July 2020

Shipboard Forklift Risk Assessment

Abstract: Forklifts are used daily to perform essential cargo movement onboard ships, from pier side operations to underway replenishments. Forklifts provide efficient cargo movement that would not be safe or possible using only working parties and human lift, so maintaining appropriate human risk controls to operate these machines is essential to prevent injury, and avoid damage to critical shipboard systems and supplies.

References:
(a) NAVSUP Request 17JUN20
(b) WESS Shipboard Forklift Mishap Data (2014-2020)
(c) DOD HFACs
(d) OPNAVINST 5100.19F
(e) NAVSUP P-538 (6th Edition)
(f) NAVEDTRA 43100-6T (Personnel Qualification Standard) Catalog
(g) LHA/LHD NATOPS Manual (NAVAIR 00-80T-106)
(h) NASA TM 2016-219421
(i) Speed of Sight – Why Visuals Matter, p. 1-6

Enclosure: (1) KM Risk Assessment for Shipboard Forklift Mishaps

Figure 1. Forklifts provide essential cargo movement and organization onboard ship.

Upon request of NAVSUP, reference (a), the Naval Safety Center (NAVSAFECEN) Knowledge Management (KM) Afloat Division once again put into practice its Safety Management Systems (SMS) based risk assessment model defined in enclosure (1), to analyze reported shipboard forklift mishap data, locate potentially deficient forklift risk management designs, and measure current risk mitigation levels.

What is Happening?

Shipboard forklift mishap data compiled from safety reports from the Web Enabled Safety System (WESS), reference (b), was analyzed to identify potential unmitigated risks within current forklift operations risk control designs (Figure 2).

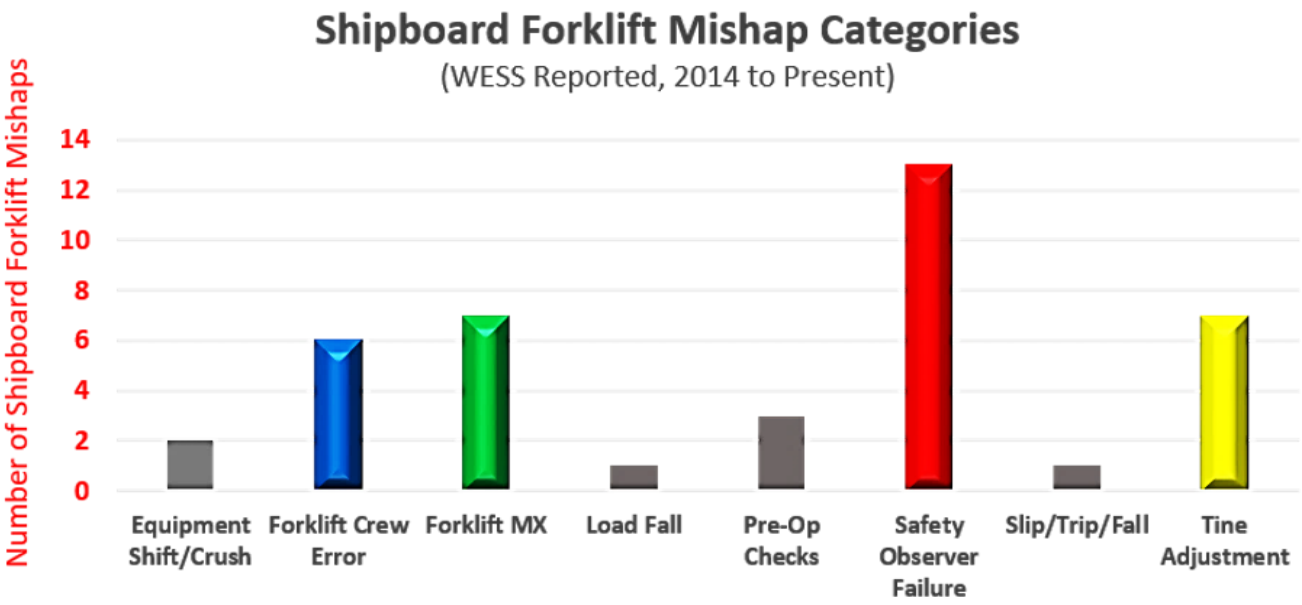


Figure 2. Shipboard forklift mishaps, October 2014 to Present.

