CG NAVCEN Work Instruction 2022-01

Waterway Analysis Tactics, Techniques and Procedures

September 2022

RECORD OF CHANGES			
CHANGE	DATE	EDITOR	CHANGE(S) MADE
01	09/22/2023	Amilynn Adams	Updated tolerability assessment criteria. Changed incident frequency from incidents/year to years/incident. Minor editorial changes for clarity regarding applicability/scope to CG NAVCEN analysts as non-definitive, general guidance document.

Table of Contents

Introduction

This work instruction provides recommended tactics, techniques, and procedures (TTPs) to conduct spatial data analysis of the United States Marine Transportation System (US MTS.)

The body of knowledge, models, methods, and frameworks available to analyze maritime risk is large, complex, dynamic, and highly dependent on the unique aspects of each waterway scenario and the attributes being analyzed. This work instruction provides a general framework to conduct spatial analysis, extract actionable information, and provide waterways decision support to operational commanders.

This work instruction provides criteria and guidance for USCG Navigation Center (CG NAVCEN) analysts to assess and identify impacts to the US MTS using the best spatial data science techniques currently available to the USCG. This work instruction is not a methodology to accept or reject activities which may take place within the US MTS. It is a general framework applied by CG NAVCEN analysts to waterways analysis projects that can assist to identify interactions between the US MTS and other waterway uses and characterize risks that may require further evaluation and risk abatement strategies.

AIS

AIS is the foundational dataset for conducting analysis of the US MTS. Population metrics for all maritime activities in the US MTS are unable to be extracted from AIS due to AIS carriage requirements[1] which generally provide exemptions to smaller vessels. Without a correlation factor for these exempt vessels, AIS data can only be relied upon as a general indicator of vessel activity for the non-compulsory carriage segments. Additionally, due to the effective date of the domestic AIS regulation, AIS data prior to March 1, 2016[2] should not be considered representative of the entire population of domestically regulated vessels.

Authoritative Vessel Registries

AIS data may require augmentation with additional authoritative vessel registry data due to the unique nature of each US MTS analysis and inherent limitations of AIS data. AIS data may be augmented to meet unique analysis requirements by using information from authoritative sources such as USCG databases, international organizations, federal agencies, or commercial sources to further refine, explore, and extract insights from AIS data. Examples of commonly used authoritative registry data include IHS SeaWeb™ ship's data, and the International Telecommunications Union List V – List of Ship Stations and Maritime Mobile Service Identity Assignments (ITU List V.) ITU List V data include general

---

[1] A US Coast Guard type-approved AIS Class A device is required for: a self-propelled vessel of 65 feet or more in length, engaged in commercial service; a towing vessel of 26 feet or more in length and more than 600 horsepower, engaged in commercial service; a self-propelled vessel that is certificated to carry more than 150 passengers; a self-propelled vessel engaged in dredging operations in or near a commercial channel or shipping fairway in a manner likely to restrict or affect navigation of other vessels; a self-propelled vessel engaged in the movement of certain dangerous cargo as defined in subpart C of part 160 of 33 CFR, or flammable or combustible liquid cargo in bulk that is listed in 46 CFR 30.25-1, Table 30.25-1.

[2] 33 CFR § 164.46(j) – Implementation date. Those vessels identified in paragraphs (b) and (c) of this section that were not previously subject to AIS carriage must install AIS no later than March 1, 2016.

and individual ship type codes which are assembled in to a dictionary containing MMSIs and AIS ship and cargo type codes.

Non-Compulsory Carriage Cautions and Corrections

Caution must be expressed, and caveats conveyed in waterways analysis products that include an emphasis on vessel classes exempt from AIS carriage. The cautions and caveats regarding analysis of AIS exempt vessels should include the results of advanced analysis techniques (such as imagery analysis and AIS correlation), previous studies, surveys, or industry reports that provide any timely information regarding the population range estimate, behavior, or spatial distribution for specific classes of AIS exempt vessels. At a minimum, any waterways analysis product should caution the end user of the inherent and unquantifiable variability in the sample of AIS exempt vessels present in an analysis product by including the citation and text of the domestic AIS regulation.

Standard Waterways AIS Schema

Waterways division employs a standard AIS data set schema designed to facilitate the efficient use and reuse of quality-checked and validated AIS data, streamline python code development, and maximize the utility and scope of information that can be extracted from AIS data via spatial analysis.

