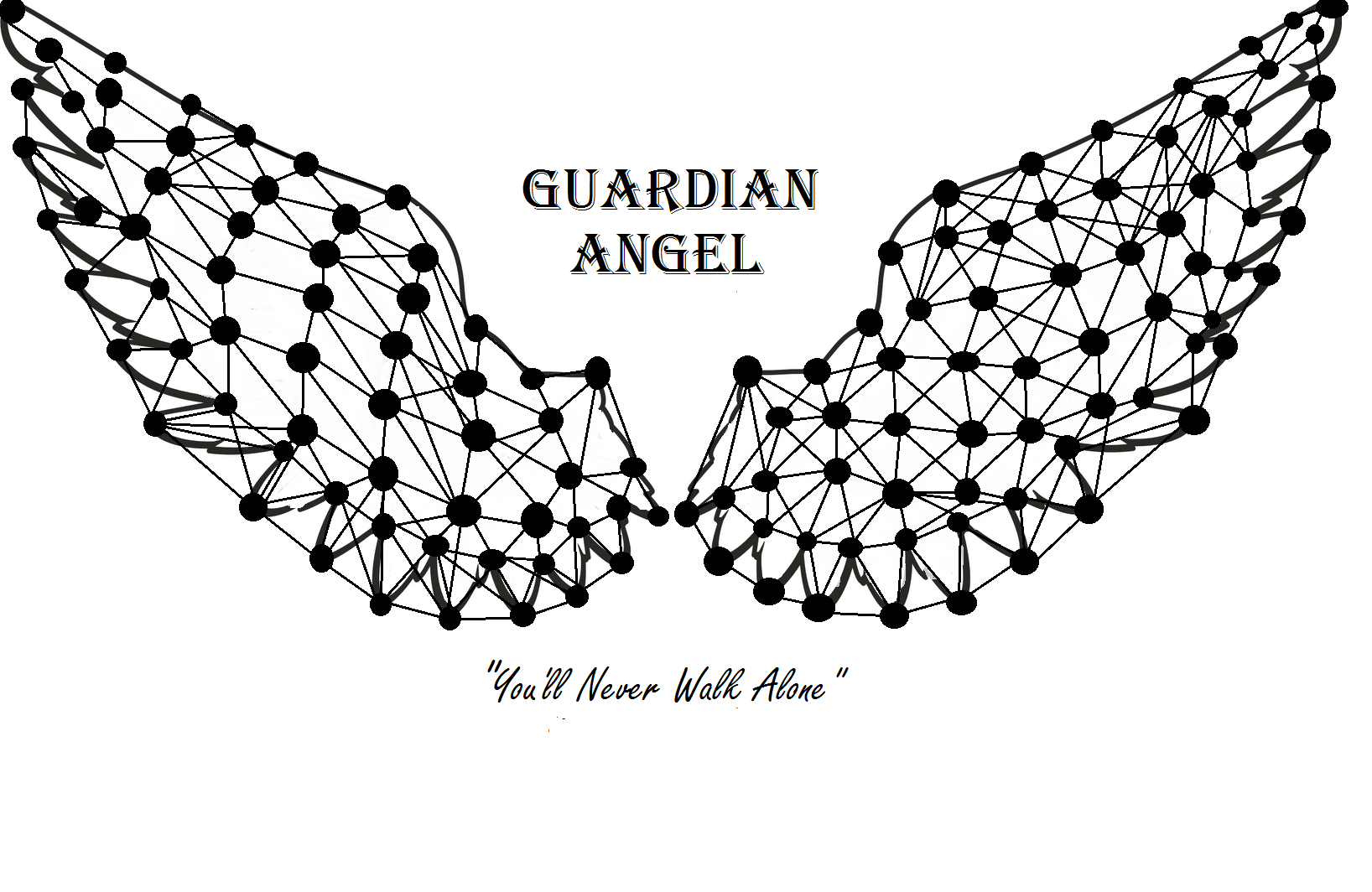
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**Guardian Angel**

**“You’ll Never Walk Alone”**

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**1.0 Executive Summary**

In the execution of any military operation, the communications utilized are essential to that operation’s success. Effective communications must provide a reliable, secured transmission of data regardless of the terrain and environmental conditions an operation is executed in. Military teams have specific and extensive requirements for their equipment that push the limit of existing technology. When this equipment falls short, temporary loss of communication can lead to a devastating loss of life. One of the most renowned instances of this occurrence is Operation Red Wings, now known as Lone Survivor. In this 2005 joint military operation, four Navy SEALs were executing a mission in the mountains of Afghanistan. This environment is susceptible to multiple radio blackout areas. At that time, there was no military radio that could overcome these environmental difficulties and fulfill the mission requirements. Because of this, radio communication was lost in the soldier’s most critical time of need and three of the four SEALs lost their lives.

