THESIS PRESENTATION

Development of Code for a Physical Optics Radar Cross Section Prediction and Analysis Application (POFACETS 3.0)

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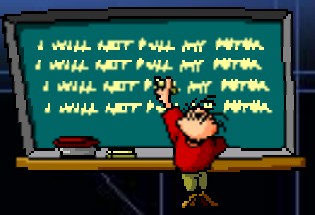
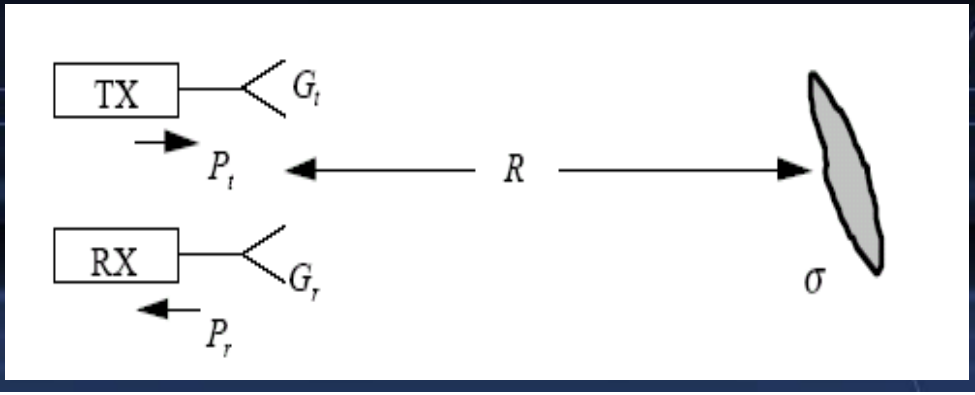
POFACETS 3.0

- PRESENTATION OVERVIEW
  - RADAR CROSS SECTION BASICS
  - THESIS GOALS
  - POFACETS OVERVIEW
  - NEW FUNCTIONALITIES
  - NEW COMPUTATIONAL CAPABILITIES
  - CONCLUSIONS
  - FURTHER IMPROVEMENTS

POFACETS 3.0



- RADAR CROSS SECTION BASICS
  - Radar Cross Section (RCS) represents the magnitude of the echo signal returned to a radar by the target
  - Formal definition: $$\sigma \equiv \frac{\text{Power reflected to receiver per unit solid angle}}{\text{Incident power density}/4\pi}$$
  - Range Independent. Depends on Frequency, Polarization & Target Aspect
  - Units of m^2 and dBsm



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- RCS BASICS
  - Why is RCS important?
    - Signal received by radar is proportional to RCS of target
    - Required Effective Radiated Power for Self-Protection Jamming also proportional to RCS
  - RCS reduction important aspect of signature reduction in military platforms (e.g. F-117, B-2, Visby corvette)

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- THESIS GOALS
  - RCS importance makes necessary to predict RCS of targets and evaluate effects of shaping and materials
  - Existing RCS prediction software packages are usually expensive, have high requirements on computer resources and feature long run–times
  - Need for an inexpensive software that will run on standard PCs and produce results in seconds or minutes for standard geometrical shapes

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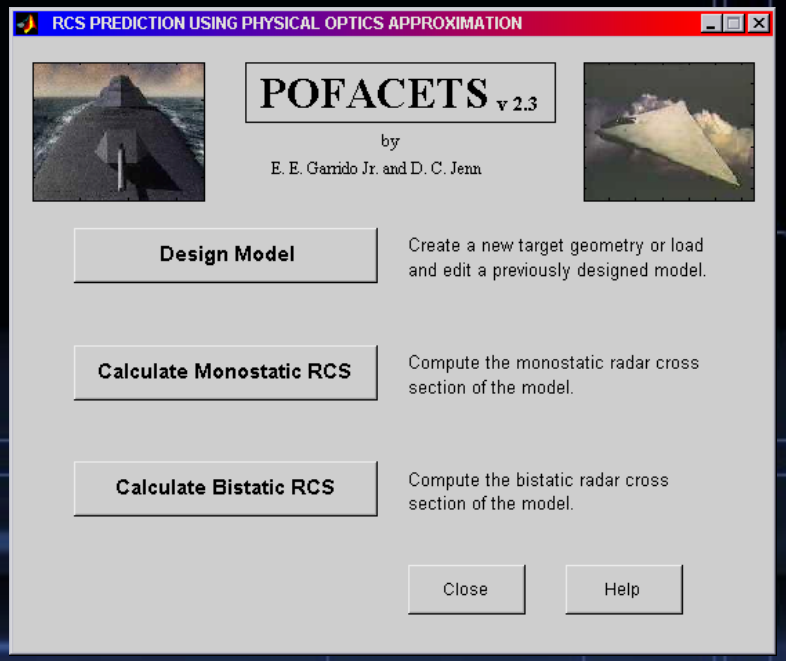
- THESIS GOALS
  - POFACETS 2.3 developed in 2000 by Prof. D. Jenn and Commander E. Garrido allows user to design a model and evaluate its RCS
    - MATLAB compatibility issues
    - Limitations in model design
  - Thesis Goals:
    - Upgrade POFACETS 2.3 version
    - Add new functionalities
    - Add new computational capabilities



