An Enduring Workforce: Fatigue Risk Management in Marine Search and Rescue and its Potential Applications to Knowledge-Based Work

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1 Introduction

It does not take much imagination to envision the potential outcome of operating heavy equipment at night and in bad weather with a fatigued worker. The risk of worker fatigue is both easily identified and obviously critical in the type of environment faced by marine search and rescue (SAR) workers. Indeed, both the United States Coast Guard (USCG) and the Canadian Coast Guard (CCG) have extensive documentation and risk management advice for fatigue, sometimes referred to as endurance, risk. The risk of fatigue is one of the top concerns of SAR crew, commanders and controllers and is constantly evaluated and mitigated before and during SAR operations[1]. While the impact of fatigued crew is obvious in marine SAR, it is much more difficult to understand in work environments where safety is not affected by fatigue. This paper will examine the potential criticality of fatigue as a risk factor in knowledge-based organizations. Following this examination, the paper will present an overview of the processes in the USCG and CCG to manage fatigue risk. These approaches may provide information to risk managers to consider when assessing and mitigating fatigue risk within their organizations.

2 What is Fatigue Risk?

The USCG defines fatigue as "a condition of impaired mental and physical performance brought about by extended periods of exertion and stress, which reduces the individual's capability to respond to external stimuli.".[2] Even considering the dangers of a maritime work environment, the USCG indicates that fatigue has the potential to impact the performance

1. This observation is based on four summers of working on a CCG primary SAR fast rescue craft including two years in command of the craft

2. Commandant, U.S. Coast Guard, *Commandant Instruction M16130.2F: The U.S. Coast Guard Addendum to the U.S National Search and Rescue Supplement (NSS) to the International Aeronautical and Maritime Search and Rescue Manual*, U.S. Department of Homeland Security: U.S. Coast Guard, January 2013, p. 5-25.

of SAR units even more than environmental conditions.[3] The dynamic workload in SAR as employees respond to unscheduled missions, leads to an unpredictable schedule which juggles missions with regular training and maintenance requirements. Likewise, in the business world, knowledge employees are sometimes required to work late hours to meet a deadline or to respond to a sudden crisis. It seems sensible to consider fatigue not during these incidents but before. The goal in SAR is to maintain a capacity to manage the unexpected while still completing training and maintenance requirements. The approach is generally to limit the risk of fatigue in order to avoid the performance impact of operating with fatigued crew.

Contrary to some common perceptions, fatigue does not substantially increase the risk of an employee making a logical error. One estimate suggests that in the worst case, disturbed sleep patterns would only increase the probability of making an error by 60%.[4] Where fatigue becomes an issue for business is its behavioral impact on employees. Research has shown that fatigue may lead to decreased self-control that leads to a loss of inhibitions.[5] One study estimated that after 24 hours without sleep an individual has the equivalent of a 0.1% blood alcohol level.[6] Even fatigue caused by limited sleep deprivation can lead to significant losses of situational awareness, ability to innovate, and ability to manage risks.[7] Fatigue has even been associated experimentally with unethical behavior.[8] While some fields dismiss fatigue because it does not inhibit logical decisions, businesses rely on more than the pure computing power of their employees. Situational awareness, ability to innovate, and an understanding of risk and ethics are essential for the smooth operation of a business.

It is illustrative to examine not only generalizations from fatigue research but also to

3. Commandant, U.S. Coast Guard, *Commandant Instruction M16130.2F*, p. 5-25.

4. James Reason, "Understanding Adverse Events: Human Factors," *Quality in Health Care* 4 (2 1995): p. 7.

5. Yvonne Harrison and James Horne, "The Impact of Sleep Deprivation on Decision Making: A Review," *Journal of Experimental Psychology: Applied* 6 (3 2000): p. 2.