These situations demand a new technology that is not only capable of adapting to difficult terrain, sudden signal blockages, and unforeseen communication failures but is lightweight and usable for soldiers. A promising new wave of military communications has arrived through the combination of software-defined radios and mesh technology which addresses this issue. The Guardian Angel is a tactical wireless mesh communication network designed for emergency communications in military operations. The mission of this product is to secure stable communications for our men and women in the military in the toughest environments and conditions.

Mesh network topology is advantageous over traditional network topology because interconnected devices can extend the range of communication without altering the waveform or increasing the power output of the individual devices. Multiple transmission paths ensure that the network is self-healing and therefore adaptable to signal losses between individual nodes. The mesh network is established through the interconnection of a series of wireless nodes which send data to each other and retransmit data to other nodes.

The nodes will use military specification printed circuit boards (MilSpec PCBs) to minimize the size of the nodes. These MilSpec PCBs would be customizable in whatever fashion to accomplish a client’s mission, whether it be adding microphones, proximity sensors, and cameras among others. There are several paths to expedited manufacturing and marketing by partnering with existing companies, such as Polaris Contract Manufacturing, Inc., that would be able to fulfill the design specifications. The nodes will be portable, camouflaged, adaptable, and secure. These nodes will be pre-dropped by air or dropped during the mission to establish a comprehensive and redundant network to be utilized during a mission.

For demonstration purposes, the team has elected to create a proof of concept which includes prototypes of the node itself, the network protocol, and the method that soldiers would implement to establish the network, using laptops to demonstrate the performance of the network. In the field, Guardian Angel would integrate seamlessly with military communications. Our product has been designed to adhere to the standards of the Software Communications Architecture (SCA), a framework established by the Department of Defense’s Joint Tactical Radio System (JTRS) program. The SCA tells commercial vendors what specific features to incorporate in their products to guarantee that their products operate in harmony within the JTRS. The Guardian Angel team has been cognizant of the SCA standards going forward: our product will be JTRS-compliant. This also means that Guardian Angel will not be competing directly against the major corporations that currently dominate the military communications market. Instead, our project with will be able to effectively communicate with other JTRS compliant devices, such as the popular handheld radios AN/PRC-148 MBITR and the AN/PRC-154 Rifleman Radio.

**2.0 Company Overview**

**2.1 Introduction**

Guardian Angel is a tactical wireless mesh communication network developed within Booz Allen Hamilton. Guardian Angel’s development began during the 2017 Booz Allen Hamilton Summer Games at the firm’s headquarters in McLean, Virginia.

**2.2 Mission Statement**

To ensure the linkage of military communications in the most dangerous conditions and environments to protect our men and women who serve.

**3.0 Business Need**

Successful communications networks are essential to any military operation. The U.S. Armed Forces uses a variety of communication networks during their operations, ranging from UHF to tactical SATCOM. These communication forms have specific requirements tailored to the environment and the goal of the mission. For each communications device, there are always tradeoffs and limitations between technical capability and functionality. The Guardian Angel’s innovative concept establishes a communication network with improved reliability and range without sacrificing a small form factor or simple implementation. The Guardian Angel team firmly believes that these improvements have a multitude of fruitful applications for the military and in turn, have the potential to generate profitable and long lasting business for the supporting firm.

* 1. **Product Opportunity Statement**

The market for military communications is vast and comprehensive, covering a range of waveforms and data types. However, an essential gap remains in a critical portion of the market: emergency communications. Reliable emergency communications that are adaptable to various terrains and environments are necessary, as there is a probability of primary communications failing. If these emergency communication devices can augment the capabilities of the current primary communication devices, military operations can be executed more effectively.

