INTRODUCING IRON MAN: EXOSKELETONS IN WARFARE

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ABSTRACT

The article looks at the latest developments in the use of exoskeletons in warfare. It attempts to address two major research gaps in the literature – (i) While there are essays on where individual countries are in terms of military exoskeleton research, there is currently no primer or overview where all the available data from various countries is collated into one coherent analysis. It will thus offer the first truly global look at the latest developments in this field as of 2021, comparing the progress made by major military powers such as the USA, Russia, China, NATO, India etc and (ii) There is very little discussion on the implications this technology might hold for the battlefields of the future. Since it would be radically new and an untested entity if used in modern warfare, it is vital that security scholars ponder the consequences of deploying such innovations in contemporary theatres of operation. The article attempts to rectify that gap as well, with a brief look at the potential changes in warfare exoskeletons could bring about. The article also attempts to frame the relevant issues in a structure that could facilitate further research. It highlights the areas of uncertainty in this new technology that could potentially disrupt the global system.

Keywords: exoskeleton, battlefield, modern warfare, technology

INTRODUCTION:

"*I knew that was where we were heading, but I didn't realize we were this close...that's Iron Man.*" these were not the words of a layman, they were from Adi Granov, one of the main illustrators of the Iron Man comic released by Marvel Comics (Mone, 2018). This was his reaction to being shown the Raytheon Sarcos XOS, one of the first models in a series of powered exoskeletons currently being developed by the pentagon. The suit lends its user increased strength, speed, and endurance (Keller, 2021), much like a battle armour would in science fiction and fantasy literature. Such technology is no longer in the realm of imagination, armies around the world are actively working on them, with some even coming close to fruition.

The purpose of this article is to address two major research gaps in the literature – (i) While there are essays on where individual countries are in terms of military exoskeleton research, there is currently no primer or overview where all the available data from various countries is collated into one coherent analysis. It will thus offer the first truly global look at the latest

developments in this field as of 2021, comparing the progress made by major military powers such as the USA, Russia, China, NATO, India etc and (ii) There is very little discussion on the implications this technology might hold for the battlefields of the future. Since it would be radically new and an untested entity if used in modern warfare, it is vital that security scholars ponder the consequences of deploying such innovations in contemporary theatres of operation. The article attempts to rectify that gap as well, with a brief look at the potential changes in warfare exoskeletons could bring about.

What is an exoskeleton? Simply put, it is a skeletal structure that forms around the body on the outside, rather than on the inside. Crustaceans like crabs and lobsters have exoskeletons, as do insects like grasshoppers and ants. These creatures have their skeletons serving as an outer armour of sorts to protect their bodies. In contrast, human beings have endoskeletons – our bones are on the inside of our bodies, covered by tissue and muscle membrane. Having endoskeletons allows organisms to grow to large sizes and allows organisms to have a great degree of flexibility (all vertebrates for instance have endoskeletons) but it also makes us more vulnerable to damage from external factors.

The purpose of an exoskeleton in the battlefield is to negate this disadvantage and to augment the physical qualities of the soldier (Weinberger, 2013). With weapons getting increasingly destructive, the plight of the common soldier is one that should be easy to relate to. While conventional warfare breaks out at a far less frequent basis than ever before, the wars that do happen tend to be highly destructive and result in large death tolls because of the increased capacity for damage. Populations are also far less tolerant of casualties in modern wars, especially in democratic nations, which makes it imperative for the State to develop ways in which fewer soldiers are sent back home in caskets.

While exoskeleton technology is nothing new, either in the realm of fiction or military research, it has only been in the 21st century that it has started to take new shapes and forms which capture the public imagination. The 'iron man' analogy is not the only recognizable comparison from pop culture. James Cameron's classic movie “Aliens” features an infamous scene where the protagonist wears a powered exoskeleton to fight against the alien creature at the end. Robert Heinlein's classic work Starship Troopers depicted soldiers wearing advanced battle suits with integrated systems. These moments in fiction are important because modern researchers and scientists grew up being exposed to such thought, allowing it to shape their own work in the real world. We often neglect what a big part works of imagination play in shaping modern science because the correlation is not made on a frequent basis.