6. Drew Dawson and Kathryn Reid, "Fatigue, Alcohol and Performance Impairment," *Nature* 388 (1997): 235.

7. Harrison and Horne, "The Impact of Sleep Deprivation on Decision Making: A Review," p.2.

8. Christopher Barnes et al., "Lack of Sleep and Unethical Conduct," *Organizational Behavior and Human Decision Processes* 115 (2011): 169–180.

look at work that directly targets the effects of fatigue in business. Harrison and Horne, from Loughborough University, conducted an experiment to examine the effects of sleep deprivation on subjects using a business strategy simulation called Masterplanner.[9] The simulation involves individuals playing a turn based game that seeks to increase the market share of a fictional product while competing against the other players in the game. Decisions in the simulation are not timed and the players were provided with time to digest the effects of their previous turn and to plan their next moves. The participants were gauged not on how they approached the simulation but upon the profit of their fictional firm.[10] The experiment was split into two groups that over a series of days each participated in the simulation twice, once fully rested and once sleep deprived by 36 hours.[11] By the end of the simulation, most of the sleep deprived group had become insolvent in the simulation while the non-sleep deprived group could have carried on.[12] Interestingly, almost at the end of each simulation, the groups were given a GMAT critical reasoning evaluation and there were no significant differences in performance between the groups or between their performances when sleep deprived or non sleep deprived.[13] This demonstrates that the participants were still able to logically process and communicate information despite their fatigue. The experimenters observed that it was not the participants logical reasoning that failed but that the fatigued participants failed to detect obvious impending changes, did not respond appropriately, were reluctant to change ineffective strategies and failed to develop innovative solutions.[14] Ultimately, they concluded that the effects of the fatigue in most cases led to "a total loss of competence for the task".[15] It could be said that sleep deprivation of 36 hours would be extreme for business. However, a single 'all-nighter' could easily lead to an employee reaching the 36 hour mark. Fatigue is a risk in any business where employees are expected to think strategically and behave

9. Yvonne Harrison and James Horne, "One Night of Sleep Loss Impairs Innovative Thinking and Flexible Decision Making," *Organizational Behavior and Human Decision Processes* 78 (2 1999): 128–145.
10. Ibid., p. 7.
11. Ibid., p. 4.
12. Ibid., p. 8.
13. Ibid., p. 8.
14. Ibid., p. 14.
15. Ibid., p. 14.

dynamically.

3 What is Knowledge Work?

The objective of exploring the fatigue management programs in the USCG and CCG is to allow risk managers to relate them to knowledge-based projects. Knowledge work may be contrasted with manual work in which the worker uses primarily physical means to complete their tasks. Manual work in most countries is subject to extensive employment legislation that specifies allowable hours of work and organizations of shift work. Furthermore, manual labor is generally covered by clear health and safety legislation which requires managers to respond to worker fatigue. Given this regulatory environment, it is unlikely that there are substantial gains to be had through risk management of manual worker fatigue. In contrast, knowledge-based work is normally internally managed and due to dynamic work hours has a potential to face problems arising from worker fatigue.

Certainly, maritime SAR has elements of manual work and it is not immediately obvious that strategies employed in SAR could apply in primarily knowledge based work. However, SAR does involve complex decision making when assessing a rescue situation and forming a plan of action. SAR personnel are technologists. Peter Drucker's research on knowledge workers defines technologists as individuals who do both manual and knowledge work.[16] Maritime SAR employees, surgeons, police and lab technicians would all be examples of technologists. Drucker believes that technologists make up the majority of knowledge workers in today's market,[17] these are workers who employ certain practical skills but require thought and understanding to apply them appropriately. While physical fatigue is important in SAR, much of the need to risk manage fatigue is related to the knowledge aspects of the work, such

16. Peter Drucker, "Knowledge-Worker Productivity: The Biggest Challenge," *California Management Review* 41 (2 1999): p. 10.
17. Ibid., p. 10.

as avoiding increased risk taking behavior.[18] In addition to knowing why something should be risk managed, it is also important to consider the inherent constraints on mitigation methods.

In his paper on knowledge workers, Drucker discusses the factors of knowledge worker productivity.[19] In order to consider applying elements of fatigue risk management to this group it will be necessary to understand how the risk and the potential mitigation strategies interact with these productivity factors. Drucker identifies six primary factors::[20]

1. A requirement to deeply understand the task.
2. Responsibility for the task and autonomy for execution must be held by the worker.
3. Innovation is a part of the process to completing the task, which may itself evolve.
4. The worker must be continuously learning and continuously teaching.
5. Quality is at least if not more important than quantity of work.
6. The workers must be treated as an asset and not a cost.

