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Ports and Waterways Risk Assessment (PAWSA) Methodology in the United States

# Summary

The Ports and Waterways Risk Assessment (PAWSA) is a tool that uses a structured two-day process for evaluating risk in a port or waterway through local expert inputs. It was adopted by IALA in 2005 as a tool for use by member nations. This paper is presented to update IALA on the ongoing U.S. Coast Guard PAWSA review. The information in this paper is presented for awareness, feedback, and potential use for IALA either in lieu of or in addition to the currently adopted version (PAWSA Mk II). A brief history of PAWSA, its goals and objectives, recent changes, and a discussion of potential changes for the next phase in development is provided. The changes stem from a desire to improve the Coast Guard’s risk assessment capability.

## Purpose of the document

This is an information paper presented to the ARM Committee for discussion with Task 1.4.4: Review Risk Management related documentation. Update as per ongoing risk toolbox developments.

## Related documents

ARM19-n.n.n (Review of amendments to the PAWSA methodology by the US Coast Guard submitted by IALA World-Wide Academy)

# Background

The Ports and Waterways Risk Assessment (PAWSA) process grew out of changes that took place during the 1990s in the United States Coast Guard (USCG) Vessel Traffic Service (VTS) acquisition program. Through a 1997 U.S. Congressional Appropriations Bill, the Coast Guard was directed, “*to identify minimum user requirements for new VTS systems in consultation with local officials, waterways users and port authorities*” and to review private / public partnership opportunities in VTS operations. As a result of this Congressional direction, the USCG established the Ports and Waterways Safety System (PAWSS) to address waterway user needs and reduce risk in the marine environment while emphasizing industry partnerships.

As part of PAWSS, the USCG convened a national dialogue group (NDG) comprised of maritime and waterway community stakeholders to identify the needs of waterway users with respect to Vessel Traffic Management (VTM) and VTS systems. Those stakeholders, representing major sectors of the U.S. and foreign-flag maritime industry, port authorities, pilots, environmental community, and the USCG, were tasked to:

* identify the information needs of waterway users to ensure safe passage;
* assist in establishing a process to identify candidate waterways for VTM improvements and VTS installations; and
* identify the basic elements of a VTS.

The NDG was intended to provide the foundation for the development of an approach to VTM that would meet the shared government, industry, and public objective of ensuring the safety of vessel traffic in U.S. ports and waterways, in a technologically sound and cost-effective way.

Work done by the NDG led to the development of the PAWSA process, which was established to open a dialogue with waterway users and stakeholders to identify needed VTM improvements and to determine candidate VTS waterways. The process developed provides a formal structure for identifying risk factors, identifying areas of concern, and evaluating potential mitigation measures through expert inputs. The process requires the participation of professional waterway users with local expertise in navigation, waterway conditions, and port safety. In addition, stakeholders are included in the process to ensure that important environmental, public safety, and economic consequences are given appropriate attention as risk interventions are selected.

The PAWSA methodology developed by the USCG uses a generic model of waterway risks that includes factors addressing the likelihood and the consequences of an incident. That model was developed from the work done by the NDG in 1998. Risk factors identified by the NDG were put into model form by Dr. Jack Harrald of George Washington University and Dr. Jason Merrick of Virginia Commonwealth University. The focus of a PAWSA is on matters related to navigational and waterways safety. As such, security-related issues are not covered during the workshop. The USCG conducts a separate series of Port Vulnerability / Security Assessments that looked specifically at security issues.

Over 70 ports and waterways have completed the PAWSA process, which generally has been well received by local maritime communities. During the course of almost thirty years of PAWSA workshops throughout the United States and in international venues, the model has twice been revised to reflect the nature of waterway risks being experienced and participant feedback. A comparison between major model changes is provided below.