Tactical SATCOM, a popular form of emergency communications in military operations, has significant drawbacks. SATCOM is an effective means of circumventing the challenges of terrain which block line of sight signal. However, such devices are often heavy, difficult to carry into the field, and require open exposure in potential combat environments. Soldiers have no control over the satellites or when they will pass overhead, and SATCOM is vulnerable to situations of significant cloud cover, storms, or potentially to efforts by adversaries to take satellites offline.

Mesh technology offers a promising alternative to Tactical SATCOM in the realm of emergency military communications. Unaffected by the drawbacks of SATCOM, mesh networking technology facilitates the usage of lighter, shorter range radios which can pass data over long distances. The minimization of weight is important for military operations, as soldiers often carry over 100 pounds of gear at a given time in the field. Mesh networking technology can be deployed prior to operations, granting commanders the opportunity to use networks as methods of obtaining intelligence on the battlefield.

Currently, the retransmission stations which help soldiers relay signals overtop mountains are manned. The optimal point for such stations is at the highest peak of the mountain, where the signal is freest to propagate. However, this places soldiers at risk, as they must travel to higher elevations in open environments, exposing themselves to adversaries. Mesh technology avoids these issues, as the placement of nodes in a mesh topology overcomes signal blockages and obstructions without the need for soldiers to operate relay stations. The commitment of fewer resources to operate communications provides soldiers more freedom in action.

Mesh technology is readily implementable and easy to use. Soldiers will have little to no difficulty in operating the mesh, minimizing potential confusion during an emergency.

* 1. **Booz Allen Fit for Opportunity**

With rising international tensions and increased defense spending in the proposed congressional budgeting plan, it is likely that the military will see funding for improvements in their tactical communications. This probable funding coupled with the wave of improvements in software-defined radio (SDR) technology and the existing standards established by the JTRS program all come together to provide a unique opportunity for Booz Allen to increase their market presence with Guardian Angel’s innovative implementation of mesh technology. Booz Allen’s existing relationship with the JTRS program creates an ideal landscape for Guardian Angel to be executed, which would secure profitable contracts for the firm.

**3.3 Competitor Analysis**

Currently, there are two major companies in the military communications market: the Harris Corporation and the Thales Group. The Harris Corporation provides the military with a bevy of communications options, ranging from tactical SATCOM high capacity line of sight radios to standard tactical handheld and high frequency (HF) radios. The Thales Group is known for its popular AN/PRC-148 MBITR, the smallest, lightest, most power-efficient multiband, tactical, handheld radio in use today.

These two companies were among the primary beneficiaries from the Department of Defense’s effort to simplify military communications using software-defined radios, the Joint Tactical Radio System (JTRS) program. The initial value of the Department of Defense’s contracts with Harris and Thales for the JTRS program was $2.7 billion and $3.5 billion respectively, with a potential total value of $7 billion for Harris and $9 billion for Thales.[[1]](#footnote-1)

Rather than compete directly with these military communications giants, Guardian Angel integrates seamlessly in usage with their products. The multi-band capabilities of the AN/PRC-148 MBITR and Harris’s counterpart, the AN/PRC-152, will permit radio communications across devices.

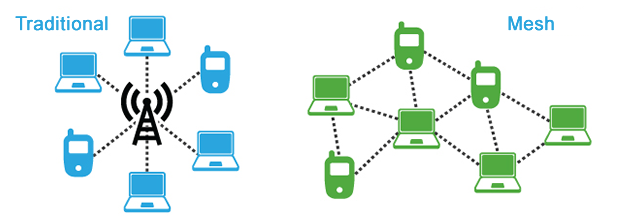
**Guardian Angel SWOT Summary**

* **Strengths** – The Guardian Angel protocol supports a multitude of functionalities, including full mesh connectivity, self-healing and configuring capabilities, and performs full-duplex communication. Physically the nodes are lightweight, camouflaged, deployable from air support, and self-destructing.
* **Weaknesses** – Nodes would need to be strategically placed such that signals can reach around blockages. A detailed understanding of the geography and other blockages is needed for optimal performance.
* **Opportunities** – The Guardian Angel has numerous uses beyond its designed function as emergency communications, going as far as becoming the primary form of communications for military operations. Multiple branches and groups of the military could utilize this technology.
* **Threats** – Products implementing mesh technology in the military exist. It will be important to show the difference between the Guardian Angel and other mesh communications devices.

