



Pilot Grants in Action:

Findings from the MSD Solutions
Lab Grant Program 2023 - 2024

Introduction

Musculoskeletal disorders (MSDs) are both pervasive and complex in nature, affecting nearly a quarter of the world's population. These injuries result from exposures to repetitive movements, awkward or static postures, and forceful exertions, and include issues like tendinitis, back strains and sprains, and carpal tunnel syndrome. MSDs are the most common causes of disability, involuntary retirement, and limitations to gainful employment, costing employers billions of dollars every year in workers' compensation and lost productivity.

To address the issue of MSDs, the MSD Solutions Lab was founded to lower the world's most prominent workplace injury by increasing awareness, conducting research, engaging key stakeholders, disseminating research, identifying new technology and solutions, and scaling results so that all workplaces can benefit. The lab functions through four main pillars:

- **Engage:** Meaningfully engage employers, workers, researchers, and innovators.
- **Research:** Conduct impactful, practical research, analyze data, and disseminate insights across industries.
- **Solve:** Identify, pilot, scale and promote unique solutions.
- **Amplify:** Create a global effort to engage operations and safety leaders across all industries.

While the lab has many activities across all pillars, a key activity of the Solve pillar is grant programs. In 2023, the lab launched two grant programs: the Research to Solutions (R2S) Grant Program, and the MSD Solutions Pilot Grant Program, to enhance collaboration with academic institutions, businesses, and technology providers in addressing MSDs. These grants are now awarded annually to foster innovative solutions for workplace safety. The goal of the pilot grant program is to develop solutions for preventing MSDs by matching organizations from the [MSD Pledge](#) community with innovative technology providers to trial emerging technologies in real-life applications. The goal of the R2S grant program is to develop, evaluate and/or disseminate effective solutions for MSDs, focusing on injury risk reduction. The 2023 - 2024 R2S grants are discussed and summarized in more detail in the accompanying [R2S grant findings report](#).



Pilot Grant Program Overview

The 2023 - 2024 MSD Solutions Lab Pilot Grant Program awarded up to \$10,000 per approved project for a total of \$50,000 in pilot grants. The 2023 - 2024 pilot grant cycle featured six providers (as shown in the table below) whose solutions address MSDs related to manual material handling. Manual material handling is a well-documented risk for MSDs. Overexertion, often from manual material handling, ranks as the top cause of the most serious workplace injuries (those causing an employee to miss more than five days of work), many of which are MSDs. These injuries also cost U.S. employers nearly \$12.5 billion annually in direct costs of medical and lost-wage payments according to the 2024 Liberty Mutual Safety Index.

These solution providers were highlighted during the 2022 NSC Safety Congress & Expo as part of the Safety Innovation Challenge (SIC), which aimed to promote innovative strategies for preventing MSDs in the workplace. The SIC is an annual event hosted by the MSD Solutions Lab at Congress and is highlighted at the Safety Technology Pavilion and the conference's closing keynote session. MSD Pledge organizations applying for grants are allowed to choose from the eligible solutions providers or they can consult the MSD Solutions Lab to determine what might be their best fit given their MSD risks and goals.

Extend Robotics Reading, UK	A human-robot interface software for a non-robotic expert to tele-operate and program robotic manipulators remotely for physical tasks.
Effidence Romagnat, France	A collaborative handling robot that behaves like a true logistic assistant and follows a picking operator, eliminating pushing or pulling.
Mobile Industrial Robots (MiR) Odense, Denmark	A robot that can transport pallets and heavy goods, be hooked to custom and existing carts, and automate warehouse logistics.
HeroWear Nashville, Tennessee, USA	A back-assist, lightweight exosuit designed to reduce muscle fatigue. It accommodates bodies of all shapes and sizes, and fits like a comfortable piece of clothing.
WearKinetic New York, New York, USA	A belt-mounted wearable sensor that automatically recognizes awkward postures commonly performed on the job, such as bending, overreaching and twisting.
TuMeke Ergonomics San Mateo, California, USA	A computer vision joint tracking system for ergonomic assessments.

The solution providers were tasked with assisting their industry partner, an MSD Pledgee, in reducing the risk of workplace MSDs. Upon completion of the grant, grant recipients were expected to present their findings at the annual NSC Congress & Expo. For the 2023 - 2024 pilot grant cycle, HeroWear and TuMeke were chosen by the five partner organizations for the pilot projects.

The goal of this report is to provide an overview of the findings from the 2023 - 2024 pilot grant projects by highlighting project aims, the implementation processes, accomplishments, challenges, and implications for future research. This report allows safety professionals to gain insights from real-world experiences of organizations that have addressed manual material handling-related MSDs, highlighting both the challenges and successes in implementing innovative solutions, as well as showcasing emerging technologies for broader MSD mitigation.



