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Safety in Shipyards:
An Exploration of Management Techniques



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Safety in Shipyards:
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by

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I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College as a whole.

David Comiske

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ABSTRACT

Industrial workplaces are inherently dangerous: shipyards are particularly dangerous given the scale of the projects. Workers are exposed to a range of hazards including falls, toxic fumes, electrocution, burns, and amputation. For the most unfortunate workers, these factors result in death. Over the last 70 years, shipyard hazards and accident rates have remained relatively unchanged. A misalignment of marginal cost and benefits perpetuate the trend. Exploring safety culture, Organizational Behavioral management, and choice architecture, a new perspective on safety programs and performance is possible. Each management strategy has a unique advantage. Safety culture proves to be the most powerful contender influencing safety performance throughout the organization. OBM and Nudges change safety performance at the worker-supervisor level. When synthesized together, these three strategies can revolutionize shipyard safety.

1. INTRODUCTION

Accidents happen: everyday people go to the hospital because of unintentional mishaps. While some of these injuries undoubtedly are represented by Homer the homeowner, an overwhelming majority of these injuries affect workers while on the job. Inherently, some professions are more dangerous than others are. The manufacturing and construction industries are among the most dangerous occupations, with injuries becoming almost routine occurrences. According to Sara Hajmohammad and Stephan Vachon (2013), workplace injuries affect the bottom line of the company through medical bills, decreased worker moral, disruptions to workflow, and inexperienced workers attempting to replace experienced, injured workers. These effects all slow production and subtract from the overall profit of the company.

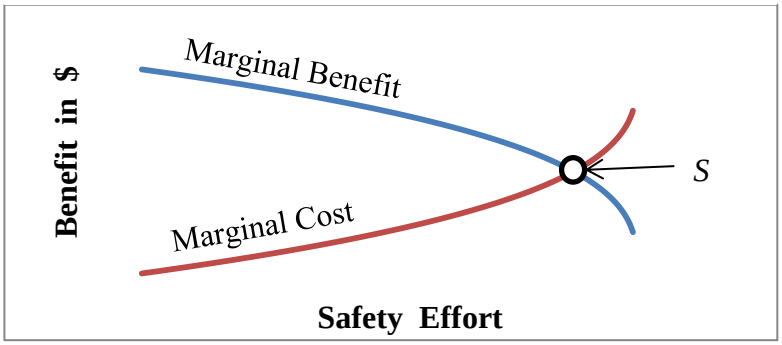
In 1944, Frank McElroy and Arthur Svenson (1944a) published a report on the safety hazards common to shipyards during the World War II era. This era called for a surge of employees into the industry to support the war efforts and the post war construction of Liberty ships. Interestingly, the average injury rate in 1943 was 31.2 injuries per million-person hours (McElroy & Svenson, 1944b). In comparison, the injury rate in 2014 was 29.5 injuries per million-person hours. (For the calculation of this figure, please refer to Appendix A found at the end of this paper.) Over a 70-year span, the injury rate remains essentially unchanged.

Since McElroy and Svenson's report in 1944, technology has advanced considerably in workplace safety. Tools are designed to be more ergonomic and safer to operate. With the advent and improvements of plastics, operators of dangerous shipyard equipment are now shielded in ways not possible in 1944. Computer technology has allowed cranes to weigh loads as they are lifted to ensure safe working limits. Wireless communications are commonplace in today's shipyards allowing workers to quickly and efficiently rely relevant information to keep

the workplace safe. Most significant, the Occupational Health and Safety Administration did not exist until 1970. In spite of the numerous rules now in place to ensure worker safety, the number of injuries between 1944 and now remains nearly constant.

One possible explanation of the unchanged injury rate is workers' inability to recognize the risks of their actions. An economist would call this misperceived marginal costs and benefits. Assuming that the average employee does not intend to cause harm to himself or his coworkers, shipyard workers believe they are operating at the optimal level of safety as seen in Figure 1. The marginal benefit of safety effort is the summation of the absolute value of lost wages, price of permanent disability, and the worker's value on being healthy. Because benefits are the summation of avoided costs, extra safety effort to avoid fines increases marginal benefit.

Figure 1. Worker's Perceived Cost-Benefit Curve



The marginal costs include the price of extra time to do a job safely, cost of negative social interactions, and the cost of procuring the proper safety equipment. At the equilibrium point *S*, if a worker felt he were taking a risk where the marginal benefit of increased safety effort exceeded the marginal cost of that effort, he would pursue a safer alternative. While most quantities of safety effort have benefits that outweigh the costs, beyond equilibrium point *S*, the return on safety effort very quickly becomes asymptotic. Safety efforts in excess of what is

required become cumbersome and greatly hinder production. Electrical work has clear endpoints on the safety effort continuum.

Disconnecting the power to some equipment is not possible because the equipment is powering other essential equipment. Handling live components is a routine activity for an electrician, and special voltage-insulated (VR) tools and gloves protect workers from most risks. Electricians learn when to use the protective gloves and when extra precaution is not needed. When repairing the 6600V bow-thruster service power, electricians know the protective gloves and tools are essential to keeping them safe in this high-risk situation. The high risk of electrocution makes the marginal benefit of the safety effort significantly higher than the marginal cost for the precaution.

When changing a 120v light bulb, the same electricians forgo the protective equipment because they recognize a very low likelihood of injury. The marginal benefit of VR gloves in this situation is low, but the marginal cost of donning cumbersome gloves is high. The VR gloves make the task more difficult without much benefit. (In the unlikely event the bulb were to shatter, the electrician would be happy he was wearing gloves.) All shipyard workers are forced to balance the tradeoffs between safety and productivity.

Fortunately, OSHA provides a standardized set of guidelines to shipyard employees. Following these policies helps workers reach point *S* on their individual marginal cost-benefit curves. Most times, workers achieve the optimum tradeoff between marginal benefit and marginal cost. When workers are overly cautious, supervisors are quick to reprimand workers not meeting productivity expectations. Conversely, when a worker incorrectly perceives the marginal cost of a safety effort to exceed the marginal benefit, he puts himself and others at risk of an incident. This is the crux of safety management: developing methods to align the marginal

costs with the marginal benefits of safety efforts. When marginal costs equal marginal benefits, workers have optimized safety effort.

Most people agree that workplace injuries and fatalities are an expensive price to pay for finished products. When the same people are asked how to reduce injuries in the workplace, the answer will not be as clear. Older schools of thought rely on levying fines, effectively increasing the price of careless behavior. Increasing the price of unsafe behavior forces workers to reconsider the marginal costs and benefits of a specific action. Levying fines is a reactive technique to reducing workplace incidents. From the author's personal experience, being reactive is not always the best strategy.

In the winter of 2013, I, the author, was employed at the Seattle based shipyard Vigor Industrial. I was working closely with the trades and project management to gain practical experience in the shipyard industry. The yard was working on several projects simultaneously including several navy vessels and an offshore oilrig, the *Kulluk*. On a Friday afternoon, Bill Shelby fell from the top of the oil derrick. He was pronounced dead at the scene. Shelby was a 39-year-old marine carpenter tasked with building stagings and platforms to allow other trades access to various areas of the rig for maintenance and painting. He was a skilled carpenter with years of experience in the trade. In the aftermath of his death, I attended a meeting detailing the facts of the incident[1].

Shelby had climbed the ladder to the top of the derrick where a small work platform was under construction. At some point while finishing the platform, Shelby fell about 90 feet. He was working alone, so there were no witnesses of the moments leading up to the incident. He

[1] Please note that the facts presented in this paper are from the memory of the author. No official report was unavailable for this paper; therefore, the views and opinions expressed in this paper are those of the author alone.

was wearing a harness designed to protect against this type of incident, and there was evidence to show that he had used the fall protection equipment while climbing the ladder to the platform. The harness he was wearing was a specially equipped "double harness" for carpenters with two lanyards attached. Lanyards are sewn fabric webbing designed to arrest a falling worker in about six feet without causing excessive injury. For the lanyard to work, one of the worker's lanyards must be clipped to a lifeline or other structure. Shelby's double harness allowed him to transition from one working area to another while maintaining constant attachment to the lifeline. Lifelines are tensioned horizontal cables to allow workers to walk from one area to another while maintaining fall protection. The lifeline on the platform where Shelby was working was properly installed and tensioned. When investigating the area, a safety official discovered a wrench lying on a beam just beyond Shelby's reach while still clipped into the lifeline. Only one person really knows what happened aboard the *Kulluk* that day, but safety officials deduced that Shelby had slid or dropped the wrench just out of reach. To retrieve the wrench, he unclipped and traversed the unguarded beam. Before reaching the wrench, he fell. I knew Shelby, and I have a suspicion about his response to a post-humorously levied fine: I do not think it will alter his future actions.

In order to levy fines, first an unsafe behavior must be observed by a supervisor. To prevent serious incidents, shipyards need to implement a proactive strategy. Mainstream economics literature suggests organizational institutions as one possible solution. Institutions as described by Elinor Ostrom (2005) include the, "rules, norms, and strategies used to structure patterns of interaction within and across organizations" (p. 822). Institutions can be incredibly powerful forces within an organization when considering employees' outlooks, behaviors, and attitudes.

Well-established institutions can lead to more profitable companies and safer work environments for employees, but research has shown that institutions as part of a bigger organizational culture can have an even more pronounced effect on a company's safety culture. Safety culture is a relatively recent term focusing on the atmosphere and underlying assumptions of an organization. Another technique to improve safety performance is organizational behavioral management (OBM). OBM uses psychology's studies of behavioral science and applies the concepts to encourage and reinforce certain behaviors in the work place. By drawing workers' attention to the hidden costs of dangerous behavior, organizations can guide workers towards the optimum safety effort. This technique relies on the worker using conscious thought and decision-making processes to be safer.

A new theory associated with behavioral economics that applies to safety is the idea of the "nudge." Nudge theory uses small signals in a worker's everyday life to subconsciously nudge him towards one decision or the other. Ultimately, the creation of policies developed from each theory would push a worker towards safety.

All companies can benefit from improved safety practices. This paper will focus primarily on the ship construction and repair industry. Shipyards are dangerous places with unique hazards not found in combination elsewhere. In an average day, a shipyard worker is susceptible to slips, trips, falls, toxic fumes, burns, confined spaces, overhead lifting hazards, overexertion, electrocution, fires, being struck by a vehicle, and drowning. While this is a long list of hazards, each job has additional dangers that must be accounted for before each task is completed. Every vessel is unique and requires its own upgrade and refit specifications. Because of the dynamic nature of the projects found in a shipyard, the potential hazards are always evolving and changing: shipyard workers must always be diligent to avoid these hazards

and remain safe. This paper intends to explore the methods a shipyard can implement to improve safety.