**4.0 Project Overview**

The initial challenge we faced in the development of this project was the establishment of a mesh network using low cost, commercially available software-defined radios. Faced with a short deadline and a limited starting budget, our team opted to use the cost-effective and open source Arduino hardware and software as the starting point for our mesh network. The usage of Arduino microcontrollers was a practical method to begin working towards our solution of a fully-fledged mesh network capable of becoming Guardian Angel. The abundance of open-source software programs for Arduino became the base from which we developed and adapted the nodes to serve our needs. Moving forward, we will use the lessons we learned throughout the course of our development of a mesh network via Arduino and implement similar ideas in the creation of a mesh network using software-defined radios. As Guardian Angel improves in its functionality, we will continue working on additional features which will aid the military in its missions such as signal propagation, form factor, durability of the nodes, and cost among others.

**4.1 Traditional Networks and Wireless Mesh Networks**



Traditional networks have numerous drawbacks. These networks rely on a small number of wired access points or wireless hotspots to connect users, typically through line of sight signal propagation. The topology of a traditional network makes it unsuitable for military operations. These networks lack a multiplicity of paths for data transmission, resulting in a severance of communications if a critical connection of the network is compromised. The signal strength of traditional networks is frequently an issue, as dead zones may occur while the dissipation of signal can only be mitigated through increasing the power of the network. This would result in US soldiers carrying larger batteries and consequently a heavier load of gear, detrimental to the mission of our soldiers.

A wireless mesh network overcomes these challenges easily. The topology of a mesh network enables the spread of the network connection among all the wireless mesh nodes, which effectively function in the same way as a wireless router. Redundancy is an integral feature of a mesh network, as the multiple pathways of data transmission ensure that a message will be relayed to its desired destination. Mesh networks are self-configuring and self-healing: the network will incorporate a new node into the existing structure without needing any adjustments by a network administrator, automatically finding the fastest and most reliable path to send data, even if nodes are blocked or lose their signal. These features enable a mesh network to overcome potential obstructions, such as mountains and buildings, as well as signal jamming which would affect a traditional network. The scalability and cost of a mesh network are two of its strongest characteristics: hundreds of nodes can easily be added to the network with no need for an expensive wired infrastructure. The nodes themselves can have a small form factor with minimal weight, as the signal transmission power of an individual node does not need to be great for an efficient mesh network.

The drawback of the usage of a wireless mesh network is increased latency. Due to the high number of nodes in a network, the number of “hops” during data transmission can create delays in communications. This is a result of the mesh topology, as the built-in redundancy and multiple pathways required for reliable communications can slow down data transmission.

**4.1.1 Key Product Features**

Current military network communications are onerous, and often difficult to utilize during an operation. Soldiers may carry over 100 pounds of equipment for extended periods of time. The weight of military equipment is an important consideration in tactical decision making, as Lt. Michael P. Murphy, the leader of the Navy SEALs in Operation Red Wings, chose to eschew the heavier AN/PRC-117g in favor of the AN/PRC-148, a radio which was incapable of communications in the mountainous environment of the SEALs’ mission. However, what if Lt. Murphy was offered with a communications device which did not compromise functionality for practicality?

Guardian Angel is designed to integrate seamlessly in military operations. As a mission progresses, Guardian Angel’s network expands as more nodes are deployed. The optimal placement of nodes by soldiers will enhance emergency communications in poor environments, as the flexibility of Guardian Angel’s network allows for communications in the most difficult conditions. The nodes have a lightweight design, and the number of nodes a soldier will be required to carry will depend on the scope of the mission. As soldiers deploy nodes, the amount of weight they carry will decrease, enabling them to act with fewer constraints.

Many mesh networks run into the challenge of feasible scalability due to the high latency of additional nodes.[[2]](#footnote-2) The Guardian Angel team has been able to minimize network latency through routing algorithms. Our nodes have been created with a mesh intelligence and decision criteria in each node, enabling the nodes to select the fastest pathing and re-routing of data. To minimize bandwidth degradation, the nodes can dedicate separate wireless bandwidth links for the entry and exit of backhaul traffic, thereby fully utilizing the highest available throughput automatically.[[3]](#footnote-3)

The Guardian Angel mesh network will apply spread spectrum technologies, utilizing frequency hopping to ensure clear and undetected communications. Our network has been designed to operate on multiple channels and frequencies, thus mitigating radio interference and signal jamming while ensuring secure, undetected communications. We are currently looking to encrypt our communications to an NSA Type 1 level.

