Team UGS:

Concept of Operations (CONOPS)

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# Executive Summary

Ground sensors are frequently implemented in strategic zones and remain in place and active in areas where conflict may seem pertinent. Amidst today’s global war on terror, our military and homeland security personnel must keep a tight hold of the security of our borders and bases here within the United States and abroad. Threats now come from all directions, in any form, at any time, hitting the weakest unmanned and unmonitored assets. The capability to provide a cost effective, autonomous, and seamless surveillance solution presently does not exist.

The US Department of Defense (DOD) and Department of Homeland Security (DHS) are rapidly expanding their areas of interest (AOI) and responsibility (AOR) with limited human and capital resources. The overall lack of resources and physical limitations of human security make traditional surveillance techniques in these AOIs inefficient and very costly. Here lies the need to provide security forces a new surveillance toolset.

Unattended ground sensors (UGS) provide a means of constantly monitoring AOIs without a physical presence and human limitations. UGS can survey AOIs through a gambit of sensing techniques (light, sound, heat, vibration, imagery, etc.) without the need for rest and/or nourishment. Although there are UGS currently in service, they tend to have high costs, limited operating life and are commonly deployed in small numbers still limiting DOD and DHS remote sensing capabilities.

The intent of the MINUS is to become a new cost effective sensor platform with emphasis on true autonomy, mesh network communications and “throw and go” emplacement. New technology developments in physical sensors and energy efficient circuitry permit state of the art unmanned sensing techniques to fill a critical capability gap for today’s military homeland security forces.

The MINUS team has designed and developed a system utilizing an UGS for the purpose of detecting human and motor movement. The goal of MINUS was to conduct a preliminary feasibility study to assess the feasibility of developing an UGS. The team has only considered the use of mote technology with a mesh network to aid in the detection of intrusion. The focus of the design and technologies was selected based on initial inputs from stakeholders and a market study (team members with insight to the UGS community). The basic assumption was made that a product of this general design is of interest to the community and stakeholders.

The team chose several preliminary design alternatives for intrusion detection based on the inputs from team sponsors, existing markets and stakeholder needs. Design alternatives were evaluated based on their detection effectiveness, cost, ability utilize advanced communication networks (mesh Wi-Fi) and ability to adapt to the DOD (customer) system of system architectures. The team has also evaluated the design alternatives for their operational performance which includes the endurance and coverage area. Size and deploy ability was weighted very heavily, and therefore played a large part in determining the utility of each design alternative.

Basic sensor technologies were evaluated to assess the feasibility of sensor detection from a ground level platform with mote equipment. The majority of the sensor types and technologies are COTS based, however the integration of these sensors into mote hardware with low power communications and support systems is an UGS advancement.

From stakeholder/sponsor input, market insight and the analysis that has been conducted, it has been determined that intrusion detection utilizing a \_\_\_\_ is a feasible option. Based on the value hierarchy and figures of merit, the best design alternative has been determined to be the \_\_\_. Although the \_\_\_\_ has a slightly higher utility than \_\_\_\_, its cost (or other figure) is significantly higher than the \_\_\_. (After further research, we will fill in this section)

# **Introduction**

## Background

On the battlefield and in the Homeland, our forces are confronting an increasingly harsh and relentless threat that demands constant attention. Improved intelligence and reconnaissance to detect potential enemies is required. A new system is needed to deliver a higher level of actionable intelligence against the threats faced by today’s Military and Homeland Security forces.

Currently, micro-robotics, counter fire systems for snipers, and other robotic systems can go in and out of buildings to check situations without putting our troops in harm’s way. A system is needed that is smaller, more cost effective and has greater force protection. A system needs to be designed specifically for non line-of-sight detection behind buildings, hills, in valleys and through wooded areas for Military forces.

U.S. Customs and Border Protection has created smarter borders by extending our zone of security beyond our physical borders. CBP has established working groups with our foreign counterparts to establish ties, improve security and facilitate the flow of legitimate trade and travel.