USA

One of the most active nation in this regard is, unsurprisingly, the United States (Stewart, 2018). There are a number of companies currently working on powered exoskeletons, many of them with their own features and characteristics that would have differing impacts on the modern battlefield. Unlike Russia and China, which are also heavily investing in development, the USA has a large pool of private sector research it can draw on to compliment any public sector developments. A number of leading defence companies, from Raytheon to Lockheed Martin, have already made huge strides in this regard.

The first and major development is the aforementioned Raytheon Sarcos XOS, the same one which made Adi Granov make the Iron Man comparison. The suit was one of the earliest innovations in this field, having reached completion more than a decade ago in 2008 (Karlin, 2011). Coincidentally, it was the same year that Hollywood released the Iron Man movie as well. The suit was impressive but it was the second generation of the armour, the XOS 2, which made huge waves and became a major news item all over the world, even being included in Time Magazine's list of Best Inventions (Raytheon's XOS 2 robotic exoskeleton nabs top innovation nod, 2010). The suit was a major improvement over the first generation, allowing its user to easily lift nearly 100 kilos with little difficulty, even being able to sustain the load for long periods of time without experiencing any physical stress. The company initially received funding from the US Defense Advanced Research Projects Agency, known colloquially as DARPA, but reports suggest that most funding since then has been private and independent.

Raytheon has recently released its third generation of the exoskeleton, known as the Guardian, which has been equally impressive. The new prototype was also featured by Time Magazine in 2020, being named as one of the 100 Best Inventions of 2020. The new suit is to be used in a number of industries beyond just defence, including oil, manufacturing, logistics, aviation and warehousing. Like its predecessor, it allows the wearer to carry heavy loads over long periods of time and over long distances without any muscle fatigue. It is expected to be ready for sale by 2022, with Delta Airlines already stating that it wants to use it for their freight and cargo maintenance teams (Edwards, 2021).

Another innovation that could have had a big impact was the TALOS battle suit, although it ultimately ended in failure. The abbreviation for it is Tactical Assault Light Operator Suit, and its story gives us some interesting insight into how exoskeleton technology might be deployed in the battlefield, along with its shortcomings as well. The idea of the suit is famously said to have originated from a 2012 raid conducted by SEAL Team 6, one of the Navy SEAL contingents of the Naval Special Warfare Development Group (Keller, 2020). The team was deployed on a night-time raid to rescue a civilian doctor who had been captured by the Taliban. Although the hostage was rescued, the leader of the team, 28-year-old Chief Petty Officer Nicolas Cheque

was killed by an assault of close-range gunfire. This ignited a conversation in American circles about the need to have a protective suit for special operations that would enhance the speed, stealth and durability of the soldiers, instead of merely boosting their brute strength with a generic exoskeleton.

Out of this was born the TALOS. A tribute to Talos, the famed giant bronze android from Greek mythology who is said to have patrolled the Crete island's shoreline, research into the suit was announced in 2013 and touted as being potentially revolutionary in the field of special operations. Stretching the Iron Man-Talos analogy even further was no less than then US President Barack Obama himself, who said "Basically, I'm here to announce that we're building Iron Man." (Poole, 2021) which was greeted with both laughter and enthusiasm.

The results however, have turned out to be a failure. After half a decade of research, it was finally announced by the US Special Operations Command in 2019 that the idea was not feasible. The reason for the failure however is not a lack of funding or even that the idea was bad in principle, it was simply that current networking capabilities are not sufficient to sustain a battle suit with a complex interplay of sensors and systems. Integrating all these individual systems into one seamless structure – from the exoskeleton to the helmet to the various communication devices – turned into a task the designers ultimately decided was too difficult to undertake. However, even though it was stopped in 2019, this is not to say that the entire endeavour was a failure, since the TALOS did make great strides forward in the battle-suit domain (Douglas, 2021).