**PAWSA Mk I**. [*1999 – 2002 / 27 assessments*] The initial PAWSA model was based on the work done by Dr.’s Harrald and Merrick. They used multi-attribute decision analysis techniques and local experts’ and stakeholders’ assessments of safety levels and the effects safety alternatives would have on risk levels. PAWSA used the Analytical Hierarchy Process (AHP) and local port participant input to weight and score a risk factor tree for a generic port and then apply the risk factor descriptors to the local port (Merrick & Harrald, 2007). The risk factor tree had 17 risk factors distributed across six groups. Four of the groups addressed likelihood factors and the remaining two groups addressed consequence factors. Each risk factor can have a value of 1-9.



Figure 1 - PAWSA Mk I Risk Factors

**PAWSA Mk II**. [*2003 – 2020 / 31 assessments*] The second iteration of the PAWSA model uses the Delphi1 method to identify major waterway safety hazards, estimates risk levels, evaluates potential mitigation measures and their effectiveness, and provides specific recommendations for selected measures to reduce risk. The Delphi method is a structured communication technique that converts the expert opinion of stakeholders into a quantitative appraisal of risk. The structure closely resembles the Mk I tree hierarchy, consisting of 24 risk factors in six groups of four. Four of the groups addressed likelihood factors and the remaining two groups addressed consequence factors. Each risk factor can have a value of 1-9. This is the model adopted by IALA circa 2005. These changes and the maintenance of port-specific models were aligned with the primary PAWSA process goals of following a collaborative process and minimizing the appearance of federal oversight. These goals were important to maximize participant cooperation (Merrick & Harrald, 2007). Also of note, PAWSA facilitation moved from primarily using contractors to using USCG personnel from the Navigation Center (NAVCEN) between 2017 and 2018.



Figure 2- PAWSA Mk II Risk Factors

**PAWSA Mk III**. [*2020 – 2024 / 10 assessments*] The third iteration of the PAWSA model introduced the Baseline Risk Value, which is calculated from the stakeholder evaluation of likelihood risk level multiplied by an average of the consequence risk levels.   
  
  
  
The structure closely resembles the Mk II tree hierarchy, consisting of 24 risk factors in six groups of four. Four of the groups addressed likelihood factors and the remaining two groups addressed consequence factors. The model was changed to increase the time available for stakeholder discussion, remove sections that participants found confusing, and to rank the likelihood risk factors based on an overall risk index instead of looking at each risk factor (*likelihood & consequence*) independently.



Figure 3 - PAWSA Mk III Risk Factors

At this point, the ultimate goal of a PAWSA had moved away from establishing a baseline for VTS consideration to providing the Coast Guard Sector Commander and members of the waterway community an effective tool to evaluate risk and work towards long term solutions tailored to local circumstances. An effective PAWSA should help find solutions to excessive risk that are both cost effective and meet the needs of waterway users and stakeholders.

In May 2024, the USCG hosted a team from the IALA Worldwide Academy to observe a PAWSA Mk III session in Tampa, FL with the goal to report back on their findings to ARM. Concurrently, the USCG used this PAWSA to assess the need for possible model changes.

# Discussion

The following Sections briefly outline the general observations from the Tampa PAWSA, the noted differences between Mk II and Mk III, and alternative methodology for Mark IV consideration.

## General Observations

The areas of interest to the PAWSA model and implementation taken from the Tampa PAWSA are summarized below.

1. **The importance of facilitation**. Facilitators are necessary for successful PAWSAs, both as the expert guide moving participants through the process and as a neutral third party who can more effectively prune unhelpful digressions without disrupting the balance of relationships that the participants bring to the PAWSA.
2. **PAWSA structure matters**. This is a guided process and having a clear roadmap and boundaries makes the facilitators job easier. Making the time to present the methodology in understandable terms is important to a smooth flow between sections. The fewer questions that need to be answered and the fewer times instructions need to be repeated, the better. Time is a finite resource during a PAWSA and transitioning smoothly to each section buys time that can be spent in productive discussion by the participants.
3. **The audience for PAWSAs is diverse**. There was a phrase that was used often during the Tampa PAWSA by the facilitators, “*This is your PAWSA*.” It was invoked when participants asked if they could discuss a certain topic and also to re-focus the discussion or remind participants that if they wanted to discuss other topics they needed to conclude this topic and move to another one. The phrase reinforces that the outcome of the PAWSA is something the participants should care about and that they have control over. However, this doesn’t fully describe how PAWSAs were, are, or could be used by the U.S. Coast Guard. Historically they were used for recommending Vessel Traffic Services (VTS) locations. Currently they are used as part of the suite of tools for the U.S. Coast Guard to make planning decisions for proposals impacting the Marine Transportation System (MTS). In general, PAWSAs should be used as more than just a stand-alone report that may or may not be leveraged by the local maritime stakeholders. The non-local uses aren’t well defined and that is something that should be explored more, or else the PAWSA could lose relevancy / funding within the Coast Guard. As a risk tool that’s been used for more than two decades, the history and longevity should not be squandered or dismissed.

