speed of the vessel if it is headed into the Puget Sound VTS area and this information will be passed along by teletype to the Seattle system.

Regulators do not require reporting vessels to enter into over-taking arrangements. (Since the Inland Rules of the Road do not apply in Canadian waters there is no requirement for a "bargain".) They do however, advise a reporting ship of all other traffic in the vicinity and make statements such as "we anticipate you will be overtaking the S.S. ________". Since the overtaken vessel should be monitoring channel 11, it should be forwarned of the approach of the other vessel.

Pilots are not identified over the system unless the Regulator happens to recognize their voices. MOT officials feel it would not be politic to ask for the pilots' identity. There is no plan for pilots to carry portable transponders as is done in the Rotterdam system to assure tracking of a particular blip. However, the second-generation system will utilize a VHF direction finder for acquisition and identification of vessel echoes at the time of radio reports.

MOT officials reported one success of the VTM system in diverting casualties when 30 knot winds prevailed in the English Bay anchorages off of Vancouver, and several ships started dragging their anchors. The VTM system personnel detected the movements on their radar and contacted the ships. They even summoned tugboats to assist one vessel which could not be reached over the radio.

the greater Puget Sound vessel traffic system

GEOGRAPHY AND NATURE OF TRAFFIC

Although a traffic separation scheme (TSS) has been established the length of strait of Juan de Fuca (*see* page 40, Jurisdictional Problems) the official VTS area is pilotage waters, *i.e.*, it begins at the line of demarcation where the Inland Rules of the Road become applicable. (*see* Appendix-5,6). The TSS is laid out with one way traffic lanes 1000 yards wide. Between the traffic lanes are separation zones 500 yards wide. The TSS begins at a line running northerly from Dungeness Spit light and one branch goes northeastward toward the southern end of Rosario Strait. Another branch heads due east to the northern end of Admiralty Inlet. A third lane runs northwest from the northern end of Admiralty Inlet in the general direction of Haro Strait. A fourth lane runs directly from the northernmost end of Admiralty Inlet to the southern end of Rosario Strait. The remaining portions of the TSS proceed through Admiralty Inlet past Seattle down to Commencement Bay (Tacoma) via the east passage around Vashon Island. At the confluence of one or more routes of the TSS there are Precautionary Areas. These are circular in appearance with a radius of 2500 yds. There are also smaller precautionary areas throughout Admiralty Inlet at points of course changes or points of departure for Elliot Bay and Commencement Bay. The widths and directions of the TSS were largely determined by the shortest routes and the available passages with sufficient water depth. A Precautionary Area not only reflects a convergence of lanes, but also takes into account the proximity of ferry crossings; traditional fishing areas; currents as recorded in objective data bases such as the NOAA current charts; and subjective inputs from local mariners. Although the traffic lanes normally have depths of 18.2 meters (60 feet) or better, in the vicinity of Partridge Bank depths decrease to 12 meters (40 feet) (App.-7). Thus deep draft ships have to be "managed" and allowed to intrude in the northbound traffic lane while proceeding southward toward Admiralty Inlet.

Traffic in Puget Sound is complicated by a great number of ferry crossings. For the most part these crossings are east and west crossings whereas deepwater traffic tends to run north and south. There are 485 such crossings daily and 448 of them cross the TSS and 187 of these cross the TSS at times of low visibility or darkness. There is both commercial and sport fishing in abundance during many months of the year in Puget Sound. There are also many sailing regattas in Puget Sound, especially in the vicinity of Seattle and Tacoma.

There are 17 buoys in the Puget Sound TSS and they are all mid-channel buoys marked with black and white horizontal stripes and lights. Because the water in Puget Sound is extremely deep, buoys are expensive to install and maintain. The cost of the 17 buoys in 1972 was $225,000. Also the frequent cross traffic, the tug and tow traffic and the difficulties gill netters have with entangling their nets in the buoys discourage large increases in the number of buoys.

In addition to deepwater tug and barge traffic originating in Tacoma and Seattle heading for Alaska there is a tremendous amount of local towage involving such things as sawdust barges and log rafts. Log rafts are made up in sections approximately seventy feet square and sometimes contain as many as seventy such sections (although a more typical number would be twenty-four sections). Such flotillas move very slowly, are not easily maneuvered, and are greatly influenced by currents. Merely adding horsepower to the tug is not the answer as this will simply submerge the leading edge of the raft and cause the other logs to float free, or will break the cables binding the raft together. Towboat officials indicated that tugs northbound in the vicinity of Double Bluff (on Whidbdy Island), when fighting a "bull" flood tide, have to cross the TSS to reach the back eddies on the west bank in order to make any progress at all (App.-7).

A sophisticated, recent study projected tanker traffic to Washington ports at 348 calls per year by 1985 in a "worst case" scenario wherein Puget Sound refineries were to serve portions of the mid-west and California in addition to the Pacific Northwest and where no Canadian crude (pipelined) oil was available. In a "best case" where only Pacific Norhtwest needs were filled and where pipelined oil from Canada was available, 45 calls were projected for 1985, (OCEANOGRAPHIC COMM'N OF WASHINGTON STATE IV-27, Table IV-34 and V-46, Table V-45 [1975]). Because of the capacities of some of the ships involved and because of recent Washington legislation (see page 41, Jurisdictional Problems *infra*) it is probable that some of these calls would be at Port Angeles. This port is just inside the present VTS area, but is at the eastern end of the Strait of Juan de Fuca. Because of the voluminous tug and barge traffic, tankers and oil barges represent only three per cent of all vessel movements, although their cargoes are 39 per cent (by weight) of all ship carriage on the Sound. (U.S.C.G. Study Report Vessel Traffic Systems: Analysis of Port Needs, Appendix D-2 [hereinafter USCG Port Needs Study].)

EQUIPMENT AND PROCEDURES

Watches on the VTS are manned by petty officers who serve as communicators and plotters and by a lieutenant who is the watch officer. The communicators are free to make most of the decisions and all of them have shipboard maneuvering experience. Non-routine decisions are referred to the discretion of the watch officer. Overall supervision, design and policy planning is handled by the commander and his executive officer.

The Puget Sound VTS utilizes remote transmitter-receiver stations for its VHF channel 13 and channel 16 communications. These stations are located at Bohokus Point (Cape Flattery), Mount Constitution (Orcas Island), Gold Mountain (Kitsap Peninsula) and Fort Lawton (Seattle). VHF communications reach everywhere in the VTS area including Olympia and Shelton. The only known "dead spots" are in the Tacoma waterway at the head of Commencement Bay and up the Snohomish River in Everett. Vessels 300 gross tons and over, vessels 100 gross tons and over carrying one or more passengers for hire, vessels 8 meters or longer engaged in towing, and all dredges are required to have channel 13 communications capability and to maintain a listening watch on channel 13.

The locations and movement of vessels is depicted by moving small wooden models on a contoured table top covered with an enlarged scale chart of greater Puget Sound. These models are color coded to indicate petroleum carrying tankers and barges, tugs with tows, ferries and cargo ships. Each model is fitted with a tiny rack which holds tiles on which are written the vessel's name, its destination and ETA at the next check point. The models also clearly indicate the bow of the ship and thus the direction of its travel. The models are relocated by VTS personnel after every radio contact and are also relocated every fifteen minutes on a dead-reckoning basis. The communicators can thus tell at a glance the traffic in any particular vicinity, the direction it is going and the progress it is making.

At least 30 minutes before a vessel enters the VTS area or starts to navigate within it, the master or pilot must report the name of the vessel, its position, its estimated time of entering or navigating, its point of entry in the VTS area, its destination and its ETA at destination. The report must also contain a description of any condition on the vessel that might affect its navigating capability. If dangerous cargo (as listed in 33 C.F.R. § 124.14) is carried on board, this too must be reported (33 C.F.R. § 161.128).

A follow-up report must be made at least 15 minutes before a vessel enters the VTS area or begins to navigate. This report must describe the type, length and draft of the vessel, any revisions to the initial report, and the vessel's intended speed and its point of entry into the TSS if any (33 C.F.R. § 161.130). Although the regulations (33 C.F.R. § 161.131) require a final report when the vessel anchors, moors, or departs from the VTS area, no specific advisories are required when vessels first reach the vicinity of their destination.

Vessel movement reports are required at nine different checkpoints, although a vessel would not normally pass all nine points on any given voyage. Reports made when passing these check-in points must include the name of the vessel, the reference point, the time of passing it, the next check-in point to be encountered, and the ETA at that point. Changes in speed are also to be reported, as are the destination and intentions of a vessel which is departing the TSS.

Vessels joining or leaving a traffic lane in the TSS are obliged to enter or emerge at as small an angle as possible, while vessels crossing a traffic lane are obliged to take the shortest possible route--usually perpendicular (33 C.F.R. § 161.156).

Fishing vessels under Article 26 of the Inland Rules of the Road may not obstruct fairways used by other vessels. Traffic lanes in the TSS are construed to be fairways for purposes of this Article.

Cooperation by fishermen with this requirement is generally felt to be good although trawlers cannot promptly reposition themselves or haul in their gear if they should, for whatever reason, get in one of the lanes. Pleasure boats and fishing boats, for the most part, are not equipped with VHF capability (they guard primarily 26.38 and 26.70 megacycles). Nevertheless, when such pleasure craft are inside the TSS, they are governed by the rules prescribing direction of traffic and prohibiting anchoring. Compliance with the bridge-to-bridge-radiotelephone statute requirements and regulations thereunder is felt to be fairly good, although sometimes when pilots are depending upon their own VHF radios (in the rare cases when foreign-flag ships do not have permanent VHF equipment on the birdge), pilots have been suspected of turning off their radios to save their batteries! Since pilots are not required in the Straits of Juan de Fuca, there is sometimes a language problem with vessels making pre-entry reports from that area.

The regulations provide for specific authorization to deviate from the rules (33 C.F.R. § 161.109). This investigator was informed that minor deviations, *i.e.*, those not involving navigational or safety problems, are granted at the rate of about one per week (*e.g.*, deep draft vessels in the vicinity of Partridge Bank as discussed *supra*). It was estimated that perhaps four times a year, on the average, an emergency deviation is authorized. The operators of the vessel traffic system are also empowered by the regulations (33 C.F.R. § 167.107) to issue "directions". It is estimated that such directions are issued at the average rate of one per day. Usually they have to do with speed during restricted visibility. Compliance with a request to reduce speed can be confirmed by comparing the actual time of arrival at the next check-point with the original ETA or the recomputed ETA. If disobedience is detected, a daily violation report is processed through channels to other units of the Coast Guard for enforcement.

Rosario Straits, because of their narrowness, require some what different procedures (App.-6). Vessels are required to report 15 minutes before entering the TSS at either end of Rosario Strait, at which time the ETA and point of entry must be given (33 C.F.R. § 161.172). Vessels are prohibited from entering the Rosario Strait unless they have made a preliminary radio report; their radio equipment is operational; the vessel is free of any defective conditions effecting navigation; and during periods of visibility under two miles, the radar on the vessel is in operation and is manned. Even ferryboats on scheduled routes, which are elsewhere exempted from the reporting requirements when crossing the TSS during daylight hours, must report before crossing Rosario Strait. Tugs with tows must be able to cross 1828 meters (2000 yards) ahead of oncoming traffic or else they will be held back and required to go astern after the traffic has passed. Vessels over 75,000 tons deadweight may proceed only one at a time and then only if visibility is in excess of two miles (day or night) and the wind is under 25 knots. If there is any question about the vessel's ability to safely navigate it may only proceed with no other traffic meeting it or moving in the same direction in the strait.

FURTHER IMPLEMENTATION OF THE SYSTEM

The next addition to the VTS for Puget Sound will involve radar coverage of the Admiralty Inlet area using naval radars presently in inventory ("off the shelf"). Antenna installations will be made at Point Wilson (Port Townsend), at Bush Point (Whidbey Island), at Point No Point (Kitsap Peninsula), and at Pier 36 (Seattle). Operating at eight mile range settings, these antennas will completely overlap the Admiralty Inlet area south to Seattle (App.-7).

The radars are Fairchild-Hiller Model SPS-51's and operate in the X band (three centimenter) wave length. Although they have greater range, they will be utilized at the eight mile range for overlapping coverage and optimal resolution. The antennas will be placed on towers to give them a height of 27.4 meters (90 feet) above sea level. Data from the remote antennas will be microwaved over leased microwave links (owned by Pacific Northwest Bell) on a ten megahert 2 band.

The displays and consoles will be divided into sectors with one module for each antenna. A roving cursor can be positioned by a device on the console and will provide a readout of range and bearing between selected target pairs. There will be no circuitry for masking or supressing images from selected areas and target acquisition will be accomplished visually by the console operator.

Although the concept of having the pilot board with a radar transponder has been considered at the national level of the Coast Guard, it is not presently envisioned that such a system will be in use in the radar surveillance phase of the Puget Sound VTS. Computerized processing of the radar data, synthetic displays, automatic tracking, and CPA/ETCPA computations are not planned for this system. Nor is any memory device creating "history" displays of the past course of a vessel or vector displays to indicate, based on instantaneous course and speed, where the vessel will be at selected future times. Coast Guard designers feel that computers would be beneficial to communicators in times of heavy traffic, but since the vessels are moving in a two-dimensional medium, the level of sophistication of the NAS program would not be required. The radar hardware that will be used could be converted to a computerized display with only a minimum of adaptation, officials say.

The capital costs of the Puget Sound VTS, when augmented by radar in Admiralty Inlet, will be $2 million. Annual operating costs (exclusive of depreciation and overhead) are projected at $673,794 for fiscal year 1976.

USER PERCEPTIONS

The material on which this section is based was gathered by means of personal interviews with officials of the Puget Sound Pilots Association, the Pacific Northwest Towboat Association, the Washington State Ferry System, and a pair of ocean phycisists whose experimental station was near the TSS off Elliot Bay (Seattle). Its inclusion is felt to be worthwhile to provide a forum for differing perspectives on the system.

The Pilots Association representative responded primarily on an emotional level, the tenor of which was set by the following remarks:

> "We know where we are . . .the pilot is not lost! [The VTS concept] was a political gambit.... The hazards and risks are all in the naive imaginations of these meddlers and busybodies [the environmentalists]...it's just a routine job for us [to safely navigate vessels]."

After discrediting the need for the VTS and casting suspicion upon the motives underlying its origination, the pilot went on to say:

> "We like the VTS...we've worked with them [the Coast Guard] from the start...the VHF [Bridge-to-Bridge Radio-telephone Act communications requirements] was a tremendous improvement and enhanced vessel safety and collision avoidence immeasureably."

In fact, what operational criticism the pilot representative had was directed to the radio communications problem. Since the pilots and masters must by law communicate over channel 13, this pilot found it annoying that the VTS insisted on too many reports being made over the same frequency, resulting in message congestion. He reported that he could not get on the air when he reached the checkpoint and sometimes was a mile-and-a-half beyond the checkpoint before his turn came to report in. Although the pilot did not suggest this, it is conceivable that excessive delays would diminish the incentive to call in once the checkpoint had been passed. The pilot suggested that tug operations which were taking place outside the lanes of the TSS might either be eliminated or drastically reduced in terms of the reporting requirement, thus alleviating the present message congestion. He felt that pilots and masters on deep-water ships (both foreign and U.S. flag) did, in fact, guard the required channel 13 frequency.

In response to a question about the size, positioning, and efficacy of precautionary areas within the TSS, the pilot felt that it really made no difference since the same amount of vigilance and care was used whether one was inside or outside the precautionary area. By implication, the pilot suggested that speed was not reduced when passing through a precautionary area unless a close-quarters situation was shaping up.

The suggestion to get the towboats exempted from the requirement to report at checkpoints, to request initial clearances, and to report termination of movements was seconded by the Operations Coordinator of the Washington State Ferry System. He too felt that such reports cluttered up communication. All but two of the ferries in operation by the Washington State System have two radars and those two have one each. All the masters of the ferries have radar endorsements and the coordinator felt that they all had "rapid radar proficiency," that is, they could plot and make navigational decisions within realistic time constraints. The ferries utilize band scanners in order to moniter channel 13, and to stay in touch with channel 16 (the emergency frequency), channel 6 (the towboat working frequency), channel 79A (the ferry working frequency), and channel 11 (the Canadian bridge-to-bridge frequency). By using a scanner, two receivers can be utilized to monitor several frequencies simultaneously. One receiver is left permanently on channel 13 and the other receiver is, by means of the scanner, rapidly and reiteratively tuned to the remaining channels until a transmit signal is detected. At such time, the scanner locks on that communication so that it can be heard over the loudspeaker. This device was felt to minimize the cost of radio receivers and reduce the temptation to shut off the receivers entirely because of excessive "noise", while still enabling the bridge personnel to fulfill their legal requirements and not miss pertinent messages.

From the standpoint of more economical and efficient operations, it was suggested that ferries moving from Edmonds to Elliot Bay for fueling late at night could be exempted from using the TSS and could hug the Seattle shoreline. Similarly it was suggested that the Indianola-to-Kingston ferry (around President Point on the Kitsap Penninsula) should not have to deviate far to eastward to get in the northbound lane of the TSS. Not only is this time consuming and longer but it necessitates one west-to-east crossing and one east-to-west crossing of the southbound lane each time this particular transit is accomplished. There is adequate water depth west of the southbound lane for this looping transit to be made entirely outside of the TSS.

The communications congestion problem and the concomitant time delays of unneeded radio reports were also stressed by the executive vice-president of the Northwest Towboat Association. He illustrated the cost and utility of the reports with two examples. In the first a tug was moving a log boom approximately a quarter of a mile inside Olympia Bay and was required to make four reports to the system: one 30 minutes before leaving, one 15 minutes before leaving, one when getting under way and one when it had completed the move. Similarly, a tug moving an oil barge from the pickett buoy off Duwamish Head in Elliot Bay to a Mobil oil dock, a run that took approximately 15 minutes and was to be done in broad daylight, had to lay alongside for 30 minutes in order to complete the reporting in sequence. Since the tug hire was $400 an hour, the client was charged $200 for standing by, in order to comply with the reporting requirements on a relatively trivial move.

The towboat representative also stressed that the VTS was not really needed but that his association was not against it. He did add, however, that the Association was opposed to improper implementation. He had further reaction to the lanes of the TSS which he referred to as "speed lanes". He felt the "going" speed in the lanes was at least 17 knots and that the Sealand containerships (with top speeds of 33 knots) ran through the lanes at between 27 and 28 knots. Since tugs with tows go far slower than these speeds, it is actually hazardous for them to comply with the lane system and navigate in the lanes with the fast-moving ships. He was not against the idea of separating traffic moving in opposite directions, but felt that tugboats should operate outside (to the starboard of) the lanes whenever possible, and that a maximum speed limit should be placed on deepwater traffic in the lanes. He felt this to be particularly necessary in the area of Point No Point (he suggested a maximum speed of 15 to 16 knots with a speed reduction beginning at Skunk Bay so as to take headway off a vessel by the time it reached the vicinity of Point No Point).

He contended that tug and tow movements in the greater Puget Sound area have numbered as many as 3700 per day, whereas the average number of transits by deepwater vessels in the greater Puget Sound area is 11 per day. The suggestion was that, in terms of ton-miles or movements, there was no reason to design the TSS with solely the deepwater ships in mind or to give them all the perogatives over slower-moving commercial and recreational traffic.

The ocean physicists have conducted experiments from a towing vessel operating at 4 knots or less. They reported that during a recent visit of the British-flag vessel, Tower Bridge, the pilot had not participated in the vessel movement reporting system over channel 13 after he boarded at Port Angeles. As a result, the Coast Guard VTS was uncertain of his whereabouts and could not advise other vessels of his approach. Moreover, the original ETA proved to be three hours after the time of his actual arrival off Seattle and therefore dead reckoning plots were not useful to the Coast Guard communicators. As the *coup de grace*, the pilot apparently navigated the vessel to the wrong side (in terms of the TSS) of buoy Sierra Hotel off West Point (App.-7). As to whether there is a right and a wrong way to transit a precautionary area (such as that surrounding bouy SH) see discussion in the next section.

This same pair of scientists reported that the Princess Margarite close-shaved them once while obviously speeding in the fog (traveling at a speed that would not enable her to stop in half the distance of visibility). These scientists also reported that an inexpensive four-channel VHF crystal receiver capable of monitoring channel 13 was available for a price in the neighborhood of $90 and would be invaluable for pleasure boaters to have on board for advisory purposes even though they were not obliged to make reports.

They also felt that pilot identification would serve a sorely needed surveillance and admonitory function as some pilots were definitely more prudent in their maneuvering practices than others. (This sentiment was echoed by representatives of the towboat industry and the ferry boat industry.) The officers in charge of the Seattle VTS felt that pilot cooperation is highly desirable and will be gained by staying away from pilot identification which they felt might intimidate the pilots or make them feel anxious or insulted. In any event, the communicators can sometimes recognize the voices of the pilots as they make their reports and the VTS operators take the position that they do nothing differently regardless of who is piloting since in every case they offer full and complete advice to the piloted ship and to other ships about the movements of the piloted ship.