RUSSIA

Not far behind the USA is its former rival Russia, which has also invested a lot of time and resources into developing exoskeleton technology. There have been reports of an exoskeleton race between the Russians and the Americans as far back as 2018 (Tucker, 2018), with both rivals gearing up to produce the next great innovation. The program to develop battle-suits, known as the Ratnik program in Russia, first came into the limelight in 2013, with Russia's Deputy Prime Minister at the time, Dmitry Rogozin, announcing its features to the media. The first prototype was reportedly made to be showcased at the Russia Arms Expo in 2013, where a range of other such innovations were showcased as well. To the chagrin of some international commentators, the New York Times reported that some pieces of the suit were seen being worn by Russian soldiers in Crimea (Herszenhorn, 2014), which meant they had already taken the lead in operationalizing it on the battlefield.

It is the third generation of this prototype though, the Ratnik-3, which is the most famous and has sparked a lot of discussion. Since it is not dependent on power, it has been able to circumnavigate many of the issues which led the TALOS project to failure. Built by Moscow's Central Research Institute, the suit is said to be capable of similar feats as its American

counterparts in terms of adding strength and durability to the wearer. Discussions of the suit often seem so deep into the realm of propaganda or science fiction that there were even reports of fitting the suit with a watch that would be nuclear resistant (Brown, 2017).

It is worth noting that an earlier prototype of the Ratnik was also deployed in Syria for bomb disposal purposes (Rostec Releases Video of Soldier Exoskeleton That Was Tested in Syria, 2021). Known as the Exoskeleteon 1 or EO-1, it underwent diligent testing in 2017 with combat engineers on the field. Russia has been actively involved in the Syrian conflict since 2015, which predominantly seems to be influenced by a 'spheres of influence' model (Yacoubian, 2021). Since Russian de-mining robots like the Uran-6 require large and heavy consoles that need to be carried, the exoskeleton helped the Russians carry the large load over long distances in Syria, something they would have been unable to do without the EO-1. This is a classic example of a military application without the use of force being involved.

Since the Russians seem more intent on small steps rather than making radical pronouncements like the Americans, it has been noted that Russia is actually taking the lead in terms of practical value. Unlike the TALOS for instance, the developer of the EO-1 was always quite realistic about what this would be capable of and what it would not. This essentially mean that in a hare-and-tortoise way, the Russians have been slowly but steadily gaining primacy here, with small innovations that make just enough headway for the next phase of research (Hambling, 2020). To add to the scope of Russia's progress in this field, there have recently been reports that the Research Institute has already delivered about 300,000 of the suits (Asthana, 2020), a number so staggering that no other country even comes close if the reports are true.

Probably the most pertinent Russian developments alongside the Ratnick, are the battle-suits known as “Schturmovik” or “Stormer”, which have been developed in parallel with the exoskeleton, but seemingly with more of a focus on flexibility and speed, similar to the difference between the XOS and the TALOS. Although the weight it allows the user to carry only seems to be around 60 kg, lower than a traditional exoskeleton, the mobility it provides has made some tout it as a major breakthrough in the field (Keller 2020) which demonstrates just how smoothly Russia has managed to use its operations in Syria to learn lessons and focus on gradual, practical innovations.

CHINA

Not to be left behind by the other major powers, China has also been focusing a lot of energy into the use of exoskeletons and battle-suits, in some way perhaps even more overtly than its rivals. China has largely depended on Norinco, the country's state-owned manufacturer for heavy equipment like ground munitions and armoured vehicles. The first generation of the Norinco exoskeleton was unveiled in 2015, with features that were more or less identical to

the early versions produced by the USA. The second generation of it was unveiled in 2018, once again with upgraded features that put it on par with the American and Russian versions (Lin and Singer, 2018). The Chinese versions are built for mountainous terrains, since those are the conditions under which they are most likely to be deployed. The first version of the Norinco had a top speed of nearly 3 miles an hour, a speed it would allow the user to sustain for about 12 miles, and while it is claimed that the second generation improves on it, the metrics are still unclear.

