Inserting Safety Into the Acquisition Process

Andrew Seamans

August 2014

ANALYSIS & SOLUTIONS

This document contains the best opinion of CNA at the time of issue.
It does not necessarily represent the opinion of the Sponsor.

Distribution:

Approved for Public Release; Distribution Unlimited. Specific authority: N00014-11-D-0323. Copies of this document can be obtained through the Defense Technical Information Center at www.dtic.mil or contact CNA Document Control and Distribution Section at 703-824-2123.

Approved by: **August 2014**

Ronald H. Nickel

Ronald H. Nickel, Director
Cost Acquisition, Readiness, and Logistics Team
Resource Analysis Division

Executive summary

- Over 1,000 non-catastrophic mishaps reported aboard ship per year
- Naval Safety Center asked CNA to look at ways of updating the acquisition process to be more responsive to identified safety issues
- Mishap findings and recommendations
  - Many reported mishaps are caused by individual error
  - Identifying mishaps that may be best solved by acquisition solutions will likely yield cost-effective results
  - Lack of complete data on existing mishaps makes it difficult to identify the cause of mishaps and find solution
    - We suggest reemphasizing the mishap data collection effort focusing on not only tracking all mishaps but also including more complete information

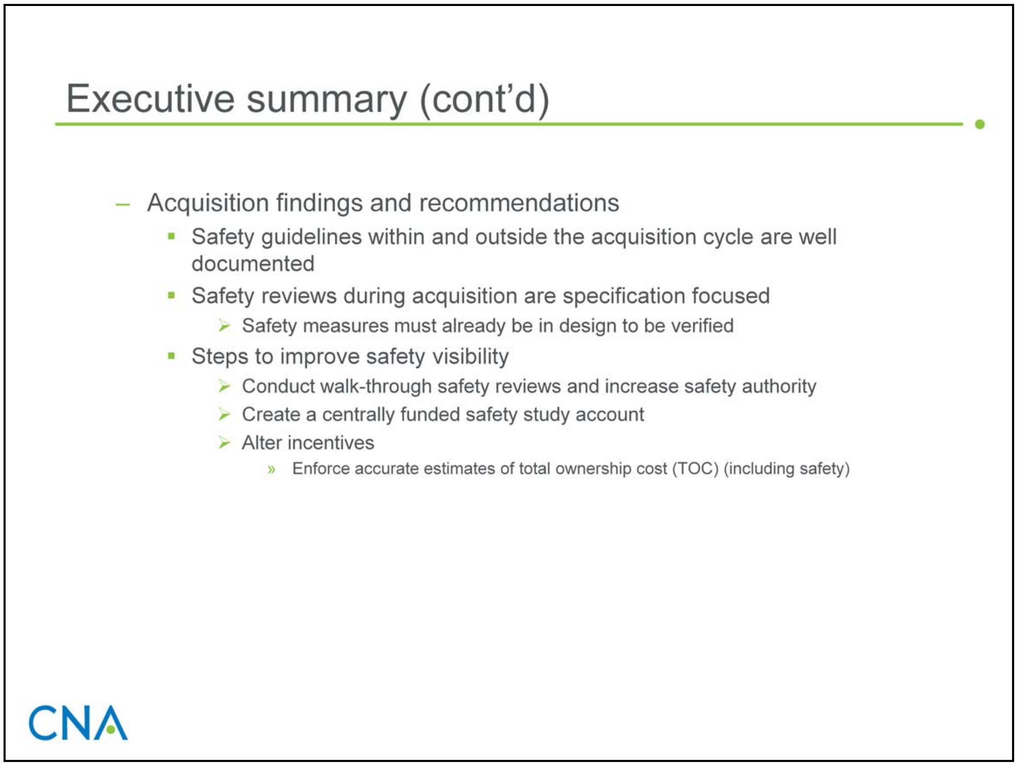
CNA

Every year, more than 1,000 sailors are injured aboard ship in non-catastrophic mishaps. The reported mishaps often do not include potential long-term health hazards following years of exposure, such as hearing loss. The Naval Safety Center asked CNA to look at ways of updating the acquisition process to make the system more responsive to safety issues identified by the Safety Center and operational commands.

CNA undertook a two-pronged approach: (1) examine safety data to identify the number of injuries by type to determine the cause of injuries and (2) interview safety and acquisition personnel to identify the mechanisms that have made the process successful in high-risk safety areas for application to non-catastrophic mishaps.

We found that a large number of reported injuries occur because of individual error, such as running into objects. These may not be economically solved by design or technical solutions. Rather than trying to find design solutions for all mishaps, a focused approach that seeks to identify mishaps that may be best solved by acquisition solutions will be more likely to yield cost-effective results. Subcategories in specific areas, such as “distribution” within “electrical” mishaps, warrant greater attention and further study.

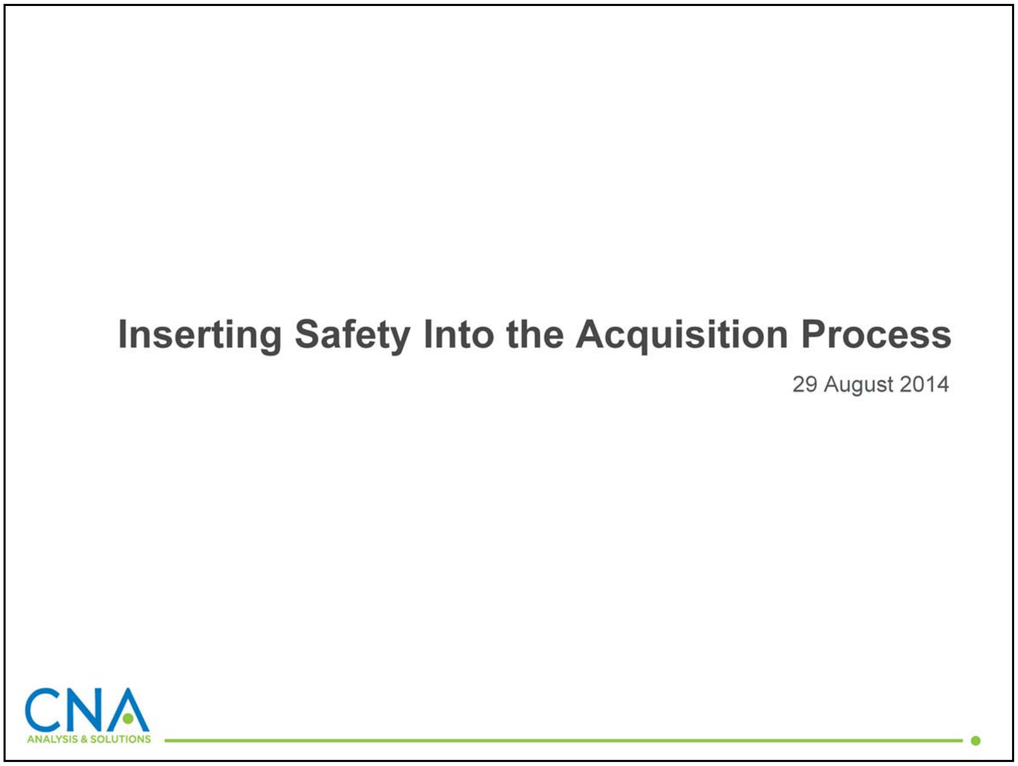
The lack of complete data on existing mishaps makes it difficult to identify their causes, in turn, making it impossible to find solutions—either procedural or design. We suggest reemphasizing the mishap data collection effort to focus on including more complete information in addition to tracking all mishaps.



For high-risk items, such as ordnance, we found that safety is an integral piece of the design-build process, but the safety involvement for low-risk/high-density hazards is less well defined. The safety procedures are well documented and, even though there are a number of safety analyses conducted during the acquisition cycle, we found that these turn out to be primarily specification verifications. The time available for safety reviews is consumed by ensuring that the correct specifications were used and that the shipyard correctly followed the design requirements. This is one aspect of safety but does not address safety measures that were not designed in from the beginning.

We suggest conducting a physical or virtual walk-through of new designs to ensure that adequate human systems integration (HSI), ergonomic, and other safety factors are considered. In addition, we recommend creating a centrally funded safety study account that could be used to identify and investigate safety concerns. We found in our discussions that that field commands were often left to fund analyses that could benefit the Navy as a whole. We also suggest increasing the authority of safety personnel outside the high-risk areas. For lower or long-term risk items, the same level of authority may not be necessary, but greater authority than providing suggestions is needed.

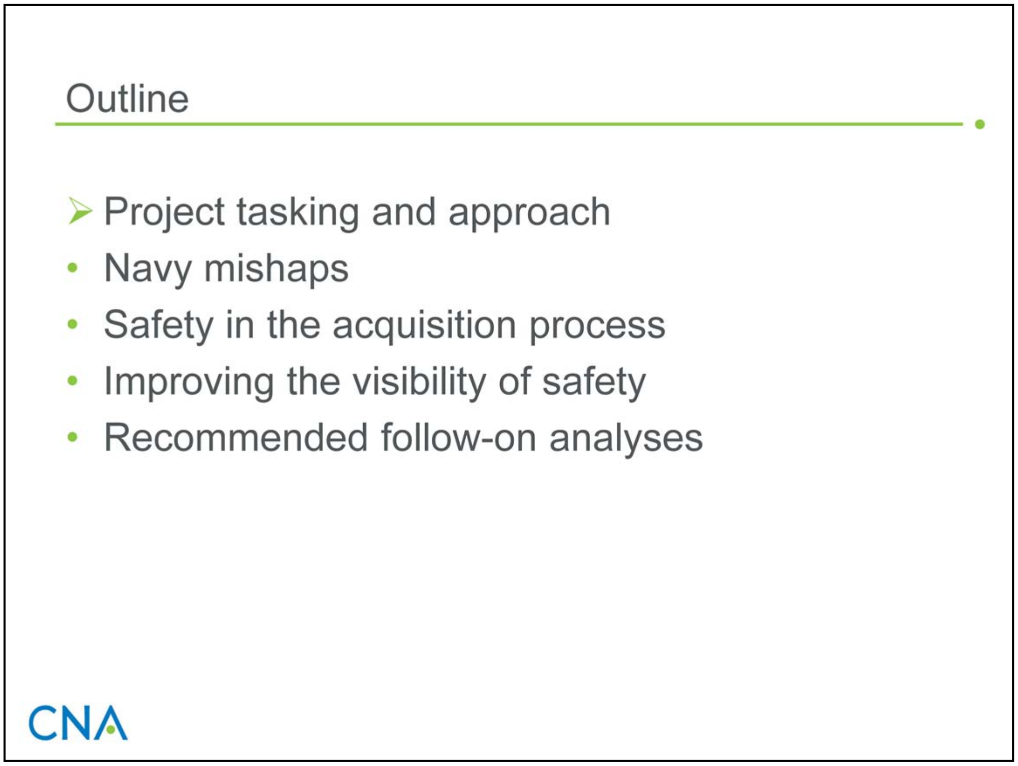
The last recommendation for improving safety visibility is to alter incentives. This will result in greater attention to safety through a self-reinforcing mechanism. To alter incentives, we suggest placing greater emphasis on ensuring accurate estimates of TOC—including projected mishap costs.