Field	Data Type	Description
MMSI	int32	Maritime Mobile Service Idendtity
DateTime	datetime[ns]	Date and Time of aggregate or individual AIS ping
Lat	float32	Average or instantaneous latitude
Long	float32	Average or instantaneous longitude
Name	object	Vessel Name
IMO	object	International Maritime Organization Number. International vessels over 100 gross tons
SOG	float32	Average or instantaneous speed over ground
COG	float32	Average or instantaneous speed over ground
HDG	float32	Average or instantaneous compass heading
NavStatus	object	Navigation status - user entered
ShipType	int32	Ship type as determined by AIS encoding guide - user entered
VesselGroup	object	Vessel group - determined through grouping of individual ship types according to study requirements
LOA	float32	Length Over All - determined via user entered fore-aft antenna placement dimensions
Beam	float32	Beam - determined via user entered athwartships antenna placement dimensions
Draft	float32	Draft - user reported
AOI	object	Area of Interest - field used to denote points from a specific spatial location
CY	int32	Calendar Year - derived from DateTime, used in PowerBI Analysis
CM	int32	Calendar Month - derived from DateTime, used in PowerBI Analysis
AorB	object	Optional - AIS Unit Type - Class or Class B
CallSign	object	Optional - Vessel Radiotelephone License Call Sign
NavSensor	object	Optional - Primary positioning sensor information
MID	object	Optional - Maritime Identity Digits - 3-digit code or text identifying vessel Flag State
MsgType	int32	Optional - AIS Message Type

Figure 1-Standard Waterways AIS Schema

Ship Classes

Ship classes are a convenient means to summarize multiple ship and cargo type codes into a related group of vessels. Careful consideration should be given to the aggregation of ship types in to related groups depending on the observed vessel activity and regional differences evident in AIS encoding. Figure 1 provides one of the more common ship classification groupings:

Ship And Cargo Type	ShipClass
1-19, 38, 39	Reserved
20-29	WIG
30	Fishing
31, 32, 52, 57	Towing & Tugs
33, 34, 53, 54	Workboats
35, 51, 55	Military, SAR, LE
36, 37	Pleasure
40-49	HSC or Ferries
50	Pilots
60-69	Passenger
70-79	Cargo
80-89	Tanker
0, 56, 58, 59, 90-99	Other

Figure 2-Common AIS Ship and Cargo Type Encoding and Corresponding Ship Classification

Temporal Range

Analysis may need to be conducted on several years of AIS data to provide a baseline to determine spatial distribution and historical use patterns of vessels in a waterway. AIS data should be analyzed to gain insight into the presence and behavior of certain ship classes for the time period prior to the commencement of a new waterway use scenario. Additional guidance regarding presence and behavior of historic waterway use is contained in the "Assessment of Access to and Navigation Within, or Close to, a Structure" section.

COVID Impacts[3]

Increases and decreases in AIS activity exist across spatio-temporal dimensions when comparing 2018, 2019, and 2020 AIS activity. Analysis has shown a decrease in ship activity in the spring of 2020 in the northeastern US when compared to spring 2018 and spring 2019, while ports in the southeastern US showed an increase in the same time frame. However, in the fall of 2020 ship activity in the northeastern US outpaced national-level ship activity in the fall of 2018 and 2019.

Nationwide a ~5% decrease in vessel activity occurred between calendar year 2019 and 2020. This summary level difference has not been determined to be statistically significant. A nationwide summary level correction is also problematic due to spatial, temporal, and industry specific variation. Correcting AIS data to account for COVID impacts is not advised. Analysis products should reference the DCO-51 analysis dashboard (footnote 3) for any known spatio-temporal variance evident when comparing vessel activity between calendar years 2018-2019 and 2020-2021.

Periodicity

Most waterways analysis involving large sea areas may be sufficiently analyzed using AIS data aggregated (averaged) into a maximum period of 5-minutes. Waterways analysis involving vessel

3 DCO-51 analysis PowerBI dashboard published at https://app.mil.powerbigov.us/links/k5U-JJGyjL?ctid=369ba0d5-02cb-4d2f-94fd-9212cc24b78c&pbi_source=linkShare&bookmarkGuid=ad293279-238c-4270-b2a7-66bbdad00032

incident frequency modeling and prediction, or analysis involving narrow or sinuous waterways may require full periodicity datasets (full AIS dataset) to obtain sufficient spatial fidelity for analysis products.

Nationwide Automatic Identification System (NAIS)

Spatial Coverage

NAIS[4] provides coastal AIS signal reception coverage to at least 50 nautical miles from each NAIS reception antenna site. There are NAIS coverage areas that exceed the 50-mile performance standard, usually due to placement of NAIS towers on the top of a bluff or coastal hill or based on the height of the transmitting ship's antenna. As OREI move further offshore, NAIS may need to be supplemented with satellite-based AIS (S-AIS) data to provide sufficient data coverage.

The determination of when to supplement NAIS data with S-AIS data is conducted by a spatial and numerical comparison of NAIS and S-AIS data. When NAIS coverage for a waterway analysis area appears sparse by visual comparison of NAIS and S-AIS pings, or the number of unique vessels present in vessel classes of interest in the S-AIS dataset exceeds NAIS, the NAIS dataset should be merged with S-AIS dataset. Duplicate pings are culled from the combined datasets based on the MMSI and date-time fields.