In addition to the terrain, China has also been exploring the possibility of optimizing its suits for high-altitude areas (Osborn, 2020), where it is likely to see the most military action. In addition to the possibility of a direct confrontation, logistical military activities in these regions are constantly hampered by the climate, which necessitates some kind of human intervention for maintenance purposes. Standard equipment such as robots and drones are commonly deployed in such areas and break down quite frequently in the rocky terrain, which often means human soldiers have to be sent in there to conduct manual repairs. Carrying large loads into such areas for the human operator is usually a daunting task, often having to deal with elevation levels upward of 3000 meters. Donning an exoskeleton however, would make the task much easier for the manual repairman being sent in.

In 2019, the PLA conducted what it called the 'Super Warrior Military Individual Exoskeleton System Challenge', a contest between nearly a hundred teams from various think-tanks, companies and universities in the country to see who would build the best exoskeleton. The suits were tested for their mobility, ability to operate in rough terrain and physical enhancements. While the systems showcased were still basic (Xuanzun, 2019), what it did demonstrate was the Chinese government's continued commitment to tap into its public resources and population to make advances in this field.

It was in late 2020 though, that China unveiled what is arguably its first overtly militaristic use of exoskeletons. China Central Television ran a program in December 2020 on the latest developments, showing video footage of a suit that was now intended to be worn by soldiers deployed in Southwest China's Tibet Autonomous Region (Peterson, 2021). Since the suit is non-powered, it once again bypasses many of the challenges that made the American TALOS unfeasible. The video showed troops hauling a supply delivery to one of the outposts in Ngari prefecture known for its mountainous terrain (Xuanzun, 2021), carrying the load with little effort. There has also been heavy speculation that the Chinese might be planning to use this to counter India (Ellmer, 2021) in the Gulwan River Valley.

THE REST

These developments of the three major powers do not mean the rest have done nothing about it. Although other regional and global powers have not been able to pump as many

resources into the technology as the aforementioned ones, ample progress has been made in places like Australia, Japan and India.

Australia has developed its own exoskeleton known as the Operational Exoskeleton or OX. While it is not a full-bodied and heavy suit, the emphasis is a lot more on decreasing the strain for infantry troops by using cables to help them carry larger weights. The mechanism works on a simple principle using Bowden cables (Husseini, 2019) to redirect the load on a soldier's back right into the ground. Since the mechanism only weighs about 3 kilograms, it is significantly lighter and less cumbersome than the XOS or HULC. Australian soldiers are required to carry loads of around 85 kg into combat regularly (Williams, 2015) and this is expected to ease the effort required.

India has also expressed an overt interest in the development of exoskeleton technology for military applications. Reliable information about their forays into the field first surfaced in 2019, revealing that the Defence Research and Development Organization, the Indian army's official research organization had already begun to explore such possibilities (Siddiqui, 2019). The private sector is also being utilized for research, with the DRDO laying out parameters for what it considers to be the optimal features for an exoskeleton. The DRDO's guidelines are essentially to ensure that any private sector contributions are in line with their requirements, to avoid sub-par contributions.

Some of the features listed out by them shows that they do have a keen understanding of how the technology can be used in Indian terrain, rather than simply trying to mimic their Western counterparts. The DRDO's requirements include things like the weight not exceeding 5 to 6 kgs, an uplift load of over 100 kgs, the ability to operate under temperatures from -20 C to +45 C (since India has regions like Kashmir with freezing climates and Rajastan with arid deserts), and a service life of at least ten years (Sagar, 2019).

