

Design Issue Assignment  
**Interactive Radar System for Children**

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Team five's objective is to produce an electromagnetic (EM) learning platform based on the Massachusetts Institute of Technology (MIT) Lincoln Lab radar project. This platform is designed to increase the younger generation's interest in EM and radar concepts through hands-on and interactive experiments. It will be a portable device that is to be displayed in the MIT Museum. This system uses the Arduino MEGA R3 to process the radar output signal and communicate the ranging and speed information gained thereby to the PICASO GX2 for graphical processing. The PICASO will be used for image processing to display the range and velocity versus time. Range will be displayed through a 'Pong' simulation and velocity will be displayed with a spectrogram.

Several design issues may arise from the portable radar system. This reading will discuss the matters regarding the product lifecycle management, design for accessibility and, standards and liability. Product lifecycle and management issues are related to the maintenance and the retirement of the radar system. The radar system is designed specifically for a targeted group of users therefore it might not be feasible for a certain individuals with disabilities to use. Standard and liability issues are regarding the legal obligations and requirement that the design has to fulfill.

One of the lifecycle management issues is long term maintenance of this system. The technical functionality of this product is usually understood by only a group of professional or enthusiasts in the field of radar, electromagnetic, circuits and programming. Therefore, the person in charge of repair and maintenance of this radar system needs to have interest or be trained in these fields. However, to assist all users in general, this issue can be resolved by providing a technical manual on the system operation to the user. If, under any circumstances, the user still faces difficulties repairing or maintaining, they can send the system back to the manufacturer to be examined and fixed.

Modularity is integral to the ease of maintenance in any system. Ideally, all components would be easily accessible and interchangeable but in reality this can rarely be the case. The radar and processing segments of this radar system, while difficult to divide them have been connected via buses for ease of use. If, for example, the PICASO unit fails replacing it would be a simple matter of disconnecting a few connectors instead of an

involved dismantling process involving de-soldering. Improved modularity of the radar system could be achieved by separating the antenna onto a moveable board. This would allow the system to be aimed without rotating the majority of the components. Detached antenna mounted on a controllable surface would additionally allow advanced functionality in the form of remote aiming and SAR imaging.

Another product management issue is the retirement of the product. Engineering is a fast developing field. New or enhanced technologies emerge frequently to provide better service for the users. The systems owners may prefer a radar system with for instance, better performance, faster computation, or a better graphic display. Incremental technological changes are unlikely to be seen in a museum exhibit, but if this prototype were to be mass marketed such changes would mark drastic improvements in signal fidelity and interpretation.

Updated signal processing components permit greater interpretive functionality and data throughput for graphical output. Current generation Arduino Mega have a 16MHz clock cycle. In the future, the Arduino could be replaced with future generations in the same line or hardware with an additional performance edge. Higher clock rates or ADC resolution would improve signal processing and open up new possibilities for graphical interactivity.

Graphics processing and display technologies are in constant flux due to their wide consumption in the consumer market. Future video interfaces will change the essential methods of signal generation in small scale devices. VGA adaptors, like the PICASO, need to create an analog signal which introduces inefficiencies limiting the quality of the signal. When small scale processors are able to handle the requirements for full scale digital video output, modular designs with current generation are displays will be achievable. The PICASO has an SD memory card slot that allows additional graphical programming as well as file storage. Further enhancements to the game program(s) may include higher resolution graphics, pictures and video. Therefore, the PICASO is well suited for further improvements or inclusion of new features in future designs.

Another issue that could possibly arise is the accessibility of the radar system to people with disabilities. This educational module is taught mostly via graphical image and body movement. People with poor visual acuity will not be able to view the output of the radar from the screen. It will also be hazardous for them to participate in the “Pong” game because it requires them to move in a fast motion to and from the radar system. In addition, the radar system might not be able to detect users who are incapable of fast movement. In theory, the slowest speed that the system can detect is approximately 1 meter per second. To address this issue, the system can be improved by incorporating audio output as well. The system could output the range and speed values after a set interval. Instead of or in addition to outputting a spectrogram, the system could also produce an audio composition that varies in frequency depending on the range or speed.

Every engineer must be aware of the various standards pertaining to his or her line of work. Some standards, such as those set forth by government bureaus, are mandatory, while others, set forth by professional organizations, are recommended but are by no means mandatory. Compliance with a widely-recognized industry design standard does not guarantee legal absolvment in a liability trial, but it shows some care was taken in the design of a product. Our design team recognizes the importance of compliance with standards, so we kept in mind both legal liability and user safety.

| <b>Standard</b>       | <b>Freq. range</b>      |
|-----------------------|-------------------------|
| IEEE 802.11a,b,g,n[2] | 2.4000 GHz - 2.4835 GHz |
| ISM band              | 2.4 GHz - 2.5 GHz       |
| Bluetooth             | 2.4000 GHz - 2.4835 GHz |

One of our greatest concerns in the design of this project is the power radiated by our transmitting antenna. Transmitting around 2.4 GHz, the antenna operates within the open-spectrum ISM (industrial, science, and medical) band spanning the range from 2.4 GHz to 2.4835 GHz. The United States Federal Communications Commission (FCC) mandates a 1 W, or 30 dBm, maximum emission limit for this band. Exceeding this limit is a direct violation of US Code, Title 47, §15.247. It is important to consider our radiated power, as there are many devices operating in the same band as our antenna (Fig. 1). The

output power of our antenna is less than the mandated limit, and it can be calculated in the following manner. The voltage-controlled oscillator (VCO) produces a 6 dBm RF signal, which is fed into a +14 dB RF amplifier. Half (-3 dB) of the resulting 20 dBm signal goes to the transmitting antenna, which has a gain of 11 dBi. The total radiated power amounts to about 28 dBm EIRP (effective isotropic radiated power), which is close to half (again, -3 dB) of the 30 dBm FCC-mandated limit.

We believe that the radiated power could be reduced by employing antennas optimized for our purposes, so as to couple reflected waves more efficiently. If our receiving unit is more sensitive to incoming fields and waves, it is not necessary to transmit the same amount of power to produce the same quality of signal in the processing chain; therefore, we could transmit less power and get the same signal quality.

In conclusion we've discussed several design issues in relation to the Radar system project. Product lifecycle management is essential to proper functioning over a products lifecycle. Designs accounting for this were included from the inception of the planning process. Industry EM standards were referenced and followed to reduce or eliminate liability for future owners. By nature, this design concept leaves little room for accessibility constraints or adaptations. Radar essentially requires fast moving targets for proper detection, making it impossible for physically impaired people to fully use this product.