

# A *MATLAB* PHYSICAL OPTICS RCS PREDICTION CODE

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## SUMMARY

*POFACETS* is an implementation of the physical optics approximation for predicting the radar cross section (RCS) of complex objects. It utilizes the scientific computational features of *MATLAB* and its Graphical User Interface (GUI) functions to provide an error-free encoding of input parameters and efficient calculation. *POFACETS* provides a convenient tool for a “first cut” at the RCS of complex shapes by representing its constituent parts by triangular facets. The software calculates the monostatic or bistatic RCS of the object for the parameters specified by the user and displays plots for the model geometry and its RCS. There is a limited capability to include shadowing, and resistive surfaces can also be modeled. The simplicity of the GUI design does not require the user to have a detailed understanding of the various steps involved in the RCS calculation. The software is available free of charge on the ACES web site.

## INTRODUCTION

The Physical Optics (PO) approximation is one of the most convenient RCS prediction methods for an arbitrary three-dimensional target. The induced currents are integrated over the illuminated portions of the target surface to obtain the scattered far field, while setting the current to zero over the shadowed portions. Thus, the current is approximated as

$$\vec{J}_s \approx \begin{cases} 2\hat{n} \times \vec{H}_i, & \text{for the illuminated portion} \\ 0, & \text{for the shadowed portion} \end{cases}$$

where  $\vec{H}_i$  is the incident magnetic field intensity at the surface and  $\hat{n}$  is the local surface normal unit vector. The current is then used in the radiation integrals to compute the scattered far field from the target. PO is a high-frequency approximation method that gives best results for electrically large bodies ( $L \geq 10\lambda$ ) and is most accurate in the specular directions. However, because PO abruptly sets the current to zero at a shadow boundary, the computed field values at wide angles and in the shadow regions are inaccurate.

One approach to high frequency prediction calculations is to estimate a complex model with an array of simple shapes, such as triangular flat plates. The RCS is obtained by computing the scattered field of the collection of these simple shapes to obtain the total RCS of the target. *POFACETS* computes the scattering from each triangle as if it is isolated in free space. Multiple reflections, diffraction and surface waves are not included. There is a limited capability to include shadowing. For example, if a particular

triangle is part of a closed structure, then the software can be instructed to ignore the scattering from the triangle if the incident wave direction is from the back of the plate. Resistive surfaces can also be modeled. The capabilities include the following:

- Matlab Graphical Users Interface (GUI)
- Limited shadowing option
- Surface resistivity
- Bistatic or monostatic RCS calculation
- One dimensional RCS cuts or surface contours in direction cosine space
- $\theta$  or  $\phi$  incident polarization
- Cross polarized RCS can be computed
- Approximate diffuse RCS component can be computed
- Open code architecture allows the user to tailor the code to specific needs
- Help functions and error checking are included for all windows
- Several model files are included
- A user's manual with theory, references, and examples is available

## THE POFACETS GRAPHICAL USER INTERFACE

*POFACETS* approximates scattering objects by arrays of triangles (facets) and uses superposition is used to compute the total RCS of the object. The GUI consists of three modules: Design Model, Calculate Monostatic RCS, and Calculate Bistatic RCS as shown in Figure 1. The program allows creation of a model comprised of triangular facets with options for approximating the roughness of the surface. It also calculates the monostatic or bistatic radar cross sections of designed models given certain computational parameters.