It is a priority of the United States Armed Forces to retrieve all equipment employed in field operations. This, however, is not always possible. To account for the possible failure to retrieve equipment and mitigate the possibility of adversaries acquiring our technology, the Guardian Angel team has implemented a self-destruct feature into each node. All nodes can be manually terminated by the operator of the network, and if a node is moved out of a certain radius without authentication of the person moving the node, the node will self-destruct. The node’s self-destruct mechanism will be inconspicuous: the hardware in the node will simply melt inside.

**4.1.2 Primary, Alternate, Contingency, Emergency – PACE Communications**

Communications are a vital aspect of any military operation. The proper implementation of communications could be the difference between the successful execution or compromise of a mission. The acronym “PACE,” which stands for primary, alternate, contingency, and emergency means of communication, is the standard methodology used to build a communication plan by the military.[[4]](#footnote-4) This method establishes the best four forms of communication between parties throughout the duration of a mission while simultaneously designating the order in which parties will utilize available communications systems until contact is established.

As each mission and task in the military can differ vastly in available capabilities, environmental conditions, and scope, PACE-based communication plans provide the appropriate ordering of communications given the considerations of a mission. [[5]](#footnote-5) PACE-based plans are mission dependent, resulting in situations in which a certain technology or waveform would function as the primary form of communication, while in another scenario it might be the emergency form of communication. For example, tactical satellite communications might only be the contingency option in a mission with an area of operations entirely within line of sight, whereas it would be the primary option in a mounted mission beyond line of sight. The flexibility of PACE encourages the development of communications systems with multiple uses.

In the case of Guardian Angel, we have designed the mesh network specifically for a use case scenario with similar conditions to that of Operation Red Wings, familiarized to the public through the memoir and blockbuster movie, *Lone Survivor*. The Navy SEALs assigned to Operation Red Wings were entrusted to eliminate an insurgent leader and his followers. The operation took place at Sawtalo Sar Mountain in Afghanistan, an area in which standard communications were not possible because of steep mountains. The SEALs were ‘soft’ compromised due to a civilian intrusion and unable to call back to base for evacuation. Ambushed by insurgents soon after, they were forced to expose themselves to gunfire to utilize an Iridium satellite phone to call for support. In this scenario, Guardian Angel would have served as the E in PACE, or the emergency communications. Guardian Angel’s implementation in this operation would have enabled the Navy SEALs to call back to a contact point without the need to expose themselves to gunfire, allowing for safe evacuation from the area. However, Guardian Angel does not need to be boxed in to merely one category of communications under a PACE-based plan. In an alternative use case scenario involving conventional fighting in an established battlefield such as an urban setting, Guardian Angel would function as the primary option. Its implementation as a mesh network in an urban battlefield would be akin to the commercial usage of mesh networks by municipalities.

**4.2 Marketing Landscape for Guardian Angel**

Our team believes that the Guardian Angel mesh network will attract attention in the markets Booz Allen services. We have explored two strategies that would fit within the firm’s established approaches:

* Section 2.2.1 – Manufacture and direct sales of Guardian Angel for initial and future models
* Section 2.2.2 – Contract revenue through research entities for further advancement of existing research or through facilitation of new research

**4.2.1 Manufacture and Direct Sales**

The successful development and drive of the Guardian Angel to field operations will require significant innovation from Booz Allen and the manufacturing, sales, and distribution channels of trusted partners. The drive to save lives will push this forward.

**4.2.1.1 Product Design Partnerships**

Clients of Booz Allen know the firm is meticulous in the work it is contracted to, and the development of the Guardian Angel would be no exception. The best way to develop the Guardian Angel mesh network will be working side-by-side with the Department of Defense during its development. The Defense Department understands the promise of software-defined radios, and has invested greatly in the technology through the Joint Tactical Radio System program (JTRS). The Guardian Angel team would look to design our product with the consultation of Army technologists, as well as seek the advice of active-duty and retired soldiers in the U.S. Army and special operations groups such as the U.S. Navy SEALs. Close collaboration with these partners will aid the development team in creating a product which is prepared for field conditions and use.