2. LITERATURE REVIEW

People innately understand the ideas of rules. From a young age, children are taught right from wrong using a well-established system of rules. Parents enforced these rules using punishments ranging from loss of privileges to corporal punishment. As children mature, physical punishment loses its edge and reprimanding almost always comes in the form of lost privileges: to a sixteen-year old, losing the family car for one week will likely leave a more lasting impression. To adults functioning in the real world, punishments have not changed much. When a driver is caught speeding, he has to pay a hefty fine. If the infraction is significant enough, the driver loses the privilege to drive all together. Just like a child's parents, the law punishes individuals who chose to ignore the law.

I. Tort Law and Antiquated Safety Policy

Traditionally, tort law allows victims to sue the injurer for damages resulting from negligence. If the injurer is found to be negligent, the victim is entitled to compensation equal to the utility lost, in the form of a cash settlement. Claims of negligence incentivize people and businesses to maintain their reasonable duty of care to others. If the injurer breaches this duty of care, the injurer bears the full cost. If the injurer can show that the injured was acting unreasonably and contributed to the negligence, in most jurisdictions, the injured party cannot recover. The standard of care and contributory negligence rule force both parties to take precautions to prevent incidents from happening. Thereby, tort law can reduce the number of incidents but only when ideal assumptions are valid. (Cooter & Ulen, 1997, p. 270-6)

Real-world circumstances do not maintain many of the assumptions of tort law: workers often misunderstand the costs and benefits of a given safety effort. Robert Cooter and Thomas Ulen (1997) describe potential victims as unable to perceive very small probabilities. Victims assume these values to zero while inflating other values: "people simply cannot accurately estimate low-probability events; they seem to deal with them by assuming that 'low-probability' means that the event will never happen… [However,] some well-publicized, potentially catastrophic outcome – such as accidents from nuclear power plants – *most* people systematically exaggerate the probability of an accident's occurring" (p. 296). Because people behave irrationally in some situations, using tort law as the primary means of reducing incident rates becomes problematic. Shipyard workers face situations where the probability of injury is low, but not zero, the very situation Cooter and Ulen describe. Insurance adds another layer of complexity and confuses incentives further. In fact, if the insurance company assumes the full risk of the victim, neither the victim nor the injurer has incentive to take precautions. The insurance company faces a moral hazard. All full-time shipyard workers have medical insurance to cover work-related injuries. In most instances, the companies are also responsible to maintain workers' compensation coverage in the event an employee is injured on the job. In many instances, the torts liability system cannot adequately incentive workers to be safer. More recently, economic literature has turned to the idea of culture and, more specifically, safety culture to incentivize safer work practices.

II. Workplace Culture

The idea of culture in the workplace is not a new idea. As early as the 1950s, researchers began to investigate the concept of using behavioral analysis in the business world (Dickinson,

2001). This new technique evolved over the next three decades. These new principles were thought to be a tool used to manipulate the workplace. In the 1980s, some believed that culture could be used to "coerce and control" (Glendon & Stanton, 2000, p. 194). Institutions and culture were later recognized to be a living idea that could not be changed by flipping a switch. By the mid-1990s, the academic discourse had adopted this approach and recognized culture to be, "not owned by any group but is created by all the organization's members" (Glendon & Stanton, 2000, p. 194). Defining culture is difficult because often the underlying assumptions and ideas are complex, changing, and in many cases unable to be articulated. The underlying assumptions evolve over time and culture changes as a result. If culture were thought of as a line, then each point on the line would consist of a particular set of institutions, working conditions, and interrelationship dynamics. These "snapshots" would be the climate of an organization.

A. Components of Culture

New Institutional Economics defines the conversation about institutions and their functions. Within any society, there exist institutions composed of rules and norms. Businesses and organizations have a particular set of institutions that apply specifically to each unique entity. Rules can develop in any cooperating group of individuals, but are more formal than norms. Ostrom (2005) explains, "All rules are the result of implicit or explicit efforts to achieve order and predictability among humans … [who] are then required, permitted, or forbidden to take…actions" (p. 831). Alston, Muller, and Nonnenmacher (2015) simplify this definition: "A rule has an explicit 'or else' and an agent assigned to enforce it." While rules are formal, they are not required to be written down.

Ostrom differentiates between the "rules-in-form" and the "rules-in use." Rules-in-form are the formalized language of the rule often laid out by a written rule of law. The rules-in-use are the rules that are followed "on the ground" in an institution defining the "do's and don'ts," and can vary considerably from the formal "do's and don'ts" defined by the rules-in-form. Rules-in-use as defined by Ostrom are essentially norms that were established from an initial set of rules. Norms, like rules-in-use are rarely written down and are considerably less formal. Alston et al. (2015) clarifies this, "Norms do not have an explicitly stated penalty or enforcer, making them less formal than rules." Because norms are embodied within the members of an organization, they are far more difficult to recognize and change. In the context of safety, changing the rules-in-form seems to be a simple solution to a complicated problem. Changing the rules-in-use (the rules that actually change actions) proves a more complicated problem.

Working conditions and interrelationship dynamics are essential to analysis of climate and thereby culture. Working conditions for the extent of this paper is the time schedule and urgency of a given job, as well as the amount of pressure exerted by management to meet these requirements. Interrelationship dynamics is a much broader category including dimensions such as communication between workers and management, the availability of appropriate tools and equipment to complete a task, and the number of training exercises used to educate workers. Institutions, working conditions, and interrelationship dynamics are important to developing the climate and ultimately the culture of an organization.

B. Safety Culture

As a sub-category of culture, safety culture was suggested after the initial ideas of culture. In fact, the origins of the term *safety culture* can be traced to reports of the Soviet

nuclear disaster at Chernobyl in 1986 (Meshkati, 2007). In the context of Chernobyl, "safety culture is defined as, 'that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance'" (Meshkati, 2007, p.810). In the following years, the focus of safety culture was expanded to include other industries while maintaining the "attention warranted" of all safety issues. Safety managers and safety experts implemented the concept for their own purposes.

While there was a single source, by 2000, A.I. Glendon and N.A. Stanton were discussing the various definitions of safety culture. These definitions of safety culture ranged from broad contexts without a clear distinction between organizational culture and safety culture to very specifically the, "group values, attitudes, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's safety programs" (p. 194). Shiney Chib and Medha Kanetkar (2014) indicate there is still some debate about a unified definition about the "buzzword" safety culture.

Chib and Kanetkar (2014) create a synthesis of safety culture with traditional ideas of culture and climate to form the definitions. They add to Glendon's definition, "Norms and policies related to safety," and, "common values, beliefs, attitudes and behaviors regarding safety" as parameters of safety culture. Interestingly, Chib and Kanetkar note," Despite the lack of a universally accepted definition, and the dearth of work focusing on defining 'good' and 'bad' safety cultures, safety culture has been identified as perhaps the main recent issue in organizational safety" (p. 132). Regardless of definition, several studies have concluded the significance of safety culture and reducing incidents in the workplace. While the evidence is clear, changing and driving the desired cultural change is a complex objective.

Working conditions, interrelationships and institutions compose climate. Climate over time develops into an organization's culture. Culture is a path dependent structure; climate is often a state dependent function and can change very quickly. As a result, culture can evolve very rapidly with changing climate. It is important to note that while culture can vary, culture does not simply unlearn the past and adapt to new conditions seamlessly. In a simplified metaphor, think of a typical wedding reception deejay.

The deejay controls the climate of the event by selecting the appropriate tracks at any given point in the night. He has institutions to follow with rules defined between him and the wedding couple and norms established outside of this particular event such as "appropriate" dinner music. The music played also defines the working conditions and the activities the event is encouraging at any given point. During dinner, soft, easy listening music plays quietly to encourage conversation among guests. After dinner, the music cues guests to dance and mingle as the music increases tempo and volume. Throughout the remainder of the evening as the social "climate" changes from one song to the next, there is visual evidence of confusion if a techno track fades into a slow country ballad. Guests on the dance floor have experienced an evolution in climate, but they adapt quickly to this new change.

The overall culture of the event could be defined as the genres of music played and the overall atmosphere of the event: a wedding of Nirvana fans would be very different from that of Sinatra aficionados. Guests can remember the playlist from one song to the next and this allows them to attempt to anticipate the next song in much the same way culture and safety culture tell workers how to anticipate the appropriate action in a given situation. Now imagine if management could be the deejay and the guests became the workers. If management could play

the right tracks to encourage the right style of "Safety Dance[2]," workers would be safer by following the preexisting rhythm of the organization. Using conditioned responses to aid in workplace safety is one of the many goals of organizational behavioral management.

III. Organizational Behavioral Management

The second theory designed to improve workplace safety, Organizational behavior management (OBM), is the strategy of using behavioral psychology to design management strategies that reinforce the desired outcomes. Safety is an easy target for this technique because there are easily observable outcomes to monitor and correct. Around the same time as culture started to come into discussion, the ideas behind OBM started to coalesce into a cohesive idea.

A. History of OBM

Dickinson (2000) lays out an overview of the history of OBM. In the late 1950s, B.F. Skinner wrote the foundations of OBM in his book *Science and Human Behavior*. This book was a springboard for other behaviorists and soon the ideas expanded and many were applying them to organizations ranging from schools to hospitals.

By the mid-1960s, OBM solidified into the study of "performance-based training" and is commonly applied to management strategies in all types of organizations. In 1978, Beth Sulzer-Azaroff published the first article applying OBM to safety in the workplace. In the decades since, Sulzer-Azaroff has published over 100 articles and several books. Her application of OBM to safety makes her a notable authority on the subject. Dickinson (2000) presents a note from L. W. Frederiksen of the shortcomings of OBM, "'OBM has been seen as a technique for solving isolated problems rather than as an approach to managing the human resources of the

[2] Sometimes the most obvious choice is not the best choice; though, people that are more intelligent are at a higher risk of making such quick decisions. (Lehrer, J., 2012)

entire organization.'" The concepts of OBM are easily applied to repetitive tasks that have clear rules, but are difficult to utilize when the tasks are more dynamic.

B. Applications of OBM

In numerous studies by Sulzer-Azaroff, she uses behavioral strategies to influence workers' compliance with safety regulations within an organization. She considers the question, "Workers may…have already demonstrated their mastery of the skills involved in performing safely on the job. Nevertheless, sometimes they take risks. Why should this happen?" (1987, p. 178). Sulzer-Azaroff (1987) determines the answer is misplaced reinforcement. The primary tool in the behaviorist's toolbox is using positive reinforcement to encourage the optimal behavior. This reinforcement can come from a worker's peers or his supervisor by way of praise or reward.

In many successful examples, the praise came to the worker in the form of a visual chart showing successes or failures within a given group and through individual praise. Workers responded well to this type of reinforcement with reduced rule infractions. Workers maintained the new behavior two years after the official study concluded and likely beyond. The key to a successful reinforcement program is doing effective foundational work. In the many studies and experiments, Sulzer-Azaroff clearly defined the problems she hoped to address. She then devised an objective way to measure whether these problems had been addressed; for example, in one industrial setting, workers were not storing cords not properly coiled. To assess whether the cords were stored appropriately, an observer could easily count the number of properly and improperly stored cords and then record these numbers. In this way, Sulzer-Azaroff and similar studies analyzed data and determined a successful reduction in dangerous behaviors. With

repeated success, this technique is a proven method for changing the way people approach safety.

