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Paper Title: Great Ideas: Industrial Productivity Enhancement and Fatigue/Injury Reduction in U.S. Naval Shipyards using Passive Exoskeleton Device; Human Augmentation and Exoskeleton Development

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Abstract: Purpose

Injury Type# of InjuriesDays away

Sprains, strains, tears7784895

Back pains45551

Pains not in back64519

Muscles, Tendons, etc...24414

Other39207

Industrial operations in Naval shipyards are labor intensive, physically demanding, and workers are frequently at risk of injury due to muscle fatigue. Ship repair, modification, conversion, and demolition require workers to operate with the vessel in situ, without benefit of optimizing

Table 1. Number of injuries in Naval Shipyards 2008-2010 the work to eliminate overhead and vertical work with heavy, hand-held tools, such as grinders, heat induction tools, welding torches, and chipping or needle guns. These tasks are ubiquitous requirements during every overhaul and ship repair availability. By focusing on the most physically demanding tasks, which are performed regularly by industrial workers in the Naval Shipyards and commercial ship repair facilities, Lockheed Martin's New Initiatives team is determined to increase productivity while simultaneously reducing the risk of injury for those at greatest risk by means of using an industrial human augmentation system called FORTIS.

Method

In cooperation with the U.S. Navy and the National Center for Manufacturing Science, Lockheed Martin spent the last three years designing, testing, refining, and producing human augmentation exoskeleton systems. Beginning with an informal trial of the HULC™ at Puget Sound Naval Shipyard and a demonstration at Newport News Shipbuilding, the Navy and Lockheed Martin determined the significant potential benefits of this technology. The results of these two events prompted Lockheed Martin to fund the development of MANTIS™ industrial passive exoskeleton prototypes. Lockheed Martin leased MANTIS™ units to the National Center for Manufacturing Science (NCMS), who loaned them to Portsmouth Naval Shipyard and Puget Sound Naval Shipyard as well as providing a unit to Naval Air Systems Command (NAVAIR) for evaluation. During testing conducted by the Navy to measure the productivity and fatigue of Navy shipyard workers, we began to define the benefits of the system and identify engineering challenges that we would have to overcome in order to realize the full potential of this technology.

Results

During the trials conducted by the Navy, MANTIS™ delivered impressive results. The lowest productivity increase recorded was 16 percent. The average user's productivity increased by 2 times. Test subjects reported that they felt 80 percent less fatigued when augmented with MANTIS™ than when working without it.

Table 2. Portsmouth Naval Shipyard Testing Feb. 2014 Through feedback and continuous improvement, Lockheed Martin developed the FORTIS™ industrial exoskeleton. Half the weight of MANTIS™, the FORTIS™ exoskeleton transfers the load of hand-held power tools and counterweights to the ground without relying upon batteries or external power supplies. It moves with the user through his/her full range of motion. The FORTIS™ exoskeleton enables users to use heavy power tools for much longer periods because it greatly reduces the fatigue felt by the user, reducing risk of injury and increasing productivity. Counterweight can be adjusted by the user, and both the tool arm and counterweight can be removed without assistance in the event of an emergency. It can be donned and doffed easily by the user without assistance and can be resized without tools in just a couple minutes to fit approximately 90 percent of the workforce<sup>1</sup>. All materials in the FORTIS™ exoskeleton were designed to hold up in a maritime environment and are suitable for use in a "hot work" area.

#### Conclusions

Passive Industrial Exoskeletons provide augmentation to users enabling them to be more productive for longer periods and with a decreased risk of injury. The NCMS Commercial Technologies for Maintenance Activities recently purchased two FORTIS™ exoskeletons with funding provided by the Office of the Secretary of Defense, for the Navy to test and evaluate. The Technology Readiness Level is 7/8, and the Manufacturing Readiness Level is 7. The FORTIS™ exoskeleton product is ready for broad application in industrial operations and is available for sale.

1. Fits females in the 10th to 95th percentile and males in the 5th to 95th.