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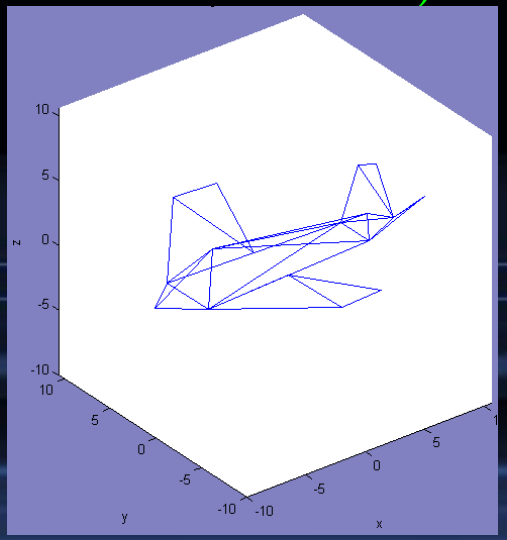
POFACETS 3.0

- POFACETS OVERVIEW
  - Program implements 2 main tasks:
  - Target Model Design
    - Model surfaces defined by use of triangular facets
    - Nodes defined by their x,y,z coordinates
    - Facets defined by three nodes (right hand rule used to define external facet side)



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- POFACETS OVERVIEW
  - RCS Calculations
    - Monostatic and Bistatic Cases
    - Physical Optics method is used to calculate current on illuminated facets. Current is set to zero in non-illuminated facets
    - Radiation integrals and Taylor series used to compute scattered field from each facet. Total scattered field is sum of fields from each facet.
    - RCS is computed as: $$\sigma = 4\pi \frac{\left|\vec{E}_s\right|^2}{\left|\vec{E}_i\right|^2}$$
    - Diffraction, Multiple Reflections, Shadowing, Surface Waves are not included in calculations