Drucker's second factor, autonomy, is an essential consideration when applying risk management to knowledge worker behavior. Knowledge workers must have responsibility to manage their own quality and quantity of work, particularly with respect to time.[21] Therefore, it would not be productive to attempt to regulate knowledge workers' behavior directly. Prescriptive fatigue interventions would not be successful as knowledge workers must act to regulate their fatigue autonomously. This reveals a potential weakness when considering

18. Commandant, U.S. Coast Guard, *Commandant Instruction M16114.32C: U.S. Coast Guard Boat Operations and Training (BOAT) Manual, Volume 1*, U.S. Department of Homeland Security: U.S. Coast Guard, January 2013, 2-21.
19. Drucker, "Knowledge-Worker Productivity: The Biggest Challenge."
20. Ibid., pp. 5-6.
21. Ibid., p. 8.

fatigue risk management in SAR as a potential inspiration for fatigue risk management in knowledge work. In general, since SAR agencies are often branches of the military or special branches within government, they have substantial powers of direct control over their employees' behavior. If this power was used to a great extent to manage crew fatigue, then there would be little to no applicability within knowledge work. However, upon examining strategies from the CCG and USCG, it appears that their approaches to identify, quantify and mitigate fatigue risk are almost entirely non-coercive. A great deal of the risk management approaches used in marine SAR would act as excellent guidance within a knowledge-based business.

4 Risk Management of Fatigue in Marine SAR

The following two sections will describe the fatigue risk management approaches used in the USCG and the CCG. In general, the USCG has a more prescribed approach to fatigue risk management whereas the CCG provides more general guidance to employees while still assigning responsibility for the risk to specific actors. A comparison between the two organizations disperses concerns about overly coercive approaches which would not function within a business environment. While the USCG is a branch of the military, the CCG is a branch of a civilian government department and yet, both organizations have very similar approaches to the management of fatigue risk.

4.1 USCG Approach

The USCG operates an endurance management program across their entire organization.[22] This program was initiated by the USCG after employee concerns about fatigue triggered research on the issue. Ultimately, the research concluded that the existing work practices did "not leverage basic principles of human physiology that are necessary for members to adapt to and endure work environments".[23] Following their initial research, the USCG conducted tests to examine the effectiveness of introducing fatigue and endurance principles into the workplace. The positive outcome of their workplace tests led the USCG to develop a crew endurance management (CEM) program that manages the exposure of crew to what they identified as endurance risk factors.[24] While the USCG identified risk factors associated with what they term 'endurance', all of their primary risk factors deal with fatigue. The CEM system is based upon the seven core and six modulating risk factors[25] listed below.

Core Risk Factors

1. Insufficient Daily Sleep
2. Poor Sleep Quality
3. Fragmented Sleep
4. Main Sleep During the Day
5. Changing Work/Rest Schedule
6. Long Work Days
7. No Opportunities to Make Up Sleep

Modulating Risk Factors

1. High Workload
2. Lack of Control over Work Environment
3. Exposure to Extreme Environments
4. Poor Diet
5. Lack of Exercise
6. High Stress

22. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2: Crew Endurance Management*, U.S. Department of Homeland Security: U.S. Coast Guard, March 2006, p. 1.
23. Ibid., p. 2.
24. Ibid., p. 2.
25. Ibid., pp. 2-4.

These risk factors were identified through a scientific literature review[26] and form the basis for the CEM program. Interestingly, the USCG does not only apply this program to their seagoing personnel. The orders which lay out the CEM approach apply to all personnel including land-based technicians, office employees and management.[27] The approach used to develop CEM plans for individual workplaces follow a basic pattern of risk management. Initially the workplace establishes a working group to identify their specific risk factors using tools provided by the framers of the CEM process. Each workplace then develops and deploys an appropriate CEM plan. Finally, each workplace assesses their implementation's effectiveness in addressing the identified risk factors.[28] By adhering to a very basic risk management framework, the USCG has developed a program that is easily implemented across their organization with limited need for specialized risk management training.