Within shipboard forklift mishap data, here is how 83% of the shipboard forklift mishaps are occurring:

- 18% Forklift Crew Error
- 21% Performing Forklift Maintenance (MX)
- 39% Safety Observer Failure
- 21% During Forklift Tine Adjustment

Eliminating Data Inconsistencies

In order to perform a fair risk assessment for current forklift risk controls, it is important to initially look for any "inconsistencies" to the data. In order to ensure there

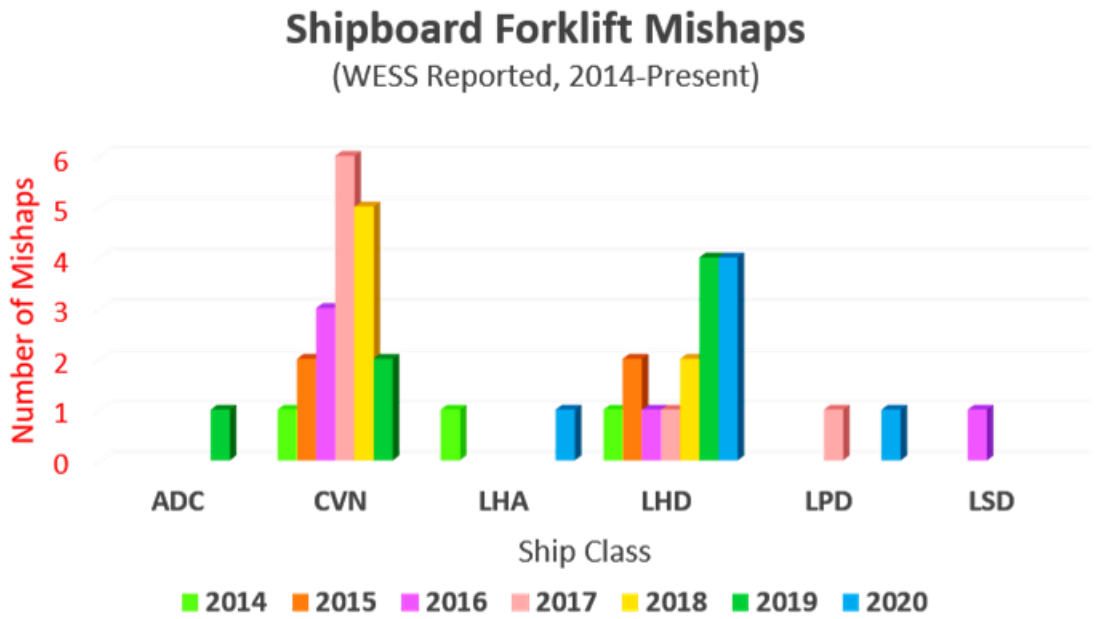


Figure 3. The ship classes where forklift mishaps are reportedly occurring.

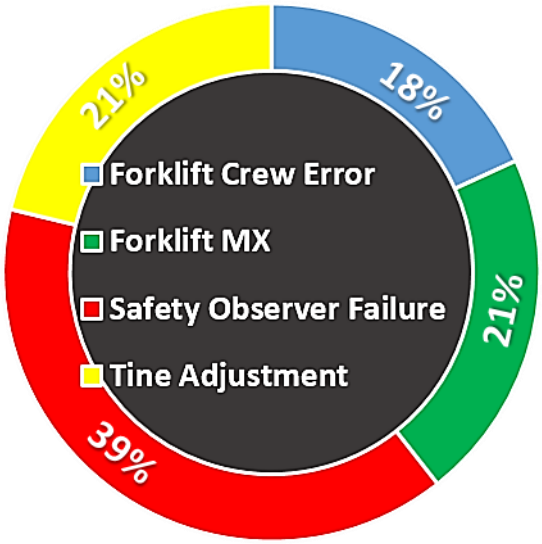
were no obvious factors obscuring the WESS reported mishap data, KM analyzed each reported ship class (Figure 3).