IV. Nudge Theory

The final theoretical approach examined gained momentum in 2008, when Thaler and Sunstein published *The Nudge*. In the book, Sunstein and Thaler describe the power of a nudge. Simple changes in the way foods in a school cafeteria are arranged greatly affect the buying habits of students. With this insight, cafeteria administrators could design a food layout to maximize the sale of healthy foods or the sale of foods that maximize profits. While on the surface this sounds like gross manipulation, Thaler and Sunstein stress that nudges are very different from imposing bans or laws. Free choice is still widely available and in many ways encouraged. Ultimately, as they point out, the food in the cafeteria must be arranged in *some* way and this could be an opportunity to *nudge* students into making choices that are more healthful. The way the food is arranged is *choice architecture*. Choice architecture is at play in nearly every aspect of our lives and many have been choice architects themselves. When presenting two ideas but presenting one idea as the better is an example of choice architecture: salespeople are experts at this. The idea of choice architecture and nudges encouraging people to improve their own well-being has recently come into the spotlight. *New York Times* journalist Binyamin Appelbaum (2015) reported President Obama issued an executive order in September 2015 encouraging the use of nudges in government organizations. Obama's order came after experimentation in the UK has showed nudges to be rather effective. Nudges are inexpensive but can potentially have big results.

In the arena of safety, researchers are investigating the power of the nudge. In the techniques of safety, the design of a workspace influencing a worker's subconscious adherence

to safety policies opens a new frontier for safety professionals. Jennifer Lunt and Malcolm Staves (2011) consider the possibilities of using nudge theory in relation to safety, but note its limitations. Nudges cannot easily nudge a worker towards safe scaffolding assembly or to prevent safety violations. On simpler concepts, nudges are quite effective at encouraging behavior such as hardhat use and other relatively straightforward safety procedures. Considering the lack of formal studies into the effectiveness of nudges, Lunt and Staves hesitate to prescribe nudges as a safety panacea, but encourage further investigation into the observed benefits.

V. Why Safety Culture has the Strongest Influence

Every person has an innate sense of culture. In essence, culture is unavoidable. Every organization has safety culture. While some organizations sculpt their safety culture to better suit their overall safety goal, others ignore the power in managing it. Without guidance, safety culture can develop into a counter-productive force encouraging high-risk behavior. Often the goal of unmanaged safety behavior is to "avoid incidents." As Galloway points out this fosters a high-risk situation:

> When excellence in safety is measured by zero failures, a self-limiting organizational viewpoint and very dangerous employee belief is created: "If safety means no incidents, then anything that I do that doesn't result in an incident or get me hurt, must be safe." When this occurs, risk will be overlooked, complacency will set in, an important and healthy degree of vulnerability of risk will be lost, and organizations will be surprised by an incident that occurs out of nowhere. This will often sound like: "I can't believe that experienced, well-

> trained employee did that," or, "How did we miss that?" (As cited in Crutchfield & Roughton, 2014, p.25)

This "no incidents" norm can develop in any high-risk industry including, but certainly not limited to, shipyards: dangerous industries such as construction and commercial irradiators[3] develop poor safety culture in the same manner. In his book *Safety Culture*, John Bernard Taylor (2010) analyzes several case studies for the power of safety culture. In each example, safety norms degrade to allow dangerous activities to go unchecked.

A. Case Study 1

The first case study examines the events surrounding a "Dropped Load Event." This incident took place at the construction site of a high-rise apartment building in a congested neighborhood. The task was for two construction workers to lift large wooden forms used to pour concrete. The forms were about 100 ft^2, about 6 inches thick, and weighed over 2,000 pounds. The forms were delivered to the base of the building, but on the opposite side of the building from where the crane was positioned. This required the crane operator and a spotter known as a banksman to lift the forms using a blind-lift method. This means the crane operator cannot see any of the lifting operations and is relying entirely on the banksman's directions to lift the load safely. Because the lifting operation was taking place in a congested area, the procedure required a "personal exclusion zone" under the overhead hazards. As one of the forms was lifted

[3] "Irradiators expose products to gamma radiation to eliminate germs and insects or for other purposes. Food products, food containers, spices, fruits, plants and medical supplies are the most commonly irradiated products. The process does not leave radioactive residue or cause the treated products to become radioactive." (United States Nuclear Regulatory Commission, 2014, p.1)

to the roof, it struck the ninth floor of the building. The impact caused the form to split and fall from the crane rigging. The banksman inside the personal exclusion zone was killed instantly.

Taylor points out some important contributing factors for this incident. When using a banksman or completing a dangerous lift operation, procedure requires a risk assessment to be completed and overall risk minimized as required by law. In addition, a manager should be present to supervise the lifting operation.

Taylor learned that the crane operator and banksman did not have a specific risk assessment for the operation. There was a generic one in place, but during the following court proceedings, the courts questioned whether either the crane operator or the banksman actually saw the assessment. Furthermore, there was no evidence of exploring other possible options that may have reduced risk or avoided the blind lift operation. No manager was present during the operation. Taylor continues by adding, "A comprehensive [risk] assessment may have been considered unnecessary as the lifts were considered a 'straight-forward' task, possibly considered routine. The safety-belief that 'they know everything they need to know about the task,' would reduce the inclination to go through the 'bureaucracy' of a risk assessment for this specific lifting operation" (pp 76-7). These attitudes likely resulted from management stressing production over safety and the workers feeling they were qualified for the task. The banksman entering the personal exclusion zone may have been an accepted norm, and without supervisor commitment to prevent such behavior, the banksman was killed. The court found the company negligent and forced the company to pay heavy fines.

B. Case Study 2

In 2004, at an irradiator facility owned and maintained by an American healthcare company, two workers were nearly exposed to lethal doses of radiation. According to Taylor (2010), "Although irradiator facilities are high-hazard they are designed to be very low-risk for the operators" (p. 110). This particular facility used radioactive cobalt as its radiation source. The cobalt was loaded onto a storage rack that operators could raise and lower along a track from a six-foot by ten-foot pool of water that was about twenty feet deep. When the rack was at the bottom of the pool, the water shielded workers from the radiation if maintenance was required in the irradiator room.

When the rack was exposed, the room's thick steel doors and concrete walls shielded the operators from radiation. To prevent someone from inadvertently entering the room, when the programmable logic computer (PLC) sensed the rack was out of the pool, all of the doors were automatically interlocked. The PLC relied on two sensors: one located at the bottom of the pool and the other at the exposed end of the track. Throughout the existence of the facility, the rack-up sensor was a chronic problem. The switch never operated correctly resulting in the PLC sensing a fault condition. Under a fault condition, the PLC was designed so the rack would return to the bottom of the pool automatically.

There was a safety procedure in place for a rack sensor fault, and the workers and management at the plant were aware of the procedures that ensured the rack was actually shielded in the pool before workers entered the space. For a while, the procedures were followed, and each time workers found the rack safely at the bottom of the pool. Because of a tight production schedule, the high frequency of sensor faults, and the time required to follow the proper procedure, plant operators developed a "trouble shooting procedure." This procedure

involved removing fuses from the PLC to override the door interlock system allowing workers access to the space. The management and plant radiation safety officer (RSO) were aware of the procedure. In fact, the "trouble shooting" required approval from the RSO before the operation could be carried out. This procedure was used for several years before the incident. On the day of the incident, there had been a rack fault signaled, and workers had entered the space to replace the switch using the trouble shooting procedure. After finishing the task, the workers left, but forgot the ladder that was leaned across the rack-storage pool. When the rack was raised from the pool, the new switch malfunctioned, and the rack began to descend back into the pool. The ladder jammed the rack causing the rack to remain above the pool. When the crew heard the alarm, they assumed it was the usual sensor problem and the RSO approved the trouble shooting procedure. When the two workers opened the door to the adjoining room, they entered with one carrying a handheld radiation meter. The worker carrying the meter kneeled to clear some type of obstruction from their path and when he picked up his meter noticed the high rates of radiation. He and the other worker retreated. Had the two workers been in the direct path of the radiation, they would have received a lethal dose of radiation in about 30 seconds. Fortunately, these men survived without any likely long-term health complications.

Taylor notes that had the proper procedure been followed, this incident could have been easily avoided. Because of chronic issues with the rack, workers and management became complacent. The tight production schedule encouraged the workers, safety, and management to implement the workaround that traded safety for speed. The group also had a groupthink attitude where they believed they always knew what was wrong without doing any further investigating. Taylor proposes, "[T]he founding operational belief that the protection of the operator at all times from high-radiation fields is a priority under all conditions probably remained. However,

it appears to have been modified by a deep-seated belief in inherent plant safety and the staff's belief that this fulfilled the priority belief" (p.126).

In each organization, management presented the rules-in-form while silently endorsing the less stringent rules-in-use that resulted in one death and a near miss for two others in these case studies alone. In hindsight, these incidents were incredibly easy to avoid. The challenge is recognizing and assessing negative safety culture before an incident occurs.

C. Safety Culture Evidence

Safety culture can be broken down and evaluated based on three levels of evidence. The most superficial evidences are considered artefacts. Nathan Crutchfield and James Roughton (2014) define artifacts as," visible organizational structures and processes [including]….appearance of equipment and its maintenance, the visible work environment that includes the type and design of facilities, warning signage, written safety materials, policies, training rooms and dress codes" (p. 27). Artifacts are simple to observe and measure to develop a preliminary measure of safety culture.

The intermediate level of safety culture is centered on the "espoused values" composed of values and beliefs. These take the, "form of safety slogans, safety mission statements, and various commitments made with regard to safety" (p.27). Glendon (2000) expands on espoused values to include "behavioural [sic] norms, which can be inferred from observed behaviours" (p. 196). Safety culture is built on a foundation of underlying assumptions and unspoken rules. Glendon (2000) and Crutchfield and Roughton (2014) agree this deepest level of safety culture is hard to measure directly.

Crutchfield and Roughton (2014) suggest a synthesis approach using data collected on the two superficial levels to approximate the deepest level: underlying beliefs and assumptions. Glendon (2000) advocates a more methodical approach using safety climate surveys to estimate the unarticulated assumptions. He cautions, however, that, "surveys are limited by their methodology and can only report on attitudes at the time that they are undertaken and perhaps also a little in the past" (p. 199). If significant time and funding are available, Glendon (2000) suggests an experimental approach to measuring safety culture. Using the "Controlled Adaptive and Flexible Experimental Office of the Future in an Ecologically Valid Environment" (CAFÉ OF EVE) (p. 210) method, researchers would become fully immersed in the safety culture being researched. By integrating with permanent employees, researchers are able to understand the underlying beliefs through day-to-day practices. In addition, researchers would conclude each day with a reflection period on safety culture where Glendon (2000) suggests, "[T]he end of day briefing is more akin to an after work report to the worker's spouse or partner, than to a distant researcher. Within this context it is expected that worker reactions will be less abridged than would be the case in typical research interviews" (210). While this seems to be an ideal situation for in-depth research, Glendon (2000) does not elaborate or approximate the time required for this experiment suggesting that the costs of such an endeavor outweigh the benefits. Given the relative success of climate surveys, this seems to be the preferred method of gathering safety-culture, baseline data.