ANALYSIS

The choice of Admiralty Inlet as the first place to install radar surveillance is justified on the basis of a simulation done by an interdisciplinary team from the University of Washington (see Oil on Puget Sound, pg. 137-38, University of Washington Press 1971). Five Puget Sound channels were considered, using a model developed by the Sperry Piedmont Co. for predicting the probable number of vessel collisions in a channel of a given configuration. They were the Straits of Juan de Fuca, Haro Strait, Rosario Strait, Admiralty Inlet, and the east and west passages around Vashon Island. Although the ultimate interest of this study was collisions leading to the spill of oil, the number of collisions per year was determined to be highest in the Admiralty Inlet area, both historically and as computed for the year 1970 by using the model (*see Id.* at Appendix 13 Tables 13-2 and 13-3).

see With regard to the relatively open sea area centered around the precautionary area marked by buoy Romea Alfa, and with regard to the Straits of Georgia, the Sperry model was not workable as it was limited to relatively narrow channels. A comparison between the two open water areas was possible by using a two-dimensional, free gas model that was thought to be reflective of the less restricted courses of ships in these areas. This computation was carried out by weighing the various areas according to the channel-to-channel cross traffic (with reference to the other five channels identified elsewhere in the study). Since the simulation model looked 20 years into the future, a "deflation" factor was used to account for the facts that oil as well as dry cargo will move in larger ships, and that vessel size will increase at a greater rate than the absolute growth in commerce, leading to fewer total ship transits in a given time period. This was further weighted to adjust the deflators for tanker size increase which will be much more dramatic than the increase in size of packaged cargo vessels. This comparison showed that there is greater collision risk in the area off buoy Romeo Alfa than in the Straits of Georgia (App.-5).

The projected results of the program over five year intervals up to 1990, for the number of collisions having oil spills in a given year, again show Admiralty Inlet to be the most spill-prone area (*Id.* Appendix 13 at Table 13-15). The program took into account not only the ship movements along the channel but also ship movements traversing the channel (*Id.* , Appendix 13 at 584).

Insofar as speed limits are concerned, some interesting findings were developed by a Department of Transportation-US Coast Guard contract study. This risk analysis study showed that for a parallel approach scenario (*i.e.* the type one would expect to find in a meeting situation in a narrow channel, such as the deepwater route through Admiralty Inlet), the chance of an oil spill actually diminishes as the vessel's speed increases above eight knots. Obviously if a collision were to occur, shell plating would definitely rupture on single-skin ships. But the time of exposure to collision in such meeting situations is sufficiently reduced at higher speeds that the actual risk of collision, and the concomitant risk of oil spill, become slightly reduced (*see* Spill Risk Analysis Program, Phase II, [DOT-CG-31571-A] 47, 99, 118). However, this finding does not address itself to the human safety factor from displacement waves, collisions with pleasure craft, or ferry boats on crossing courses, etc.

With regard to Rosario Strait, Coast Guard officials felt that pilots and masters have complied with the spirit of 33 C.F.R. § 161.174 and the comments thereto which encourage pilots to adjust the speed of their vessels so as to limit movement of large vessels through the Strait to one direction at a time. The Strait itself is 13 miles long, so bridge-to-bridge radio communication is possible between two ships before either of them enters the Strait or commits itself to such an entry (App.-6).

The Coast Guard is well aware of the message congestion problem in the Seattle VTS area, but without radar surveillance it is difficult to know which reports should be deleted. One approach, suggested by the commander of the system and now under evaluation at higher headquarters, is to incorporate some of the data reported in the follow up report (15 minutes before departure) in the initial report, and thereby obviate the need for the follow up report. A second proposed modification was to divide vessel traffic into two catagories: ships traveling at eight knots or faster; and ships proceeding at speeds of less than eight knots. The latter category of vessels would not be required to operate in traffic lanes at all, thus partially meeting one of the concerns of the towboat industry. Under this proposed modification, if such vessels and their tows were to enter a traffic lane, they would have to report ten minutes previous to the estimated time of entry and they would have to report when departing the traffic lanes. While outside the traffic lanes the slower moving traffic would not have to make periodic reports as it passed check-in points. The slow-moving traffic would not be exempted under this proposal from guarding channel 13, and thus would still receive the usual navigational information by listening to other persons' reports and to advisories from VTS personnel. The VTS dead-reckoning plot board could be updated at times of sparse channel 13 usage with intervals of several hours between querying slow-moving traffic. Whether or not the exemption from the reporting requirements would result in a relaxation of the effort to monitor channel 13 is problematical.

No effort will be made to actually direct traffic by the Puget Sound VTS. Advisories of traffic and weather conditions to be met by an oncoming ship will continue to be given, as will suggestions if a speed adjustment or alternate routing seems feasible and called for by special circumstances ahead. In the event a ship was in an emergency situation due to some casualty or to the failure of both of its radars in a low visibility situation, the communicators would simply direct the vessel to leave the traffic lane and seek a safe anchorage outside the fairway until such time as the problem could be corrected. No effort would be made to conn the ship down the lane from the vessel traffic system control center.

One of the greatest inherent difficulties with any TSS is the presence of pleasure boats and other small craft following random courses and not equipped with sophisticated navigation equipment. It is all well and good to say that certain lines are printed on the chart denominating the boundaries of the traffic lanes. The hard fact remains, however, that there is nothing to be seen on the water (except the occasional center line buoy which is, on the average, six miles from the next such buoy) by means of which the small boat mariner can determine the boundaries of the lane. Of course certain general rules of thumb can be utilized such as "stay close to shore," or "stay far from the general direction of any deep water traffic". But commercial and sport fisherpersons may be out even in times of limited visibility when such general guidelines would be of little use. Obviously something is needed whereby the small boat owner can get a definite fix on his position by very simple reference to a chart. Until such time as the River and Harbor Aid to Navigation System (RIHANS) is fully developed and operational, greatest hope must be placed on the private sector merchandising low-cost position determining equipment. Teledyne Corp. has developed a Loran C receiver coupled with a minicomputer (equipped with a read-only memory and a light emitting diode readout) which is light weight and can give highly accurate position coordinates instantly. It is reliably estimated that if a market of 100,000 units or greater were established, the receiver-minicomputer unit could be priced as low as $300. Whether pleasure boat owners and fisherpersons would voluntarily spend the money to acquire such equipment, carry up-to-date charts, and learn to use the equipment and the charts to ascertain their position is an open question. Perhaps the equipment would have to be made mandatory to assure its acquisition. Even so, there is no guarantee that just because a person knows where he is he will refrain from entering the lanes except when necessary to transit to the far side.

Admiral Kenneth Ayres of the Pacific Northwest Towboat Association has pointed out that the explanatory comment to 33 C.F.R. § 161.156 which provides that "small vessels should not impede the passage of 'radio-equipped vessels' in the traffic lanes" could be inconsistent with the very next sentence of the comment which requires obedience to the Inland Rules of the Road. Assuming that ferry boats are not within the meaning of the phrase "small vessels", consider the situation of an inland waters tug proceeding without a tow from west to east across the southbound lane of the TSS. Assume further that a southbound vessel is coming out of the north. Under the Inland Rules the tug is the privileged vessel and is obliged to hold its course and speed (33 USC § 54 Art. 19 and 21), yet under the "shall not impede" language it would seem that the tug would have to alter course to port and reduce its speed if there was a possibility that by not doing so it would "impede" the southbound vessel. Under the assumed circumstances it would be impossible for the vessel to carry out the mandates of the two consecutive sentences in the explanatory comment. Even assuming that the crossing rule were to be suspended inside the traffic lanes, there is the previously discussed problem of knowing exactly when one enters the lane. Considering the distances and times involved, this would be a much more acute problem than knowing when one has passed the line of demarcation between areas where the International Rules apply and areas where the Inland Rules apply.

Finally the problem of the precautionary areas deserves mention. 33 C.F.R. § 161.152 (d) requires that ships transiting or turning through precautionary areas shall keep the center buoy always to port. Obviously this was not done in the case of the TOWER BRIDGE incident described earlier. One possibility to enhance obedience to this section would be to have a circular traffic separation zone with the marker buoy as its center. Thus the precautionary area would take the configuration of a round-about as is occasionally used for vehicular traffic on land. The benefits of such a scheme would be to reduce the chances of corner cutting and to provide greater separation when two or more vessels converge in the precautionary area. The disadvantage would be extra steaming time, the need for ships to hold continuous curving courses and the aforementioned difficulty of relating an area of water to a designated a area on a chart, while moving at normal speeds.

Apparently the system communicators make no effort to record whether or not meeting or overtaking vessels have negotiated a passing by means of the channel 13 frequency. Of course it is possible that the ships have negotiated the passing by whistle signals; or that they are in a meeting situation but are not head and head, or nearly so; or that they are in a crossing situation. In such cases no negotiation is required by the Inland Rules. Of course insofar as meeting vessels are inside the TSS and are using the lanes, there would be no need to negotiate a passing since all passings would automatically be port to port. Traffic outside the TSS is most likely to be either very slow moving or on random, changing courses so that efforts to anticipate meetings would not be particularly productive on the part of the communicators. It would seem worthwhile, however, to keep special records with regard to traffic entering and leaving Commencement Bay, Elliot Bay, Bellingham Bay, Bellingham Channel and the Guemes Channel much the same as such attention is given to traffic entering and leaving Rosario Strait. Such attention might include a confirmation that passing arrangements had been made if it was not evident from monitoring channel 13 that such was the case.

The Coast Guard has determined that a VTS such as that which will serve the Admiralty Inlet area of Puget Sound could reduce collisions by 63 per cent and groundings by 50 per cent, compared to the casualties to be expected without such a system and without mandatory bridge-to-bridge communications (*see* Oceanographic Commission of Washington, OFFSHORE PETROLEUM TRANSFER SYSTEMS FOR WASHINGTON STATE V-52, Table V-51 [1975]). An analysis of the Coast Guard study is beyond the scope of this paper, but it is noted that the preponderant share of the improvement comes from the bridge-to-bridge communication requirement. In terms of the estimated composite reductions of property damage, pollution, deaths, and injuries, the Puget Sound VTS in its present configuration (*i.e.* without radar surveillance) was rated fourteenth out of twenty-two relative to reductions attributable to hypothetical VTS in other ports and waterways. This estimate is based on historical data from Corps of Engineers records and does not take into account the anticipated increase in traffic and tonnage in Puget Sound resulting from the Trans-Alaska Pipeline System.

This same study indicated a vessel-movement-reporting system can be expected to reduce collisions (as opposed to rammings and groundings) by nearly 50 per cent. By comparison a TSS was estimated to reduce collisions by 25 per cent and a simple radarized system was credited with a 60 per cent reduction (USCG Port Needs Study at 30). Although rational guidelines were employed, the ultimate estimates were subjective (*Id.* at 23). The study assumed a VTS was unable to prevent collisions due to: mechanical failure of on-board equipment; pleasure craft; ramming of piers or dolphins while docking or undocking, or ramming of navigation aids; groundings due to set of current or wind, groundings of barges due to broken tow lines or groundings due to (undiscovered?) channel silting; or rammings of uncharted submerged objects (*Id.* at 16).

the San Francisco vessel traffic system

GEOGRAPHY AND NATURE OF TRAFFIC

The San Francisco system employs a TSS but because of the narrowness of waters within the Bay that have sufficient depth for deepwater traffic, no separation zone is used. *See* App.-9,10. Instead there is simply a separation line with the one-way lanes abutting each other on opposite sides of the line. The TSS begins at the seaward edge of Potato Patch Shoal where the dredged channel begins. It extends inward under the Golden Gate and splits around Alcatraz Island where it enters a precautionary area just east of Alcatraz. One set of lanes then diverts northward just east of Angel Island and the Tiburon Peninsula toward the west span of the Richmond-San Rafael Bridge and thence up into San Pablo Strait. A second branch goes southward for about two miles below the San Francisco-Oakland Bay Bridge. The area south of Yerba Buena Island, and east of the northbound lane of this southern branch leading to Oakland Outer Harbor and Oakland Inner Harbor is defined as a Limited Traffic Area. (For a discussion of procedures in this area see p. 22, Equipment, Organization and Procedures *infra.*)

Although the system at the present time is voluntary, there is a definite probability that compliance with the system will become mandatory in the future. The traffic separation scheme procedures apply to vessels of 300 gross tons or over, except for ships engaged in intraharbor movements whose routes do not "infringe" upon the TSS. (Pub. Notice 12-55, V.C.2. March 1, 1973). Other vessels are free to maneuver outside the traffic lanes though when they do enter the traffic lanes (except to cross them) they must comply with the TSS procedures. Vessels are encouraged to join and leave the traffic lanes at their ends or in the precautionary areas. Vessels crossing the lanes should cross at as close to a right angle as practicable while those joining or leaving the lanes should enter or depart respectively at as shallow an angle as possible. (Public Notice No. 12-55 SFVTS Operating Procedures V.C.)

The San Francisco waterfront is active

primarily south of the Bay Bridge where passenger ship terminals and a Lighter Aboard Ship (LASH) facility are located. Containerized ships berth primarily at the Oakland piers while tankers turn north to the Richmond, Molate Point, and Point Orient oil terminal piers. Some deepwater traffic proceeds northbound through San Pablo Strait to the Sacramento deepwater channel or up the San Joaquin River to Stockton. These ships are typically bulk carriers. A ferry makes frequent runs from Sausalito in Marin County to the San Francisco waterfront. Tour boats leaving from San Francisco make circular runs out to the Golden Gate, around to Alcatraz Island and back to the San Francisco waterfront. Infrequently, bulk carriers turn southward to Redwood City. Naval vessels arrive and depart from Treasure Island and Alameda. Major shipyards are located at Alameda and at Richmond.

Tug and barge traffic upriver is greatly reduced from earlier years but is still not inconsequential. Railroad car barges proceed across the Bay at least twice a day. There is no log raft traffic. Pleasure boats are moored at marinas throughout the Bay and sailing regattas frequently take place in a triangular area with apexes at the Tiberon Peninsula, the Golden Gate Bridge and Alcatraz Island or variations thereof.

Recreational Areas dedicated to pleasure boating and sailboat regattas lie close inshore on the northern San Francisco waterfront and in Richardson Bay and Racoon Strait north and west of Angel Island. Insofar as Very Large Crude Carriers (VLCC's) are concerned, it is unlikely they will proceed into San Francisco Bay because the controlling depth is fifty-five feet in the area of Potato Patch Shoal outside the Golden Gate. Also, the refinery piers are presently maintaining depths of only thirty-four feet. Tankers and tank barges comprise only 13 per cent of the vessel transits in the Bay, but petroleum and chemicals constitute 70 per cent of the total seaborn commerce by weight (USCG Port Needs Study; Appendix D-2).

Coastal fog is quite common in the Bay, especially during summer evenings and early mornings, and occasionally during December and January. Fog tends to concentrate under the Golden Gate and in the area north of San Francisco. It sometimes penetrates as far inland as Suisun Bay to the north. The precautionary area east of Alcatraz Island is thought to be relatively fog free.

EQUIPMENT AND PROCEDURES

Most of the San Francisco VTS area is under radar surveillance. Antennas at Point Bonita outside the Golden Gate and at the Center facility at Yerba Buena Island provide coverage from the pilot boarding station in the west to Point San Pablo in the north and almost to the San Mateo Bridge in the south. The Point Bonita radar facility is fully redundant except for the antenna. The radar data is sent, after PPI scanning by TV camera, by microwave to Yerba Buena Island. The radar system is completely solid state and was custom designed to Coast Guard specifications by Airborn Instrument Laboratories (a division of Cutler-Hammer). Although normally operated on the sixteen or eight mile ranges, the radars can operate at 32 mile range and they have offset display capability. At a range of one nautical mile they have resolution down to thirty feet and down to 3/10th of a degree. The antennas have the capability of circular polarization which is felt to be effective in eliminating rain clutter. They rotate at 20 RPM.

Because of the danger of shoal water outside the TSS lanes, most of the buoys mark the exterior boundaries of the respective lanes and only five center line buoys (plus an Oakland Bay Bridge pier) are utilized as references for the separation line. The buoys are equipped with radar reflectors, and the large navigational buoy at the approach to the VTS area outside the Golden Gate is a racon buoy. Coast Guard officials estimate 90 percent compliance with the TSS lane system (*see* p. 27, Analysis, for an evaluation of the justifications for non-compliance).

Radio reports over channel 13 on the VHF are expected prior to departing a berth or anchorage; when entering or departing the waters of the VTS area; and when passing buoy Sierra Foxtrot (the offshore approach buoy), Hunters Point, Oakland Inner Harbor light No. 4, Point Potrero (in Richmond Harbor), and Point San Pablo (App.-9). Such reports are to be kept terse and should include only the vessel name and pilot unit number, movement information, position at time of report, ultimate destination, and other relevant information such as pilot changes and lightering. The communicator notes the salient features of these reports on a 3 1/4 inch X 7 1/2 inch preprinted card (*see* App.-12) along with the vessel's draft, if reported, and, in some cases, the estimated and actual times of arrival at the successive reporting points (in actual practice many of the entries are only the actual calling-in times). These cards are simply laid flat on the edge in front of the communicator's radar console in a left-to-right orientation generally representing the west-to-east location of the ships as confirmed by radar sightings. Speeds and courses are not requested or recorded but communicators feel that they can determine direction from the excellent radar resolution, which shows the wakes and displacement waves of the vessels, and that they can estimate speed fairly accurately by watching progress between familiar landmarks.

There is complete redundancy on the radar and microwave linkages (except with regard to the antennas) and on the VHF radio transmitters including the one positioned atop Mount Diablo for transmission up the rivers and through the Delta. While this investigator was present there was a minor equipment malfunction which caused the radar picture to disappear. The total function had been restored and the system was back on line within ten seconds thanks to the backup hardware. The communicators were confident that if a ship's pilot were to report a radar malfunction at night or in times of limited visibility, they could give the pilot such accurate advice by means of their radar surveillance that the ship could be guided to a safe anchorage area. The only shadow area for radar echoes is the area immediately to the west of Yerba Buena Island, but this area is easily "watched" by the Point Bonita radar and therefore the surveillance can be maintained on the PPI of the Point Bonita sector.

The consoles are presently divided into two sectors: one pertaining to each of the radar antennas. When a vessel crosses from the coverage of one sector into the coverage of another, the "handoff" is accomplished by the communicator manually sliding the card referring to that vessel across to the other communicator.

When vessels proceed beyond Point San Pablo and thus pass out of the radar surveillance area, they are still on the VTS and there is an informal understanding that they will check in as they pass Port Chicago (Concord) and New York Point by VHF radio. Ships heading for Sacramento can be located by monitoring channel 13 as they communicate with the Rio Vista bridge tender. Thereafter, they are requested to report as they pass light 51 at the start of the Sacramento Deepwater Channel and when they arrive at Sacramento. The latter report is often obtained by monitoring the ship's communication with the Sacramento Port Authority on channel 13, as it enters the turning basin. For tug-and-barge traffic using the Army Engineers' locks and proceeding eastward (and ultimately northward up the Sacramento River), there is a stoplight at the east end of the lock canal indicating whether there is traffic heading eastward in the canal. This serves as a warning to traffic coming south and preparing to make the 90-degree turn to go westward through the canal toward the locks (*See* 33 C.F.R. § 207.640 [q][3]; U.S. Coast Pilot 7, p. 94 [11th ed. 1975]; NOAA Chart 18662 [6th ed. April 1975]).

The VTS can tell when vessels proceeding up the San Joaquin River to Stockton reach the Antioch Bridge by monitoring the channel 13 communications with the bridge tender. There is an understanding that the inland pilot will call in to the VTS when he passes Prisoner Point and when the vessel reaches the Stockton turning basin.

Tracking of vessels moving upriver (or downriver) is accomplished simply by taking the cards earlier referred to off the ledge in front of the radar console and stacking them upright on a bracket projecting from the face of the console. No effort is made to color code them for direction and they may or may not be reshuffled to reflect the passage of other ships. Communicators report that visualizing the present position and direction of the ships is no problem and say the most they have ever had up there at one time is eight vessels.