The current data shows that during a nearly six-year timeframe, only six total forklift mishaps occurred onboard during all of the operations onboard our hospital, LHA, LPD, and LSD ship classes. Given the numbers and frequency of forklift operations necessary to successfully complete amphibious missions, combined with the smaller operational quarters onboard these ship classes over a six-year timeframe, *safety underreporting must be considered when weighing the content of this risk assessment.*

Zeroing in on Risk Data

Looking inside the top four mishap categories (Figure 2), the reported mishaps were caused from the following:

1 - **Forklift Crew Error.** These mishaps occurred as a result of either the crew not adhering to the safety calls of their safety observer, or the forklift was operated in a manner that resulted in inadequate clearance for operation, or caused a nearby pallet strike;



2 - **Forklift Maintenance.** These mishaps occurred during the performance of forklift maintenance, and resulted in finger cuts, smashed fingers while lifting the battery, a few electrical shocks tightening battery terminals, and cleaning;

3 - **Tine Adjustment.** Tines or "the forks" of a forklift are normally very heavy, and used to counterbalance the center of gravity of a forklift. As written, tine adjustment mishaps may have all been preventable, citing the weight of the tines as a 'common denominator' to each injury, with the injuries occurring due to one person trying to make tine adjustments alone;

4 - **Safety Observer Failure.** These mishaps occurred due to the safety observer's actions, either being out of position to safely observe the ongoing forklift operations, or losing control of the forklift operations by conducting forklift operations without the ability to "emergency" stop unsafe forklift operations.

Performing the KM Risk Assessment. Now, with an understanding of each mishap, the KM risk assessment model was used to "zero in" our KM analysis on the existing procedural guidance and human error management tools – or risk controls – that are used by the fleet to help mitigate the risks of shipboard forklift operations. By reviewing the primary procedural guidance and human error management tools provided to the fleet to standardize and define *general* forklift operations, forklift operator training, and forklift team training, KM "operationalizes SMS," and is able to

determine the larger root causes of reported shipboard forklift mishaps, as well as provide potential solutions for risk design shortfalls.

OPNAV Review. Reference (d), the Navy Safety & Occupational Health Program Manual for Forces AFLOAT (OPNAV 5100.19), Section C, Chapter 2, *Dry Cargo Operations, Stores Handling, and Rigging* contains solid general forklift safety procedures. In contrast, the Navy Safety & Occupational Health Program Manual (OPNAV 5100.23) states that "…the movement of materials in storage facilities using forklift trucks, overhead cranes and powered hand trucks, where materials are stacked above three feet in height…" represent a Job Hazard Category of 'B," and a "Moderate" Hazard Level. However, no other forklift procedures exist among any other written safety procedures, nor is a reference made to use the NAVSUP P-538 for "all other forklift operation requirements" to help guide forklift users to necessary procedures; therefore, OPNAV 5100.23 was eliminated as part of the useful risk design for the fleet's forklift operations.

NAVSUP Review. Reference (e), Management of Materials Handling Equipment (MHE) and Shipboard Mobile Support Equipment (NAVSUP Publication 538) provides the primary guidance for "…the management, maintenance, and safe use of industrial MHE and their approved attachments, and Shipboard Mobile Support Equipment (SMSE) at U.S. Navy units ashore and afloat."

NAVEDTRA Review. Reference (f), the NAVEDTRA 43100-6T (Personnel Qualification Standard (PQS) Catalog), was reviewed to determine if a general forklift operations PQS had been developed to help "train the trainers" using an organized and standardized methodology that was not developed in the NAVSUP P-538 – possibly even provide a template to provide local commands with various forklift devices to assist in the development of local Job Qualification Requirements (JQRs) to provide operational and HFM standardizations. However, this research resulted in the discovery that there are no stand-alone forklift PQS for the fleet. There are elements of forklift use standardization embedded in other PQS, but not contained – and therefore not content managed – solely for the purpose of managing the diverse skill sets required to safely operate forklifts.