D. Empirical Evidence of Safety Culture

In 2010, Jon Ivar Håvold published his findings after analyzing the safety culture aboard Norwegian fishing vessels. This study follows after the Norwegian Maritime Directorate issued

a report in 2008 stating, "[T]raining routines have failed seriously, risk assessment and safety evaluation of work operations have been inadequate and…supervision of workers with little experience have been inadequate" (cited in Håvold, 2010, p.1054). Initial research showed that inexperienced workers between the ages of 20 to 29 had the highest injury rate among fishermen. Bruises, broken bones, and severe cuts were among the most common injuries among this age group. The majority of fatality victims were in the 40 to 60 year-old age group. The most frequent cause of death among fishermen was drowning after falling overboard. Slippery decks, trip hazards, or unexpected waves caused many fishermen to lose their lives. One possible explanation of this trend is complacency: younger workers are still new to the environment and alert to constantly changing hazards. While they are injured by not knowing best practices for handling equipment and machinery on deck, they do not overlook potential trip hazards. More experienced fishermen understand the equipment, but ignore the dangers in their work after adapting an it-can't-happen-to-me attitude and becoming complacent.

Håvold conducted a survey of fishermen to assess the safety cultures aboard vessels and its effect on complacency among the crews. He and three research assistants surveyed fishermen as they disembarked from their vessels in the Aalesund Harbor, Norway. In total, 209 completed the survey. Håvold analyzed the survey data using varimax rotated principal component factor analysis. The nine factors with an Eigenvalue greater than one were retained explaining 57% of the variance. A summary of results are seen in Table 1.

Using the nine factors from the factor analysis, Håvold uses an OLS multiple regression model to estimate the effect of each factor on the company's overall safety policy. He concludes that three primary factors affect a vessel's safety culture performance: the frequency of safety training and drills, the fishermen's attitudes towards safety, and management's safety attitudes.

Management's attitude towards safety influences safety performance twice as much as the other two factors. Håvold finds that management has the greatest effect on safety performance, but acknowledges injury-reporting issues across multiple dangerous industries. Underreporting injury statistics provides corporate management and government agencies a false sense of optimism that slows improvement measures. He concluded that the construction industry shares many of the same factors for underreporting injuries as crews aboard fishing vessels.

Table 1. Summary of the Results of Håvold:

Items and Factors	No. of Items	Range of Factor Loadings	Alpha	R^2
Factor 1. Attitudes to rules and regulations I get the work done better by ignoring some rules	3	0.73 – 0.80	0.82	8.2
Factor 2. Attitudes to safety training and drills All new crew members get proper safety training before they start work	5	0.40 – 0.82	0.76	8.2
Factor 3. Job Satisfaction I am satisfied with my work	3	0.53 – 0.70	0.73	7.6
Factor 4. Fishermen's safety attitude I am concerned about safety	3	0.52 – 0.81	0.71	6.4
Factor 5. Cooperation and working conditions Cooperation is better now than earlier	2	0.68 – 0.79	0.78	6.0
Factor 6. Stress and negative influence from work Work Pressure leads to sleeplessness	3	0.67 – 0.83	0.71	5.8
Factor 7. Conflict between work and safety Efficiency goals often conflict with safety goals	2	0.70 – 0.74	0.76	5.3
Factor 8. Pressure Sometimes the situation keeps me from working safely	2	0.74 – 0.75	0.76	5.1
Factor 9. Managements Safety Attitude Management is concerned about employees' health	3	0.45 – 0.48	0.68	4.4

Source: Håvold, 2010, p. 1057

He summarizes the reasons for underreporting in the construction industry as,"[L]ack of management commitment, negative or skewed perceptions of construction costs and their relationship to safety, poorly designed and implemented safety incentive programs, and workers' fear of reprisals from their supervisors" (2010, p. 1060). The lack of information flow can result in a disconnect between workers at risk and managers in positions to mitigate risk.

Håvold's statistical findings support a more recent survey conducted in 2014 by Safe Work Australia. The organization surveyed employers, workers, and health and safety representatives (HSRs) about risk taking practices in seven industries including the construction industry. The Safe Work found across the seven industries, 70% of HSRs and 64% of employers, "said that they never accept risk taking even if the work schedule is tight" (p.3) while 53% of workers report *taking* risks under the same conditions. In addition, approximately half of construction and trade workers, similar to those found in shipyards, feel that risks are unavoidable and consider minor incidents a regular part of the work-day. A disconnect of information is apparent as less than 20% of employers acknowledge that minor incidents are a routine occurrence even though over 40% acknowledge the dangers of the construction industry. These dangers are compounded by upper management pressure for production as in the crane and banksman culture study. When working under pressure, nearly 70% of construction workers admit to taking risks to complete the job on time. This presents a dangerous situation Taylor calls "Fear Culture."

E. Fear Culture

If safety culture is unchecked, it can develop into a negative force in the workplace. As Håvold demonstrated, management opinions of safety are essential to maintaining a strong safety

culture presence. When management constantly demonstrates value in production over safety, workers take notice of this attitude. Workers may be forced to improvise new solutions for tasks to increase production while being forced to sacrifice safety. If there are no incidents, managements opinions are reinforced that higher rates of production are possible. Given the survey results presented by Safe Work Australia, the unsafe practices may never reach the management level.

In the extreme case of the irradiator incident, plant management knew but the lack of any mishaps only confirmed the use of the "trouble shooting procedure." This encourages management to place more emphasis on production and less on safety. The worker is walking a fine line between losing his job for poor production or causing a major incident.

Similar situations existed in both the irradiator incident and the dropped load incident. In the case of the irradiator, the plant was managed by a company located in the United States while the facility was located in Puerto Rico. The geographic distance likely manifested a management distance as well. In the case of the banksman, a clear sub-culture had developed to avoid the "bureaucracy" of filing the appropriate paper work and delaying production. In both cases, these workers lost sight of the marginal costs and benefits of their safety efforts. Taylor (2010) explains the dangers of this situation:

> In this scenario, the workforce safety-beliefs are not aligned with management's beliefs. Productivity is essential but secondary [to the workers]. For the workforce the priority given to…safety has become entrenched possibly by experiencing first-hand the consequences of mismanaging the hazard. In their own self-interest the workforce may have established ad hoc [rules-in-use] safety behaviors for handling the [hazard]…. These become learnt behaviors and

> possibly independent of any organizational management system. The behaviors, good or poor, are adopted for 'survival' and passed down to each workforce generation. The workforce acts as a subculture. Perversely, the sense of self-preservation and the sub-culture's imposed safety rules may be all that keeps the business from a major event. (10)

Because of the "misaligned" safety beliefs, this puts workers in opposition to management. Taylor names this "Fear Culture." Workers will be afraid to voice concerns about working conditions with peers or management because challenges will likely be viewed as "Appearing to lack knowledge," or as "Letting the team or side down, not being 'on board'" (pp. 10-11). Once fear culture is established, there is a dangerous cycle of unchallenged, deteriorating safety practices.

3. POLICY SUGGESTIONS FOR MARGINAL COST-BENEFIT REALIGNMENT

The difference between a journeyman and an apprentice in a shipyard is experience. With experience comes knowledge of which tool to use and the best practice for a given task. Using the right tool for the job produces the best result with the least waste. When considering various approaches to safety management, selecting the right tool for the job is essential to producing a safer workplace. Like any process in a shipyard, there are multiple tools to accomplish the same goal. Culture, behavioral management, and nudges are all helpful tools for improving safety, but each tool is best for a specific task.

I. Changing Safety Culture

Most people resist change. Inertia in a person's day-to-day life can perpetuate the status quo for many years. The same is true of safety culture. If allowed, negative feelings and fear

culture can continue unrestricted, but the outlook does not need to be so bleak. With a firm commitment to safety from management, fear culture can be reversed to healthy, thriving safety culture. In shipyards, there are numerous positive benefits to robust safety culture.

Hajmohammad and Vachon (2014) explored the possible benefits of a strong safety culture. After surveying 1001 Canadian firms with more than 100 employees, the data was collected and analyzed. The paper differentiates between environmental performance and practice. Environmental performance according to the authors examines a company's attempts to minimize pollution at the source while environmental practices are a company's commitment to handling present pollution output in an environmentally conscience way. Using a partial least squares regression model, Hajmohammad and Vachon determined that safety culture has a positive effect on both safety practices and environmental practices at the 1% significance level. Ships and shipyards have a reputation for not being environmentally friendly, leading to stricter regulations about environmental practice. Making a shipyard safer and more environmentally friendly is a definite path to improving the organization's bottom line.

In addition, strong safety culture has a positive effect on environmental performance and financial performance at the 5% level. Other intangible gains according to Hajmohammad and Vachon conclude, "[O]rganizations…where (i) top management is concerned about employees' safety and well-being and (ii) employees are empowered and… participate in safety-related activities, are more likely to gain better financial, environmental, and safety outcomes as a result of their increased employee's commitment in pursuing organization goals and objectives" (273). The benefits of safety culture are quite intuitive: if an employer watches out for its employees, its employees watch out for the employer. The benefits are clear, but charting a course for perfect safety culture is a more obscure.

In order to overcome organizational inertia, there must first be recognition of the problem. Recognition may come after a serious incident, an outside inspection report, or an internal audit of the organization's safety culture. Using surveys and incident reports, safety professionals within the organization can establish the present state of working conditions, interrelationship dynamics, and the rules-in-use. While Glendon's (2000) discussion of the immersive research method CAFÉ OF EVE seemed cost prohibitive for researchers, safety professionals are in the perfect position to have the candid conversations with workers the method suggests. Artefacts, espoused values, and accepted norms factor into the final safety culture evaluation. Once the report has been finalized and management accepts a change is required, the next step is to establish safety goals.

Establishing goals make the transition period easier for current employees and executive management. Taylor (2010) warns, "To reduce the level of anxiety the compelling vision of a better future has to be effectively communicated….An unsuccessful communication will be replaced by rumour. The anxiety generated by the rumour of change may be so great that resistance may emerge before proposals are formally suggested and fail against the 'old' stability" (p.173). Redefining safety culture must come from upper management and the trickle down through the ranks. Often at this level of the organization, executives rarely must admit they are wrong making this process potentially difficult. As Taylor expressed, clear goals are imperative to establish the benefits of safety culture improvement. Once senior management is onboard, supervisors and workers need to learn quickly that changes do not equate to job loss or required humility. Training sessions and information can be distributed that explains the roles of each level of the organization in the new safety culture structure. The idea is to create a unified force working towards a safer workplace, not to alienate employees who are skeptical or

resistant. Through mentoring and open dialogue, additional concerns can be addressed and added to the safety culture program. More ideas and concerns are likely to come forward after a safe environment for discussion is assured. The ultimate goal for any safety culture realignment is to encourage understanding of risk management and how to minimize potential risk.