**4.2.1.2. Manufacturer Partnerships**

Vertical integration and in-house manufacturing of the Guardian Angel would be a costly and time-consuming venture. Utilizing contractors and vendors to fulfill the production needs of the Guardian Angel allows Booz Allen the option to continually maintain state of the art electronic components, avoiding potential obsolescence in this area because of rapidly developing technology, yet minimize costs and maximize output.[[6]](#footnote-6) There are an abundant number of vendors and contractors from which Booz Allen could seek to fulfill the manufacturing, testing, and design needs of the Guardian Angel, again minimizing the cost of production. The Guardian Angel team has drawn up a shortlist of potential partners, not limited to:

* **Polaris Contract Manufacturing, Inc. –** A wholly-owned subsidiary of Lockheed Martin, Polaris specializes in the production of printed circuit board (PCB) assemblies and full box assemblies. Polaris offers manufacturing engineering, test engineering, full environmental testing, and complete assembly of the product.[[7]](#footnote-7)
* **Sechan Electronics –** A leading Department of Defense contractor and electronics manufacturer, specializing in military electronics and electronic contract manufacturing services. Sechan has done significant work with circuit board manufacturing, design engineering, and testing.[[8]](#footnote-8)
* **San Francisco Circuits –** A vendor which provides cost-efficient military specification (MilSpec) PCBs. San Francisco Circuits could potentially be a single point of contact for vending, as it utilizes a wide network of manufacturers, designers, and assemblers to design and build military-grade PCBs.[[9]](#footnote-9)
* **Sierra Circuits, Inc. –** a vendor similar in services to San Francisco Circuits. This contractor offers a vertically integrated design and production process, minimizing the number of partners Booz may have to work with.[[10]](#footnote-10)

**4.2.1.3 Sales and Distribution Opportunities**

The Guardian Angel has been designed for usage by the U.S. Armed Forces. Booz Allen Hamilton’s experience providing services for the federal government and the military are critical in identifying the contracts and partners which will execute the procurement of the Guardian Angel.

**United States Army –** The U.S. Army has been seeking for years to revamp its communications infrastructure through the implementation of software-defined radios. The Pentagon has typically awarded large contracts to firms such as the Harris Corporation, the Thales Group, and General Dynamics. The Army recently granted a Full-Rate Production contract to Harris and Thales to produce the AN/PRC-154 Rifleman Radio. The Army is expected to procure 150,000 Rifleman Radios over the course of five years[[11]](#footnote-11), but demand will still exist in sections of the Army and other branches of the Armed Forces for military radios and communications devices.

**4.2.2 Contract and Grants Revenue**

The process by which the Armed Forces selects its contractors and vendors for equipment and services remains a competitive one. To minimize costs, Low-Rate Initial Production contracts and Full-Rate Production contracts in military communications are frequently designed in the scope of ongoing competition of which contractor can provide equipment which passes Army testing at the lowest price. The Guardian Angel will need to be designed keeping in mind the military’s desire for cost-effective equipment.

**4.2.2.1 Trends in Military Communications Spending**

After a general decline in defense spending during the Obama Administration, the election of President Donald J. Trump has renewed optimism of a significantly larger budget for the Department of Defense. The Trump administration has made it clear that it desires to increase the defense budget and eliminate sequestration, positions shared by the Republican-controlled Congress. President Trump has called for an increase of $54 billion in defense spending for FY18, composed of $603 billion for the base DoD budget and $65 billion for Overseas Contingency Operations (OCO), totaling $668 billion. Congressional Republicans have crafted a budget plan which would provide $621.5 billion in base defense spending and $75 billion in OCO for a total of $696 billion for FY18. The President and Congressional Republicans have justified their defense budgets as efforts to modernize an aging military which is underequipped. The U.S. Army, Navy, and Air Force’s unfunded priorities lists were $18.3 billion, $4.8 billion, and $10.7 billion respectively for FY18.[[12]](#footnote-12) Both budgets are significantly higher than the 2018 defense spending budget cap of $549 billion which Congress will need to raise for the legislation to be enacted.[[13]](#footnote-13)

As geopolitical tensions rise in regions such as the Middle East, Eastern Europe, the Korean peninsula, and the East and South China Sea, the defense spending of the U.S. and regional powers such as China, Saudi Arabia, and Japan will likely increase in response. The Guardian Angel has been designed for usage by the U.S. Armed Forces. However, we believe that our product will be a sought-after communications device not only by the U.S. Armed Forces, but by regional powers as well. The global military communications sector is expected to grow to over $40.82 billion in 2020, representing a CAGR of 12.1%.[[14]](#footnote-14) Although North America will be the largest regional end market, by 2025 Asia will surpass the United States in C4ISR spending.[[15]](#footnote-15) The Asia-Pacific region is expected to drive spending on tactical radios for land-based communications, eventually becoming the largest end market.