POFACETS 3.0

- PRESENTATION OVERVIEW
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  - NEW COMPUTATIONAL CAPABILITIES
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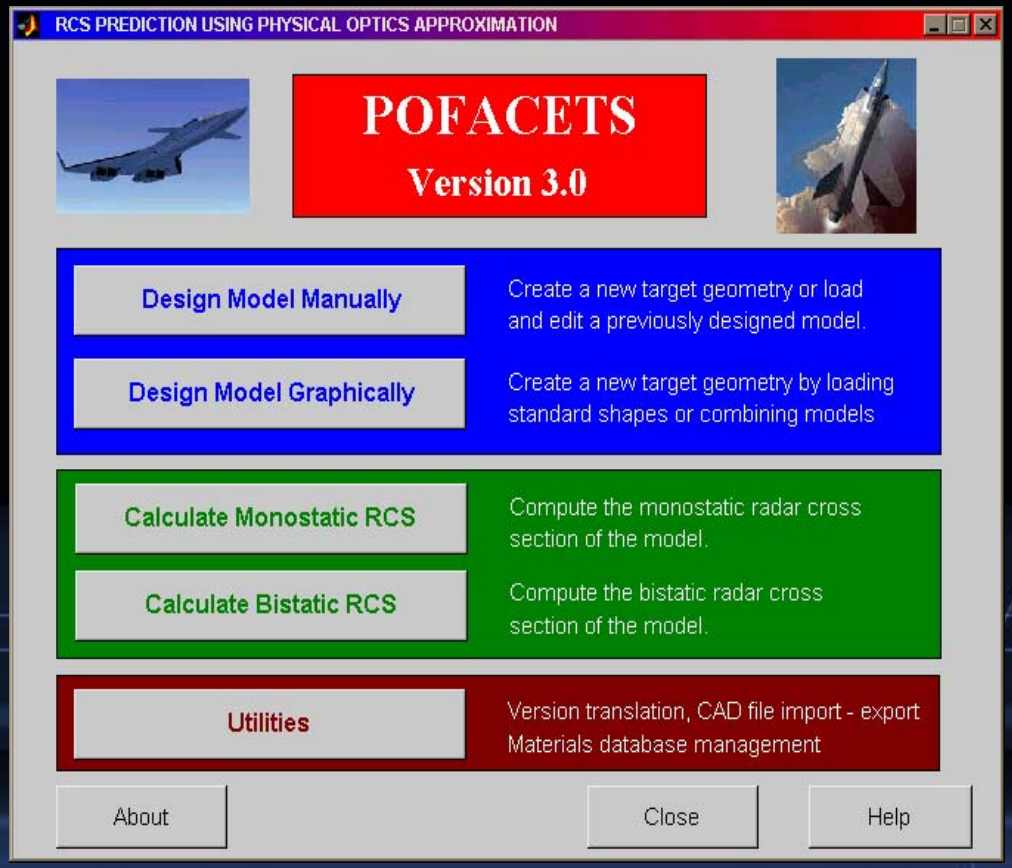
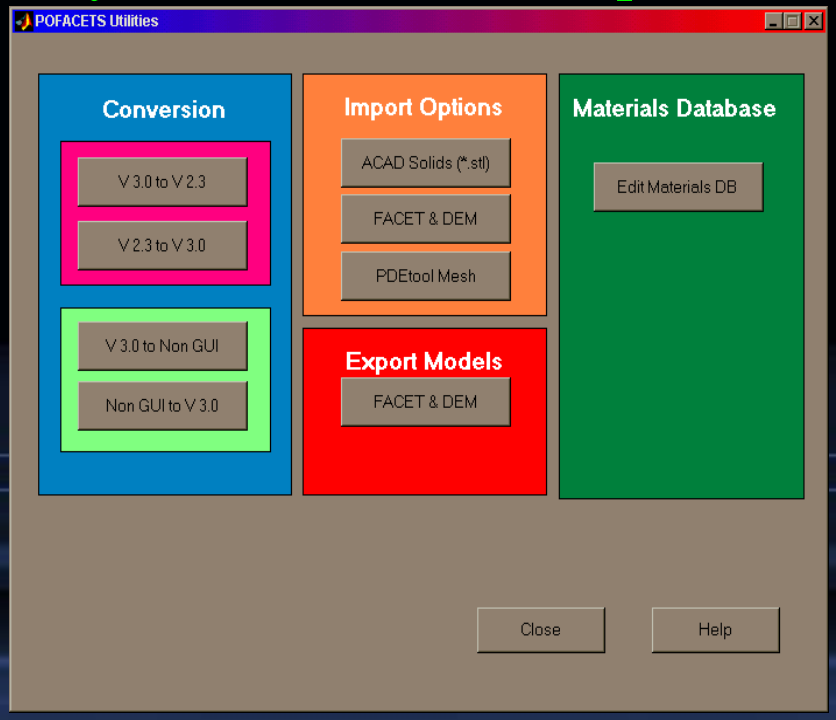
POFACETS 3.0

- NEW FUNCTIONALITIES
  - Upgrade of existing GUIs to MATLAB 6.5
    - Only standard Windows components used



POFACETS 3.0

- NEW FUNCTIONALITIES
  - Upgrade of existing model file database
    - Only one file per model used (previous POFACETS versions used two files for each model)
    - Capability to convert from/to previous versions files