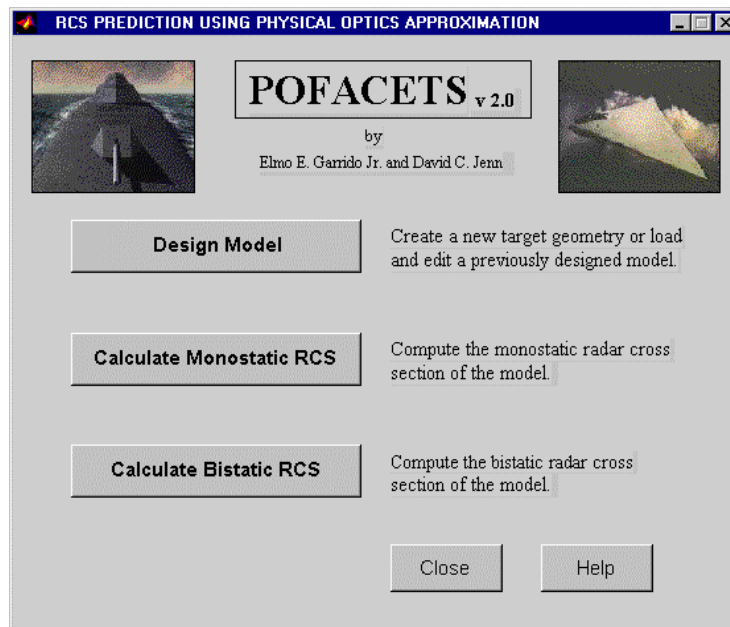


Figure 1. POFACETS main GUI.

## Designing and Editing a Model

The *Design Model* module provides a convenient way of modeling a complex object or to load and edit or scale a previously designed and saved model. The geometry of the model is defined using two sets of data: *coordinates.mat* and *facet.mat*. The first data set defines the  $x,y,z$  coordinates of the vertices. The second set specifies the nodes of the component triangular facets and their illumination and resistivity characteristics. Examples of the two files are shown in Figure 2.

Clicking the Design Model button displays the Design Model Coordinates GUI where the *File menu* may be used to choose between creating a new model or editing an existing one. To edit an existing model, its data files are first retrieved and then displayed so that editing or scaling can be performed. Help windows and messages guide the user throughout the use of this GUI.

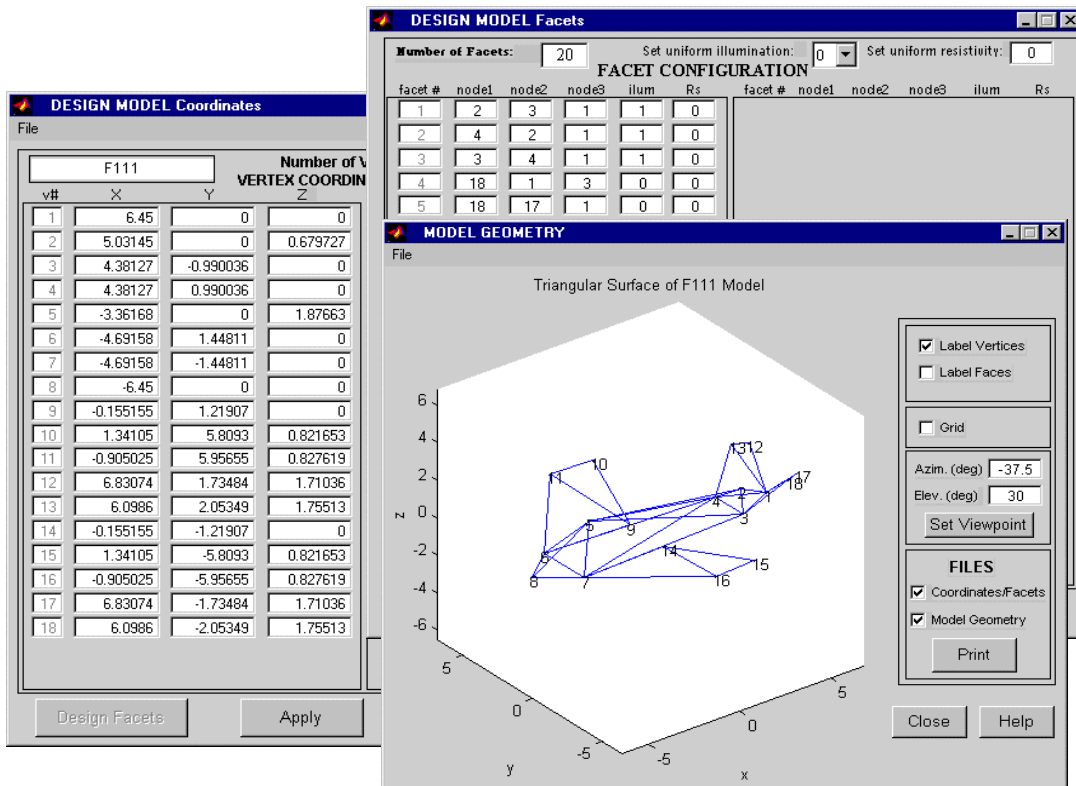


Figure 2. A display of a V-tail aircraft model using the design model GUI.

