12 December 1973

Appeal of the OMB Decision
to
Direct Selection of Loran A
As the Coastal Confluence Radionavigation System
and to
Declare Omega and Loran C as Military Systems Only

The National Plan for Navigation announced that 1972 would be the year the long-awaited decision would be made regarding which radionavigation system would be provided for all users in the Coastal Confluence Region (CCR)--waters out to 50 miles from the coast of the United States or the 100 fathom curve, whichever is greater. Final decision was postponed until this year to permit further study of competing systems, the principals of which were Loran C, Loran A, Differential Omega and Decca.

After considerable study, the Secretary of Transportation concluded that no single system now available can provide for the needs of all users. Needs range from long-range, general purpose, moderate accuracy to specialized, high-precision capability. He concluded that a mix of two systems is needed--Loran C for the Coastal Confluence Region of the continental United States (including southeastern Alaska) and Omega for use on the high seas by United States users world-wide.

The Department of Transportation budget request for FY 75 for the Coast Guard includes a request for funds to expand the existing Loran C system by the first of three phases to establish it as the Coastal Confluence Region system. The Office of Management and Budget action on that request directs that Loran A become the National System with Loran C and Omega designated as military systems with both to be funded by the Department of Defense.

That decision by OMB will have far-reaching, detrimental effects which will be felt nationally and internationally for years to come, and it precludes a wide range of ancillary benefits which would otherwise be available to the United States. At a cost greater than the recommended system, and at considerable technological risk, it will result in the United States discarding a multi-purpose system of great potential and offering instead a single-purpose navigation system which boasts little more than that it maintains the status quo and avoids requiring present users to shift to new equipment over a period of time. It is

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considered a short-term, non-cost effective decision and as such is appealed, with the recommendation that the basic decision of the Secretary of Transportation in his selection of Loran C be approved.

The attachments speak in more detail to the basis for this reclama, but briefly it is as follows:

(1) A system of prescribed one-quarter mile accuracy is required to provide a reasonable hedge against a massive marine, evnironmental disaster that could also involve a major energy loss if, for example, the cargo were oil.

(2) When the National Plan for Navigation (NPN) speaks of augmenting Loran A to 1/4 mile accuracy, it is referring to "1/4 mile drms."* Later studies have shown that risks inherent in several selected areas warrant an accuracy of "1/4 mile 2 drms,"* which is roughly equivalent to twice the accuracy called for in the NPN. It is doubtful that Loran A technology can be stretched to provide the doubly greater accuracy. If we succeed, tolerances will be at their outer theoretical limits and range for the greater accuracy would be limited to 50 miles from the coast. Loran C is operating at this accuracy and better now and has been for several years, with ranges out to 1000 miles. The limited range of Loran A will have significant implications for future efforts such as enforcement of the Law of the Sea Treaty and other, specialized treaties like those concerning the fisheries today.

(3) The ability to meet the "1/4 mile 2 drms" accuracy standard is significant. Without it the probability of two passing ships straying out of their lanes simultaneously and creating a collision situation is 1:1600. In the channel out of New Orleans, for example, this would mean about four collision-potential incidents per year. With the refined accuracy the odds drop to 1:1,000,000 and there would be virtually no chance of a collision-potential incident resulting from radionavigation system errors.

(4) Loran C offers a wide range of ancillary benefits, including such things as precise timing for all U.S. space flights while Loran A offers none.

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*"1/4 mile drms" means that 63% of the measurements will fall within a 1/4 mile circle.

"1/4 mile 2 drms" means that 95% of the measurements will fall within a 1/4 mile circle.

(5) It appears the decision is motivated to a large extent by desire to avoid antagonizing present users of Loran A. This is a proper motivation, but there are ways to accommodate it without sacrificing everything that Loran C has to offer. It too high a price to pay to avoid a problem for which viable alternative solutions are available or can be developed. Implementing them is a component part of the plan to establish Loran C as the national system.

(6) International implications of the decision to declare Loran C and Omega as strictly military systems are grim. The action threatens our national credibility and that of the governments of some of our allies. If Loran C were named the system we will provide for all our users, it would be proof positive of our integrity and would bolster the governments and others who support us.

(7) Loran C will serve not only the Coastal Confluence Region but the High Seas (within 1000 miles) and Rivers and Harbors (a recent demonstration in Delaware Bay is particularly good for it showed consistent accuracies of 100 feet (95%) and 38 feet (50%) using commercial low cost receivers. It also showed accuracies in the differential mode of 40 feet (95%) and 15 feet (50%)).

In consequence, adoption of the Loran C system recommended by the Department of Transportation in its FY 75 budget request is strongly urged.

Appendix I - Comparison Table
Appendix II - The Need for a Precision Radionavigation System (w/3 attachments)
Appendix III - Can Loran A Achieve the Required Accuracy?
Appendix IV - Growth Potential of Loran C
Appendix V - International Implications of Designating Military Radionavigation Systems
Appendix VI - User Attitudes

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Appendix I - Table of Comparison, Loran A vs Loran C

		Loran A	Loran C
Capable of one-quarter mile accuracy?	Theoretical	Yes	Yes
	Proven	No	Yes
Presently performing to required one-quarter mile tolerances?		No	Yes
Can system of one-quarter mile accuracy be ready when TAPS is?		Doubtful	Yes
Presently in general purpose use?		Yes	Some
Receiver Cost?		Not available for increased accuracy. $1000 or less for present ones	$3000 - $5000
Fully automatic receiver operation?		No	Yes
Aviation use?		Yes	Yes Under test for FAA approval fo airlines. USAF uses.
Repeatability (for fishing, exploration, mining, etc.)?		100 meters - 1.0 NM	15-100 meters
Ancillary benefits:			
Precise time		No	Yes
Communications		No	Yes
Traffic management		No	Yes
Air control		No	Yes
Vessel traffic control		No	Yes
Others		No	See attachment

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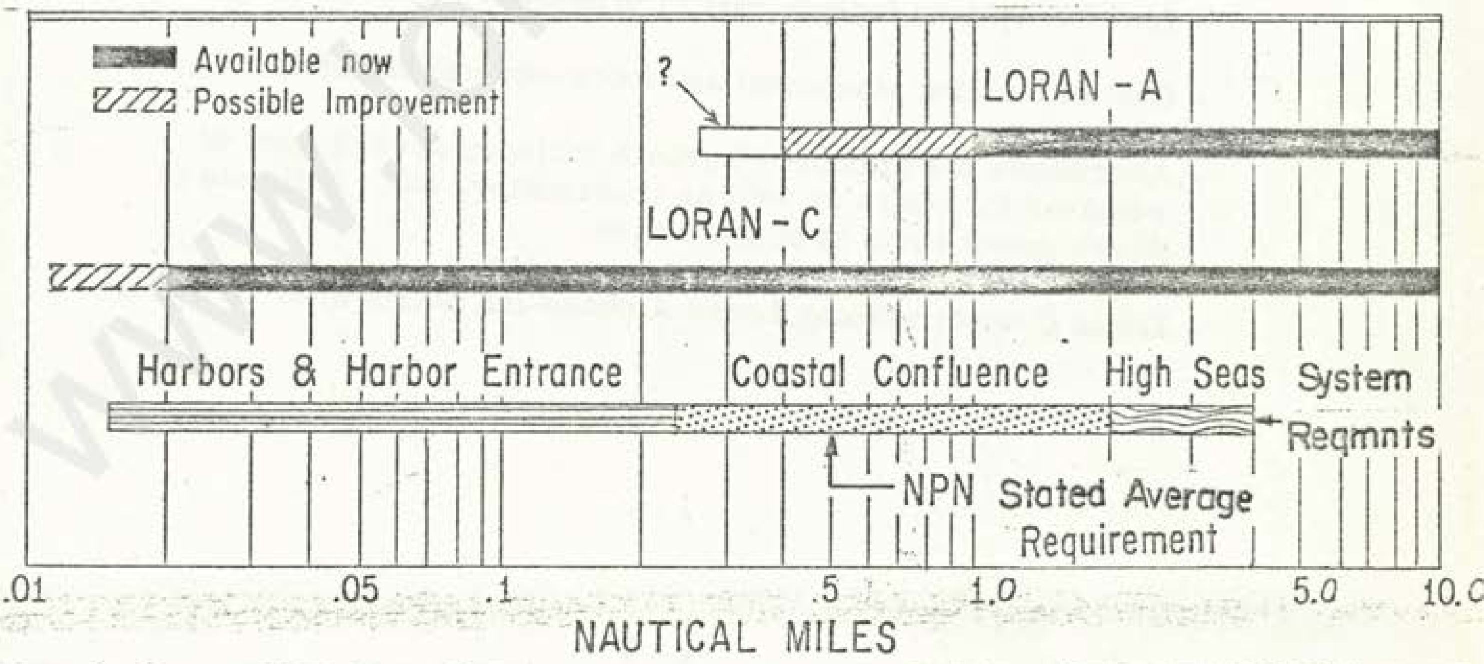
		Loran A	Loran C
Separate system for specialized military required?		Yes	No
Service available throughout country as well as maritime?		No	Yes
Cost for 10 years if adopted as the national system for Coastal Confluence. (See details on p. I-3)	In '74 $ Discounted	$92.2 $65.2	$81.5M $61.2M
Range of one-quarter mile accuracy signal		50 NM	1000 NM
Present users:			
Military		Thru CY74	Thru FY84
Fishermen		Most	Some
Exploration and mining		Some	Yes
Airlines		Yes	No
Marine navigation		Yes	Some
Foreign		Yes	Increasingly
Yachtsmen		Yes	No
Receivers on market?		Not for 1/4 mile accuracy-to be developed	Some-esp. in Europe. Mfgrs awaiting decision re: U.S. system.

ACCURACY (2 drms)



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Cost Comparison - FY75 - FY84

Alternatives	Capital Invest $M	Op Cost $M	Total (74 $) $M	(Discounted) $M
Continue L-A "as is"	25.9	34.3	58.9	41.4
Augment L-A to provide coverage "as is" throughout CCR	37.5	42.1	79.6	56.3
Augment L-A and improve accuracy to 1/4 mi. out to 50 mi. from coast	49.9	42.3	92.2	65.2
Replace L-A with L-C allowing phase-out overlap for L-A	49.7	31.8	81.5	61.2

Note: - Great Lakes coverage is not included in the figures above. Costs to provide it would add the following to the above figures:

L-A	$32.3M plus $5.376/yr. to operate
L-C	$10.5M plus $.270M/yr. to operate

- Loran A options include cost of present Loran C for DOD
- Cost of training equipment and mock-ups not included
- Alternative for improved Loran A includes development of receiver for users as well as transmitter, etc. Estimate of development costs is conservative.
- Loran C costs assume Loran A phase-out starts after five years

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Appendix II - The Need for a Precision Radionavigation System

There will be a surge of activity in the CCR during the next decade. As a result, there will be a dramatic increase in the number of fixed structures located in the CCR and in the number of ships traversing that area. These fixed structures will include platforms for the exploitation of oil and other mineral and sites for nuclear power plants. They will be accompanied by a significant increase in the number of pipelines and transmission lines lying on the ocean floor. In addition, there is also the probablity of selected areas of the ocean being "fenced off" for sea-farming. The number of vessels traversing the CCR will be far in excess of present numbers and many will have drafts two or three times deeper than most present vessels.