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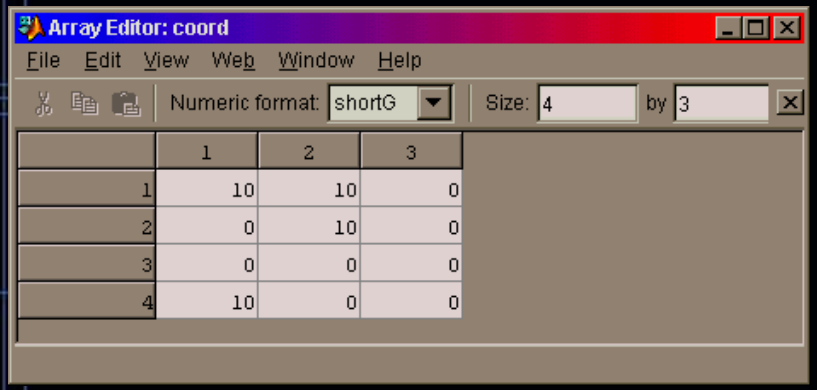
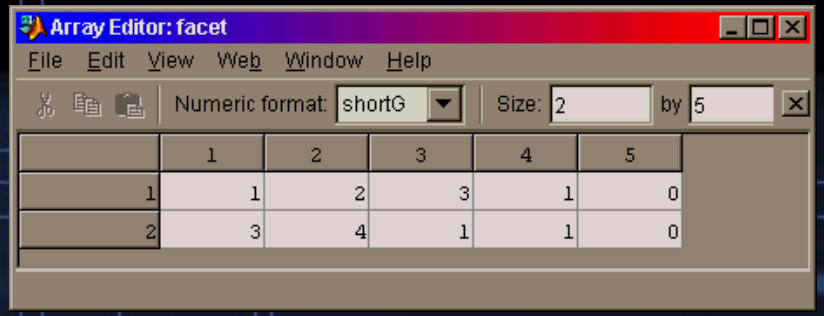
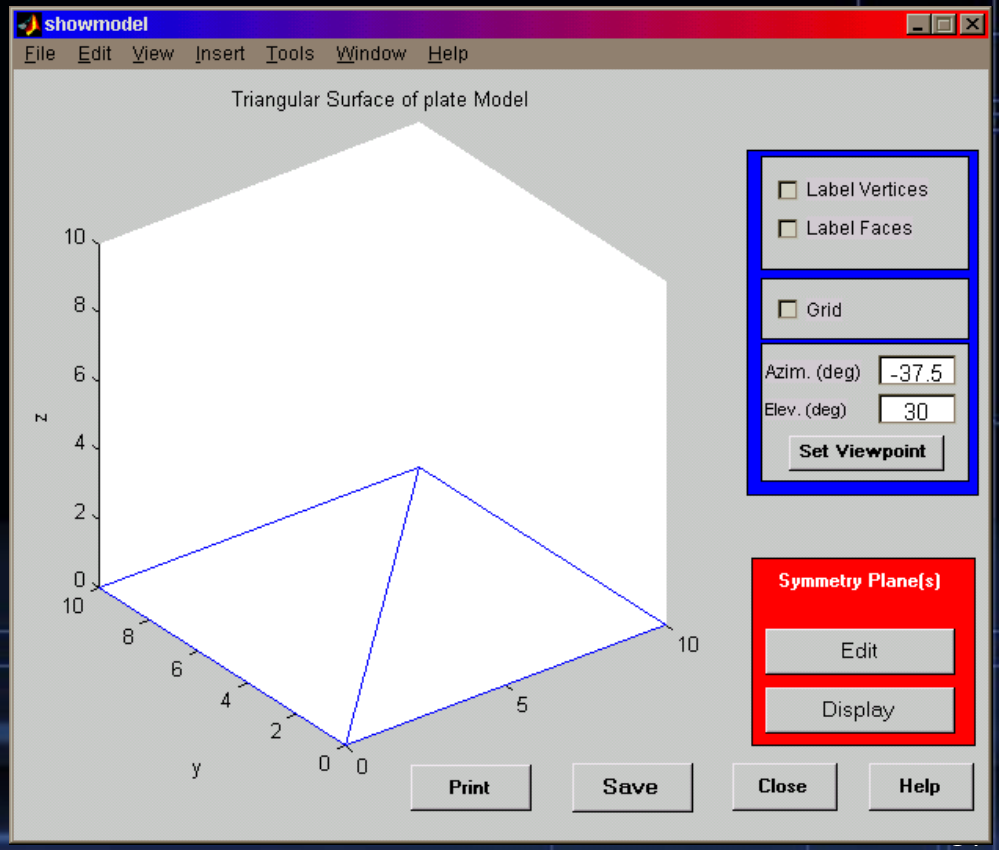
- NEW FUNCTIONALITIES
  - Upgrade of Manual Model Design
    - Unlimited numbers of vertices and facets

