Effect of Meshing in Radar Cross Section of Complex Surfaces

M. S, Vani R[1], Bhavya E V[1] and B. Choudhury[1]
Center for Electromagnetics, CSIR-National Aerospace Laboratories, Bangalore, KA, India

INTRODUCTION: In military aviation, detection systems use various bands of electromagnetic spectrum such as microwaves, infrared and visible. Stealth technologies aim to counter all these bands of detection.

COMPUTATIONAL METHODS: Radar cross section (RCS) is estimated using current based, high frequency asymptotic methods. Physical Optics (PO) is the best suitable method for RCS calculation of large and complex targets. In PO, scattering field is calculated by integrating surface current over surface of the target. RCS estimation using PO method depends on meshing size of the target. Meshing can be classified as 2D meshing (surface meshing) and 3D meshing (solid meshing). Surface meshing includes triangular and quadrilateral whereas, solid meshing includes hexahedron, tetrahedron, pyramid and triangular prism.

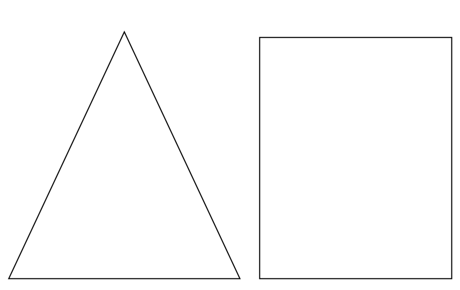

Figure 1. 2D meshing

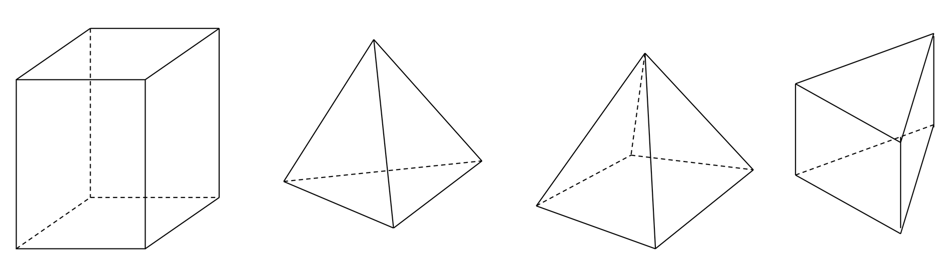

Figure 2. 3D meshing

2D surface meshing is done by using COMSOL Multiphysics® software. The triangular mesh element data is considered as an input for in-house developed "SPARCS" software.

