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Human radar cross section algorithm simulation for microwave camouflage application

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This article proposes an analysis of the effect of combat textile on human radar cross section (RCS) for microwave camouflage applications. Based on numerical simulations for the definition of geometric profile of the human body and measurement of electromagnetic parameters of the fabric, made by cotton and polyester, the work proposes the union between real and simulated data to reveal the direct influence on the absorption (8 dB) of electromagnetic waves from hypothetical radar The ability to render objects invisible to observers and detection tools has come a long way since its first military use. Artificial camouflage patterns of some sophistication appeared in the 1914–1918 time frame propelled by First World War advances. Its importance became magnified during this period because of the use of airplanes and aerial photography. However, the camouflage for the visible spectrum was no longer sufficient for combat over the years. The Korean War saw the introduction of night vision devices, which added the need to disrupt the human form not only in the visible but also in the near infrared range. Nowadays, the camouflage become a rapidly growing scientific field where its fundamental challenge to make objects undetectable is to conceal all the signatures over the electromagnetic spectrum. In this line, microwave stealth is one prominent approach to hiding a specifically spectrum band and has been extensively investigated on recent years. Radar absorbing and shielding technology have attracted a growing interest due to the recent advances in electronic warfare and detection capabilities, leaving specially infantry forces vulnerable to detection across the microwave spectrum range. Advanced battlefield and ground surveillance radar (BSR/GSR) are readily available in military markets that are highly effective, portable, and automated for large area monitoring. These equipment commonly are within the X-band (8.2–12.4 GHz) or Ku-band (12.4–18 GHz) and represent an powerful advent against infantry troop movements by the fact of stealth movement is a key priority for military. Despite existing many recent studies for RCS reduction, such as ultra-thin absorber metasurfaces, diffusers, tunable metasurfaces, and with high potential applications on textile clothes, such as flexible metasurfaces, there is not so much works related to the combination of human body and textile materials used for combat contexts.This article aims to analyze the effect of combat textile cloth on human RCS for a X-band (9.375 GHz) frequency. Based on a numerical model simulation for human geometry besides experimental characterization of a combat textile cloth to determine material parameters, such as electrical and magnetical permittivity and permeability, and tangent losses, the work proposes a 360-degree azimuth profile reflection for a human illuminated by a hypothetical radar.

Conclusion: The results reveal that the average human RCS, without textile cloth, for a height of 1.70 m has an average value of −0.41 dBsm and with the use of the uniform, an average value of −8.61 dBsm. The measured data showed that a significant variation in human RCS under the simulated conditions is mainly due to the contribution of the attenuation effect. By the combination of two factors, the impedance matching of the material close to the air and the loss of the propagation of the electromagnetic wave, in the fabric, due to the dielectric and magnetic loss tangents, the combat textile cloth shows an absorbing behavior to 9.375 GHz. Furthermore, in specific azimuth regions, the attenuation effects increase considering the frontal and rear conditions, average values of −12.51 dB and −10.52 dB, respectively. These results demonstrate the effectiveness of the combat textile cloth on reducing the human RCS for a specific frequency inside the microwave spectrum. This work also shows that a fabric made of cotton and polyester, conceived under requirements of tenacity, weight, resistance to humidity, and sunlight, which correspond to inhospitable environments, can still present favorable characteristics for absorption of microwave frequencies and was only possible by optimization algorithms that joined simulated and real data.

Biography

Renan Richter is a Brazilian Air Force Officer and PhD researcher in Materials Science at the Instituto Tecnológico de Aeronáutica (ITA), Brazil. He has experience in microwave photonics and combat survivability directed to Eletromagnetic Warfare (EW). He is also Association of Old Crows (AOC) and American Institute of Aeronautics and Astronautics (AIAA) speaker