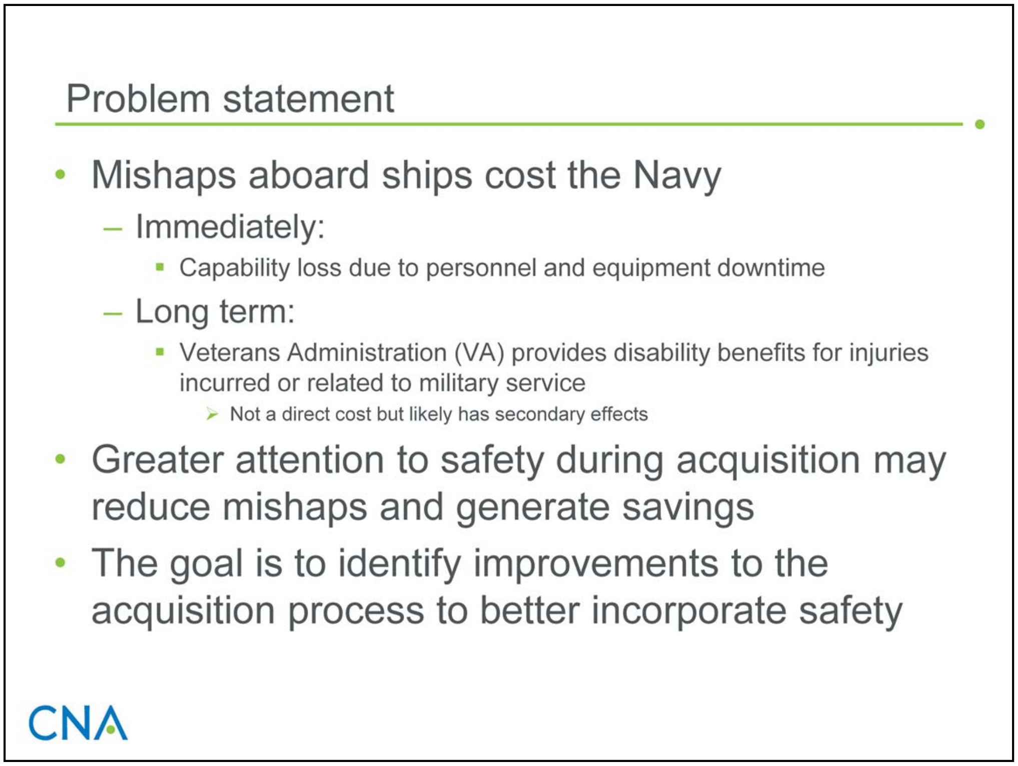
Life aboard ship can be hazardous—not only because of adversarial actions during operations, but also because of the day-to-day duties members are required to perform and the conditions under which they are asked to perform them. Each year, hundreds of personnel are injured aboard ship and require medical attention. In some areas, such as flight operations and ordnance handling, the Navy has made changes (e.g., safety review boards) that have reduced the number of injuries in these low-density/high-risk areas. The numbers of catastrophic (Class A) injuries are at historically low levels [1]. However, more than 1,000 sailors are injured aboard ship each year in high-density/low-risk* mishaps, not including potential long-term health hazards that only result in symptoms following years of exposure, such as hearing loss or chemical exposure.

The Naval Safety Center (NAVSAFECEN) asked CNA to look at ways to update the acquisition process to make the system more responsive to identified safety issues enabling rapid incorporation of solutions into ship design. To address this issue, we took a two-pronged approach. First, we examined safety data to identify the number of injuries by type to determine in what areas do most injuries occur. Second, we interviewed safety and acquisition personnel to identify the mechanisms that have made the process successful in other areas.

* We use the term *high-density/low-risk* to refer to the immediate risk. However, there is potential for severe injury following prolonged exposure to some hazards.



The organization of this annotated briefing follows. We begin with further discussion of our tasking for this project. We then examine data on Navy mishaps developed for this study. Next, we present the results from our interviews with subject matter experts (SMEs) on how safety is integrated in the acquisition process. We then discuss our recommendations for improving the visibility of safety. We conclude with recommendations for follow-on analyses.

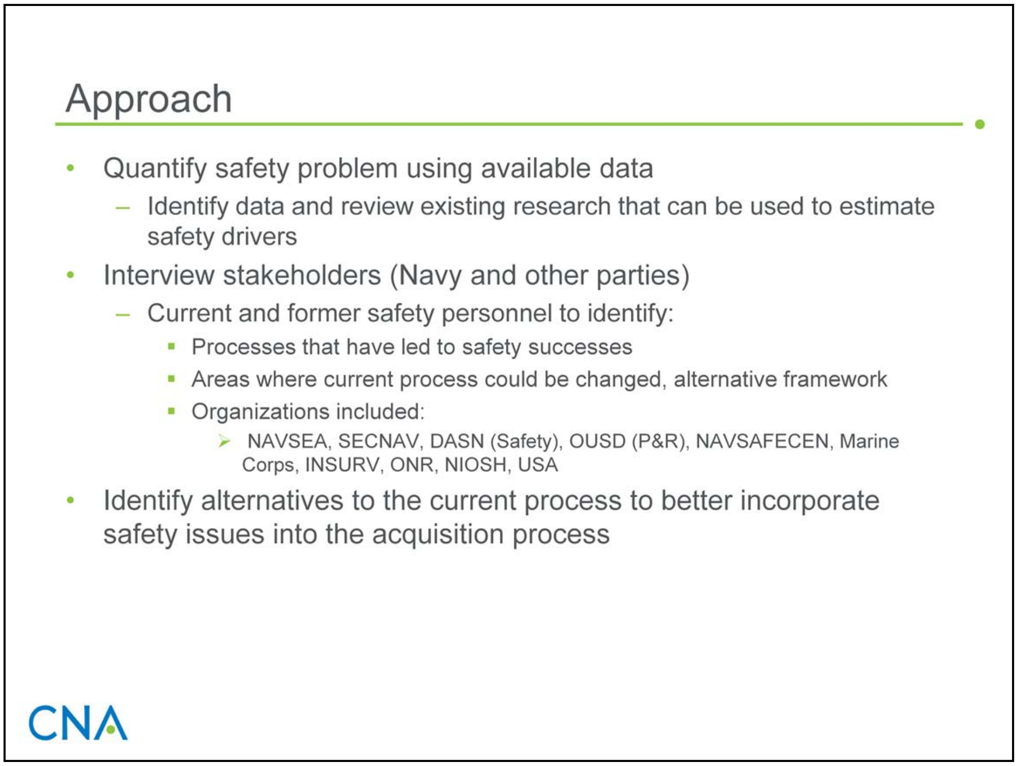


Mishaps* aboard ships have both immediate and long-term costs to the Navy. Right after a mishap, the ship can incur a loss of capability caused by a reduction in skilled personnel for the duration of their recovery and potentially a loss of equipment. Equipment downtime will depend on the severity of the mishap and/or the type of incident. The ship may also incur medical costs associated with immediate and continued treatment.

Depending on the type of injury, the duration, and the potential detrimental effects of long-term exposure, mishaps can cost the Navy long after personnel leave the service. The VA provides disability compensation, a tax-free monetary benefit, to veterans with disabilities that are the result of a disease or injury incurred or aggravated during active military service. Compensation may also be paid for post-service disabilities that are considered related or secondary to disabilities occurring in service and for disabilities presumed to be related to circumstances of military service, even though they may arise after service [2]. The Navy does not currently reimburse VA for these benefits but suffers indirectly as the “cost of defense” increases trigger spending controls and potentially recruiting and retention effects if the work environment is viewed as more hazardous.

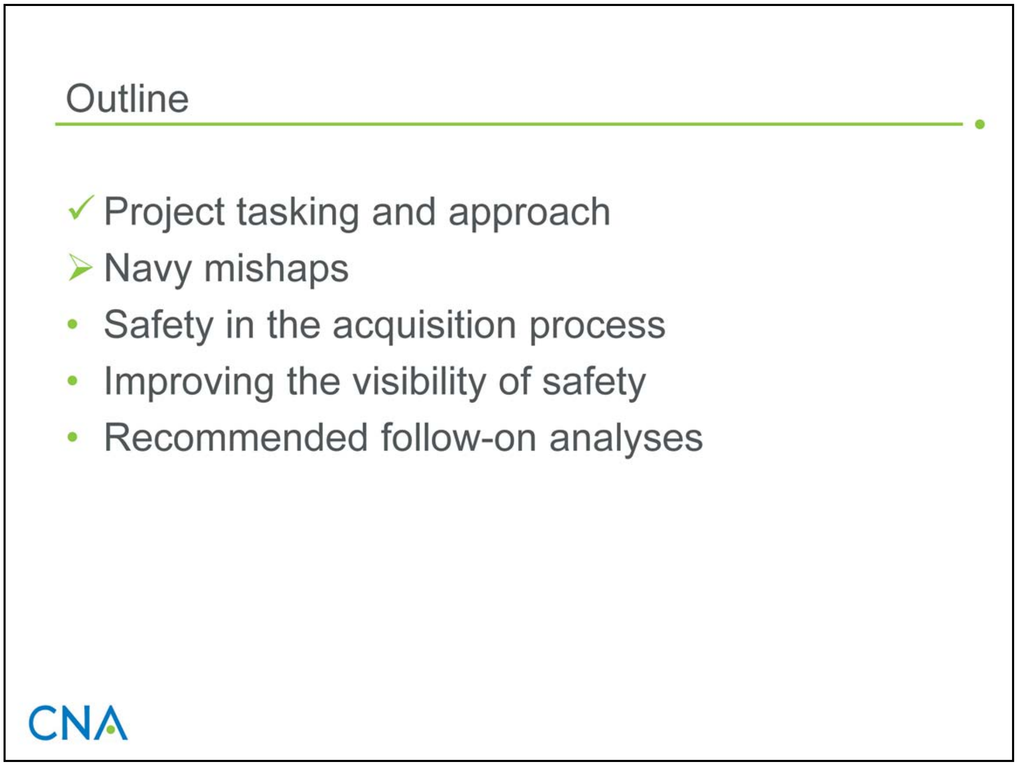
The study objective is to identify improvements to the acquisition process to better incorporate safety.

* *Mishap* is an unplanned event or series of events resulting in death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment [3].

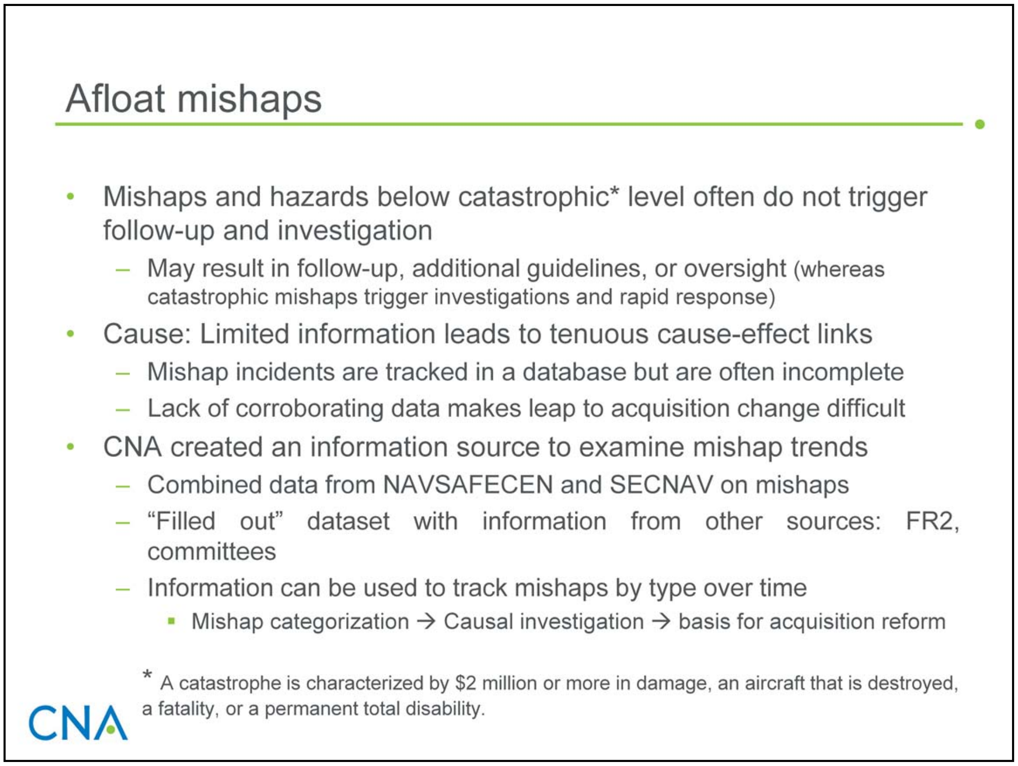


The overall objective was to identify alternatives to the current acquisition process that would lead to improvements, higher priority, and/or more rapid incorporation of hazard mitigation designs. We took a two-step approach. We began by quantifying the dimensions of the safety problem. We identified data and reviewed existing research that can be used to describe the characteristics of Navy ship mishaps, such as the number, type, and severity. A good understanding of the type of mishaps that occur can be used to identify the areas where new technologies or designs can mitigate safety hazards.

