

suitX Exoskeletons Increasing Safety and Productivity for Workers in Delivery, Industrial, and Construction and Provides Mobility for Individuals with Spinal Cord Injuries and Stroke**Homayoon Kazerooni**
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“suitX industrial exoskeleton (MAX for Modular Agile eXoskeleton) is composed of three modules: backX, shoulderX, and legX. Each module can be worn independently and in any combination depending on need. The suitX exoskeletons substantially reduce the risk of work-related injuries.” - Homayoon Kazerooni

CEOCFO: Dr.Kazerooni, what is the concept for SuitX?

Dr. Kazerooni: SuitX, in Berkeley California, develops, manufactures and markets robotic exoskeleton systems for the medical and industrial markets. The entire approach to the design of these exoskeletons is based on being practical and affordable. suitX products are designed to solve consumers' problems effectively. The medical exoskeleton suitX is called Phoenix; it weighs about 13 kilograms; it is modular, and its battery lasts for eight hours of operation. We are currently in the process of applying for FDA approval. suitX industrial exoskeleton (MAX for Modular Agile eXoskeleton) is composed of three modules: backX, shoulderX, and legX. Each module can be worn independently and in any combination depending on need. All modules intelligently engage when you need them. backX substantially reduces the forces on a wearer's lower back region during stooping, lifting objects, bending or reaching. legX allows the wearer to squat repeatedly or for prolonged periods of time by reducing the knee joint and quadricep muscle forces. shoulderX reduces gravity-induced forces at the shoulder complex, enabling the wearer to perform chest to ceiling level tasks for longer durations and with less effort.

CEOCFO: Where would your devices be applicable?

Dr. Kazerooni: Our industrial exoskeletons can be used by workers in delivery services such as by FedEx, UPS or Amazon. They are applicable in work settings where workers move around objects, such as loading and unloading trucks, conveyor belts and pallets. suitX exoskeletons can be used by workers in warehouses and distribution centers where workers manipulate boxes all of the time. Workers in construction sites, ship building facilities, factories, manufacturing facilities and food processing also use suitX industrial exoskeletons. In

many industrial settings, workers put their bodies into abuse eight hours a day moving around objects, bending, squatting and reaching. Our industrial exoskeletons are designed to substantially reduce the knee, shoulder and back forces during these operations.

CEOFCO: *Where does comfort level come into play?*

Dr. Kazerooni: During the last five years of design, we made sure to not only reduce the forces on the users but also to keep the users comfortable. Our exoskeletons are designed to feel entirely transparent to the users. The workers hardly feel they are wearing exoskeletons and the devices do not impede the workers. The workers can climb stairs, ladders and even drive a truck. The workers, when wearing our exoskeletons, can perform the same maneuvers when they are not wearing the exoskeletons. However, once a worker wears our industrial exoskeleton, s/he will have an additional capability, and that is the decrease of the stress on the worker's back, knees and shoulders. Another benefit of our exoskeletons is that it increases the workers' productivity.

CEOFCO: *Are the devices individualized for the worker or a there a range of sizes?*

Dr. Kazerooni: The suitX exoskeletons come in two parts; soft parts and hard parts. The soft parts are in contact with the wearer's body, and the hard parts are load bearing components and transfer forces. All suitX exoskeletons are adjustable in height, width and depth. The very first time a worker wears an exoskeleton, the user should adjust the dimensions for proper fitting. After the initial adjustment process, donning the exoskeletons takes less than a minute.

CEOFCO: *Are workers looking for a better way? Do companies understand that they can get more productivity and increased safety for their workers? Are both groups pushing for your devices?*

Dr. Kazerooni: We have given demonstrations of our exoskeleton technology to a countless number of industrial entities in the US, Europe, and Asia; we have not had a single case where a user did not like our exoskeletons. Every single plant manager valued devices to the point where they purchased some exoskeletons for evaluations. Up to now, at least fifty of our industrial exoskeletons are being evaluated by a variety of industries worldwide.

CEOFCO: *Does it seem a little too science fiction for many people?*

Dr. Kazerooni: You are right; suitX exoskeletons are based on new technologies. If you look at my background, you would see that I have been working on exoskeleton technologies over thirty years. Our current exoskeleton technology is the product of an engineering program initiated by White House called the National Robotics Initiative (NRI). In 2010, President Obama launched the NRI to accelerate the development of robotics technology that works cooperatively with humans, transforming the way people work. What makes our development categorically different from the other systems is that suitX scientists and engineers worked with workers throughout the development to ensure the resulting exoskeletons are practical, accessible and can be accepted by workers. These exoskeletons would not impede the workers' daily maneuvers. These exoskeletons are designed based on solid engineering foundation to reduce the risk of injuries to workers in construction sites, factories, manufacturing facilities, and shipyards. You

might have seen large and bulky exoskeletons in science fiction movies that teach violence; our exoskeletons are completely contrasting these large systems. suitX exoskeletons are designed to help workers whose safety devices up till today were hard hats, safety glasses, and steel-toed shoes. We are bringing bionics to increase the workers' productivity and safety. In construction sites, workers might repeatedly squat for 8 hours a day; in delivery services, workers repeatedly bend for hours to move around boxes; in airports, luggage handlers move luggage all day long. Our objective is to create a better-quality work environment for the workers through the use of accessible exoskeletons.