Data Quality

User-entered data fields in NAIS data may be improved via validation with authoritative registries. Basic data cleaning routines include vessel dimension verification using IHS SeaWeb ships data (formerly "Lloyd's List") for vessels over 100 gross tons, and ship and cargo type code validation using the ITU's List V – "List of Ship Stations and Maritime Mobile Service Identity Assignments." The ITU List V validation routine has reduced the quantity of erroneous SHIP_AND_CARGO_TYPE field values classified as either "Other" or with an invalid code by approximately 44%. Improvement in vessel dimension data quality using IHS SeaWeb registries have not been measured. Validation scripts and supporting dictionaries are maintained in the Waterways Team Python channel[5]. Scripts are written in Python and can be run in ArcGIS Pro's python environment using Jupyter Notebooks.

National Marine Fisheries Service Vessel Monitoring System Data (VMS)

Consultation with National Marine Fisheries Service experts is strongly advised before attempting to draw conclusions from VMS-monitored fisheries data analysis. VMS data have been analyzed to increase confidence in establishing a lower limit of the population estimate for fishing vessels. An AIS fishing vessel population correction factor is developed by enumerating unique fishing vessels enrolled in a VMS-monitored fishery and comparing this number to vessels enrolled in VMS and broadcasting AIS signals. The correction factor derived from this analysis provides a lower bound for estimating the population of fishing vessels in an analysis area. VMS should not be relied upon as a definitive indicator of fishing activity due to low temporal fidelity, poor spatial accuracy, averaged vessel speeds, and

---

[4] NAIS data can be accessed at https://marinecadastre.gov/accessais/. NOTE: 2015, 2016, and 2017 data require correction for SHIP_AND_CARGO_TYPE field values due to the use of a 4-digit vessel type code. The original 2-digit SHIP_AND_CARGO_TYPE field values in these years were assigned to a field labeled "Cargo."

[5] https://dod.teams.microsoft.us/_#/files/Python%20Palooza%20-%20Coding%20Stuff%2C%20References%2C%20etc?threadId=19%3Adod%3Af8229f9c060a43e79e083f10255a8885%40thread.skype&ctx=channel&context=Python%2520Palooza&rootfolder=%252Fsites%252FWaterwaysDivision%252FShared%2520Documents%252FPython%2520Palooza

omission of many fisheries that are either managed through other regulatory frameworks or are currently unmonitored.

National Marine Fisheries Service Vessel Trip Report Data (VTR)

National Marine Fisheries Service VTR data presents an opportunity to correlate additional fisherman-reported details regarding the location of a subset of fisheries fishing gear types with AIS. VTR data, like VMS data, does not provide a population but rather a sample of fishing vessels by VTR-monitored fishery in a region. This information provides the opportunity to further refine and understand aspects of historical waterway use and potential impacts from offshore installations, facilities, or structures.

Traffic Survey

Study Area

A traffic survey study area should be large enough to encompass patterns in traffic routes surrounding and adjacent to the primary waterway analysis focus area. Surrounding and adjacent areas should include major shipping routes, fishing grounds, and concentration points for traffic such as precautionary areas, traffic separation schemes or natural constrictions such as a straight, narrow, or pass. Analysts should conduct an initial study design brief with the cognizant District or Sector unit to discuss questions the unit wishes to answer and to gain insight in to any specific location, waterway use natural features, or traffic patterns of concern to arrive at an appropriately sized traffic survey study area. Additionally, areas of particular interest within the study area should be defined and identified for additional in-depth analysis and investigation of vessel types, characteristics, and navigation profiles.

Data Products and Visualizations

A traffic survey should answer the following questions:

- What kind of vessels are in this area?
- How many vessels of each type are in the area?
- How often are vessels present in the area?
- How often are vessels present in a traffic route?
- Do certain types of vessels appear to be burdened/working in any specific areas?

Typical data products and visualizations include, but are not limited to:

- Traffic survey study area overview map
- Vessel track line density or track line count per unit area maps
- Passage line analysis graphs showing vessel "trips" (tracks/day) and number of unique vessels by ship classification extracted via vessel track intersection with a line or presence within a polygon area.
- Results of surveys or information from other data sources regarding maritime industry segments that are not well represented in AIS data.

Analysis of Installations, Facilities, or Structures (IFS) and the US MTS

Traffic Separation Schemes (TSS) and IFS Setbacks

The appropriate setback distance between an IFS and a TSS is determined by applying spatial analysis techniques to the principles contained in The World Association for Waterborne Transportation

Infrastructure (PIANC) Report No 161 "INTERACTION BETWEEN OFFSHORE WIND FARMS AND MARITIME NAVIGATION." The goal in determining acceptable separation between an installation, facility, or structure and a TSS is to avoid increasing the risk of collisions and allisions, prevent detrimental impacts to the safety and efficiency of the US MTS, and enable access to the resources of the United States Exclusive Economic Zone.

