ECE4011/ECE 4012 Project Summary

Project Title	Low-Cost VHF Antenna
Team Members (Names and majors)	Mohammed Deafalla, EE Kenneth Holder, CompE Seidi Kartal, EE Seunghwan "Michael" Lee, CompE Sanket Sane, EE
Advisor / Section	Dr. Nima Ghalichechian
Semester	2021/Fall Circle: **Intermediate (ECE4011)** or Final (ECE4012)
Project Abstract (250-300 words)	With the advancements in stealth technology, it has become increasingly difficult to detect and track objects with low radar cross-sections. Stealth aircraft absorb radar signals and reflect signals away from the source to reduce their cross-sections. These objects are optimized to avoid detection from radars using high frequencies around the X and Ku bands. However, if the frequency of the radar is decreased to a level where the wavelength becomes comparable to the size of the target, we begin to see the effects of resonance take shape. The radiation-absorbent material surrounding a target is not as effective against the lower frequency causing the target to induce a larger return signal allowing for more effective detection. By selecting a frequency whose wavelength is approximately twice the size of our targets of interest, we can design an antenna to take advantage of resonance and detect objects that would prove to be difficult at typical radar frequencies. For this project, the targets have radar cross-sections of around $1m^2$. The VHF band in the radio spectrum has wavelengths ranging from 1m to 10m, providing a desirable range of values for resonance. The goal of our project is to design and create a fabrication plan for a low-cost, low power antenna operating in the VHF band. This antenna will be incorporated into a radar system to detect objects with low radar cross-sections. As part of this project, we will be selecting an appropriate frequency within the VHF band, researching and deciding on a particular antenna configuration, simulating the candidate designs, and determining the detectability of a target using the radar range equation.

Project Title	Low-Cost VHF Antenna
List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	Allocation of the Radio Spectrum by the National Telecommunications and Information Administration (NTIA). The allocation data influenced our design by limiting the frequencies at which we can operate our antenna. Our antenna needs to avoid interference, but also not inflict its own interference on other systems [3]. Input Impedance – The input impedance of an antenna is typically 50Ω and transmissions line are built with that assumption. To maximize the antenna's radiated power and reduce mismatch losses, our antenna's input impedance should closely match 50Ω [4]. IEEE C95.1-2019 standard provide limits for the maximum electric and magnetic field. These limits are derived from potential health effects of human exposure to EM fields. The standards list exposure reference levels (ERLs) to avoid these effects. The IEEE defines two ERLS, one for persons permitted in restricted environments and a second for those in unrestricted environments. IEEE 149-1977 provides test procedures for the measurement of antenna properties. This standard will guide the testing and measurement for radiation pattern, gain, antenna impedance, and power draw [5]. Cypress AN91445 describes various aspects of our antenna design and its RF layout. The guidelines include application notes on antenna-tuning procedure, antenna geometry, RF trace, power supply decoupling, PCB stackup, and choice of RF passive components [6].
List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	Radiation Resistance One of the key parameters affecting antenna size constraints is radiation resistance, which is part of feed point resistance caused by electromagnetic waves. In order to achieve maximum efficiency, the antenna load value must be as close as possible to its radiation resistance [8]. As the dimensions of the antenna decrease, its radiation resistance decreases too. Such decrease leads to the increased difficulty of matching antenna with the rest of the system, from which it follows that the resistance of the antenna conductors must be reduced in proportion to the square of the length of the antenna. Small antennas made of thin wires would not be able to achieve high efficiency, while the use of thick conductors would result in losses due to the skin effect. Overvoltage, Overcurrent and Q-Factor The quality factor of a small antenna is inversely proportional to the volume occupied by its magnetoquasistatic field. The Q factor cannot be reduced by varying the design of the antenna, since in any case, with decreasing dimensions, the active radiation resistance decreases very quickly in relation to the reactive one. At the same time a decrease in the size of the antenna leads to an increase in the field strength near it; according to the minimum estimate, the field strength is inversely proportional to the size of the antenna. Since fields are generated by voltages and currents, overvoltage and overcurrent are inevitable in small antennas .
Briefly explain two **significant trade-offs** considered in your design, including options considered and the solution chosen.	By scaling down the size of the antenna, we decrease the overall cost of the entire system. However, we would have to increase the frequency of a signal, which leads to the higher precision requirements. Another important thing to consider is the relationship between directivity and physical length of antenna. According to the design, our antenna needs to have high directivity. However, higher directivity results in a physical length of dipole being equal to 1.25 wavelength. At the same time, lower directivity allows us to build an antenna which length is only half of the wavelength.

Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	The antenna needs to be installed with little human interaction and be low maintenance. This means that the antenna should be designed to physically and electrically connect to the radar system with a minimal number of connections and be easily assimilated to the system. For simulation and analysis of the antenna, HFSS and MATLAB will be used to determine the effectiveness of the antenna in detecting a target.

Project Title	Low-Cost VHF Antenna
Leadership Roles (ECE4011 & Forecasted for ECE4012) (NOTE: ECE4012 requires definition of additional leadership roles including: 1.Webmaster 2. Expo coordinator 3. Documentation	<u>Leadership Roles:</u> Mohammed Deafalla – Communication/Documentation, Design Team Lead Kenneth Holder - Webmaster Seidi Kartal – Simulation Team Lead Seunghwan “Michael” Lee – Fabrication Team Lead Sanket Sane – Expo Coordinator

International Program: Global Issues (Less than one page) (Only teams with one or more International Program participants need to complete this section)	N/A