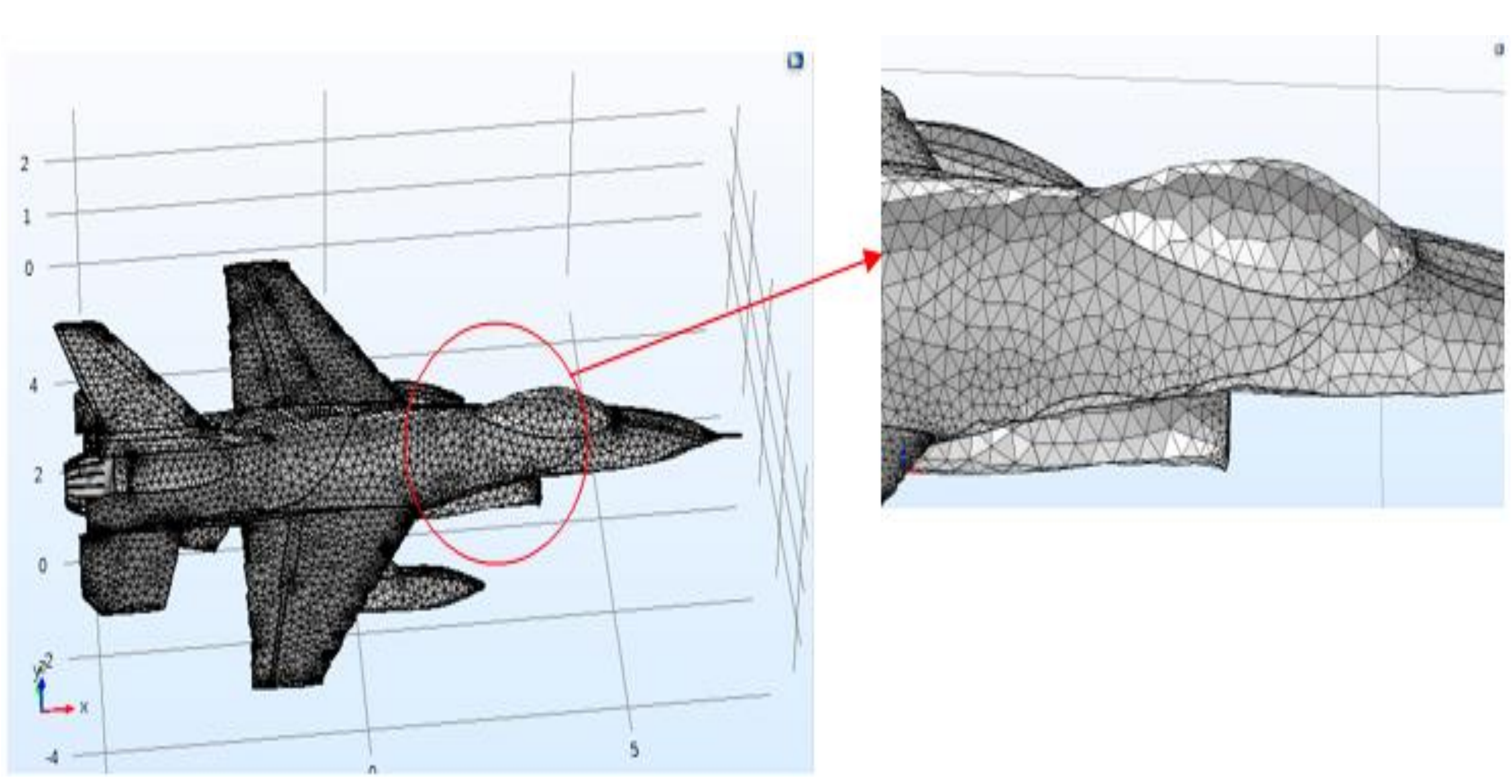

Figure 3. Triangular surface meshing of fighter aircraft

The induced surface current is estimated for each front illuminated facets, facing towards the source plane. The non-illuminated facets (shadowed region of the target), induced current is considered to be zero.

$$\vec{J}_s = \begin{cases} 2\hat{n} \times \vec{H}_i & \text{for all illuminated facets} \\ 0 & \text{for all shadowed facets} \end{cases}$$

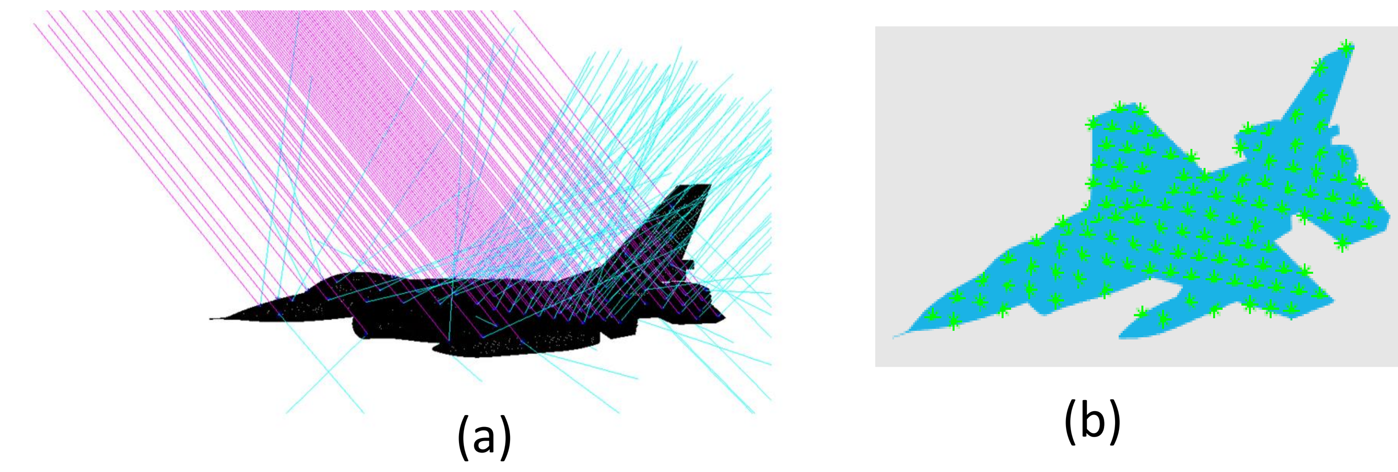

Figure 4. Rays intersecting on the target (a) incident and reflected ray visualization (b) hit points on the targets

RESULTS: The RCS of fighter aircraft is analyzed for different mesh size using "SPARCS" software. As the meshing size decreases, the number of meshing element increases which, results in better approximation.