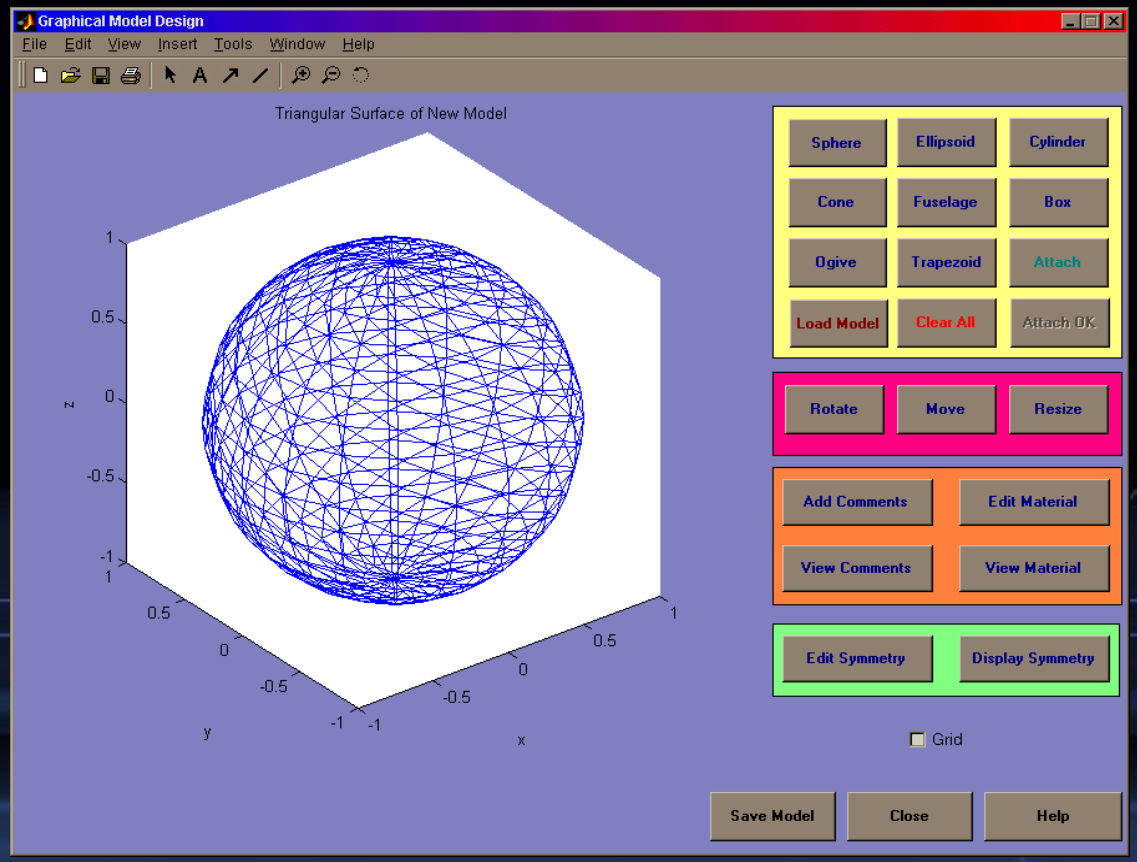






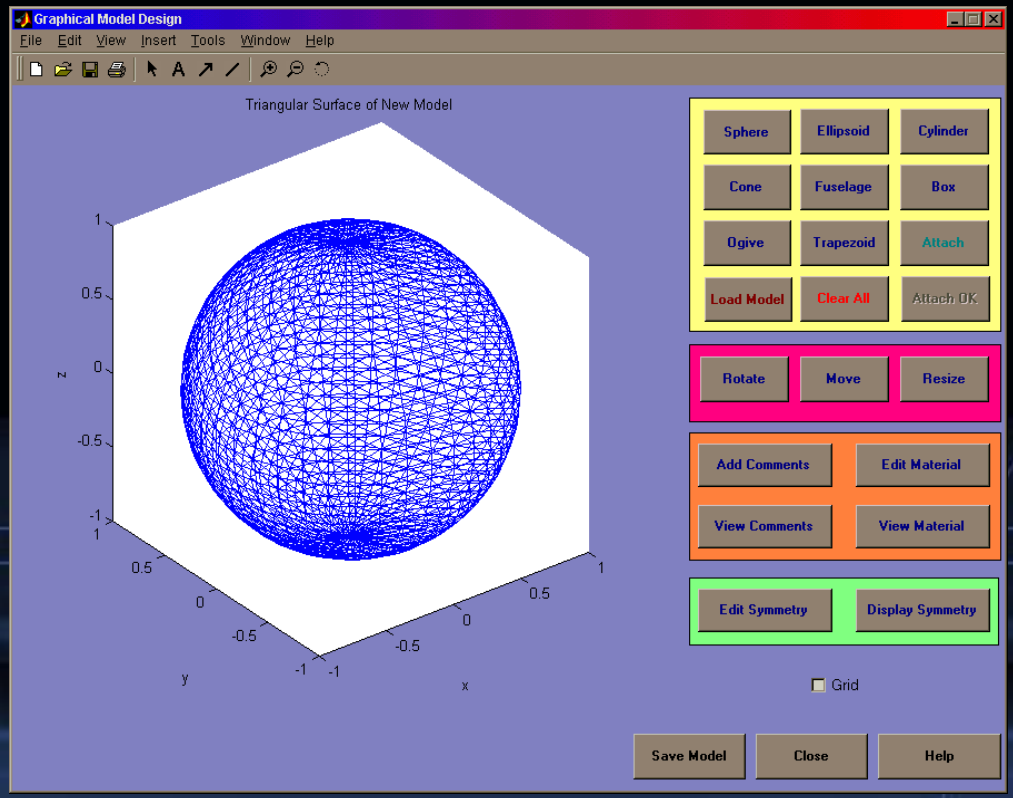
POFACETS 3.0

- NEW FUNCTIONALITIES
  - Graphical Model Design
    - Standard geometrical shapes implemented