Clearly, the increased number of deeper draft vessels traversing the CCR combined with the increased number of structures, both above and below the water, will magnify the possibility of accidents in the CCR. Let us review that potential risk and some of the other reasons why a precision system is needed.

Safety

The need for safety takes several forms each of which has significant national implications. And each evolves about two primary factors--

(1) Being able to avoid shoals in shallow water when operating near shore.

(2) Being able to keep clear of other vessels and man-made obstructions when operating in congested areas.

Failure to succeed in achieving either of the above two factors has the following implications--

(1) Economic

Vessels plying U. S. waters are becoming increasingly sophisticated and expensive. It is clear that the only cost effective way to carry the volumes of petroleum and similar products needed will be in mammoth super tankers and bulk carriers, and the number of super tankers in operation will increase manyfold, particularly on the West Coast of the U. S. as oil begins to flow from the Alaska pipeline starting in 1977. The loss of a single vessel of this super tanker category would result in a

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cost to the economy of the cost of the ship itself plus the value of the cargo, plus the cost of pollution clean-up and the loss of revenue not only from the cargo being carried in that particular voyage but for all succeeding voyages that would have been undertaken by that ship. For example, it has been estimated that the loss of a single 300,000 dead weight ton (dwt) tanker (known as "very large crude carrier") would result in a direct economic loss in excess of $49 M plus $3000 per day in operating losses until the ship could be replaced at a future capital investment of $43 M. Assuming about a two-year time to replace the lost vessel, the cost to the economy of the loss of a single vessel of this category would approximate the cost of installing and running the entire proposed radionavigation system for ten years.

(2) Environmental Damage

It is not really possible to judge the impact of the loss of the entire cargo from a ship carrying crude oil in the quantity that will be carried by the tankers shuttling from the West Coast of the U.S. to the Alaskan terminal. An example of what can happen is the collision that occurred in San Francisco Bay a few years ago, when 800,000 gallons of oil were spilled. The cost to clean up that spill was $4 M and the damage to the ecology of the area was major. The ships from Alaska will each carry 40 times as much oil as was spilled on that one occasion! The area they will traverse in bringing oil into the continental U.S. from Alaska is crucial in its role of providing natural resources, particularly fish and water mammals. The damage that might be done to the salmon, halibut, seal, etc. is inestimable. The same kind of rationale applies to shipments to other areas and to shipments of hazardous materials, LNG, etc.

(3) Energy Loss

If an entire cargo were lost from one of the 120,000 dwt ships coming from Alaska, it would amount to a loss of over 800,000 barrels. 800,000 barrels of crude oil equates to something in excess of 420 million kilowatt hours of power--enough to provide for the entire State of Rhode Island for over two months. Expressed another way, the fuel oil that could be produced from that cargo would be sufficient to heat over four million homes for one day, or to heat over 20,000 Washington area homes for the entire winter.

The United States cannot afford the risk of shunning any reasonable effort which will reduce probability of such a loss of critical energy to a minimum.

The way to avoid the catastrophic consequences discussed above is to provide traffic separation schemes, accurate charts, and a navigation system which will permit vessels to know when they are straying from

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safety areas. A number of traffic separation systems are currently in effect, as illustrated in Figures 2.1-2.5 of Attachment 2. The principle is much the same as that used in air traffic separation systems, although the factors governing navigation within them are considerably different. Using calculations of probability and taking into account the various factors affecting navigation of a vessel shown in Figure 2.6 of Attachment 2, it has been determined that with a navigation system that provides a one-half mile accuracy with 95% certainty there is a one in twenty chance of a vessel straying outside a mile-wide traffic lane. When that accuracy is improved to one-quarter mile, the probability of a vessel straying from its lane reduces to one in five hundred. In some areas, such as within congested harbors and harbor approaches, even that relatively remote probability is too great to accept in view of the magnitude of risk. However, in general, one-quarter mile accuracy can be considered the maximum requirement in the Coastal Confluence Region with many parts of the Region being able to be safely traversed with accuracies of one-half to one mile available. (The areas of the Coastal Confluence Region where the various accuracies are described in para 2.3 of Attachment 2.) Since it would be unreasonalbe to try to provide systems of different accuracies in different parts of the Region, it was determined that the system to be selected must be able to provide one-quarter mile accuracy wherever it might be required throughout the Coastal Confluence Region.

Attachments 1 and 3 are alternate methods of arriving at the conclusion that a system is needed which can provide at least one-quarter mile accuracy wherever traffic congestion or separation limitations warrant in the Coastal Confluence Region.

Law Enforcement

Effective prosecution of violators of international and national laws and treaties often requires precise determination of the location of the violation--for example, to determine whether or not the alleged violator was in a treaty area or not. With increasing interest of foreign nationals in the natural resources which abound in our waters, this is becoming an increasingly important requirement. It is important for both enforcement agencies and those who are operating in the areas, who must have the means to determine when they are within the fishery area and when they are not.

For the future, the outcome of the Law of the Sea Conference may well require a significant increase in law enforcement effort in our coastal waters. These will require the ability for accurate navigation for location of offenders. Other current law enforcement requirements are those imposed by legislation requiring surveillance of ocean dumping and marine pollution.

Exploration and Charting

Most charts for the Coastal Confluence Region of the United States are the result of surveys conducted in the days before precision navigation systems were available. Furthermore, they did not concern themselves with the precise location of wrecks and other obstructions below the depths of 60 feet because there were no vessels drawing that much water at that time. Now with deep draft vessels drawing as much as 90 feet, the risk of striking these obstructions has become a factor to be reckoned with. New charts must be made and fairways must be laid out to carry deep draft vessels safely around the shoals and obstructions which have not heretofore been a problem.

The increasing quest for knowledge and location of resources on our continental shelf has created demand for an all-weather, continuous service precision navigation system. Typical of the extent of interest is the application filed by some users to permit them to establish their own localized Loran C stations in areas where we have not yet provided coverage. In these applications, precision beyond the simple "one-quarter mile accuracy" level is required. Locations throughout the Coastal Confluence Region have the potential for scientific and exploratory operations, hence have a requirement for precise navigation capability.

We do not know exactly how many fixed structures for the exploitation of oil and other mineral resources, pipelines and transmission lines, nuclear power plants, and sea-farms will be located in the CCR. We do expect them to be there in significant numbers. We do not know exactly how many vessels of each size will be traversing the CCR nor the draft and cargo carried by each vessel. We do expect they will be larger in both size and number, and that many will be carrying LNG and oil. As a result of these knowledge limitations, we do not know exactly how much the probability of accident in the CCR will increase over the next decade, but we do know the potential risk will increase significantly. We therefore, believe that a highly accurate location system in the CCR is necessary and find it reasonable to conclude that there is a definite relationship between reducing risk of accident and accuracy of location such that risk of accident decreases as precision in location increases.

The attached papers present some approaches to determining the degree of accuracy required. While they do not demonstrate conclusively what specific accuracy is required, they do show a significant reduction in risk when accuracy for confined or congested waters is increased from one-half mile to one-quarter mile. The catastrophic potential of not making such an improvement staggers the imagination.

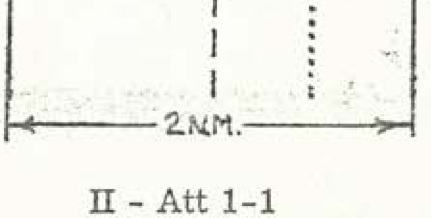
APPENDIX II

ATTACHMENT 1

Determining the probability of a collision or grounding in various specified areas of the Coastal Confluence Region (CCR) is a complex and exacting task. The knowledge and the models which have been applied to the aviation field may, in some measure be applicable to the marine transportation problem. A prohibitive effort would be required to examine and analyze the CCR traffic patterns in order to develop probabilistic models for the various marine traffic situations such as sea lanes, fairways, and other traffic separation schemes. However, using the work that has been done on probabilities of vessels straying from designated lanes or safety areas with statistics on numbers of passages we can determine the order of magnitude of risk involved using radionavigation systems of different accuracies.

Indicators of the magnitude of the problem we may face in the future can be gleaned from an examination of the casualty statistics of the recent past. Applying casualty figures and traffic density figures to a simplistic model may be crude. However, it may suffice to give us a feeling for the order of magnitude of the probability of vessels moving outside of designated lanes. This movement outside of a designated lane into the lane of oncoming traffic does not ipso facto imply a collision will occur. The determination of the probability of collisions for a given set of circumstances over a given period of time, is an exceedingly complex task.

How may we get a handle' on the chance of two vessels moving in opposite directions in adjacent and parallel lanes (with no buffer zone) being in a situation where a collision is possible? The fairways in the Gulf of Mexico are 2 N. M. wide with two-way traffic and no buffer zone between opposing directions of traffic. Therefore each vessel attempts to stay in its half of the lane. Each vessel then tries to stay in a lane 1 N. M. wide, and if each stays in the center of his 1 N. M. lane, he has 1/2 N. M. between his ship and the center of the 2 N. M. total width.



With a lane width of 1/2 N. M., what is the chance a vessel will stray into the adjacent lane of oncoming traffic? If we assume the vessel has no bias to port or starboard track-keeping, then the deviations from the center line of his intended course should be equally distributed among the port and starboard areas. Deviations to starboard by either vessel in the diagram above will be away from a collision course. Whereas deviations to the port side (or toward the centerline of the 2 NM lane) will be in the direction of the lane of oncoming traffic. Assuming a navigation aid system which gives track-keeping ability of ± 1/2 N. M. or ± 1/4 N. M. (95%), the following chances of two vessels being in the opposing vessel's lane apply:

Trackkeeping (95%)	Chance of 2 Vessels being in Each others lane
1/4 N. M.	$\frac{1}{1,000,000}$
1/2 N. M.	$\frac{1}{1600}$

How can we relate these chances to our knowledge of traffic statistics? We would expect that in the case of a system which provides 1/2 N. M. track-keeping capability, in the long run, one incident of 2 ships crossing into each other's lane would occur for 1600 vessel passings. A vessel passing occurs when 2 vessels each travelling in opposite directions, pass each other. By comparison, we would expect one incident per 1,000,000 passings for the system which provides 1/4 N. M. track-keeping capability. The foregoing assumes the vessels are navigating using a radionavigation system such as Loran-A or Loran-C with no other assistance from any other means of being aware of other vessels. (This, or course, is rarely the case for major vessels, but it is presumed here to simplify analysis).

The two way transits for tankers, dry cargo and passenger ships of several areas for a typical year were as follows:*

Delaware Bay	Houston Ship Channel	L. A./ Long Beach	San Fran	Puget Sound & Vicinity
81,073	7517	11,575	14,121	78,875

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*See Tab 3.