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Brief Description of 2023 - 2024 Grant Projects

Five organizations were each awarded a pilot grant of \$10,000:

- **Burlington Hydro** (Burlington, Ontario, Canada), used TuMeke Ergonomics to assist with conducting ergonomic assessments of the company's powerline technicians.
- **Guarantee Electrical Company** (St. Louis, Missouri, USA), worked with TuMeke Ergonomics to detect unsafe postures and glean data-driven insights to optimize their workplace safety programs.
- **Amerisure Insurance** (Farmington Hills, Michigan, USA), worked with both computer vision provider TuMeke Ergonomics and HeroWear, which specializes in passive back-assist exosuits, to prevent MSDs enterprise-wide.
- **General Electric Aerospace** (Erlanger, Kentucky, USA), partnered with HeroWear to better understand the operational benefits and worker impact of using exosuits to unload cargo trailers.
- **Lafarge North America** (Surrey, British Columbia, Canada), teamed up with TuMeke Ergonomics to scan construction workers' movements during manual material handling activities to better identify MSD risks and assess targeted solutions.¹

This report will highlight each grant project. Each project description will resemble a case study, discussing the problem being addressed, project aims, implementation processes, lessons learned and impacts, return on investment, challenges, and future implications as applicable.

Case Study 1: Burlington Hydro and TuMeke Ergonomics

What's the Risk?

For Burlington Hydro, a services and utilities company in Burlington, Ontario, manual handling of heavy objects, awkward postures, and other overexertion activities are prominent issues for powerline technicians. Burlington Hydro reports that MSDs are their most common injury. To significantly reduce injuries in this trade, implementing innovative and effective solutions is essential to empower employees to perform their work safely and efficiently.

Before the pilot program, Burlington Hydro took significant steps to mitigate the risk of MSDs in their workplace by including ergonomic risks in their health and safety policy, implementing an ergonomics and MSD prevention program, conducting risk assessments, and performing ergonomic evaluations along with collecting individual or group discomfort surveys. Burlington Hydro also utilized an office-based MSD hazard identification tool. Their more traditional approach to ergonomics and MSD prevention was deemed by Burlington Hydro as reactive, tedious, time-consuming, and expensive without ergonomic expertise in-house. Without proper assessments, it was difficult to know where to invest resources to address concerns and eliminate risks.

Project Aims

To address their reactive approach to ergonomics, Burlington Hydro sought to use a vision-based application for ergonomic assessments, aiming to shift towards a proactive approach. Using the computer vision software from TuMeke allowed Burlington Hydro to video job tasks, identify risks for each task, and determine solutions to prevent MSDs. This was intended to have a positive effect on injury rates and their workplace culture. Further, it aimed to lessen the load of employees to manually complete ergonomic assessments.

¹Due to implementation issues and personnel changes, the Lafarge North America grant project has been delayed.



Description of Project Activities and Implementation

Burlington Hydro piloted the TuMeke technology for six months, from September 2023 to March 2024. Burlington Hydro outlined four main project steps. Those steps and the components are:

- 1. Create a department task list** – This involved working with various departments to gather a list of tasks using safe work procedures, risk assessments, hazard registries, past ergonomic assessments, incidents, and discomfort survey data. A total of four department task lists were generated that highlighted 137 tasks across powerline, metering, maintenance, and stores departments. Tasks with the highest MSD risk were identified.

Task Name	Safe Work Procedure #
Attaching slings	LNE 5.04 Overhead Live Line Work – Rigging and Hoisting
Carrying heavy material	GEN 1.05 Manual Lifting
Change the insulator	LNE 5.16 Overhead Live Line Work – Insulator Change Tangent Structure
Climbing and descending portable ladders	GEN Portable Ladders and Inspection
Hand digging with shovel	LNE 5.12 Overhead Live Line Work – Temporary Support of Wood Poles
Handling load lines	LNE 5.04 Overhead Live Line Work – Rigging and Hoisting
Handling pole with rope or guys	LNE 5.14 Overhead Live Line Work – Handling Structurally Damaged Poles
Handling tools while in the bucket	LNE 5.03 Overhead Live Line Work – Material Handling
Install jumper	LNE 5.10 Overhead Live Line Work – Work on Dead-Ends
Install jumpers	Various
Install lighting arresters using the mounting provision	LNE 5.05 Overhead Live Line Work – Installing SCADA-Mate Switches
Install line equipment	LNE 5.10 Overhead Live Line Work – Work on Dead-Ends
Install temporary rope guys	LNE 5.12 Overhead Live Line Work – Temporary Support of Wood Poles
Installing and removing grounds	Various
Installing fibreglass guard	LNE 5.07 Overhead Live Line Work – ABS Maintenance or Repair
Installing in-line switches	LNE 5.15 Overhead Live Line Work – Installing of In-Line Switches
Installing quick sleeves	Various
Installing rubber coverup	Various
Installing the leads	LNE 5.17 Overhead Live Line Work – Single Phase Distribution Tx
Installing vehicle blocking	Gen 1.13 Wheel Chocks
Loading poles onto the pole trailer	Various
Make all repairs and adjustments	LNE 5.07 Overhead Live Line Work – ABS Maintenance or Repair
Manual lifting	GEN 1.05 Manual Lifting
Mounting and installing the transformer	LNE 5.17 Overhead Live Line Work – Single Phase Distribution Tx
Mounting/installing the transformer	LNW 5.06 Overhead Live Line Work – Paralleling Single-Phase Tx
Open and installing all six Pig Tail connectors	LNE 5.07 Overhead Live Line Work – ABS Maintenance or Repair
Operating hand tools	GEN 1.12 Hand tools
Removing submersible vault lids	Various
Replacing damaged conductors	LNE 5.09 Overhead Live Line Work – Insulator Change on Angle Structure
Rigging material or equipment	LNE 5.04 Overhead Live Line Work – Rigging and Hoisting
Securing load on truck/trailer	LNE 5.03 Overhead Live Line Work – Material Handling
Setting out traffic signs and cones	GEN 1.11 Traffic Control Procedures
Take secondary voltage readings	LNW 5.06 Overhead Live Line Work – Paralleling Single-Phase Tx
Taking amperage reading	LNE 5.13 Overhead Live Line Work – Working on Neutral Conductor
Using meter stick with hot-pot adapter	LNE 5.25 Underground Live Line Work - Hi-Pot adapter Procedure
Using metering stick	Various

