Daniel Luthcke
Russell Hager
Jared Dickman

Robotic Mobile Beamforming Platform

Section 1

	Daniel Luthcke	Russell Hager	Jared Dickman
% Towards Assignment	40%	30%	30%

Daniel Luthcke - Researched Beamforming implementation and constraints

Russell Hager - Researched Robotic platform options and limitations

Jared Dickman - Researched Autonomy limitations and requirements

Section 2

Transmission System

Beamforming involves using an RF signal to your advantage by using various patterns of antennae as well as varying the phase of the signal coming out of these antennae to create a pattern of usable RF signal in a shape which is not a near perfect circle as a single omnidirectional antenna does. This can be very helpful because it is an efficient way to propagate signal to a certain area while keeping signal going to unneeded areas to a minimum. More complex patterns can be created and controlled using more antennae, however, a minimum of two antennae is all that is needed. In order for this to be successful, a high level of accuracy is needed. The frequency being transmitted is necessary to know to determine proper antenna spacing. Without this information the signals will just overlap and create an unusable signal on the client side. The accuracy of the phase shift on each signal is also important because without that the user does not know exactly where the information is being transmitted to.

Beamforming itself can become a fairly large expense in itself between processing power needed to perform the necessary calculations as well as obtaining the necessary hardware to properly arrange the transmission signals to create a usable signal on the far end. For this aspect, cost and efficiency need to be kept in mind. A software defined radio transmitter/receiver would be able to achieve the proper timings, be able to precisely control which data is sent or received over the signal and be able to change required frequencies on the fly. This, however, can be upwards of $1000 and in turn be cost prohibitive when going into mass production. Software defined radio also requires a lot of

processing power to process the data needed for successful transmission. This can also hurt the overall cost because an FPGA or high power microprocessor is needed to keep up with the data flow. Another way to achieve beamforming capabilities is to use an already existing transmission platform and modify the transmission system to support RF beamforming. This can be done by splitting the existing antennae into an array of two or more and adding phase shifter modules to the output signal. This approach is significantly cheaper than the former approach, however, when building the product there is much less control over what can be controlled to ensure the transmitted signal is usable.

Mobile Platform/Locomotion System

The mobile platform is an important part in the design because it makes the system more usable in many more applications. When the system can move around remotely it opens up the customer base, allowing users who may be in dangerous situations to remotely maneuver the platform to wherever it has to be without being in harms way or out in the elements. The platform needs to be designed in a fashion where it is power efficient as well as rugged to survive the toughest environments. Various Mobile platform designs can achieve a very high level of reliability. An innovative possibility would be to create this system on a quadcopter and fly to the required area to transmit in. While this is very useful for traversing rough terrain there are some large setbacks which need to be kept in mind. When flying, the payload carried becomes a huge limiting factor since most quadcopters can only carry a few pound of gear. Power also becomes a large issue because this platform will need to transmit for a long period of time and flying is a very power hungry process, requiring a larger battery and in turn increasing the weight carried. A 4 wheeled platform makes more sense as far as power consumption goes but there are also constraints which need to be looked at here as well. When driving a 4 wheeled platform over rough terrain it is necessary to have a 4 wheel drive system to help overcome any obstacles which may be encountered. This adds manufacturing cost as well as extra power needed. Some coding of traction control may also need to be implemented because if the wheels start slipping the platform will need to know how to react in order to be able to move again. The final, and probably most efficient design would be a tracked robotic system using a skid steer turning mechanism. Tracked robots are very efficient as they only require two drive motors and therefore will use slightly less power. They also have a large area in contact with the ground which will help greatly with any possible traction issues. Using a tracked design would be the best approach because it’ll satisfy our need of carrying a fairly heavy payload reliably without using an excessive amount of power and allowing the Transmission system to be active as long as it can.

Autonomy System

Autonomy is the final most important part of this design. When a robot is autonomous it doesn't require any human intervention to get to where it needs to go. This is important because if long distances need to be traveled, a human would not need to spend the time getting to the exact location it is needed. The coordinates would be able to be set in the main user interface and the robot will use its sensors to navigate to the correct destination. In order to implement autonomy reliably and efficiently lots of time is

needed to design effective algorithms. Sensors are also needed for the platform to see its surroundings as it is moving along. A GPS sensor will let the robot know approximately where it is on the earth and be able to move towards the position requested from the user interface. A collision detection system is also needed because if the robot collides with an object it will need to determine where that object is as well as how to get around it properly. Another helpful set of sensors would be Gyroscopes, accelerometers and magnetometers. A combination of these would allow the robot to determine its attitude and respond appropriately if it has flipped over or is climbing/descending at an angle greater than it is designed to handle. An ultrasonic or some other rangefinding sensor would be the last useful sensor for navigation. When the robot sees it is coming close to an object on any side it will be able to compensate and potentially avoid needing to navigate around a collision. With all of these sensors working together complex algorithms are needed to efficiently navigate, however, if the time is taken to develop these processes to be as reliable as possible then the user would be able to set it and forget it until it reaches its destination. In a product like this full autonomy would be a great asset to any customer or investor and definitely increase the value of the product.