We then interviewed safety stakeholders in the Navy and in the other services to identify processes that have led to safety successes. In other words, we sought to identify and develop lessons learned from instances where safety shortcomings were identified and where the system worked to put in place mitigation efforts to increase personnel safety. The safety successes provide a framework for what worked and what did not, enabling us to identify areas where the process could be changed. Our interviews included personnel from NAVSEA, SECNAV, DASN (Safety Acquisition), OUSD (P&R), NAVSAFECEN, Marine Corps, Board of Inspection and Survey (INSURV), Office of Naval Research (ONR), National Institute for Occupational Safety and Health (NIOSH), and United States Army (USA).



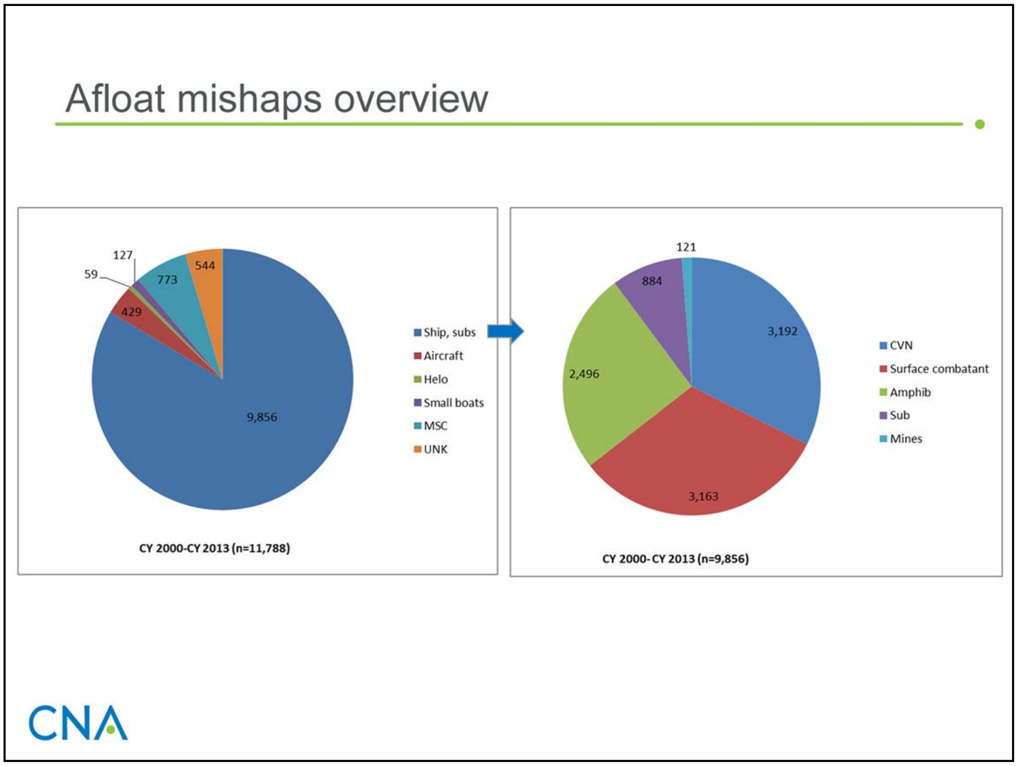
In this section, we discuss the dataset that CNA created to categorize Navy shipboard mishaps. A thorough understanding of the types of mishaps that occur, the frequency, and the severity is the first step in developing a better understanding of the potential drivers and whether new technology or design improvements could lead to hazard mitigation.



Non-catastrophic afloat mishaps and hazards (i.e., not resulting in $2 million or more in damage, loss of aircraft, fatality, or permanent disability) receive less attention than catastrophic (Class A) mishaps. Class A mishaps typically trigger investigations into the causes and often result in a rapid response to mitigate hazards to prevent recurrence. Non-catastrophic hazards (e.g., chemical exposure or high noise levels) that could lead to disability over time do not receive the same scrutiny. Since these high-density/low-hazard mishaps occur more often and can have severe effects, some question why they do not get more attention.

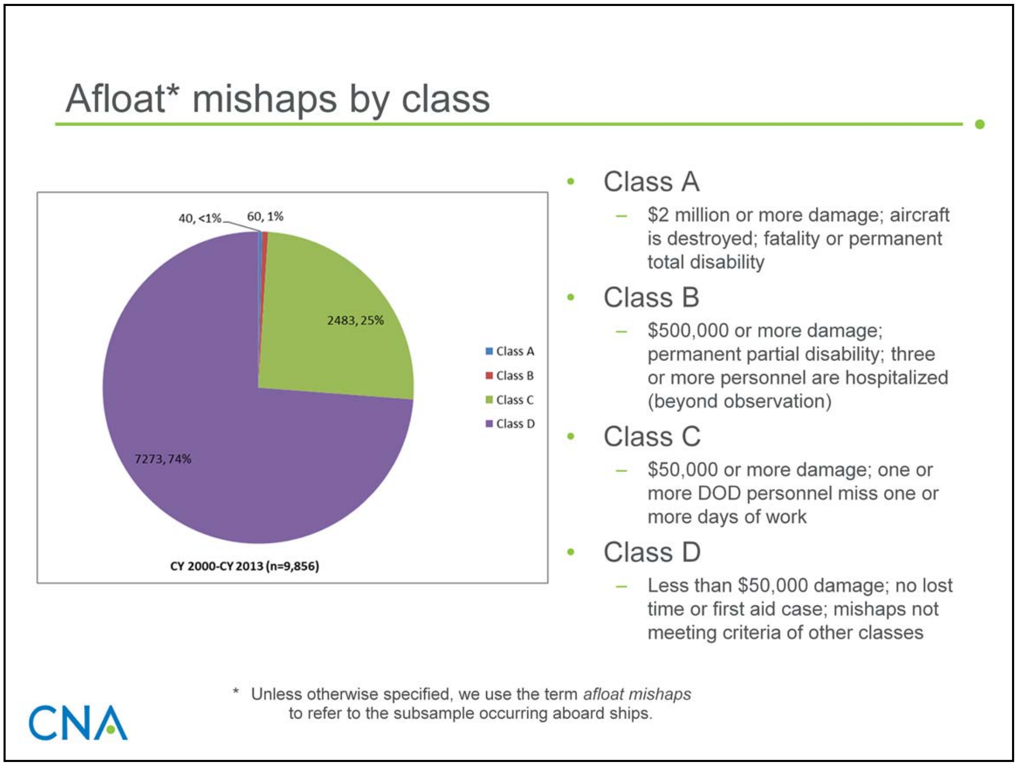
We examined the related research and investigated available data sources. We found numerous reports on Class A mishaps, including an annual report by the NAVSAFECEN, but analysis of other mishaps were not available. In addition, we found that granular data that record the type of mishaps, the level of injury sustained, and where they occur aboard ship were not readily available. Data on mishaps are collected but information is often incomplete. Without supporting data, developing a cause-and-effect relationship is tenuous at best, making the argument for potential acquisition hazard mitigation solutions impossible.

CNA created an information source to bridge the data gap. We combined data from NAVSAFECEN, SECNAV, and other open data sources, such as Force Risk Reduction (FR2), and other safety committee sources, to create a dataset that lists afloat Navy mishaps from calendar year (CY) 2000 through CY 2013. The CNA dataset is the first link in the chain from mishap categorization to causal investigation to the basis for acquisition reform. We use this to examine mishaps by year and over time.



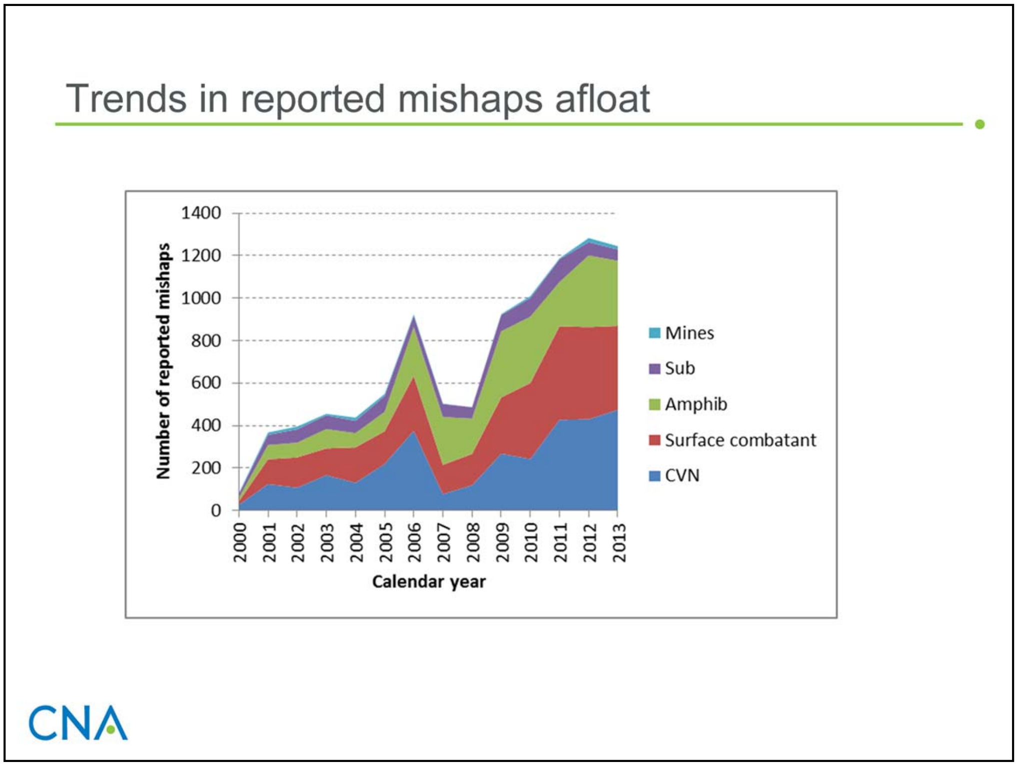
The mishap database contains 11,788 records spanning CY 2000 through CY 2013. In the left-hand graphic shown above, we provide a breakdown of the records for the time period based on six broad categories: ships and submarines (subs), aircraft, helicopters (helos), small boats, a miscellaneous (MSC) category that includes support ships and specialty ships (AGM, AH, AKR, AO, AOE, AKE, ARC, ARS, AS, ATF), and an unknown (UNK) category, which includes records for which the ship is not listed. Based on the records we used to build the dataset, the primary mishap category is for ships and submarines—9,856 records over the time period.

In the graphic on the right, we provide a breakdown of the ship and submarine category into five groups: aircraft carriers (CVN); surface combatants (CG, FFG, DDG); amphibious ships, or "Amphib" (LPD, LHD, LSD), submarines, or "Sub" (SSBN, SSN); and mine ships, or "Mines" (MCM, MCS, MHC). The number of mishaps reported aboard CVNs is roughly equal to the number reported on surface combatants over the period—about 3,100. The number of reported mishaps on amphibious ships is next with about 2,500 for the period.