Analysis Guidance

In regions where an IFS and a TSS are adjacent[6] to each other, the analysis should determine a minimum acceptable distance between the nearest TSS and IFS. The methodology to determine this distance is based on measuring the sea space necessary for the largest vessel navigating a TSS to conduct an emergency evasive maneuver in any environmental condition without running hard aground[7] or alliding with the IFS.[8] This distance may also include a recommendation to the Captain of the Port for an appropriate safety zone of up to 500 meters[9]. The recommended size of the safety zone should take into account IFS design/footprint, traffic density, traffic type and size, cargo types, incident frequency analysis (causation probability, see "Risk of Collision, Allision, or Grounding) and local environmental conditions.

Determining minimum recommended setback for emergency evasive maneuvers

An emergency evasive maneuver consists of a greater than 180-degree change in a vessel's course over ground. The ship type with the largest maneuvering characteristics of vessels navigating a TSS will serve as the basis for determining the maximum distance necessary to execute an emergency evasive maneuver. Analysis methodology:

---

[6] Within 5 miles of each other.

[7] The criteria for "hard aground" as used in this context is highly dependent on bottom type and other factors. The relationship between bottom type, draft and depth of water for hard aground can vary from a water depth of ~50% for very soft bottoms (M/V EVER FORWARD, March 13, 2022, Chesapeake Bay, Maryland, United States) to 100% of vessel draft (M/V EXXON VALDEZ, March 24, 1989, Prince William Sound, Alaska, United States.)

[8] IMO General Provisions on Ship's Routeing 6.8 – Traffic separation schemes shall be designed so as to enable ships using them to fully comply at all times with the International Regulations for Preventing Collisions at Sea, 1972, as amended (COLREGS).

[9] 33 CFR § 147.15 Extent of safety zones. - A safety zone establishment under this part may extend to a maximum distance of 500 meters around the OCS facility measured from each point on its outer edge or from its construction site, but may not interfere with the use of recognized sea lanes essential to navigation.

1. The starting point to measure the emergency evasive maneuver distance is the outer bound of the 2nd standard deviation (2σ, ~95th percentile) of the cargo, tanker, passenger and tug and tow traffic distribution in a TSS. The normal distribution depicted in Figure 2 is for illustrative purposes only. Other distributions may exist and the 95th percentile determined accordingly.