Harbor pilots report that they call in to the VTS whenever they are passing underneath the Bay Bridge, the Richmond-San Rafael Bridge, or the San Francisco Golden Gate Bridge; when they are effecting pilot changes; and when they pass Point Blunt on Angel Island. All of these reports are in addition to that called for by the Public Notice, but they seem appropriate especially since the blip on the PPI may be lost momentarily when vessels pass underneath the bridges. Docking pilots also report that they call in five minutes before leaving a pier and again when they leave. While this falls short of the 15 to 30 minutes suggested by the Public Notice, it does show a spirit of compliance. The communicators are especially anxious for early reports with regard to ships departing the Oakland Inner Harbor or the Oakland Outer Harbor. Vessels in this area will be going through a Limited Traffic Area and the Public Notice says that "it is the intent . . . that [this area] be utilized by only one vessel at a time or by vessels proceeding generally in the same direction. However under favorable conditions and only after a clear understanding has been reached between vessels as to the point and manner of passing, two vessels may agree to pass within this area." The communicators feel that they have succeeded in keeping traffic one way within the Limited Traffic Area. They assert that they can do this by mental dead-reckoning, by watching their radar scopes, and by giving advance advisories to traffic planning on entering or leaving the area (*see* p. 26, User Perceptions *infra*, for the views of a harbor pilot).

There is no report required for a vessel crossing the TSS. Charter fishing boats (for example, those leaving Fisherman's Wharf) do not customarily report when cutting across the lanes, even though some of them may be required to have channel 13 capability under the Bridge-to-Bridge Radiotelephone Act. Harbor tour boats do advise the VTS of their departures from the San Francisco waterfront. Since they run on fixed and familiar courses, they can be depended upon to cross the lane approximately five minutes after their departure report and the communicators have no difficulty recognizing their blips on the PPI.

VTS officials report only minor difficulty with people fishing in the TSS lanes. Since it is against the Rules of the Road for a fishing boat to obstruct a fairway (33 USC § 154, art. 26), violators could be cited if they are identified and detected. Again, there may be some difficulty in proving that the violator knew he was within one of the traffic lanes, although if his craft were equipped with a fathometer, depth readings could serve as a pretty good rule of thumb for determining the boundaries of the traffic lanes in most parts of San Francisco Bay.

The vessel traffic system manages traffic during times of heavy fog or restricted visibility under the Golden Gate Bridge so that vessels are transiting only one at a time underneath the bridge. The VTS communicators accomplish this by advising speed reduction by one of the vessels so as to avoid the meeting under the bridge.

Officers in the Port Captain's Port Security Division require a Coast Guard escort vessel (usually a 12 meter craft [40 footer] or a 25 meter craft [82 footer]) to escort vessels carrying more than 100 net tons of ammunition from the ammo berth at Concord as far as the Golden Gate bridge. The escort vessel is equipped with a loud hailer and a siren and its purpose is to keep small boat traffic clear of the area in front of the ammo ship so that its maneuvering is in no way restricted. In coordination with this effort, VTS communicators will stall or delay traffic to avoid ships passing in an area such as the Pinole Channel. Although there has been no experience in San Francisco Bay with chlorine barges, Coast Guard officials indicated that similar procedures would be invoked were such a ship to call in San Francisco. Vessels carrying hazardous cargoes are required to give twenty-four hour advance notice of arrival or departure (*see* C.F.R. § 121.14[a]) and are provided with escorts during transit of the Bay.

On the presently operating system, magnetic tapes are maintained of all radio communications participated in or monitored by the VTS. After a retention period of thirty days the tapes are recycled unless a casualty has occurred raising a need for further retention of the recorded communication. An automated camera is also set up to take a still picture of the PPI every three minutes. If a casualty has occurred this film can be processed and will give a series of "snapshots" of the developing maneuvers of the ships involved.

The communicators' radar consoles are also equipped with wandering cursers which can be positioned between any two designated targets by means of a joy stick. A digital readout will then give the range in yards and the bearing of the point of the far end of the curser from the point at the beginning of the curser. Besides having great utility in assisting ships to anchor, this has proven useful in vectoring search and rescue units, especially helicopters to the site of a capsizing, a man overboard, or the like. If the helicopter maintains an altitude of less than 305 meters (one thousand feet) the radar easily locates it en route.

The communicators are usually first-class petty officers or chief petty officers and the watch officer is a lieutenant. The communicator and the watch officers generally make all decisions with regard to advising vessels. The commander who directs the entire VTS operation is of course at the top of the chain of command. The staff is divided into five sections with at least two communicators and a watch officer each, and when not actually operating the VTS the personnel are engaged in an extensive training program which includes riding ships to familiarize themselves with currents, buoys, and visual landmarks firsthand.

PROTOTYPE EQUIPMENT

The computerized radar surveillance equipment has been installed for some time. Using the SFVTS Yerba Buena Island facility as a test bed, developmental changes have been made and reliability studies are in progress. Programs are being de-bugged and display modes are being modified from time to time. VTS communicators already spend some time operating and evaluating the computerized equipment, thus in a sense it is quasi-operational even at the present time. It cannot be said with certainty that this system will ever be fully operational at San Francisco although it may well be the prototype for the projected New York Harbor system. Indeed one of the hard questions that must be analyzed is the cost-benefit issue. Will the VTS capabilities be enhanced in terms of avoiding property and and human losses and environmental contamination sufficiently to offset the installation, operational and maintenance costs of the computerized version?

A wholly synthetic radar display, including the programmed generation of map outlines and, eventually, certain shoal contours is presently being tested. Additionally, software is being designed and developmentally tested by the Air-born Instrument Laboratories of Cutler-Hammer under the acronym of CAPPI for Computer Assisted PPI. CAPPI has tracking ability, and once the communicator "hooks" a displayed echo by encircling it with a track circle (controlled by a joy stick) he can put correlative data into the computer, such as draft, cargo, etc. Thereafter the display will include a simple alphanumeric data block adjacent to the symbol for the identified echo. The computer will assign an identification number by which the communicator could at any future time call up on a separate display all stored data pertaining to that vessel. The communicators are requesting a display modification to enable vessels to be identified by alphanumerics instead of by a computer-assigned sequential number. This request is for two reasons: it is easier to utilize a pneumonic if they can tag the blip with some familiar abbreviation; and second, the inland (river) pilots identify themselves by numbers also and a definite possibility of confusion exists between vessel number and pilot number.

By special console input the communicator can "hook" two different echoes and the computer will display on a separate display panel information about CPA and ETCPA. The computer memory can track as many as 253 targets on each computer (one computer per radar antenna) thus having a capability of keeping track of 500 targets in the present radarized VTS area. With regard to a tracked vessel (*i.e.*, one that has been "hooked" and assigned an identification number) the computer can also display instantaneous heading and velocity. A type code will also appear on the data block associated with the synthetic radar display (for examples of the type code presently utilized see vessel data cards in App.-11, 12).

The CAPPI program also has the capability of providing collision alerts whenever two echoes are closing and have come within a predesignated range of each other. During the developmental period operators have complained that the alerts are not sufficietly discriminatory. A pilot boarding from a pilot boat, a vessel entering a berth, or a vessel passing a buoy close at hand would all be viewed by the computer as an impending collision even though the maneuver in question presented no abnormal risks. Program designers are now seeking to minimize this problem, but operator evaluation will continue to be necessary and desirable.

USER PERCEPTIONS

An official of the San Francisco Bar Pilots Association and a veteran San Francisco harbor pilot were interviewed as the basis for the material presented in this section. Harbor pilots often (though not inevitably) are skippers of harbor tug boats that are used to assist vessels in berthing and leaving berths. Thus they participate in the system in two ways: while commanding their own tugs and while on the bridge of an assisted ship.

The harbor pilot felt that traffic in San Francisco Bay so far as the harbor pilots were concerned (and in terms of total intra-harbor vessel movements) had decreased because ships were larger and were typically containerized, therefore they called only at a single berth and did not shift from berth to berth within the Bay. He felt that the VTS could handle the traffic now because there were so few ships, but contended that it "would never have worked 12 years ago" when there was more vessel movement in the Bay. He further opined that if traffic density were to become very high again he would prefer not to have the TSS, since staying in the traffic lanes might put him "too close to trouble" with less freedom of movement. He also had doubts that the Coast Guard personnel (communicators) could "handle" the increased communications volume. Moreover, he had doubts that they could distinguish radar blips when the vessels were close together in a thick fog. He persisted in this belief even after the proposed tracking and data block display capability was explained to him.

With regard to communications on channel

13, he thought that the harbor tour boats called in too often and contributed to communications congestion. He also said that when he was on the bridge of a ship and communications got "too noisy" he would sometimes "turn down" the volume on channel 13. If this is a typical reaction it means that the pilots are not zealous about guarding channel 13. Whether the ostensible reason ("too much noise") is the real motivation is not entirely clear. If it is, perhaps some consideration should be given to reducing congestion on channel 13.

With regard to the TSS, the harbor pilot (tugboat master) indicated that if his tug was running light he would stay in the traffic lanes where he could maintain a higher speed. But if he were towing a barge he would deviate to starboard so long as there was adequate draft to stay clear of the traffic lanes. This seems a salutory procedure as it clears the lanes for faster traffic. Commercial traffic should not however deviate or transgress in the Recreation Areas except on an emergency basis.

When discussing piloting of deepwater ships, the attitude towards traffic lanes was somewhat cavalier. The general impression was that all the pilots keep the ships in the lane just as a matter of custom and didn't require any lines on the chart to help them pass port-to-port. Whether or not this custom had always kept traffic under the spans of the Oakland Bay Bridge separated was less than clear to this investigator, however. The harbor pilot also stated that "if no one was around, and visibility was good" many pilots "cut the corner" at the center-line buoy off Quarry Point on Angel Island, while making a dog-leg to the west in northbound traffic. In short, they trespass in the southbound traffic lane. Superficially, the decision to cut this corner seems justified on pragmatic grounds. The pilots apparently do this when they think no one is around, and when visibility is good. But visibility could still be defined as good on a clear night and a pilot could be mistaken. Thus if the practice ever took place at night it is conceivable that the very risks that the TSS was designed to eliminate, *i.e.*, head-and-head meetings, could arise as the result of an undetected southbound ship meeting a northbound ship cutting the corner. Admittedly, this is not a probable occurrance, but for that matter neither are collisions generally, and the whole object of the TSS is to reduce those odds even further.

With reference to the Limited Traffic Area and encouraging one-way traffic inside the Area, the harbor pilot characterized this as, "ridiculous". He said that the pilots always managed to work it out over channel 13 and that the VTS monitored these arrangements and usually had told each ship beforehand of the other's approach. He felt that in virtually every case of concurrent traffic they went ahead and passed inside the zone after an agreement. There appears to be nothing wrong with this: it simply demonstrates that the modal passing situation is occurring under the second sentence of Public Notice No. 12-55 V. D(1) instead of under the first sentence of that paragraph. In short, the exception has become the rule.

Asked for his reaction to the surveillance by radar of pilots' movements by VTS personnel, he responded, "They're up there over ya," and "They could make you into a kind of machine if they went mandatory." He said VTS advice was easily tolerated and was often useful. But he added sometimes they make "recommendations" and those were "tantamount to an order."

An official of the San Francisco Bar Pilots said that the TSS was feared by the pilots at first but, in fact, has worked out "not too badly." He said the Bar Pilots preferred that the system be kept voluntary but asserted that the Bar Pilots were not particularly worried by the "big-brother" aspect of the radar surveillance. He said the resentment might be somewhat at a philosophical level, based on government encroachment over individual enterprise, but implied there was little difficulty at the operational level.

He felt that the Bar Pilots had no trouble knowing when they were in the proper lanes, but felt that the lane system did not particularly reduce the number of head-and-head meetings since the pilots had already treated the Golden Gate Bridge as a narrow channel even before the lanes were instituted.

This official thought that the Long Beach situation where a certain amount of shore control of piloting has occurred, was distinguishable since there a private contractor employs the pilots and also employs the shore-controller. He said that in the unlikely event that the SFVTS attempted shore control techniques, the San Francisco Bar Pilots would want a SFBP member ashore at the VTS center.

He, too, thought that the channel 13 frequency was overworked and pointed out that it was conceived only for bridge-to-bridge communications, not for VTS advisories. He said that it seemed less important to monitor to monitor channel 16 (the emergency frequency) once the pilot had boarded, and suggested that VTS might move to another frequency so that the vessels would only have to monitor 13 and the VTS frequency in place of channel 16.

He said the VTS advisories were beneficial when there was fog or limited visibility and that the pilots appreciated confirmation of proper anchorage from the VTS. He said if the radars went out on a ship he was piloting during limited visibility, he felt that he could bring the ship along on gyro compass and the audible navigation aids alone. He agreed that the VTS would be helpful in such a situation for giving advice to other traffic of the predicament of the radarless ship, but felt that the pilots would prefer not to be "talked in" by the VTS even under these circumstances.

ANALYSIS

Coast Guard officials thought they were getting over ninety-nine percent compliance with the reporting on channel 13 from harbor craft equipped to communicate on channel 13 such as the Marin Ferry, the railroad car floats and harbor tour boats.

Originally the Navy vessels were not equipped for bridge-to-bridge communication, but they are reported to be "gradually coming around" and thus participating in the reports and the advisories on channel 13.

Concern was expressed over the sailboat regatta problem. Apparently, the Recreational Area boundaries do not serve to fully contain the racers and they have cut across the traffic lanes. When the system becomes mandatory, there are no plans to expressly prohibit sailboats from crossing or using the lanes, but officials felt that either the Rules of the Road should be changed or that court decisions would have to start recognizing priority of the commercial traffic in the traffic lanes.

The SFVTS reporting procedure calls for pilot identification by a unit number. The Bar Pilots use an alphabetic designation and the inland pilots use a numeric designation. Since the number of pilots is not extremely large, this serves as a de facto identification of who is conning the ship. To the extent that the pilots' idiosyncracies and behaviorial patterns are known to the VTS communicators and to others in the industry, this would seem useful information. It would serve to warn of the approach of pilots who, although not violating the law, may take greater risks than normal.

There seems general agreement that the channel 13 frequency is gradually becoming congested. If band scanners and multiple receivers are feasible it might be worthwhile to consider having VTS communications on a separate channel. On the other hand, a certain amount of VTS messages, especially those containing recommendations, may follow directly after a bridge-to-bridge conversation. On balance, since the primary motive for creating the mandatory listening watch on channel 13 was to encourage bridge-to-bridge communication, it might be best if the VTS was authorized to use a different frequency. Such decisions will no doubt have to be made following objective studies analyzing average message length, message frequency, waiting time, etc.

A problem which is superficially "jurisdictional", but is in reality a variation of the communications congestion problem discussed previously has cropped up with regard to the San Francisco VTS. As the vessel approaches berth, there are numerous shoreside communications which must be accomplished: customs and immigration officials must be advised of the arrival, longshore gangs and line handlers must be arranged for and assisting tugs must be standing by. Even berth availability sometimes must be verified. This "ship's business" normally is carried on over a working frequency (channel 10 in the Bay Area). Since vessels are required by law to guard channel 13 and channel 16, it is technically impossible (unless 3 different radiotelephones are used) to handle this business while monitoring the other channels. In San Francisco the Marine Exchange handles the bulk of these communications as well as serving as off-hour agents for the Inland Pilots. The balance of it is handled by the port authorities at Sacramento and Stockton for ships destined for those ports. Two solutions for the problems have been proposed. One is for vessels to be equipped with band scanners (discussed at p. 15, Perceptions, *supra*). Another solution is to have channel 16 (the emergency frequency) used as a stand-by frequency. That is, the permanent equipment on the ships bridge could be left on channel 16 and requests could come over channel 16 to switch to channel 10 for a business message. The portable radiotelephone brought aboard by the pilot could then be used exclusively for channel 13 communications.

A variation of this problem is manifested by port authorities in Sacramento and Stockton interrogating approaching vessels over channel 13. Theoretically the port authority should, by monitoring channel 13 messages to the VTS, be able to note the progress of a ship as it comes up river. Apparently the shipboard transmitters are sufficiently weak in power that the ship's reports are not picked up by the port authorities until the ships are quite close. The VTS replies (sent out over a considerably more powerful transmitter) can be heard but they are typically terse and laconic (*e.g.*, "roger, we have logged you") so that often no useful information can be gained by the port authorities. It would seem that the minimal information of progress up the river and ETA at the berth could be split off from the VTS in much the same manner that the Canadian Shipping Information Office will distribute arrival notices by sharing information with the VTM Centre. This would not remedy the need of ship's agents, however, to have more voluminous communications with the approaching ship. This, it seems at the present time, can best be accomplished by some relaxation of the requirement to constantly monitor channels 13 and 16.

Officials said that Navy aircraft carriers (or tugs with large barges in tow) frequently request permission to deviate from the TSS to travel outbound south of Alcatraz Island. These requests are made on the average of once every other day and are generally granted, oncoming traffic permitting. The justification for the deviations is that in times of fog, the fog banks tend to lie north of Alcatraz and there is better visibility to the south. Also, it is easier to take a large vessel, like an aircraft carrier, through a more gradual change of course than having to go north of Alcatraz and then make a hard port turn (this assumes the carriers are leaving from Hunters Point or Alameda, both to the south of the Bay Bridge). Another justified deviation is in the case of inbound deep draft vessels (with a draft between 13 and 15 meters [43 and 50 feet]). Because of the Alcatraz Shoal, these vessels need to be routed north of Harding Rock Buoy and then need to turn starboard and proceed southeast of Blossom Rock Buoy and thence to Anchorage 9 where they can be lightered. Short of a major dredging job, there is no alternative for these vessels and so long as their deviations are announced to other traffic in the vicinity, and do not come at a time when other traffic is committed to pass through the encroached-upon traffic lane, the procedure seems perfectly acceptable.

There is little traffic from the piers on the north waterfront of San Francisco, but it was reported that passenger liners departing pier 35 will cut directly across the inbound traffic lane on their way out, rather than going eastward to the precautionary area and around Alcatraz to get into the westbound lane. This is apparently only done after the pilot advises the VTS and presumably would not be permitted if there was inbound traffic coming through the Golden Gate.

One waterfront official felt that collision-avoidance advisories from a VTS computer would not be too reliable since there was no provision to input data on currents and tides which affect the "set" of a vessel. These phenomena would be appreciated by the pilot on the bridge, but would not enter into the computer's analysis. Surely if NASA computers can set courses for astronauts a VTS computer could calculate the influence of tides and currents. Whether there would be a cost-benefit advantage to such sophistication is an altogether different question. But even without current-tide inputs, it would seem that computer advisories would be a helpful augmentation to the pilot's own wisdom and judgment.

One issue which appears to fall primarily within the authority of the Port Captain's office, but which could easily be monitored for enforcement purposes by the VTS, is the question of speed limits inside San Francisco Bay. There are no limits even for vessels over 40,000 tons deadweight. There are speed limits for proceeding up the deep-water channel to Sacramento, or up the river to Stockton, or just off the waterfront pierhead lines. The reason for these speed limits is to minimize or eliminate surge damage to moored ships* There is apparently insufficient empirical data at this time to make any judgments on whether there should be maximum speeds, especially for very large vessels, while proceeding through pilotage waters in the bay. (*See* DOT's risk analysis model, p. 17, *supra* for the theoretical proposition that speeds faster than "slow ahead" may actually *reduce* the probability of collision in bi-directional traffic areas.)

There are no requirements for any specific number of tugs or aggregate tug horsepower for assisting vessels or for handling flat tows. This is so even for areas like Suisun Bay where ships are moved as flat tows out of the mothball fleet and are frequently met with swift currents and high winds. The Coast Guard is taking the position that tug power is a question of prudent seamanship to be decided on an ad hoc basis by the responsible mariners and their mistakes, if any, will be identified by civil litigation. Admittedly empirical data is not available and *a priori* guidelines are not inevitably superior to the judgment of an experienced mariner on the bridge at a particular time in a particular place. However, it might be advisible at least to develop certain minimum guidelines for such vessel movements.

The system for keeping track of vessels not under radar surveillance as they move up river seems crude at best. It may be workable, as the operators suggest, simply because there are very few vessels at one time up river, but surely some simple visual map board with magnetized markers could be devised to provide a more reliable reminder to the communicators of the location and direction of river traffic. The USCG Port Needs Study ranked the loss reductions hypothetically attributable to a highly computerized system in the Bay ninth among 22 ports and waterways across the nation (*Id.* at 34). A 17 per cent reduction in collisions was predicted for San Francisco VTS in a highly computerized version (*Id.* at Appendix D-1).