Figure 1. Task List Example from Burlington Hydro

2. **Capture and upload field videos** – This step required coordination with the Operations department to conduct field visits to take specific videos. This process was voluntary for employees to participate in, yet employees reported positively about being recorded on video. Videos were taken via cell phone by members of the Health and Safety department or supervisors. All videos were then uploaded into the TuMeke system.
3. **Analyze and report** – Reports were generated and scores for all tasks were uploaded in the TuMeke system. Specifically, the system helped with:
 - a. **Ergonomic assessments** – each video was analyzed to identify common ergonomic risks, body parts impacted, and postures that may lead to discomfort or injury.
 - b. **Task evaluation** – all tasks were evaluated, pinpointing areas where efficiency and safety could be improved through better techniques or tools.
 - c. **Actionable insights** – reports highlighted specific suggestions for modifying tasks, including the introduction of ergonomic tools or changes in workflow to reduce strain.

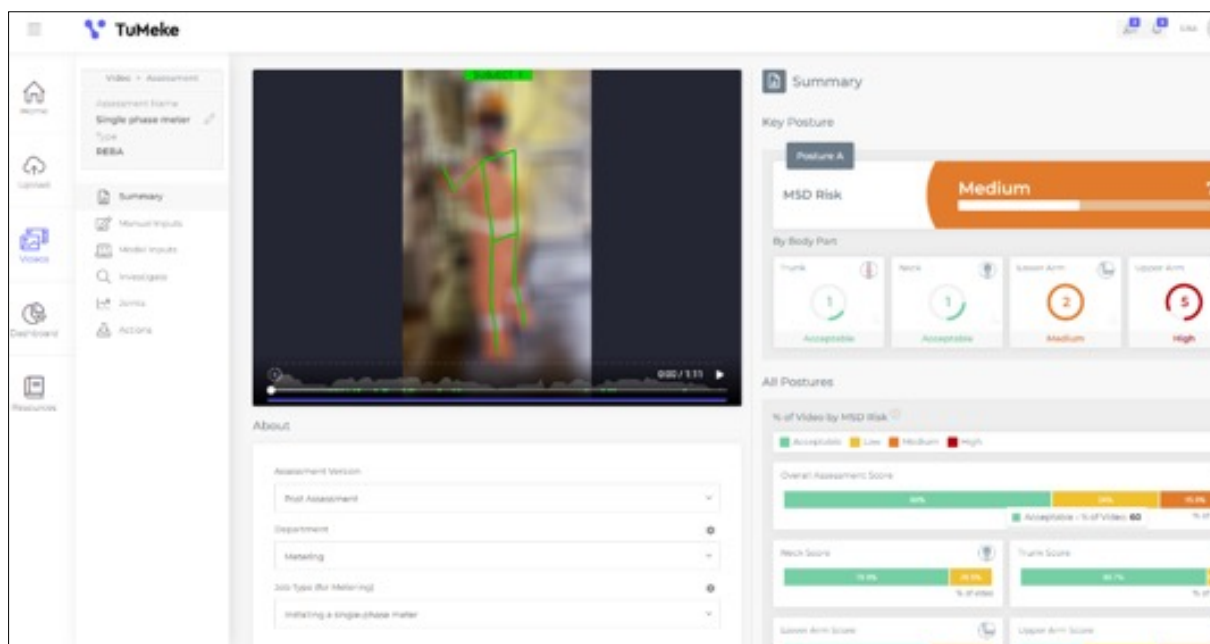


Figure 2. Example of TuMeke Analysis and Reporting Interface

Project Accomplishments and Lessons Learned

The implementation of computer vision technology resulted in several significant outcomes:

- **Video review in safety meetings:** Video analysis of job tasks was incorporated into safety meetings to highlight awkward postures, explore alternative methods for task execution, and gather additional suggestions from employees for tools and equipment.
- **Action tracking:** All corrective actions and recommendations are now documented in a tracking tool for effective follow-up and accountability.
- **Mobility program:** A stretching initiative to promote physical wellbeing was launched upon conclusion of the grant.