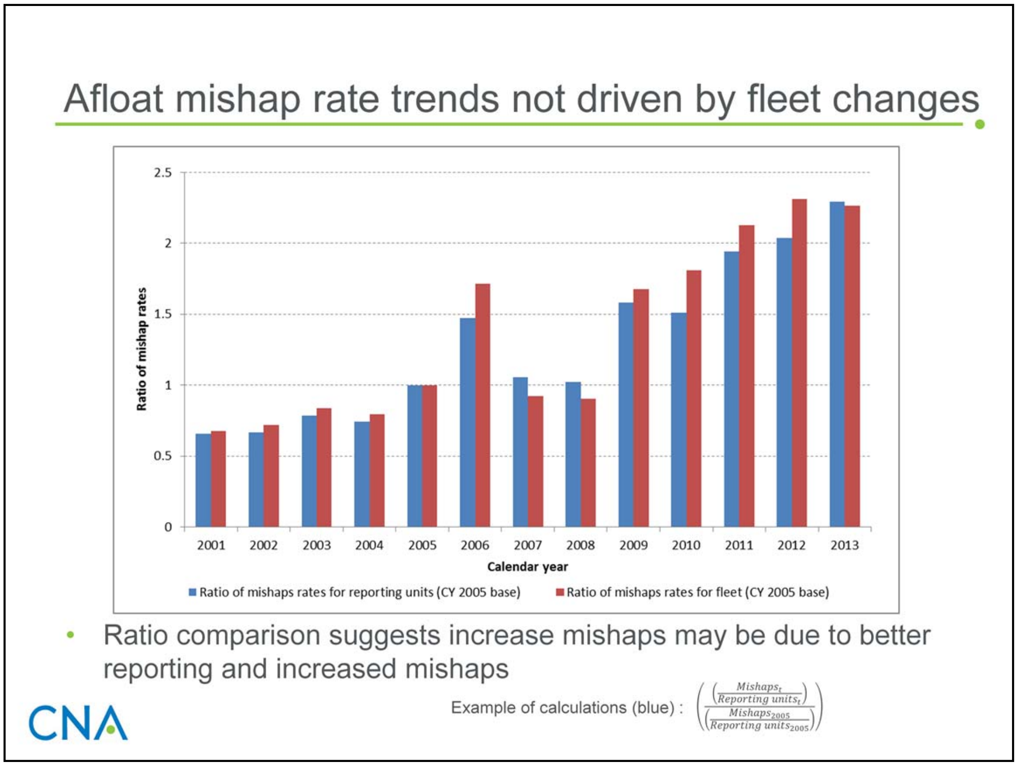


Here we show the mishaps in our dataset by mishap class. The class breakdown provides a way to categorize mishaps based on the severity of the resulting injury, occupational illness, or property damage. The mishap classification is used to determine the type of investigation, report, and record keeping required. The mishap definitions are as follows:

- *Class A.* The resulting total cost of damages to DOD or non-DOD property in an amount of $2 million or more; a DOD aircraft is destroyed; or an injury and/or occupational illness results in a fatality or permanent total disability.
- *Class B.* The resulting total cost of damages to DOD or non-DOD property is $500,000 or more, but less than $2 million. An injury and/or occupational illness results in permanent partial disability or when three or more personnel are hospitalized for inpatient care (beyond observation) as a result of a single mishap.
- *Class C.* The resulting total cost of damages to DOD or non-DOD property is $50,000 or more, but less than $500,000; a nonfatal injury that causes any loss of time from work beyond the day or shift on which it occurred; or a nonfatal occupational illness that causes loss of time from work or disability at any time
- *Class D.* The resulting total cost of reportable material (property) damage is less than $50,000 or a nonfatal injury (no lost time or first aid case) that does not meet the criteria of a Class C mishap [3–5].



We show the trends for reported mishaps over the time period for the five categories shown in the right-hand side of slide 9. The number of mishaps grows rapidly from CY 2000 to CY 2013. However, even though the upward trend is dramatic, it should not interpreted as representing increasingly hazardous conditions aboard ship. The trend is likely caused, in part, by additional reporting. Over the time period, the Navy has been stressing the importance of accurate and complete reporting of mishaps to be able to properly identify and mitigate hazards. The number of reported mishaps increases for each category, lending support to the notion of more conscientious reporting.



We examined the mishap rates over time to try to better understand the drivers of the upward trend. We calculated two mishap rates for each year—one using the number of ships that reported in a given year as the denominator of the ratio (blue) and one using the number of ships in the fleet as the denominator (red). We then divided this mishap rate by the mishap rate in the base year so that changes over time are easily observed. We use CY 2005 as the base year.

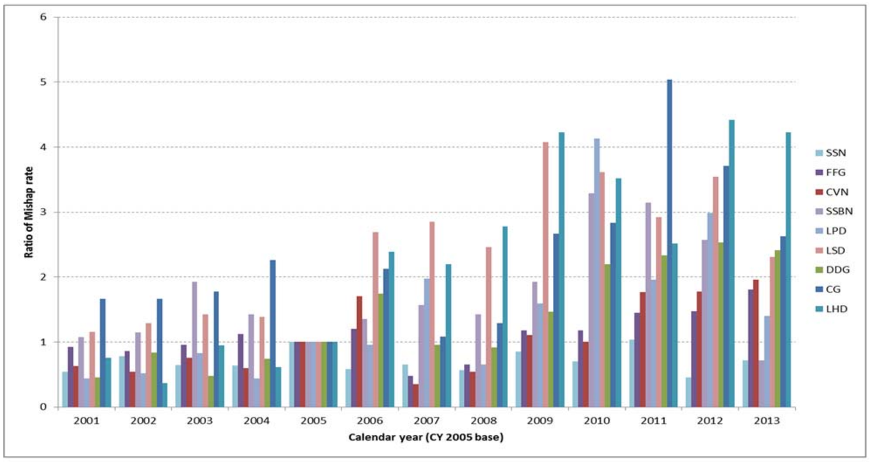
The equation for the calculation: $\left(\frac{\left(\frac{Mishaps_t}{Reporting\ units_t}\right)}{\left(\frac{Mishaps_{2005}}{Reporting\ units_{2005}}\right)}\right)$

The blue bars in the graph show the ratio of mishap rates using reporting units, and the red bars show the ratio using the fleet as the basis for the calculation.

The calculations produce slightly different numbers for each of the years but result in the same overall trend. This suggests that the reporting ships provide a representative sample.

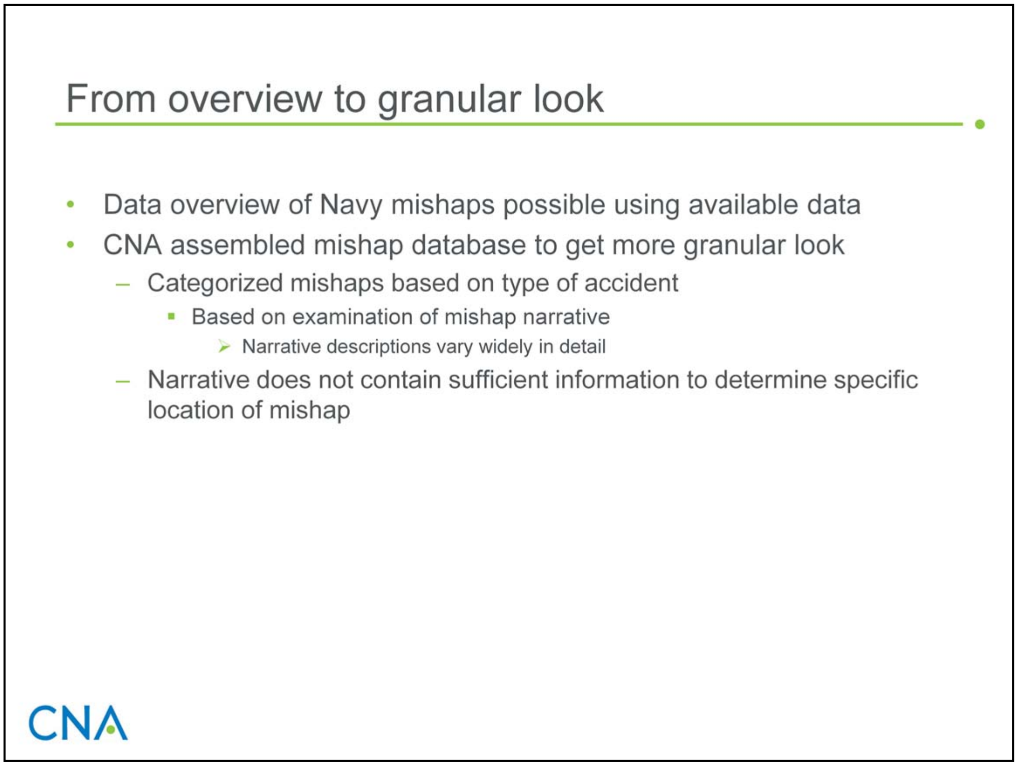
The reported mishap rate in CY 2013 is roughly 3 times the reported mishap rate in CY 2001. However, we are unable to determine the level of reporting bias present (i.e., the higher rates are due to more conscientious reporting based on the available data). Therefore, caution should be used before drawing any conclusions from the trend.

Mishap ratio comparison over the sample



We break down the ratio of mishap rates by class of ship on this slide. We use the same base year, CY 2005. The overall trends show that most ship classes reported a higher number of mishaps in CY 2013 than in CY 2005. We also looked at the number of mishaps per crewmember. The number of crew per ship did not vary significantly over this period so the ratio of mishaps per crewmember is the same as that shown above. Over all of the reporting ships in the sample, there were about 2.2 reported mishaps per 1,000 crewmembers in CY 2005 and about 5 per 1,000 crewmembers in CY 2013. As noted previously, however, caution should be used when interpreting the trends because we are unable to determine the level of reporting bias present.

Even though we cannot determine the level of reporting bias present, the data can be used to further investigate mishap drivers within a given year. We turn now to a more granular look at afloat mishaps.



In the previous slides, we presented an overview of the data and presented some information to suggest that the number of reported mishaps is increasing for a number of reasons. These contributing factors include the added emphasis placed on mishap reporting by the Navy, an increase in the mishap rate, and other potential reasons. However, we are unable to accurately apportion the increase over time to the potential causes based on the available data. Therefore, caution should be used when making any comparisons over time.

The information discussed provides an overview of Navy mishaps but could have been conducted using available data, such as those that exist on the Force Risk Reduction site. The FR2 data provide a good starting point but do not provide sufficient information to go beyond broad mishap summaries.

In the following slides, we use the mishap database that CNA created to take a more granular look into mishaps to better understand the causes. We now turn to the examination of Navy mishaps by category using the database CNA created.