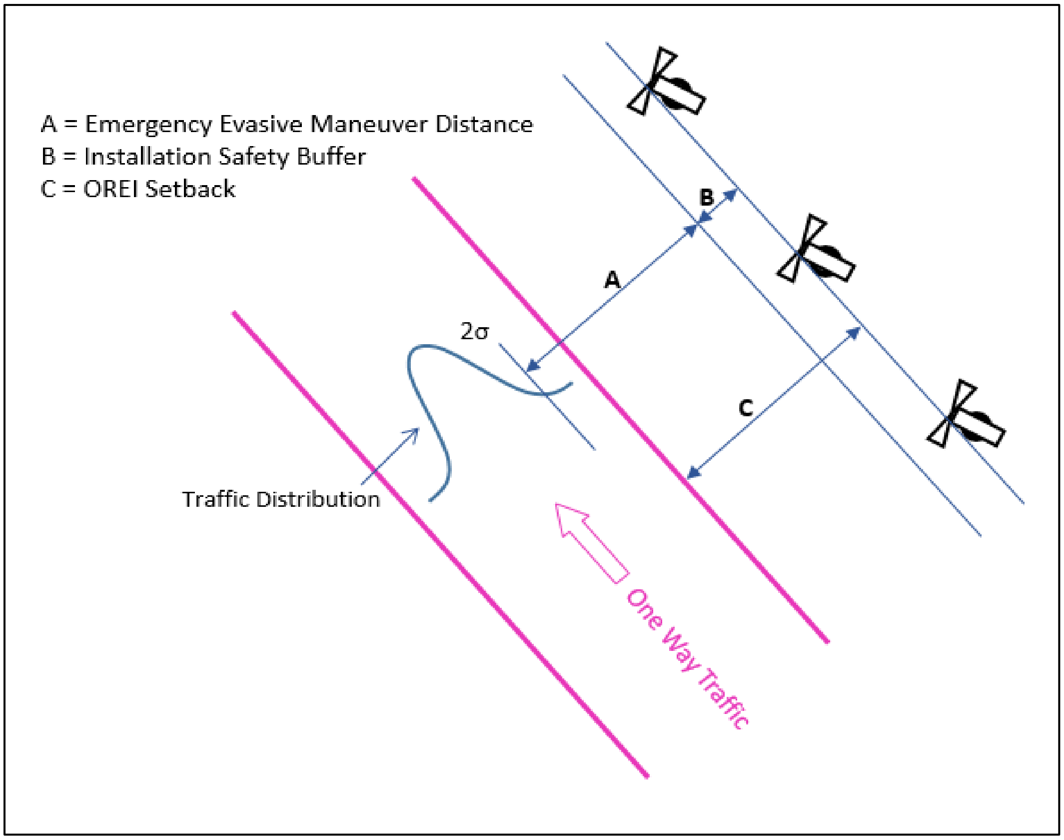

Figure 3-Setback Determination Where No Grounding Risk Exists

2. From the starting point in step 1, dimension A is the turning diameter of the largest ship calculated by 6 × length overall + 1.5 × length overall (LOA.) [10],
3. The recommended safety zone, Dimension B, is added to dimension A
4. Dimension C is the minimum setback from the TSS and is measured from the closes edge of the TSS to the IFS.

Determining minimum setback when grounding would occur during emergency evasive maneuvers

In waterways where the largest ships would run aground prior to alliding with an IFS, the next largest ship that could conduct an emergency evasive maneuver without running aground should be used to determine the minimum setback.

[10] A turning diameter of 6x the vessel length accounts for the myriad real-world influencing factors on ship handling characteristics including: wind and current; hydrodynamic forces (interaction); fairness, condition, or cleanliness of hull and running gear; vessel loading/draft; and vessel yaw/sway while executing a full-rudder turn. The trackline offset of 1.5

For example, in Figure 3 the grounding isobath is 20 feet at mean high (or mean higher high tide for mixed tide waterways) and the bottom type is hard sand the setback from the TSS can be calculated based on the distance required for the largest vessel with a draft of less than 20 feet to conduct an emergency evasive maneuver.

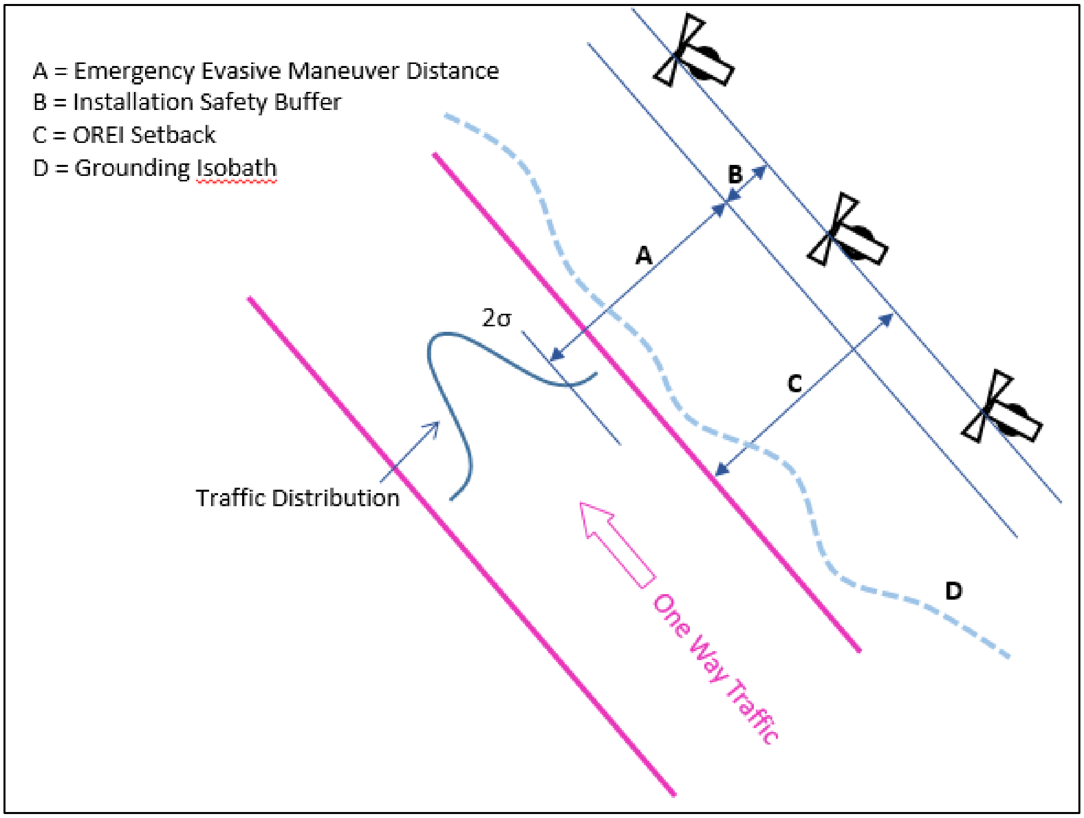

Figure 4-Setback Determination Where Grounding Risk Exists

Data Products and Visualizations

An analysis of IFS and the US MTS should answer the following questions:

- How much space is necessary for the largest vessel in a region to maintain compliance with COLREGS?
- In what other spatial or temporal dimensions will an IFS impact the US MTS? For instance, draft vs. height above seabed of underwater portions of an IFS, ship's air draft and height of above water portions of an IFS, topple risk and obstructing channels?