NOTE

Procedural evaluation is a critical part of the procedural development process, and an important guard against potential failure of the whole endeavor. No matter how many smart people are working on a procedure design and development project, errors will occur and unintended consequences will materialize. The only way to catch mistakes and avoid costly new problems is to perform a careful evaluation. (NASA, p. 5)

NATOPS Review. Reference (g), the LHA/LHD NATOPS, as a powerful TYCOM procedural guidance contributor, was reviewed for shipboard forklift operations and team cargo procedures based on the lack of existing team forklift operations procedures and HFM standardization present in references (d), (e), and (f). Forklift operations were discussed in relation to night vision devices, and U.S. Army H-47 helicopters. A stand-alone section for general cargo handling and staging, non-ship's company forklift

operator qualification requirements, forklift team operations, general forklift operations, or a minimum safety standards framework for PQS or local JQR design are not contained in reference (g).

NOTE

The KM Risk Assessment Model assigns a percentage of risk mitigation to every procedural guidance and human error management tool evaluated, where each area analyzed is weighted equally. A Risk Assessment Tool with derived averages will be introduced through future safety studies.

Result: The current risk design for shipboard forklifts results in the successful mitigation of 46% of shipboard forklift operational risk, and yields a 54% risk design shortfall. This shortfall, then, translates unmitigated risks – that must be identified and mitigated – directly into the Unit Level, as the procedural guidance and human (error) factors management instructions reviewed contain vulnerability for producing the next mishap based on current mishap data. See enclosure (1) for complete analysis.

CURRENT VULNERABILITY	**Mitigated Risk**	**Unmitigated Risk**
	46%	**54%**

NAVSUP Recommendations

1. Develop a Forklift Operation Safety Training Video. It may seem overly basic, but developing a shipboard forklift operation safety video would help accelerate the understanding of safe forklift (and other) MHE equipment, and serve to compliment all existing afloat forklift training that is otherwise "hidden" by being embedded in specific rate manuals. This serves a few purposes:

A - Not just "one rating" operates shipboard forklifts, and training should not require added "extra effort to locate the right training" in order for Sailors to learn and operate forklifts safely, and for Leadership to use to develop local procedures;

B – Supervised unsafe forklift operations for visual presentation, from pre-op checks and designing a cargo movement plan to actual forklift operator "typical mistakes" could ultimately be a part of the training video content, allowing a real-time and accurate – but safely staged – reenactment of unsafe conditions. This will prove invaluable as "what not to do" as Sailors start training to operate forklifts onboard ship.

2. Develop a General Forklift Operation NAVEDTRA. A general forklift operation NAVEDTRA, would provide the fleet with a tool that provides forklift guidance organized into a more humanly learnable fashion. Integrating a NAVEDTRA with a Forklift Operation Safety Training video, would strengthen the fleet's local forklift operation procedures immeasurably.

3. NAVSUP P-538, Revision 7. During the performance of this KM Risk Assessment, the development of NAVSUP P-538, Revision 7 was confirmed through liaison with NAVSUP WSS Mechanicsburg, making the development and deployment of recommended changes in this risk assessment possible PRIOR to the deployment of this revision. As 83% of reported shipboard forklift mishaps are occurring as a direct result of the current procedural guidance in place to prevent forklift mishaps – making these critical changes would best serve the fleet's operational readiness.

Recommended Distribution: NAVSUP
AFLOAT TYCOMS
Afloat Units

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Credits

Ashton, Danny. 2019. Speed of Sight – Why Visuals Matter. NeoMam Studios, London United Kingdom, p. 1-6. Used with permission, granted 14AUG19. Retrieved from: https://neomam.com/interactive/13reasons/.

How the KM Risk Assessment is Performed. Utilizing an operationalized SMS design, KM AFLOAT employs a simple risk assessment relationship to perform systemic risk assessments on established organizational risk management designs, namely procedural guidance, and human (error) factors management (HFM) instructions. What are HFM tools? Formal and informal skill schools, PQS, and periodic skill testing would all qualify as organizational HFM tools.