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It should be noted the traffic information is for port areas and does not include the CCR. We are using the statistics only as an indicator of the level of traffic). From the above figures one would expect approximately 5 incidents each, for the port areas of Delaware Bay and Puget Sound in a 2 year period if we use the 1/2 N. M. system and a chance of 1/1600 of an 'incident.' If we use a 1/4 N. M. system and a chance of 1/1,000,000, then it would take approximately 24 years or more for an 'incident' to occur in Delaware Bay or Puget Sound.

Additional material on traffic densities and probabilities of accidents occuring may be found in the enclosed tables.

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Annual Casualty Totals for Collisions, Rammings, and Groundings (C/R/G), FY 1968-71(1)

	FY '68		FY '69		FY '70		FY '71	
	Cases	Vessels	Cases	Vessels	Cases	Vessels	Cases	Vessels
Total Casualties, All Types	2,570	4,011	2,684	4,183(1)	2,582	4,063	2,577	4,152
Collisions/Rammings	1,047	2,221	1,109	2,336	1,163	2,271	1,119	2,349
Groundings	525	656	567	690	540	670	604	807
C/R/G Subtotal	1,572	2,877	1,676	3,026	1,703	2,941	1,723	3,156
CRGs as % of Total	61.1%	69.3%	62.4%	72.4%	65.8%	71.6%	66.9%	76.0%
Location	CRG Cases	% of All CRGs	CRG Cases	% of All CRGs	CRG Cases	% of All CRGs	CRG Cases	% of All CRGs
All U.S. Waters	1,342	85.4%	1,274	76.1%	1,307	76.7%	1,460	84.8%
Inland-Atlantic	299		388		307		386	
Inland-Gulf	511		406		502		568	
Inland-Pacific	211		189		180		189	
Coastal Subtotal	1,021		983		989		1,143	
Great Lakes	141		130		132		133	
Western Rivers	180		161		186		184	
Estimated Losses ($ Thousands)	CRGs	CRG% of Total	CRGs	CRG% of Total	CRGs	CRG% of Total	CRGs	CRG% of Total
Vessel	23,895		29,041	42.6%	27,646	39.9%	31,155	39.5%
Cargo	1,300		1,823	17.8%	4,116	23.7%	1,910	28.8%
Property	7,927		7,190	90.8%	9,325	87.8%	8,492	95.3%
Total	42,122		38,054	55.8%	41,087	42.2%	41,557	43.9%
Persons Killed/Injured	33/32		(2)98/88		24/26		75/62	
Cases with Person K/I	27		47		33		53	

NOTES:

(1) Casualty tape lists only 4180 vessels for 1969. All other totals in Statistical Summaries agree with tape totals.

(2) Total of 98 dead was verified from tape printout. A total of 23 vessels were involved, three accounting for 63 of the 98 killed.

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Total Damage by Vessel Class for all C/R/G in U.S. Waters for FY 1969-71

Vessel Type		Total* Vessels	Total Est. $ Loss (Thousands)				Oil Pollution Cases			Personnel Casualties			
										Vessels	Number of Persons		
			Vessel	Cargo	Property	Total	Light	Med.	Heavy	Involved	K/M	Inj	Total
CARGO SHIPS													
<400 ft		249	2,852	509	698	4,059	1	0	0	4	2	2	4
4-600 ft		698	11,438	899	5,834	18,171	3	0	0	3	46	44	90
>600 ft		225	4,696	40	797	5,533	1	1	0	0	0	0	0
	SUBTOTAL	1,172	18,987	1,448	7,329	27,764	5	1	0	7	48	46	94
TANK SHIPS													
<400 ft		89	714	22	105	841	9	4	0	0	0	0	0
4-600 ft		193	2,483	79	1,170	3,732	4	3	1	2	2	2	4
>600 ft		221	4,915	105	2,157	7,177	5	5	2	0	0	0	0
	SUBTOTAL	503	8,112	206	3,432	11,750	18	12	3	2	2	2	4
FREIGHT BARGE		1,109	7,147	1,856	3,719	12,722	1	0	0	3	2	1	3
TANK BARGE		1,303	9,219	1,149	2,660	12,028	99	33	14	2	0	2	2
TOW/TUG		2,505	6,244	6	3,324	9,574	31	10	2	20	14	17	31
FERRY		68	318	0	259	577	0	0	0	2	0	4	4
OTHERS		1,640	17,595	550	3,452	21,597	3	1	0	83	89	86	175
	TOTALS	8,300	67,622	5,215	24,175	97,012	157	57	19	119	155	158	313

*Total number of vessels involved in C/R/G regardless of whether or not loss was reported.

One-Way Port Transits by Commercial Vessels - 2 Year Totals (CY 1969-70)

Ship Type	Delaware Bay	Houston Ship Channel	Los Angeles/ Long Beach*	San Francisco Bay	Puget Sound and Vicinity
Tank Ships	12,213	4,670	4,407	6,404	955
Dry Cargo and Passenger Vessels	149,934	10,365	18,743	21,839	156,796
Tank Barge	34,139	35,139	11,168	9,095	5,667
Freight Barge	26,737	30,047	1,420	24,660	22,067
Tow/Tug	73,395	35,233	31,876	49,953	99,549
Totals:	296,418	115,454	67,614	111,951	285,034

*Transit figures shown are for these two ports. (Accident statistics are given elsewhere for Southern California Coast.)

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Average Loss per Vessel per Accident for Tank Ships

(All U. S. Waters, FY 1969-71)

Accidents				Sample Mean	Sample Standard	Upper 90% Confidence
Type* j	Number of Vessels	(i)	Type Loss**	$\overline{D}_{i,j}$	Deviation	Limit
1	83	1	Vessel & Cargo	15.590	29.95	19.8
		3	Pollution	136.140	1101.50	295.0
		4	Death/Injury	0.0480	0.346	0.10
2	59	1	Vessel & Cargo	11.980	24.90	16.2
		3	Pollution	37.290	182.79	68.1
		4	Death/Injury	0.0	0.0	0.0
3	106	1	Vessel & Cargo	7.490	13.90	9.3
		3	Pollution	21.700	137.33	39.1
		4	Death/Injury	0.0	0.0	0.0
4	59	1	Vessel & Cargo	36.580	119.33	56.7
		3	Pollution	69.490	253.43	112.3
		4	Death/Injury	0.0	0.0	0.0
5	196	1	Vessel & Cargo	17.170	55.39	22.3
		3	Pollution	121.940	1013.0	215.0
		4	Death/Injury	0.0	0.0	0.0

*Accident Types: #1, Collision, two or more moving vessels, #2, Collision, one moving and one other vessel; #3, Ramming, fixed object; #4, Ramming, floating object; and #5, Grounding.

**Type Loss: Vessel and cargo (\$ x 10^3); Pollution in gallons; Deaths/Injuries in number of people killed and injured.

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APPENDIX II

ATTACHMENT 2

SAFETY REQUIREMENTS

2.1 Traffic Separation Schemes

The dramatic increase in the industrialization and growth of the world's population within the last one hundred years has, among other things, resulted in a "shrinkage" of the safely navigable waters of the world. There have been substantial increases in all classes of ships trying to use the available waterways, from the smallest recreational boat to the largest super-tanker, each trying to avoid colliding with another while going about trying to accomplish their individual objectives.

Besides avoiding other vessels, a ship must also contend with natural hazards such as hidden reefs and treacherous currents. Formidable as the natural hazards may be, the most predominate hazard to navigation in certain waters is man-made, e.g., the off-shore oil platforms in the Gulf of Mexico and Santa Barbara Channel.

Because of the increased number of ships and the proliferation of man-made hazards in navigable waters, various traffic separation schemes have been instituted at the approaches to certain harbors, along selected trade routes and through the extensive off-shore oil fields of the Gulf and Pacific states. The future is expected to bring more extensive use of traffic routing and separation in all waters in an effort to improve the poor safety record of the maritime community.

Improved safety can be achieved by increasing the effectiveness of the present traffic separation systems through two measures: (1) establishment of navigation aids that will allow ships to locate the traffic lanes and aids with enough accuracy to ensure that the ships can stay within the lanes; and (2) the implementation of laws addressed specifically to the use of traffic lanes to help introduce a uniformity of procedures among the users.

A description of the different types of traffic lanes follows along with the navigational requirements necessary to assure track maintenance capability within the lane boundaries.

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2.1.1 Sea Lanes

In the coastal confluence area two forms of the sea lane concept are used to maintain vessel separation in congested and/or converging areas: the harbor approach lanes and the coastal traffic lanes. Both forms are composed of a separation zone separating traffic proceeding in opposite directions and the traffic lanes themselves within which one-way traffic proceeds. Typical dimensions of each separation scheme are shown in Figures 2.1 and 2.2. The important dimension is the one-way traffic lane width within which the vessel must maintain track. For the coastwise traffic lane, as exemplified by the Santa Barbara - San Pedro traffic lanes of Figure 2.3, the lane width is a constant 1 n. mi. For the harbor approaches that extend more than approximately fifty miles out to sea, such as New York, Figure 2.4, the lane width is 5 n. mi., narrowing to 1 n. mi. at the harbor entrance.

Aids to navigation currently in place to mark the sea lanes are in most cases inadequate. For example, a navigator trying to follow the Eastern approach lane to New York has a total of three buoys to mark the entire 200 miles of sea lane. A notable exception is the Chesapeake Bay approaches where buoys are located approximately every 2 miles.

If a position fixing aid is to be used to assure that the ship has the capability to stay within the bounds of its shipping lane a very high percent of the time, the accuracy of that aid must be at least ± 0.25 n. mi. 95 percent of the time for the one n. mi. lane width and at least ± 1.0 n. mi. for the five n. mi. lane width. (See Section 2.2 for the development of these numbers.)

2.1.2 Fairways

In certain navigable waters, mainly the Gulf of Mexico and the Port Hueneme area of the Santa Barbara and San Pedro Channels, the predominate hazards to navigation are man-made objects, oil wells. The waters of the Gulf of Mexico contain over 8,000 oil wells. Almost 2,000 of these wells are in waters exceeding 10 fathoms in depth, and they extend out as far as 70 miles from shore. In order to promote safety of shipping in these regions, the Department of Army has designated certain areas as shipping safety fairways. These are areas within which they do not intend to grant any permits for construction of oil wells.