Japan has been active in this regard as well. Back in 2015, the defence ministry announced that it was allocating USD 7.5 million into researching “highly powered mobile suits” (Simpson, 2015). Even going back nearly a decade, Japan unveiled a pair of robotic legs in 2012 that could be worn by a soldier to leap over a meter in less than a second. While the amount of less than eight million was criticized in some circles as being insufficient to produce anything, it still demonstrated a commitment towards public funding for these developments. In 2019 was when Japan really entered the sphere in a big way, unveiling for the first time the exoskeleton mechanism it had been working on. It has been noted that the technology itself is more or less comparable to the American versions (Marinov, 2020) despite some criticism.

Lastly, NATO has also become cognizant of the need to develop exoskeletons, although it is surprisingly behind many of the other names listed here. Other than launching the Integration of the Exoskeleton in the Battlefield Workshop series, which is a series of workshops

conducted to facilitate research on using exoskeletons for military applications (Marinov, 2018), there is little evidence that it has taken any proactive action in this direction as an institution.

With that overview of where various nations are right now, the article will now explore the possible implications of this technology for modern security.

IMPACT ON THE BATTLEFIELD

One of the primary worries about advancements in military technology in general is that they might exacerbate differences that already exist between the great powers of the world and smaller nations. Just as how nuclear weapons created a significant divide between those who have it and those who do not, it is not only possible but highly probably that new, disruptive technologies will create a similar hierarchy. It isn't likely to be much different in the case of exoskeletons either. The overview above clearly shows that countries that can afford to delve into this technology are already doing so in a large scale. And when those developments reach fruition, it is likely to widen the already existing gulf between the powerful and the powerless.

Will this make it easier for countries in intervene in other parts of the world. It would be difficult to argue to the contrary. The rise of drone technology has already demonstrated how easy it is for countries to operate in other territories while facing little to no domestic pressure. Contrasting the American interventions in Iraq and Pakistan demonstrate this point. In Iraq, local American protests broke out almost immediately and dissent has almost become a part of daily life. Almost every day, there was some anti-war protest in some part of the USA criticizing the intervention in Iraq. The interventions in Pakistan and Yemen by contrast, done primarily through drones, faced almost no resistance at all. The reason for this is not that Iraq's sovereignty was somehow more important to the average American protester than Pakistan's or Yemen's. Rather, it was because there were no dead American soldiers coming back.

Human casualties can often play a big role in the psyche of the public. Similarly, the lack of human casualties can often make the public apathetic to a problem, even if the problem itself is just as destructive as the one that was causing human casualties on their side. This is the reason some have argued against the use of drones and robots in the modern battlefield, because it would make war much cheaper for the larger powers in terms of lives lost, which in turn would make them wage war with even more impunity than before.

Consider the case of Russia for instance. As mentioned earlier, there are reports that battle-suits were being used in Crimea, a portent of things to come. In future conflicts in that region, Russia is only going to ramp things up even more. What this means is that the inherent power-gap between Russia and its adversaries is going to grow even further, despite the gap already seeming quite insurmountable. The same could be said of China. As stated above, China has

already deployed exoskeletons for troops in the Tibetan region, which means their ability to enforce any type of military action grows even stronger there, with the writ of that State being exercised to an even larger degree than before. There would be very little anybody could do against this even if the State behaved in a tyrannical way, barring intervention from some other nation which did have the technology to counter new and disruptive technologies.

The other, perhaps even more dangerous implication is the possibility of such technology landing in the hands of non-state actors, either via innovation or because of proxy warfare. It is not impossible to think of scenarios where countries that do have access to such technology, arm insurgent groups in countries that do not. Proxy warfare is one of the norms today since the great nuclear powers can no longer wage war against each other. What would happen if a rich country armed local terror groups with exoskeleton technology, particularly in countries where the governments in charge had no real answer to the destruction these battle-suits could be capable of? The result would a flipping of the basic principles of asymmetric warfare, where the non-state actor suddenly has the technological advantage instead of the State.

This could lead to a tectonic shift in the nature of warfare itself, where some conflicts are waged with the State being on the defensive while the non-state actors were the ones who were capable of attacking head-on.