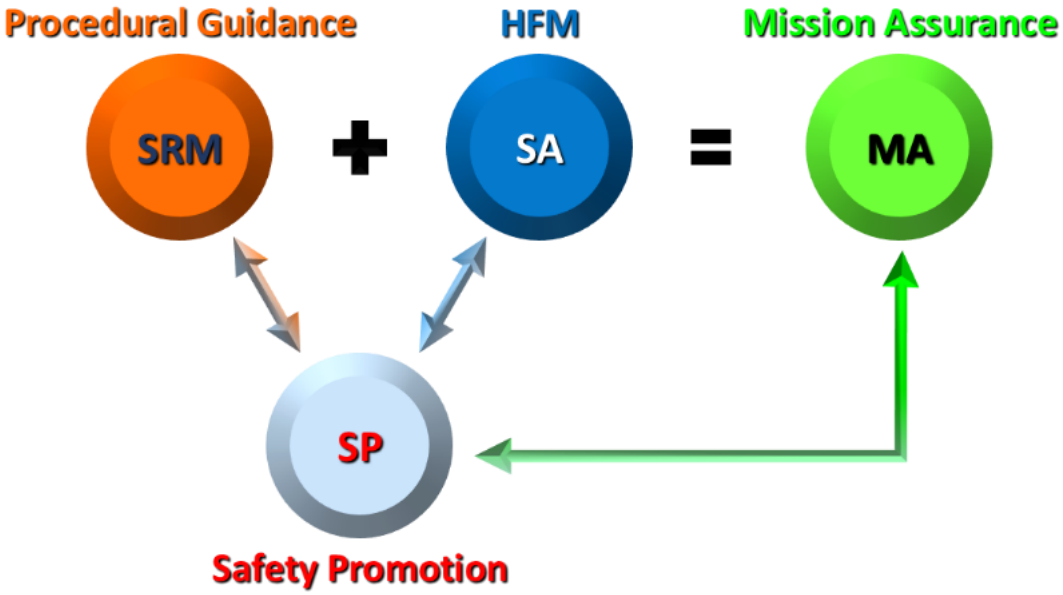

Figure 4. KM AFLOAT defined SMS-based risk assessment relationships.

If you are familiar with SMS, do not let yourself get "hung up" on the terminology of the KM risk assessment relationship before you understand it. Decades of SMS research and application have grouped a tremendous amount of organizational function into 3 stovepiped categories of Safety Risk Management (SRM), Safety Assurance (SA), and Safety Promotion (SP)...yet still fallen short of clearly defining their interrelationships. Without defining these operational interrelationships, all existing SMS guidance is little more than "lists," with limited actionable value.

However, by realigning SMS functions, KM harnesses the SMS function of "self-assessment and verification," positioned as a safety promotion task. Keep in mind that SMS Pillars represent not only "things" but also "actions," simultaneously. By clarifying self-assessment actions to the SP SMS pillar, ***the traditional SMS model transforms into an active and continuous risk management process.*** This transforms traditional SMS into a risk predictive methodology, instantly serving an organizationally foundational "all purpose" risk identification and management role, adaptable to any platform, process, or warfare specialty mission.

What follows is the KM risk assessment model directly applied to the reported forklift mishap data, depicting how risk interrelationships can be objectively measured for their presence, structure, and ability to manage the organizational risk designs that have been identified as causal for reported mishaps.

KM Afloat Risk Assessment Results

1 - Forklift Crew Error (18% Total Mishaps). By reviewing references (d) and (e) and then applying the DOD Human Factors Analysis & Classification System (HFACs), reference (c), the following safety yield is achieved:

RISK ASSESSMENT	
OPNAV 5100.19	❖ Does not specify team cargo movement procedures for shipboard forklift operations ❖ Does not define the need for integrated crew procedures to orchestrate safe cargo movement ✓ Does specify multiple "crew safety precautions," although these are not organized into a discernable safety framework, pre-op checklist, or mandatory review prior to performing forklift operations
NAVSUP P-538	❖ Does not specify team cargo movement procedures for shipboard forklift operations ❖ Does not define the need for integrated crew procedures to orchestrate safe cargo movement ✓ Does specify multiple "crew safety precautions," although these are not organized into a discernable safety framework, pre-op checklist, or mandatory review prior to performing forklift operations