Typical data products and visualizations include, but are not limited to:

- Spatial distribution of vessel traffic present in routing measures or shipping lanes
- Vessel LOA distribution and frequency
- Vessel draft distribution and frequency
- Visualization of isobaths vs. distribution of vessel drafts
- Calculation of minimum setback to enable an emergency evasive maneuver.

Historical Waterway Use Analysis

Historical Access

An assessment of access to and navigation within a waterway should seek to identify the historical users of a waterway via analysis of AIS data for at least one year prior to commencement of IFS site survey operations. Information on vessel dimensions, operational profile, and maneuvering characteristics are necessary to determine whether continued historical access to a waterway will be impacted. Analysis should be based on specific vessel data and operational profiles (where known) and should identify likely access barriers or impediments caused by presence of IFS which will impact specific classes of historical users. Analysis should include an evaluation of access to and navigation within or close to an IFS during the construction, operation, and decommissioning phases.

Historical Use and IFS Analysis

The assessment of historical access to and the ability to continue navigation within, or close to, a structure requires an approach that identifies the diversity of vessels and the nature of their employment in a proposed IFS area. Certain classes of vessels that operate outside traditional shipping lanes and in, or in the vicinity of an IFS, may be burdened with respect to navigation and maneuvering characteristics by their occupation. Examples of burdened vessels include, but are not limited to, vessels engaged in fishing, sea planes, survey vessels, dredges, aggregate mining, marine construction, and diving support vessels. Analysis should include literature review, expert opinion, and where possible obtain information regarding navigation and maneuvering characteristics through consultation with industry stakeholders. In addition to vessel navigation and maneuvering characteristics, analysis must consider potential subsurface and above surface attributes of an IFS and whether the IFS presence will interfere with the occupation of historical users. This information can then be applied to describe the risks and range of possible impacts associated with continued burdened vessel operations within an IFS.

Data Products and Visualizations

A historical use analysis should answer the following questions:

- What kind of burdened vessels are in this area?
- What are the sea space, sea bottom, water column, or air draft requirements for a burdened vessel to conduct their occupation?
- What aspects of an IFS may interfere with or impinge upon a burdened vessel while engaged in their occupation?

Typical data products and visualizations include, but are not limited to:

- Count of unique vessels by vessel classification within a proposed IFS footprint.
- Distribution of speed over ground by vessel classification within a proposed IFS footprint.
- Determination of the attributes associated with the employment of burdened vessels.
- Identification of hazards introduced by the OREI which may impact navigation safety or the execution of a burdened vessel's occupation.

Risk of Collision, Allision, or Grounding

IALA Waterways Risk Assessment Program (IWRAP)

International Association of Marine Aids to Navigation and Lighthouse Authorities' (IALA) Waterways Risk Assessment Program (IWRAP) is the modeling tool used to develop waterway models and evaluate predicted changes in vessel collision, allision, and grounding frequency based on a set of user-supplied assumptions.

Model Runs

The following standard model conditions are part of every IWRAP analysis.

Alpha – Pre-installation, facility, or structure (IFS) traffic incident prediction analysis. Run the IWRAP model with a recent AIS dataset, current traffic patterns, and no IFS farm present.

Bravo – Introduce a change to the waterway, such as an increase in vessel traffic or the introduction of an IFS. Maintain current traffic routes and shipping lanes. Run the model with the same AIS dataset used in Alpha.

Charlie – Modify the traffic routing in the Bravo model based on likely behaviors of maritime industry segments. Run the model with the same AIS dataset used in Bravo.

Model Study Area

The definition of a model study area is a critical component in probabilistic models. There are no standards to reference in determining whether a model study area is appropriately sized. However, some general guidelines based on an understanding of underlying model framework can be applied to ensure model outputs have a reasonable degree of correlation with real-world conditions.

Port Access Route Study (PARS) Area

When conducting an incident frequency analysis for a PARS, the model should be sized to capture major shipping routes and include the areas where proposed changes to routing measures are being considered. By definition, a port access route would necessitate a large sea area, typically covering from 5,000 to 15,000 square nautical miles.