II. Strategies to Minimize Risk

Many methods exist to analyze and minimize risk in the workplace. This paper focuses specifically on two methods: Organizational Behavioral Management (OBM) and Nudges. While neither of these schools of thought is specifically designed to provide in-depth risk analysis, both of these programs are relatively easy and inexpensive to implement. To a newly improved safety culture, these two techniques are a way to train all levels of the workforce to be more aware of their safety environment through structured improvement processes. It is important to note, that a supportive safety culture must be in place to guarantee the success of these efforts: OBM and nudges do not improve safety culture. Safety culture improves OBM and Nudges.

A. OBM

The concept behind OBM is really quite simple: make a worker aware of a problem behavior, and he will correct it. The challenge originates with the average worker's inability to analyze risk when probabilities are very low. In fact, Howard Kunreuther, Nathan Novemsky, and Nobel Laureate Daniel Kahneman (2001) explain, " the need to give individuals enough context to draw on their own experiences and well-developed risk perceptions, if we are to ask them to evaluate an unfamiliar risk which has a small likelihood of occurring" (p. 117). By

reminding workers of potential risky behaviors, workers consider the actual marginal costs and marginal benefits of a safety effort.

Consider the incident at the irradiator facility. While a poor safety culture allowed all levels of plant operators to ignore the deteriorating situation, the use of the "trouble shooting" procedure was reinforced each time workers entered the irradiator room and the rack was safely at the bottom of the pool. The possible reward to facility management was acknowledgement by corporate and perhaps a financial bonus for increased productivity for all of the plant operators. In many industries including dangerous industries, financial bonuses correlate with production. This gives workers an incentive to skip or rush though simple processes to increase productivity. Workers do not initially understand the likelihood of an incident occurring, so the worker takes a seemingly insignificant risk. When that worker completes the task without injury, the risk-taking behavior is reinforced and the marginal costs and benefits are skewed compounding the initial problem.

Instead of providing individuals context to understand the probability of low-risk, high-impact hazards, OBM provides a different stimuli to encourage reduction of unsafe activities by realigning marginal costs and benefits. Sulzer-Azaroff (1987) explains that positive reinforcement for risky behavior forms unwanted "contingencies" in work practices: "As…behavioral analysts have demonstrated repeatedly, behavior is a function of *contingencies* (i.e. relations between responses and stimuli). When unsafe behavior occurs, we can assume that past and present contingencies have played a role" (178). As Sulzer-Azaroff and Kunreuther et. al. pointed out, workers are facing a compounded problem. Breaking the cycle of reinforcing unwanted behaviors is the goal of OBM.

1. Incentives

To reduce unwanted behaviors, the organization must first recognize the existing incentive structure. Sulzer-Azaroff examines a simple example of a cabinetmaker sharpening his chisel with a grinder. While the cabinetmaker's safety glasses are in reach at the grinder, the employee does not use the eye protection. During the operation, a small piece of metal flies into the worker's eye. Sulzer-Azaroff lays out the incentive structure for this incident:

- If the worker had not sharpened his chisel before finishing his work, "The groove would not be cut to his standards….He has learned in the past to avoid using a dull tool because the consequences were consistently and immediately punishing" (p.179).
- If the worker had chosen to wear his safety glasses, his work would have been delayed by a few moments, and his peers could potentially harass him. The only positive outcome of the safety glasses would be eye protection from an unlikely risk. Sulzer-Azaroff summarizes, "Avoiding the immediate negative consequences, the time and effort he would need to take, and the possibility of being ridiculed, outweighed the positive ones" (179).

In this example, the incentive structure reinforces the cabinetmaker to not wear his safety glasses. A strong safety culture would prevent the worker from being "ridiculed" by his peers, but cannot change the incentives surrounding eye protection. Through reinforcement, much more than eye-protection habits can be improved.

2. Identifying Problem Behaviors

To improve workplace habits, first the problem behaviors must be identified. Sulzer-Azaroff describes three methods for identifying problem areas: incident reports, interviews, and

direct observations. Incident reports provide detailed information about the situations surrounding recurring incidents. Incident reports can be complied to uncover chronic problem areas such as personal protective equipment (PPE) use or trip-hazards. Interviews with multiple levels from workers to upper management can provide insight of behavioral practices. These interviews must be anonymous so workers feel comfortable talking about potential safety problems.

In one interview series Sulzer-Azaroff (1987) recounts, employees disclosed information about particularly dangerous practices such as a fork lift operator speeding around corners to potentially scare workers (p.183). While this seems like absurd behavior, researchers and management would have remained unaware of such overtly dangerous behavior without the interview process. Workers are often the best resource for identifying problem areas and unsafe practices. The final method that Sulzer-Azaroff suggests is a direct observation of the workplace. Direct observation will confirm suspected problem areas uncovered through interviews and incident report research. Touring the facility also gives the OBM program coordinator to identify potential solutions to the problems.

3. Modifying Behaviors

With known problems, the next step is to determine the best method for modifying behaviors. Previously, safety doctrines have promoted training and punishment. Sulzer-Azaroff asserts the former, “produces either ineffective or ephemeral change” while the latter, “might cause more problems than it solves” (p.187). Traditionally, organizations have used fines to align the organization and individual costs of unsafe behavior in the work place. However, punishments such as, “reprimands, fine, penalties and adverse personnel actions” (190) can cause

an employee to be alienated from the work force or feel unable to properly communicate with his supervisor in the future. In some instances, the punishment may be frustrating for the employee if a viable, safer alternative is unavailable to the employee. Instead of the supervisor helping to correct the problem, the supervisor reprimands the employee for not following the prescribed procedure. An alternative to training and punishment is reinforcement.

Reinforcement is anything that encourages a desired outcome. Reinforcement can come in many forms and can range from simple to elaborate. Sulzer-Azaroff (1987) advises:

> "unless used with care, (individualized, presented irregularly and sometimes unexpectedly) prizes and awards soon begin to lose their appeal, while having one's efforts specifically and sincerely acknowledged or praised by a respected peer or supervisor will tend to keep serving a reinforcing function. The costs involved in the latter are so comparatively minimal that continuing to deliver those consequences pose no major challenge" (p.188).

Intuitively, this is an approachable concept already explained by the law of diminishing marginal utility. If every time a worker wears his safety glasses he wins a new bicycle, he will soon have an overabundance of bicycles when he may not have even wanted one. In this way, a prize can actually reinforce the wrong behavior. Praise and acknowledgement is something that most everybody enjoys. While praise is also subject to diminishing marginal utility (a supervisor commending every action, "Great job eating your lunch!"), most people's threshold for diminishing total utility is such that some praise is welcomed reinforcing the target behavior. Sulzer-Azaroff makes a distinction between reinforcement and feedback: feedback is a highly effective form of reinforcement.

4. Providing Feedback to Measure Success

Determining the delivery method of feedback and tracking progress are the final step in the OBM system. Several methods have proven successful to disseminate to progress of the program and thereby reinforce the target behavior. In a typical case, supervisors and an OBM expert discuss problem behaviors and develop a list of target behaviors to correct using the steps above. Once these target behaviors have been defined, supervisors randomly assess the workplace for these target behaviors. From one study conducted by Jorma Saari and Merja Näsänen (1989) that examined the interaction between industrial housekeeping and incidents, examples of target behaviors include coiling and storing cables and hoses when not in use, placing scrap material into the scrap bin, and protecting by-standers from welding arc-flash with UV screens (p.204). The important commonality among these target behaviors is each behavior has a definitive yes or no status and specific violations are apparent and quantitative. When the supervisor inspects for the violations, he can tally the total numbers. Several supervisors inspect the same areas to prevent inaccurate observations. After a baseline has been established, the workers are presented the data collected. For the Saari and Näsänen study, seven weeks of data established the baseline.

The workers are presented the data in several possible ways. The data can be verbally shared with the workers or presented with a graphic in a convenient location. The graphic seems to be more effective especially when supervisors discuss the chart during daily or weekly crew meetings. While presenting the baseline data, supervisors need to explain the definitions and the pass/fail criteria of each measure. Educating the workers builds confidence among the crew that improvement can be made. At this time, goals should be set that are optimistic but realistic. As Taylor (2010) explained above, change makes people uncomfortable. Explaining to workers the

process and reinforcing the benefits is essential to the project success. Saari and Näsänen found that after the feedback was presented, workers increased compliance to the survey criteria by 23% to an average compliance rate of 85% (p.208).

Saari and Näsänen tested the differences between the baseline and improved compliance rate variances. They used an F-test to determine whether the differences in the compliances rates were statistically significant. If a number is statistically significant, this means the difference between sample variances is in fact correlated to the experiment and not attributable to random variation in the observations. The F-test as Gerald Keller (20140), "pointed out…can be used to address problems where we need to judge the consistency of a production process" (p.481). In this case, the production process is worker compliance rates. Compliance rates before training formed the baseline data. The second population consisted of worker compliance rates after being educated. To conduct the F-test on the two populations, Saari and Näsänen defined the null and alternative hypothesizes. Since they are testing for significant difference of population variance, the null hypothesis was:

$$H_0: \frac{\sigma_1^2}{\sigma_2^2} = 1$$

If the variances of each population are the same, the ratio is equal to one. The alternative hypothesis would be:

$$H_1: \frac{\sigma_1^2}{\sigma_2^2} \neq 1$$

After defining the hypothesizes, next the test-statistic is calculated by computing the ratio of sample standard deviations. Saari and Näsänen do not publish the sample standard deviations in their paper, but include the test-statistic for F [1,19] =107 (p. 208). To reject the null hypothesis, the test-statistic must be greater than the F-critical value found on the F-distribution table. For F [1,19] at the 0.001 significance level, the F-critical value is 10.1. The test statistic

exceeds the critical F-value; therefore, the null hypothesis is rejected. This means that there is a difference between the two sample population variances. With over 99% certainty, Saari and Näsänen concluded that their experiment had improved the overall compliance of workers with the behavioral management program. This improvement remained two years after the initial study without change. After two years, Saari and Näsänen concluded OBM has lasting effects. These results are in-line with other studies in the literature (Sulzer-Azaroff, 1980; Bumstead & Boyce, 2005).