The deciding factor of how influential battle-suits would be, is how well they synergize with other technological developments in the field. The large powers are working on many other types of weaponry that could compliment the use of exoskeletons, leading to doctrinal changes that one cannot anticipate at the moment. For example, innovations in areas such as genetic engineering and enhancement drugs will play a major role in the wars of tomorrow, and could be used to devastating effect in conjunction with exoskeleton technology. Invisibility technology is already becoming possible, with prototypes being tried out. 3D Printing is already transforming the way in which military power – especially on the logistical front – is being imagined. Even terror groups have already started using 3D printing and drones (Hambling, 2016), incorporating it into their arsenal, so this logic would apply to non-state actors as well.

CONCLUSION

Not all of this might be doom and gloom, there is much to look forward to in terms of the benefits this could bring. As mentioned earlier, it could drastically lower the fatality rates of the soldiers, bringing fewer of them back home dead. While this might seem like a bad thing to some, it would be difficult to objectively argue that protecting human life, combatant or non-combatant, should not be welcomed. This could also have a positive impact for civilians, given the elderly and the paralyzed a new lease on life.

Besides, there is an equally large contingent which claims exoskeleton technology itself is never going to be a major factor in the battlefield, given all the challenges. The failure of the TALOS might prove them right. Some of the features required for exoskeletons to be viable might turn out to be impractical in the battlefield. For instance, exoskeletons would have to be worn by a number of soldiers for them to revolutionize warfare, a handful of suits worn by a handful of soldiers would not have a big impact. This presents a major problem since each suit would have to be custom made for different soldiers. If the joints and actuators in the suit any misalignment, that could be both dangerous for the user and make the suit itself immobile (Mittal, 2020). The cost of making thousands of custom suits might far outweigh any benefit.

Ultimately, the impact of this technology may not even be monumentally different from what we've seen with other disruptive invention. While there is no doubt that it is revolutionary in nature, the same could be said about developments in drone strokes, space warfare, 3-D printing, invisibility technology, hypersonic missiles etc. There are dozens of new areas in which military researchers are currently making breakthrough after breakthrough. There is no one single tech that will reinvent the wheel by itself. Rather, it will be a combination of different inventions that will actually lead to a metamorphosis in combat.

REFERENCES

Asthana, M. (2020) Watch: Rostec Arms Russian Troops With 300,000 'Ratnik' Exoskeleton Suits For Next-Gen Warfare. *Latest Asian, Middle-East, EurAsian, Indian News* [online]. Available at: https://eurasiantimes.com/watch-rostec-arms-russian-troops-with-300000-ratnik-exoskeleton-suits-for-next-gen-warfare/ [Accessed 17 June 2021].

Brown, D. (2017) Russia's 'Star Wars' combat suit is reportedly getting a nuclear-resistant watch. *Business Insider* [online]. Available at: https://www.businessinsider.com/russias-star-wars-combat-suit-getting-a-nuclear-resistant-watch-2017-10 [Accessed 17 June 2021].

Defenseworld.net. (2020) Rostec Releases Video of Soldier Exoskeleton That Was Tested in Syria. *Defenseworld.net.* [online] Available at: https://www.defenseworld.net/news/27952/Rostec_Releases_Video_of_Soldier_Exoskeleton_That_Was_Tested_in_Syria#.YMsIuGgzZPY [Accessed 17 June 2021].

Design Engineering. (2010) Raytheon's XOS 2 robotic exoskeleton nabs top innovation nod. *Design Engineering* [online]. Available at: https://www.design-engineering.com/raytheons-xos-2-robotic-exoskeleton-nabs-top-innovation-nod-15096/ [Accessed 17 June 2021].

Douglas, R. (2021) TALOS Project: How the U.S. Military Tried to Make an 'Iron Man' Suit. *The National Interest* [online]. Available at: https://nationalinterest.org/blog/buzz/talos-project-how-us-military-tried-make-iron-man-suit-179863 [Accessed 17 June 2021].