CBP has implemented joint initiatives with our bordering countries, Canada and Mexico: The Smart Border Declaration and associated 30-Point Action Plan with Canada and The Smart Border Accord with Mexico. The Secure Electronic Network for Travelers' Rapid Inspection (SENTRI) allows pre-screened, low-risk travelers from Mexico to be processed in an expeditious manner through dedicated lanes. Similarly, on our northern border with Canada, we are engaging in NEXUS to identify and facilitate low-risk travelers. Along both borders, CBP has implemented the Free and Secure Trade (FAST) program. The FAST program utilizes transponder technology and pre-arrival shipment information to process participating trucks as they arrive at the border, expediting trade while better securing our borders.

According to independent research, the cost of building and maintaining a steel fence between the United States and Mexico could cost $49 billion. An alternative effort called Virtual Fence; that utilizes expensive camera systems and monitoring stations has also been underway and is valued at $20.6 million for a 28 mile stretch.

A method is needed for detecting and tracking both vehicles and dismounted threats.  Currently there is no early warning, asset protection and surveillance to protect our troops, borders and national assets. Given the magnitude of threats and terrorism that our troops are facing today and the CBP's responsibility, the development and deployment of sophisticated detection technology is essential. UGS have the ability to sense an array of physical properties beyond visual characteristics detected with EO cameras and the human eye.

## Statement of Need

Since humans and motorized vehicles can be difficult to detect and deter with the human eye and continue to be a great danger in many areas, there is a need to identify them efficiently and accurately. Currently there is no method in place that effectively detects intrusion in a safe, timely, and cost efficient manner. The purpose of this new UGS system is to fill the present capability gap of today’s sensor systems used by the Military, DOD and the DHS. The focus area of this program is to provide a new surveillance asset that will allow for large area surveillance coverage with unattended sensor networks at a relatively low cost. Thus there is a need to consider developing an effective system using UGS capabilities to detect intrusion.

# Description

## Problem Statement

In order to detect personnel and motorized open ground intrusions at a minimal cost, the US Government and Military need modernized detection methods that are user friendly, efficient and accurate. Currently fences and border patrol personnel are used extensively to secure our nations borders. These intrusion prevention methods come at a high cost/covered area, and provide no autonomous "24/7" surveillance. One solution is to utilize unattended ground sensors in support of surveillance and force protection. UGS are used as tactical surveillance barriers to monitor disputed borders or as force protection devices to notify of enemy presence. Although there are UGS systems on the market and in use, very few can provide the capability of rapid deployment, extended operational life, small physical footprint (mote technology), low cost and up-to-date technologies. Without an effective open ground intrusion detection system, personnel and motorized intrusions will continue to be a major threat to military troops as well as civilians in certain border regions in the United States. The Unattended Ground Sensors (UGS) team would like to evaluate UGS and mesh communication technologies to develop an initial design for a cost effective, user friendly, and efficient mote-based intrusion detection system that can cover large areas of interest. Team UGS will bring a new concept to market that will focus on low cost mesh communication motes, capable of providing persistent UGS surveillance to large ground space areas.

## Scope – Mission Statement

The team will conduct a feasibility study and preliminary design for future intrusion detection system utilizing various UGS technologies for unattended ground based surveillance. The purpose is to determine the necessary minimum constraints and/or requirements to continue with a large scale project for future use. The team is acting as a contractor independent research and design team with the intent on investigating a concept for potential future business development. The end product of this study will be a preliminary design and feasibility study that will determine whether or not the contractor shall invest more money into the effort (similar to a government white paper). The team will evaluate several methods to determine the best and most effective and operational performance.

## Value Statement

This new UGS development provides exceptional value in new mission capabilities, cost savings and technological advancement, based on the expressed interests of stakeholders, and insight into the UGS community.

The cost of building and maintaining a double set of steel fences along 700 miles of the U.S.-Mexico border could be five to 25 times greater than congressional leaders forecast last year, or as much as $49 billion over the expected 25-year life span of the fence, according to the nonpartisan Congressional Research Service.