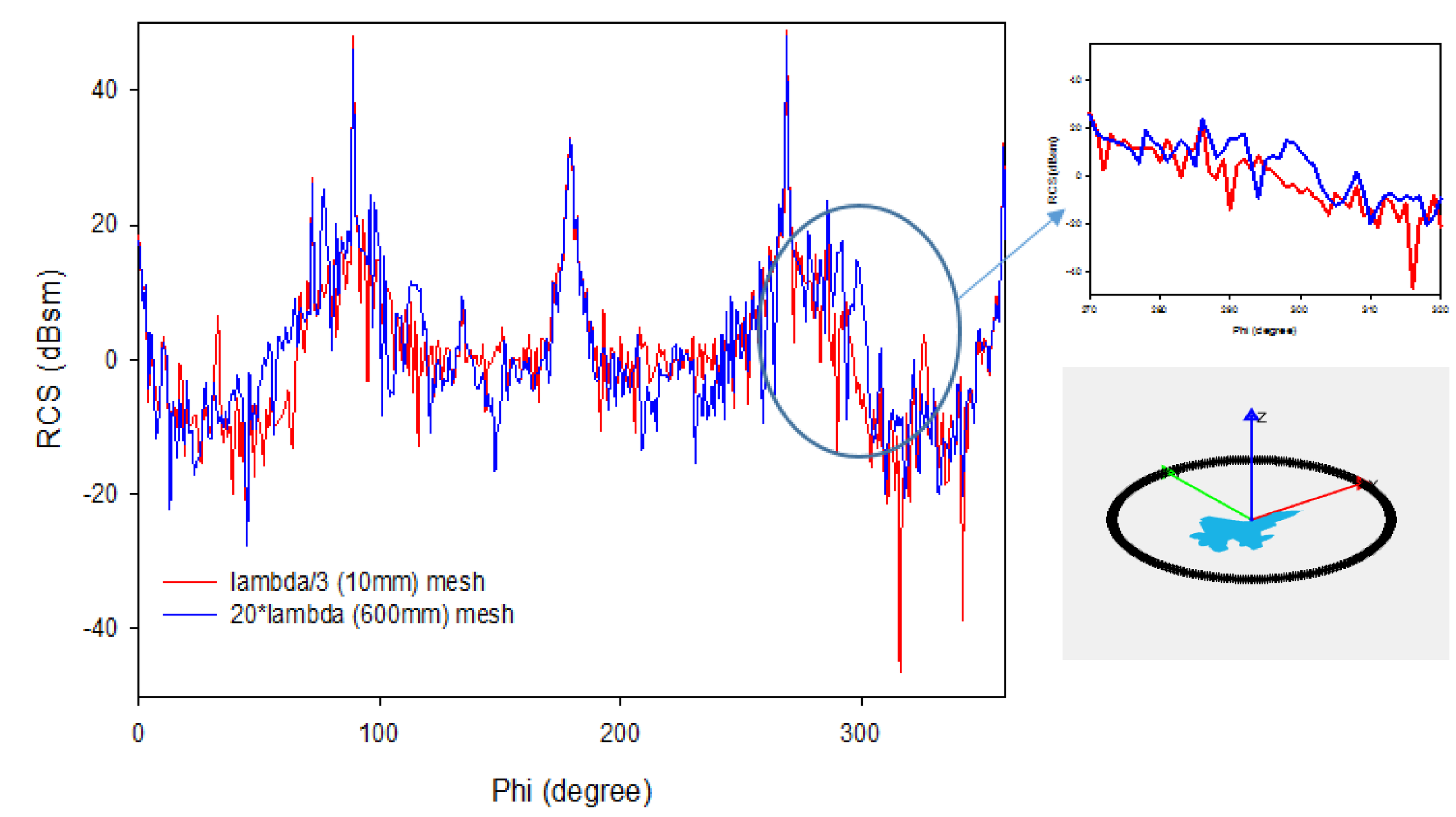

Figure 5. RCS of fighter aircraft for λ/3 and 20λ mesh elements at 10GHz

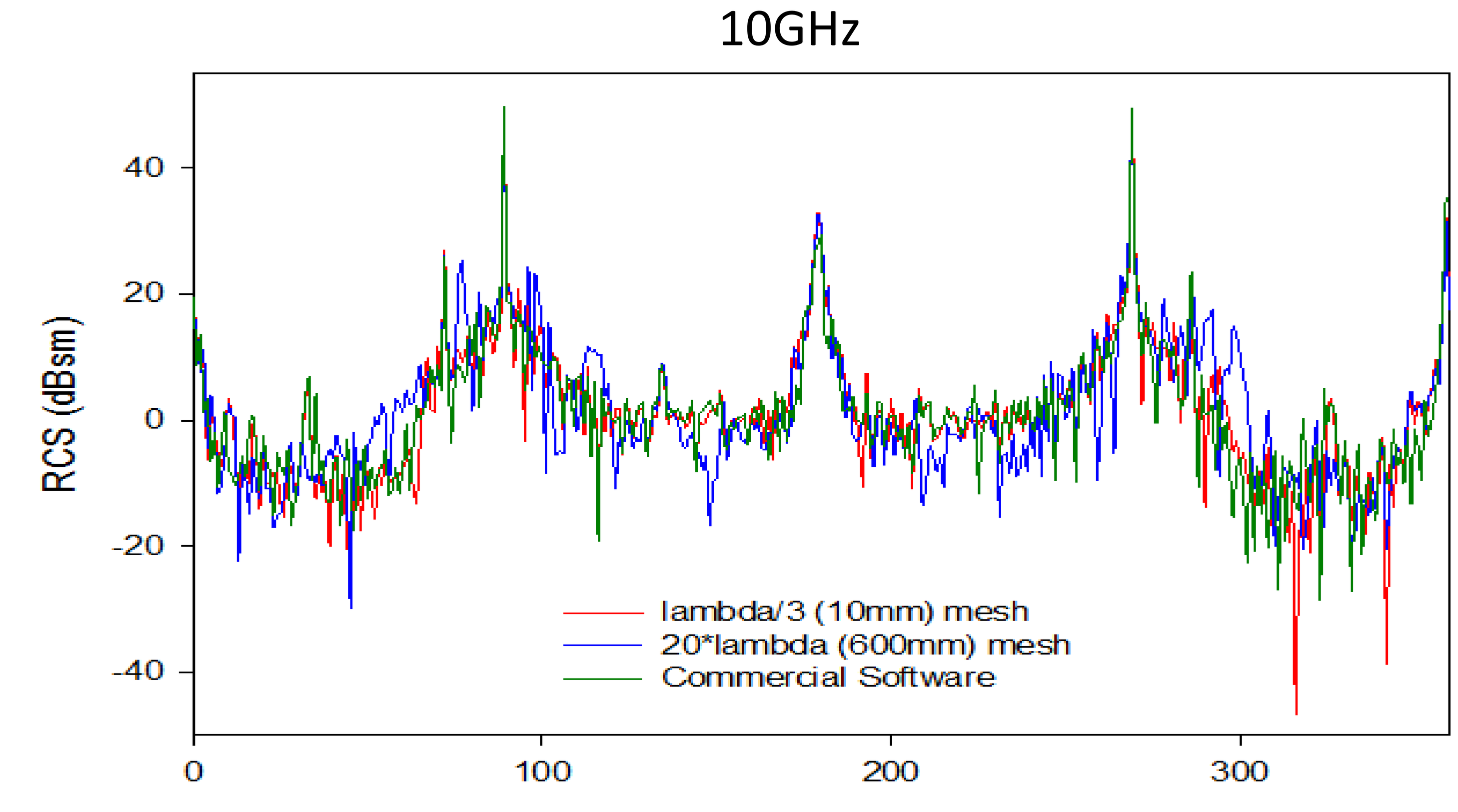

Figure 6. RCS of fighter aircraft for λ/3 and 20λ mesh elements and commercial software at 10GHz

CONCLUSIONS: RCS has been estimated for the fighter aircraft by "SPARCS" software. A parametric study of the software is done by considering different mesh size. Achieved high accuracy in RCS estimation for fine mesh elements.

REFERENCES:

1. Balamati Choudhury and R.U Nair, Stealth platform asymptotic radar cross section software (SPARCS), Registration No.:003CR2019, 2019.
2. Frank Weinmann, "Ray tracing with PO/PTD for RCS modeling of large complex Objects," *IEEE Transactions on Antennas and Propagation*, vol. 54, no. 6, pp. 1797-1806, June 2006.
3. Francisco Saez De Adana, Ivan Gonzalez Diego, Oscar Gutierrez Blanco, Pablo Lozano and Manuel F. Catedra, "Method based on physical optics for the computation of the radar cross section including diffraction and double effects of metallic and absorbing bodies modeled with parametric surfaces," *IEEE Transactions on Antennas and Propagation,* vol. 52, no. 12, pp. 3295-3303, December 2004.
4. Fernando J. S. Moreira and Aluizio Prata, "A self-checking predictor-corrector algorithm for efficient evaluation of reflector antenna radiation integrals," *IEEE Transactions on Antennas and Propagation*, vol. 42, no. 2, pp. 246-254, February 1994.

Excerpt from the Proceedings of the 2019 COMSOL Conference in Bangalore