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Effect of Meshing in Radar Cross Section of Complex Surfaces

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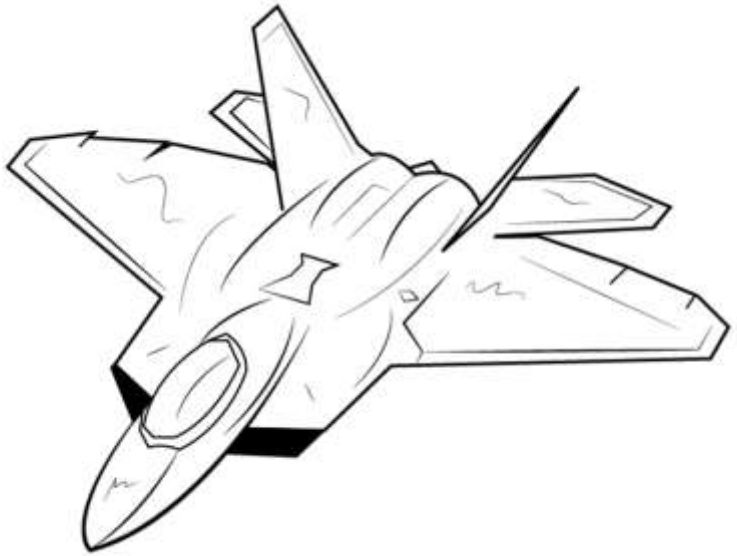
Outline

- Introduction
- RCS Estimation: Heart of stealth technology
- High Frequency Asymptotic method: Physical Optics
- Effect of Meshing
- Results
- Conclusion

Introduction

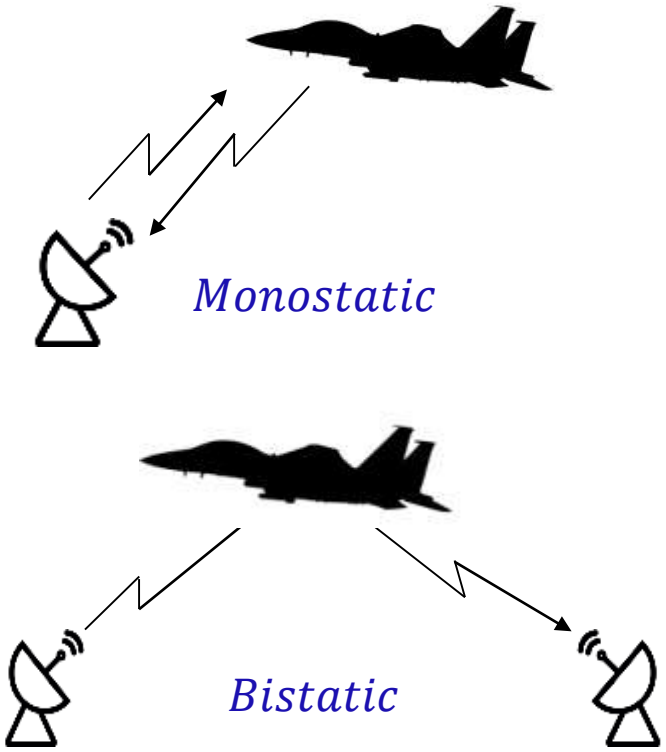
- In military aviation, detection systems use various bands of electromagnetic spectrum
  - Microwaves
  - Infrared and visible
- Stealth technologies aim to counter all these bands of detection
- Stealth Techniques :
  - Shaping
  - Absorbing Materials
  - Cancelling signals: EM jammers
- *A priory* requirement:
  - Broadband RCS estimation
- The modern radars frequency (in GHz)
  - The aircraft becomes electrically very large
- Solution for RCS estimation:
  - HF asymptotic methods



RCS Estimation: Heart of stealth technology

- Ability of a target to reflect back in the direction of transmitter

$$\sigma = \lim_{R\to\infty} 4\pi R^2 \frac{\left|\vec{E}^s\right|^2}{\left|\vec{E}^i\right|^2}$$