## Calculating the RCS

The *Calculate Monostatic RCS* and *Calculate Bistatic RCS* modules compute the total radar cross section of the model. An example of one of the GUI windows is shown in Figure 3. A  $\theta$  or  $\phi$  cut is generated when the start and stop values one of the variables

are the same. A contour plot in direction cosine space ( $u = \sin\theta \cos\phi$  and  $v = \sin\theta \sin\phi$ ) is generated when both of the variables take on a range of values. Examples of RCS plots are shown in Figures 4 and 5. RCS-theta is  $\sigma_{\theta\theta}$  ( $\theta$  polarized incident wave;  $\theta$  polarized receiver). This is the co-polarized component when the incident wave is  $\theta$  polarized. RCS-phi is  $\sigma_{\phi\theta}$  ( $\theta$  polarized incident wave;  $\phi$  polarized receiver). The latter is the cross-polarized component, which in Figure 6, happens to be at a level below the specified threshold in the code. The user can change the contour levels and thresholds if desired.

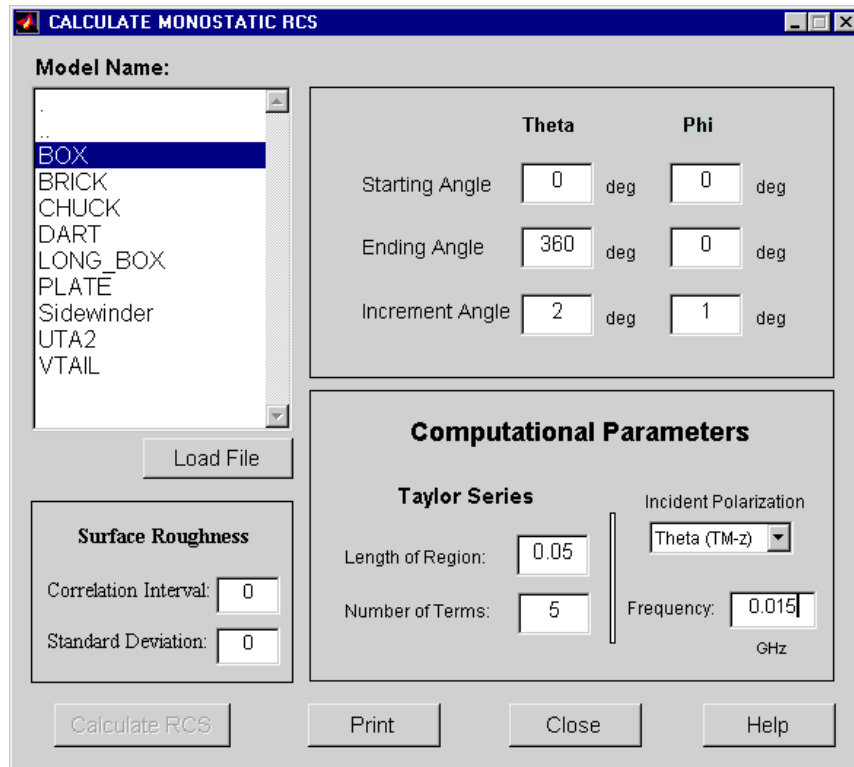


Figure 3. The Calculate Monostatic RCS GUI for a smooth PEC box.