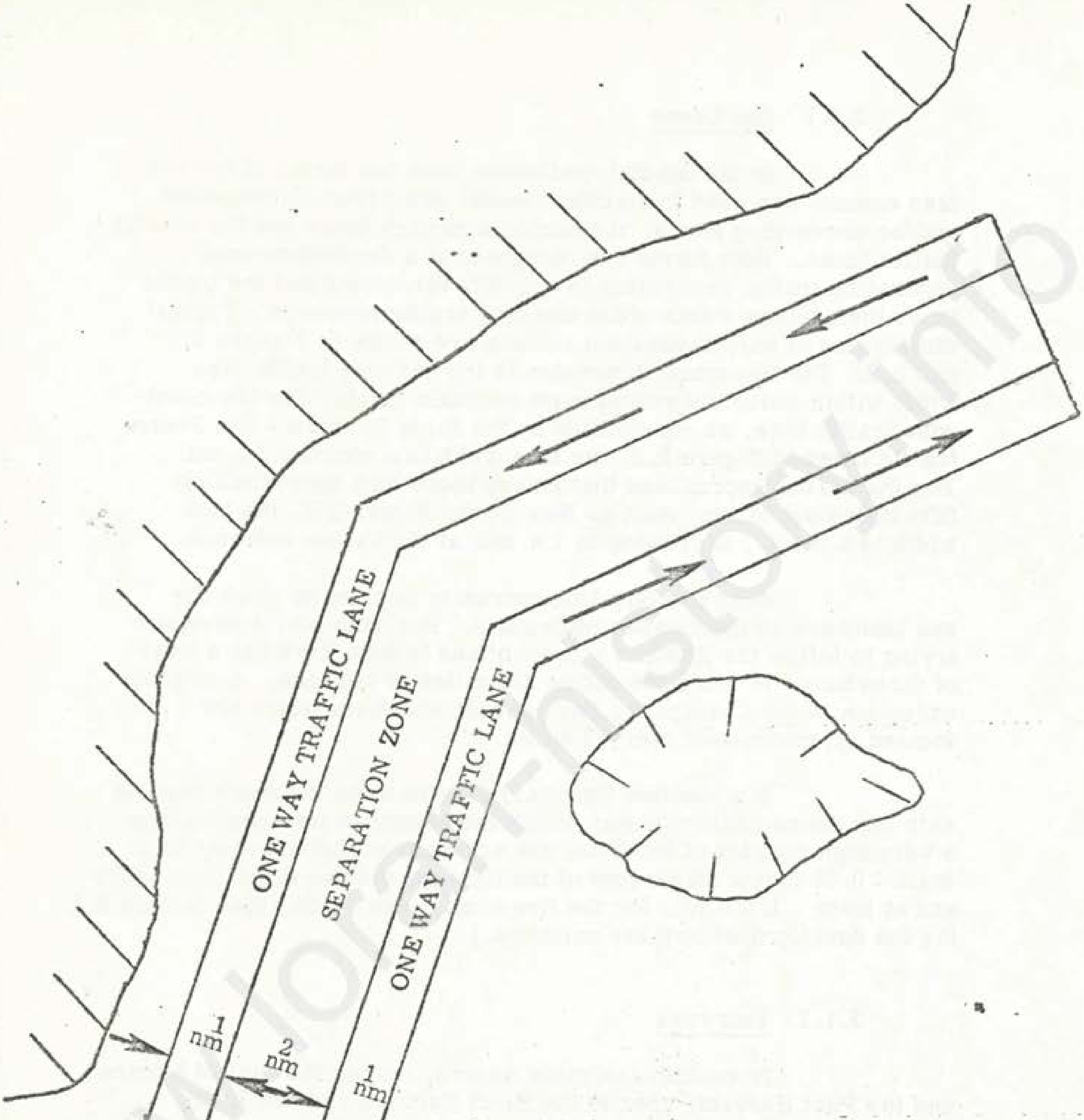

Figure 2.1
COASTWISE TRAFFIC LANE DIMENSIONS

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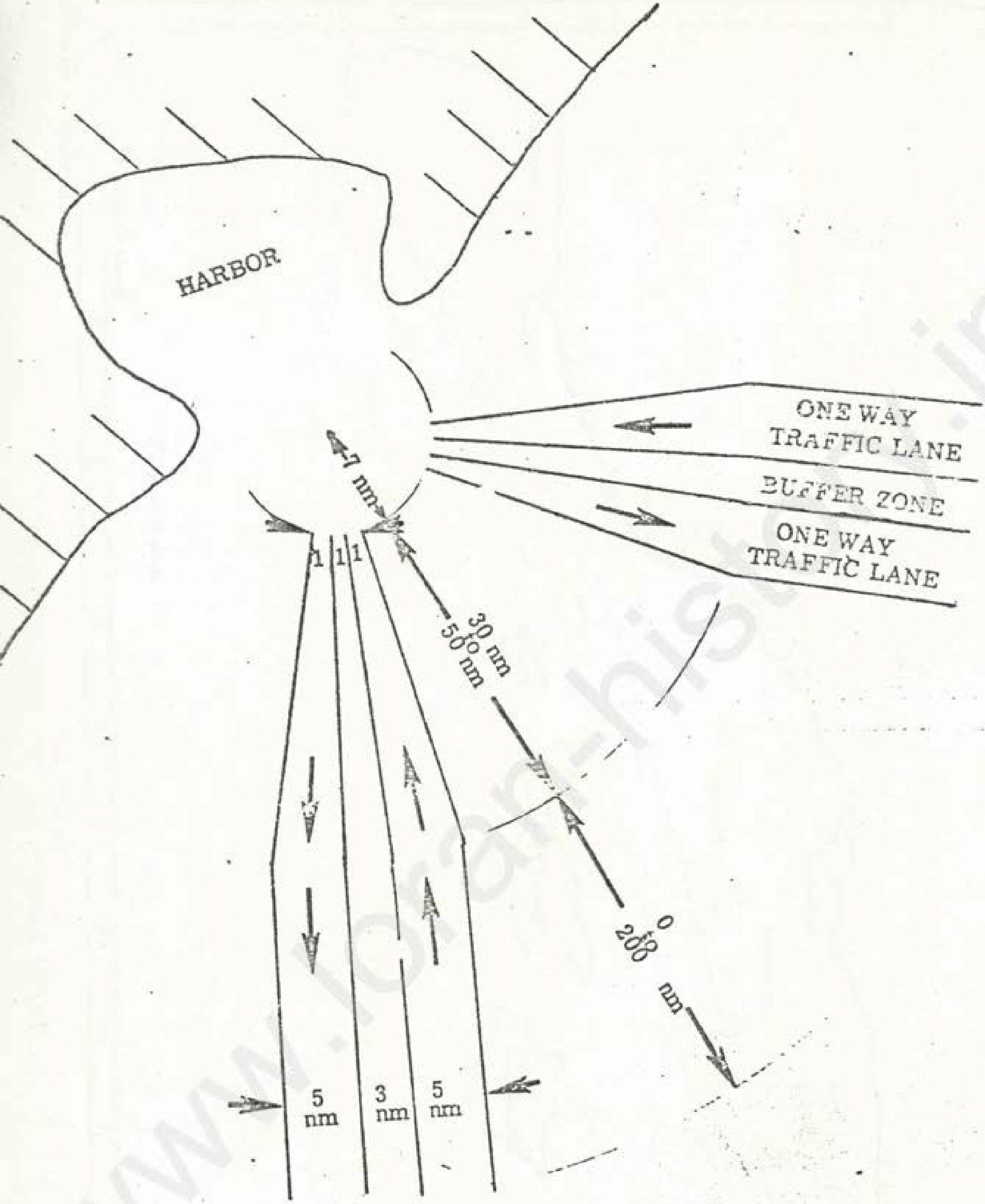

Figure 2.2

HARBOR APPROACH
TRAFFIC LANE DIMENSIONS

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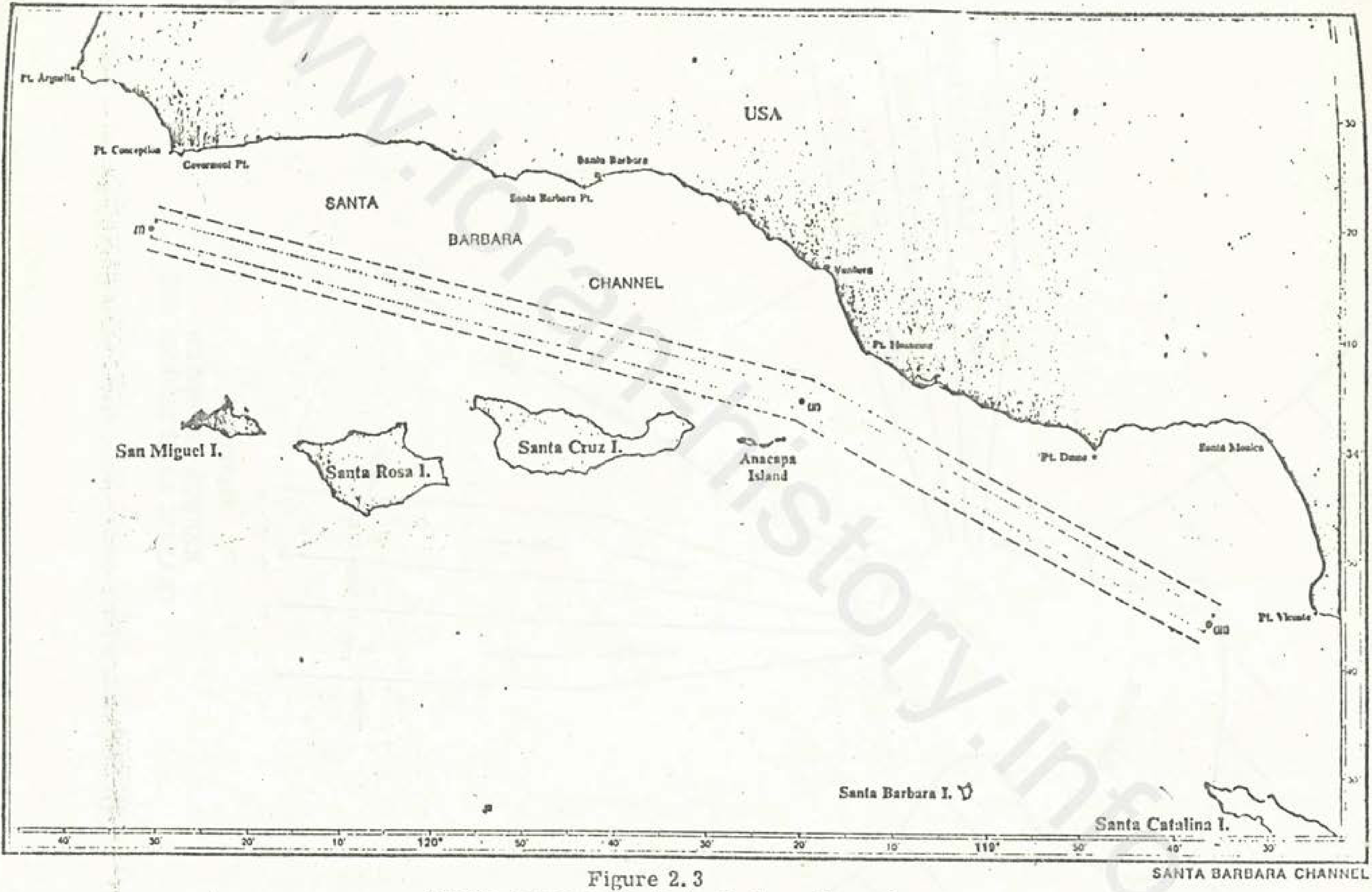

Figure 2.3
Traffic Lanes in the Santa Barbara Channel

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The fairways are two nautical miles wide and contain two-way traffic (see Figure 2.5). There is no buffer zone separating the traffic going in opposite directions either from other ships or from the oil wells. Thus the effective route width for one-way traffic is one nautical mile.