VULNERABILITY	Mitigated Risk	Unmitigated Risk
	33%	66%

Discussion. From reference (c), **HFAC PP101 (failure of crew or team leadership) is present** when the crew or team leadership techniques failed to facilitate a proper crew or team climate, to include establishing and maintaining an accurate and shared understanding of the evolving task and plan on the part of all crew or team members. With a mission vulnerability quantified by an unmitigated risk of 66%, left uncorrected, *shipboard organizations operating forklifts are presently more than halfway to their next forklift mishap caused by a lack of Forklift Team operating procedures, team learning scenarios, or routine forklift team operation evaluation.*

Vulnerability Reduction. A greater understanding that individual deckplate skills are not team deckplate skills is needed. As important as establishing a foundation and growing individual skills in our Sailors is, team skills **must be similarly taught and developed** for every organization trying to accomplish any team task safely and effectively, not just assumed to be "learned along the way." This is exactly where unmitigated risks roll out the red carpet for mishap potential. The following recommendations lower our risk vulnerability:

A – Forklift operations team concept must be developed, similar to CRM
B – Deploy this via a "bolt on" Appendix for NAVSUP P-538 or NATOPS
C – Create a NAVEDTRA for General Forklift Operations with JQR Template

2 - Forklift Maintenance (21% Total Mishaps). By reviewing references (d) and (e) and then applying the DOD Human Factors Analysis & Classification System (HFACs), reference (c), the following safety yield is achieved:

RISK ASSESSMENT	
OPNAV 5100.19	✓ Does specify general electrical safety and some battery maintenance precautions ✓ Clearly states the requirement for demonstrated mechanical competence prior to completing any machinery maintenance ✓ Does specify verifying equipment is properly tagged out of service before attempting repairs or preventative maintenance ❖ Does not specify any "recommended team maintenance actions," i.e., where a safety observer could or should be used
NAVSUP P-538	✓ Does specify very good detail regarding general forklift maintenance safety precautions ❖ General warnings still contain reference to Material Safety Data Sheets versus Safety Data Sheets ❖ No general warnings regarding static electricity discharges possible during cleaning; poor PPE reinforcement during cleaning around forklifts ❖ No warnings associated with battery handling with respect to their heavy weight; poor PPE reinforcement during battery handling ❖ No warnings associated with forklift tong weight, no procedures or requirements for 2-person lift or repositioning/handling ❖ No general instruction on tire replacement ❖ No Team Maintenance concepts or team required tasks

VULNERABILITY	Mitigated Risk	Unmitigated Risk
	36%	64%

Discussion. From reference (c), **HFAC SP 000 (planned inappropriate actions) are present** when supervision fails to adequately plan or assess the hazards associated with an operation and allows for unnecessary risk. **HFAC SP006 (performed inadequate risk assessment and/or mitigation - formal)** is a factor when the supervision does not adequately evaluate and/or mitigate the risks associated with a task or when pre-mission risk assessment tools and/or programs are inadequate. **HFAC PC 105 (negative habit transfer)** and **PC109 (technical or procedural knowledge not retained after training)** are present when individuals revert to highly learned behavior used in a previous situation and that response is inappropriate for current task demands and when an individual fails to absorb and/or retain required information or is unable to recall past experience needed for safe task completion.

Although references (d) and (e) represent several maintenance actions, providing a good general overview for afloat units to use as a baseline to develop their local procedures, the forklift maintenance mishaps "found the safety seams," and are not currently bounded by existing procedural guidance in either reference. In several

instances, the insertion of at least a "warning" at the appropriate sequence point of the written procedures where it is significant to associate that warning knowledge with the procedure and maintenance action. Not one technician is going to stop in mid-maintenance action, return to the front of the manual, and look for associated warnings. These must be with their associated procedures in order to be learned, and therefore yield the safety protection they are designed to achieve.