Trends by mishap type (afloat)*

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mishap type total
Burn		2			3	19	35	9	20	28	31	18	34	24	223
Chemical	8	26	19	66	35	13	6	1	3	1	2	10	6	5	201
Electrical	33	163	177	195	160	113	93	68	57	63	118	169	169	125	1,703
Eye	6	40	13	2	9	27	30	18	14	18	14	34	20	15	260
Hearing	1	2	1	2			15	14	9	17	35	46	39	59	240
Impact injuries	1	4	8	6	25	53	117	70	76	179	168	198	210	244	1,359
Laceration/amputation/puncture	2	10		2	14	29	92	46	36	84	104	139	182	173	913
Ladder	4	15	34	33	41	68	95	59	55	117	136	119	142	144	1,062
Lifting (not exercise)	1	11	27	29	14	14	14	13	11	13	13	20	33	34	247
Recreation	3	14	12	14	10	25	44	25	18	55	35	26	36	43	360
Run over/crush/pinned		3	2	2	4	10	16	8	19	21	15	9	20	26	155
Slip,trip,fall	2	19	18	18	21	52	86	53	49	78	87	96	104	109	792
WTD, hatch, scuttle lid, locker door	4	11	5	7	12	37	65	25	32	64	60	76	78	103	579
Other	13	37	67	73	75	80	210	93	88	183	183	223	191	125	1,641
Year total	78	357	383	449	423	540	918	502	487	921	1,001	1,183	1,264	1,229	9,735

* Category classifications are mutually exclusive

- Other category
  - MISHAP VICTIM (MV)
  - MISHAP VICTIM (MV) SUSTAINED ANKLE INJURY
  - Lack of attention/loss of focus
  - SNM punched wall, broke hand
  - HUMAN BITE
  - Service member (SVM) was kicked in the eye

CNA

In the mishap database created by CNA, we categorized each record into 1 of 14 categories. Mishap records do not include a category classification, so we analyzed the narrative provided with each record to identify the general type of mishap. Regrettably, the data did not include sufficient information to determine exactly where mishaps occurred aboard ship. The narrative also does not include information on the function being performed, but for some types of mishaps it can be determined. The definitions we used for some of the categories follow:

Burn	Burn suffered from contact with hot object
Chemical	Injury by chemical (except eye)
Electrical	Mishap caused by contact with electrical current
Hearing	Reported permanent threshold shift
Impact injuries	Hit by or running into objects (incl. shins on watertight door (WTD))
Laceration…	Any of the categories listed not already covered elsewhere
Ladder	Mishaps due to falls down ladders
Lifting	Injuries occurring during lifting
Rec	Mishap occurring in non-work-related (i.e., recreation) activities
Run over	Run over, pinned, or crushed by movable objects, such as fork truck
WTD (watertight door)	Mishaps caused by these items usually consisting of dropping on hands
Other	Mishaps records lacking injury specification or not fitting the definition of the previous 13 categories

Trends by mishap type (afloat)* (cont'd)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mishap type total
Burn		2			3	19	35	9	20	28	31	18	34	24	223
Chemical	8	26	19	66	35	13	6	1	3	1	2	10	6	5	201
Electrical	33	163	177	195	160	113	93	68	57	63	118	169	169	125	1,703
Eye	6	40	13	2	9	27	30	18	14	18	14	34	20	15	260
Hearing	1	2	1	2			15	14	9	17	35	46	39	59	240
Impact injuries	1	4	8	6	25	53	117	70	76	179	168	198	210	244	1,359
Laceration/amputation/puncture	2	10		2	14	29	92	46	36	84	104	139	182	173	913
Ladder	4	15	34	33	41	68	95	59	55	117	136	119	142	144	1,062
Lifting (not exercise)	1	11	27	29	14	14	14	13	11	13	13	20	33	34	247
Recreation	3	14	12	14	10	25	44	25	18	55	35	26	36	43	360
Run over/crush/pinned		3	2	2	4	10	16	8	19	21	15	9	20	26	155
Slip,trip,fall	2	19	18	18	21	52	86	53	49	78	87	96	104	109	792
WTD, hatch, scuttle lid, locker door	4	11	5	7	12	37	65	25	32	64	60	76	78	103	579
Other	13	37	67	73	75	80	210	93	88	183	183	223	191	125	1,641
Year total	78	357	383	449	423	540	918	502	487	921	1,001	1,183	1,264	1,229	9,735

* Category classifications are mutually exclusive

- Other category
  - MISHAP VICTIM (MV)
  - MISHAP VICTIM (MV) SUSTAINED ANKLE INJURY
  - Lack of attention/loss of focus
  - SNM punched wall, broke hand
  - HUMAN BITE
  - SVM was kicked in the eye

CNA

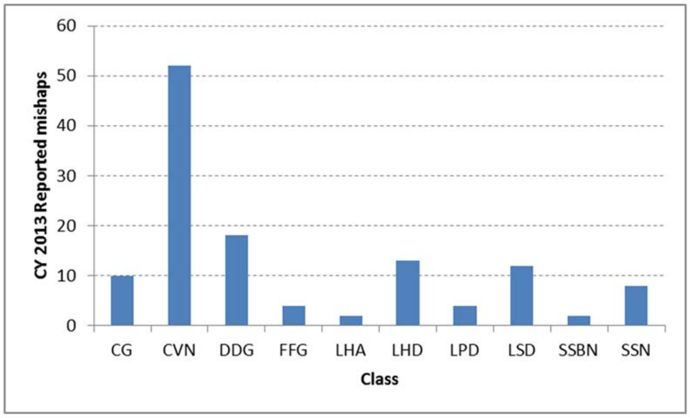
Recall that the primary focus is to identify changes to the design/acquisition process that result in a greater safety emphasis lowering overall fleet mishaps. An argument can be made that design improvements can eliminate nearly all mishaps. However, the design cost of reducing or eliminating people bumping their heads on the edge of watertight doors ("Impact injuries"), for example, will likely far outstrip the benefits from the change. Examining the trends by category provides a first step into understanding the drivers of reported mishaps. It also provides a first look into potential areas where technical design solutions may have the greatest impact.

The largest category by total mishaps, "Electrical," appears reasonably consistently across the sample time period. This suggests that reporting bias may play a lesser role for this category, likely due to the potential for a catastrophic outcome. Based on these issues, additional review of mishaps in this category is warranted to determine if an acquisition/design solution is needed.

However, many of the other categories appear to be a poor fit for a technical solution. For example, the next largest category, "Impact injuries," covers servicemembers running into objects and doorways and includes a large number of mishaps caused by personnel coming into contact with and scraping their shins on the frame or door of watertight doors (WTD)s.

The "Other" category is made up of records that do not contain sufficient information to categorize the mishap (about 40 percent of the 1,641 records). "Other" also includes a wide range of mishaps, such as those due to servicemember interactions. We show a sample of those items in the "Other" category below the table.

Drilldown into CY 2013 electrical mishaps by class

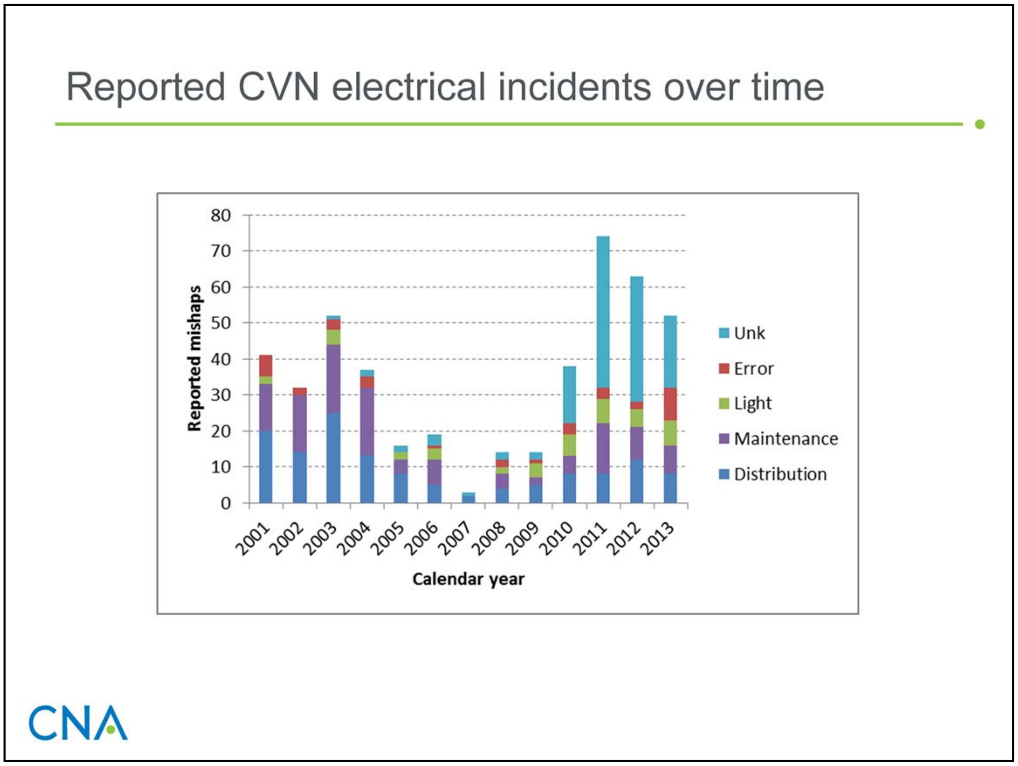


- CVNs reported the highest number of electrical mishaps in CY 2013

CNA

We break down the reported electrical mishaps for CY 2013 by class on this slide. We begin with this look at electrical mishaps because the power distribution systems can be significantly different when moving from one class of ship to another. Therefore, identifying whether a particular ship class demonstrated a higher level of mishaps is the first step of focusing in on the problem.

There were 1,703 electrical accidents reported from CY 2001 through CY 2013; 2 were Class A mishaps, and the rest were Class C (5 percent) or Class D (95 percent). In CY 2013, there were 125 electrical mishaps in our dataset. About 42 percent of the electrical accidents reported in CY 2013 (52 records) occurred aboard an aircraft carrier. The nature of propulsion and electrical distribution along with a larger crew aboard a carrier may create the potential for additional contact opportunities. SSBNs and SSNs had far fewer accidents—10 mishaps, or 8 percent of those reported. However, the likelihood of an incident per crewmember was similar—about .2 percent. While the potential for electrical mishaps per crewmember is similar, we present additional details on the reported CVN accidents in the following slides due to the greater number of mishaps.



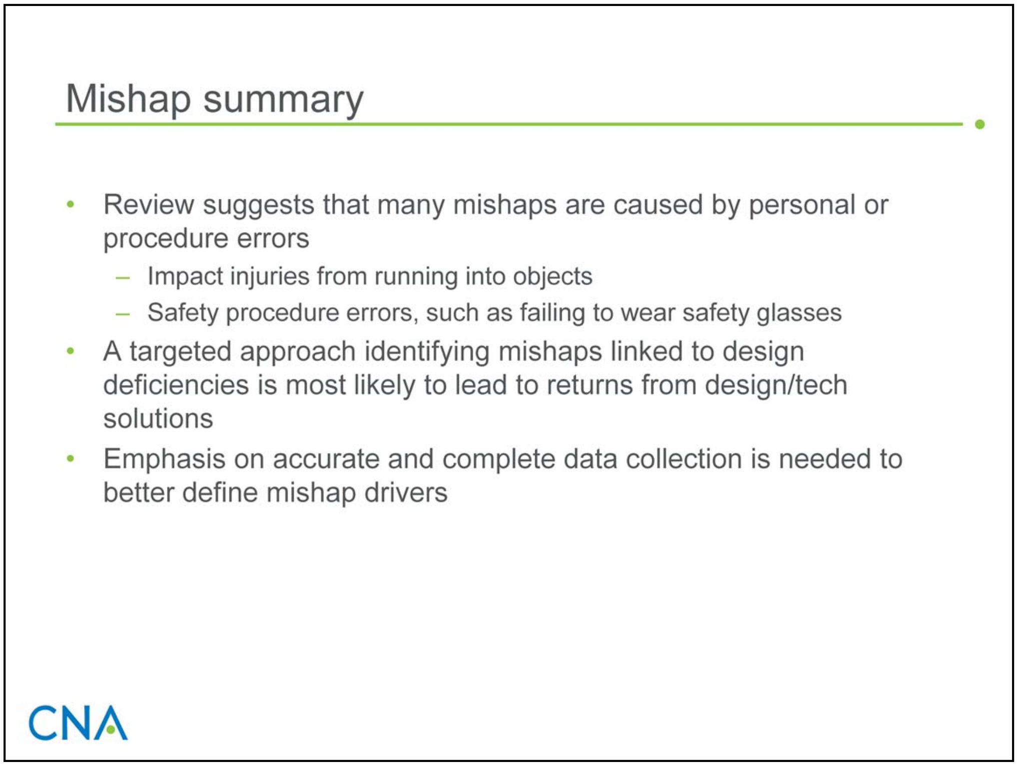
The number of reported electrical mishaps is shown here. We exclude CY 2000 because of the extremely low number of reported mishaps overall.

We provide an additional breakdown of the electrical mishaps based on five broadly defined cause categories:

- Unk—unknown
- Error—personal error, such as touching the prongs when plugging in equipment
- Light—changing light bulbs or igniters
- Maintenance—occurred during maintenance (not a light fixture)
- Distribution—shocks potentially due to wiring/distribution issues (e.g., receiving shocks from touching door frames, outside of electrical boxes, etc.)

The bimodal distribution suggests that there may have been a period of underreporting from CY 2005 through CY 2009. The increasing proportion of shocks listed as “Unk” indicates that additional attention is required to accurately document reported mishaps.