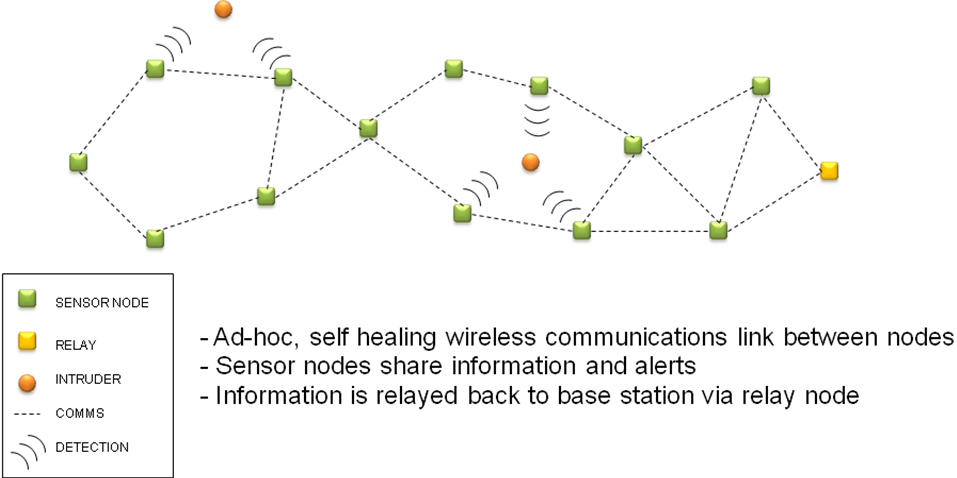
Additionally it will save man-hours and the risk of deploying human personnel at the front line. There are many different terrains that can be dangerous for troops to enter and remain in for prolonged periods of time. Thus a reduction in the number of occupying personnel will result in less casualties and a lower risk for the border patrol.

The network that the system will be using is also the highest known technology to date and will be adapted to this system. Mesh networking will provide accurate and real-time analysis of sensors by a constant stream of communication between nodes. When one node dies out or becomes obsolete the mesh continues working, thereby allowing for a dynamic system to be constantly updated be the introduction or reduction of nodes.

# Design

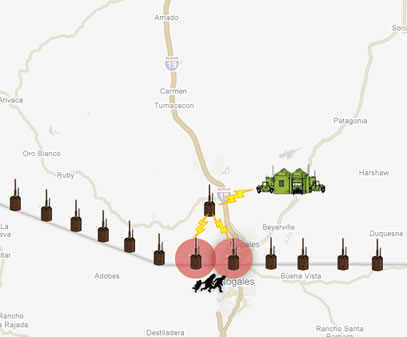
## Operational Concept

Operationally the system shall function as an autonomous unattended surveillance system to provide intrusion detection to open ground areas such as areas between US – Mexico border. The system shall be based on mote sensory node technology that will be able to be deployed with minimal effort and time compared to current UGS systems. The MINUS system will boast the new sensor mesh Wi-Fi communications technologies to create a self healing, ad-hoc communications architecture that can cover a large area with large amounts (100+) sensor nodes. Ideally the system shall blanket an AOI with various sensors able to detect sound, vibration and heat disturbances and relay alerts via Wi-Fi and long haul radios back to a base station. The system will alert users of potential intrusions and their locations within the AOI. The overall system concept shall have a very small form factor (less than 3” in diameter) and very light weight (less than ½ lb each) so they can be deployed in very large numbers with limited required training, setup time and danger to deployment teams.