No navigation aids exist in the Gulf to mark the fairways; however, the oil wells are required to be lighted at night. In examining the Gulf situation, it is apparent that the fairways are entirely inadequate for the critical nature of their job. An environmental disaster is just waiting to happen. Even if adequate navigation aids existed in the Gulf of Mexico, the fairways would still be too narrow. The present system leaves no margin for human or machine error. One-way traffic lanes are recommended, with buffer zones separating the traffic going in the opposite direction. In addition, buffer zones should also be established between the fairway lanes and the oil wells. A typical section of the fairways is shown in Figure 2.5.

As developed in Section 2.2, the fix accuracy requirement for a one n.mi. wide lane is ± 0.25 n.mi. 95 percent of the time. This requirement in the Gulf extends from the near shore area out to the 100 fathom line, the limit of the present fairway system.

2.2 Position Fixing Accuracy Requirements

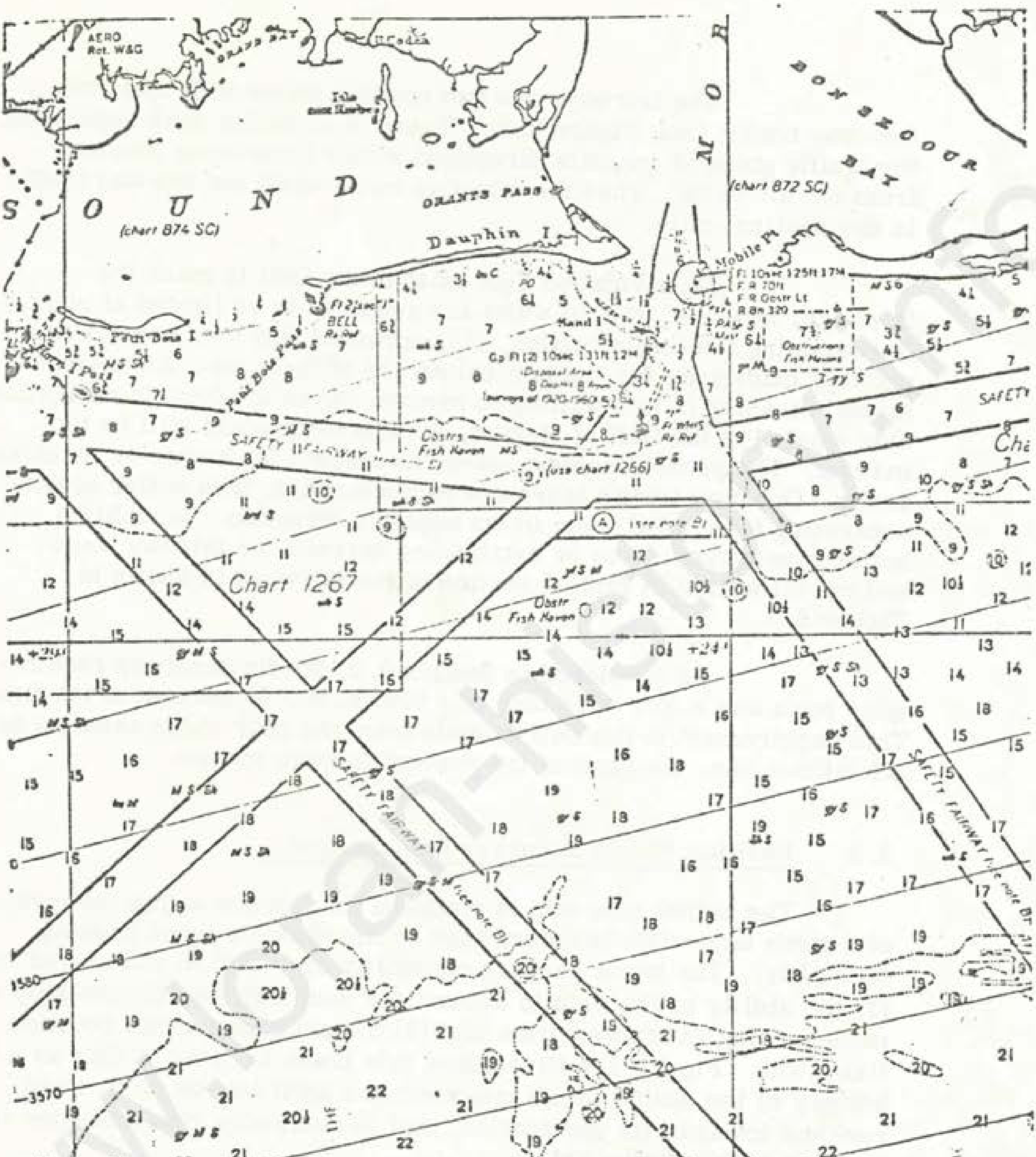
The ability of a ship to maintain its position within the confines of a given lane width is determined by the vessel's track keeping capability. The track keeping capability of a ship is influenced by (1) the ability of the ship to accurately dead reckon, (2) the ship's maneuvering characteristics and (3) the accuracy of the position fixing aid. Figure 2.6 illustrates this track keeping ability as a time history of the ship's cross track errors as it leaves port, dead reckons towards its destination, and periodically reestablishes its position with a fixing aid.

Since the accuracy of the position fixing aid is highly independent of the dead reckoning ability and the maneuvering characteristics of a ship, one can formulate the track keeping ability of a ship by summing the variances of the individual error sources that contribute to the total track keeping error, thus:

$$\epsilon^2_{\text{track}} = \epsilon^2_{\text{fix}} + \epsilon^2_{\text{DR}} + \epsilon^2_{\text{man}}$$

or,

$$\epsilon_{\text{track}} = \sqrt{\epsilon^2_{\text{fix}} + \epsilon^2_{\text{DR}} + \epsilon^2_{\text{man}}}$$



CAUTION

Oil well structures, some submerged and capped, are charted only where offshore of the indicated limits of the 1200 - series charts.

Figure 2.5
GULF OF MEXICO FAIRWAY

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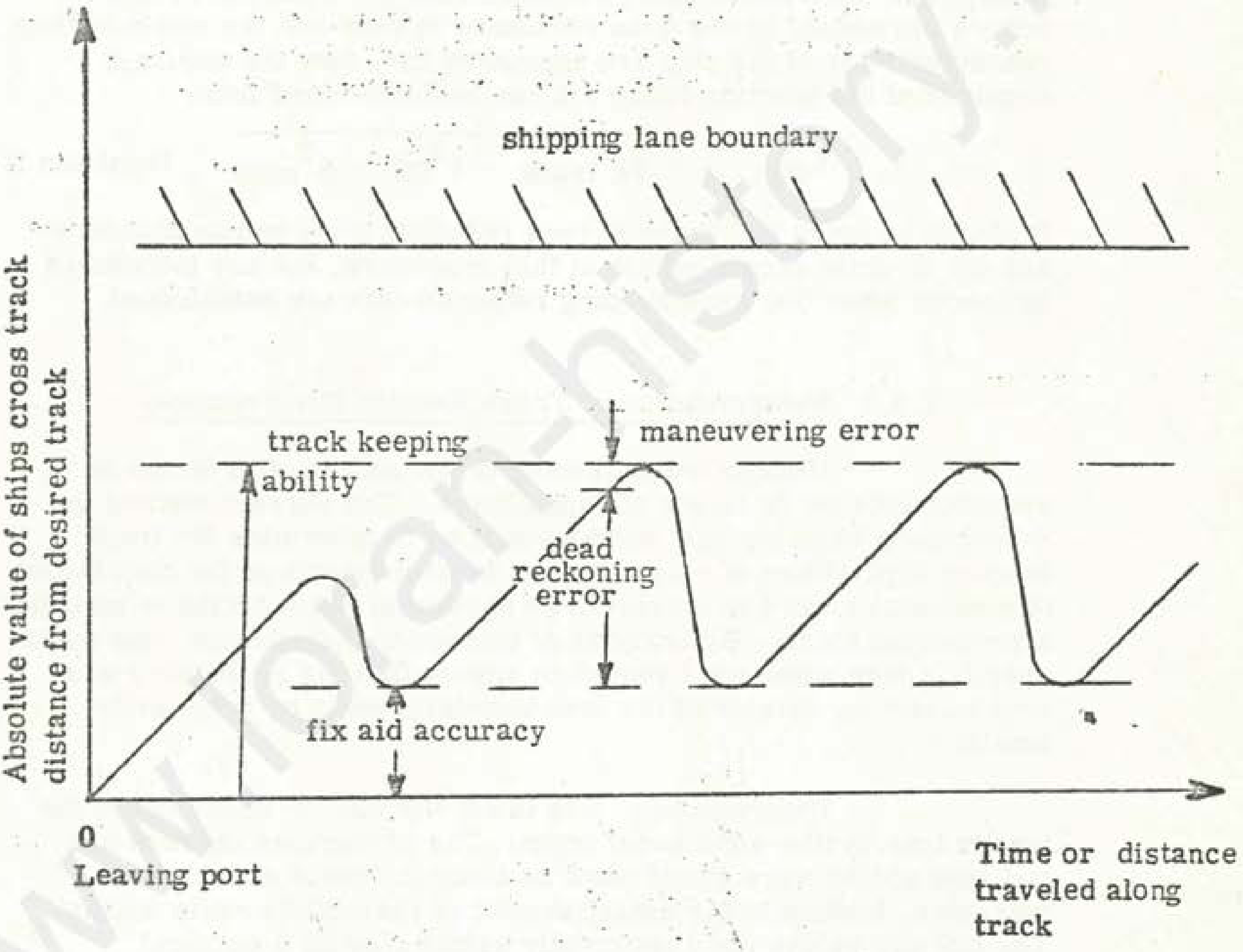

Figure 2.6

TRACK KEEPING ABILITY

where:

ϵ_{track} = track keeping error or requirement

ϵ_{fix} = cross-track error (or accuracy) of the position fixing device

ϵ_{DR} = cross-track error resulting from dead reckoning

ϵ_{man} = cross-track maneuvering error

Thus, once the track keeping requirements are established and the errors introduced by the dead reckoning system and the maneuvering characteristics of the ship are accounted for, then the accuracy required of the position fixing aid can be determined from

$$\epsilon_{fix} = \sqrt{\epsilon^2_{track} - \epsilon^2_{DR} - \epsilon^2_{man}} \quad \text{(equation 1)}$$

It should be noted that track errors resulting from human blunders are not directly accounted for in this procedure, but are introduced indirectly when the track keeping requirements are established.