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*(from preceeding page) Wash damage to levies is also a function of the speed of passing ships.

legal aspects of vessel maneuvers inside VTS areas

RULES OF THE ROAD

Sound Signals

Pilots and other mariners have indicated that with the advent of bridge-to-bridge radiotelephone communications, sound signals have fallen into disuse (a Puget Sound pilot indicated that sound signals had not been used there for many years even before channel 13 communications became prevalent). No doubt, so far as the masters or pilots of the respective vessels are concerned, verbal communication is superior to a signal on the whistle which may be difficult to hear due to the prevailing winds and topography. Obviously too, the nuances and richness of verbal communication far surpasses that of a coded signal on a whistle. The case for abandoning whistle signals rests on the assumption that a true bilateral understanding has been reached via the radiotelephones. If one vessel has simply announced its intentions over channel 13 but has not received a confirmation that the other vessel heard the communication and assented to it, the risks may be increased over those which would prevail if whistle signals had been attempted. Similarly, reliance upon a traffic separation system as precluding a true head-and-head meeting situation assumes that the other vessel (a) knows where the lane boundaries are, and (b) is planning to comply with the separation scheme. Finally, the whistles provide information to other boats in the vicinity which may not have the capability to monitor channel 13 and thus to be aware of whatever arrangements were made between the masters of the larger vessels. This is particularly true of slip whistles while departing berths along a heavily trafficked waterfront and of overtaking situations. Admittedly radio communications will be superior to whistle communications (one needs only to think of a dredge trying simultaneously to work out whistle agreements with traffic upstream and downstream of its position under the Pilot Rules); but whistles are a useful supplement to the bridge-to-bridge communications. The practice of whistling should not be abondoned merely because the vessel is equipped with a radiotelephone. Moreover, should a collision occur with a third craft not equipped and not required to be equipped to hear channel 13 conversations, a failure to whistle might constitute a Rule of the Road violation which in turn would invoke the *Pennsylvania Rule* (86 U.S. 125, 22 L.Ed. 148 [1873]) requiring the non-whistling ship to prove that its lack of a whistle signal could not have contributed to the collision.

Speed in Fog

Although the present radar annex cautions against overreliance on radar and that range and bearing alone when determined from radar do not constitute ascertainment of the position of another vessel under Rule 16b, it is scarcely definitive of the problems that develop from the use (or misuse) of radar. In *Afran Transport v. the Bergechief*, 274 F.2d 469 (2nd Cir. 1960) the court held that there was no basic duty for a vessel to have radar but that if it *did* have it, it had to be in operable condition and had to be properly used and interpreted when needed. *Accord, Licensee of Parnell*, 1971 AMC 2212. With regard to speed in the fog, the recent Supreme Court decision in *Union Oil Co. v. Tug San Jacinto*, 409 U.S. 140 (1972), reaffirmed the judicial gloss of the "half-distance" rule pertaining to speed in the fog under Inland Rules, Art. 16. This rule essentially says that a vessel must proceed at a speed in the fog such that it could stop within half the distance of visibility. In the case of *The Silverpalm*, 94 F.2d 754 (9th Cir. 1938) the Ninth Circuit Court of Appeals added a gloss upon the gloss by saying that the half-distance was to be computed by using the distance of visibility to a fog bank parallel to the projected path of the ship. The Supreme Court in the *San Jacinto* did not reject the rule of the *Silverpalm*, but held it to be inapplicable to the facts of the *San Jacinto* (a tug proceeding normally downriver on the north bank suddenly making a U-turn out of a fog patch on the north side and colliding with an upbound tanker running along the south bank of the river). The Supreme Court described the tug's maneuver as "totally unorthodox" and found "no relationship" between the *Silverpalm* variation of the half-distance rule and the reasonable expectations of the upbound tanker. Although now somewhat circumscribed and limited to fact situations where a reasonable pilot could expect cross traffic from a parallel fog bank, the *Silverpalm* rule still makes eminent good sense. Nevertheless there seems abundant anecdotal evidence and even some objective evidence (based on elapsed times between check points under confirmed foggy conditions) that ships continue to travel through fog or along the edge of parallel fog banks at speeds in violation of Art. 16. Although radar would not be able to give an accurate account of visibility through the fog, it certainly could record and measure the velocity of a ship and first-hand reports of visibility could be obtained over the VHF radio. Thus radarized VTS's could perform an enforcement-deterrent function with regard to speeding in the fog.

Radar range settings

A second problem involving the use of radar in fog is that of choosing the proper range when observing the PPI. Coast Guard officials in Seattle described the collision of the navy tug Lipan with the tanker Atlantic Prestige in the vicinity of Pillar Point on the Strait of Juan de Fuca. Tha tanker, when approaching a tug and tow approximately head-and-head, had its radar range set so that the tug and tow had just appeared on the edge of its scope when it radioed the tug "we are coming astern of you tug and tow." Being unable to distinguish the blip of the tug from the blip of the tow they assumed they were overtaking instead of meeting. The tug, after receiving the message, checked its radar scope and saw a vessel to its stern. The tug's radar was on a shorter range and it did not pick up the tanker. It thus assumed that the message it just received was from the vessel whose blip appeared behind it. If either vessel had had its radar on a longer range, or if it had made further observations on the radar scope, it is possible that the ambuigity of the radio message could have been straightened out and the collision avoided. Obviously one answer to such problems is to have an all-seeing shore-based radar surveillance system so that more definitive advisories can be broadcast to all ships involved in a closing situation. Another solution might be to require certain ranges on radar and to require repeated frequent observations instead of a single-glance analysis. The difficulty with this is that local topography and traffic density may dictate different range settings from time to time and *a priori* guidelines might be difficult to design.

Apropos to this discussion is the following passage from the Coast Guard findings in the San Francisco Bay collision of the Oregon Standard and the Arizona Standard quoted in MARINE CASUALTY REPORT: Collision involving the SS Arizona Standard and the SS Oregon Standard at the entrance to San Francisco Bay on January 8, 1971 (Nat'l Transportation Safety Board, Dept. of Transportation, Aug. 1971).

"...The Oregon Standard's master used the Raytheon radar to pilot his vessel through the Bay. He kept it on the 5-mile range scale from departure until the vessel drew near Harding Rock Buoy. The Arizona Standard, being more than 5 miles from his ship, would not have appeared on the scope. The master then switched the radar to the 1½-mile scale and kept it on that scale until the vessel was about to pass under the bridge. On this scale the Arizona Standard would not have appeared on the scope until the Oregon Standard was off Lime Point. At that time the master was trying to determine when Lime Point was abeam, to line up the bridge piers on his scope, and to make his course change to pass under the bridge. He may simply have failed to notice the blip of the Arizona Standard at the edge of his scope even if it appeared there....

"...The Decca radarscope was being observed by the second mate. He kept the scope on the 3-mile or the 1½-mile scales until the tankship was off Harding Rock. Then he switched it to the 6-mile scale for 2 or 3 minutes. At this time, the Arizona Standard should have been close enough to be observed on this scale. Yet the mate did not observe her, perhaps because he was absorbed in logging hearings and distances off navigational points, supervising the helmsman, tending the engine order telegraph, listening for fog signals, acting as a lookout and performing other duties of a deck watch officer. He then switched to the 3-mile scale. When the vessel was off Point Cavallo, he switched to the 1½-mile scale until just prior to passing under the bridge. The contact was finally observed by the master when it was just 0.8 mile distant. Most probably the failure of the Oregon Standard to observe the Arizona Standard was the result of neither radar being checked on a range-scale greater than 6 miles, and the preoccupation of the master and of the second mate with their other duties...."

Radar Plotting

An analysis conducted by the Liverpool Regional College of Technology on the basis of a questionnaire survey of 550 masters and deck officers showed that "at most only 25 per cent have sufficient knowledge to use their radar fully in conditions of reduced visibility and the majority of masters at sea take only partial advantage of the full potential of their equipment." (Quoted in Oil on Puget Sound 306 [University of Washington Press 1971]). This same publication reports the establishment of a radar training facility by the Maritime Institute of Technology at Linthicum, Maryland. This facility utilizes a simulation system developed by the makers of Link Trainers for aircraft (a division of the Singer Company). The equipment provides a pre-programed radar display presentation of the passage of the trainee's ship through congested waters with as many as fifteen other vessels, as well as buoys, land points, harbors and waterways depicted. If this training program has proven successful for those who have gone through it, it would seem that these facilities should be replicated to permit many more people to undergo this kind of training or refresher course. Such centers might even be subsidized by the government and successful participation in such a program might be made a prerequisite to obtaining or renewing a deck-officers license. In any event, tests involving radar plotting should be administered on a real-time basis to demonstrate rapid proficiency in radar plotting and analysis. Although a correct solution to a plotting problem obtained after many minutes or hours of laborious work is better than no solution at all, it scarcely serves to demonstrate compentancy to handle realistic maneuvering situations on the bridge of a ship during times of limited visibility. (*See also* Spill Risk Analysis Program Phase II, 102-106 [O.R.I. Contract DOT-CG-31571-A]).

One ranking Coast Guard officer stated that he felt merchant masters were generally not so proficient in "interpreting" radar data as Navy or Coast Guard personnel. He felt that they were particularly troubled by relative motion presentations and hoped that this would be ameliorated by the availability of true-motion displays. He also said that most masters were incapable of performing closest point of approach (CPA) calculations. Again, modern shipboard collision-avoidance computers used in conjunction with radars may solve this problem. When asked whether the merchant marine should be required to have a full-time radar observer in the wheelhouse, he responded that he thought that this depended on the training of such an observer and the attitude which he manifested while standing his watch. In short, a responsible pilot making frequent checks of the radar scope might glean more useful information than a dissultory and untrained AB forced to stand a watch. There was general agreement with the investigator's suggestion that if the only plotting facility is remotely located in the chart room aft of the wheelhouse, this itself is a deterrent to plotting. Even without integrated computer systems, plot boards should be located next to the radar scope in the wheelhouse and personnel should be trained to plot with grease pencils right on the PPI.

Sailboats

There seems widespread agreement among the maritime industry that Article 20 of the Inland Rules of the Road giving a sailing vessel the right of way when it is being approached by a steam vessel on an intersecting course so as to involve the risk of collision is both obsolete and unjustified. In the United States inland waters sailing vessels are, for all practical purposes, pleasure craft. This means they are relatively small and although they go slowly they are more maneuverable than large seagoing craft or commercial tug-and-barge combinations. While this investigator is sympathetic to the human values inherent in recreational sailing, the realities of modern sea-borne commerce can scarcely be ignored, nor can the very real threat to safety which is inherent in the remarks of one pilot interviewed who said,

> "If you slow down to nothing, they [the sailboaters] have you bluffed. They disappear under your bow and you hope they don't take that last tack . . . [you] just lay on the whistle and keep going."

(It should be added that another pilot from San Francisco defended sailboaters saying, "If they are large enough to sail on San Francisco Bay they are usually pretty smart." This pilot, however, had real concern about irresponsible maneuvers by powerboat operators.)

Puget Sound Coast Guard officials reported fairly good cooperation with yacht club officials in staging regattas. In addition to obtaining the required permit from the Coast Guard (and thus affording it advance notice of their plans) officials of yacht clubs are tentatively agreeable to suggestions that races be designed to keep the boats outside of the traffic lanes. Since racers like to make turns around buoys, one problem that must be met is designing and installing some sort of buoy outside of the traffic lanes, preferrably in a designated Recreation Area. Some modification of the sailboat right-of-way rule is required. One solution might be simply to suspend the right of way whenever the sailboat is within a traffic lane of a TSS. Again, the difficulty lies in the sailboat's ability to determine *when* it enters the lane.

ACTIVITIES, REGULATIONS AND REQUIREMENTS UNDER THE PORTS AND WATERWAYS SAFETY ACT OF 1972

Research

Anticipating its responsibilities in the vessel traffic management and oil pollution areas, the Coast Guard and related agencies had undertaken data collection and studies even before the passage of the Ports and Waterways Safety Act. One brief example of this work is the National Transportation Safety Board's report entitled "Analysis of the Safety of Transportation of Hazardous Materials on the Navigable Waters of the United States" (NTSB-MSS-72-2). The report stresses the identification of "risk peaks" which occur during the movement of hazardous materials on waterways. Topographic, demographic, meteorological and traffic density factors are quantified over the course of the waterway and the aggregate risk potentials are compared to locate the "peak". In addition to risk peaks, other factors necessary to produce a catastrophic incident are the presence of hazardous material capable of bringing about large scale injurious events, and a "triggering" mechanism. Once a casualty has occurred there is a fairly good chance of reconstructing its causes and thus identifying the triggering mechanism. This is not a complete solution, however, since there are many ways similar accidents can occur and casualties themselves are sufficiently infrequent to develop any reliable statistical base if the causal paths are not indisputably obvious. However, as the NTSB Report indicates, by using historical data, expert opinion, and the transference of existing knowledge from related areas, it is possible to identify a good number of triggering mechanisms.

Analysis utilizing logic trees or fault trees looks promising. Certainly this method is useful in schematically depicting causal pathways, alternative causes, and the steps in the process where preventative measures would be most effective. For any serious cost-benefit analysis however, there must be some effort to quantify the probabilities associated with the various risk pathways. Given a minimal or non-existant data base, much of these probabilities must be "guestimated" by such techniques as the Delphi process (reiterative estimation by a panel of experts with feedback from the estimates and comments of the prior round). So long as the inputs bear some relation to objective occurrences and are not arrived at simply by "picking a number" for the sake of going forward with the simulation, these techniques are probably a viable starting point. No doubt, sensitivity analyses can be used to give a feeling for reliability whenever a particular input appears crucial.

The Coast Guard is presently conducting a detailed study designed to identify and quantify factors influential in collision avoidance and casualty-free navigation of vessels. Though still in the developmental stage, this model is indicative of an awareness on the part of the Coast Guard that modern analysis techniques may augment the historic (and sometimes elusive) wisdom of the "prudent navigator".

Under an ongoing contract with the Coast Guard's Office of Research and Development, the Operators Research, Inc. (ORI) has completed a Final Technical Report 840 (DOT-CG-31571-A) entitled Spill Risk Analysis Program, Phase II (hereinafter ORI Risk Analysis). This document describes the development of an analytical model and a logical model of spill risks. The former uses three submodels: scenario; energy exchange; and tank rupture. Scenarios include long-range crossings, sudden appearances around heads, and parallel approaches. A "collision region" is sized and located mathematically. It is defined as the area within which a vessel on a collision course cannot maneuver (including accelerating and decelerating) so as to avoid collisions. Parameters used include ship lengths and velocities, turning radii of the deviating ship, deceleration capability of the non-deviating ship, lateral separation distance, and the "response fraction" (fraction of the separation distance encroached upon before the non-deviating ship effects a response). Outputs from the scenario submodel (*e.g.*, which ship is struck by the other, the angle of impact, and the impact) serve as imputs to the energy exchange submodel. The scenario proceeds on the assumption that one vessel will deviate from a parallel course by making a turn to port. Misapprehension of the non-deviating ship's course, mechanical failure, and unawareness of the non-deviating ship (*e.g.*, when the deviating ship is leaving the basic course for a berth or tributary channel), are given as reasons for using this scenario. While these are undoubtedly valid in certain instances they do not seem to take into account situations where the ships, each aware of the other, *both* maneuver into collision. The relative frequency of this scenario will be investigated in the next phase of the research. (ORI Risk Analysis p. 28, n. 2.) The energy exchange submodel assumes inelastic kinematics which is unrealistic but is conservative for the purposes of the model (ORI Risk Analysis p. 30-31). The rupture submodel does not appear to take into account the possibility of sparks from metal friction igniting fumes in an empty (but not gas-free) tank thus causing an explosive (as opposed to a stress) rupture. Seemingly, this additional pathway would increase the spill probability since even low-angle collisions could produce small penetrations and sparks.

It is possible to use the model to mathematically evaluate the effectiveness of various regulatory measures. As a demonstration, the ORI report models a situation involving a 183 meter (600 foot), 35,000 DWT tanker traveling in a narrow channel (separation distance 122 meters [400 feet]) at eight knots. Regulatory changes such as decreasing speed by 25 per cent (to 6 knots) and increasing separation by 50 per cent are shown to decrease the chances of an oil spill by 22 per cent and 13 per cent respectively. The effects of two or more regulatory changes are not additive and both of the above changes, simultaneously applied, should reduce the likelihood of a spill by 76 per cent (ORI Risk Analysis p. 41-45). Another application of the model shows that for a 274 meter (900 foot) ship to avoid being hit by errant oncoming traffic moving at eight knots with a separation of 122 meters (400 feet) it would have to stop more than ten times as quickly as present tanker designs of that length (ORI Risk Analysis p. 55-58).

The logical model developed by ORI utilizes, among other techniques, a safety analysis logic tree (SALT). This is a variation of fault tree analysis which includes all causal steps including those which are not "faults". By continuous refinement original causes of a marine casualty can be identified. Once specific causes are identified, the feasibility--physical, psychological and economic--of actions to preclude or minimize the occurence of such causal factors can be studied. Besides its value as a preventative forecasting tool, SALT is useful to diagnose the true causes of casualties which have already occurred, thus gaining insight into causal modalities and frequencies. (*See* ORI Risk Analysis pp. 176-190.)

In conjunction with SALT the logical model utilizes "casualty analysis gauges". These are a series of questions which two experienced investigators apply to a casualty and answer "yes" or "no". Confidence limits can be computed with the matching of the two investigators' answers as a validator. Affirmative answers indicate a casualty avoid-able by the regulation under scrutiny. One of the regulations studied was the Bridge-to-Bridge Radiotelephone law. Two results were postulated: causing all passing agreements to be made by radio; and causing all traffic approaching a blind spot in a channel to make a "security call" to determine the existence, location, and direction of traffic beyond the blind spot. Achievement of these results was used to "gauge" whether a collision would have been "preventable". An immediate problem was encountered: although the law requires all ships in specified categories to have channel 13 capability and to listen on that channel it leaves the judgment of when a communication is "necessary" to the discretion of those navigating the ships. Assuming that existing technology, the enactment of the law, its attendant publicity, and government/industry educational efforts result in compliance with the law's literal requirements, there is still a problem in assessing its impact on the judgmental factor (ORI Risk Analysis pp. 75, 81-84, 86). Using a simplified categorization of "preventable" collisions over a historic period, ORI estimates the maximum "effectiveness" of the bridge-to-bridge law to be as high as 75 per cent (ORI Risk Analysis p. 76). "Effectiveness" here is defined not as how many collisions could have been prevented by radio communication, but rather, as how many of those that were so preventable would not occur after the law is enacted.

Later phases of this research should produce even better models and methodologies for assessing the impact of regulatory changes and new design requirements.

In March of 1973 Computer Sciences Corporation submitted its "Final Report" of the Vessel Traffic Systems Issue Study. One of the three principal objects of this study was to develop an algorithm to assess the probable damages to be sustained in given ports. The algorithm was designed to use available historic data and to offer specific assessments broken down by vessel type (cargo vessels, tankships, tank barges, cargo barges, and tugs) by nature of casualty (collisions with fixed objects and with moving objects, rammings and groundings) and by type of damage (vessel and cargo damage, community and third-party property damage,* oil pollution, personal injury and death) (Tables 6-7 and 6-22A, CSC Final Report No. DOT-CG-22870-A).

Eighty different projections can be derived from these parameters for any given port. By using a student's T-distribution statistic a 90 per cent confidence level "bound" can be determined around the resulting point estimates (CSC Final Report 6-38, 6-82).

Since historic data (principally from the Coast Guard's Marine Vessel Casualty Reports and the Army Engineers' Waterborne Commerce Statistics) is utilized, accident rates (probabilities) are assumed to be proportional to the historic rates. Whether the assumption of constant traffic volume is realistic is debatable (C.S.C at 6-35). As larger ships are employed, fewer transits are required but maneuverability decreases and contaminant capacities increase. The algorithm methodology uses the approach of summing the average expected losses per transit rather than integrating instantaneous hazard probabilities (an approach which seems justified in view of quantification difficulties). (*Id.* at 6-18.) For comparison (ranking) purposes pollution was left in gallonage,** and loss of life and serious injuries affecting humans were not converted to monetary units (*Id.* at 6-20).

Because factors such as water body configuration, traffic density, visibility, currents, winds, vessel condition, speeds, and personnel competence are not deducible from historic data, there is no quantifiable way of assessing the impact of a VTS on such potential causes (*Id.* at 6-25). Moreover, there was so little experience under operational VTS's at the time the CSC study was made that the derivation of the altered probability of accident under a VTS became a judgmental, non-mathematical process (*Id.* at 6-7, 6-35, 6-108, 6-116-119). Obviously collisions in times of limited visibility have a higher potential for avoidance under a VTS (*see Id.* at 6-50) than do rammings of moving, submerged objects or rammings of piers during berthing operations. It is significant that the historic data used as input for the CSC study antedated passage of the Bridge-to-Bridge Radiotelephone Act (*Id.* at 6-7) and thus some of the "improvement" ascribed to VTS operations may in fact be due to recent availability of economic equipment and navigator willingness to voluntarily utilize this communication capability.

Assuming the accuracy of the improvement

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* Property losses were found to depend upon casualty type and port features but were relatively independent of vessel type or size. (CSC Final Report 6-52-56.)

**CSC recommended input data be converted to spillage incidents since gallonage figures were either unreliable or (in the case of the average, small spill) unrevealing (CSC Final Report 6-125).

factors and disregarding inflationary impacts on damage costs (which is appropriate if inflation is uniform from port to port), the algorithm will permit useful comparisons to be made between the utility (loss avoidance potential) of a given level of VTS at different ports. It will also permit comparisons of the incremental advantage of a more sophisticated VTS configuation over less sophisticated versions (or none at all) in a given port. The technique appears least effective when used for direct cost-benefit computations.