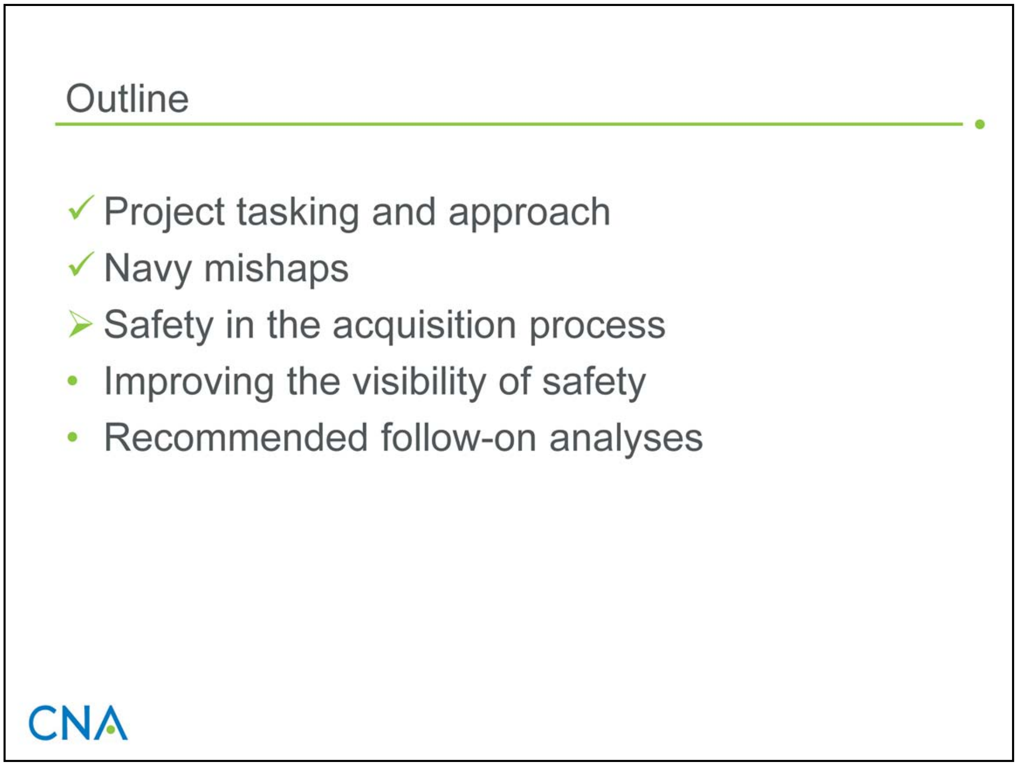
The four categories, excluding “Unk,” are about equal; each represents about 15 percent of the mishaps. Based on the information available in the narratives, mishaps in the “Distribution” category may warrant further attention because they involved electrocution following contact with nonelectrical objects.



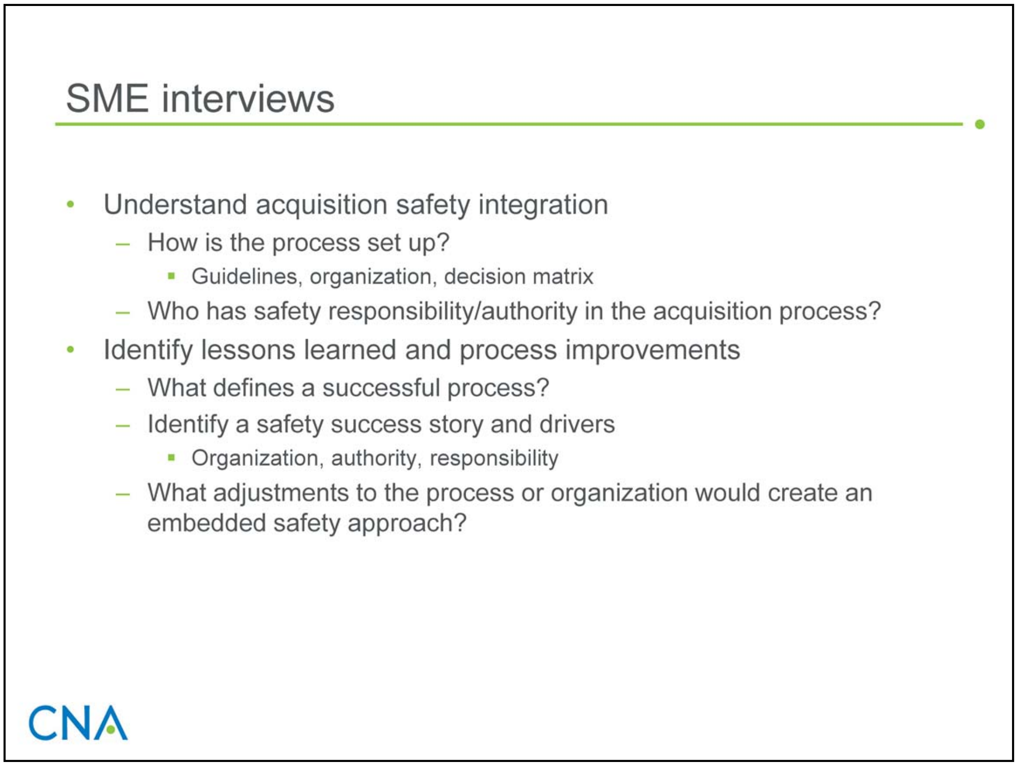
Our review of the mishap data suggests that many mishaps are caused by personal or procedural errors. Mishaps in the second largest category, "Impact injuries," result from personnel running into objects as they move through the ship. Reports of injuries in other categories, such as "Eye," getting hit in the eye from foreign debris, often contained narrative indicating that the servicemember was not wearing proper safety equipment. These types of injuries could, in theory, be solved by design or technology solutions, but a cost-effective first step would be to reemphasize the hazards of working and moving about aboard ship and reiterating the benefits of job-related safety equipment.

The large number of injuries that may not be economically solved by design or technical solutions suggests that a focused approach to seeking acquisition solutions will be more likely to yield cost-effective results. Some subcategories in specific areas, such as "Distribution" within "Electrical" mishaps, warrant greater attention and further study.

In addition, the lack of complete data on existing mishaps makes it difficult to identify their causes. This, in turn, makes finding the solution to the problem not possible—neither a procedural nor a design solution. We suggest reemphasizing the mishap data collection effort focusing not only on tracking all mishaps but also on including more complete information.



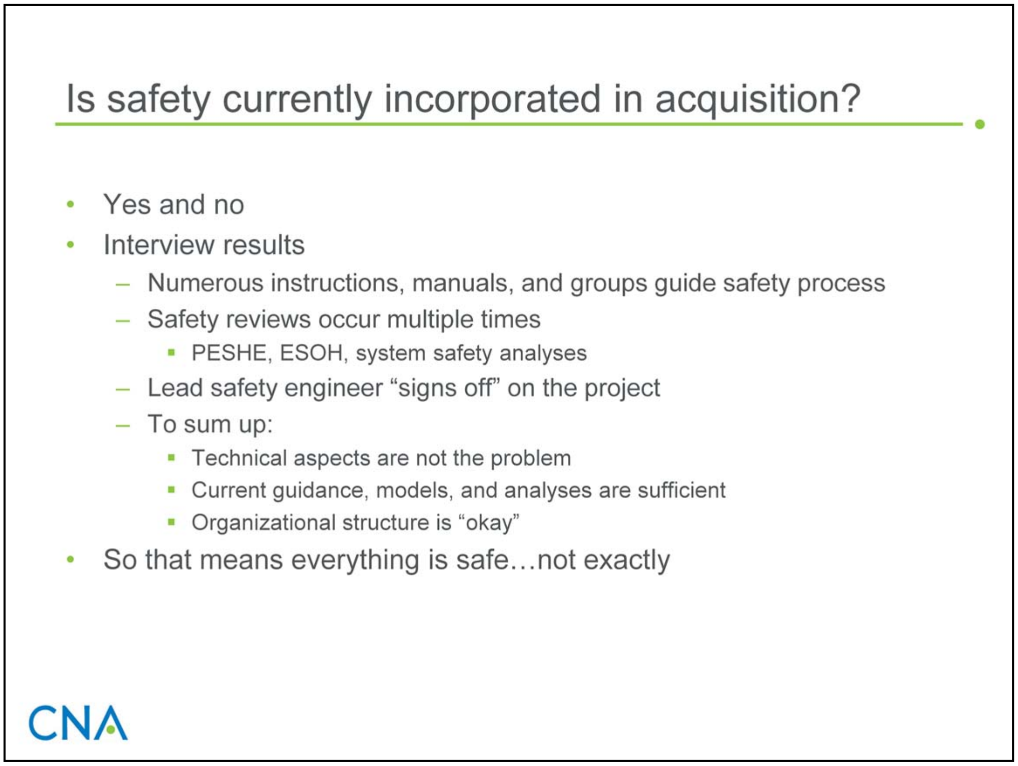
In this section, we present our approach and the results of our examination of our interviews with subject matter experts on how safety is integrated in the acquisition process.



There are a number of Navy instructions and guiding documents for incorporating safety in the acquisition process. We reviewed this information to understand the Navy's approach to safety. Based on this review, the Navy guidance is clear that safety is a priority in system development and in the field.

To better understand how the guidance is incorporated and applied in the acquisition process, we undertook a number of interviews to determine how the process is set up to include who has the safety responsibility and authority during design and acquisition. In other words, we sought to identify, when a probable safety item is identified, what ability does the safety official have to request that changes be made. The first step was to understand the acquisition process regarding safety in day-to-day execution.

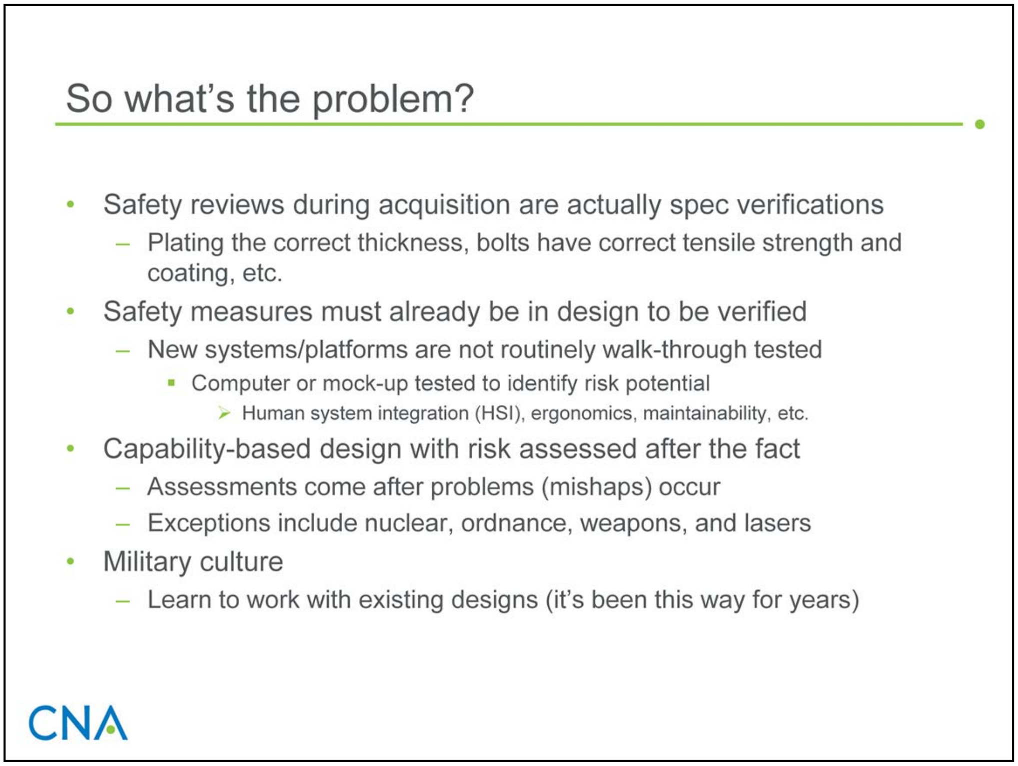
The interviews were also designed to capture information on safety acquisition success stories. We asked SMEs about what defines a successful process in terms of safety and sought suggestions on spreading these improvements to other safety areas. We identified lessons learned and suggestions for improvements that would help create a more embedded safety approach.