Similarly, many detailed maintenance actions are described without any visual references, or maintenance action sequence photographs – to help learners not only understand these maintenance procedures, but also not only more quickly retain learned knowledge, and more accurately refresh these skill currencies. **Road signs make a perfect example to illustrate this very common procedural guidance failure.**

Prove it to yourself. Which "identical warning" do you understand the best in Figure 4? A or B? Remember the cliché "a picture is worth a thousand words." Okay, but why? Neuroscience has proven for decades that humans are 90% visual learners. Moreover, people following directions with text *and* illustrations do **323%** better than people following directions without illustrations, reference (i). Therefore, the fact that the existence of "complete maintenance instructions" for the mishaps reported must also consider that this existing guidance is not achieving its safety goal, and our workforce is getting injured and breaking equipment in the meantime. Hence, the following recommendations will lower our risk vulnerability:

A – Develop illustration for all critical maintenance processes versus just text
B – Deploy these as "bolt on" Appendices for NAVSUP P-538 or NATOPS
C – Create a NAVEDTRA for General Forklift Operations with JQR template that details a "process approach" to illustrating critical maintenance actions

When driving along this roadway, it is possible that due to meteorological conditions, i.e., freezing and thawing that occurs naturally and is unforecastable, from time to time, hazardous falling rock may occur without warning, and could pose vehicle impact dangers to automobiles, RVs, trucks, and other vehicular traffic as it passes by this rock formation. Drivers are asked to be watchful, and exercise caution anytime while driving along this stretch of road, day or night.

A

B

Figure 4. Leveraging human neuroscience *accelerates* understanding, and retention.

3 - Tine Adjustment (21% Total Mishaps). By reviewing references (d) and (e) and then applying the DOD Human Factors Analysis & Classification System (HFACs), reference (c), the following safety yield is achieved:

RISK ASSESSMENT	
OPNAV 5100.19	✓ Provides PPE direction for protective headwear, footwear, hands, hearing and eye protection, though not specific to forklift operators, team members, or Safety Observers ✓ Provides general safety for machinery operation, situational awareness during cargo operations, horn use, backing signals ❖ Does not address forklift tine safety, identify general tine safety procedures, or warnings ❖ Addresses checking tine thickness, but stops short of providing pictures of how to adjust tines safely
NAVSUP P-538	✓ Provides PPE direction for protective headwear, footwear, hands, hearing and eye protection, though not specific to forklift operators, team members, or Safety Observers ✓ Provides general safety for machinery operation, situational awareness during cargo operations, horn use, backing signals ❖ Addresses checking tine thickness prior to forklift use in depth, but fails to address how to adjust tines safely ❖ Does not address forklift tine safety, identify general tine safety procedures, or warnings
VULNERABILITY	**Mitigated Risk 50%** / **Unmitigated Risk 50%**

Discussion. From reference (c), **HFAC SI 004 (failed to provide appropriate policy and/or guidance) factors are present** when policy and/or guidance, or a lack of policy and/or guidance - leads to an unsafe situation. Additionally, "working hand-in-hand" with **HFAC SI 004, HFAC AE201 (inadequate real-time risk assessment)** can also be a mishap causal factor when there is a lack of guidance because this can cause an Individual to fail to adequately evaluate the risks associated with a particular course of action, and this faulty evaluation leads to inappropriate decision-making and subsequent unsafe situations.

Vulnerability Reduction. Risks for general forklift operation must be completely identified in both references (d) and (e) if these references are going to provide the right level of direction for TYCOMs, SYSCOMs, and individual naval units to produce their own – complete – local procedures. Therefore, the following recommendations are needed to lower our risk vulnerability:

A – Develop general forklift tine adjustment procedure to address weight concerns, securing tines when underway for transport in heavy weather, and annotate heavy weights associated with tines
B – Deploy this via a "bolt on" Appendix for NAVSUP P-538 or NATOPS
C – Create a NAVEDTRA for General Forklift Operations with JQR Template

4 – Safety Observer Failure (39% Total Mishaps). By reviewing references (d) and (e) and then applying the DOD Human Factors Analysis & Classification System (HFACs), reference (c), the following safety yield is achieved:

RISK ASSESSMENT	
OPNAV 5100.19	✓ Addresses assigning a Safety Observer during any evolution that could injure personnel or damage equipment ✓ Defines specific Safety Observer qualifications and duties, then defines 23 cargo handling precautions for Supervisors ✓ Sets requirement to perform informal safety brief ✓ Reinforces using a Ground Guide in congested areas ❖ Safety precautions are not organized into a repeatable work routine – Conduct a Safety Brief is 21st on the first list of 23 items ❖ Safety Observer duties are mixed into general forklift safety precautions making them difficult to determine if all specified actions are understood and taking place during a forklift operation
NAVSUP P-538	✓ Addresses the requirement for forklift operators to assess the working areas prior to forklift operations ✓ Identifies the general requirement to ensure all working areas are visually inspected for structural weaknesses prior to performing cargo movement with forklifts ✓ Presents a "Safety Walker (Spotter) Requirements," Section, 5-3.4.4 ❖ Multiple lists of precautions do not constitute an organized delivery of sequential work routines to learn, perform, or assure ❖ No qualification process or scenarios, Safety Observer minimums or sample JQR to become a Safety Observer is present ❖ Safety Observer duties are mixed into general forklift safety precautions making them difficult to determine if all specified actions are understood and taking place during a forklift operation

VULNERABILITY	**Mitigated Risk**	**Unmitigated Risk**
	58%	**42%**

Discussion. From reference (c), **HFAC OP002 (organizational program and/or policy risks not adequately assessed)** exist when the potential risks of a large program, operation, acquisition, or process are not adequately assessed and this inadequacy leads to an unsafe situation. **HFAC OP003 (provided inadequate procedural guidance or publications)** exist when written directions, checklists, graphic depictions, tables, charts, or other published guidance are inadequate, misleading, or inappropriate.

HFACs are present in both references (d) and (e) due to the poorly organized duties of a Safety Observer. The lack of a Safety Observer qualification process, including forklift operation scenarios to ensure that Safety Observers understand general forklift operations that detail geometry of lifting loads, carry and movement of loads on flat decks and inclined ramps, but can also synthesize the entire cargo movement operation, from brief and plan, to execution, including forklift emergencies.

Because of these procedural guidance shortfalls, **HFAC SI 003 (failed to provide proper training)** and **HFAC PC104 (confusion)** also exist when local commands select and designate their Safety Observers using locally prepared guidelines that do not have any solid rooting in either OPNAV or NAVSUP guidance.

Vulnerability Reduction. Safety Observers provide an essential and required function to the operational readiness of the fleet. Few stores can be hand-carried to restock and resupply ships. Untold numbers of specialized equipment, to include weapons and critical systems, must be moved and positioned by forklifts. This places even more importance upon the role of Safety Observers to manage forklift operators, and the entire cargo handling evolution, each time it occurs. Therefore, the following recommendations will lower our risk vulnerability:

- **A** – Develop Safety Observer Actions and Qualification guidance that organizes all published Safety Observer actions into one section within reference (d) and/or reference (e)
- **B** – Define using a checklist the General Cargo Movement Plan to emphasize critical Safety Observer actions – in their proper sequential order
- **C** – Create a NAVEDTRA for General Forklift Operations with JQR Template, that includes qualification pathway minimums for Safety Observer selection, training, qualification, and recurrent training that also includes pictures to define different problem scenarios to ensure future Safety Observers understand forklift operation, managing forklift operator safe behaviors, and typical cargo movement evolutions, pier to ship, ship only, unrep (as it may apply), amphibious operations, etc.
- **D –** Develop a specific General Forklift Operations Checklist for different cargo handling missions, to better organize work actions, i.e., Pre Event MHE Pre-Op Checks, Cargo Event Safety Brief, Cargo Staging, Cargo Movement Plan, etc. “As is,” forklift operators have to figure this out without a standardized approach, which can introduce human error at their level of skill experience, versus forcing a safer, standardized approach to every cargo handling evolution.