5. Sustaining OBM Programs

Once an OBM safety feedback system is in place, evidence shows that the systems are typically self-sustaining. This is particularly true in cases where the unsafe behavior is an issue of education. Terry McSween and Grainne Matthews (2001) use the example of a child safety seat. They explain during the late 1990s, child safety seats were notoriously installed incorrectly with an estimated 85% have more than two problems (p. 77). After a campaign aimed at educating parents, McSween and Matthews believe parents will continue the new found safe behavior without any "maintenance." Maintenance echoes Sulzer-Azaroff's warning about a specific reinforcement losing its effect over time. McSween and Matthews argue that correcting educational deficiencies are self-sustaining, but caution about over types of interventions. They assert to maintain an intervention system, employees need to periodically be retrained on the process and why the process works. Workers, supervisors, and management need to be actively involved in the process at all levels. A preexisting strong safety culture will make implementation a smooth process. Most importantly, a single entity within an organization needs to take charge of the OBM system and maintain the process, conduct observations, and

analyze the results. For any organization that has a safety professional and a well-established safety culture, OBM is an ideal solution to common issues.

6. OBM Challenges

Unfortunately, OBM does have some challenges. The system works well for observable behaviors such as coiling cords and placing scrap steel into a bin. The problem arises when unobservable or briefly observable behaviors are the target behaviors. For example, in a shipyard galvanized steel is a commonly welded material. When galvanized steel is welded, it produces a poisonous smoke that can make the welder and those around the operation sick very quickly. If the target behavior is to ensure welders are wearing respirators while welding galvanized steel, this could be difficult to document. The welder may be only tack welding a piece of galvanized and decide the extra effort of finding a respirator is not required for such short exposure. Unless the safety observer is present to watch this behavior, there is no way to record the action making the OBM system impossible to use. Another example recalled from the author's memory is handrail usage while traversing the gangway on or off the vessel. The vessel had a policy that required crewmembers and shipyard employees to have at least one hand in contact with the gangway railing at all times. This particular gangway was set at a shallow angle that was easy to walk and the walkway was fully enclosed in safety guards. Shipyard employees who used the gangway numerous times each day and often carrying tools and other equipment had difficulty remembering to use the handrail even after being reminded by project management on numerous occasions. The OBM system relies on data to drive people in the intended direction. Collecting data on the handrail usage would require a safety official to spend a

significant time watching people use the handrail. Time that could be better spent enforcing violations that are more dangerous. This is the idea situation for a nudge.

B. Nudges

A nudge is a simple machine. In terms of labor and financial commitment, the nudge is the Holy Grail of management practices. The idea behind a nudge is using choice architecture to direct people to the intended action without taking away any of their rights. An example of a very simple nudge would be a fire extinguisher stored behind a piece of glass. The piece of glass nudges people to prevent tempering, but allows the extinguisher to be used by simply breaking the glass. According to Thaler and Sunstein (2008), the amounts found on a charity donation form are an intangible nudge compared to the piece of glass. When charities include donation options in the thousands rather than the hundreds, people are likely to give more money to the charity simply because the charity asked for more. Understanding how people think is important to why the nudge works.

1. Underlying Nudge Framework

The principal behind nudge theory is the different ways people think. People have two systems of thinking: the automatic and reflexive systems. The automatic system is composed of instincts and thinks much faster than the reflexive system, which is dedicated to problem solving and thought provoking tasks. Both systems are analyzing information constantly while a person interacts with the world. When a person touches a hot stove and quickly pulls his hand away the automatic system made that decision. When a person converts the temperature of the stove from Fahrenheit to Celsius, that person is using his reflexive system. When people try to solve

problems quickly, the automatic system often interferes with the reflexive system. Thaler and Sunstein (2008) use the example, "If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?" (p.21) 100 minutes seems like a tempting answer at first glance. Once the reflexive system processes the information, five minutes is clearly the right answer. In the few moments that it took for the brain to process the information, 100 seemed like the most logical answer.

In order to compensate for the errors of the automatic system, people's brains develop rules of thumbs that can guide them to decisions faster or when there is incomplete information. Thaler and Sunstein (2008) separate rules of thumb into three heuristics: anchoring, availability, and representativeness.

- Anchoring discusses the way the brain processes information. Like the suggested contribution amounts on the charity donation form, humans process information and numbers based on other information. Kunreuther et al. (2001) demonstrated anchoring with his study about people's inability to comprehend very low probabilities without additional reference points.
- Availability explains the way people estimate risk. The easier an available example comes to mind, the more likely the perceived threat. If the reader of this paper were asked to name a nuclear power plant accident, the Chernobyl reference might be an easy connection to make. If asked to name someone struck by lightning, the answer might not be quite as easy even though being struck by lightning is far more likely.
- Representativeness is the proclivity of people to look for patterns in random data. Thaler and Sunstein use the example of a coin toss. The coin toss is equally likely to

result in heads or tails. When a person flips the coins several times and each time the coin lands on tails, people have a tendency to think a pattern exist.

The rules of thumb couple with several other human tendencies when considering human behavior. People hate losing things. Thaler and Sunstein claim that a person hates losing something about twice as much as he likes to have something new. Formally, this is known as loss aversion. Fortunately, most people do not think they are going to be the person who loses something. People have an innate sense of optimism and self-confidence. Statistically, about half of marriages end in divorce, but near the wedding day, neither party believes there is any possibility of divorce. Since humans are typically followers of the status quo, a divorce can be a very difficult thing. Often, once a person commits to doing something; there is a tremendous hesitation to change. There may be less hesitation depending on how a specific piece of information is framed. If a doctor informs a person he needs a procedure and that 90 of a 100 people survive, that person's reaction will be very different than if the doctor informs the patient 10 out of 100 people die. (Thaler & Sunstein, 2008, 31-37) Learning to use these human tendencies can produce simple but efficient solutions to problems.

2. Practical Nudging

Shortly after the book *The Nudge* was published, government officials implemented nudge policies. The United Kingdom formed the Behavioural Insight Team (BIT) in 2010, Mark Kosters and Jeroen Van der Heijden (2015) explain. This appropriately named "Nudge Unit" was created by the UK to explore government applications of nudging. Binyamin Appelbaum (2015) wrote in a *New York Times* article describing the successes of the Nudge Unit, "The British government…found it could increase collections from delinquent taxpayers by telling

them nine in 10 neighbors had paid up…" (p. 1). Within a few years of the Nudge Unit, President Obama was authorizing the American "Nudge Squad." Appelbaum (2015) explains the American government altered the layout of a form used to report money owed to the federal government. Instead of leaving the signature for the end of the form, the new layout required users to pledge their honesty at the beginning the form. The results: $1.59 million more was paid to the government than previous periods. Changing the layout of the form is an easy process for an extra $1.59 million. Simple changes like the form or explaining the payment rate of a person's neighbors are nudges. These are low cost solutions to increasing compliance are a new frontier for government policy: to safety officials, nudges are old news.

In the realm of safety, nudges have existed for many years. Jennifer Lunt and Malcolm Staves (2011) claim that nudge theory is," already used in health and safety by many professionals to raise situational awareness, make safe behavior the default action, promote employee participation and secure management commitment" (p.42). They provide examples such as color-coding pipes to allow workers to know the characteristics of the contents of the pipe, painting walkways to segregate pedestrian and forklift traffic, and color-coding dangerous parts of machinery to nudge avoidance. Lunt and Staves argue that the nudge is a useful tool in overcoming challenges of OBM. The nudge reminds workers of the risks involved with difficult to observe behaviors or extremely low-probability disasters that could result in serious incidents.

Some organizations have taken advantage of the availability heuristic and produced posters to remind workers of potential outcomes. Other organizations rely on the representative heuristic when designing gauge readouts for different processes. Different processes have uniquely designed gauges forcing the observer to differentiate between the multiple readings, thus reducing the likelihood of confused readings. One infamous nudge can be found in the

men's restroom at Schiphol Airport in Amsterdam. The urinals in the restroom have all been etched with an image of a common housefly. According to Thaler and Sunstein (2008), the fly resulted in an 80% reduction in "spillage" (p.4). These and other techniques are becoming more prevalent in UK industries since the Nudge Unit has come on the scene.

3. Nudge Challenges

Nudges are subject to the same adages as everything else: "you get what you pay for." The cost for most nudges is extremely cheap: changing a form layout, painting a pipe, or etching a fly on the inside of a urinal. Nudging is well equipped to deal with simple tasks as Lunt and Staves indicate, "Nudges are…more applicable to one-off behaviors than more complex chains of actions. Nudging a construction worker to wear a hard hat is easier than nudging safe scaffolding assembly" (p.42). A nudge is not a generalized push towards safety, but is limited to encouraging safety conciseness in one task. For example, the cabinet maker who often neglected appropriate eye protection would be an ideal candidate for a nudge. By placing a sign near the switch to activate the grinder, reminding the worker of the possible outcomes would encourage the proper use of his eye protection. While most of the literature agrees this type of nudge would be effective, the question becomes how long. After the cabinetmaker sees the same sign every time he sharpens his chisel, how soon before he forgets to heed its warning? Appelbaum (2015) quipped in response, "Mr. Thaler noted that alarm clocks wake people up every morning" (p.2).

The bigger issue as Mark Kosters and Jeron Van der Heijden (2015) point out is whether the nudge is effective at all. Many studies have shown the nudge to be very effective while an equal number of studies have shown less promise. Kosters and Vander Heijden note several studies appearing successful have published percent increases instead of absolute increases

causing inflated optimism (p.284). In other instances, nudges have been transplanted to a new location and have had drastically different effects. Authors of nudge studies counter these accusations by including, "many caveats, the most recurring being that the finding holds in a particular setting" (p.286). Ultimately, Kosters and Vander Heijden (2015) note that, "with nudging being such novel terrain it is unlikely that large-scale cross-sector, cross-time and cross-country studies can already be carried out" (p.287). With the preliminary data available from numerous studies and professional commentaries on nudge theory, nudging as Lunt and Staves (2011) assert nudging, "could be just what is needed to drive health and safety performance to the next level" (p.44).

4. SHIPYARD APPLICATIONS

Shipyards are dangerous places to work. According to the US Department of Labor and Statistics (BLS), nearly 6 of every 100 shipyard employees were injured on the job in 2014. This is twice the national average for private industry reported by BLS for the same year. While shipyards are not the most dangerous place to work, there are many challenges unique to constructing the largest moving objects on earth.

I. Shipyard Safety in the 1940s

McElroy and Svenson (1944a) found numerous unsafe working conditions. The proper personal protective equipment (PPE) was not always readily available to workers completing dangerous tasks. Eye protection was the most commonly lacking PPE. Poor housekeeping caused 13% of the incidents (1944a, p.15). Examples noted in the report include workers slipping on welders' hoses and cables, tripping on excess material scattered around the worksite,

and slips caused by puddles of water or oil on walkways. McElroy and Svenson describe "Defective Agencies" as broken hand and power tools; also included in this category are staging platforms. Staging platforms are temporary structures constructed to allow workers access to otherwise out of reach areas of the vessel. Because of a ship's size, staging is required to perform most tasks. The report found that many stagings were not constructed by certified-staging assemblers and therefore never inspected before use. Welders created an additional problem by positioning bracing and applying only a temporary tack-weld to hold a part in place[4]. These parts were never fully welded compromising the strength of the assembly. When workers walked on these under-welded portions, the decks gave way below them.