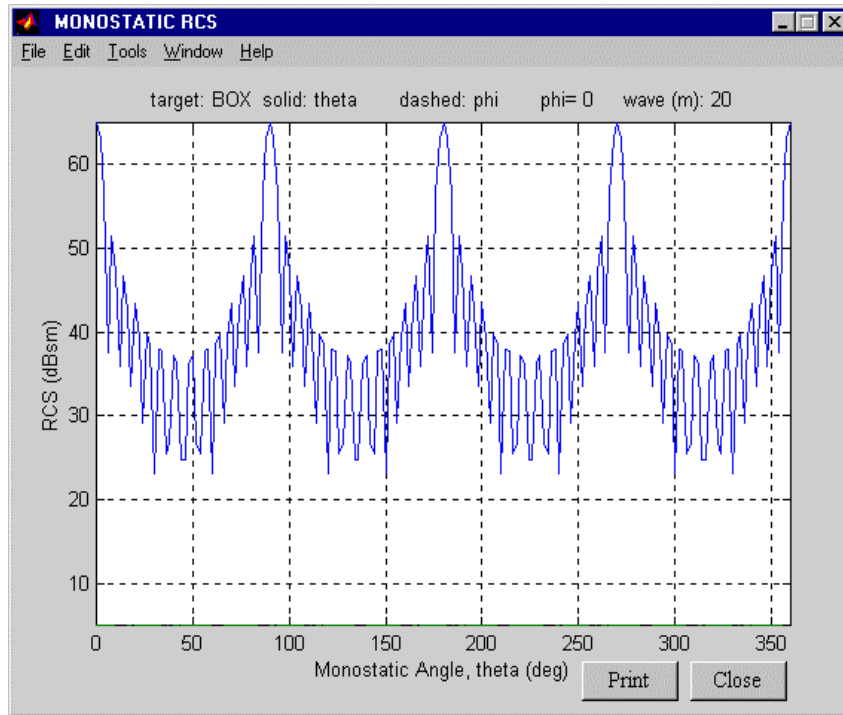


Figure 4. Example of a pattern cut for the monostatic RCS of smooth PEC box.

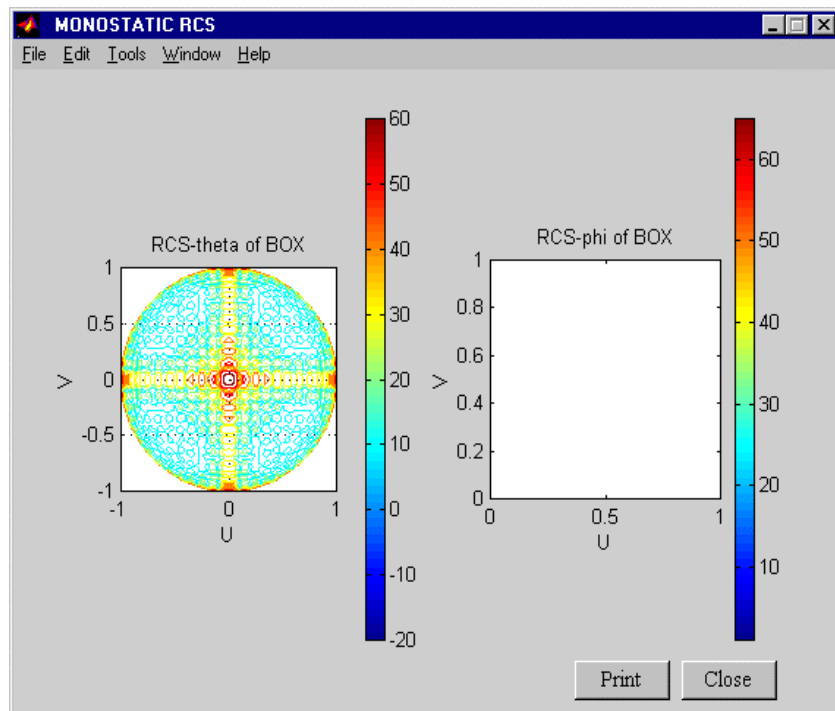


Figure 5. Example of a RCS contour plot for a smooth PEC box.

## **AVAILABILITY**

*POFACETS* is available free of charge and can be downloaded from the ACES web site (<http://aces.ee.olemiss.edu>). It is also available from the author's web site (<http://web.nps.navy.mil/~jenn/>). Although the software runs under MATLAB it is not entirely platform independent. The GUI version available on the web sites has been tailored for Windows. A version without the GUI is provided for use on UNIX and Macintosh platforms.