Computer Science Corporation has also investigated kinematic mathematical modeling as a means of predicting loss reduction achievable by VTS operation. (*See* CSC Final Report, Appendix G.) An algebraic-trigonometric formula for determining the minimum safe detection distance was developed, using vessel speed, maximum vessel rotation rate (with angular velocity rudder hard over), distance of object to be avoided from maneuvering vessel at instant of detection, reaction time of navigator, beam of vessel, lateral offset between vessel and object, and object diameter as inputs (*Id.* at G-5). Expert judgment was then used to assign cumulative probabilities of visual detection for various distances (*Id.* at G-7 and Fig. G-4). Assuming low hazard (a slow speed and relatively quick reaction time) a bivariate distribution of accident probabilities based on offset and distance was derived. The sum of the probabilities in all the cells of this matrix represents the cumulative probability of one vessel impact per transit. (*Id.* at G-10.)

The CSC kinematic model, however, does not appear to take into account the possibility that the "object to be avoided" is another ship. If it were another ship on a reciprocal course and if it did not itself alter course, the two speeds could be added together and the model might be useful. Absent these assumptions, the model appears most useful when applied to the avoidance of known, stationary objects such as aids to navigation.

It is assumed that a sophisticated VTS will bias a vessel away from such objects, (thus tending to maximize offset), and provide earlier warnings than visual detection from the vessel thus increasing the distance. The magnitude of these increases are again based on expert judgment (*Id.* at G-10-13). Computer Science Corporation's analysts believe the model shows that a high-level VTS should reduce the probability of this type of accident by about 85 per cent of the probability when no VTS (not even bridge-to-bridge communication) was in operation (*Id.* at G-11).

Vessel reports and on-board inspections

Although all VTS managers indicated they did not query reporting vessels as to the type of cargo being carried specifically, they obviously do learn this information in some cases and make use of it. For example, ships carrying specified hazardous cargos must give twenty-four hours advance notice of arrival. (*See* 33 C.F.R. § 124.14.) In the Puget Sound system, tankers are color coded to distinguish them from other vessels (apparently no distinction is made whether the ship is in ballast or laden). In the San Francisco system the chart filled out by the communicator has a place for a type code which indicates at least that the vessel is an ammunition carrier. The Coast Guard's proposed regulations for marine traffic (*see* 39 Fed. Reg. 24157-59, June 28, 1974) suggest that the port captain, when formulating orders relative to the hazards of particular areas or particular ships should take into account, among other things:

" * * * *

"(6) Type and amount of cargo being carried.

"(7) Hull design of the vessel involved including the presence or lack of a double hull, double bottom, and cargo segregation.

"(8) Propulsion system of the vessel including factors such as horsepower, number of shafts, size of propellers, bow thrusters, stern thrusters, and other similar variables which affect controllability and maneuverability of the vessel.

"(9) Tugs in attendance.

"(10) Inoperative or deficient equipment aboard the vessel that may affect its ability to safely transit the navigable waters.

" * * * *

"(14) Vessel speed and intended time of transit.

"(15) Intended route and destination of vessel."

Obviously a very simple and expedient pathway for the communication of such information would be by means of the reports to the VTS. Indeed, other factors listed in the regulation, *e.g.*, "type and density of other vessel traffic operating in the same waterway" make it desirable that the port captain and the VTS commander work in close liason. Of course it would be desirable to get as much of this information as possible even before the vessel physically enters the VTS area. But, message congestion permitting, it would seem highly desirable to have confirmation through the VTS.

The Coast Guard has issued special interim regulations concerning letters of compliance with hull structure requirements for carriers of liquid bulk cargos which are considered to involve potential unusual operating risks to life and property (38 Fed. Reg. 15776-81, June 15, 1973). The issuance of these letters of compliance is to be done by the Commandant of the Coast Guard. To qualify for such a letter, plan reviews of existing vessels and plan review for new construction must be accomplished by the Commandant's office. If the applicant for the letter of compliance is a foreign vessel, it must notify the Commandant and the appropriate port captain or OCMI of the date and place of the vessel's initial arrival in U.S. waters at least two weeks prior to arrival. Upon arrival, an initial onboard inspection will be conducted. Re-examinations in the form of shipboard inspections are to be conducted biannually. Serious discrepancies such as leaking piping, inoperative safety equipment, and non-explosion proof electrical connections may require immediate correction prior to cargo transfer operations (46 C.F.R. Part 154 § 4[d][1][iv]). Vessels may be boarded while en route to berth and underway tests and examinations of the various safety equipment may be conducted. Inoperative equipment may result in the vessel not being permitted to enter the port or to conduct cargo operations (*Id.* at paragraph 4[d][3]). Among other things, the design and arrangement of cargo tanks, including piping and venting systems, are of interest to the Coast Guard during the plan review.

Shipboard equipment

Proposed regulations for marine traffic requirements (39 Fed. Reg. 24157-59, June 28, 1974) will require vessels of more than 10,000 gross tons to have 2 radars, at least one of which is equipped with an "anti-collision device". Shipboard collision avoidance radar has been the subject of much discussion in recent months. Several papers on this subject were presented at the last meeting of the Radio Technical Committee on Marine Services of the Institute of Navigation.

Collision avoidance radar has many of the capabilities of the radar data processing computer systems discussed earlier with regard to shoreside systems. The Maritime Administration recently (Fed. Reg., July 25, 1975) revised Sec. 94, Art. 4(b) of its Standard Specifications for (subsidized) Merchant Ship Construction. The revised specification calls for collision avoidance radar capable of alerts (visual and audible) triggered by preset CPA ranges and ETCPA times. The radar must also be able to display vectors representing courses and extrapolated future positions and to display alphanumerics presenting range, bearing, course, speed, CPA and ETCPA. The system will also be required to have the capability to simulate a trial maneuver (presumably only by the observing vessel). (For a summary of some of the collision avoidance systems available in 1971, *see* Oil on Puget Sound, 307-311 [University of Washington Press 1972]). Additionally, Magnavox research laboratories are in the late stages of development of a system tentatively called the SCAN-100 system. This system, comparable in some ways to the Iotron Digiplot System, will be quite sophisticated and should be commercially available within the next two years. One shortcoming of these systems is that they do not store information about the Rules of the Road. Thus the computer cannot simulate obedience to the Rules. The systems also operate on the assumption that all vessels involved will hold their course and speed. This seems an unlikely assumption even ignoring the Rules of the Road and extremis situations. One type of improvement, given adequate computer memory, would be to utilize game theory principles to simulate the possible avoidance tactics used by the other vessels and thus present an array (in terms of descending probability) of the most successful avoidance maneuvers. Whether or not such sophisticated capabilities are ever incorporated into the systems, the lesson remains that the computer solution is not infallible and cannot be relied on to the exclusion of the common sense and contemporaneous judgment of the person conning the vessel. Computers can serve a useful purpose as sources of warnings and suggestions. They should not reduce the pilot to a mere automaton simply carrying out orders given by the computer.

The Coast Guard is presently concluding a survey in which Coast Guard officers make boardings with checklists to survey the type and operational status of equipment on vessels. Some of the pieces of equipment the Coast Guard is interested in are radar;

gyro compasses; fathometers; rate-of-swing indicators; RPM indicators; LORAN C; course/speed recorders; and up-to-date copies of charts, tide tables, current tables and the Coast Pilot. They also are determining whether or not tactical data is available to the pilot. Additionally, the inspectors are noting whether a lookout and an anchor detail were posted when operating in pilotage waters. The proposed regulations for marine traffic requirements (30 Fed. Reg. 24157-59, June 28, 1974) would require that vessels of more than 1600 gross tons have a gyro compass and a recording fathometer, and a means to visually indicate the speed of the vessel, among other things. (*Id.*, Paragraph 2b.) Tankers over 35,000 tons are required to have a rate-of-turn indicator (*Id.*, Paragraph 2e) and all those vessels over 150,000 gross tons bound for or departing U.S. ports would be required, before getting under way or before entering U.S. waters, to test and log the adequacy of the following systems: (1) steering (all modes and stations); (2) emergency generator; (3) remote machinery control; (4) main propulsion for power ahead and astern; (5) internal vessel communications; (6) vessel alarms and signaling devices. (*Id.*, Paragraph 3a.)

A ranking Coast Guard officer told this investigator that generally these requirements were part of an overall approach to carry out the mission of marine safety. He suggested however, that some of the proposed regulations were incomplete while others appeared to be unnecessary. For example, with regard to a recording fathometer, specifications should include its salinity calibration; water temperature calibration; alarm system; its calibration with regard to density of the bottom; whether or not it depicts depth below keel or depth below water; and whether it is kept synchronous with a time reference on the recording. The rate-of-turn indicator was felt to be useful primarily for berthing and for mooring to a monobuoy at sea.

Coast Guard officials at San Francisco and Seattle made no attempt to verify whether any check-off similar to the proposed pre-entry systems testing had occurred when vessels made their initial reports. All felt that this pre-entry testing was good, but there was a general feeling that these procedures were already being followed on any well-maintained vessel. This of course raises the question "what happens on a vessel that is not so well run?" One Coast Guard official felt that there was little need to test the emergency steering system and suggested that doing so might actually jeopardize the safety of the ship. The emergency system was described as being so simple that nothing could happen to it, or if something did happen, for example as a result of a collision, the damage could easily be visually inspected without a test. It was felt that to adequately test it, the primary system would have to be disengaged and under certain circumstances this could be hazardous.

Apparently most ships are presently designed so that the emergency generator only powers navigation lights and does not power the electric or hydraulic steering systems or the master gyroscope. Thus any requirements that the emergency generator be tested might well be coupled with a modification of electrical system requirements specifying additional functions for the emergency generator. A San Francisco bar pilot indicated that pilots do not generally ask if the equipment has been tested. They indicated a high degree of trust in equipment, especially of foreign ships. As an example of finely equipped ships, the Johnson Line vessels were mentioned. Many of these vessels are equipped with twin screws and bow thrusters and consequently are considered very easy to maneuver.

With regard to the requirement of posting tactical data, a San Francisco bar pilot reported that in his experience some ships had it posted in the wheelhouse but others did not. A Coast Guard official said that tactical data was not presently required in the bridges of foreign ships. He conceded that it might be useful to the pilot on board. Whether or not the port captain or the VTS should also have the data raised a more difficult question, however. A recent amendment to Coast Guard regulations (40 Fed. Reg. 2689, January 15, 1975) requires tactical data to be displayed in the wheelhouse of all tankers over 1600 gross tons. This data is to include, at both full and half speed, turning circle diagrams both to port and starboard indicating time and distance for advance and transfer. Also required is the time and distance for crash stop for full and half speeds ahead. Tables correlating RPM with speed ranges for fixed propellers and pitch settings, or power settings, with speed ranges for variable pitch propellers are also required. The tactical data is to be derived when the ship is under normal load and ballast, in a condition of wind under ten knots, in a calm sea with no current, and in deep water with a clean hull. Whether the pilot's need-to-know will occur under conditions sufficiently similar to the conditions under which the tactical data was originally determined is uncertain. Moreover, as a Coast Guard officer put it, "Yes, it would probably be useful to have it, but what would we ashore do with it after we got it?" In short, there are such a multitude of variables which operate in conjunction with the physical capabilities of the ship to affect its maneuvering that there is presently no computer program or mathematical formula which will give reliable advice even when the tactical data is provided. Thus shoreside officials would be extremely reluctant to second-guess a pilot conning the vessel. The important thing then, is to make the data available to the pilot and to encourage him to take as much time as is necessary to acquaint himself with the data and with any other special characteristics of the vessel before he actually takes over. Since there will be economic deterrents to leisurely familiarization, perhaps confirmation of familiarization should be made a required part of the initial report to the VTS.

Most sea-going vessels are equipped with course recorders although practice with regard to keeping them running when the vessel is in pilotage waters appears to vary from time to time and vessel to vessel. Coast Guard authorities in both Seattle and San Francisco feel that, for the most part, the course recorders are kept operating. The proposed marine traffic regulations would require that the recorder be operative and that records be retained onboard for at least 30 days (39 Fed. Reg. 24158, June 28, 1974, Paragraph 2b [3]). While this has nothing to do with avoiding accidents before the fact, it can provide a good source of objective data for reconstructing a casualty after it has occurred and learning what mistakes to avoid in the future. On more modern ships with automated firerooms, records of course and speed are often maintained automatically until "finished with engines" is signaled.

JURISDICTIONAL PROBLEMS

U.S.-Canadian problems and solutions

The geography of the Pacific Northwest is such that the international boundary between the United States and Canada is not a straight line following the 49th Parallel. In order to avoid an impractical division of Vancouver Island, the boundary is drawn to bisect the Strait of Juan de Fuca. The boundary curves around the southeastern tip of Vancouver Island (in the vicinity of Victoria) and, by following the principal straits northward and bisecting the Strait of Georgia, eventually reaches the 49th Parallel, almost due south of the entrance to Burrand Inlet. This configuration divides the San Juan Archipelago into the Canadian San Juans and the American San Juans. While all this is very practical from the standpoint of the governance of land masses, it presents certain difficulties for the administration of vessel traffic systems through the various waters involved.

The officials of the Canadian and Puget Sound systems have worked out a solution which is both efficient and practical. For vessel traffic administration purposes, the Canadians have informally relinquished control to the Americans through the Straits of Juan de Fuca. The TSS that appears on charts is essentially under the surveillance of the Americans and if the Puget Sound VTS area should be extended westward for the length of the Strait, the Seattle facility would monitor traffic on both inbound and outbound lanes in that Strait and would set up additional check points throughout the strait.

There are presently no commitments to establish radar along the American shore of the Strait. However, if additional radars were added beyond Admiralty Inlet they would next be emplaced in the Strait of Juan de Fuca and, after that, would be emplaced in Rosario Strait. The Canadians do not plan to install any radars on the north shore of the Strait of Juan de Fuca. To the extent that the Tofino or Victoria antennas may offer partial coverage of the Strait of Juan de Fuca, officials expect to work out a communications net whereby the Canadian radar data can be remoted for shared viewing in Seattle.

The line of demarcation for the application of the Inland Rules of the Road in U.S. waters starts at Angeles Point (essentially the east end of the Strait of Juan de Fuca) and angles generally northeastward to the Hein Bank Buoy and thence slightly west of north, skimming the western coast of San Juan Island until it reaches Turn Point on Stuart Island, from whence it angles sharply northeastward to the western tip of Skipjack Island and thence northerly to the Alden Point Light, on the west end of Patos Island, and thence northwesterly to the southwest tip of Point Roberts. The general consequence of this configuration is that a vessel heading for Canadian ports through Haro Strait and Boundary Pass would not enter U.S. pilotage waters even if, as a northbound vessel, it might be in U.S. waters during most of its passage. Indeed, vessels on such a routing normally carry British Columbia pilots. It was logical then for VTS officials on both sides of the border to agree that Canada should administer the Haro Strait-Boundary Pass-Strait of Georgia route (App.-6). Thus it is Canadian radars that will afford coverage, and Canadian calling-in-points and Canadian frequencies will be utilized, regardless of the position of a ship relative to the international boundary as that ship transits this route. This trade off in administrative responsibility is, at the moment, unofficial. Obviously, diplomatic finalization of the arrangement will be complex and may be deferred for a considerable time.

Certainly, one problem that could conceivably arise is enforcement for violations of the Canadian VTS rules that occur in the American side of Haro Strait, or conversely, violations of the American VTS rules which occur in the Canadian side of the Strait of Juan de Fuca. At the time this investigation was under way, neither system was mandatory in these areas so enforcement problems had not arisen. The most logical solution, pending an international agreement, would seem to be that the Americans incorporate by reference the Canadian rules for U.S. waters in Haro Strait and Boundary Pass, while the Canadians do likewise for Canadian waters in the Strait of Juan de Fuca. Then, if the Canadians detected and identified a violator of their rules in American waters, the Americans could be called upon to issue the citation and levy the sanctions. Technically, the citation would be for a violation of the American rules, although, in actual fact, the American rules would be mirror images of the Canadian rules in those particular areas. The converse would be true with regard to an American request for Canadian enforcement of a violation on the Canadian side of the Strait of Juan de Fuca.

The pilots handling ships which move from Canadian ports to Puget Sound ports or vice versa generally do not bother to board at the boundary line or even at the Canadian or U.S. pilot boarding stations (at Brotchie Ledge and Ediz Hook respectively). Rather, the pilot flies to the point of origin of the voyage. For example, the B.C. pilot would fly to Seattle and join the ship there, riding as a passenger as far as the boundary of the Canadian VTM area, and then relieving the Puget Sound pilot who would thereafter ride as a passenger to Vancouver and fly back home.

State-Federal conflicts

Several states have recently proposed or enacted legislation concerning the hull construction and equipment of ships entering their waters and carrying hazardous cargos. To the extent this may call for exclusion of non-complying ships there is a serious question of whether it is preempted by federal law. For example, the State of Washington recently enacted a law relating to water pollution from petroleum spills (Substitute House Bill No. 527, Ch. 125, 44th Sess., 1975, as modified by partial veto). The requirement that tankers of 50,000 deadweight tons or greater take a licensed Washington state pilot aboard seems non-controversial and protected by the maritime-but-local doctrine. *See Cooley v. Port Wardens*, 53 U.S. (12 How) 299 (1851). Another section prevents tankers greater than 125,000 deadweight tons from proceding beyond a point east of a line extending from Discovery Island Light south to New Dungeness Light. Although limitations of water depth at refinery piers and economics of oil transportation make it unlikely that the industry would find it feasible to use such ships on Puget Sound, it is questionable whether the State of Washington could make such an exclusion based on its police power. As an additional technicality, there are waters east of the described line which lie outside of U.S. waters and obviously the Washington legislation, however valid it might be elsewhere, could not apply to those areas.

A further provision of the Washington law states that tankers between 40,000 and 125,000 deadweight tons may proceed into the greater Puget Sound area only if they have all of the following features: (a) shaft horsepower in the ratio of one for each two and one-half deadweight tons; (b) twin screws; (c) double bottoms underneath bunker and cargo tanks; (d) two radars in operating order, one of which is equipped with a collision-avoidance device. A provision allows tankers in the indicated capacity range to proceed into Puget Sound if they are in ballast or if they are under the escort of tugs with an aggregate shaft horsepower equivalent to five per cent of the ship's tonnage without satisfying the requirements set out above. Given the present state of the art in marine architecture and vessel hydrodynamics, it seems unlikely that these Washington requirements could qualify under the "actually unsafe and unseaworthy..." test which describes the kind of defects that can be outlawed at the state level and which further circumscribes state regulations by requiring that they be "plainly essential to safety and seaworthiness." *See Kelly v. Washington*, 302 U.S. 1, 15 (1937). In *Huron Portland Cement Co. v.*

Detroit, 362 U.S. 440 (1960), the Supreme Court upheld a municipal air pollution ordinance that made certain discharges of smoke which occurred during the "blowing" of boilers on a vessel a punishable violation. The Court felt that the local ordinance was not related to shipboard safety but was a valid exercise of the police power to protect the health and welfare of the residents of Detroit through the quality of the air they breathed. Whether such a state requirement, even under the guise of the police power, could extend to such permanent, substantive configurations as double bottoms and twin propellers* is in serious doubt, expecially in view of the burdens it would impose on interstate commerce and the interference it might create against the foreign affairs powers of the President. For a more detailed discussion of these problems and the recent case of *Askew v. American Waterways Operators*, 412 U.S. 933 (1973), see Swan, *American Waterways: Florida Oil Pollution Legislation Makes it over First Hurdle*, 5 J. Mar. Law & Commerce 77 (1973).

The proviso allowing transit under an escort of tugs with specified horsepowers may constitute a reasonable alternative which will not be in conflict with federal objectives or priorities and may thus make the statute constitutional. The bill further requires that legislative committees study the feasibility of requiring speed limits for such vessels under escort. As a practical matter, the maximum speed of the escorting tugs may constitute a *de facto* speed limit in any event. However the "escort" provision may be ill-conceived. Suction forces would preclude the tugs getting too close to the tanker and even at a distance, few tug skippers would make fast lines to a massive relatively fast moving tanker for fear of becoming "in irons" and capsizing. Thus the only effect may be to have as many as four large tugs moving at top speed in convoy with a tanker, thus *increasing* the odds of collision. This is not to say, of course, that very slow speeds with tugs made fast alongside might not be advisable in truly constricted waters.

