Ron Freeman

The one thing that the recent pandemic has made undeniably clear to me is the importance of the connections among us. I watched a number of the Naval Horizons STEM Videos, especially those covering topics in Electrical Engineering, and anything related to Radio Frequency & Microwave Engineering, because its my personal passion and because of its past, present and potential future impact in the modern world. RF & Microwave Engineering enables cell phones to synchronize to cell towers. GPS localizes position to the millimeter (with RTK GPS). Massive, decentralized networks self-organize and communicate at scale. RF & Microwave Engineering advancements helped us talk to spacecraft and helped NASA transmit video of Neil Armstrong stepping on the moon.

Dr. Dio Placencia's talk on Optoelectronics is very inspiring. The impact of his work on everyday aspects of our lives is incredibly important. His work on reducing process requirements in optoelectronic fabrication processes especially inspired me. My personal career goals are similar to his, to earn a Ph.D. in RF & Microwave Engineering and to work on sensor and microscale design projects for communications and radar systems, generally involving systems and circuit design.

I think new innovations in RF & Microwave Engineering are essential to our Navy and Marine Corps of today and the future. In the Arctic, a new trade passage is opening, with significant economic and strategic opportunities and ramifications for the United States and the world. The Arctic is as big as Africa, holding an estimated 22% of earth's natural gas and oil resources. Preparing for this new future requires accurate models of englacial movement. The problem: Accurate 3D models of glacial movement are not well understood. Monitoring the conditions within glaciers is difficult. Glaciologists use Ice-Penetrating Radars (IPR) to image within ice sheets. However, these radars are not perfect. Running an IPR study is costly, requiring a research team to fly a plane over a glacier, and it only gives a snapshot in time.

Furthermore, due to the low frequency of operation and low bandwidth of IPR, the resolution of these radars are limited (bandwidth is critical for determining the resolution of FMCW radars, the center frequency is critical for determining the resolution of monopulse radars enhancing resolution with phase measurements). Additionally, IPR's tend only to track a cross-section of an ice sheet, not the entire 3D structure required to model the 3D motion of a glacier. Being able to communicate without wires, sense without contact, and image miles away, I think RF & Microwaves will be a better way to do it. Investing in RF led to the development of the Microwave, cell phones, and radar. Its exciting to think about innovations and the advancements RF & Microwave Engineering will provide.

In the year 2040 I imagine new approaches to the problems of 2021. This fall I will be a high school junior, and I aim to earn a PhD before 2040. I've been thinking about a possible solution to the englacial movement challenge, to create a static localization matrix network around it. A system would track a matrix of low-cost backscatter tags embedded in a glacier. As the glacier moves, the tags would move, enabling the system to use the displacement of the matrix to build a model for glacial movement. Using a system similar to GPS, the tags would be localized in a three-step process. First, a transceiver sends out a Pseudo-Random (PN) sequence into the glacier space. The tags would receive this sequence and then backscatter it with an added Walsh code modulation (an orthogonal code with a high autocorrelation). By using Walsh codes, the system can be designed so all tags can backscatter simultaneously without interfering with each other due to the nature of the orthogonal codes they are modulating the PN sequence with. The transceiver can receive responses and determine the time of flight (ToF) delay of the signal and thus localize the tags. My dream would be to build and place prototypes in a test glacier to build a better model for glacial movement and create a system to track the emergence of the Northern Sea Trade Route and other emerging trade routes in the Arctic. While the problems of 2040 will not be identical to those of 2021, they will be inspired, so starting to understand them with a head start is an advantage we should not to pass up.

In 2040 I imagine new RF & Microwave technologies and applications not existing in 2021. I can imagine massive MIMO beyond the MIMO existing in current communication standards like 5G. This MIMO could enable massive communications bandwidth using the untapped THz spectrum. I can imagine new advancements in phased arrays enabling wireless power transfer to drone swarms. Other exciting future applications include fusion reactors based on RF plasma generation techniques currently existing in 2021. Microsensors embedded in fabrics for smart cities and mesh networks more resilient than ever to natural disasters and catastrophes. Additionally, new kinds of antennas on spacecraft bringing the first humans to Mars and on space probes exploring the furthest reaches of our galaxy.

Wherever the future may lead, one thing is for sure: innovations in RF & Microwave Engineering will continue to be essential in communications, imaging, and remote sensing impacting the world in an immeasurable amount of ways. RF & Microwave Engineering is at the exciting intersection between Electrical Engineering and Physics, enabling new technologies that can transform our world. How could any not be interested and excited for the future of RF & Microwave Engineering and how it can help the Navy, the United States and society?