Guardian Angel’s usage of software-defined radios places it as an innovator in military communications. The military has emphasized the desirability of radio systems which can support multi-band and/or wideband operation, a market which will account for 47% of the total global military radio market in 2024. Combining the flexibility, ingenuity, and efficiency of software-defined radios and mesh network topology, Guardian Angel has a significant advantage over traditional radio communications.

**4.2.2.2 Joint Tactical Radio System**

The United States military has invested in the development of software-defined radio for decades. The Joint Tactical Radio System was a program created by the U.S. Department of Defense as an attempt to unify the communications infrastructure of the military by replacing existing radios in the U.S. military with a single set of software-defined radios that could have new frequencies and modes (“waveforms”) added via upload.[[16]](#footnote-16) Accomplishing this would eliminate the need for multiple radio types in ground vehicles, as well as the usage of circuit board swaps to upgrade equipment.

The significance of this program was its creation of the Software Communications Architecture (SCA). The SCA is a framework for software-defined radios established by the Department of Defense which tells commercial vendors what specific features to incorporate in their products to guarantee that their products operate in harmony within the JTRS.[[17]](#footnote-17) The core software and waveforms are freely available to anyone, including companies which are not on a main JTRS program. This has lowered the initial costs of production, as well as minimized barriers to entry in the software-defined radio market.[[18]](#footnote-18)

The Guardian Angel will be designed to fit into the JTRS program through its division of Handheld, Manpack, and Small Form Fit (HMS).[[19]](#footnote-19) The HMS division of JTRS consists of lightweight, portable radios which are rugged in form factor and capable of the following:

* Simultaneous voice, data, and video communications
* Increased throughput using networking waveforms
* Voice and data route and retransmission
* Multi-Channel operations
* Interoperability with currently fielded radios and a variety of other waveforms, including Soldier Radio Waveform (SRW)

The JTRS has seen over $15 billion in investment into the program, with more funding likely to flow in because of the promise of software-defined radios. Booz Allen Hamilton has had a positive relationship with the JTRS program. The introduction of the Guardian Angel can expand Booz Allen’s involvement in this venture, fueling potential opportunities for significant growth and lucrative contracts.

**4.3 Schedule**



The Guardian Angel would have a relatively fast turnaround time from the beginning of its planning phase to end production. Utilizing a MilSpec PCB through one of the listed partners in the manufacturing section of this report will yield a faster pace of design, testing, building, and production.

The bulk of the Guardian Angel’s production schedule will be devoted to the testing of the product itself. For the Guardian Angel to become an essential device in military communications, it must show that it can function excellently under the most difficult conditions and environments. It will be important to devote time to planning and testing the ruggedness of the form factor of the nodes, as neither signal propagation and durability can be lowered at the expense of the other.

To construct the prototype, the Guardian Angel development team will require a variety of professionals from diverse backgrounds. Electronics engineers will be needed to build upon the PCBs, while software engineers will be needed during the early development and testing phase. An RF specialist, whether it be an engineer or a consultant, will work together with the software engineers and electronics engineers to optimize signal propagation. This RF specialist will also work with a mechanical or packaging engineer, creating a slim, rugged encasing for the Guardian Angel node which does not interfere with communications. Designing nodes which are inconspicuous in field operations will be essential, so a designer will be needed to create camouflaged nodes. An Army technologist will be necessary to create a product which better fits the needs of the military, and active-duty and retired service members of various branches and details will be brought in to give input on the Guardian Angel throughout the scheduling process.