LIABILITY OF THE SYSTEM OPERATORS AND OTHERS

Liability for providing erroneous or incomplete information

Although the general common law doctrine of *Ultramares Corp. v. Touche, Niven & Co.*, 255 N.Y. 170, 174 N.E. 441 (1931) that there will be no liability for a negligent misrepresentation is still the majority rule, there is a rapidly growing minority of jurisdictions which reaches a contrary result. See, for example, *Miller & Co. v. Central Contra Costa Sanitary District*, 18 Cal. Rptr. 13 (1961). (Incorrect soil analysis report by civil engineers used by contractors bidding on a tunneling project.) The emerging rule (presently the minority) would make the information supplier liable even to those with whom he has not directly contracted. Although no fees are paid and no commercial relationship exists, the VTS operators are supplying information directly (as opposed to indirectly) to the "users", the vessels and their pilots. Thus, one must consider the possibility that they shall be liable if the information supplied was erroneous or incomplete due to their negligence in gathering it or relaying it. The negligence standard suggests that there is a duty only to use reasonable care. Thus it would probably not be reasonable to require that an on-the-scene report from a vessel in the vicinity not be relied upon by the Coast Guard without an immediate confirmation by helicopter reconnaissance.

There are very few reported opinions dealing with misinformation by the Coast Guard and none at all arising out of the operation of a VTS. Some of the closest parallels therefore arise out of air traffic control cases. The following are representative of the decisions in this area: *Ingham v. Eastern Airlines Inc.*, 327 F.2d 227 (2nd Cir. 1967) *cert. denied*, 389 U.S. 931 held that an air controller was concurrently negligent for the crash of an airplane for failing to give an accurate weather advisory about swirling fog on the airport runways. Similarly, in *Gill v. United States*, 285 F.Supp. 853 (E.D. Tex. 1968), *modified on other grounds*, 429 F.2d 1072 (5th Cir. 1970) the court held that an air traffic controller's misleading understatement of the severity of a storm front to a pilot flying on visual flight rules (thereby causing him to fly closer to the storm than he would otherwise have flown and to crash while making an emergency landing during a thunderstorm at dusk) was enough to make the government liable. See, for example, Todd v. United States, 384 F. Supp. 1284 (M.D. Fla. 1975). (ATC clearances must be "reasonably designed to insure the safety of aircraft flight... granting discretion to descend instead of ordering to maintain altitude held negligent".)

*At least one marine architect feels that twin screws may offer less stopping power than one larger-diameter propeller. He also feels that the "couple" effect of twin screws on a heavily laden tanker is negligible with regard to enhancement of steering.

When the hazard is "immediate and extreme" and the air traffic controller has reason to know that a taxiing plane is disregarding a take-off warning, the government will be liable for failing to revoke the take-off clearance. *See, Furumizo v. United States*, 245 F.Supp. 981 (D.Haw. 1965) *aff'd* 381 F.2d 965 (9th Cir. 1967). (Air turbulence from prior take-off of large plane.) Similarly, if the danger is known only to the controller and is not available to the pilot, a failure to warn a pilot which has a causal effect on a crash will be grounds for government liability. *See, United Airlines v. Wiener*, 335 F.2d 379 (9th Cir. 1964) (military aircraft maneuvers); *Hochrein v. United States*, 238 F.Supp. 317 (E.D.Pa. 1965) (unobservant pilot cleared for landing did not notice other plane doing touch down on the runway and controller failed to alert).

It must be remembered that weather is more vital to the operation of aircraft than to the operation of ships and incomplete weather advisories are not so likely to be causally connected to ship casualties. Moreover there is always the possibility that the pilot will have acquired the necessary weather information on his own, either through supplementary radio reports or radar observations and thus the communicator's ommission would not be detrimental. *Cf., Somlo v. United States*, 416 F.2d 640 (7th Cir. 1969) *cert. denied*, 397 U.S. 989 (1970) (failure to update weather report for light-plane pilot).

In the aids to navigation area, it is clear that the Coast Guard may be held liable under the Federal Tort Claims Act for negligent maintenance of a light. *See, Indian Towing Co. v. United States*, 350 U.S. 61 (1955). This principle has also been applied to incorrect or inaccurate charts, (*see, De Bardeleben Marine Corp. v. United States*, 451 F.2d 140 [5th Cir. 1971] and *Universe Tank Ships, Inc. v. United States*, 388 F.Supp. 276 [E.D.Pa. 1974]) although the government defended in these two cases by reason of lack of causation and a failure of burden of proof respectively (actions brought under the Suits in Admiralty Act).

A recent case against an air traffic controller is *Freeman v. United States*, 509 F.2d 626 (6th Cir. 1975), where the controller confused two blips on his radar scope and referred to a plane carrying skydivers, heading away from the landing area toward Lake Erie, as if it were a second plane which was heading toward the landing area. Since there was a cloud cover beneath the plane, and the skydivers jumped through the clouds, they landed three miles offshore in Lake Erie and most of them drowned. The court held the failure to correctly identify the two different blips and the resultant misleading message to be grounds for liability.

A problem could arise in non-radarized VTS's when a vessel, confronted by a slow moving log-boom or a trawler in a traffic lane, requests permission to deviate to port. If there were a small craft in the opposite traffic lane which did not have channel 13 capabilities, its presence would be unknown to the VTS operators. They would therefore approve the deviation and if the sea-going ship did not notice the small boat and collided with it as a result of transgressing in the opposite traffic lane, the small boat owner might sue the Coast Guard. Since the Coast Guard was genuinely ignorant of the presence of the small craft, it is hard to say they could be held negligent (even jointly with the unobservant pilot of the sea-going ship). Depending on traffic patterns and the locale, it might be possible to establish a case that small craft were known to frequent the other traffic lane and that the Coast Guard should never approve such deviations but instead should require the sea-going ship to back down sufficiently ahead of time to allow the obstruction to clear the lanes so that it would not have to deviate to get past. This is obviously a complex question and its resolution would depend upon the advance warning of the obstruction, the need for the sea-going ship to maintain steerage way, and whether the deviation was to be merely into the separation zone or clear into the opposing traffic lane. Since liability in such a case would turn on the question of reasonableness, no *a priori* evaluation can be made and each case would be determined *ad hoc*. On the whole, liability in such a situation seems unlikely, but it cannot be ruled out as a possibility.

Liability resulting from orders, "suggestions", and "judgmental advisories"

If a vessel inside the VTS area is logged, either on radar, or by radio report, as passing a check point at a given time and reliable reports from the vicinity report heavy fog, and the vessel then proceeds to the next check point and reports in after an elapsed time which indicates the maintainence of an illegal rate of speed, some problems could arise for the VTS. If the vessel were to immediately thereafter get into a collision and if speeding through the fog was found to be a partial cause of that collision, could the Coast Guard be liable for acquiescing in this conduct? The line of argument of the non-speeding collision victim would have to be that in addition to a traffic management function (which is closely related to safe navigation), the Coast Guard has sanctioning authority over the vessel and the license of the pilot and possibly the master. Thus, when a simple calculation would have disclosed that the vessel was traveling at high speed, rather than at a reduced speed more appropriate for the reported conditions of visibility, the Coast Guard should have stepped in. The issuance of a citation after the fact is not the point, but rather, the argument would run, the Coast Guard should have verbally reprimanded the pilot over the radio or asked for a confirmation that visibility was better than had been reported, thus justifying the higher speed. Presumably when called to account in this manner, the pilot would take speed off the ship and thus eliminate that particular cause of the collision. If speeding was a substantial cause, or the sole cause, the victim could claim that the Coast Guard was jointly responsible for its injury.

No court opinions could be discovered on this precise point, although two of the air traffic controller cases shed some light by analogy. In *Stork v. United States*, 430 F.2d 1104, (9th Cir. 1970) the government was held liable because a traffic controller failed to dissuade a chartered airplane pilot from taking off in zero-visibility storm conditions. Rejecting the argument that the controller's authority extended only to clearances with regard to other aircraft traffic and did not extend to coercing the pilot into obeying the instrument flight rules concerning take-offs, the court held that, at the very least, the controller should have warned the pilot that he would be breaking the law if he took off. The take-off attempt resulted in a crash, killing many of the passengers on board. The court found the government jointly liable with the airline to the decedents' survivors. Similarly, in *Furumizo v. United States*, *supra* the court held the traffic controller at fault for doing nothing to stop a plane which was attempting to take off in disregard of an earlier warning. Although the facts in both of these cases presented immediate threats to the plaintiffs which were fully appreciated and understood by the defendant controllers, and the risk of speeding through a sea lane is neither so obvious nor so immediate, there are definite parallels between the two situations. The longer the duration and the more flagrant the violation, the more risky it will be for the VTS communicators to "wink" at it. If harm results to third parties as a result of the violation, the Coast Guard might find itself liable for failing to deter the conduct in time to avert the casualty.

In *The Guam Bear*, 314 F.Supp. 1339 (N.D. Cal. 1970) a claim was asserted against the Navy because it had scheduled the arrival and departure of traffic through the narrow inlet in the atoll at the harbor of Apra, Guam. The Navy harbormaster arranged the schedule so that an inbound vessel would be arriving very close to the time that an outbound vessel would be departing. This was done for the convenience of the navy tugboats and the pilot who would be working both vessels sequentially. As a result of this close scheduling, the vessels got in a collision while trying to navigate the narrow inlet after the pilot had debarked the outbound ship. The court held that it was not negligent for the Navy to schedule the arrival and departure so close in time. This is a case of a considerable amount of shoreside control which, with the benefit of hindsight, turned out to be an exercise of poor judgment yet did not result in liability to the government.

The sovereign immunity issue

Operators of vessel traffic systems will be government agencies and suits against the United States will, in all likelihood, be brought under the Federal Tort Claims Act, which raises the issue of defenses. Under 28 U.S.C. § 2680 (1970) two relevant defenses would be the "discretionary act" exemption of subparagraph (a) and the "misrepresentation" defense of subparagraph (h). In *United Airlines Inc. v. Wiener*, *supra*, the court held that the communications and decisions of CAA (now FAA) tower operators are "operational details" rather than matters of "discretion" and therefore are not exempted from the waiver of sovereign immunity under the FTCA. Similarly in *Ingham v. Eastern Airlines, Inc.*, *supra*, the court said that once the air traffic control system was established (admittedly a discretionary act) the function of an individual negligent controller was not a discretionary act for FTCA purposes. The *Ingham* case also struck down the defense's contention that the negligent failure to disclose the military aircraft maneuvers in the vicinity was a "misrepresentation" and thus exempt under subparagraph (h). *See also*, *Sullivan v. United States*, 299 F.Supp. 621 (N.D. Ala. 1968) *aff'd*, 411 F.2d 794 (5th Cir. 1969). (Preparation of flight chart held an "operational" task and not a "misrepresentation".) Compare the earlier lower court decisions of *Rowe v. United States*, 272 F. Supp. 462 (D. Pa. 1964) which said the decision not to include visual-flight-rules pilots in the procedures which called for air traffic controllers to furnish radar assistance was "discretionary" and this fact would constitute a defense to a suit by a VFR pilot based on failure to advise. Thus it appears that if the VTS operators can be found at fault for a negligent act or ommission in an area in which they have undertaken to render assistance, provide guidance, or issue orders, the exemptions under the FTCA will be of no avail to them.

Rights of recourse based on equipment failure

With the built-in redundancies and fail-safe backup devices built into the VHF and radar systems, it seems unlikely that information derived from or passed through these systems could contribute to a casualty. However, other hardware such as computers, and software such as computer programs could be defective in ways that it would not be reasonable to expect the Coast Guard to detect. Assuming such a defect contributed to a marine casualty, the victims of the casualty might sue the operators of the VTS. Assuming that a duty to act with care devolves upon the operator either by reason of its undertaking to run the system or by reason of the special relationship whereby the pilots come to rely on the operator's advisories (*see e.g.* Restatement (2d) Torts §§ 308,311), the question remains: what would constitute a breach of that duty? If the equipment in question was negligently designed or manufactured then the system operator may be held to a non-delegable duty with regard to the reliability of the equipment, even though it would not be reasonable for him to detect the defects through pre-acceptance testing. *See generally*, Freed, *Legal Aspects of Computer Use in Medicine*, 32 Law and Contemporary Problems 674, 686, 689 (1967) (prophesizing suits against operators of medical computer systems). In cases like these where liability of the operator is based on a non-delegable duty, the technical violation of a statute, or on passive negligence, and where the true, active fault lies with the equipment manufacturer, suits for indemnity are commonly brought. *See, e.g., Noto v. Pico Peak Corp.*, 469 F.2d 358 (2nd Cir. 1972) (negligent manufacturer of ski lift); *Blue v. United Airlines*, 98 N.Y.S. 2d 272 (N.Y. Superior Ct. 1950) (negligent design causes airplane crash); *John Wanamaker, New York, Inc. v. Otis Elevator Co.*, 228 N.Y. 192, 126 N.E. 718 (1920) (negligent manufacturer of elevator).

In addition to indemnity actions based on negligent manufacture it is possible that the strict tort principles of manufacturing liability may be utilized (*See*, Restatement (2nd) Torts § 402A). Under such a theory the victim would sue as a "user" of the information supplied by the defective hardware. This is obviously one step attenuated from the typical user-of-a-product situation where the product itself directly inflicts injury on the user. Here, the product (the computer) has a product of its own (the information which is acted upon by the VTS operator) which contributes to the injury of the victim. *Cf. Ford Motor Credit Co. v. Swarens*, 447 S.W. 2d 53 (Ky. 1969) (wrongful repossession triggered by error in computerized payment record). If the VTS operators were held liable on strict liability principles, an indemnity action based on strict liability principles, would lie against the manufacturer of the defective equipment. *See, e.g., First National Bank v. Otis Elevator Co.*, 2 Ariz. App. 80, 406 P.2d 430 (1965), 2 Ariz. App. 596, 411 P.2d 34 (1966) (defective elevator); and *Ingalls v. Meissner*, 105 N.W.2d 748 (Wis. 1960) (burns from apron made out of flamable fabric); *Cf. N.Y.M. Mosso v. N.Y. Skow Co.*, 1967 AMC 1034 (N.Y. Supreme Ct.) (defective towing hawser).

Of course if the system operator were not legally liable and simply settled the victim's claim as a matter of good will it would be denied indemnity on the theory that it settled the case simply as a "volunteer". *See, Southwest Mississippi Electric Power Ass'n v. Harmagill*, 182 So.2d 220 (Miss. 1966). It should be noted also that rights in this regard can be effected by statutes of limitations, by the question of whether the computer hardware-software system was "consumer goods" or was otherwise covered under Article 2 of the Uniform Commercial Code, and by contractual provisions with the system vendor such as "hold harmless" agreements, or liability limits.

THE PRACTICES OF PILOTS

Lookouts

Pilots interviewed in Seattle and San Francisco were asked whether they would request that a look-out be posted forward in the eyes of the ship in daytime during periods of good visibility. Apparently it is not the practice to request such a lookout in Puget Sound waters. In San Francisco, it was felt that a ship's officer was customarily forward in any event once the ship passed under the Golden Gate. Also some San Francisco pilots would request a look-out if they were passing close to or through a sailing regatta. Generally, however, the attitude seemed to be that such a lookout was not necessary. Given the configuration of most large tankers or bulk carriers with the bridge aft, there is a large "blind spot" dead ahead of the vessel that is obscured by the hull. The blind spot becomes even larger if the vessel is in ballast or is high in the water. This does not present a great peril for seagoing craft, but has more than once been a contributing cause with regard to running down smaller craft. An anchor watch, although commendable for reasons of preparedness to drop the anchor, is seldom a good lookout. For one thing, he cannot give undivided attention to being a lookout. Second, his duties as anchor watch usually require him to stand on a platform aft of the anchor windlass. On most vessels this is so high that the so-called lookout can scarcely see over it and, in any event, he does not have unrestricted visibility forward.

The following cases, among others, have held ships liable for insufficient lookout despite good visibility during the daytime: *Butcher No. 1/Peggy and tow*, 1968 AMC 1386 (E.D.La. 1967) (collision around bend in Gulf Inter-coastal Waterway and push tugs failed to have lookouts on front barge of two and three barge flotillas respectively); *U.S. v. Sigfridson*, 1964 AMC 2341 (D. Or.) (pilot's request for bow lookout ignored). Two other cases have imposed liablity for failure to have bow lookouts at dusk. *See, Cartogena/Syra*, 290 F.Supp. 260 (D.Md. 1968) (jumboized liberty ship with lookout on bridge wing did not hear or see dredge); *Skaustrand/PW Thirtle*, 227 F.Supp. 281 (D. Md. 1964) (wheelhouse 450' aft of bow of ore carrier). Many other cases have stressed the need for a lookout in the eyes of the ship when the wheelhouse is a long distance aft of the bow. *See., e.g., Tug Management Limitation Proceeding*, 1971 AMC 2511 (E.D. Pa.) (lookouts 250' and 425' aft of respective bows, 6pm); *Virgina K/Teresa Seley*, 1967 AMC 815 (E.D. Mo.) (lookout 1000' and 780' aft of respective bows, 2am).

Perhaps the best summary of lookout law was articulated by the Second Circuit Court of Appeals:

> "It is true that the statute [Inland Rules of the Road] fails to prescribe any specific place on a vessel for the lookout to be stationed. But the courts have held that good navigation makes it necessary that the lookout shall be stationed in the forward part of the vessel and at a point best suited for hearing and observing the approach of vessels and where his vision will be free from all obstructions."

The Buenos Aires, 5 F.2d 425, 432 (2nd Cir. 1924).

Some senior Coast Guard officials are skeptical about the utility of placing an AB or an OS forward as a lookout. They feel that such people are often poorly motivated and despite their ostensible function are not at all watchful. In this day of extremely long distances between bow and bridge it is imperative that an allweather telephone system be directly at hand at the lookout station since bell signals or loud hailers are scarcely adequate. Some knowledgeable people are proposing a closed-circuit TV camera positioned on the bow of the ship with remote focusing and aiming as a device for reliable scanning of the "blindspot". This seems like a sound suggestion although it should be remembered that another function of the lookout is to listen for sounds that might not be heard at all inside a closed bridge. Moreover even with low-light-level TV cameras, in the depth of night a human eye coupled with human intelligence would probably be a far superior lookout. Another solution required by Panama Canal regulations is to have two pilots on board large vessels, one of whom assumes the lookout position on the bow of the vessel while in regular communication with the conning pilot.

In any event, it seems that an educational compaign designed to get pilots and masters to think in terms of utilizing a bow lookout on large vessels even during times of daylight and good visibility would be very worthwhile.

The case for speed limits

Although occasionally a pilot has a reputation of being careless, or a "speed burner", this is certainly the execption and not the rule. This is not to say that many pilots do not navigate their vessels at imprudent speeds. It is generally felt that the reason for this is economic pressure. The pilots often are, subject to prior commitments and availability, competing with each other for business. Even where the pilots are members of associations and are paid on a share basis, there seems to be a competition for "clients". (Possibly because the shares are not all equal and the size of the share may depend upon the number of trips per month, etc.) Perhaps the pressures are not directly economic but simply stem from a sense of sympathy and identification with the master of the vessel who *is* under economic pressure to prosecute the voyage with utmost dispatch. In any event, pilots quite often proceed against their better judgment because they do not want to be criticized for slowing the vessel down as a result of "hypercaution".

VTS officials must be careful not to assume that the speeds must be safe because no collision has occurred "yet". If the risks are in fact increased by imprudent speeds through constricted channels* or through areas of poor visibility, it is just a matter of time until such speeding leads to a casualty. The response of establishing speed limits after the fact would seem tragically belated--especially where instances of violations have been matters of common knowledge before the fact. This is not to say that inflexible speed limits should be set. Several variations are possible. For example there could be different speed limits after sundown (just as are enforced on the highways). There could be speed limits in certain geographic areas only, or there could simply be more stringent enforcement of apparent violations during times of demonstrable fog or low visibility. One positive consequence of such judiciously applied regulatory power would be to take the pressure off the pilots, thus neither their egos nor their economic interest would be involved and they could justify their prudence by saying that it was required of them by law.

*See pages 21 and 41, *supra* for discussion of the Coast Guard's mathematical submodels for the narrow channel scenario.

summary

It has seemed evident from this investigation that the single most efficient aspect of the VTS in terms of cost and benefits has been the implementation of channel 13 capability and the use of that capability under the Bridge-to-Bridge Radiotelephone Act. The Coast Guard and the industry are enthusiastic about this improvement in navigation. Its potential for eliminating uncertainties in overtaking and meeting situations is manifest. Traffic separation schemes also seem successful although channel configuration, vessel drafts, and habits of expediency tend to create exceptions which may erode the ostensibly "automatic" safety advantages of separated traffic. Nevertheless, no system should be inflexible and in most cases the deviations and exceptions are justified, if not absolutely necessary to enhance safety. Under these circumstances, deviations can be tolerated provided the intentions of all concerned are properly communicated. The problem of speed limits in the traffic lanes is something that deserves further consideration by VTS officials. Shallow draft traffic should be permitted to proceed to the starboard of traffic lanes in a TSS area unless they are traveling at high rates of speed, *e.g.* a hydrofoil vessel. The problem of cross traffic can be serious. Predictable, scheduled cross traffic such as ferry boats are not so much of a problem as are fishing trawlers and sailboat regattas.