The USCG emphasizes the importance of a local working group to implement the CEM process. The purpose of using employees at the workplace is two-fold, first they will often be more familiar with the objectives and needs of their unit, and second participation in the process is considered to promote ownership in the outcomes. The USCG provides suggestions to the make up of the working groups to ensure that they have a broad perspective on the workplace.[29] Each working group is responsible for identifying which primary and modulating risk factors exist in their work environment. An important factor for the group to consider is whether their unit conducts multiple types of missions or activities. For example, SAR crews will have regular training and maintenance objectives which present different risk factors and consequences for fatigue. In order to manage this consideration, CEM requires separate assessments to be conducted for each activity type. CEM goes further still and suggests that assessments differentiate between different tempos of work. In SAR, certain times of the year are substantially busier than others and these different tempos may benefit

26. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, p. 2.
27. Ibid., p. 6.
28. Ibid., Encl(1), p. 1.
29. Ibid., Encl(1), p. 1.

from separate approaches to risk management of fatigue. In order to facilitate the analysis of the assessments, the USCG has produced an internal software tool which will ask the user questions relating to the frequency of each of the risk factors and develop a 'risk profile' that highlights key and frequent risks.[30] The risk profile software also highlights the presence of multiple risk factors in order to communicate that multiple risk factors often lead to more negative outcomes than just the sum of the outcomes of the factors taken individually. Based on the frequencies of each primary risk factor, the software qualifies the factor as having either acceptable, moderate or high levels of risk exposure. Modulating risk factors do not have qualitative levels set because their nature as modulators makes them difficult to predict; however, the USCG does suggest a threshold level at which workplaces should consider controlling modulating risk factors.[31] Overall, the completed risk profiles for a unit's activities act as the basis for their mitigation plans.

The CEM process provides a comprehensive system-based framework to develop controls for fatigue risk mitigation. The framework is broken into four levels: mission level, personal level, organizational level and environmental level.[32] There are potential controls at each level for each risk factor and the working groups are responsible for determining where intervention should occur. The CEM process document warns that controls at one level may have positive or negative impacts on the risk at other levels in the framework and that it is very important to consider the relationships between the risk factors and their controls.[33] The mission level examines controls that can be implemented in an operational setting, in particular, it considers what changes could be made to control risk factors without impacting on mission performance. The personal level examines controls which can be implemented by individual workers to improve their endurance. At the personal level, the primary method for implementing controls is educating the employees on appropriate behaviors to limit fatigue.

30. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, Encl(1), pp. 3-4.
31. Ibid., Encl(1), p.3.
32. Ibid., Encl(1), p. 4.
33. Ibid., Encl(1), p. 4.

The organizational level examines controls which are available to command staff (managers) that directly support endurance, these controls are generally at a policy level and would affect more than one workplace. Finally, the environmental level looks at workplace specific controls in terms of ergonomics and exposure to severe weather and noise.[34] The controls that are considered by the working group will form the basis for their CEM plan and, if effectively chosen, will decrease the fatigue risk of their unit.

The USCG provides some suggestions for control measures but it places primary ownership onto the individual working groups to identify control options within their work environment.[35] There is a strong emphasis within the program on the importance of education as a control at all levels. In particular, education is a primary method for achieving both personal level changes and organizational 'buy-in' of the CEM approach.[36] The CEM document recommends that for every potential control, the working group should consider which risk factor would be controlled and what mechanism allows the control to mitigate the risk factor. The working group eventually classifies the potential implementation of each control as immediate, mid-range or long-term to assist in the development of a deployment plan.[37]

While the approach to risk factor identification and controls identification is fairly unstructured and designed to enable critical and creative thinking, the approach used for deployment of a CEM plan is much more rigid. The program calls for five sequential steps: education, environmental changes, light management, endurance coaches and schedule changes.[38] Practitioners are warned that experience has shown deviations from the sequential approach often result in failure.[39] In the earliest stage of deployment, education is not solely used to impart knowledge but also to allow other workers to develop a sense of ownership in the planned changes. The USCG suggests that education should deal broadly with

34. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, Encl(1), pp. 4-5.
35. Ibid., Encl(1), p. 10.
36. Ibid., Encl(1), pp. 4-5.
37. Ibid., Encl(1), p. 7.
38. Ibid., Encl(1), pp. 10-11.
39. Ibid., Encl(1), p. 10.

the topics of endurance and fatigue while also providing workers with the opportunity to comment on and improve the working group's deployment plan. In order to combat resistance from uninformed employees, the CEM process recommends that no workplace changes occur until everyone in the workplace has an understanding of what changes will be made and the rational for those changes.[40] Following the education phase, most non-schedule related controls can be implemented. These controls primarily center around the physical work environment and light aboard ship but can also include policy-based changes or attempts to influence the organizational culture towards fatigue.[41] The process introduces the idea of an 'endurance coach', often one or more members of the working group, who works throughout the deployment phase to maintain employee support and act as a contact for workers to learn more about the changes or fatigue in general.[42] The final deployment task, if necessary, are changes to the employee work schedule to help to control fatigue related risk factors.[43] The CEM strongly indicates importance of operational success and reminds practitioners to not focus so strongly upon improving endurance that they decrease performance.[44]

Following the initial implementation, the working group is expected to evaluate their program regularly and re-iterate through the process when necessary.[45] To evaluate the deployment the working group regenerates the risk profile for each unit mission and tempo in order to attempt to quantify the impact of the deployment. The expectation is that a CEM process will be ongoing and involve a permanent working group that will regularly update the plan and continue education to employees.[46]

The USCG has also adopted the idea of risk ownership with respect to the CEM program. The orders establishing CEM issue specific responsibilities to specific roles within the

40. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, Encl(1), pp. 10-11.
41. Ibid., Encl(1), p. 11.
42. Ibid., Encl(1), p. 11.
43. Ibid., Encl(1), p. 12.
44. Ibid., p. 8.
45. Ibid., Encl(1), pp. 12-13.
46. Ibid., Encl(1), p. 13.

organization. These roles are assigned both for implementing the CEM program, ensuring that the CEM is deployed with limited resistance throughout the organization, and for the continuing evolution of the CEM process as a whole.[47] Overall, the USCG CEM program is a very detailed approach that applies risk management principles to fatigue in SAR positions as well as other positions within their organization.

4.2 CCG Approach

While, the CCG does not seem to have a specific program similar to the CEM in place, it does provide its members with direction and tools to identify and mitigate fatigue risk. The CCG's approach is three-fold, assigning specific responsibilities and instructions to unit commanders, providing educational materials on fatigue to employees and considering SAR unit fatigue in high level mission planning. These three approaches provide fatigue risk management that is adaptable depending on the role and mission of each unit.

The CCG defines key roles and responsibilities in their fleet orders to ensure that fatigue risk is considered during operations. The CCG Fleet Safety Manual[48] states the responsibilities of both the Regional Fleet Directors and Commanding Officers aboard CCG vessels. While the Commanding Officer is responsible for fatigue in an operational setting, it is interesting to note that they share a responsibility with the Regional Fleet Director when it comes to minimizing the travel time of employees who are expected to work immediately on arrival at the vessel. For the most part, the duties listed involve ensuring that work schedules are clearly posted and that crew members record their hours of work and rest.[49] While the Fleet Safety Manual applies to all vessels in the CCG, there are often more specific guidelines for SAR vessels. The CCG in conjunction with the Royal Canadian Navy operate

47. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, pp. 9-10.
48. Canadian Coast Guard, *Fleet Safety Manual*, 4th ed. (Fisheries / Oceans Canada, 2012), 7.A.3.
49. Ibid., 7.A.3.