Burlington Hydro also noted several important lessons learned that will impact their workforce moving forward:

- **Collaborative learning:** Reviewing videos during safety meetings has fostered open discussions about awkward postures, encouraging team members to share insights and alternative approaches to tasks.
- **Employee engagement:** Involving employees in discussions about safety and ergonomics has increased engagement and ownership of their work environment.
- **Measurable outcomes:** Tracking actions in a structured way allows for the assessment of the program's effectiveness and highlights areas for further improvement.
- **Enhanced awareness:** The mobility program raised awareness of the importance of stretching and physical health among employees, leading to a culture that prioritizes wellbeing.

Overall, these lessons emphasize the value of integrating computer vision technology into assessment and developing safety practices, leading to a healthier and safer workplace.



Case Study 2: Guarantee Electrical Company and TuMeke Ergonomics

What's the Risk?

Field employees at Guarantee Electrical engage in manual material handling daily in their jobs. Field employees handle power tools, conduit, cable trays, and other equipment that can leave them feeling fatigued and overexerted. Moreover, these electricians commonly find themselves in awkward positions doing repetitive movements for the entirety of their workday.

Workers at Guarantee Electrical are also often required to lift heavy objects. To circumvent issues related to heavy lifting, Guarantee Electrical has lifting policies based on the weight of an object, but adherence to such policies is not well understood. Technology to better understand risky job tasks in general could provide a deeper insight when completing ergonomic assessments.

Project Aims

Guarantee Electrical aimed to alleviate the burden of doing traditional ergonomic assessments with pen and paper by shifting to using computer vision software which could automate assessments. Using the computer vision software from TuMeke allowed Guarantee Electrical to video job tasks, identify risks, and determine solutions to prevent MSDs within the TuMeke platform. More specifically, Guarantee Electrical Company aimed to:

- Utilize TuMeke to assess and verify various tasks in electrical construction and other sectors of work.
- Evaluate TuMeke software for cost benefits and efficiency.
- Use objective data and videos for employee training, and to determine the applicability of exosuits to reduce risk in specific applications.

Description of Project Activities and Implementation

Guarantee Electrical utilized the computer vision software for tasks in electrical construction to help establish objective data in the form of Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and National Institute of Occupational Safety and Health (NIOSH) lifting equation criteria. During the pilot period, Guarantee Electrical tracked data collection by industry sector and these risk exposure groupings:

1. Conduit bending
2. Wire pulling
3. Cable tray installation
4. Device wiring/trimming out
5. Ladder/above ceiling work
6. Miscellaneous power tools use

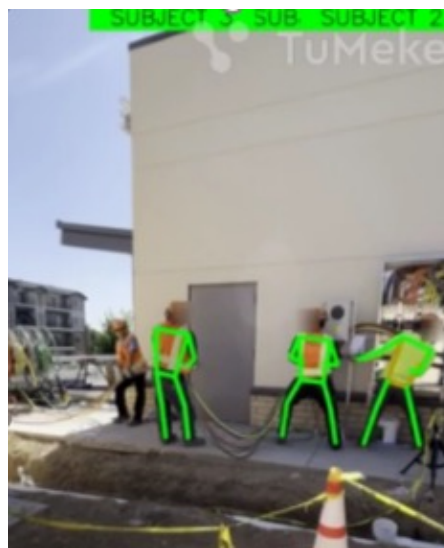


Figure 3. Example of Wire Pulling Task with TuMeke Video Capture



Project Accomplishments and Lessons Learned

Due to the extreme variability of construction work and body positions, Guarantee Electrical did not have enough time with the software to gather data on their entire operation or collect enough data to determine statistical validity. However, the videos with overlaid risk level warnings proved to be valuable for on-the-spot and task-specific ergonomic risk reduction training.