IFS Model Area

The impacts of individual installations, facilities, or structures (or groups of structures) on the US MTS should be modeled using an area encompassing the footprint of the development plus a buffer of no more than eight miles. The exact extent of the buffer is determined by consideration of the potential for the IFS to impact or influence mariner behavior or creating conditions that result in navigation choke points. Adjustments to the buffer should be made to eliminate the possibility of capturing incidents that might skew incident frequency higher than reasonably attributable to an IFS. For example, a buffer that includes inland waters of New Jersey would skew predicted grounding frequencies higher than expected due to presence of a barrier island and shoal bathymetry in the model, neither of which could be attributed to the presence of an IFS when located more than six miles from the barrier island or inland waterway. In general, buffers should be no less than 4 miles and no more than 8. Large buffers over open ocean can result in dilution of predicted incident frequencies and poor model correlation to observed data.

Cumulative IFS Impacts

The impacts of multiple groups of IFSs within 12 miles of each other should be modeled to provide cumulative impacts. The buffer surrounding multiple groups of IFS in the cumulative model should be sized according to the same principles involved in modeling impacts from a single IFS project or development.

Temporal Scale

Tolerability thresholds are based on the number of predicted incidents per year. Models should be based upon 365 days of AIS data to minimize extrapolation of data.

Cumulative Incident Frequency Measurement

In cases where multiple IFS comprise a project, incident frequency is a cumulative measurement of the entire group of IFS. Incident frequencies for individual IFS in a group may be considered during the risk control option step of the formal safety assessment process, however tolerability determinations are based on the cumulative total of multiple IFS in a group.

Incident Frequency, Consequence, and Change

IWRAP does not provide consequence modeling and therefore cannot be used to measure risk. Analysts employ an incident frequency change management approach to identify and characterize tolerability. The incident frequency change management approach is based on the following assumptions and considerations:

Assumption 1 – Managing incident frequency is an effective strategy

Risk is the product of the frequency of an incident and severity of it's consequence. Preventing incidents is a more effective strategy than minimizing consequences.

Assumption 2 – Thresholds for Incident Frequency Tolerability can be defined

Incidents are never acceptable outcomes. Nevertheless, we cannot eliminate all incidents without halting waterway operations, which is also unacceptable. Given these alternatives, we must define tolerability thresholds for incident frequency to allow for continued use of the waterway. General incident frequency tolerability thresholds can be defined using limits and change between modeled conditions. Exceeding incident tolerability thresholds requires a deeper evaluation of abatement strategies in accordance with the IMO's Formal Safety Assessment framework.

Assumption 3 – Higher traffic density provides greater opportunity for incidents

Increases in incident frequency due to natural growth in maritime activity over time is likely. Choke points create additional opportunities for vessel collisions, allisions, and/or groundings. It is unknown how much the mitigations provided by advances in modern navigation or regulatory standards and enforcement offset this risk.

Consideration 1 – Local knowledge and data must temper incident frequency tolerability

Local knowledge regarding cargo, vessel conditions, and port-specific hazards such as bottom type, proximity to heavily populated areas, or sensitive environmental areas are not captured or modeled in IWRAP. Other data sources should be consulted to determine whether consequences from a collision, allision, or grounding event may be amplified due to regional conditions. This information may temper the tolerable amount of change in predicted incident frequency.

Consideration 2 – Model wisely

The range of navigation safety impacts attributable to a change in a waterway will be limited to the area in which the change can influence mariner behavior or create an increase in traffic density. Consider developing model sub-areas to capture smaller scale waterway impacts more accurately at the port level. For example, increased traffic resulting from an IFS crew transfer vessel collision occurring in a location beyond sight or RADAR range of an IFS, or beyond the confined waters of a port supporting the IFS, is not attributable to the presence of the IFS.

Incident Frequency Thresholds

Intolerable Incident Frequency

An incident frequency is deemed to be intolerable if it is predicted to be less than 100 years between powered allision incidents. If the Alpha (baseline) model incident frequency is less than 100 years between incidents, the charlie model incident frequency is intolerable when less than the alpha model incident frequency.

Broadly Acceptable Incident Frequency

An incident frequency may be deemed to be broadly acceptable if it is predicted to occur less frequently than the baseline incident frequency for each specific or summary incident type in a region. The baseline incident frequency is obtained by probabilistic model via the alpha model run.