## PAWSA Mk II vs. Mk III Comparison

At ARM18 in April 2024, the Coast Guard presented the PAWSA model history in detail and the relative advantages / disadvantages of each model. This can be summarized in the following table.

|  |  |  |
| --- | --- | --- |
| **Topic** | **Mk II** | **Mk III** |
| *Calculations* | Independent impact, scale is 1-9 | Averaged impact, scale is 0-1 per consequence. |
| *Trends* | Not documented or quantified. | Documented, but not quantified. |
| *Expertise* | Considered. | Not considered. |
| *Mitigations* | Categorized with free-form details. | Documented, but not categorized. |

The implications of the Mk III model when compared to the Mk II are that:

* Expert knowledge is discounted. Everyone counts the same for all risk factors.
* Possible to show 0 risk. While not likely, if encountered, this is a fundamental issue in a risk model.
* Does not allow for discussion of impacts or the associated consequence mitigations.
* Discounts low-likelihood / high impact events through averaging. A bridge collapse like the M/V DALI allision with the Francis Scott Key Bridge may be the worse economic consequence, while the safety and environmental factors in the area are relatively mild in comparison. Averaging all the consequence factors together, however, puts these two impacts on equal footing, thus masking the potentially high impact.
* Likelihood and consequence factors are linear, not exponential. This does not reflect the general sense that a large oil tanker running aground has significantly worse consequences than a small passenger vessel running aground. The model, however, only moves the consequence numerically from .5 (some impact) to 1(significant impact) in severity.
* Mitigations are 100% free-form and not categorized. The subsequent analysis is therefore more difficult and requires after the fact categorization.
* It is unclear if there is a preferred mitigation, or if participants think one mitigation would be more impactful than others. From a decision-making perspective being able to rank options is very useful, especially if the ranking includes a way to compare relative impact.
* BRV has no meaning beyond a PAWSA. This is similar to the values assigned to risk factors in Mk II. BRV provides a way to categorize elements of risk to focus on the highest perceived risk factors for a specific PAWSA. Determining a way to make the PAWSA results have inherent meaning outside of risk categorization would be beneficial.

Mk III made some useful changes in the PAWSA methodology when compared to Mk II. It combined the likelihood and consequence elements to show a more holistic risk picture. It also removed the baseline assessment of un-mitigated risk factors that made sense at the beginning of Mk II implementation but were later deemed unnecessary. Finally, Mk III removed the expertise self-assessment. While removing expertise weights within the model does have negative implications, use of the expertise weights can also be fraught with interpretive issues and could introduce uncertainty into the results.