Guarantee Electrical also has several key lessons and takeaways from the pilot process:

- The TuMeke technology was great for fast evaluations of manual material handling tasks, while also providing follow-up analyses.
 - > As a result of the pilot, Guarantee Electrical incorporated the TuMeke videos into their orientation and manual material handling programs to provide further information about risks and the importance of safe handling.
- The software served as a training mechanism for the safety and industrial hygiene teams, as they were able to learn more about RULA, REBA, and the NIOSH lifting equation.
- The interaction with employees before, during, and after the video assessments were rewarding and highly informative for the employees as they were able to quickly see risk levels and discuss alternatives for task completion.
- Application of the TuMeke technology within the construction industry could be vast, as workers perform many variable tasks.
- An opportunity to incorporate the use of exosuits for overhead work was identified for Guarantee Electrical through data provided by the technology.
- The amount of involvement needed from the solutions provider should be determined up front. More support or involvement during the implementation and pilot process from TuMeke would likely have made the pilot smoother.

Overall, Guarantee Electrical found benefits in the TuMeke Ergonomics software. Due to the value seen, Guarantee Electrical plans to continue use of the TuMeke software to further their MSD risk reduction efforts and MSD prevention program improvements.

Case Study 3: Amerisure Insurance, Beverage South Distributors, Auto-Wares, Inc., and HeroWear

What's the Risk?

Reducing MSDs is a high priority for Amerisure as MSDs are consistently in the top two causes of loss frequency and loss severity for their policyholders. Every year, nearly 280,000 U.S. workers miss work due to MSDs. To address this issue, Amerisure partnered with two policyholder organizations whose employees face risks from manual material handling tasks, such as frequent lifting, carrying, lowering, and moving objects. This collaboration aimed to reduce the risk of MSDs, particularly those affecting the lower back. Evaluating the impact of innovative solutions such as HeroWear with multiple organizations and removing common stumbling blocks can advance Amerisure's goal of reducing lower back injury risks through the use of technology.

Project Aims

This project had the overarching goal of lowering MSDs, specifically lower back MSDs, as well as increasing safety culture in organizations. Workers from the chosen policyholder organizations, Beverage South Distributors, a beer and soda distributor, and Auto-Wares, Inc., an automobile parts distributor, piloted the HeroWear exosuits. Before launching this pilot, Amerisure had established the use of TuMeke in many of its policyholder organizations. While monitoring tasks with TuMeke technology will be addressed, it is important to note that this technology was not the specific focus of the pilot grant project. Instead, the aim was to explore new solutions for preventing MSDs using HeroWear exosuits.

There were several more granular goals outlined for the project:

- Utilize pre- and post-surveys to obtain input from management teams and frontline users regarding the safety technologies' perceived exertion, perceived benefits, and desire to continue use of the products.
 - > Administer a perceived exertion and output survey before and after the pilot to compare results.
 - > Administer an employee survey to gather information on identified problems, comfort, adoption, level of desire to continue usage, perceived impact, and perceived value.
 - > Administer a management survey to gather information on identified problems, level of desire to continue usage, perceived impact, and perceived value, and to follow up on the TuMeke results.
- Compare pre-pilot and pilot data shared by the partner organizations regarding absenteeism rates, employee productivity/production rates, and/or injury rates for pilot group employees, as well as non-pilot group employees (baseline/control group).

Description of Project Activities and Implementation

The HeroWear pilot with Auto-Wares ran from December 11, 2023, to March 19, 2024 (100 days) and was conducted at Auto-Wares' Chicago, IL warehouse. The pilot with Beverage South Distributors ran from December 11, 2023, to March 14, 2024 (95 days) and was conducted at Beverage South's Columbia, SC location. Each company was provided with HeroWear exosuits for 10 of their order pickers at the chosen warehouse locations.



To better understand the exposure to MSDs faced by employees of Auto-Wares and Beverage South, multiple tasks were evaluated prior to the pilot using TuMeke Ergonomics' software. Thirteen tasks at Auto-Wares' facility were evaluated and three tasks at Beverage South's facility were evaluated. As displayed in Table 1, 77% of Auto-Wares' task assessments and 67% of Beverage South's task assessments were determined as high risk for MSD injury. An additional 15% of Auto Wares' tasks scored in the very high-risk range.

Table 1. Pre-Pilot REBA Assessments of Tasks

Risk Level	Auto-Wares Tasks	Beverage South Tasks
Acceptable Risk	0	0
Low Risk	0	0
Medium Risk	1	1
High Risk	10	2
Very High Risk	2	0

Once the pilot began, additional data were collected in three formats:

- Exosuit users provided feedback via employee perception surveys, which were administered before the pilot began (as a baseline), during the pilot, and at the end of the pilot.
- Qualitative feedback was received from the exosuit users and managers administering the pilot.
- Anonymized performance metrics were received from both companies. These metrics included injuries and productivity for the pilot period as well as similar non-pilot periods for benchmarking comparison. Turnover and absenteeism data were also reviewed.

Project Accomplishments and Lessons Learned

Of the Auto-Wares employees in the HeroWear pilot, 10% refused to wear the exosuit, 30% stopped wearing the exosuit before the midpoint survey, and 60% wore the suit to completion. Of the six employees who wore the exosuit until the end of the pilot, five employees (83.3%) indicated they would be somewhat disappointed if they could no longer wear the exosuit, and one (16.7%) indicated they would not be disappointed if they could no longer wear the exosuit.