McElroy and Svenson (1944a) continue their report by describing "unguarded agencies" as deck openings and elevated work platforms without proper handrails or guards to prevent a worker from falling. They also noted the dangers of guards removed from machinery and workers subjected to unshielded welding arc flash. In addition to unguarded agencies, the report notes workers often lifting heavy loads without using proper lifting techniques resulting in back injuries. The report concluded with injuries caused by improperly rigged overhead loads and, "failure to stand clear of slings and sling loads" (p.23). Unfortunately, over 70 years have passed since McElroy and Svenson penned this article, but shipyard workers are still suffering the same injuries.

II. Shipyard Safety Today

In 2013, Alliance, an organization of various shipbuilding trade organizations published a leaflet discussing the importance of wearing eye protection. The leaflet cites the US Department

[4] A tack-weld to a welder is what a straight pin is to a tailor. There is not much strength in a tack-weld with the idea that a few hammer blows can break the weld, and the part can be repositioned if needed.

of Labor stating, “Eye injuries alone cost more than $300 million per year in lost production time, medical expenses, and worker compensation.” (n.p.) In 2015, *Marine Log* reports of a Great Lakes shipyard being cited by the US Occupational Safety and Health Administration (OSHA) for numerous violations including removing guards from machinery: the same machinery that had amputated a man’s arm in 2008. Newport News shipyard was fined after a worker fell to his death from an unguarded work platform in 2008 (Richards, 2008). The examples of present day shipyard incidents are endless, but the circumstances of each incident are nearly identical to the dangerous behaviors identified in 1944.

This paper finds the best practice for reducing shipyard incidents is to educate workers about the marginal costs and benefits of safety efforts. When a worker recognizes that the perceived benefits outweigh the costs, he will become a safer worker. Improving safety in shipyards is not a matter of selecting the best of the three strategies, but selecting the best *combination* of these strategies to remind workers of the actual marginal costs and benefits they face. The bottom line: shipyards are dangerous places. The challenge is minimizing the safety risks for workers and employers while still being able to produce finished projects. To accomplish this, a three-level approach to safety is required. Safety culture is essential to maintain a high-level of safety awareness throughout the organization bringing safety cost-benefit analysis into the conscience thoughts of the work force. Trade supervisors should implement OBM to encourage and promote safe behavior on vessels and around the shipyard, and nudges should be used to remind workers of the immediate risks at hand. Working in concert, these three theories will positively influence safety performance.

III. Positive Safety Culture in Shipyards

When workers feel like nothing more than ID numbers, the relationship between the worker and the company is often strained. Workers feel like executive management is focused only on profits and losses while the people who do the physical production are written off as replaceable. Workers sense a lack of commitment by management regardless of the espoused management statement to workers. When this situation happens, workers are not fully committed to the company and go to work to collect a paycheck. Workers' pride in their work begins to suffer. As a result, overall work quality declines creating a cycle of unhappy workers producing poor quality work who are then reprimanded by supervisors and upper management. With supervisors constantly scolding workers' poor performances, fear culture can easily manifest itself in the workplace. Workers hesitate to comment on all shipyard practices including safety. When workers do voice their concerns, little or nothing is done with the information further discouraging workers. This disconnect in information flow creates opportunity for dangerous situations.

Changing safety behavior in shipyards starts with changing safety culture. Establishing a positive safety culture is the foundation for other safety initiatives to gain momentum within the organization. When management values worker safety over other goals, workers notice. A commitment to workers gives the workforce an improved sense of self-worth and a more positive relationship with the company, thereby laying the groundwork for a robust safety culture. When workers are recognized as important contributors to the overall success of the company, they feel obligated to continue to provide the same level of excellence to avoid letting their team down. This supportive environment establishes an open dialogue between workers, supervisors, and upper management. These lines of communication are essential to improving overall safety and

worker moral. When a strong safety culture exists, workers feel supported by supervisors if a project takes more time to complete safely. Supervisors are available and receptive about new ideas and strategies devised by workers. When workers have safety concerns, supervisors address concerns and have access to the resources needed to correct the problem. Simply, workers and supervisors are playing on the same team: both want to help the other to the best of their abilities.

Positive safety culture in a shipyard helps to overcome challenges with new worker turnover. In shipyards, trade workers and subcontractors are assigned to specific projects that can last for weeks or months. During the duration of a project, some workers may be transferred to other projects, workers may be laid off, or others may be hired. The workforce on any particular project is in constant flux even if the overall employment within a yard remains the same. This makes safety training challenging particularly with new and subcontracted employees. While there is no substitute for a trained worker, how outside workers use their training can be significantly affected by the safety culture on a particular project. When the existing workforce has a positive safety culture, new employees are encouraged to follow suit. A positive attitude really is contagious; safety culture is evidence.

Over time, the importance of safety becomes an underlying assumption of the workforce: achieving that level of commitment takes time. Unfortunately, there is no exact recipe for the ideal safety culture. The literature suggests the most important ingredient is upper management commitment to safety. From the top, the idea flows down to middle management and then workers. Often times, upper management needs to be educated to understand the dangers involved with the projects happening in the shipyard before serious changes are supported. Working in an office making decisions about timelines and needed equipment is a very different

experience from trying to weld a piece of boilerplate with too little time and without the right equipment. The second most important ingredient, communication allows management to understand the exact needs of the production team. By communicating needs, tasks can be completed in a safer and more efficient way. Over time, workers, supervisors, and managers will begin to trust the abilities and opinions of each other. This is evidence that the optimal safety culture exists. Reflecting on the incident at Vigor Industrial, safety culture was a dominate factor.

IV. Safety Culture at Vigor Industrial

About two months before the incident, Vigor Industrial purchased the former Todd Shipyard. The employees in the yard were from many different Vigor shipyards to work in Seattle. The new ownership was restructuring the way the company operated in the Seattle yard. Think of the new Vigor shipyard as an automotive mechanics' shop just on a much larger scale. When Todd Shipyard managed the shipyard, the entire yard functioned as one entity. Each service bay in the mechanics' shop worked together with mechanics worker on one vehicle and then another. If one bay had a tool needed in a different bay, the tools were passed between the two bays and work progressed smoothly. Under the new Vigor management, the yard was split into three separate entities. The yard was still a mechanics' shop, but now each service bay was its own entity with separate equipment and workers. While there was no fence to separate the work areas, tools sitting idle in one bay of the garage could not be used in another bay of the shop. Instead of using equipment available elsewhere in the yard, equipment occasionally had to be transported in from another yard. This challenge plagued the workers aboard the *Kulluk*, and proved incredibly frustrating to the employees in the former Todd Shipyard.

Because of the equipment issues, the work on the *Kulluk* was perpetually behind schedule. Management had difficulty tracking who showed up to work on a given day before ever considering the equipment they needed. Trade workers were voicing their frustrations with the process and constant reprimand from management for being behind schedule. With increased pressure, workers made mistakes and safety was definitely subordinate to production. In the weeks leading up to Shelby's death, several other safety "near-misses" resulted from other workers. Management's response to these events dictated the offending worker to be sent home without pay to "think about his actions." The observed workers did not appear very reflective on their return.

That day that Shelby climbed up to that platform, there was no reason to suspect he did not plan to come back down. Under pressure from management and approaching lunchtime, there is no doubt that Shelby was working as quickly as he could to finish his assigned task. Standard practice dictates workers working overhead must secured their tools to their person. A wrench falling from the height of the platform could easily kill someone below. Why Shelby's wrench was not secured to his person, is a question without an answer. Perhaps the tool room was out of retractable tool straps, or maybe Shelby could work faster with the wrench unattached. The fact that it was not attached and out of reach forced Shelby to make a decision. He could descend the ladder and retrieve a longer lanyard for his harness to safely reach the wrench. This option was the safer option, but may have led to reprimand and a suspension if Shelby were discovered: an unsecured tool would constitute a near-miss. In addition, the wrench could fall in Shelby's absence and kill someone. A wife and six children at home probably incentivized Shelby not to "risk" being suspended. Instead, he thought he could traverse the beam and retrieve the wrench in order to save time and that week's paycheck.

Safety culture played a role in this incident when the group consensus valued production over safety. As management exerted more pressure on workers, trade workers began to take shortcuts. The increased pressure changed the workers' perceived marginal cost of safety effort. Management's reprimanding convinced workers that the costs of safety behaviors far exceed the marginal benefits. A strong safety culture educates and supports workers to make accurate evaluations of the optimal amount of safety. There was not a strong safety culture at Vigor Industrial.

V. Managing Behavior is Shipyards

Once safety culture change is underway, OBM is a great way to further safety improvement. Safety culture creates an environment where workers will support positive change and supervisors will readily complete the needed observations. Supervisors and managers working together define the target behaviors by looking at past incident reports and through personal experience. Some important areas to consider would be housekeeping and PPE use. Housekeeping items may be similar to items noted by Saari and Näsänen (1989) such as properly stored cords, scrap metal placed in the scrap bins, properly routed welding leads to reduce tripping, and ensuring Lockout/Tagout procedure compliance. Lockout/Tagout (LOTO) procedure is a method for securing a piece of equipment or a system before maintenance is performed. This is typically performed on electrical equipment by locking the power source in the de-energized position with a physical padlock. The worker tasked with the maintenance operation keeps the key to the padlock in his possession so power is not inadvertently restored to the piece of equipment being repaired. A similar procedure is followed for piping systems.

LOTO is a prime target behavior for OBM because an observing supervisor can quickly assess whether a system has been locked and tagged out. This also encourages supervisors to be aware of each day's tasks and what areas and systems of the vessel are going to be involved. Most vessels are still living spaces for crewmembers while in a shipyard, so shutting down the ventilation system or some other essential system will require communication with multiple parties. Employees' wearing appropriate PPE is a possible target behavior for OBM. Most shipyards require workers to wear hardhats and safety glasses at all time. In these yards, checking for compliance is simple for a roaming supervisor. In particular areas of danger such as inside painting containment or in areas with extensive galvanized welding operations, supervisors can determine whether painters or welders are wearing the appropriate respirators and other PPE.

By reminding workers of the requirements and then showing compliance using a graphic produced weekly for the workers by a safety professional, the literature suggests housekeeping efforts and PPE usage will increase. The main idea with OBM is to encourage workers to be aware of safety issues and use positive encouragement to correct those issues. If a well-established safety culture exists, workers will be more receptive to the feedback given by supervisors. Once basic safety challenges are addressed, OBM can be used to address more complicated issues such as staging construction. Staging can easily be inspected by supervisors to ensure staging construction guidelines are followed. Because staging should be inspected periodically to confirm its safety, this would not add any additional burden to the supervisors. Inspections can include criteria such as the presence of handrails, toe boards, and appropriately braced platforms. Providing feedback for these inspections will have two benefits. First, carpenters will build stagings to the guidelines more often and fewer forgotten safety features,

e.g. handrails. Second, the results will educate workers not trained to construct staging of some of the basic parts of a safe working platform. By educating workers, they can better understand the marginal costs and benefits of avoiding dangerous stagings. In the future, workers can apply this knowledge to quickly inspect the stagings in their work areas for obvious defects. Having more workers looking for safety risks keeps safety in the front of the workers' minds.