The overall question is whether safety is currently incorporated in the acquisition process. The answer is an ambivalent yes and no.

A number of documents provide guidance on incorporating safety decisions in the acquisition process. These include specific safety milestones, such as the programmatic environmental safety and health evaluation (PESHE), the environmental, safety, and occupational health (ESOH) assessment, and periodic system safety analyses conducted during an acquisition. There is also a safety structure in place to identify potential hazards, and the lead safety engineer "signs off" on projects.

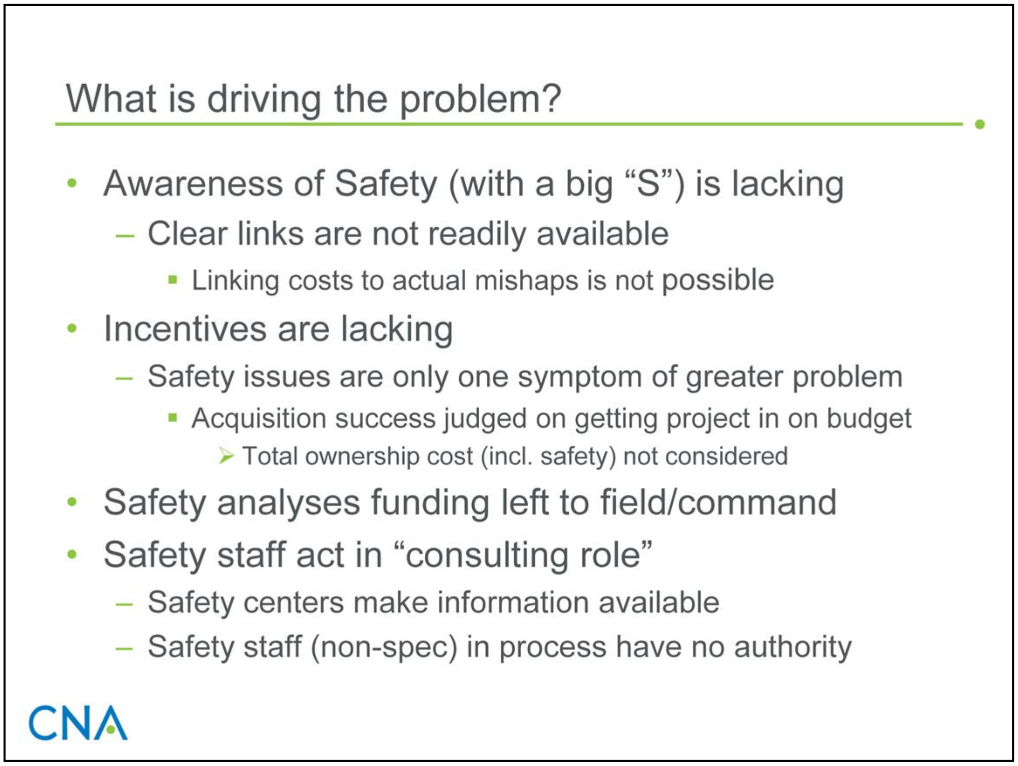
The combination of all of the safety guidance and mechanisms would seem to ensure that the equipment that is fielded is as safe as feasible given cost and time. In application, however, there are shortcomings in the process, which we will discuss on the next slide.



We found that for high-risk items, such as ordnance, safety is an integral piece of the design-build process, but the safety piece for low-risk/high density hazards is less well defined. Even though a number of safety analyses are conducted during the acquisition cycle, we found that they turn out to be primarily specification verifications. Designing and building a complex system, such as a ship, requires thousands of specifications (plating thickness, tensile strength, etc.) to ensure that the completed ship is not unsafe. The time available for safety reviews is consumed by ensuring that the correct specifications were used and that the shipyard correctly followed the design requirements. This is one aspect of safety but does not address safety measures that were not designed in from the beginning.

We also found that new systems/platforms are not routinely "walk-through tested" for safety. We use this term to include computer or mock-up representations where the space can be physically or virtually walked through to assess the safety risk potential—HSI, ergonomics, maintainability, and so on. SMEs noted that designs for ships and systems are capability based and are tested for function but the risk and maintainability aspects are often considered only after the fact. Assessments of potential risk most often come after problems occur; notable exceptions include nuclear, ordnance, weapons, and lasers.

The last stumbling block we heard involved military culture. Military leaders at all levels aboard ship have learned to work around unsafe situations during their careers and expect new personnel to do the same.

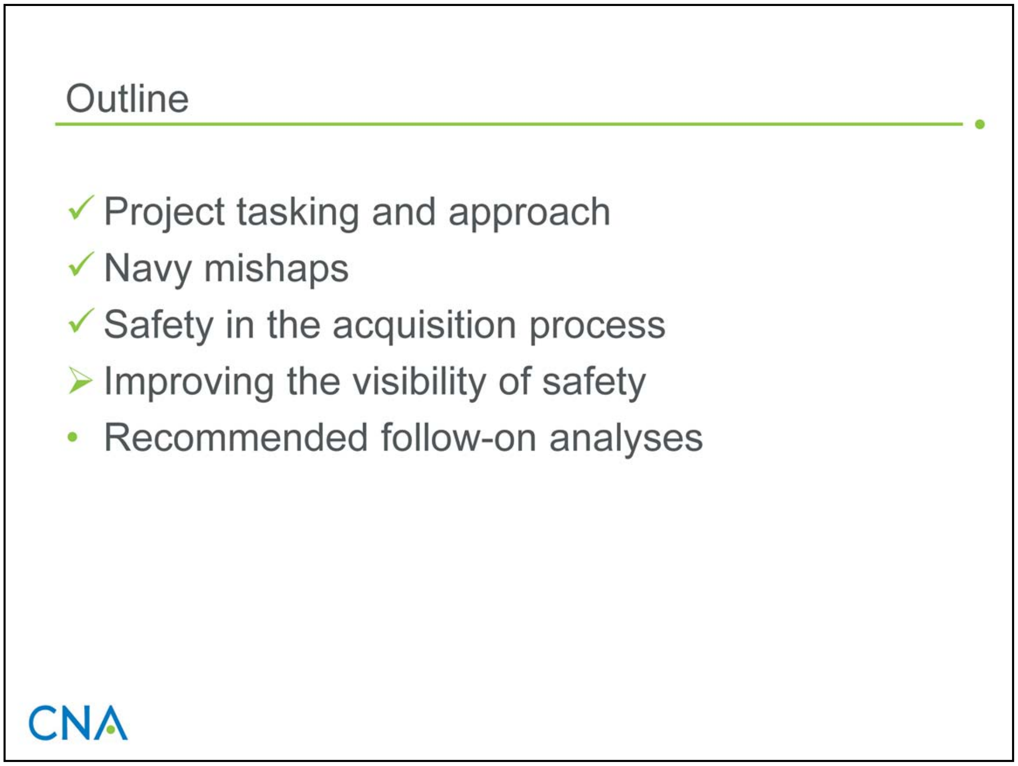


The SMEs noted that a comprehensive view of safety was lacking. We refer to this as Awareness of Safety (with a big "S") to capture the notion that day-to-day safety issues are not treated with the same level of importance as potentially catastrophic injuries. This stems from a combination of factors, including military culture and an inability to clearly link causes and effects. The latter is caused by the lack of clearly and consistently collected mishap data, and by such long-term risks as noise, vibration, and head trauma that may result in no immediate accident but result in a disability after years of repeated exposure.

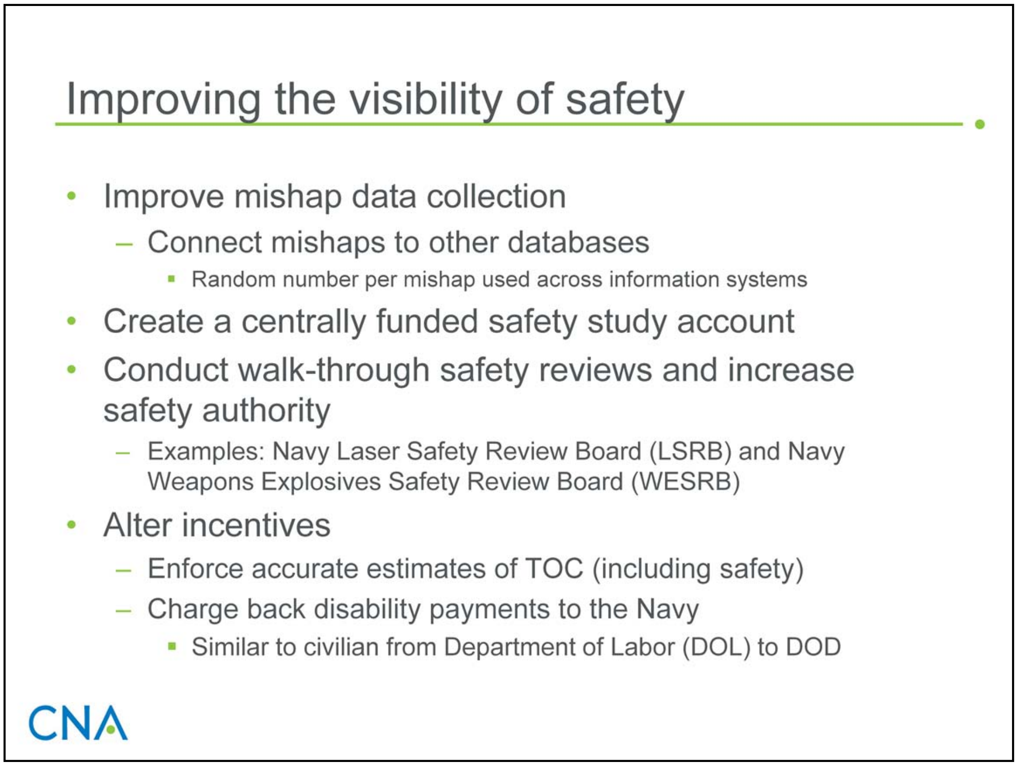
The acquisition process is not set up to produce the right incentives for safety management; success is judged by being on time and under budget. The long-term total ownership cost (TOC) of ships (including potential safety costs), while required for the cost estimates, may not be carefully estimated and can be significantly inaccurate.

We found that safety analyses are often left to the field or individual commands. For design changes to be considered for retrofit or new construction, we were told that a study linking the cause and the effect to the solution was needed. This is a logical requirement; however, the command that proposed the solution was required to fund studies connecting the dots—studies that were never undertaken because of the expense to the command.

The last key driver we identified was that safety staff often acted in a "consulting" capacity for non-catastrophic safety issues. Their ideas were considered, but they had no authority to ensure that they were implemented.



In this section, we present our recommendations for improving the visibility of safety in the acquisition and design process.

