Entomological Target Radar Cross Section: Numerical Modelling and Estimation

Omar Alzaabi[1,2], Mohammad M. Al-Khaldi[3], Diego Peñaloza[2], Julio Urbina [2], James K. Breakall[2], and Michael Lanagan [4]

[1] Department of Electrical Engineering and Computer Science, Khalifa University, Abu Dhabi, UAE

[2] Department of Electrical Engineering, Pennsylvania State University, University Park, PA 16802, USA.

[3] Constellation Observing System for Meteorology, Ionosphere, and Climate Program, University Corporation for Atmospheric Research, CO 80301 USA.

[4] Department of Engineering Science and Mechanics, Pennsylvania State University, University Park, PA 16802, USA.

The tracking of a broad range of entomological targets is of particular interest for a wide range of applications including understanding broad foraging trends affecting agricultural security, conservation and development, in addition to relating these dynamics to underlying needs pertaining to their nesting sites and feeding necessities. While the utility of much of the related analysis pursued as part of this work can be extended to a vast range of radar targets, it is the role of the Honeybee as being the most important pollinator that makes testing the proposed methodologies using their models and samples, of most interest. A different approach is proposed herein in which radar based characterization of airborne insects is undertaken. In this approach a numerical scheme for predicting insect Radar Cross Section (RCS) through numerical modelling is developed. Effective radar tracking capability of these targets can only be achieved through the ability to predict their radar cross sections under varying observational scenarios and system operating conditions. This includes factors relating to the targets' size, composition and flight behavior as well as the viewing system's frequency, polarization of illumination and a number of other factors, accounting for all of which will ultimately dictate the system's tracking performance.

This paper will demonstrate the ability of using the commercially available computational electromagnetic modelling software to predict radar cross sections of the honey bee (Apis mellifera), a type of airborne insect, under a variety of conditions, as a preliminary step towards enabling detection and tracking of these organisms more effectively. A Method of Moments solver made available by Altair's FEKO is used to conduct the analysis over varying frequencies (2.0-18.0 GHz), illumination angles and polarizations. To produce realistic scattered fields from biological scatterers such as insects, prior knowledge of their dielectric properties is required. An approach for doing this, will also be described. Using these findings, the RCS was then simulated and predicted using commercial modeling software FEKO. Results obtained from simulation are validated with experimental analysis within the ElectroScience Laboratory's anechoic chamber at The Ohio State University (ESL-OSU) and revealed a high degree of correlation and complementary trends against modelling studies. These results indicate that numerical electromagnetic techniques could be applied for airborne insects and could have a significant impact on the field of radar entomology; for instance, quantifying scattering wave properties of these insects can be used with other parameters (time of flight, altitude, etc.) for developing an AI classification system to discriminate between species of flying insects.