Intolerable Change in Incident Frequency

A change between model incident frequencies is intolerable based on the magnitude of the logarithm of change in incident frequencies. Specifically, a change in incident frequency is intolerable when within the bounds of the intolerable and broadly acceptable threshold, or once in 10,000 years, and the logarithm of the difference is greater than 0.2. Additionally, a change in incident frequency is intolerable when greater than the broadly acceptable threshold, or once in 10,000 years, and the logarithm of the difference is greater than 1.0. Specifically, where λ is incident frequency of a collision allision or grounding type expressed in units of years between incidents, an intolerable change in predicted incident frequency is defined as:

$$\log \lambda_{Model\ 1} - \log \lambda_{Model\ 2} \geq 0.2, when\ 100 < \lambda \leq 10{,}000$$

and

$$\log \lambda_{Model\ 1} - \log \lambda_{Model\ 2} \geq 1.0, when\ \lambda > 10{,}000$$

Application of Formal Safety Assessment Methodology

An analysis result designating a category of incident frequency or change in incident frequency as intolerable should trigger steps 3 through 5 of the IMO Formal Safety Assessment process below. The designation of an incident frequency as intolerable or experiencing an intolerable change is not a final or

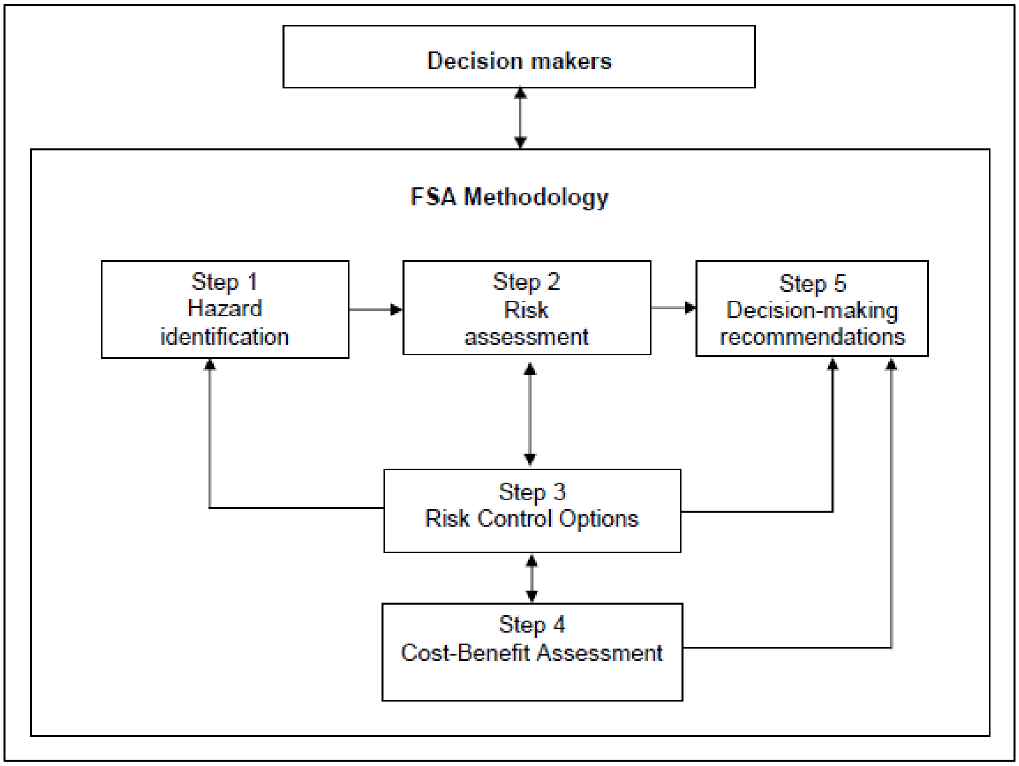

Figure 5-Formal Safety Assessment Methodology Flow Chart

definitive judgment by the USCG regarding the acceptability of a change to a waterway.

Data Products and Visualizations

Data products and visualization outputs from of allision, collision, and grounding models are highly variable based on the specific probabilistic model employed. NAVCEN recommends:

- Summary table of collision, allision and grounding frequencies for the alpha and charlie model expressed in predicted years between incidents for each incident classification.
- Identification/map of specific routes (model legs) or intersections (waypoints) where incident frequency is intolerable, broadly acceptable, or are predicted to have an unacceptable change in incident frequency between the charlie and alpha model.
- Rank order of vessel classes anticipated to experience the greatest change in incident frequency, their respective alpha and charlie incident frequencies expressed in predicted years between incidents, and percent change.
- Incident frequency by ship class and incident class expressed in predicted years between incidents.

References

MarCom WG Report n° 161 - 2018 INTERACTION BETWEEN OFFSHORE WIND FARMS AND MARITIME NAVIGATION, The World Association for Waterborne Transport Infrastructure (PIANC)

GUIDE FOR VESSEL MANEUVERABILITY, American Bureau of Shipping

Revised guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process (MSC-MEPC.2/Circ.12).

Improving the coexistence of offshore wind farms and shipping: an international comparison of navigational risk assessment processes, Medhi, et. al., 2018.

COAST GUARD TACTICS, TECHNIQUES, AND PROCEDURES 3-71.7 - WATERWAYS MANAGEMENT (WWM): NAVIGATION SAFETY RISK ASSESSMENTS (CGTTP 3-71.7), 3 Sept 2015