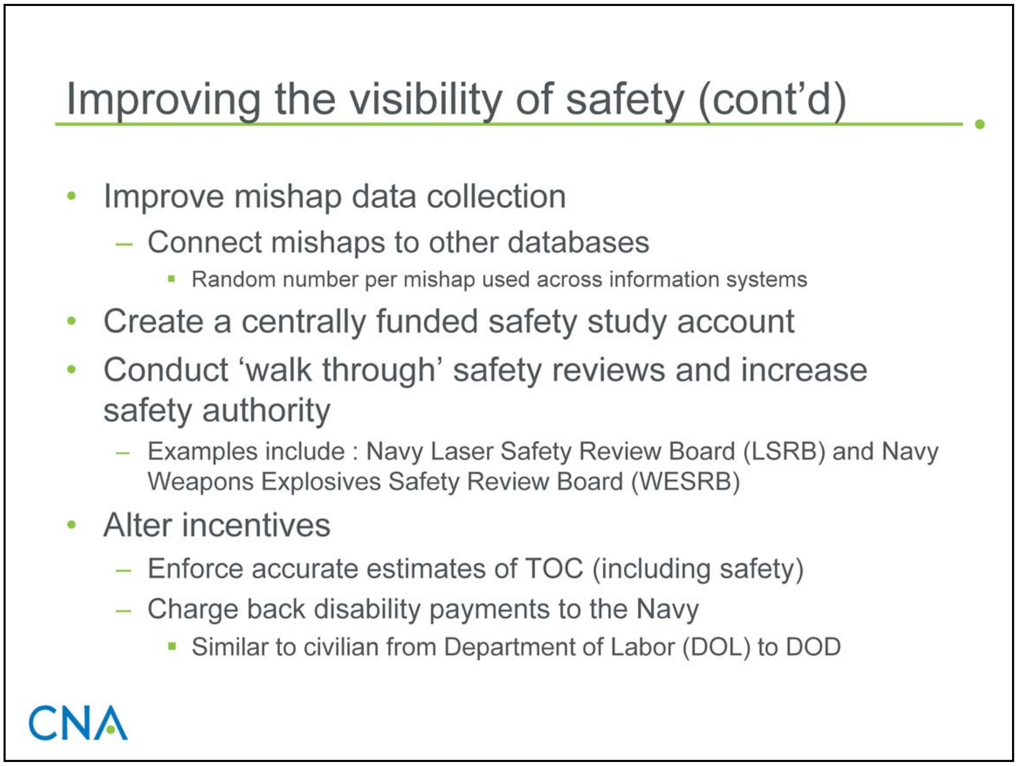


Based on our review of the data and interviews with SMEs, we developed several recommendations to improve the visibility of safety during acquisition.

The first step to increasing visibility is to improve mishap data collection. Clear, complete, and consistently collected data for mishaps will create the basis for analysis of potential design/technical solutions to improve safety. In addition, we noted that the different systems assign case numbers for the mishap, treatment, and follow-up treatment. There isn't an efficient way to link the datasets because of missing or incomplete data. A centrally provided random number, perhaps generated by the safety center, could be assigned to each mishap and then used in each database to provide an easy way to link those data without requiring the use of personally identifiable information.

We also suggest creating a centrally funded safety study account that could be used to identify and investigate safety concerns. In addition, a physical or virtual walk-through should be conducted of new designs to ensure that adequate HSI, ergonomic, and other safety factors are considered.

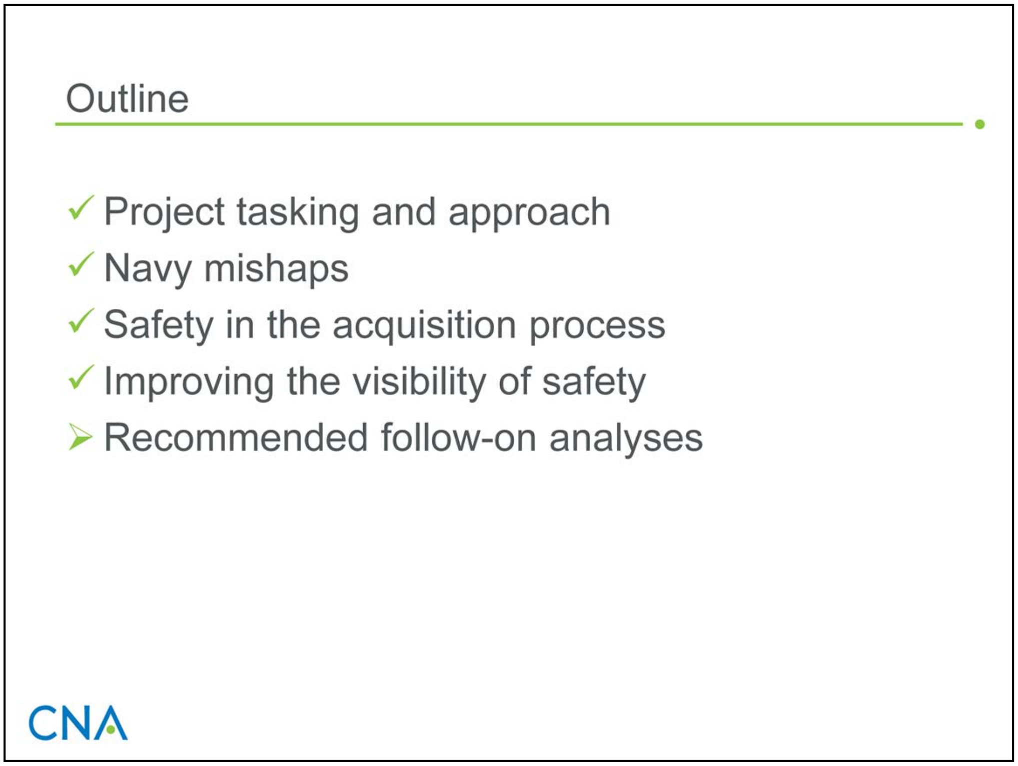
The acquisition process works fine in some cases and not so well in others, in terms of safety. The cause of this is not an inherent safety flaw in the process but rather the level of involvement and authority of the safety professionals. We suggest increasing the authority of safety personnel in non-high-risk areas. For lower or long-term risk items, the same level of authority may not be necessary as in lasers or ordnance, but greater authority than providing suggestions is needed.



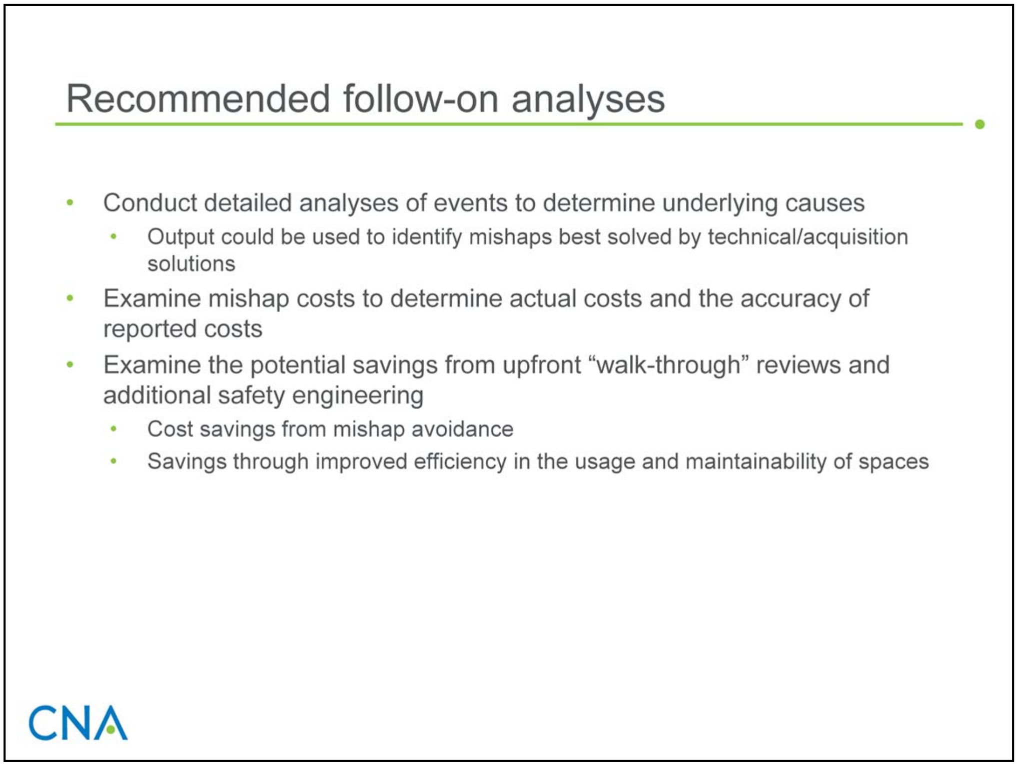
The last recommendation for improving safety visibility is to alter incentives. Altering the incentives will result in greater attention to safety through a self-reinforcing mechanism.

To alter incentives, we suggest placing greater emphasis on ensuring that estimates of TOC are accurate. The TOC estimates should not only include expected operation and maintenance costs but also the potential safety costs. This will provide decision-makers with full knowledge when choosing between design options that may be cheaper but contain a higher risk potential for sailor injury and those design options that are inherently safer. The higher visibility of the costs of safety would lead to greater attention to safety issues early in the acquisition process.

Another possibility for altering incentives is to charge back disability payments to the Navy. A similar mechanism exists for the chargeback of payments from DOL to DOD. This suggestion would alter incentives by creating a higher visibility of safety costs and a penalty for ignoring safety. A chargeback mechanism would alter incentives for the Navy as a whole and would require congressional approval.



In this section, we discuss recommendations for follow-on analyses based on the findings from this study.



The analysis and results described here provide insight into the type and potential cause of injuries, the current state of mishap reporting, and ideas on how to improve the responsiveness of the acquisition system to identified hazards. The analysis also revealed several areas where follow-on analyses could be used to further improve the mishap identification and mitigation process. We suggest three areas for further analysis.

The first recommended follow-on is conducting more detailed analyses of common types of mishaps to determine underlying causes. The gaps in reported safety data would need to be filled in using a detailed case analysis approach and onsite analysis. The output from this type of analysis could be used to identify mishaps that may be best solved by technical/acquisition solutions.

Second, we suggest an examination of mishap costs to determine the total direct and indirect costs and the accuracy of reported costs for a representative number of cases. We found that reported costs did not appear to be accurately reported and could not be used for cost analysis; examples include widely varying costs for the same injury and reported costs of thousands of dollars for minor impact injuries while severe injuries requiring medevac cost only a few hundred dollars.

Our third recommendation for follow-on analysis is to study the potential efficiency gains and cost savings from up-front "walk-through" reviews and additional safety engineering of new and existing designs. This analysis would examine the cost savings from mishap avoidance and the potential savings through improved efficiency in the use and maintainability of the space resulting from this approach.

References

CNA

[1] "How Goes It?" *Naval Safety Center (COMNAVSAFECEN) website*, last accessed Oct. 30, 2013, at http://safetycenter.navy.mil.

[2] "Compensation." *U.S. Department of Veterans Affairs website*, last accessed Jun. 20, 2014, at http://www.benefits.va.gov/compensation.

[3] Office of the Chief of Naval Operations Instruction (OPNAVINST) 5100.24B. *Navy System Safety Program Policy.* Feb. 6, 2007.

[4] Office of the Chief of Naval Operations Instruction (OPNAVINST) 5100.23G. *Navy Safety and Occupational Health Program Manual.* Dec. 30, 2005.

[5] Office of the Chief of Naval Operations Instruction (OPNAVINST) 5102.1D/MCO P5102.1B. *Navy & Marine Corps Mishap and Safety Investigation, Reporting, and Record Keeping Manual.* Jan. 7, 2005.

The CNA Corporation

The Resource Analysis Division provides analytical services to help develop, evaluate, implement policies, practices, and programs that make people, budgets, and assets more effective and efficient. Our roots are traced to World War II, where its analysts provided services to help manage the operations and tactics of our combat forces. In 1962, when Secretary McNamara was pushing for the introduction of corporate business practices and cost benefit analyses into DoD decisions, RAD's operations analysts joined a group of economists and cost analysts in Cambridge, Massachusetts and became the Center for Naval Analyses. The Resource Analysis Division is the direct descendant of that founding group.

DAB-2014-U-008100-Final

CNA Corporation is a not-for-profit research organization that serves the public interest by providing in-depth analysis and results-oriented solutions to help government leaders choose the best course of action in setting policy and managing operations.

CNA Corp: Nobody gets closer—to the people, to the data, to the problem.

www.cna.org ● 703-824-2000

3003 Washington Boulevard, Arlington, VA 22201