It is noteworthy that Beverage South's employees did not participate for the entire pilot period. The frontline manager who was overseeing the employees in the pilot resigned shortly after the pilot's launch. As a result, employees at Beverage South wore the exosuit for about one week, then most employees did not wear it for about 60 days until upper management required its usage for the last three weeks of the pilot. Of the nine employees who wore the exosuit during the last three weeks of the pilot, five (55.6%) indicated they would be somewhat disappointed if they could no longer wear the exosuit, and four (44.4%) indicated they would not be disappointed. Other results from both organizations' pilots are highlighted in the tables below that utilize pre- and post-pilot data to make determinations about changes in employees' perceptions about completing the work tasks and the levels of discomfort.

Table 2. Employee experience wearing exosuit

Using the HeroWear Apex 2 exosuit resulted in a:		
	Auto-Wares	Beverage South
Change in the rating of how tired an employee feels after a typical workday	3.5% reduction	8.0% increase
Change in the rating of how tired an employee feels from a typical lift	3.7% reduction	31.4% reduction
Change in the rating of how tired an employee feels from their heaviest lift	40.7% reduction	42.2% reduction

Table 3. Discomfort after wearing exosuit

Using the HeroWear Apex 2 exosuit resulted in a:		
	Auto-Wares	Beverage South
Change in the rating of shoulder discomfort	22.7% reduction	28.6% increase
Change in the rating of upper back discomfort	No change	18.6% reduction
Change in the rating of lower back discomfort	26.9% reduction	32.8% reduction
Change in the rating of hip discomfort	31.3% reduction	No change
Change in the rating of thigh discomfort	80.0% increase	50.0% increase
Change in the rating of knee discomfort	No change	3.7% reduction

As shown in Tables 2 and 3, Beverage South employees indicated an 8% increase in fatigue at work and a 50% increase in thigh discomfort due to wearing an exosuit. Qualitative feedback from Beverage South employees gave insight into these ratings. Order pickers in the pilot stepped on and off certain equipment to complete their tasks 100+ times per day. Although the exosuit does have a feature to turn off the exosuit's tension/support when stepping up onto equipment, the employees felt it was cumbersome to turn the exosuit on and off 100+ times per day. As a result, the exosuit remained active as employees stepped on and off the equipment, creating tension and placing pressure on the legs. When this motion was performed incidentally, the user did not feel fatigued, but when repeated 100+ times per day, it likely created discomfort and increased fatigue in the legs. Auto-Wares' employees similarly indicated an increase in thigh discomfort, which deserves more attention in future pilots to discern the cause.

As shown in Table 3, both Auto-Wares' and Beverage South's employees indicated the greatest benefit from the HeroWear Apex 2 exosuits was realized when they were performing their heaviest lifts, with Auto-Wares' employees indicating a 40.7% reduction in fatigue from their heaviest lifts and Beverage South's employees indicating a 42.2% reduction in fatigue from their heaviest lifts. Employee comments consistently expressed that they want to continue to use the HeroWear Apex 2 exosuits, particularly when performing heavy lifts.

In addition to employee perception surveys, data regarding the productivity of employees was also available through the pilot. Comparing the average piece count of Auto-Wares employees who participated in the pilot during the study period to their average piece count during the same period one year prior, there was a 20.2% increase in productivity. Meanwhile, the increase in the average piece count for the employees who did not participate in the pilot was only 5.5% when comparing the same two timeframes. This contrasts sharply with the 20.2% increase observed among those who did participate, highlighting the significant impact of the pilot on productivity.

Beverage South employees' productivity was slightly lower during the pilot period than the month before and after the pilot. Comparisons for those participating in the pilot and those not participating could not be made, as data for those not in the pilot were not evaluated. More insights into the productivity impact of wearing an exosuit are needed in future pilots and research.

Overall, the pilot of the HeroWear Apex 2 exosuit showed it can have positive impacts on reducing worker fatigue and improving worker productivity. However, these impacts are not realized in all instances. Organizations will achieve the highest return on investment from their exosuit pilot if they appropriately assign an exosuit to suitable tasks and ensure that the pilot is managed by a trained individual who understands how to properly fit the exosuits.



Case Study 4: General Electric Aerospace and HeroWear

What's the Risk?

MSDs, specifically back injuries, are a major focus at the General Electric Aerospace Erlanger warehouse facility. Over 80% of all General Electric Aerospace's parts and components pass through the warehouse weekly. The 400,000-square-foot Erlanger distribution center has about 155 employees who perform material handling tasks that often demand bending and twisting to complete their tasks. Manual material handling is described at the site as dynamic, incongruent, and repetitive.