## Methodology Alternatives Considered

1. *Adjust the Baseline Risk Value to reflect alternative calculations using the prior 1-9 risk factor scales.* Reverting to the 1-9 scale would expand the range of possible values and provide for a more nuanced understanding of risk by spreading the BRV from a 0-8 scale to a 1-81 scale, in the instance where the model simply multiplies a likelihood value to a consequence value.
   1. **Benefits**:
      1. Less conceptual change, approximate return to prior system.
      2. No possible zero risk outcome.
   2. **Costs**:
      1. Linearity makes determining risk break points more arbitrary. From a stakeholder perspective, what is the functional difference between a BRV of 18 and a BRV of 21? The difference in perceived risk could be viewed as negligible.
      2. The time it takes to facilitate this section of the PAWSA will increase. If the intent is to explore all combinations of likelihood risk factors and consequence risk factors, participants will be cycling through the eight consequence risk factors 16 times. Facilitating this will be difficult.
      3. Alternatively, the methodology could change to only look at a subset of consequence risk factors for each, such as what the participants think are the four most significant ones for each likelihood risk factor. Reaching consensus on which four will be discussed, however, will also take time.
2. *Adjust the Baseline Risk Value to reflect the Risk Index Number (RIN) calculations used in an existing Coast Guard navigation safety risk assessment tool.* The US Coast Guard uses a 5-Step Navigation Safety Risk Assessment as part of their Risk Based Decision Making framework to calculate RIN. This kind of assessment is used to evaluate the expected change in risks with the introduction or change to the waterway. The change could be the addition or removal of infrastructure or a change to the waterway configuration or usage. This RIN is based on a logarithmic scale and not a linear scale like PAWSA has always been. This better aligns with experimental studies about how people perceive risk (Duijm, 2015). It also accounts for low likelihood / high consequence events more cleanly than the Mk III linear scale; a low consequence outcome like a bucket of oil spilled is given a consequence score of .5 and a large tanker-sized oil spill would be given a consequence score of 1. That scale does not capture the relative difference in impacts of the different consequences that most people would assign.
   1. **Benefits**:
      1. This is a much better alternative to the BRV. The RIN is based on a set of Coast Guard tools from the early 2000s that included a national risk assessment that was normalized on consequence cost. This allowed for equitable comparisons between economic, environmental, and safety risks.
      2. A weakness of the NSRA RIN is it only shows a change in the risk level if a change to the waterway is introduced, but is not able to show what the overall risk is in the waterway – either before or after the change. The PAWSA may be able to fill that role as a baseline risk tool. Additionally, because it is using the same calculation, it will link cleanly with the risk changes documented in NSRA 5-Step tool.
      3. This aligns with the IMO FSA risk definition, making PAWSA potentially more useful in broader contexts.
   2. **Costs**:
      1. The RIN is a highly quantitative. Explaining it in detail is not recommended for the meeting, although including it in any pre-read material would be recommended. The facilitation of this section would need to be very well scripted to reduce stakeholder confusion or reluctance to try translating their experience into numbers.
      2. The time it takes to facilitate this section of the PAWSA will increase. While the BRV does a combination of likelihood and consequence, the RIN is both more meaningful and more conceptually complex. The framework of linking a risk factor to a specific and singular event and then linking to one or more consequences is likely a new concept for most of the stakeholders and will require careful facilitation. It could also very likely introduce novel facilitation complications not yet considered.
3. *Account for more than just worst-case scenarios when calculating the BRV or equivalent risk value.* All PAWSAs have been facilitated to only look at worst-case scenarios when assessing risk. The Mk I and Mk II explicitly asked participants to rate their port against a theoretical “Port Heaven” (lowest risk port ever) and “Port Hell” (highest risk port ever). This biases the results towards low-likelihood / high-consequence risks. In reality there are a multitude of high-likelihood / low consequence risks that represent the bulk of what a port experiences on a regular basis. Failing to account for a fuller spectrum of risks means the full picture is not explored during PAWSA.
   1. **Benefits**:
      1. This significantly improves how robust the PAWSA results are and accounts for risks that are not currently captured in the Mk III worst-case calculations.
      2. It exposes some of the uncertainty that is invisible in all prior versions of the PAWSA.
      3. Improves stakeholder awareness of the contributions of all levels of incidents to risk in the waterway; not just low-likelihood / high-consequence events.