VI. Nudging Shipyard Practices

While safety culture and OBM are occupying workers' consciousness, nudges can be sub-consciously guiding workers towards safety. Nudges have large potential in shipyards because they can affect workers exposed to a nudge only once. Because long trainings are not required of nudges, they will be particularly effective on subcontractors and new employees who may be least familiar with the shipyard and safety practices. There are three types of nudges that will potentially improve shipyard safety: financial, physical, and poster campaigns. Each type has distinct applications and limitations, but the low implementation costs allow multiple nudges without much cost to the organization.

A. Financial Nudges

Financial nudges are quite simple. People go to work to earn a paycheck, so more money makes people happier. In the past, workers often earned bonuses after meeting certain production goals. This practice encouraged production over safety by encouraging workers to ignore safety procedure to finish the job quicker. By changing the incentives, organizations can encourage safety with performance bonuses. Financial nudges are not fines levied on workers who do not follow safety procedures. Fines will create disgruntled employees and a disconnect

between supervisors and workers. Financial nudges should aim to reward workers for being safer and following safety procedure. If OBM data were collected on housekeeping and PPE, this would be ideal determinant of the bonus. Because bonuses are being determined from the data collected, the data should be published without workers' names. If in the pay period a certain threshold is exceeded, then the bonus is paid out. The bonus should be small, maybe an extra hour's wage to each worker, but enough that the worker notices a difference. Each pay period, the target threshold is adjusted to keep the challenge interesting. The threshold should be designed in such a way that the goal can be met, but not every time. Given people's tendency to loss aversion, this should encourage workers to be more proactive about safety.

B. Physical Nudges

The second type of nudge is physical. These types of nudges involve simple changes to the physical layout of the shipyard. Lunt and Staves (2011) suggested simple physical nudges like painting the first several and last several steps of a flight of stairs to draw attention to the changing walking conditions reducing trips and falls (p. 42). Thinking about shipyards, there are many opportunities for physical nudges. At entrances of building with overhead cranes, "Look Up" painted on the floor would remind workers focused closer to the ground to search for potential overhead hazards. Making the tool room where PPE equipment is distributed closer to the vessel would force workers to walk by a supply of PPE at least twice per shift. By displaying things such as respirators, eye and ear protection, and fall protection where passing workers can see it, workers may remember to take with them a need (but often forgotten) piece of PPE. Similar to the school cafeteria, if workers see certain items, they may be more likely to use them. Moving the tool room closer to the vessel also increases efficiency as workers are spending less

time gathering tools and more time on production tasks. Though slightly more complicated, designing controls for machinery shared by multiple trades to be intuitive can be a life-saving nudge. A friend of the author recounts an incident where a worker reached through a large sliding door to activate the motor and open the door. Unfortunately, the worker operated the switch in the wrong direction. The closing door crushed the worker. While there were several unsafe practices surrounding the incident, had the switch been oriented in such a way to indicate the direction the door would travel when activated would have nudged the worker to safety.

C. Signs and Slogans

The final type of nudges is signs. While signs are already in use in many industrial settings, nudge theory suggests maybe these signs are placed in the wrong places and displaying the wrong images. Recall the cabinetmaker who forgot to wear his safety glasses while sharpening his chisel. If there had been a sign placed near the switch to activate the grinder, perhaps the worker could have been nudged to wear eye protection. On the poster may have been an image of a cabinetmaker that lost his sight or an example of a serious eye injury. In shipyards, workers use fixed equipment including grinders, lathes, and other machining equipment. A sign could be placed next to the lathe to remind workers to remove their gloves before using the lathe. The sign could be a cartoon character depicting the result of a worker's glove wrapped around a spinning part. Other signs could be placed in areas where people often gather such as the lunchroom or the time clock. These posters might remind workers of general safety rules. A "Look Up!" poster could remind workers of the dangers of overhead loads with a picture of the Wicked Witch crushed by Dorothy's house. This is an image most workers would

quickly recognize and associate with a hazard. Safety professionals would have the opportunity to explore the power of the nudge in numerous other areas of safety.

5. CONCLUSION

Shipyards are unique places with a very specific task, but safety is universal. Any organization can benefit from learning to manage safety. The literature has demonstrated the benefits of a robust safety culture extend far beyond preventing incidents. Organizations with a positive safety culture are higher performing and more profitable than their less organized peers. While safety programs may seem expensive at the outset, the increased productivity will offset any additional costs. Workers will have a sense of pride in their work and will be more willing to give, "an honest day's work, for an honest day's pay." When an organization works as a team, every project can be a success.

Safety culture is the main ingredient to reducing incidents in shipyards and other industrial settings. People are highly influenced by the attitudes of others working around them. When the common consensus is, "safety doesn't matter," then it does not. Most people do not like to alienate themselves from the group by espousing an entirely different set of values. In this way, an organization's culture can perpetuate itself indefinitely. Under real-world circumstances, there is no easy way to break the culture cycle. Through commitment of management and educating employees about the benefits of a robust safety culture, change is possible.

A possible area for further research would examine the steps required to change an organization's safety culture. This research could experiment with different techniques of dispersing information and measuring the rate of safety culture change through culture surveys

and researcher observation. Involving an organization's safety professionals would aid in the research process. Because of the difficulties associated with measuring safety culture, quantifying techniques to compare safety cultures need to be researched and/or developed. The long-term goal of this research is to develop a systematic guide for safety professionals to change their organization's safety culture.

In many ways, safety is more than people going home at the end of the workday. Safety performance is a measure of how well an organization can manage risk. Most businesses can recognize risk in investments, marketing strategies, or global expansion. Safety is perceived differently. Individuals often claim injuries result from "accidents." Accidents are very different from incidents. *Accident* implies there was some outside force acting on the situation, e.g. fate. People often finish a recount of an accident with, "there was nothing anyone could have done." This statement is false. *Incident* does not carry the same connotations as *accident*. In every incident, there is some way to minimize risk. The organization has a legal obligation to minimize risks to the worker, but many organizations fail to perceive these risks. When organizations fail to recognize risks, workers are easily lulled into a sense of security and begin to incorrectly perceive the costs and benefits of risky behaviors. Safety culture forces safety risk management to center stage. This is an important discussion for any organization.

Though slightly limited in its capabilities, OBM is a powerful tool in increasing worker awareness. By observing problem behaviors, compiling data, and providing feedback, safety professionals are able to encourage safer practices. The applications of this process in a shipyard are nearly limitless. There are countless opportunities to observe and change behavior to reduce risk. Further research requires shipyard experimentation to explore which unsafe behaviors are best modified with OBM. These experiments would be modeled after Sulzer-Azaroff (1987) and

Sarri and Näsänen (1989). Exploring several different angles of OBM will expose researchers and safety professionals to different vantage points encouraging new ideas for testing. For behaviors that are not easily observable, safety professionals must rely on the organization's safety culture or implement the nudge.

Nudges are new to the safety arena. While some simple nudges have been in use for some time (e.g. color-coded pipes), nudge theory pushes the idea of what can be nudged far beyond painting pipes. The biggest challenge to nudge theory is the unpredictability in translating success from small experiments to universal success. Fortunately, shipyards are each unique, and the nudges would need to be designed accordingly. Each nudge idea would need to be tested to confirm its effectiveness. Further research into nudge effectiveness would be required to fully understand the theory's capabilities. In theory, the nudge is only limited by the creator's imagination. Since the cost is so low to produce a nudge effect, even small increases in safety performance are beneficial.

Over 70 years ago a report detailed safety factors that resulted in numerous incidents. In the last decade, the same factors have caused fatalities. Safety is an important component of any industrial organization. From the author's personal experience, the safety professional is often the least liked person on the jobsite. Now is the time to change that relationship. By making safety important to workers, managers, and executives, everyone can live a longer, healthier life. Hopefully, 70 years from now, workplace injuries will be a distant memory.

6. APPENDIX A

In order to compare the1943 injury rate published by McElroy and Svenson (1944b) to the 2014 incident rate published by the Bureau of Labor and Statistics (2015), the units need to be converted. The 1943 rate was 31.2 incidents per million-person-hours worked. The 2014 data gives the shipyard incident rate of 5.9 incidents per 100 fulltime workers. The BLS also publishes the total number of incidents in shipyards, 7,900. To convert the 2014 data to the 1943 units, the total number of hours worked in shipyards is required. The BLS provides the formula:

(Eq. 1) $$IR = \frac{N}{EH} * 200{,}000$$

This formula is used to calculate incident rate where *IR* is the incident rate, *N* is the number of injuries in one year, *EH* is the total hours worked in shipyards, and 200,000 is a constant representing hours worked by 100 fulltime employees working 50weeks per year. Solving equation 1 for *EH* yields:

(Eq. 2) $$EH = \frac{N}{IR} * 200{,}000$$

Substituting known values, *EH* for 2014 was 267,800,000 person-hours. To convert person-hours to million-person-hours, a unit conversion is required:

(Eq. 3) $$(267{,}800{,}000 * PersonHrs) * \frac{MilPersonHrs}{1{,}000{,}000 * PersonHrs} = 267.8 * MilPersonHrs$$

To find the 2014 incident rate, the number of incidents is divided by the number of million-person-hours worked. 7,900 hundred injuries over 267.8 million-person-hours yields an incident rate of 29.5 injuries per million-person-hours worked.

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8. ABOUT THE AUTHOR

I have often wondered about the motivations behind worker's safety behaviors. When confronted with dangerous tasks, even I sometimes take the easier, more dangerous way because it is well, easier. I know I do not want to be injured, but I also want to finish the job quickly and efficiently. When I had the opportunity to explore this paradox, I was excited to finally uncover the many factors at play. I have learned a lot about safety strategies and realized just how important safety culture really is.

People, including myself, like to fit within an organization. I see this everyday on Allegheny's campus. Just the other day, I found myself in the middle of a heated debate about whether encouraging safer pedestrian practices was "victim blaming." I recognized this as a safety culture issue right away. I am amazed by how applicable the ideas I have explored in this paper apply to everyday life. I am eager to graduate and apply the skills I have learned.

Though my exact career path is undecided, I am exploring opportunities as a building inspector or a project manager for a naval architect consulting firm in Ft. Lauderdale, Florida. With my senior project finally finished, I am excited to decide between the two. No matter what path I choose, I know the lessons I have learned in this paper and during my time at Allegheny will prove invaluable.