- Solution for RCS estimation:
  - HF asymptotic methods
    - Geometrical Optics (GO)
    - *Physical Optics (PO)*
    - Uniform Theory of Diffraction (UTD)
    - Physical Theory of Diffraction (PTD)
  - Advantages: Lesser computational cost
  - Limitations: At lower frequencies asymptotic methods are less accurate
- Indigenously developed *SPARCS (Stealth Platform Asymptotic Radar Cross Section)* software

High Frequency Asymptotic method: Physical Optics

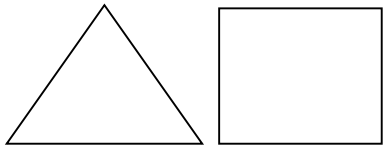
- PO is a current based high frequency asymptotic method
- Used for RCS calculations of large and complex targets
- Scattering field is calculated by the integration of surface currents over the surface of the target
- Surface Current

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

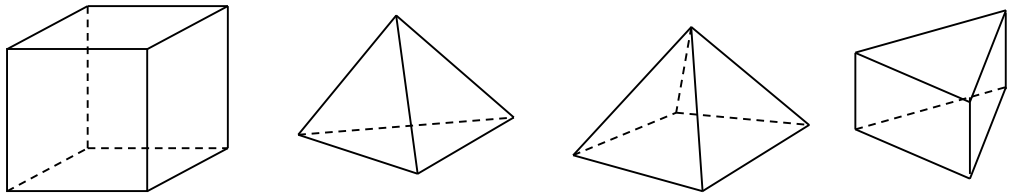
- The induced surface current is estimated for each front illuminated facets
- Induced current in non-illuminated facets is considered to be zero

Effect of Meshing

- Meshing splits a continuous structure into distinct geometric parts
- Types of meshing:
  - Surface meshing (2D)
  - Solid meshing (3D)