   2. **Costs**: The time it takes to facilitate this section of the PAWSA will increase. It will increase for any use of RIN and expanding that to some combination of low / medium / high risk scenarios will increase it even more.
4. *Auto-calculate initial Risk Factor review priorities.* Currently the risk characterization questions in Mk III are displayed to the participants and they choose which risk factors to include in the discussion of mitigation options. In general, the Coast Guard has found participants select risk factors that are not currently well mitigated and that have with increasing risk. This discussion takes time. In the interest of increasing the time spend on discussing mitigations, this change would automate the initial selection of risk factors based on risk characterization
   1. **Benefits**: Reduces how long it takes to get stakeholder consensus. Being presented with the criteria for prioritization and then having the list generated based on that criteria is relatively easy to facilitate. A short validation segment to make minor adjustments is possible, just in case there is a politically sensitive but low-risk concern that the stakeholders want to include.
   2. **Costs**: Minimal challenges expected. The logic is easy to incorporate to any tool that is calculating the results of stakeholder inputs.
5. *Re-introduce Stakeholder Expertise Weights.* Expertise weights were originally introduced to PAWSA to account for different knowledge baselines between participant teams. Everyone has opinions regardless of experience or training, but the Coast Guard felt it was reasonable to listen more closely to experts for specific factors. For example, this would weigh the responses to navigation questions more heavily from pilots and other mariners while environmental impacts would be weighted more from marine scientists.
   1. **Benefits**: A PAWSA covers a very broad set of factors that are likely to influence risk in the port. No one stakeholder can reasonably be considered an expert in all of them. Weighing inputs will give respective experts more sway in the calculations over non-experts. It should be noted, however, that historically, very few people rate themselves as non-experts and most self-identify as either average or an expert.
   2. **Costs**:
      1. The time it takes to facilitate this section of the PAWSA will increase slightly. In an unweighted methodology, the question of fairness does not seem arise. Introducing weights will likely cause some concern about whether the time stakeholders spend doing a PAWSA will be worth it if their ‘vote’ is less than others’. If not well facilitated this could undermine stakeholder buy-in of the results.
      2. Given the historical identification trends, the expertise weights may not make much of a difference to the scoring.
6. *Re-introduce Mitigation Effectiveness and Categorization.* Currently there is not much of a framework to analyse mitigations, whether from national level Coast Guard perspective or for local stakeholders to account for when deciding on which mitigations to pursue. This change would reintroduce a section for stakeholders to estimate mitigation effectiveness and would bucket proposed mitigations into pre-existing categories for summarization and future analysis at a higher level.
   1. **Benefits**:
      1. Helps with prioritizing mitigations. Absent an idea of how effective a mitigation would be, the only real factors in deciding to pursue it is cost and difficulty to implement. Very few mitigations are easy and inexpensive. When deciding between difficult / expensive mitigations, being able to include a risk reduction effectiveness factor allows stakeholders to estimate an efficiency for each mitigation – how much risk can be bought down with this mitigation that costs this amount.
      2. Can help with facilitation of the mitigation discussion by focusing the discussion on reasonable mitigations and not “*we’re going to save the world from [large issue outside the scope of the port to address]*” kind of discussions. For example, expanding eel grass protected areas may improve biodiversity locally, but it will not measurably change the strength of offshore winds.
   2. **Costs**:
      1. The time to facilitate this additional section would need to be accounted for. Feedback from stakeholder participants indicates that the most popular and rewarding portion of a PAWSA is the discussion of mitigations. Reducing time for the open exchange of ideas should not be reduced too much or else participants may not feel like the PAWSA outcomes reflect their input because there was not enough time to discuss everything.
      2. This is an inherently challenging concept. It is one thing to ask the stakeholders about operational risks they are familiar with (weather, traffic density, etc.) and a very different thing to ask them how effective a general licensing regulation would be at reducing collisions, or how effective a new current sensor would be at reducing risk. Participants know they want certain mitigations but quantifying that is much harder. Adding this would likely add significant facilitation time.