2.2.1 Determination of Track Keeping Requirements

Usually track keeping is not spoken of in terms of requirements but in terms of capabilities. The correct method for determining shipping lane widths would be to determine the track keeping capabilities of ships through measurements of the distribution of positional errors of a very large number of ships trying to maintain a predefined track. By analysis of this error distribution, one could specify a lane width wide enough to ensure that the probability of a ship wandering outside of the lane boundary would be arbitrarily small.

Unfortunately, this is not the way by which any of the traffic lane widths were established. The prescribed courses and sea lane widths were established by a committee of experienced mariners, leading to the establishment of reasonable route widths. The fairway widths were apparently established by a political compromise between the oil interests and the mariners. Consequently, the results are of dubious value, from the standpoint of safety.

Our problem is to work backwards, i.e., starting from the existing lane widths, to determine what track keeping requirements are now necessary to ensure a high probability of containment of the ships within these boundaries.

Since one desires a high probability of containment, one must analyze the "tails" of track keeping error distributions, for it is here that the rare occurrences of large errors occur. Unfortunately, there is no information in existence on the shape of tails based on observational data, since a prohibitive amount of data would be needed to infer the detailed shapes of these rare occurrences.

To circumvent the problem, many separation studies done in the aviation field have fit Gaussian error distributions to the few track error measurements at hand to help infer the frequencies of occurrence of the rare errors in the tails of the distribution. However, as more observational data have been collected, it has become apparent that the frequency of occurrence of large navigational errors is much greater than one would predict using Gaussian distributions. Because of this, some of the more recent analytic studies on traffic separation have assumed exponential error models for the behavior of systems. Exponential distributions are being used, not because they approximate the true shape of the distribution of rare occurrences (which is unknown), but because they predict the occurrence of rare events at a much higher frequency than Gaussian distributions. Thus, the exponential distribution yields more conservative safety predictions (approximately five times more conservative at the three-sigma point).

Track keeping requirements necessary to support a given lane width are shown in Figure 2.7 with the probability curves based on the standard exponential error function

$$f(x) = \frac{1}{\sqrt{2}\,\sigma} \int_0^x e^{-\frac{\sqrt{2}\,x}{\sigma}} \, dx$$

At this point, a judgment must be made as to what is an acceptable chance for going outside the traffic lane. Even if the calculations are carried one step further to the determination of the probability of occurrence of a collision with another ship or fixed object, a decision would still be necessary as to what is an acceptable chance of collision occurrence. Containment of a ship within its lane at least 99 percent of the time (1 in 100 chance of going outside its lane) has been established as a reasonable goal of the Coastal/Confluence Navigation System.

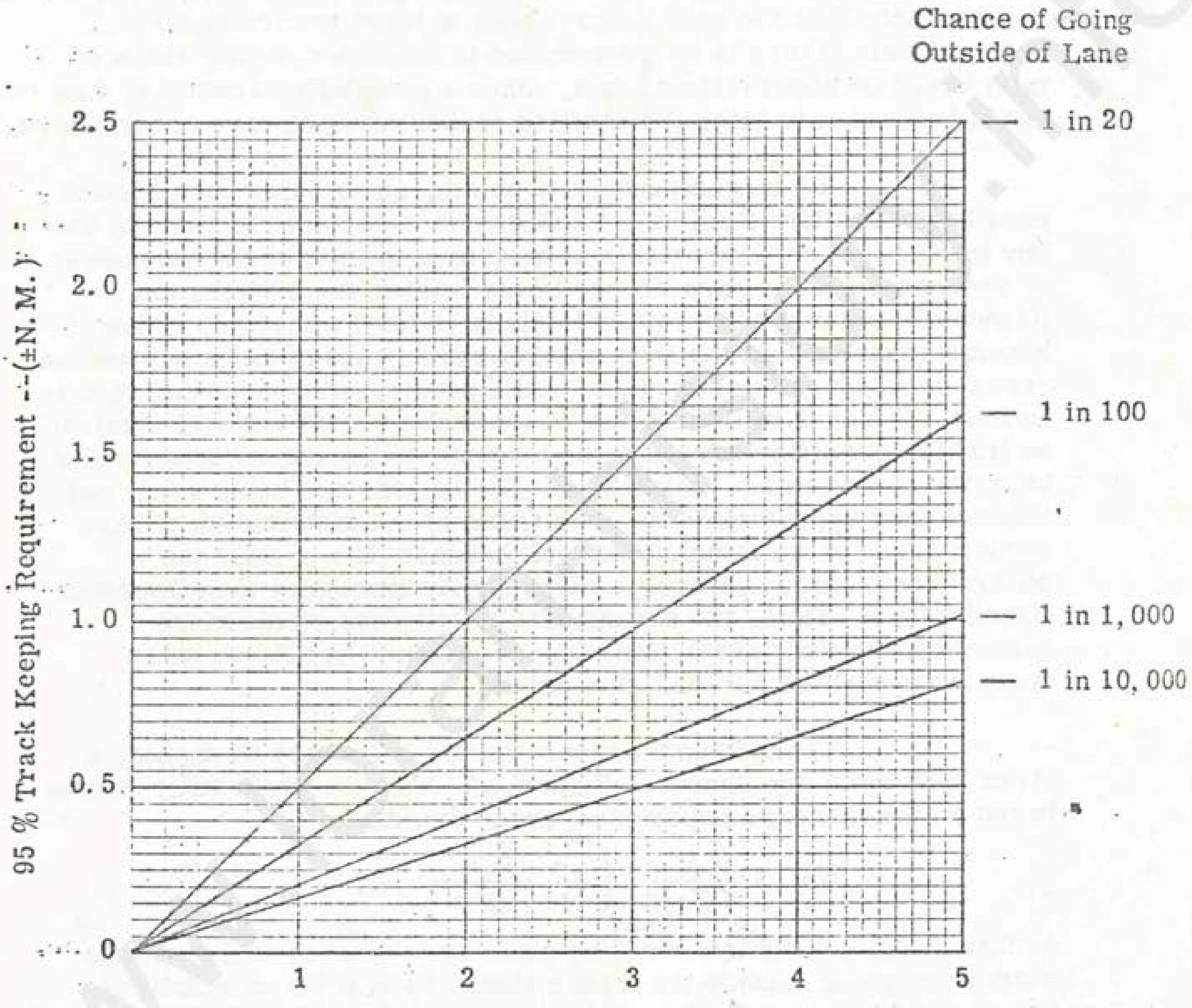

Figure 2. 7 Track Keeping Requirements to Stay Within a Given Lane Width

Using this criterion, the following track keeping requirements are obtained:

Lane Width (n. mi.)	Track Keeping Requirement 95% (n. mi.)
1	± 0.3
2	± 0.6
5	± 1.6

Before the accuracy requirements of the fixing aid can be established, it is necessary to determine the other two error components that contribute to the track keeping capability of the ship, that is, the dead reckoning capability and the maneuvering characteristics.

2.3 Specific Requirements

Presented below is an explanation of the Safety Requirement Accuracy Contours for the Coastal Confluence Region.

1. 0.25 n. mi.

   a. Atlantic Coast

   As developed earlier in this section, a 0.25 n. mi. fix accuracy is required to ensure that a ship can stay within a one n. mi. wide lane. The harbor approach sea lanes taper down to this one n. mi. width at a radius of approximately seven n. mi. from the harbor entrance. This requirement currently exists for the New York, Delaware and Chesapeake Bay areas. Looking to the future, traffic increases in Long Island, Cape Cod Canal and Boston harbor areas are expected to require the institution of a similar sea lane system. Thus, 0.25 n. mi. contours are shown for these areas also.

   b. South Atlantic

   Within the next 20 years, traffic increases at the Charleston and Jacksonville harbors are expected to require the institution of similar harbor approach traffic separation systems.

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c. Gulf of Mexico

In the Gulf of Mexico, the 0.25 n.mi. fix accuracy requirement exists throughout the entire Gulf from the near shore areas to the 100 fathom depth contour. This is necessitated by the randomly distributed criss-crossing two n.mi. wide fairways (two n.mi. width for two-way traffic) which extend out to and in most areas follow the 100 fathom contour.

d. Pacific Coast

Currently, one n.mi. wide traffic lanes and two n.mi. fairways extending coastwise from Point Conception to Los Angeles and seaward from the near shore area out to the channel islands require 0.25 n.mi. fix accuracies to ensure that the ships can stay within the required lane width.

The existing harbor approach system of San Francisco has a similar requirement for 0.25 n.mi. fix accuracies based on the one n.mi. wide lanes that are centered on an approximate seven n.mi. radius from the San Francisco diaphone which is located 10 n.mi. seaward off the harbor entrance. Harbor approach traffic increases in the San Diego, Portland and Seattle areas are expected to require the institution of similar traffic separation systems in the near future.

e. Great Lakes

For those areas near the harbors and interconnecting waterways where the prescribed courses converge to separations of one n.mi. or less, 0.25 n.mi. fix accuracy requirements also exist.

2. 0.5 n.mi.

a. Great Lakes

A lane width of two n.mi. has been adopted in this study for all of the Great Lakes. This width is based on the smallest existing course separations, excluding those converging areas near ports and interconnecting waterways. As developed earlier in this section, a two n.mi. lane width requires a fixing aid accuracy of ±0.5 n.mi.

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b. Atlantic, South Atlantic and Pacific Coasts

For those areas where harbor approaches have been designated, a 0.5 n.mi. accuracy requirement exists. This contour intersects the points at which the approach lanes narrow to a two n.mi. width. Along the entire coast an inner 0.5 n.mi. (95%) accuracy requirement also exists. This contour coincides with the sea buoy line (approximately 10 fathom line).

This inner contour is in response to the stated objective of the National Plan for Navigation, i.e., 0.25 n.mi. rms (hence, 0.5 n.mi., 95 percent) accuracy within those zones which encompass the more complex and heavily used waters. The requirement for this level of accuracy is based on the consensus of experienced mariners in response to the question of what fixing accuracy is required to help ensure safe and efficient point to point navigation in the waters directly off the coastline.

3. 1.0 n.mi.

At approximately 50 n.mi. off-shore the harbor approach lanes widen to five n.mi. As developed earlier, a one n.mi. fix accuracy is required to ensure that a ship will have the capability to stay within such a lane width. In response to this requirement, one n.mi. accuracy requirement contours are considered to exist along points 50 n.mi. off-shore for the harbors identified in previous sections.

Some of the existing approaches do not yet extend to 50 n.mi. off-shore, but, based on the New York system experience, it is expected that it will be necessary to extend the lanes to at least 50 n.mi. and perhaps beyond to the 100 fathom line in order to handle the anticipated future volume of traffic. This philosophy has been extended, in this study, to the approaches of other harbors even though the requirement does not yet go out this far. Along the Pacific Coast, the one n.mi. contours of the individual harbors have been combined into one unbroken contour 50 n.mi. off-shore. This is done to provide the coastwise shipping with continuous unbroken coverage.

4. 2.0 n. mi.