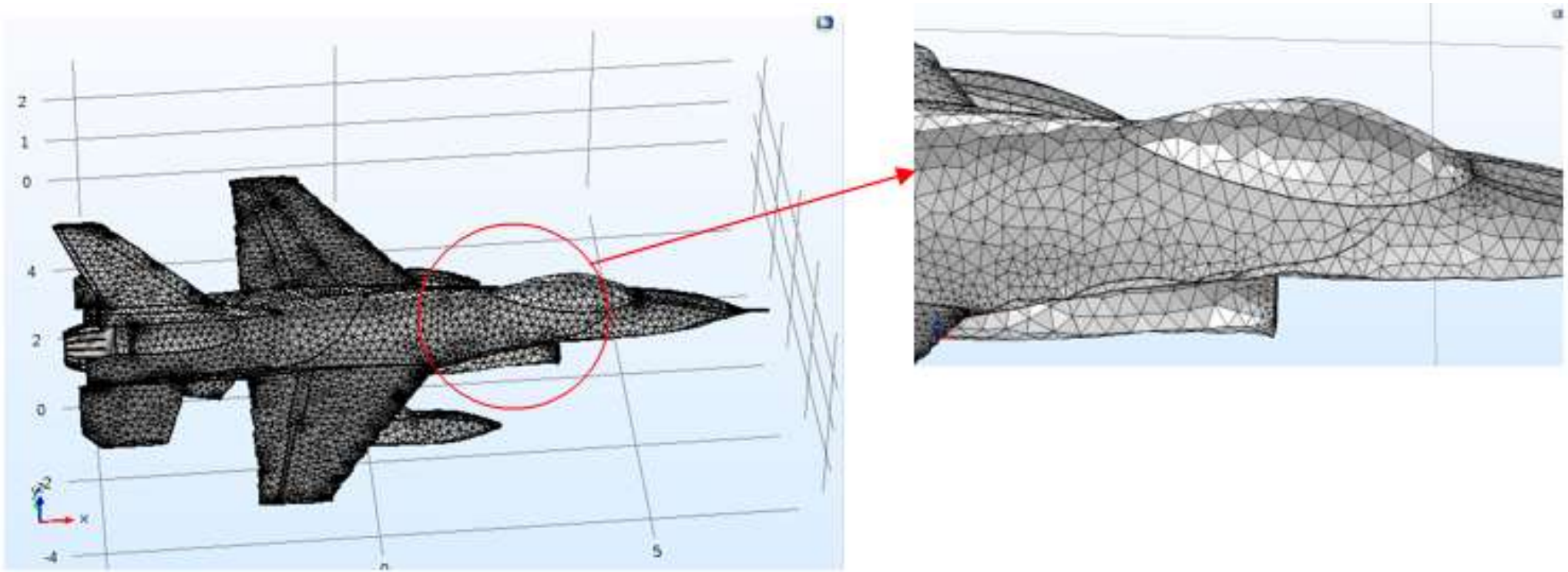


2D Meshing



3D Meshing

- RCS estimation by PO depends on meshing size
- Triangular meshing is preferred in SPARCS

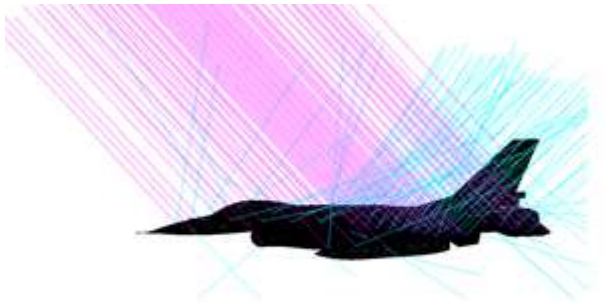


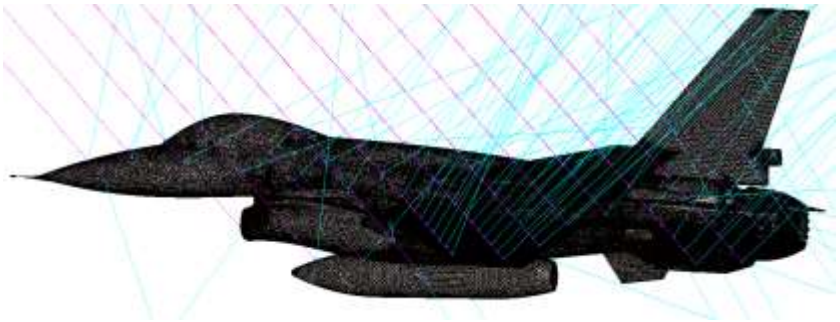
Triangular surface meshing of fighter aircraft