As a result, back injuries are the most common injury at the warehouse (about 26% of strain-related injuries), followed by shoulder injuries (about 19% of strain-related injuries). From 2019 - 2023, 53% of injuries at the distribution center were caused by lifting or lowering material. Due to the risks, General Electric Aerospace at the Erlanger location considered that exosuits could be a potential solution to address the risks associated with manually unloading trailers and to help accommodate an aging workforce.

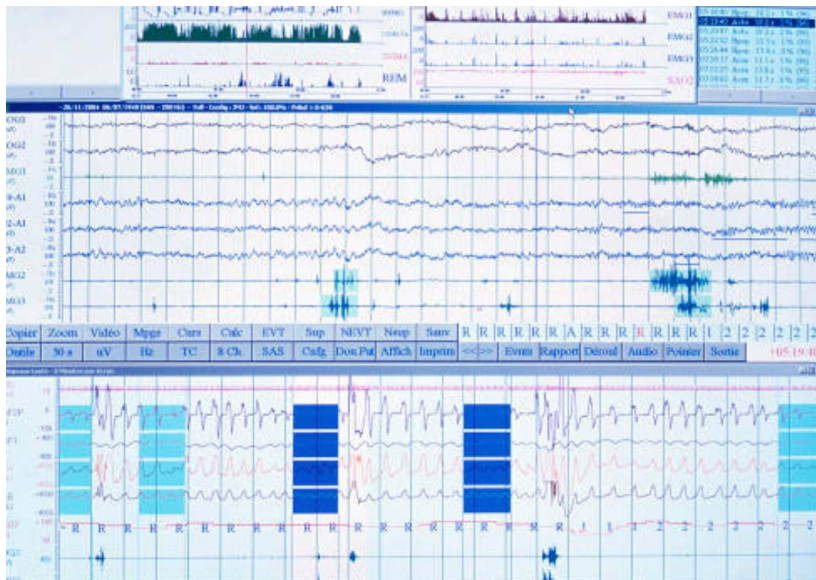
Project Aims

The goal of the project was to investigate the effectiveness of HeroWear's Apex 2 exosuit on reducing fatigue, muscle strain, and other ergonomic risks in users. The initial focus of the study was on the job task of unloading tractor trailers, as this job involves several employees per truck that manually lift and carry boxes off the truck. General Electric Aerospace was also interested in determining the employee acceptance and operational benefits and efficiency of using the HeroWear exosuit.

Description of Project Activities and Implementation

Ten randomly selected employees were trained and fitted on how to wear the HeroWear suits by the HeroWear training team. Employees wore the suits over the course of six weeks to get familiar with and learn how best to use the exosuits for their specific tasks. Participants completed initial questionnaires and surveys at the start of the pilot program, three weeks in, and at the end to provide feedback on how the exosuit helped reduce fatigue, lowered physical demands, and enhanced efficiency.

To evaluate the ergonomic risks, wearable surface electromyography sensors were used to measure muscle activity. Nine employees, seven men and two women, participated in the muscle testing. Eight wireless, surface electromyography sensors were attached bilaterally to biceps, quadriceps, hamstrings, and lumbar extensor muscles. Calibrations for maximum voluntary contraction, a measure of muscle strength that indicates the greatest amount of force a muscle or group of muscles can generate, were conducted for each individual and each muscle. Employees were coached over a two-to-three-week period on how to perform maximum voluntary contractions prior to the muscle testing data collection to reduce error when performing the maximum effort.



Pilot implementation began with a team kick-off meeting to provide an overview of the project. Following this, HeroWear personnel conducted training sessions on how to use the exosuit and ensure proper fit. Coaching was also offered by HeroWear staff on the correct usage of the exosuit, along with gathering feedback from participants. Baseline measurements were taken to assess ergonomic risks and productivity levels for the job, both with and without the exosuit. Over four to six weeks, employees continued to practice using the exosuit, during which time productivity and employee questionnaires were administered. After one to two months of usage, ergonomic risks and productivity were evaluated using wearable sensors and time study techniques. An interim report was then developed to highlight the benefits observed and lessons learned during this phase. Based on these findings, course corrections were made to adjust the pilot parameters, followed by an additional four to six weeks of usage of the exosuit, where productivity and employee questionnaires were again collected. Finally, after this extended period, a second round of data collection on ergonomic risks and productivity took place using wearable sensors and time studies, culminating in the developing of a final report and case study.

Project Accomplishments and Lessons Learned

Results of the muscle activity data from the wearable sensors were inconclusive, and the exosuit appeared effective for only some employees. Muscle activity was compared for each testing condition while wearing and not wearing an exosuit. An analysis of muscle activity for each task condition and individual shows that, for some muscles, activity decreases in certain cases, while for others, it increases. These results seem to be specific to the tasks performed and the body mechanics involved. A reason for this inconsistency in muscle activity may have been asymmetric twisting while material handling. Since boxes without handles were used, employees staggered their hands to make it easier to lift boxes. This creates asymmetric postures of the arms, back and legs, and could explain the differences in bilateral muscle activity. Moving forward, boxes with handles may circumvent some of these issues with asymmetrical postures and subsequent differences in muscle activity and strain.