7. *Revise risk factor descriptors to include numeric thresholds.* This change would re-anchor risk factor descriptors to be more grounded in numbers instead of more subjective versions. Experiments in the medical field found that communicating risk perception using qualitative descriptions reduced confidence and using quantitative descriptions had no effect (Weidemann, Boerner, & Freudenstein, 2021). Qualitative descriptors can be misleading, since each person will interpret them differently. In a survey of risk of various experts and corporate users of risk tools, all asserted that qualitative descriptors worked best when they were paired with numbers or very clear definitions (*i.e. instead of “major” as a consequence descriptor, “one week spent in hospital” is more commonly understood between participants*) (Roos & Selitski, 2023).
   1. **Benefits**:
      1. A reduction in variation between stakeholders because of vagueness of descriptor meanings.
      2. It would be hoped that the facilitation team would see reduced time spent on discussing the risk factor descriptors, since they would be more inherently clear.
   2. **Costs**: The facilitation team would need to do more extensive preparations to anchor the discussion using facts from the port and historical incidents from around the country.
8. *Explicitly account for uncertainty.* A continuous challenge in risk assessments is conveying the uncertainty aspect in risk communication. Uncertainty exists in all aspects of an assessment, from the likelihood of an unwanted event to the consequences of that event. Even experts can have differences of opinion on the same issue which complicates how to communicate all the variances into an actionable recommendation for a decision maker. The conclusions have less practical value if the decision makers cannot account for how sound the conclusions are (Fischhoff, 2012).
   1. **Benefits**:
      1. Accounting for uncertainty would move the PAWSA closer to acknowledged risk assessment / risk management best practices.
      2. This change should enhance both the PAWSA’s usefulness to decision-makers and all audiences of the outputs.
   2. **Costs**:
      1. Experts are often overconfident in their judgements, that is, events did not occur at the frequency experts believed. For example, events with a perceived 70% chance of occurring, do not in fact occur 70% of the time (Fischhoff, 2012). Without a way to calibrate, the PAWSA would suggest more confidence than the decision maker is likely to experience.
      2. Accounting for uncertainty is difficult to do and effectively communicate. The PAWSA would be at risk of being discounted or undermined solely from misunderstandings of how uncertainty impacts the conclusions.
9. *Add a step in the methodology to cap consequences for the port based on reasonable port data.* Not all ports or waterways are the same. Each have different mixes of vessel types, different traffic patterns, different infrastructure, and more. As a result, it is difficult to compare ports, especially since stakeholders strongly believe that their problems are the biggest. In the interest of improving port risk comparability, this change would have stakeholders identify the highest-level descriptor of each consequence risk factor for their port. When scoring their port, the PAWSA would use the results from this step to prevent selection of non-applicable descriptors from being used. Actual consequence data from the US and their port would be presented for context. For example, a question concerning oil spills may cap a maximum oil spill consequence at 50,000 gallons spilled. If a port does not have any bulk oil traffic and historical data shows a maximum of 10,000 gallons spilled in a single incident during the past 15 years, it is probably reasonable to cap the maximum oil spill consequence for this port at 50,000 gallons. At another port, like Houston-Galveston, Texas, which has very significant bulk oil traffic, this would not be the case and the highest descriptor of more than 50,000 gallons spilled should be available for selection.
   1. **Benefits**:
      1. Coarse cross-port comparisons or classifications by risk level potential would be possible. This is not currently feasible with PAWSA or other USCG risk tools. This could allow for strategic prioritization based on potential risk (*ex. Tier 1, 2, 3, and 4 ports in descending risk*). In scoring terms, you’d expect Tier 1 ports to dominate all other ports. However, if there is a need to spread resources across all types of ports, knowing the full spectrum and ranking of all tiered ports would allow Administrations to prioritize the applicable resources accordingly.
      2. Risk results would be more comparable between ports. This change would prevent unreasonably high scores from being assigned to lower risk ports, which cleanses the data for more consistent scoring.
   2. **Costs**:
      1. The time it would take to facilitate this additional section would need to be accounted for.
      2. The facilitation could be difficult, similar to the expertise weighing. No port wants to be told or admit that their issues aren’t comparable in importance to any other port. A more objective viewpoint would be useful, but getting stakeholders to acquiescence to the concept may be too difficult.

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# Action requested of the Committee

The Committee is requested to:

1. Take note of the information provided and the ongoing review of PAWSA in the United States.
2. Forward to WG 3 for discussion and consideration for future PAWSA development.