CEOCFO: *Are there newer materials that allow you to make exoskeletons lighter?*

Dr. Kazerooni: Every aspect of technology around us is progressing, and suitX engineers are taking advantage of this progress. It is not only the new materials but also the latest state of technology in engineering, sensors, computation, control sciences and artificial intelligence are impacting our exoskeleton technology. The bottom line is that we create and employ new technologies to provide exoskeletons for a better quality of work environment for workers at an accessible price. While the notion of the exoskeleton in science fiction movies is to make someone strong, we strive to give a more accurate and realistic definition for exoskeletons. The exoskeletons in movies can run fast and jump over the buildings or even fly; they have always considered the essentials of strength in aggressive and violent conflicts and fights. These science fiction movies are entertaining, but they do not inspire us. Creating better work environments for ordinary people who need strength to perform their daily jobs is inspiring us.

CEOCFO: *Does it ever become second nature for the worker using your device, so just part of a standard work experience?*

Dr. Kazerooni: There is a natural progression during the use suitX exoskeletons. suitX exoskeletons do not amplify the wearer's power. One cannot use our devices to hurt another person. These devices are designed to reduce the stress on the back, knees, and shoulders. Imagine you are picking up a twenty-pound box - which is not heavy. However picking up twenty-pound boxes from the floor and placing them on a conveyor belt for eight hours a day will lead to repetitive injuries. suitX exoskeletons make a twenty-pound box seem like a ten-pound box to the worker's back. The worker's back and knee joints will feel less stress and strain. There is a vast difference between suitX technology and Iron Man. The suitX technology effectively reduces the gravity forces on the user's joints. The suitX exoskeletons substantially reduce the risk of work-related injuries.

CEOCFO: *How do you work with the medical community?*

Dr. Kazerooni: The medical exoskeleton (Phoenix) is different from the industrial exoskeletons. Phoenix is designed for people who have limited mobility due to spinal cord injury, stroke or other neurological disorders. Phoenix allows them to be upright and mobile. Phoenix's anticipated cost is about \$30,000. Phoenix is currently the most accessible exoskeleton in the market. In designing Phoenix, we had more emphasis on the software and intelligent control than on the hardware. Phoenix has only two actuators in its hip and is very light. The knee joints do not have any power. However, an intelligent controller can faithfully maneuver each leg through swing and stance organically. Once the users are upright and mobile for a few hours a day using Phoenix; the secondary injuries

due to prolonged sitting will be postponed, and general health will be improved. Phoenix has not been approved by FDA for sale in the US yet; currently, it is an investigational device. We are currently conducting various clinical evaluations for FDA approval. We are also developing exoskeletons for children with cerebral palsy. In many cases, walking becomes a non-functional and exhausting skill for children with CP. This usually causes these children not to acquire locomotion skills, and consequently to lose their independence. However, bipedal locomotion, an embedded characteristic of the human, ensures the best physiological motor pattern acquisition. Our goal is to develop a set of technologies that lead pediatric exoskeletons that naturally promote the walking skills among children in a very short period.

CEOCFO: *How do you know where to focus with so much opportunity?*

Dr. Kazerooni: Currently we are focusing on industrial exoskeletons until we receive FDA approval for the sale of medical exoskeletons in the US. Passion drives suitX, that is why suitX can push through and focus on all opportunities. We simply cannot let go of any potential. In fact, we are currently developing a set of exoskeletons for a completely new market. For medical applications, we see many potentials in rehabilitation and patients' assistance. We are seeking resources and partners from worldwide to help us push our medical exoskeletons forward. Our medical exoskeletons are now for sale in Europe. Our industrial exoskeletons have been recognized enthusiastically by industries worldwide. Rather than replacing workers with robots, we want to augment the workers with exoskeletons to increase productivity and safety. We rely on three elements in our developments: creating superb products based on solid engineering foundation; passionate employees; and dedicated investors and strategic partners.

The logo for SUIT X features the word "SUIT" in a bold, black, sans-serif font. To its right is a large, stylized "X" composed of two thick, dark red diagonal bars that intersect in the center.