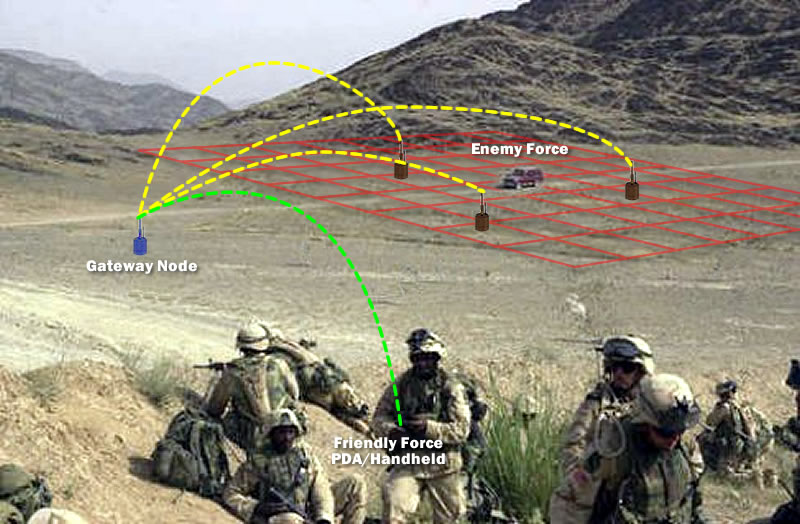


### Operational Scenarios

**Border Patrol – DHS:** Border Patrol agents would first select an AOI along the US Mexico border. The DHS patrol would then deploy a large amount of sensors (partially random distribution) over the AOI via man or air deployed. Given the assumed small size of the sensor nodes, and ease of emplacement, DHS will be able to deploy a large number of these sensors very rapidly compared to conventional UGS systems. Once the sensors were deployed, a relay would be placed in the area (similar to one of the sensor nodes, but with a long haul radio capability). This relay would be used to collect MINUS data and relay it back to the base station. The relay point could be a hard wired antenna system in a border patrol situation, where AC power is accessible. The sensors would operate using wi-fi mesh communications technology so they would hand off information to each other, eventually returning to the relay point. The mesh network would allow for system errors such as missing sensor nodes, power failures, theft, etc. without the loss of the entire system. The sensors would then operate in the AOI for at least 60 days autonomously. The power system of the sensors should be a battery system with the potential of a solar power source for additional operational life.



**Urban Force Protection – Military Forces**: The MINUS system would be used for force protection via emplacement behind troop movements. In this situation, a military unit could place sensors while they “clear” an AOI. Military units would be able to carry multiple sensor nodes due to their size. As the unit moves from one area to the next, the team would drop the MINUS sensors behind them. The sensors would immediately form the mesh communications network and sense any movements behind the military unit. In this situation PIR sensors could be used to detect opposing forces from coming up behind the unit. As the sensors are placed, they would communicate with a PDA carried by a team member, relaying location and potential intrusion alerts. The sensors could be left in place or discarded because of their low cost and limited stored information.



## Design Diagrams

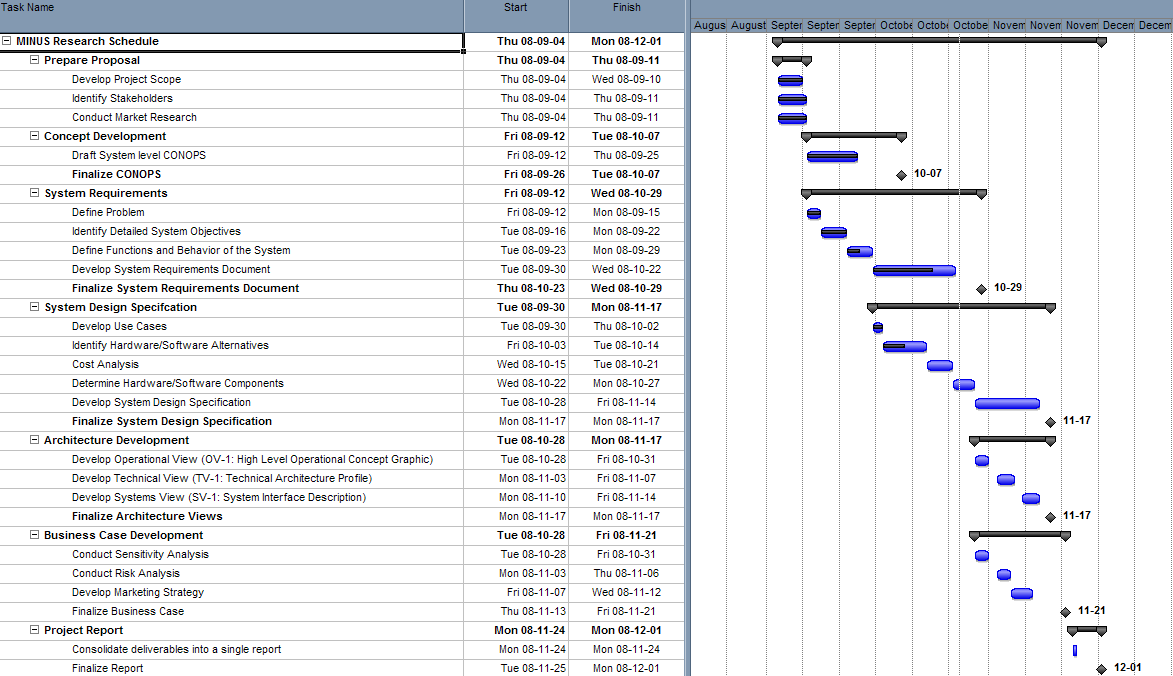
The team has developed an external systems diagram (ESD). The team has also developed functional, physical, and operational architectures of the system. These can be seen \_\_\_\_