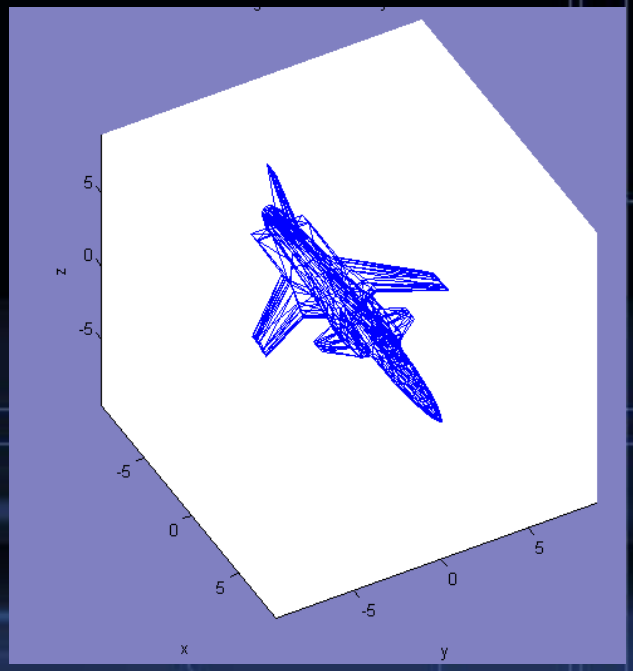
POFACETS 3.0

- NEW FUNCTIONALITIES
  - Graphical Model Design
    - Models can be resized, moved or rotated
    - User selectable number of facets for curved surfaces



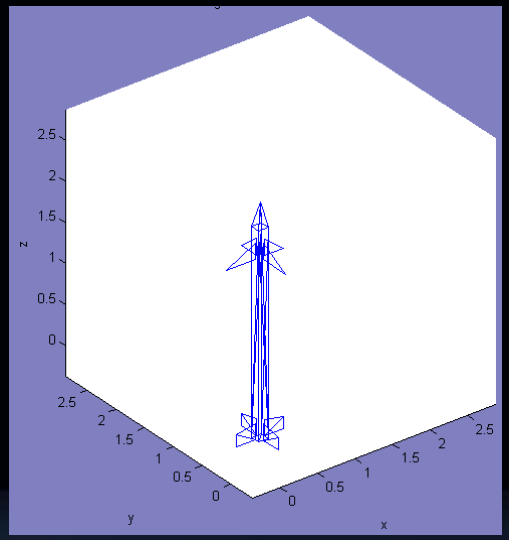
POFACETS 3.0

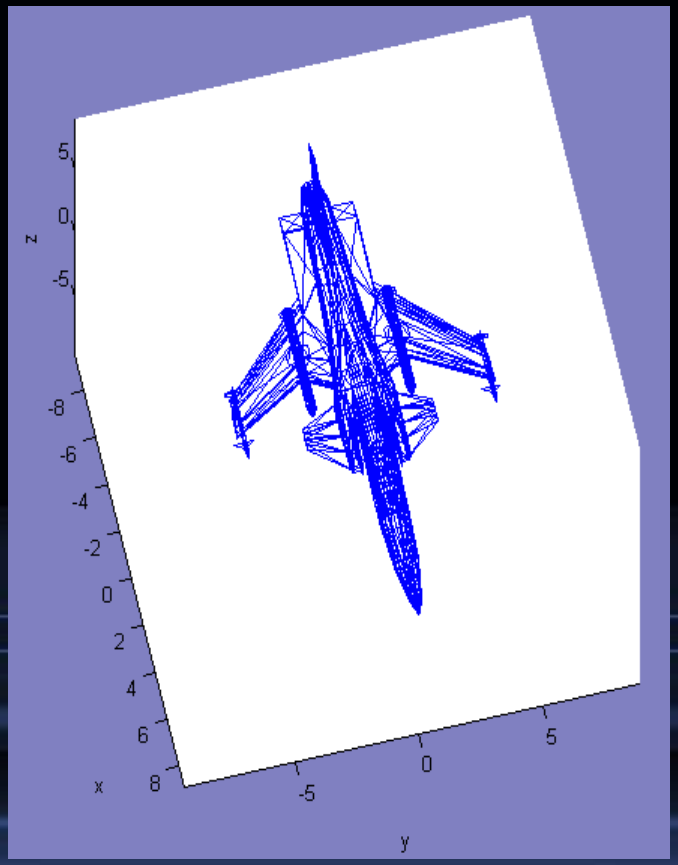
- NEW FUNCTIONALITIES
  - Import/Export of models from/to other CAD & RCS software
    - Import from CIFER, ACADS, AUTOCAD (stereolithographic format only), MATLAB's PDETOOL
    - Export to CIFER and ACADS