a series of inshore rescue boats manned by university and college students throughout the summer. These vessels are responsible for SAR and operate on two week shifts where the crews are expected to be able to respond to incidents at any time.[50] The standing orders for this program provide more detailed SAR specific fatigue guidelines which are in addition, but not in conflict, to those provided by the Fleet Safety Manual.[51] Once again, it is made clear that the individual in charge of the unit is responsible for monitoring and acting based on crew fatigue. The orders are written to ensure that non-SAR activities should never lead to a decreased SAR capability and that any non-SAR work should be scheduled during the day. The orders specify the minimum rest requirements for the crew. There is a differentiation between the amount of rest in a 24 hour period (6 consecutive hours) and in a 48 hour period (16 hours). This difference allows for long hours to be run when necessary, for SAR purposes, in a single day but ensures that fatigue does not build over a period of days to dangerous levels. While these time periods are prescribed, there is some latitude given to allow units to continue on SAR missions beyond the limits on work if it is safe and necessary to do so. A further inclusion that is made in order to support the SAR objective of the organization, is a responsibility to notify superiors in advance of standing down for fatigue purposes; this allows superiors time to allocate other resources if possible and necessary to the SAR area.[52] At an operational level, responsibility is clearly allocated with respect to fatigue risk but further mitigation through education also occurs.

The CCG provides its members with access to a guide on fatigue management that was developed in partnership with a Canadian research organization.[53] This guide acts on a personal level to provide education to CCG members about fatigue risk and strategies to mitigate this risk with a specific focus on their work environment. Some areas examined

50. Canadian Coast Guard: Central and Arctic Region (Great Lakes Sector), *Inshore Rescue Boat Program: Operational Standing Orders* (Fisheries / Oceans Canada, 2014), p. 8.
51. Ibid., p. 25.
52. Ibid., p. 25.
53. Ronald Heselegrave, Scott Davis, and Barbara Cameron, *Fatigue Management: A Guide for Canadian Coast Guard Managers, Officers and Crew* (BC Research Inc., 1999).

include, exploring risks for fatigue, sleep advice for irregular watches, napping advice and sleep etiquette.[54] It goes beyond sleep and also educates the reader about modulating factors such as drugs, alcohol, diet, exercise and stress.[55] The authors also provide a self-assessment tool for fatigue that is designed to help members determine their current levels of fatigue and to monitor changes as they attempt to take personal steps to mitigate fatigue. As the guide notes, if the risk of fatigue is not properly managed and severe or persistent fatigue occurs the results may lead to decreased alertness and ultimately unsafe actions or behaviors.[56]

Managing the risk of fatigue, and the risks arising from fatigue, are also managed at a planning level within the CCG. When SAR missions are ordered, the plans are established and revised in reference to the Canadian National Search and Rescue Manual.[57] Fatigue is considered explicitly when determining the sweep width, the distance between consecutive rows in a search pattern, for a search.[58] While the manual acknowledges that there is no test to determine impairment due to fatigue, in recognition of its criticality to SAR they introduce a fatigue factor into their sweep width calculation. In the event of fatigue, search planners introduce a fatigue factor into their equations which decreases the sweep width to mitigate the risk of the search object being overlooked due to fatigue.[59] This approach ensures cooperation on the problems presented by fatigue between the search planners and the crews directly involved in SAR.

The assignment of roles and responsibilities, education of crew, and consideration at a planning level towards fatigue ensures that the CCG considers fatigue risk at all levels of its SAR program. This comprehensive approach is similar to the USCG CEM in terms of its focus on education and assignment of specific responsibility. The impact of fatigue is complex

54. Heselegrave, Davis, and Cameron, *Fatigue Management: A Guide for Canadian Coast Guard Managers, Officers and Crew.*
55. Ibid.
56. Ibid., p. 6.
57. Government of Canada, *National Search and Rescue Manual* (1998), p. III.
58. Ibid., Chpt 7, pp. 25-26.
59. Ibid., Chpt 7, pp. 25-26.

and both the CCG and USCG have reviewed or conducted research when developing their approach to fatigue. There is much that can be learned from a risk management approach to fatigue in an organization.

5 Lessons for Business

The approaches of USCG and CCG towards fatigue risk can provide insights into how fatigue risk could be managed in a knowledge work environment. It is important to reiterate that the objective of managing fatigue risk is not to somehow make employees more productive, but is to make them productive when it counts. Specific lessons from the cases of the USCG and CCG can be applied in knowledge businesses to identify risk factors, identify controls, and manage deployment of fatigue risk management.