Core documents will be inserted here at a later time:

# Project Management

## Schedule

The team has developed a Gantt chart to track and assess project tasks as identified in a work breakdown structure. A Program Evaluation and Review Technique (PERT) chart has been developed and a critical path identified. Project milestones and deliverables are shown in the schedule.



## Major Project Assumptions

Several assumptions are made to de-scope and regulate the size of the UGS project due to the limitations of a semester long schedule and the overall complexity of the subject matter. Team UGS is focusing this project around a concept of operations, requirements definition, preliminary design, and a business case. This CONOPS assumes that the stakeholders are committed to this type of UGS design using mesh communication architectures. Limited tradeoff analysis, market research, and designed alternatives will be analyzed. Several assumptions throughout the CONOPS and future project deliverables are made in order to complete several phases of the project in a timely manner.

Other assumptions made include the development of the Base Station portion of the system. Team UGS will focus on the sensor and relay design and assume that the Base Station and its user software is a simple task and completed for the purposes of this project.

## Process

The UGS team has selected the Waterfall model for the following reasons:

* MINUS will be a small system with well defined requirements closely mapping to the Waterfall model process
* Waterfall begins with requirements phase which closely ties to UGS IRAD and stakeholder objectives
* Waterfall is not iterative, but a onetime process with a linear life cycle
* A prototype of MINUS is not needed or required early on for stakeholder buy in
* There is very limited technology risks associated with implementing MINUS
* Waterfall is more cost effective and affordable
* Waterfall is easier to use
* MINUS software will be developed in a later phase

The UGS team will focus on completing the requirements and design phases of the Waterfall lifecycle in conjunction with meeting milestone A of the JCIDS framework which includes the development of the CONOPS, Architectures and a Capability Based assessment. The following will be items will be completed as part of the Waterfall requirements and design phases.

## Architecture

The purpose of architecting is to produce actionable decision information by the application of reliable knowledge through mature processes. Today’s dynamic warfare has motivated architecture, many different systems come together to carry out one overall mission, therefore interoperability is not an option. The exchange of information and data between these systems are critical in saving lives and winning battles. The Department of Defense Architecture Framework (DoDAF) was developed both for war fighting operation and business operations. The intention of the framework was to ensure the architectural descriptions can be compared and related across organizational boundaries joint and multinational. The DoDAF defines three architectures; operational (OA), systems (SA) and technical (TA).

OA describes the tasks and activities required to accomplish or support military operation. SA describes the system and interconnections providing and supporting military functions. TA is defined as “the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements, whose purpose is to ensure that a conformant system satisfies a specified set of requirements.”

DoDAF defines a standard way to organize a [systems architecture](http://en.wikipedia.org/wiki/Systems_architecture) into complementary and consistent views. All major [U.S.](http://en.wikipedia.org/wiki/United_States) [Government](http://en.wikipedia.org/wiki/U.S._Government) [Department of Defense](http://en.wikipedia.org/wiki/United_States_Department_of_Defense) (DoD) weapons and information technology system procurements are required to develop and document a systems architecture using the views prescribed in the DoDAF. While it is clearly aimed at military systems, DoDAF has broad applicability across the private, public and voluntary sectors around the world, and represents only one of a large number of [systems architecture frameworks](http://en.wikipedia.org/wiki/Systems_architecture_framework). It is especially suited to large systems with complex integration and interoperability challenges, and is apparently unique in its use of "operational views" detailing the external customer's operating domain in which the developing system will operate

In conclusion DoDAF is key in creating a data-centric environment. Because our main stakeholders are the government and military and our team’s objectives are in line with the DoDAF process, the UGS team has chosen to follow the DoDAF architecture.