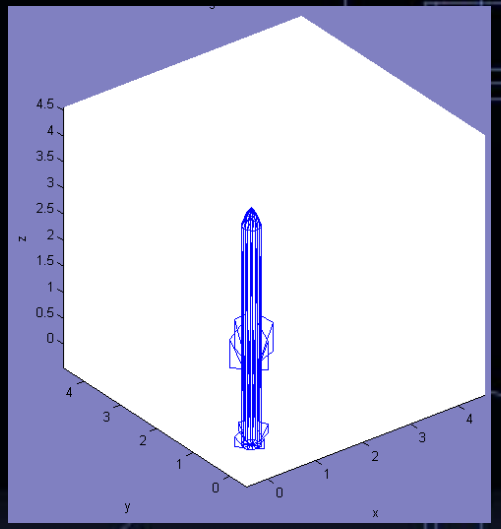


POFACETS 3.0

- NEW FUNCTIONALITIES
  - Combination of existing models
    - Allows the design of very complex models

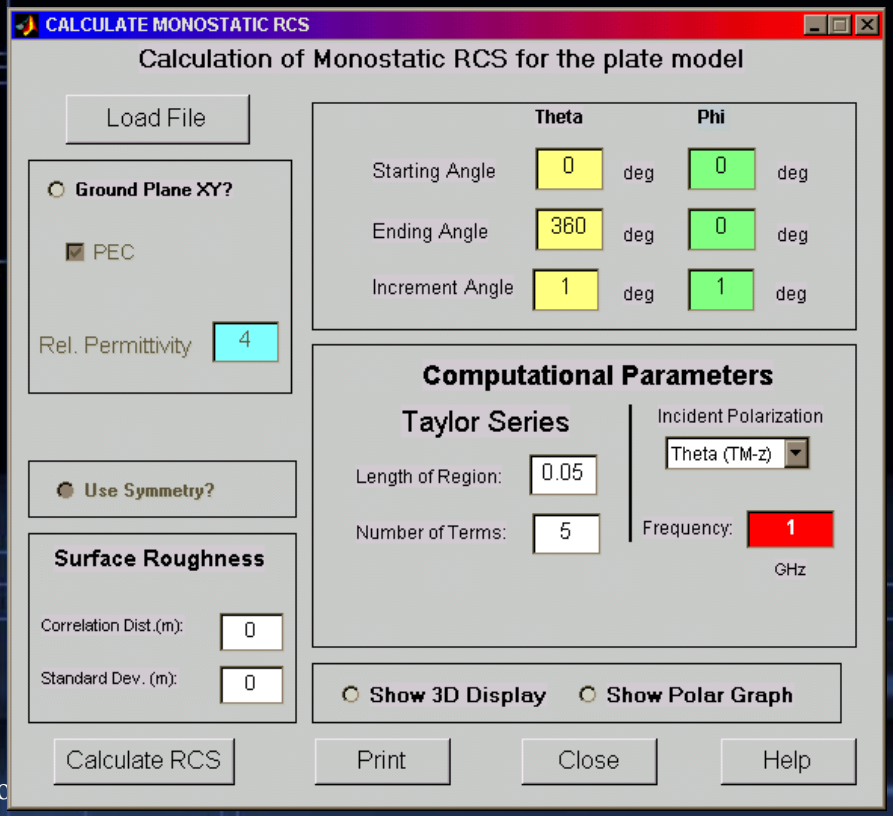