In order for a business to consider mitigating fatigue risk, it is necessary to identify what, if any, fatigue risk factors impact their business and whether these factors are large enough to warrant intervention. The examination of fatigue in SAR identified the importance of context in assessing risk factors and also provided a detailed list of general risk factors which could be used by business. An important insight from the USCG CEM program is that not all operations are the same, context in terms of mission and work load are important. Just as different Coast Guard units have different missions so to do different groups within a firm and the risk factors that effect each group may differ dramatically. Furthermore, the workload for many knowledge workers varies over time, often predictably, which will cause the magnitude of the risk factors to change. The importance of context illustrates the value of the USCG approach of separate risk factor assessments for each mission type and consideration of variations that may occur in workload/tempo. The primary and modulating risk factors provided in the CEM documentation[60] are generic enough to be used directly in

60. Commandant, U.S. Coast Guard, *Commandant Instruction 3500.2*, pp. 2-4.

a business setting. Once the risk profiles within the business are considered, it will be easier to determine if further controls should be added to any already in operation.

When reviewing the USCG and CCG approaches, it is clear that there are various domains for control of fatigue risk factors and also that the most powerful control is education. The level based classification of controls used by the USCG parallels the presence of controls at the crew, command and planning levels in the CCG. This approach, using the USCG terminology, to mission, personal, organizational and environmental controls is highly applicable to knowledge businesses. While in SAR the primary measure of success is the mission, many knowledge organizations measure success from their projects. It is interesting to see that both the USCG and CCG implement their fatigue risk management in a way which does not compromise their missions. The focus is placed on maintaining readiness so that the crew is ready when long hours are required. Likewise, in business the focus could be on ensuring that employees are prepared to work long hours over the short-term when necessary. From an organizational level, it is essential to ensure that the business structure does not require perpetually extreme workloads that could lead to a dangerous buildup of fatigue. Environmental controls may be adopted within businesses that may help mitigate fatigue in cases where prolonged work is needed or to decrease modulating risk factors such as stress. Ultimately, both the USCG and CCG found education to be the primary control mechanism for fatigue. This is particularly useful in knowledge businesses for the management of fatigue risk on a personal level. Knowledge workers require autonomy, an educational approach would not infringe on this autonomy but would provide them with information about strategies and options that they could choose to implement. Information about fatigue could help employees to take action to support their work quality. A level based approach to control with a focus on education is an excellent starting point for deploying a fatigue risk management strategy but there are further steps required for successful deployment.

Deployment of fatigue risk management requires employee buy-in, clear responsibilities

and a willingness to iterate. The USCG approaches employee buy-in through education and involvement in the CEM process. A similar approach would be required in a knowledge organization. It would be particularly important to explain to employees that the controls would not infringe on their autonomy. In both the USCG and CCG, risk management responsibilities were clearly assigned to positions within the organizations. This step is crucial to ensure that the plan is implemented and sustained over time. If responsibilities are not assigned, it would be easy for the firm to lose focus and not experience any benefit from the process. The CEM process from the USCG relies on regular iteration to monitor the impact of controls and to identify changing risk factors. In order to respond in a dynamic business environment, firms that consider managing fatigue risk will have to be prepared to evaluate their progress and be prepared to address new challenges. This is particularly true of project organizations where each project may present a unique combination of risk factors. In many ways, deployment of fatigue risk factor controls is the most challenging stage for managing the risk of fatigue.

6 Conclusion

Fatigue is shown to have negative impacts on behavior, risk awareness and innovative thinking, all of which could inhibit the quality of an employee's work. While fatigue in manual work is largely prevented through health and safety regulation, there is a risk of fatigue in knowledge work where fatigue does not impact employee safety and is therefore often unregulated. Since knowledge workers require autonomy, the firm cannot exercise extreme levels of control. An examination of the USCG and CCG approaches to fatigue risk, specifically in their SAR operations, led to some lessons which could be applied to fatigue risk identification, control identification and deployment management within knowledge businesses. Fatigue risk management is certainly not required in all businesses, like any risk it must

be evaluated and the benefits and costs of controls must be considered. However, since the primary control is education, awareness of fatigue is very easy to implement within an organization.

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