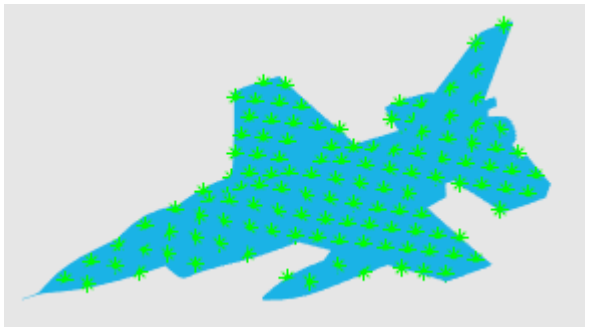
SPARCS: Raytracing

Specifications

- Test Case : Fighter Aircraft
- Frequency : 10GHz

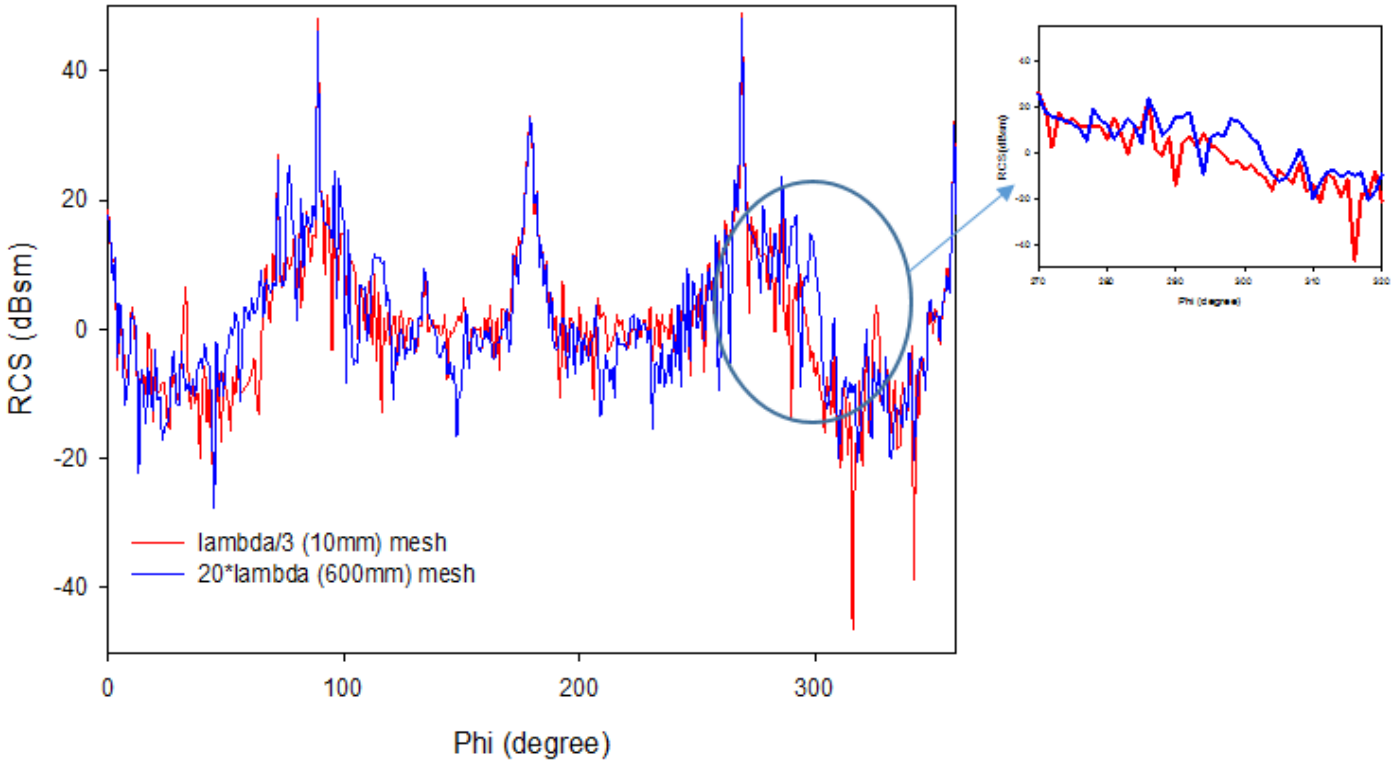


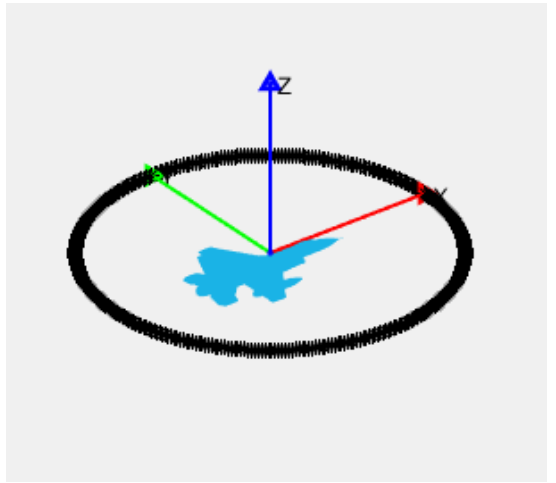




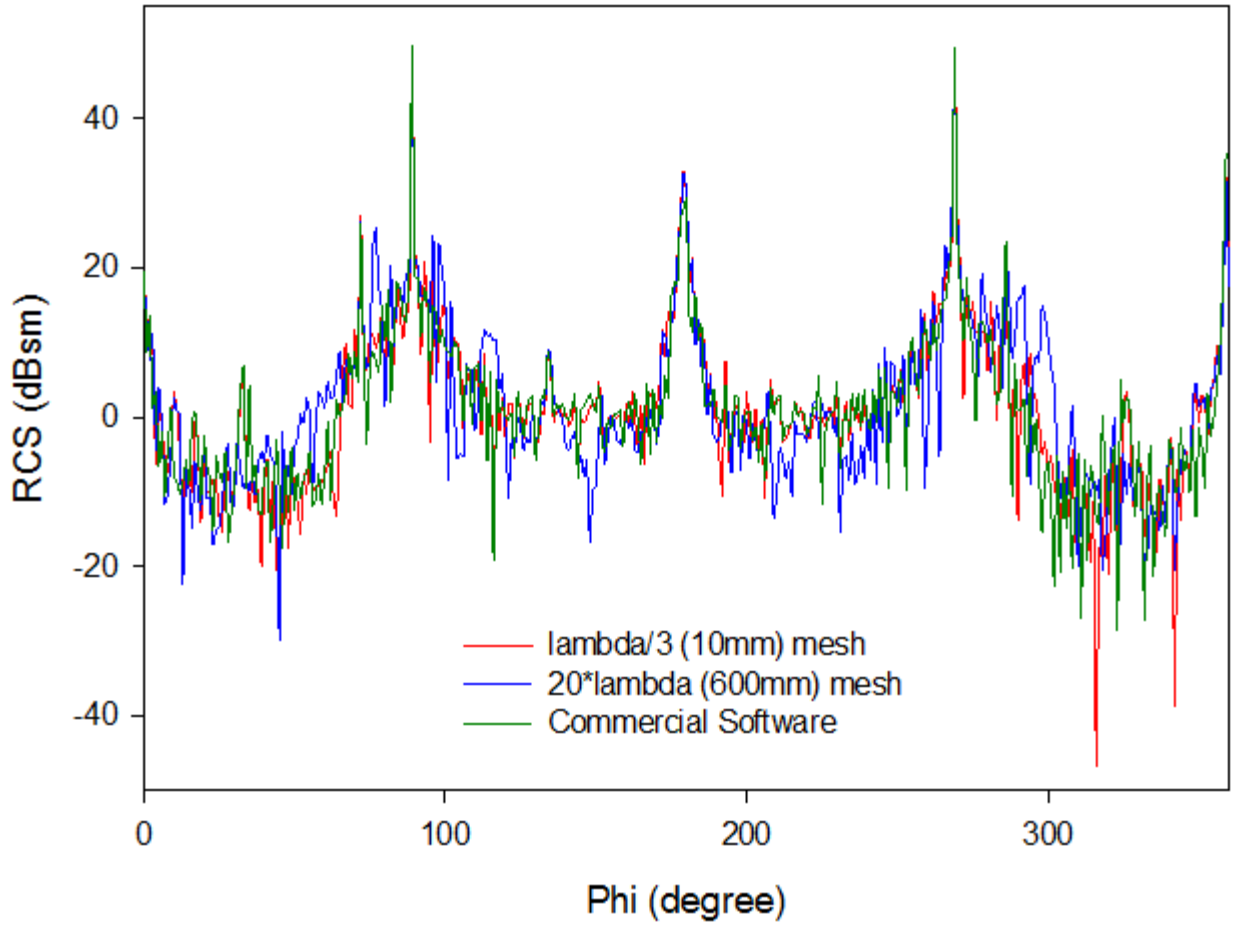
Rays intersecting on the target (Elevation = 45°, Azimuth = 25°)

Results





RCS of Fighter aircraft with operating frequency 10GHz at VV polarization (θ=90°, ϕ=0-360°)
for $\lambda/3$ and 20λ mesh elements



RCS of Fighter aircraft with operating frequency 10GHz at VV polarization (θ=90°, ϕ=0-360°) for $\lambda/3$, 20λ mesh elements and commercial software

Conclusion

- Estimated RCS of fighter aircraft by SPARCS software
- Parametric study of the software is done by considering different mesh size
- Smaller mesh size results in better approximation
- Achieved high accuracy in RCS estimation for fine mesh elements

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Thank You