The concept of periodic radio reports by vessels maneuvering in a VTS area is sound enough if the problems of message congestion can be overcome or alleviated. Consideration must be given to limiting the communications on the VTS frequency, especially if that frequency continues to be the same frequency as the bridge-to-bridge radiotelephone communications. Radar surveillance certainly enhances the awareness of VTS officials of the exact position of traffic. It also may eliminate or reduce the need for VHF reporting. It cannot be said with certainty at this time whether expensive computer and software systems designed to further process radar data and give collision avoidance advisories are worth the cost. The state of the art is such that these systems can be developed, installed and operated. It seems reasonably safe to assume that they will provide more useful information than presently is available and that the risks of erroneous information being generated and detrimentally acted upon are not likely to cancel out the benefits they could offer. Just because they offer an incremental enhancement of safety, however, does not necessarily mean that they can be cost justified. There seems an obvious danger of becoming enamoured of technological gadgetry which, even though very impressive, does not "pay its way". For the most part, VTS officals are using a cautious, go-slow approach in the area of computerization.

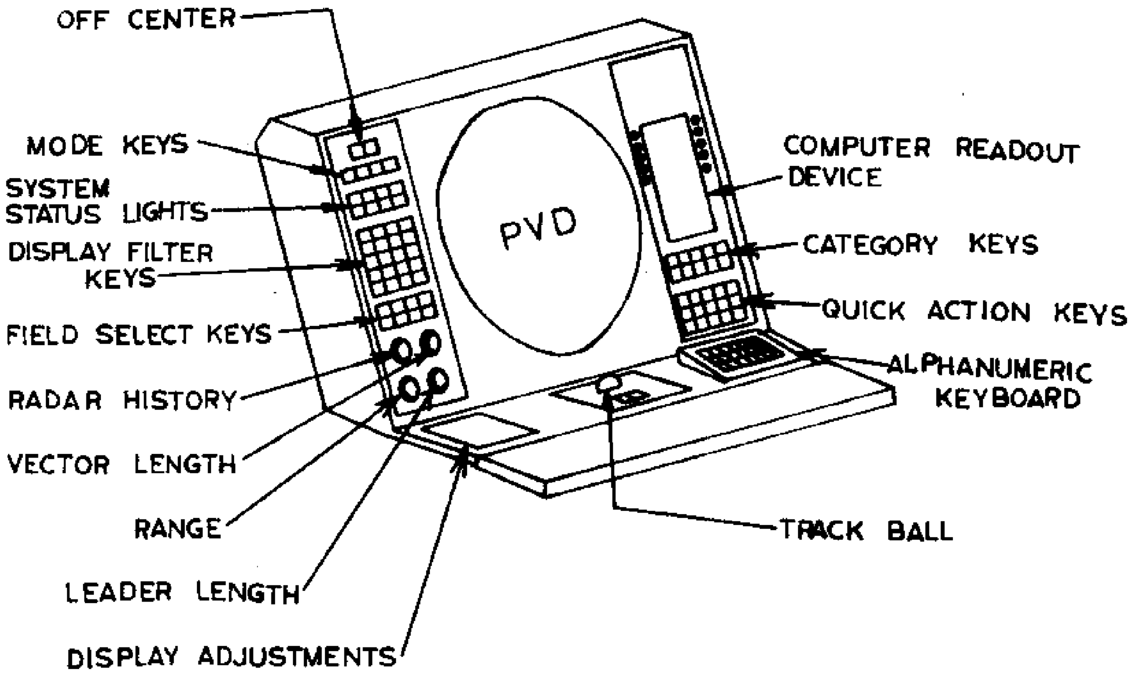
The Rules of the Road deserve study and in particular it is desireable to change the sailboat right-of-way rule. Risk analysis studies now under way will prove helpful tools, once their methodologies are perfected, in designing VTSs, in positioning aids to navigation, and in determining hull construction and equipment requirements. The on-going development and installation of shipboard collision avoidance radar systems will undoubtedly reduce the risk of collision. This is so, providing that pilots, masters and watch officers do not develop a blind faith in the computer display, untempered by common sense and the unquantifiable concepts of good seamanship.

The VTS operators* may find themselves exposed to civil liability to the extent that they provided erroneous or incomplete information which was acted upon detrimentally by vessel pilots. VTS officials do not often give direct orders to maneuvering vessels. If such an order was given and was followed with the result that a casualty occurred, system operators could be held responsible if the order was found to be unreasonable or against the tenets of prudent seamanship.

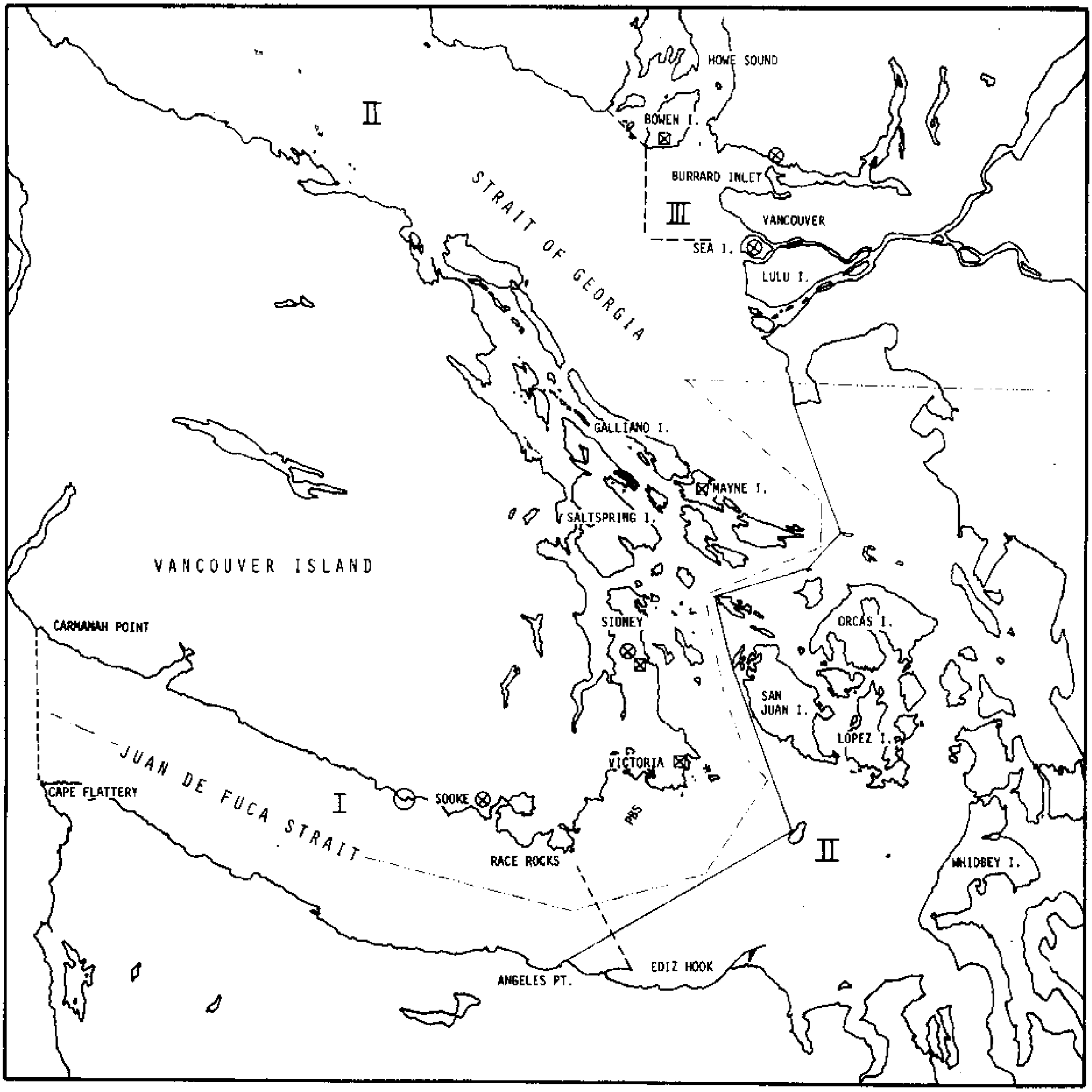
*Throughout this paper the terms "VTS operators" and "system operators" have been used as generic terms to include the acting individual, the responsible agency and the national government.

[A list of the names and positions of the individuals interviewed by the investigator is available upon request.]

appendix



App. 1. FAA ATC radar controller console.



—·—·— International Boundary

------- Sector Boundary

——— Demarcation line for inland rules of the road

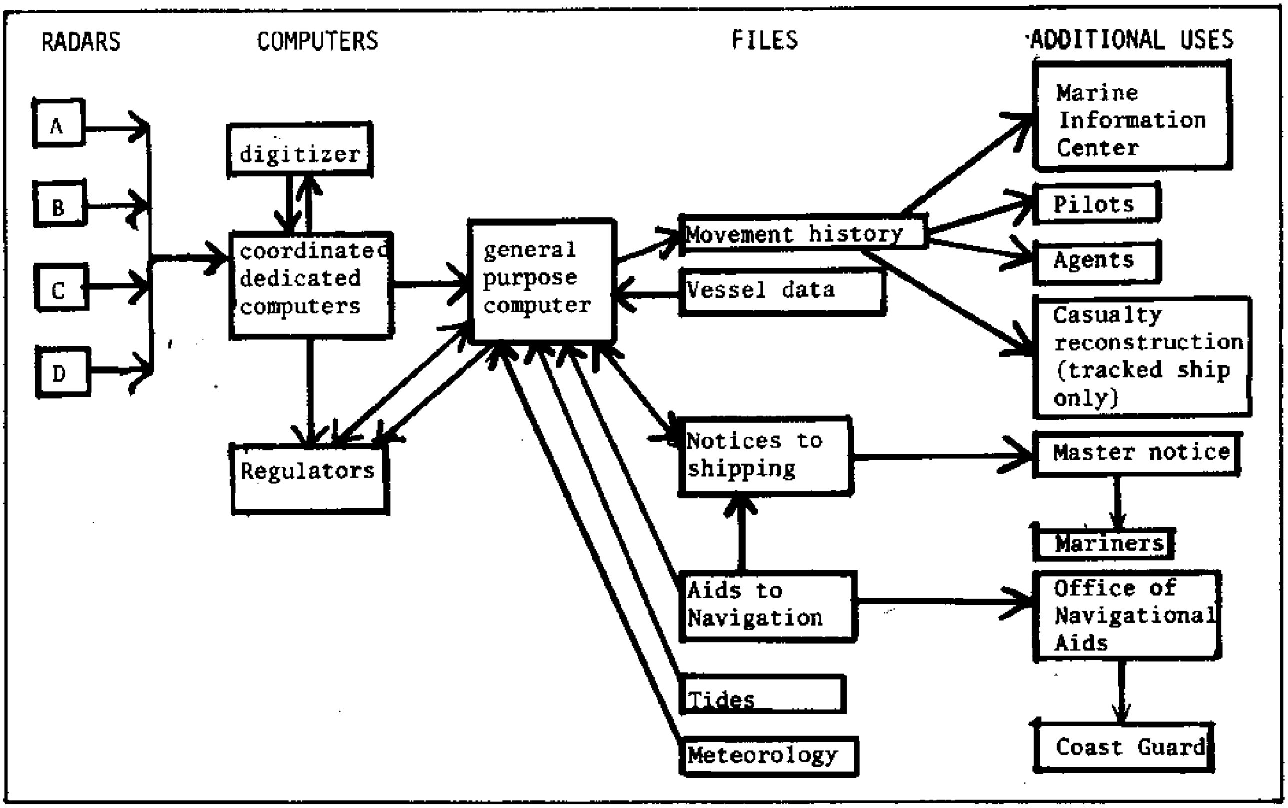
⊗ Remote transmitter-receivers

⊠ Second generation radar antennas

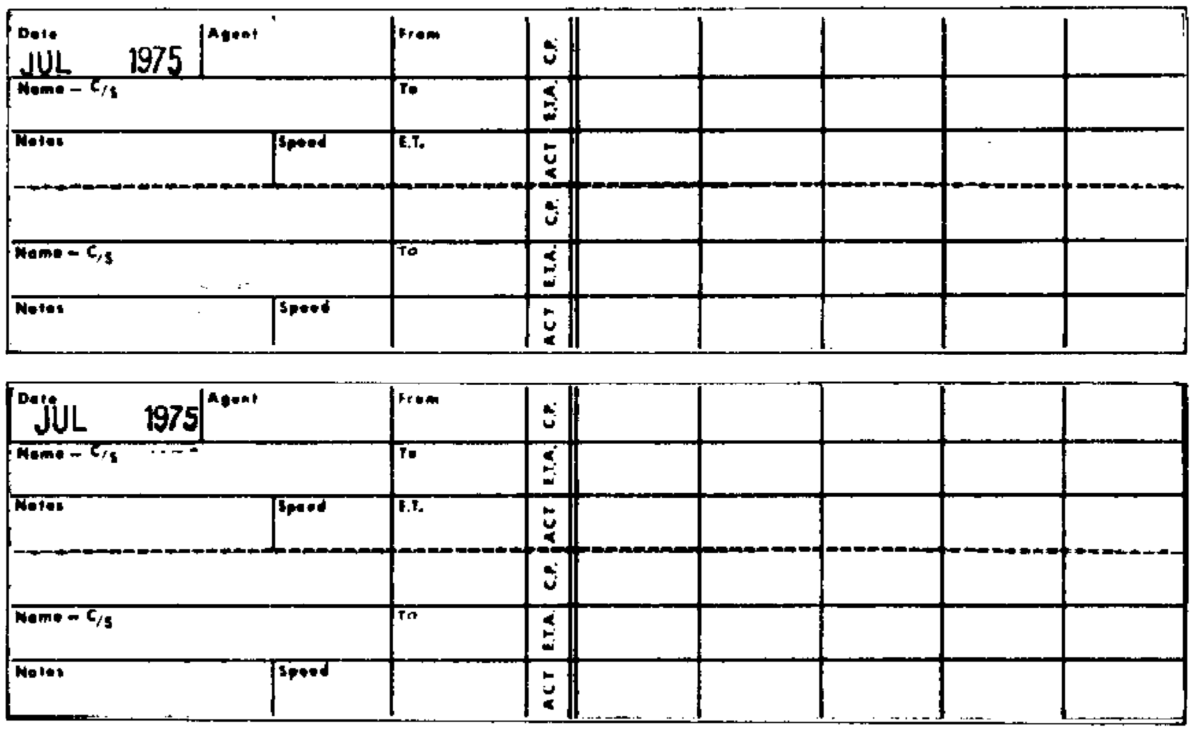
PBS Pilot boarding station at Brotchie Ledge

I, II, III The three sectors of the Vancouver traffic zone (Sector II extends north to Triangle I. and Cape Caution)

App. 2. Vancouver traffic zone.



App. 3. Canadian VTM, information flow schematic for advanced configuration.



One card will be white and one yellow to indicate general direction of vessel involved.

App. 4. Canadian traffic movement cards.

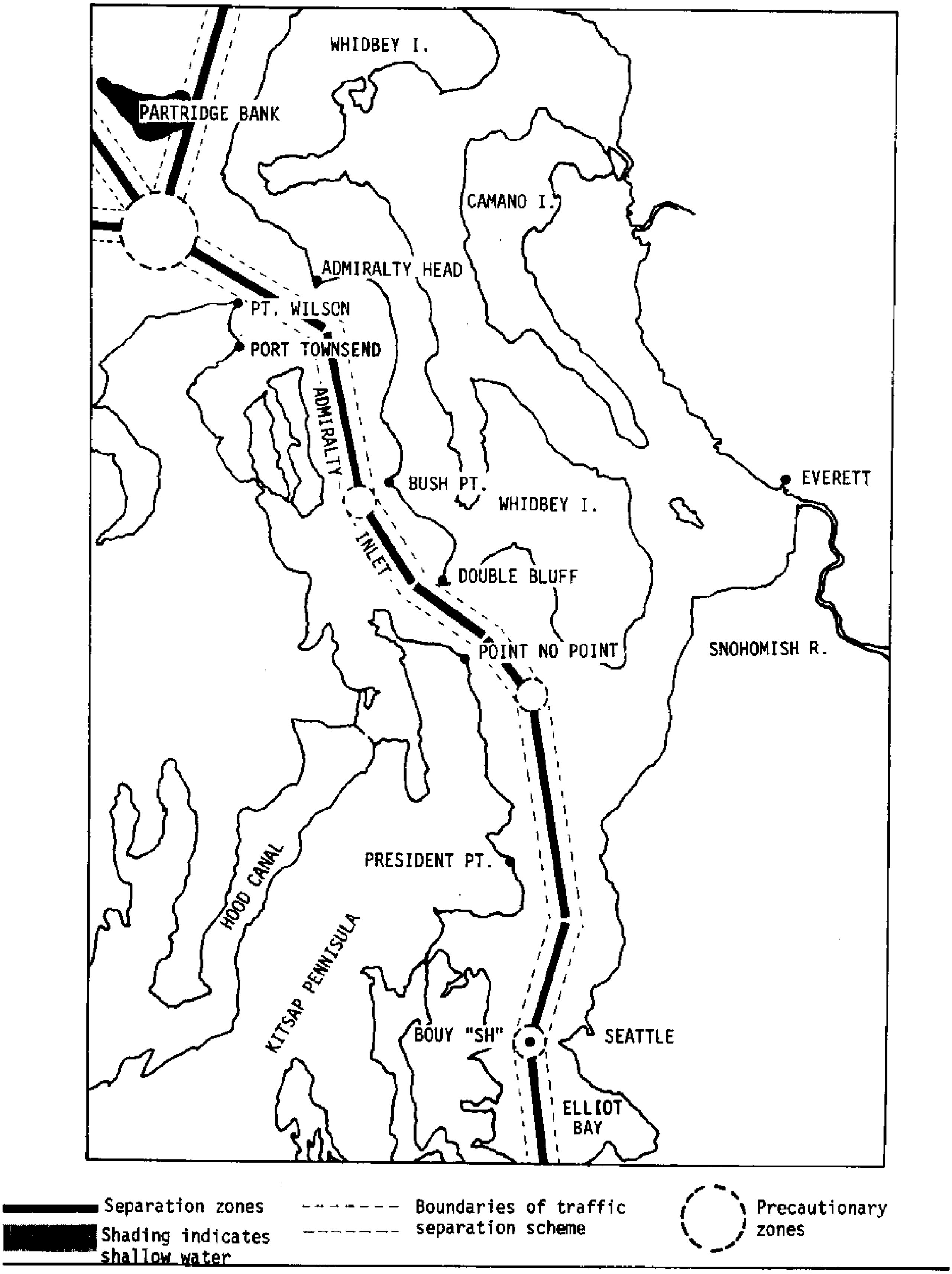
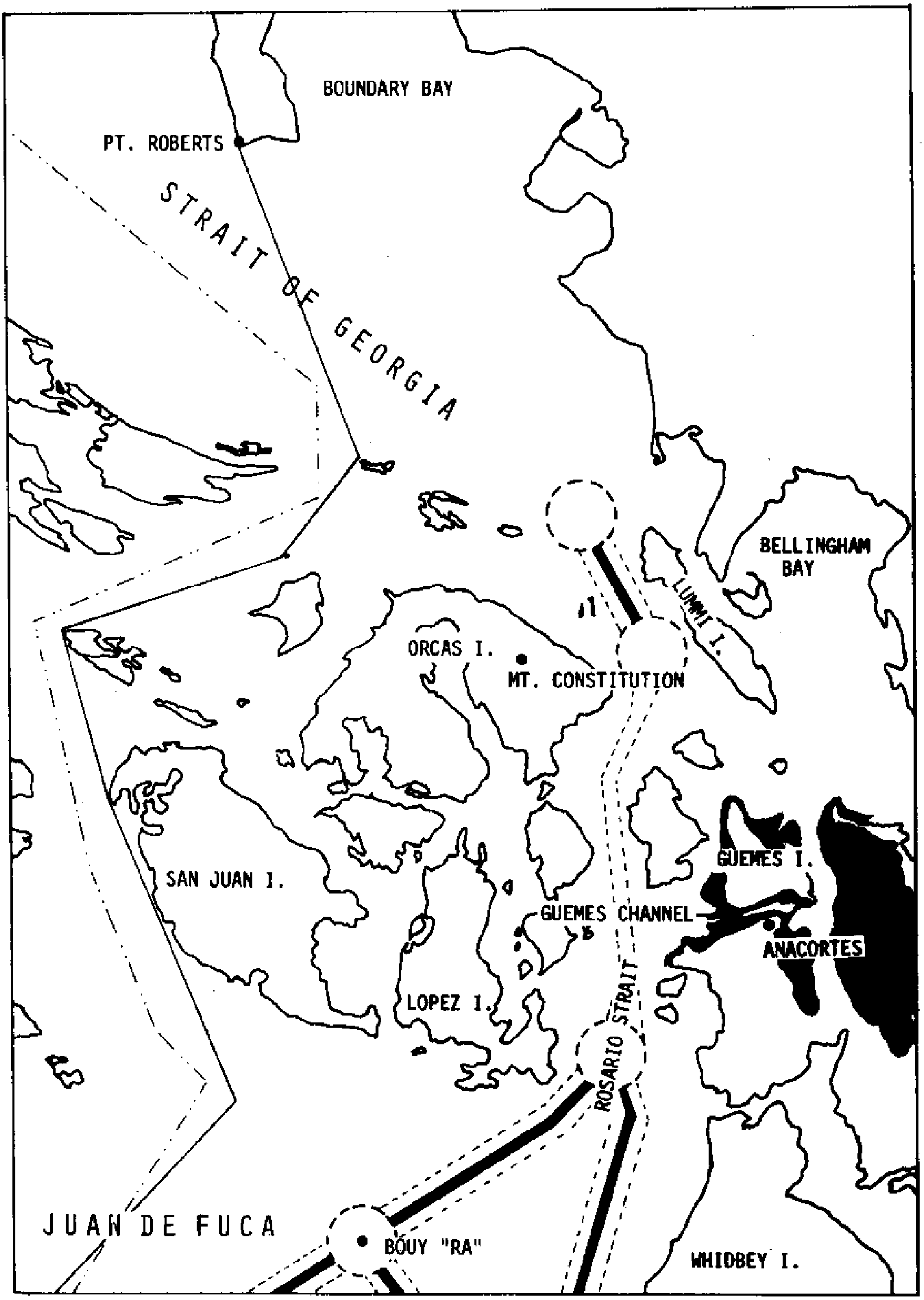


Fig. 5. Admiralty Inlet traffic area.