The Gulf Stream directly off the Atlantic Coast is used by many north-bound cargo vessels to help reduce transit time. The navigational requirements for those ships in the stream is not as stringent as for those ships trying to stay within the bounds of the harbor approaches nor is it as lax as the needs of the ship on the high seas. To this end, a two n. mi. fix contour is included along the outer bounds of the Gulf Stream.

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APPENDIX II

Attachment 3

Approach: Using traffic statistics from a selected port calculate the number of collision - potential incidents that may be expected in a given period of time with radionavigation system accuracies of 1/4 mile and 1/2 mile.

Formulas:

(1) Assume vessels moving in directly opposite directions in lanes one mile wide where no separation is possible.

(2) Vessel V_1 has a crosstrack error* with a mean magnitude of M_1, standard deviation of σ_1.

(3) Vessel V_2, using the same navigation system, has a crosstrack error mean of M_2, standard deviation of σ_2.

(4) $\sigma_1 = \sigma_2 = \sigma$

(5) At time of passing (T_1), positions of the two vessels are X_1 and X_2.

(6) A collision - potential incident (P) occurs when $|x_2 - x_1| \leq \delta$

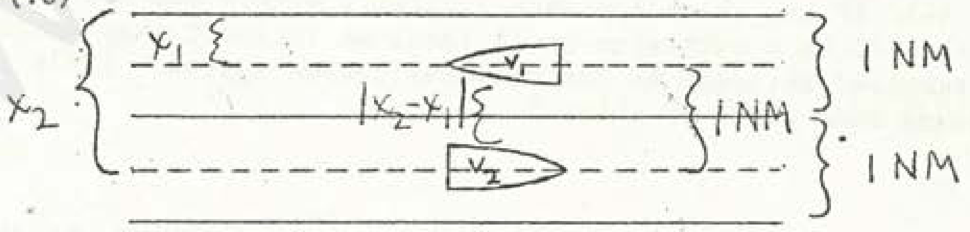
(7) $x_2 - x_1 = \xi$

ξ has a mean $= M_2 - M_1 = M$ (lane separation) and standard deviation $\sqrt{2}\,\sigma$

(8) $P_\xi(x)$ = probability density function on ξ

(9) P (collision potential) $= \int_{-\delta}^{+\delta} P_\xi(x)\,dx$ for one passing

(10)



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*"Cross track error" is the distance strayed from the intended track, measured perpendicular to the trackline.

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(11) Assume a Gaussian distribution on X_1 and X_2

$$P_\xi(x) = \frac{e^{-(x-m)^2/2(\sqrt{2}\sigma)^2}}{\sqrt{2\pi}\,\sqrt{2}\,\sigma}$$

$$\text{If } \delta << \sigma, \quad P = \int_{-\delta}^{+\delta} P_\xi(x)\,dx \approx 2\delta P_\xi(0) \approx \frac{2\delta e^{-m^2/4\sigma^2}}{2\sqrt{\pi}\,\sigma}$$

for a single passing.

(12) Number of passings per day

$$N \geq \frac{n_1^2}{2n_2}$$

$n_1 = \#$ ships each way

$n_2 = \#$ days to transit channel

Premises:

(1) Use New Orleans, specifically the fairway southwest toward Houston, where 20 ships per day stand in or out.

(2) Ships use a common radionavigation system of either 1/4 mile 2dRMS* accuracy with LOP (line of position) standard deviation of 200 feet (System #1) or 1/2 mile 2dRMS with LOP standard deviation of 1000 feet (System #2).

(3) There is an LOP more-or-less down the centerline of the fairway <u>or</u> the geometry is such that the cross-track position error approaches the LOP standard deviation.

(4) There is enough similarity of navigation equipment and operation of it on the two ships that standard deviation of position is the same for the two.

(5) The error in position has a Gaussian distribution.

(6) If the ships approach laterally within 200 ft. of each other there will be a collision or at least an incident that would have to be resolved external to the radionavigation system. (This is based on assumed beam width of ships.)

*1/4 mile 2dRMS means that the statistical probability is that over 95% of the measurements made will fall within a radius of 1/4 mile.

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Computation:

(1) Number of passings per day

$$N = \frac{n_1^2}{2n_2} \qquad n_1 = 20 \text{ ships per day } \underline{\text{each way}} \qquad n_2 = 1 \text{ day to traverse fairway}$$

$$N = \frac{40^2}{2} = 800 \text{ per day or } 29.2 \times 10^4 \text{ per year}$$

(2) Probability of being simultaneously out of lane

$$P = \frac{\delta e^{-\left(\frac{m}{2\sigma}\right)^2}}{\sigma\sqrt{\pi}}$$

Using System #1

$m = 6{,}000$ ft.
$\sigma = 200$ ft.
$\delta = 200$ ft.

Using System #2

$m = 6{,}000$ ft.
$\sigma = 1{,}000$ ft.
$\delta = 200$ ft.

$$P_1 = \frac{200e^{-\left(\frac{6000}{2(200)}\right)^2}}{200\sqrt{\pi}} = 1 \times 10^{-98}$$

$$P_2 = \frac{200e^{-\left(\frac{6000}{2(1000)}\right)^2}}{1000\sqrt{\pi}} = 1.4 \times 10^{-5}$$

(3) Number of incidents per year

System #1: $(1 \times 10^{-98})\ (29.2 \times 10^4) = 29.2 \times 10^{-94}$

System #2: $(1.4 \times 10^{-5})\ (29.2 \times 10^4) = 40.9 \times 10^{-1}$

*Risk using system with 1/4 mi. accuracy is negligible.

*Risk using system with 1/2 mi. accuracy is that there will be at least 4 incidents per year - wholly unacceptable!

(4) The calculations above apply to one place, under one idealized set of circumstances. They do not attempt to such factors as gross navigational blunders, equipment failures such as steering casualties,

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etc. However, the order of magnitude of the extent to which lesser navigation system accuracies can contribute to potential disasters is indicative of the risk in almost any port-approach or narrow fairway situation.

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Appendix III - Can Loran A Achieve the Required Accuracy?

The National Plan for Navigation specifies that in the Coastal Confluence Region (CCR) the selected radionavigation system must have "the capability of fixing position to a repeatable rms accuracy of 1/4 NM...." It also notes that a study will be conducted before the system is selected. That study, completed last year, resulted in refining the CCR accuracy needs to "1/4 NM 2 drms." This is roughly equivalent to a repeatable 1 rms accuracy of 1/8 NM vice 1/4 as contemplated two years ago when the Plan was written.

The Plan also implies that by augmenting existing chains and improving transmission tolerances, the 1/4 mile coverage can be achieved with Loran A. That is correct, in theory, for the 1 rms accuracy level the Plan envisioned. It may also be true for the 2 rms level that has since been shown to be necessary, but there is considerable doubt that it can be achieved.

If we undertake to implement a CCR system based on the theory that Loran A technology can be improved to provide one-quarter mile 2 rms accuracy, there are several caveats that apply:

(1) No development work has been done on Loran A for almost 20 years--largely because the system is a single purpose system and has been scheduled for ultimate replacement with a system that will serve a multiplicity of user requirements.

(2) It will take over four years to complete development and improve the system on the West Coast and in Southeastern Alaska. The Alaska Pipeline tankers are due to start running before then.

(3) Even if development is successful, it will be pushing the technology to the outer limits because of the basic characteristics of the system. The technical risk is great. Among other problems, there is an upper limit to the number of stations that can co-exist in an area because of interference with each other. The limit will have to be approached perhaps exceeded to get enough stations to overcome geographical contours in areas such as the U. S. West Coast.

(4) Fifty nautical miles from the coast is the maximum range in which Loran A accuracy of one-quarter mile can be expected. Loran C can produce over a range 20 times as great.

(5) Being able to achieve one-quarter mile accuracy does not include capability for ultra-precision repeatability (the ability to return to the same spot on the earth's surface by using a given signal reading).

(6) Receivers now in use will not be able to utilize the improved capability if it is developed. Receiver development must also be undertaken.

(7) There will be no inland coverage, and some land-locked maritime areas will be without coverage because Loran A signals deteriorate when crossing land. One area that will be without coverage is Prince William Sound--the approach to the Valdez terminal of the Alaska Pipeline. Others are Long Island Sound, the Great Lakes, and harbor areas.*

(8) Complete improved coverage depends on Canada's willingness to upgrade three of her stations.

(9) Precise timing and communications capability will not be possible even with improved Loran A.

(10) Long-range costs will be high and growth potential virtually zero. Loran C for military use will continue for at least ten years, so the costs will be additive to the Loran A costs.

(11) Rate augmentation will be required and spectrum clutter is likely with resultant service degradation.

To create the improved Loran A system as the national system, the following actions will be required:

(1) Work out technology for the improved operation.

(2) Develop transmitters and related equipment.

(3) Develop receivers.

(4) Construct eight new stations.

(5) Update 22 existing U.S. stations plus three Canadian stations.

(6) Augment rate structure.

(7) Revise charts.

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*Also not covered will be a triangular area of about 250 square miles off of Pt. Arena, CA (just north of San Francisco).

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Appendix IV - Growth Potential of Loran C

It is well known that Loran C is a high precision, reliable, versatile navigation system. What is not so well known is the vast scope of applications and benefits that can be realized with Loran C and from no other single system.

The following is a list of some of the applications and benefits. Many are already in use. Others require only completion of the Coast Guard's "Loran 70's Plan" or the application of existing technology. Despite the scope of this list, we still don't know all the possible uses of Loran C. More research and emerging technology of the 70's will reveal them.

Applications and Benefits of Loran C:

(1) Total Coverage of Continental U.S. (including Great Lakes and St. Lawrence Seaway).

    (a) All applications available in all areas--including rivers and harbors and land areas.
    (b) Loran A cannot be used over land, so its use is limited to ocean areas.

(2) Vessel Traffic Systems.

    (a) Arrival and departure control.
    (b) Movement monitoring.
    (c) Vessel control within system.
    (d) Precise self-navigation and helmsman guidance.

(3) Loran - Assist Device Applications.

    (a) Range from simple "steer by needle" system for helmsman to highly sophisticated uses--e.g., aircraft landing in zero visibility.

(4) Automatic Ship Control (and other vehicles too).

(5) Air Traffic Control and Routing.

    (a) Include low visibility landings.

(6) Charting.

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(a) Precision location of wrecks, shoals, etc.

(7) Oil and mineral exploration and mining.

(a) Ocean Industries Association VP Savit "Loran A useless... Loran C extensively used."

(b) Without precision system for navigation through mining areas, operations will have to be restricted in scope to allow extra-width sea lanes.

(c) Alternative - divert traffic around areas at expense of ship time and consequent losses.

(8) Vehicle location.

(a) Trucks, cabs, busses, freight cars, ships, aircraft, etc.

(9) Central display of vessel locations.

(a) E.g., all tankers in Gulf of Mexico.

(10) Provide surface update needed to make satellite navigation useful.

(a) Anomalies for moving vessels.

(11) Precise timing and time interval.

(a) Most efficient timing device known.