Edwards, D. (2020) Sarcos Robotics exoskeleton included in Time Magazine's Best Inventions of 2020 list. *Robotics & Automation News* [online]. Available at: https://roboticsandautomationnews.com/2020/11/23/sarcos-robotics-exoskeleton-included-in-time-magazines-best-inventions-of-2020-list/38439/ [Accessed 17 June 2021].

Ellmer, M. (2021 China develops new exoskeleton suits for troops on Indian border. [online] Sandboxx. Available at: https://www.sandboxx.us/blog/china-develops-new-exoskeleton-suits-for-troops-on-indian-border/ [Accessed 17 June 2021].

Hambling, D. (2016) Iraqi Officials Find Strange Collection of Makeshift ISIS Drones. *Popular Mechanics* [online]. Available at: https://www.popularmechanics.com/military/weapons/a24056/iraqi-officials-isis-drones-mosul/ [Accessed 17 June 2021].

Hambling, D. (2020)s Why Russian Military Exoskeletons Are Not Science Fiction. *Forbes* [online]. Available at: https://www.forbes.com/sites/davidhambling/2020/08/19/why-russian-military-exoskeletons-are-not-science-fiction/?sh=102b5859648d [Accessed 17 June 2021].

Herszenhorn, D. (2014) In Crimea, Russia Showcases a Rebooted Army (Published 2014). *New York Times* [online]. Available at: https://www.nytimes.com/2014/04/03/world/europe/crimea-offers-showcase-for-russias-rebooted-military.html [Accessed 17 June 2021].

Husseini, T. (2019) US Army exoskeletons: which companies are designing military suits? *Army-technology.com* [online]. Available at: https://www.army-technology.com/features/us-army-exoskeletons/ [Accessed 17 June 2021].

Karlin, S. (2011) Raytheon Sarcos's Exoskeleton Nears Production. *x IEEE Spectrum: Technology, Engineering, and Science News* [online]. Available at: https://spectrum.ieee.org/at-work/innovation/raytheon-sarcoss-exoskeleton-nears-production [Accessed 17 June 2021].

Keller, J. (2021) Army experts reach out to industry for exoskeleton technologies to boost endurance and help lift heavy loads. *Militaryaerospace.com* [online]. Available at: https://www.militaryaerospace.com/unmanned/article/14197174/exoskeleton-endurance-heavy-loads [Accessed 17 June 2021].

Keller, J. (2020) Russia just released footage of a brand new combat exoskeleton in action - Task & Purpose. *Task & Purpose* [online]. Available at: https://taskandpurpose.com/news/russian-military-exoskeleton-video/ [Accessed 17 June 2021].

Keller, J. (2020) The inside story behind the Pentagon's quest for a real-life 'Iron Man' suit. *Task & Purpose* [online]. Available at: https://taskandpurpose.com/military-tech/pentagon-powered-armor-iron-man-suit/ [Accessed 17 June 2021].

Lin, J. and Singer, P. (2018) China's working on the next generation of military exoskeleton. Here's what it can do. *Popular Science* [online]. Available at: <https://www.popsci.com/china-exoskeleton-next-generation/> [Accessed 17 June 2021].

Marinov, B. (2018) NATO Integration of the Exoskeleton in the Battlefield Project. *Exoskeleton Report* [online]. Available at: https://exoskeletonreport.com/2018/01/nato-integration-of-the-exoskeleton-in-the-battlefield-project/ [Accessed 17 June 2021].

Marinov, B. (2020) Japan Ministry of Defense, Acquisition, Technology and Logistics Agency High Mobility Powered Exoskeleton and Commentary. *Exoskeleton Report* [online]. Available at: https://exoskeletonreport.com/2020/01/japan-ministry-of-defense-acquisition-technology-and-logistics-agency-high-mobility-powered-exoskeleton-and-commentary/ [Accessed 17 June 2021].

Mone, G. (2018) Building the Real Iron Man. *Popular Science* [online]. Available at: https://www.popsci.com/scitech/article/2008-04/building-real-iron-man/ [Accessed 17 June 2021].