**5.0 Military Impact**

The importance of fast, reliable, and secure communications in modern warfare cannot be understated. Warfare has moved to an information age paradigm based on information sharing, situational awareness, and distributed points of intelligence. A widely-networked military is better able to share information about tactical operations which may be geographically widespread, asymmetric, and rapidly changing. The additional information provided by our Guardian Angel mesh network will provide commanders not only more confidence in the decisions they are making, but greater success in the achievement of broader strategic goals.[[20]](#footnote-20)

The implementation of Guardian Angel in military communications will aid our Armed Forces’ mission in the following ways:

**Information Superiority**

* With numerous nodes scattered throughout the battlefield equipped with customized sensors, our soldiers will have access to a variety of centralized and distributed information assets.

**Network-centric warfare**

* The importance of network communications in warfare will continue to grow in the modern age. Guardian Angel mesh networks provide a cost-efficient and easy way of establishing effective communications in the harshest environments and conditions. Our network is truly wireless, and can support the following four capabilities essential to modern warfare:
  + **Mobility:** In a network-centric battlefield, mobility implies more than the motion of individuals and vehicles in relation to one another and to other fixed locations. The Guardian Angel mesh network maintains high performance in motion, as the nodes have been programmed to reconfigure the network topology in the most efficient manner.
  + **High performance for real-time** **protocols:** The ability to deliver high bandwidth streams with low latency and low jitter is essential in modern command, control, and communications. Guardian Angel can maintain communications across many hops and in motion with a minimal decrease in performance.
  + **Distributed frequency agility:** The dynamic and unpredictable nature of modern warfare coupled with the peculiarities of the Radio Frequency (RF) spectrum environment place a premium on the capability of individual devices to independently choose frequencies, locate and connect with peer devices, and rapidly shift frequencies in an automated, coordinated fashion without centralized oversight. Guardian Angel’s spread spectrum capabilities allow the quick addition of nodes as well as network adaptation to inadvertent or malicious interference and jamming. The nodes automatically adjust frequencies to optimize data transmission rates and signal strength.
  + **Distributed topologies and network formation:** The modern battlefield is constantly changing, and network devices must be able to readily adapt their formations and topologies to better serve our forces. The nodes of the Guardian Angel mesh network will automatically reconfigure the network topology to the needs of our forces. This flexibility in network formation is critical to our military operations.

The Guardian Angel mesh network will give its users an edge on the battlefield, confirming the communications and information advantage to the side which uses this system. The impact of this network on the battlefield will be multivariable and tangible: whether it be a communications lifeline for a special operation, an increase in the ease of movement of supplies forward to the battlefield, or coordination of moving casualties back to ambulance exchange points. The Guardian Angel mesh network will make military communications more effectual.[[21]](#footnote-21)

**6.0 Risks**

The topology of mesh networks successfully mitigates a variety of risks which typically affect other networks. However, there are drawbacks to the mesh topology. For the network to be a “mesh” in any sense of the word, the network must have a significant degree of redundancy in node-to-node connections. This can be a limiting factor for military operations, as officers will need to manage their pathing in operations to optimize network performance while completing the mission. This could initially prove to be onerous in certain operations, but the Guardian Angel team believes that it will be a worthwhile adaption. In the urban battlefield use case, such considerations would likely be considered concurrently with the initial operations.

Another potential risk related to the strength of mesh networking is discovering defunct nodes. We plan on programming in capabilities in Guardian Angel which will alert us if a node is unresponsive, but because of the self-healing and self-configuring nature of mesh networks, it is possible that issues directing network traffic may exist if too many nodes go down.

Though nodes will be camouflaged specifically for the environment in which they are deployed, the risk of enemy combatants discovering nodes is ever existent. The possibility of nodes being taken out of combat and compromised by hostile forces has been mitigated through the addition of a self-destruct feature. This feature can be triggered manually by the operator of the network, or automatically if nodes are picked up by an enemy combatant and taken out of their designated range without the entering of an authentication key enabling such action.

Although mesh topology is effective at allaying the effects of blockages and signal jamming on network communications, the Guardian Angel nodes may be dropped prior to the start of an operation by air. The blockage of a node’s antenna because of the way it landed will be a consideration going forwards, and the form factor of nodes will need to consistently provide for the nodes to land properly for optimal signal propagation.

1. <https://fcw.com/articles/2007/06/20/thales-harris-snag-multibilliondollar-jtrs-contracts.aspx> [↑](#footnote-ref-1)
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