A review of employee feedback collected through surveys revealed more conclusive evidence. Eighty percent of employees who utilized the exosuits in the pilot found that the exosuit transformed their posture. Users reported that the exosuit helped them maintain proper shoulder posture, supported spinal alignment, and offered lower back support when they reached forward during material handling. Those using the exosuit also appreciated the adjustable tension and support offered by the device. Employee feedback also suggested that the exosuit rewards proper body mechanics, with 90% of employees saying it helped their body mechanics. Wearing the exosuit provides noticeable support when squatting down, assists with lifting when rising from a squat, and makes bending at the waist, an action that is generally not recommended, more challenging.

A few site-specific challenges arose during the pilot. The main drawback for employees was that they routinely wear fall protection for their daily work. This makes it difficult to comfortably wear the exosuit underneath the fall protection. In addition to comfort, it became cumbersome for employees to regularly don and doff fall protection and an exosuit multiple times throughout their shift.

Employees at the site have also already created safe habits, such as raising the forks of their forklift to a waist-level working height to ensure proper ergonomics while lifting and moving packages, and not engaging in lifts over 40 lbs. for a single worker. Breaks at the site are also frequent, allowing employees to rest in between strenuous work tasks. These habits contribute to the prevention of MSDs, which may complicate the assessment of the effects of the exosuits, as most employees are already practicing safe material handling movements. Yet, despite these positive habits, trialing of the exosuits was still seen as a necessary step to determine if risks and injuries could be further lessened.



Overall, although the asymmetric twisting involved in the work made it more challenging to interpret the results related to muscle activity from wearable sensors, employees believed that the exosuits helped improve their body mechanics and posture. Yet, determining how to best utilize both the exosuit and fall protection in tandem is still to be determined. Future research and pilots should continue to explore the interaction between exosuits and fall protection as well as the impact of exosuits on work sites with strong ergonomic safety processes already in place to determine their incremental impact.

Key Takeaways

The pilot projects were a unique opportunity for organizations to trial emerging technologies for the prevention of MSDs in their workplaces. While the four pilot studies had their own processes and lessons learned, there were several shared takeaways across the pilots. For example, most organizations who implemented new technologies noted that the technology benefited some, if not most, employees who trialed it.

For those organizations who piloted computer vision technology, there was a shared feeling that the videos captured by the technology were beneficial for trainings, orientations, and educating workers on proper body mechanics and postures. Use of the computer vision technology also informed organizations of further steps they could take to reduce risk for MSDs, such as implementing upper body exoskeletons or creating stretching or mobility programs. The pilot organizations also mentioned that using the computer vision technology allowed for much quicker risk assessment than could be done either manually or without the technology.

For those organizations implementing the exosuits, more varied results were found. Collectively, workers felt that the exosuit was beneficial and helped with proper body mechanics and reducing fatigue, especially as a result from heavy lifts. The exosuits' impact on muscle activity was less consistent, however, and more research may be needed to determine their impact. Lastly, return on investment will be highest for organizations that match the use of the exosuits to the correct tasks. For example, if workers participate in an activity in which wearing the exosuit is less comfortable or feasible because of other needed personal protective equipment, or requires frequent adjustment of the tension, it may be best to not wear the exosuit for such tasks.

Organizations that tested the specific emerging technologies also agreed about the importance of pilot program management and the product's ability to make a positive impact. If the pilot program is not properly managed or is not championed by leadership at the organization, it may not be successful. Readiness for technology adoption is also necessary before trialing new technologies. Similarly, the willingness and ability of workers to embrace new technologies are important in successfully implementing new technologies in organizations. Lastly, it is vital for organizations to understand the impact they want the technology to have and how they plan to measure that impact as opposed to just implementing a new technology because of its perceived utility.



Conclusion

The 2023 - 2024 pilot grant program provided five MSD Pledge members with the opportunity to partner with six leading technology providers to trial emerging solutions in real-life applications. Four projects were completed in the specified time frame, with one still pending finalization. Three organizations trialed HeroWear exosuits, and two trialed TuMeke's computer vision technology.

Organizations reported mixed, but mostly positive, results from their technology use for MSD risk reduction. Moving forward, organizations are likely to benefit the most from pilots of innovative technologies if they:

1. Ensure their workforce is [ready to implement such technology](#)
2. Make a plan for pilot implementation, including assigned personnel to oversee and manage the pilot program
3. Match the technology they plan to utilize to the tasks and risks they are trying to solve

The MSD Solutions Lab will continue the pilot grant program to empower more organizations to implement innovative technologies, especially those organizations who could not otherwise afford such advancements, to effectively address MSD risks in the workplace. More information about the grant programs is available [here](#).

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