Mittal, V. (2021) Why Military Exoskeletons Will Remain Science Fiction. *Forbes* [online]. Available at: https://www.forbes.com/sites/vikrammittal/2020/08/17/military-exoskeletons-science-fiction-or-science-reality/?sh=10b8e81fa69e [Accessed 17 June 2021].

Osborn, K. (2021) China's Low-Tech Exoskeleton Suits Could Be Surprisingly Useful. *The National Interest* [online]. Available at: https://nationalinterest.org/blog/chinas-low-tech-exoskeleton-suits-could-be-surprisingly-useful-173763 [Accessed 17 June 2021].

Peterson, N. (2021) Chinese Troops Showcase Super Soldier Exoskeleton Suits on Contested Himalayan Border. *Coffee or Die Magazine* [online]. Available at: https://coffeeordie.com/chinese-exoskeleton-suit/ [Accessed 17 June 2021].

Poole, T. (2021) The myth and reality of the super soldier. *BBC News* [online]. Available at: https://www.bbc.com/news/world-55905354 [Accessed 17 June 2021].

Sagar, R., 2019. Dawn Of Super Soldiers: India Joins the Race With The US & Russia To Build Exosuits. *Analytics India Magazine* [online]. Available at: https://analyticsindiamag.com/dawn-of-super-soldiers-india-joins-the-race-with-the-us-russia-to-build-exosuits/ [Accessed 17 June 2021].

Siddiqui, H. (2019) Indian Armymen to become Super Soldiers? May soon use Exoskeleton Technology; here's everything about next gen Exo-suits. *The Financial Express* [online]. Available at: https://www.financialexpress.com/defence/indian-armymen-to-become-super-soldiers-may-soon-use-exoskeleton-technology-heres-everything-about-next-gen-exo-suits/1693683/ [Accessed 17 June 2021].

Simpson, J. (2021) The Japanese Military Is Building a Robotic Exoskeleton. [online] Medium. Available at: https://medium.com/war-is-boring/the-japanese-military-is-building-a-robotic-exoskeleton-d1ee94a71022 [Accessed 17 June 2021].

Stewart, P. (2018) 'Super soldiers': Pentagon looks to exoskeletons to build resilience. *Sydney Morning Herald* [online]. Available at: https://www.smh.com.au/world/north-america/super-soldiers-pentagon-looks-to-exoskeletons-to-build-resilience-20181130-p50jct.html [Accessed 17 June 2021].

Tucker, P. (2018) Russia, US Are in a Military Exoskeleton Race. *Defense One* [online]. Available at: https://www.defenseone.com/technology/2018/08/russia-us-are-military-exoskeleton-race/150939/ [Accessed 17 June 2021].

Weinberger, S. (2013) Iron Man to Batman: The future of soldier suits. *BBC* [online]. Available at: https://www.bbc.com/future/article/20130121-batman-meets-iron-man-in-combat [Accessed 17 June 2021].

Williams, H. (2015) How Does The Australian Defence Force's Flexible Exoskeleton Work?. *Gizmodo Australia* [online]. Available at: https://www.gizmodo.com.au/2015/08/this-is-the-australian-defence-forces-take-on-exoskeleton-technology/ [Accessed 17 June 2021].

Xuanzun, L. (2019) China looking to build 'iron man' suits that let soldiers fly: experts - Global Times.

Globaltimes.cn [online]. Available at: https://www.globaltimes.cn/page/201911/1169147.shtml [Accessed 17 June 2021].

Xuanzun, L. (2021) China reveals powered exoskeleton suit for carrying ammunition - Global Times. *Globaltimes.cn* [online]. Available at: https://www.globaltimes.cn/page/202101/1212636.shtml [Accessed 17 June 2021].

Yacoubian, M. (2021) What is Russia's Endgame in Syria? *United States Institute of Peace* [online]. Available at: https://www.usip.org/publications/2021/02/what-russias-endgame-syria [Accessed 17 June 2021].