(b) Entire continental U.S. (and coastal areas) will have highly accurate time standard.

(c) NASA now uses for its standard for all flights.

(12) Communications.

(a) Special applications.

(13) Underwater navigation and communications.

(a) Private, commercial, military subs.

(b) Depth limited.

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(14) Iceberg tracking.

    (a) Save ship and aircraft surveillance.

(15) "DALS"

    (a) Distress alerting and locating.

(16) Precise buoy positioning and monitoring of movement.

    (a) Avoid proliferation of law suits.

(17) "LOCATE"

    (a) Hundreds of uses, for example:

        1 Balloon tracking for weather observation - Saves expensive radar.

        2 Law enforcement surveillance, tracking, pursuit.

        3 Vehicle location and others above.

(18) Sophisticated military uses.

    (a) Many with civilian applications too.

(19) Ocean Dumping and Tuna Convention surveillance.

    (a) Save cost of sending observers or flying patrols.

(20) Small, low-power chains that can be set up as needed for special, short-term application.

(21) Permit R&D to go forward, leading to newer and even more promising technology developments in the late 70's.

    (a) Other systems have no real "advancement" potential.

(22) High availability.

    (a) Even greater with new generation transmitting station equipment and antenna.

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(23) Automated station operation.

    (a) High reliability, low cost.

    (b) Reduced manpower.

(24) Vessel collision avoidance.

(25) Range of service area.

    (a) High and low flying aircraft.

    (b) Surface vehicles and vessels.

    (c) Submarines.

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Appendix V - International Implications of Designating Military Radionavigation Systems

Designating Omega and Loran C as "Military" Navigational Systems will cause serious harm to the United States internationally, cause the Omega system to fall apart, and undercut the effectiveness of the Loran C system. These systems are not in fact military systems although, like Loran A, the impetus stimulating their development was military. U. S. navigational aids are not military or civilian, but are equally usable by all endeavors in the world of transportation.

For some two and one-half years we had been unable to get the Australians to construct an Omega station which will be required in that part of the globe because the Australian press and public have construed it to be a military system or some sort of "CIA device." Very strenuous effort made over this period of time finally convinced the Australian government to take steps indirectly to put Omega under civilian handling, and work through its political party channels to have this matter shunted off to the sidelines where it could be treated as a pure and simple navigational system. It is only with these concerted efforts that the government has dared to take the steps that will lead to construction of an Omega installation. The fuss over this matter has been so strong in Australia that its designation as a military navigational system will make the Australian government powerless to proceed with its construction. Also, the to-do over this in Australia has affected New Zealand's judgment as to the character of the project. If Australia were to refuse to construct the project, New Zealand would follow suit precluding the possibility of building a station in that area. A similar situation exists in Liberia and Japan. This might, in the end, render the entire Omega project unworkable. At the very least, it will deliver a severe blow to our credibility.

There has been a strong feeling in northern Europe, as well as some other communities, that Loran C is an integral part of the Poseidon missile capability. This view has not been dispelled by the Loran C operation in Viet Nam which makes precise bombing possible. The Coast Guard has tried to emphasize that Loran C is a navigational system and mutually used by all elements, military and civil. Neutralist, leftist and others, however particularly in northern Europe, have felt that the presence of Loran C on their territory constitutes a threat to the Soviet Union. There have been clear indications that workers at these Loran stations would attempt to prevent their operation in a crisis which would, of course, reduce the effectiveness of their use at a time they were most needed. There have also been calls for closing the facilities. This view, which we have been trying to dispel, would be strongly reinforced were Loran C designated a military system. Also, problems will be created for our allies (e.g., Iceland, Denmark, and Norway) who have attempted to cooperate with the U.S. on the basis that these navigational systems are primarily of a civilian nature.

On the other side of the ledger, if Loran C were established as the system provided by the United States for all its users in the Coastal Confluence Region it would be a positive indication of the integrity of the position we have taken in international negotiations. In the vernacular, we would in fact be "putting our money where our mouth is."

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Appendix VI - User Attitudes

It can be fairly stated that few major radionavigation aid user groups in the United States would favor Loran C if it were to replace Loran A tomorrow in the CCR. There is very good reason for this in that just about everyone who uses Loran A now is familiar with it, feels that it is easy to operate, and has a vested economic interest in Loran A equipment.

On the other hand, these same users are learning more with every passing day about the virtues of Loran C. This can be expected to accelerate as the realities of future problems come into focus, e.g., offshore clutter of oil rigs, deepwater ports, power plants, scientific work, fish farms, etc; totally unwieldy ships carrying massive amounts of hazardous and polluting substances, etc. The key to accommodating user group objection lies either in allowing sufficient change-over time for present owners to amortize their equipment costs and adapt their procedures, where that is a significant factor, or in subsidizing replacement equipment.

A brief resume of current user groups attitudes toward Loran C, as expressed by selected representatives, as a replacement for Loran A follows.

I. Civilian
  A. Marine
    1. Fishermen.

The fishing industry's attitude toward Loran C is not one of consensus, but varies basically with geography and the type of fishing involved. As a whole, fishermen do not want Loran C now because of their familiarity with Loran A and their financial commitment to Loran A equipment. At the same time, they are aware of a momentum toward a replacement for Loran A, and if this becomes a necessity, the majority of fishermen support Loran C for that purpose against all other alternatives. The one major exception to this is the U.S. tuna fleet which due to its range of operation has opted for the use of Omega. Most Loran C support by fishermen will come from those involved with bottom fishing of all kinds, as typified by the major economic portion of activity in the Gulf of Mexico. There are also those who use Loran A now but are limited in its use due to poor Loran A coverage. Such is the situation in the U.S. Pacific Northwest where, due to geography, Loran A is spotty. These fishermen, too, can see the worth of a more comprehensive system such as Loran C.

At the same time, there are a considerable number of fishermen who, due to their economic investment in Loran A, would probably "fight to the death" any new system, Loran C included. What must be realized

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is that these men are usually highly independent individuals who have used Loran A for years, and it is now part of their way of doing things Many look upon Loran C as a government scheme, conceived in an ivory tower which, if adopted to the detriment of Loran A, will do nothing but disrupt their livelihood. Many others ask only that they be given a reasonable time to make the transition and that their special situation be considered in Loran C implementation plans.

2. Commercial Shipping.

Coast-wise shippers use Loran A now as their prime radionavigation system, and feel it provides all the accuracy they require. Considerable objection could be expected from this quarter if Loran A were shut down too soon.

International shippers take a similar stand. They are definitively negative toward Loran C and for rather inexplicable reasons, given their relative economic security and navigational sophistication. Their bias against Loran C is based on: relatively little exposure to Loran C advancements in receiver technology; their desire not to have more equipment on ships which already carry Decca and Loran A; and on the erroneous belief that without sophisticated receivers, Loran C is a system of low reliability.

3. Pleasure Boatmen.

Because of the extremely small percentage of radionavigation users in this category, an assessment of attitudes is hard to come by. There are very recent indications, as late as within the last year, that Loran A sales are skyrocketing in this market, particularly in the over 40 feet class; consequently, Loran C would strongly be opposed by those recent buyers of Loran A equipment. This opposition may be somewhat emasculated given the expected impact of the oil shortage on pleasure boating activity.

B. Aviation.

Commercial air carriers do not support Loran C to replace Loran A because of what they cite as large investment cost and long periods of time to retrofit their fleets with Loran C. (Equipment change-over is not new to aviation. A similar situation occurred in the 1950's when FAA replaced the old, but useable, range station system with the present omni-navigation technology Additionally, they feel Loran C has not been sufficiently evaluated in the cockpit as a doppler update, that purpose for which Loran A is used now. They are in the process of evaluating Loran C for air use, but they are doing it reluctantly as a hedge against the possibility of being forced to convert to Loran C. Their negative attitude is also based on what they feel is the unavailability of Loran C versus Loran A transoceanic flights. Their antipathy is lessening, however, as evidenced by Pan Am's initial flight evaluations of Loran C, which were satisfactory.

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C. Scientific & Ocean Industry Groups

If one user community feels it stands to gain from the implementation of Loran C it is the scientific community. They support Loran C because of its applications in hydrography, bottom-contour mapping, offshore oil and mineral explorations, precise timing and frequency, and many others. But due to this group's origin and composition, it will probably have the least voice and political impact on the fate of Loran C in the CCR.

II. Military - All Users

The military users feel that Loran C is useful, even indispensable, as it presently exists. But as to its expansion in the CCR, they look upon it with benign acquiescence. They would use it if it were there, but feel no real necessity for it. This does not address the DOD's political thinking, particularly as it relates to the fate of Omega.

Some Navy voices have argued against Loran C in the CCR reasoning that they do not want to be forced into putting Loran C on all their vessels, a rather sizable investment.

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Appendix VII - Action Plan for User Changeover from Loran A to Loran C

(1st Qtr)	1. Public announcement of acceptance of Loran C as CCR navigation system - announcements to contain statement of Loran A operational plans.
(1st - 2nd Qtr)	2. Publish "minimum Operational Characteristic" (MOC) statement - NOTICE TO MARINERS, NOTAMS, etc. Purpose is to define system and point out that full accuracy is not achieved with envelope match receivers. Include change and/or addition of specific rates.
	3. Public Ralations campaign (Coast Guard & CG Auxiliary)
(1st - 2nd Qtr)	a) Publish a simple system handbook giving details of system, coverage and methods of use.
(2nd Qtr +)	b) Furnish low cost receivers on loan basis to selected users.
(2nd - 3rd Qtr)	c) Give demonstrations of receivers and system in selected places.
(4th Qtr +)	d) Have CG Auxiliary include system training in local courses.
(4th Qtr +)	e) Hold local seminars for large user groups.
(3rd - 4th Qtr)	f) Make short simple system training film.
(3rd - 4th Qtr)	g) Promote interest among journalists, etc. to write articles for periodicals aimed at user groups.
	4. System Demonstrations by Coast Guard
(3rd Qtr and beyond)	a) Large ship operations along East Coast using Loran C.
	b) Large ship demonstration of Loran C helm devices.
	c) Operate receivers on fishing vessels.

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5. Convert fishermen's Loran A data (net Hang Data) to Loran C coordinates.

(commence 3rd Qtr)
   a) Advise of this service in 2. and 3. a. above.

6. FAA

(3rd - 4th Qtr and beyond)
   a) Furnish receivers from at least two manufacturers for FAA testing.
   b) Cooperate with FAA on desing of very low cost coordinate converters and display devices.
   c) Test use in helicopters.

(2nd Qtr) 7. Start program to develop adequate Loran C charts.

(2nd Qtr and beyond) 8. Begin R&D efforts.

   a) Ship guidance systems in CCR.
   b) Access Loran C use in VTS.
   c) Define interface between VTS & CCR.
   d) Investigate aircraft & helicopter systems.
   e) Study automatic ship plotting using retransmission.
   f) Monitor industry developments in receiver technology)
   g) Study entire field of system capabilities and possible uses.

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