Section 3

Constraints

The quality of the design is greatly impacted by the power source that is used on the robot. A heavier battery will make the motors work harder, therefore consuming more power and limiting the battery life of the robot. The design of the antenna affects the efficiency of the robot to create constructive interference patterns. The antenna will have to emit a strong enough signal that can produce quality results after experiencing path loss. The antenna characteristics also dictate how much directionality we can impose on the signal, as well as the degrees of freedom we have to play with to make precise constructive interference. Since the broadcasted signal is sent out in three dimensions, accuracy of the signal hinges on the quality of the antenna as well.

For implementation of the robot, we will ensure that it meets the necessary codes and standards of an autonomous vehicle. The product will conform to all applicable ISO, IEEE, and CE standards. The product will also conform to the quality standards set forth by the company and all manufacturing will done under GMP (Good Manufacturing Practices).

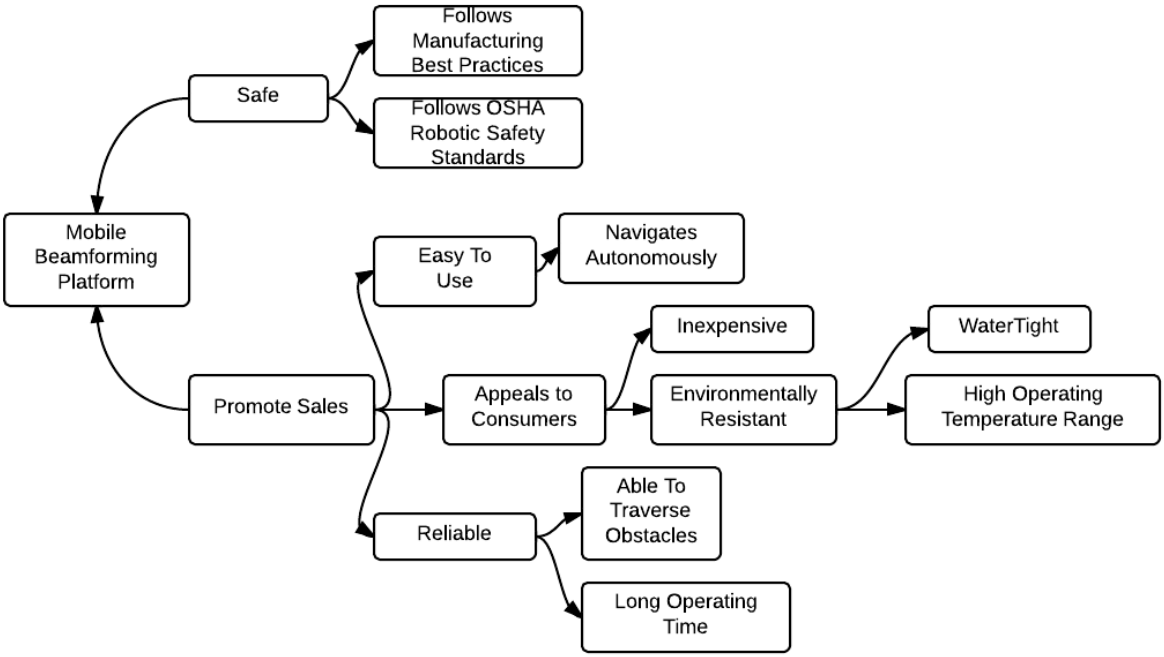
Responsibilities

In order to operate in a safe manner there are many responsibilities on the part of the designing team to ensure the product is safe for production. The Proper safety protocols must be followed to ensure there will be no injuries or failures when the platform is being used as directed. This includes following all standards set forth by professional organizations such as the ISO, IEEE and others. Environmental responsibilities also play a big factor in how the product is designed and produced. If the system goes into mass production, great care will need to go into choosing parts which are lead free as well as RoHS complaint to avoid damaging the environment in production of the parts as well as at the

end of life for the system. An environmentally friendly manufacturing facility will also need to be used in order to minimize the footprint this product has on the environment.

Section 4

Safe	DIRECTLY IMPORTANT
Reliable	Promotes Sales
Long Operating Time	Appeals to consumers
Long Operating Time	constraint to reliable
Inexpensive to Produce	Appeals to consumers
Long Range	Promotes Sales
Able to traverse obstacles	constraint on Reliable
Navigates Autonomously	constraint on Easy to use
Environmentally Resistant	Appeals to consumers
High operating temperature range	Constraint on Environmentally resistant
Water Tight	Constraint on Environmentally resistant
Easy to use	Promotes Sales
Follows Manufacture Best Practices	constraint on Safe
Follows OSHA Robotic safety standards	constraint on Safe



Links

OSHA Robotic Safety Standards - https://www.osha.gov/SLTC/robotics/

Sensors for Autonomy - http://www.autonvs.com/technology.html

Beamforming Information - http://www.altera.com/end-markets/wireless/advanced-dsp/beamforming/wir-beamforming.html

Quadcopter Example - http://www.rakuten.com/prod/udi-u817a-2-4ghz-4-ch-4-axis-gyro-rc-quadcopter-ufo-rtf-mode-2/257756509.html?listingId=315041278&scid=pla_google_WHATAVALUE&adid=18184&gclid=CPXxuZKRrr0CFa1j7AodNWEACw

4wd Robot Example - http://www.dfrobot.com/index.php?route=product/product&product_id=97#.UzGy2fldUeE

Tracked Robot Examples (Includes Professional Models) - http://www.superdroidrobots.com/shop/category.aspx/robot-kits-treaded/73/