Shading indicates shallow water (less than 10 fathoms) around Guemes Channel

App. 6. Strait of Juan de Fuca to Strait of Georgia traffic area.

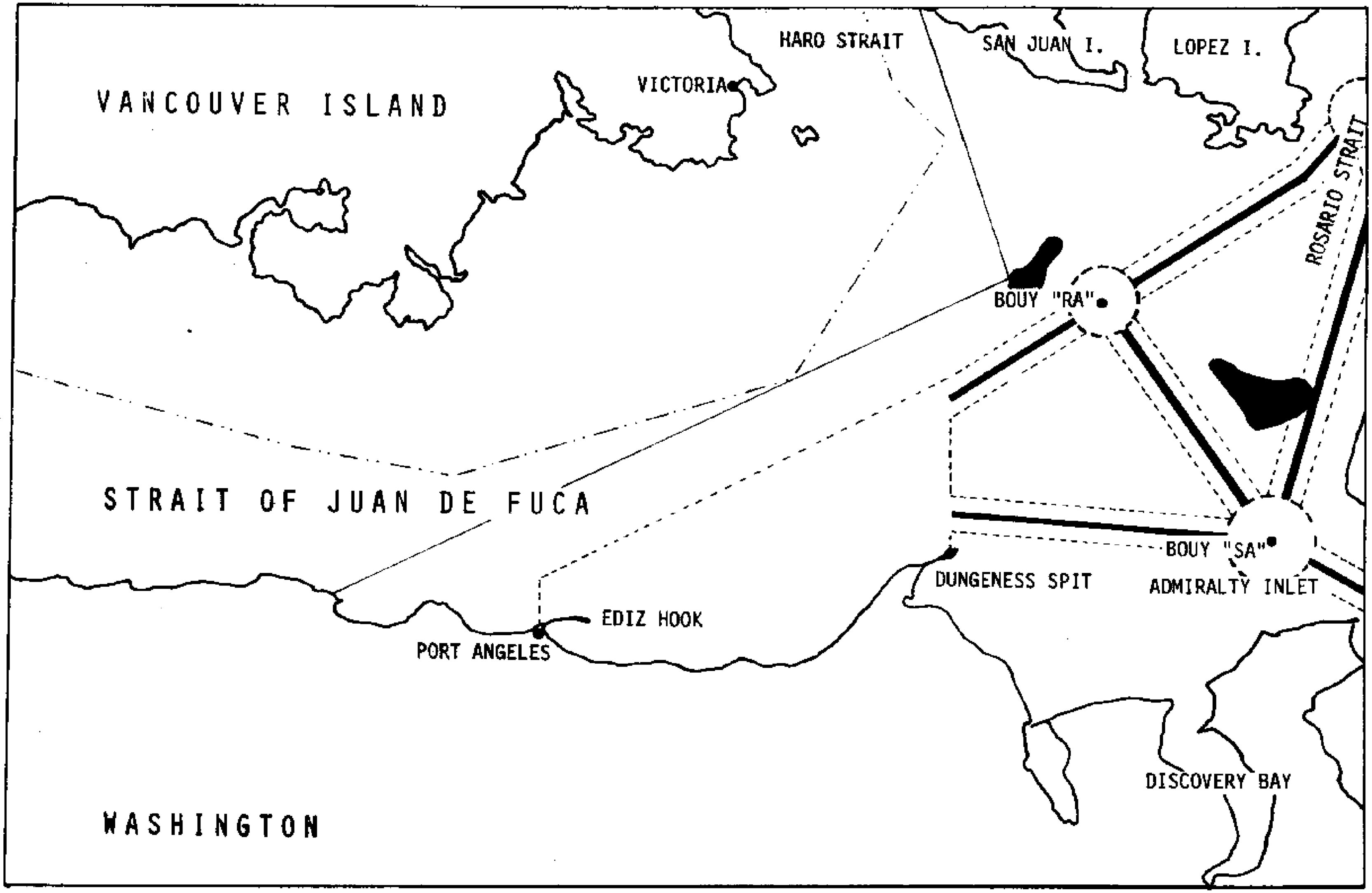
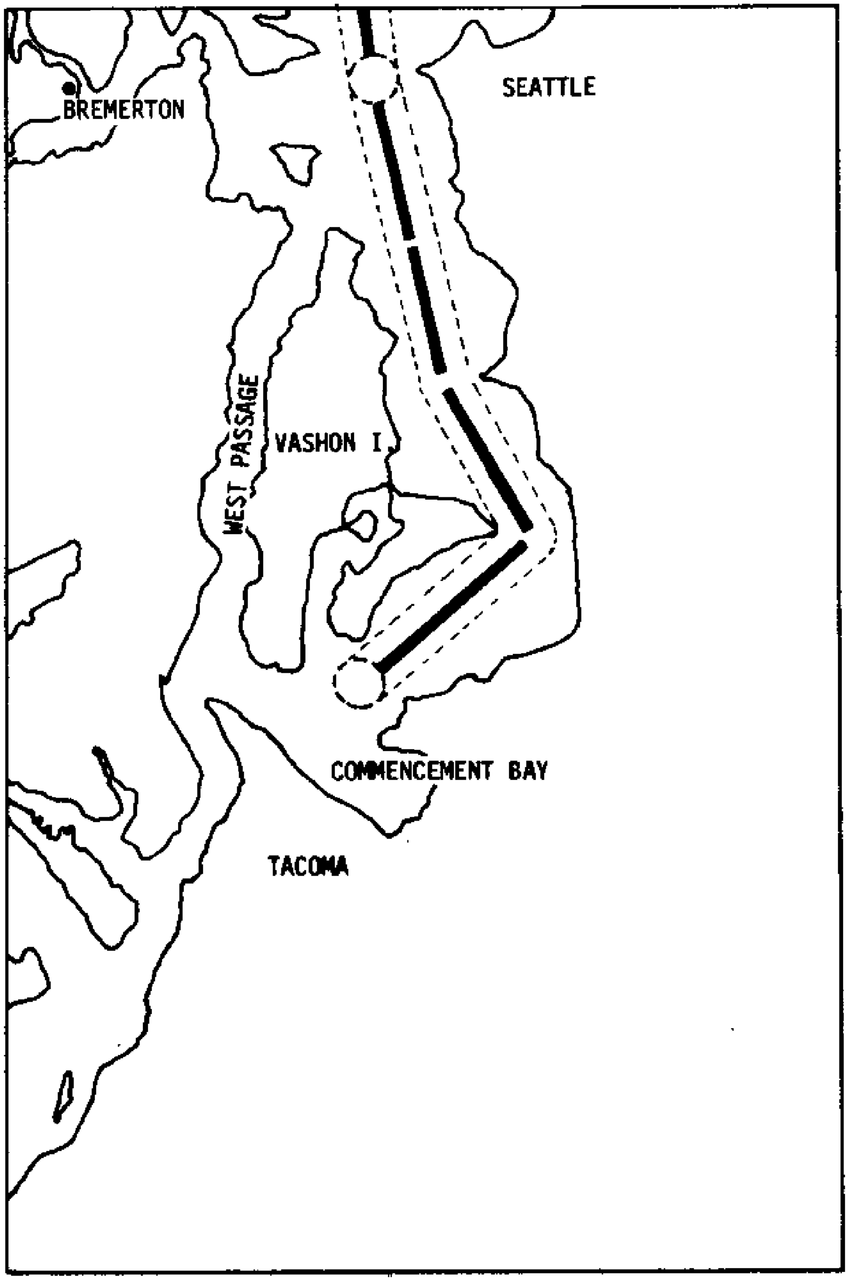
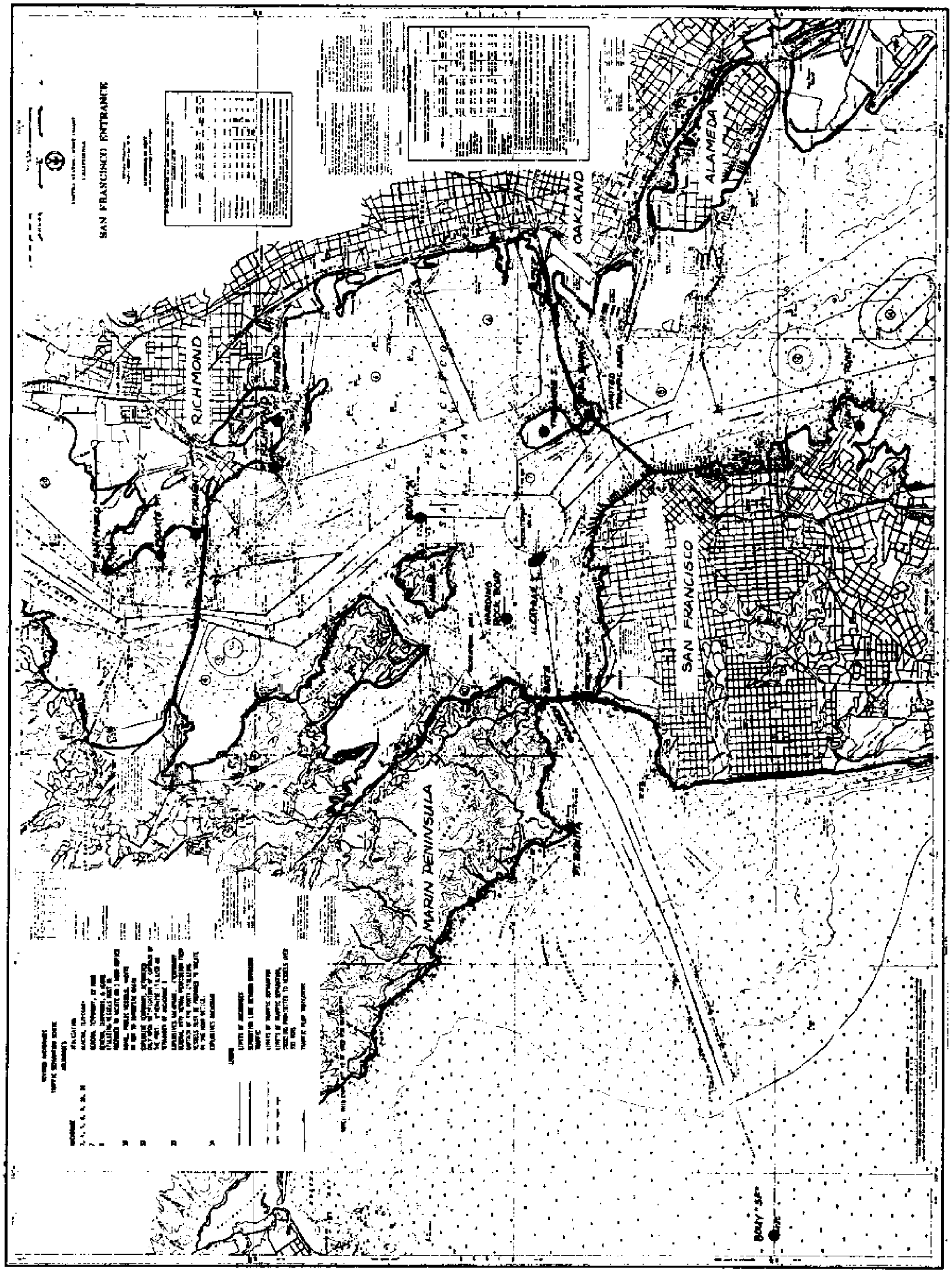


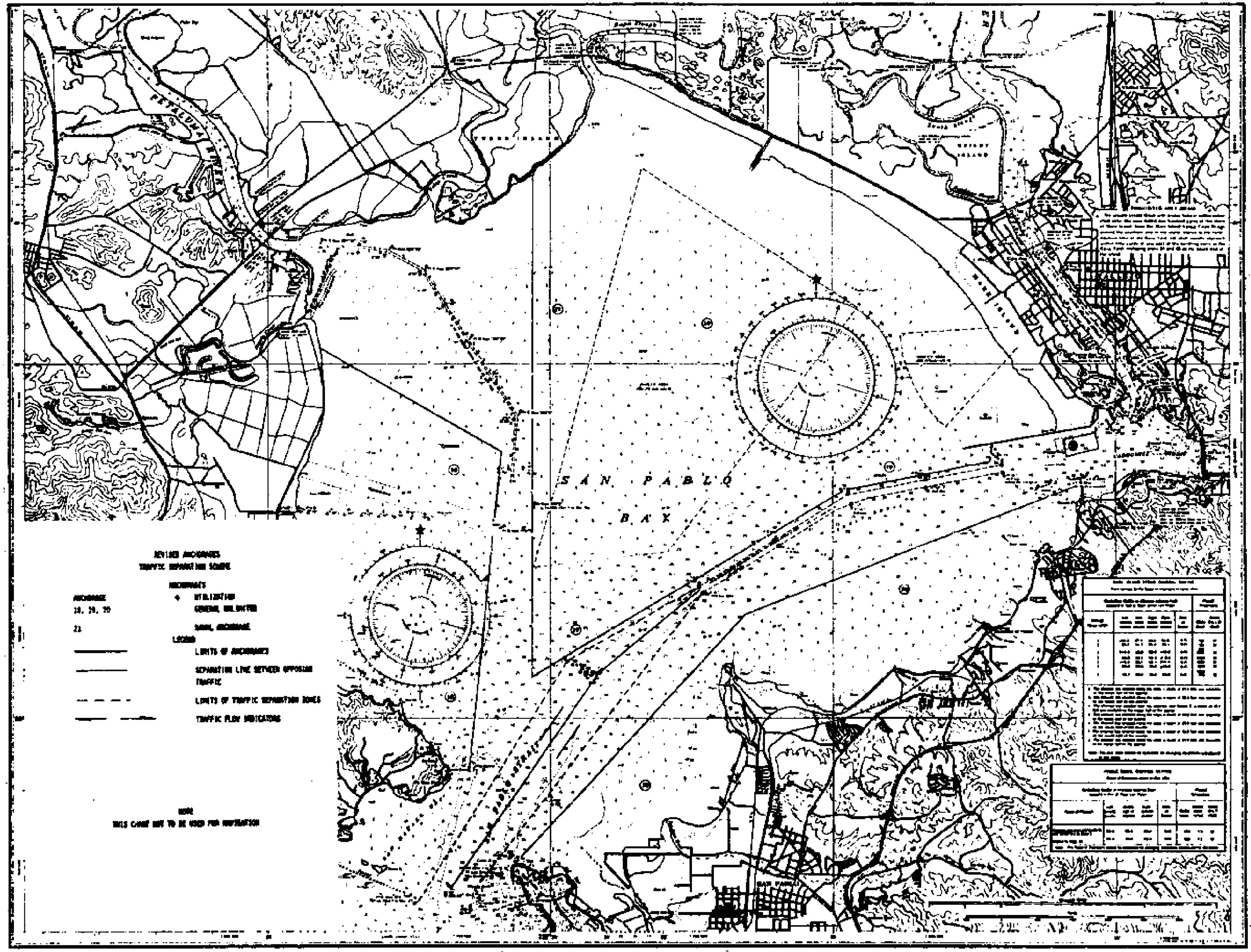
Fig. 7. Strait of Juan de Fuca (eastern) traffic area.



App. 8. Puget Sound traffic area, Seattle to Tacoma.



App. 9. San Francisco Bay traffic area.



App. 10. San Pablo Bay traffic area.

DATE:__________ TRAFFIC SUMMARY TOTAL TRF:__________

CODES	EXPLANATIONS OF CODES	INTRA-BAY	OUTBOUND	INBOUND	TOTAL
	COMMERICAL-ALL TYPES-NON CODED				
1	AMMO LADEN				
2,4,5	NAVAL VESSELS, INCLUDING FOREIGN SUBS				
3	U.S. COAST GUARD				
6	TUGS WITHOUT TOWS				
7	TUGS W/TOWS				
8	DEEP DRAFT VESSELS				
9	PASSENGER FERRIES/WATER TAXI/& TOURS				
10	RAILROAD FERRIES				
11	OTHER ESCORT,CALIBRATION,ENG TRIALS				
12	DREGES				
	SUB TOTALS				

OCEAN DUMPING INFORMATION	MISSIONS	MAN HOURS
NON TOXIC LOADS		
TOXIC LOADS		

SPECIAL REQUEST FROM OTHER AGENCIES

REQUESTER (COE/ EPA/ OTHER)	PERMIT #	REMARKS	MAN HOURS

WATCH SUPERVISOR'S SIGNATURE

App. 11. San Francisco traffic summary and vessel-type code.

PILOT: P 36 | VESSEL: HARLINA MARY | TYPE: | DATE: 2-1-75
REMARKS: MSO 1020 | DRAFT: 28

POSITION	TIME (EST.)	TIME (ACT.)	POSITION	TIME (EST.)	TIME (ACT.)
P/S	1020		BBY (AB)	1125	
66 By	1050				
P/C FRONT		1115			
			Pct	1145	

CHECK BOX IF THIS CARD APPLIES TO MULTIPLE TRIPS ☐

PILOT: 58 | VESSEL: USS KISKA | TYPE: 2 | DATE: 2-1-75
REMARKS: | DRAFT:

POSITION	TIME (EST.)	TIME (ACT.)	POSITION	TIME (EST.)	TIME (ACT.)
PILOT STA	0725				
66B	0830/	083V			
LRB (W)		0931			
			MARE IS.	1025	

CHECK BOX IF THIS CARD APPLIES TO MULTIPLE TRIPS ☐

PILOT: | VESSEL: CGG MIDGETT | TYPE: 3 | DATE: 1-FEB
REMARKS: | DRAFT:

POSITION	TIME (EST.)	TIME (ACT.)	POSITION	TIME (EST.)	TIME (ACT.)
"A"		1505			
1#2		1522			
66B		1553			
BB B#C		1614			
LT#4		1634	ARD		1714

CHECK BOX IF THIS CARD APPLIES TO MULTIPLE TRIPS ☐

PILOT: | VESSEL: AMADORE | TYPE: 7 | DATE: 2-1-75
REMARKS: | DRAFT:

POSITION	TIME (EST.)	TIME (ACT.)	POSITION	TIME (EST.)	TIME (ACT.)
RLW	0750				
			OCT	1125	

CHECK BOX IF THIS CARD APPLIES TO MULTIPLE TRIPS ☐

PILOT: | VESSEL: HARBOR PRINCESS | TYPE: 9 | DATE: 1 FEB 75
REMARKS: | DRAFT:

POSITION	TIME (EST.) ARR.	TIME (ACT.) DEP.	POSITION	TIME (EST.) ARR.	TIME (ACT.) DEP.
TIB		1507	P43½	1531	1548
RBC	1500	1555	RBC	1638	

CHECK BOX IF THIS CARD APPLIES TO MULTIPLE TRIPS ☒

App. 12. Samples of San Francisco traffic movement cards.