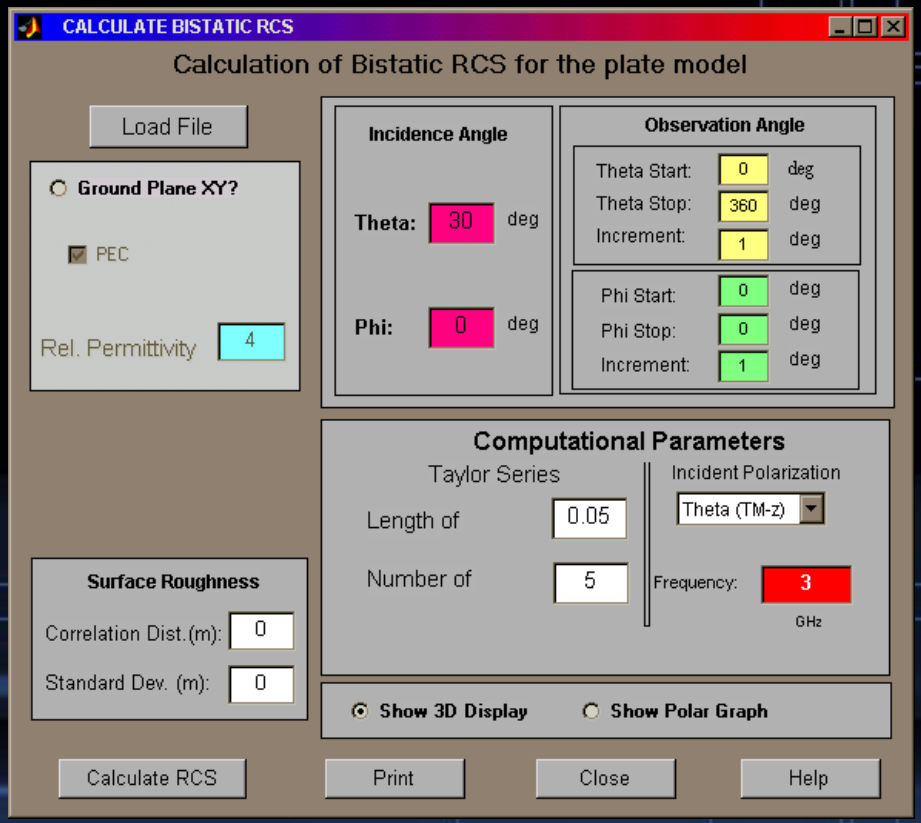




POFACETS 3.0

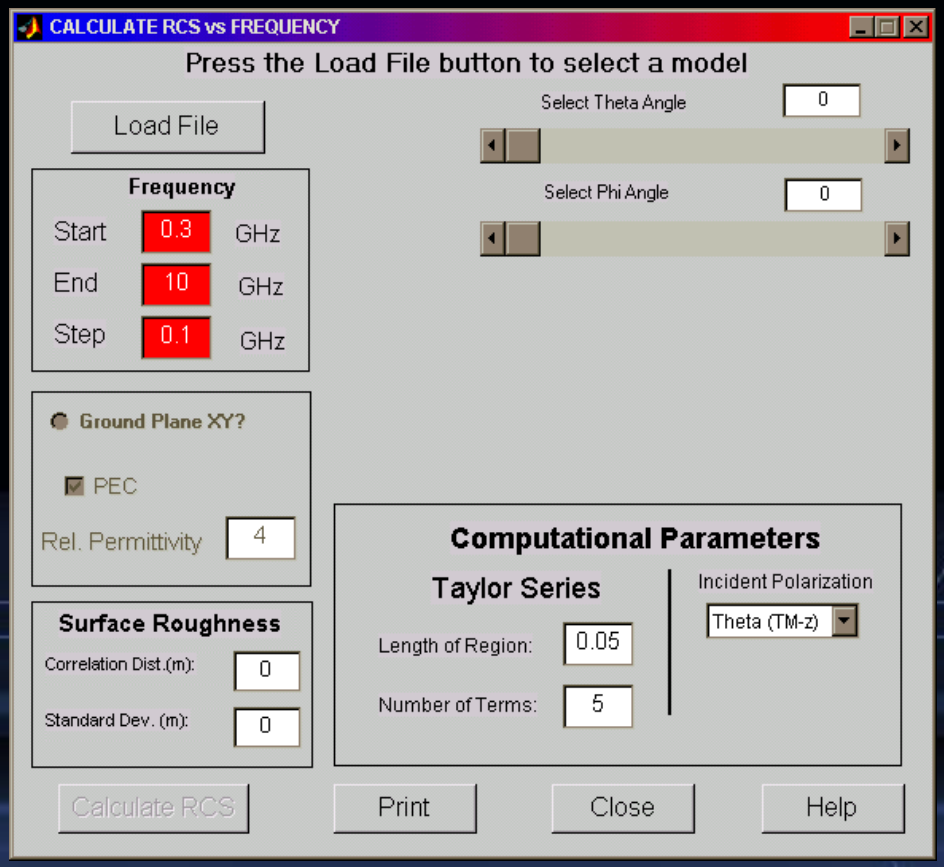
- NEW FUNCTIONALITIES
  - RCS computations vs Angle or vs Frequency
    - Monostatic and Bistatic cases implemented





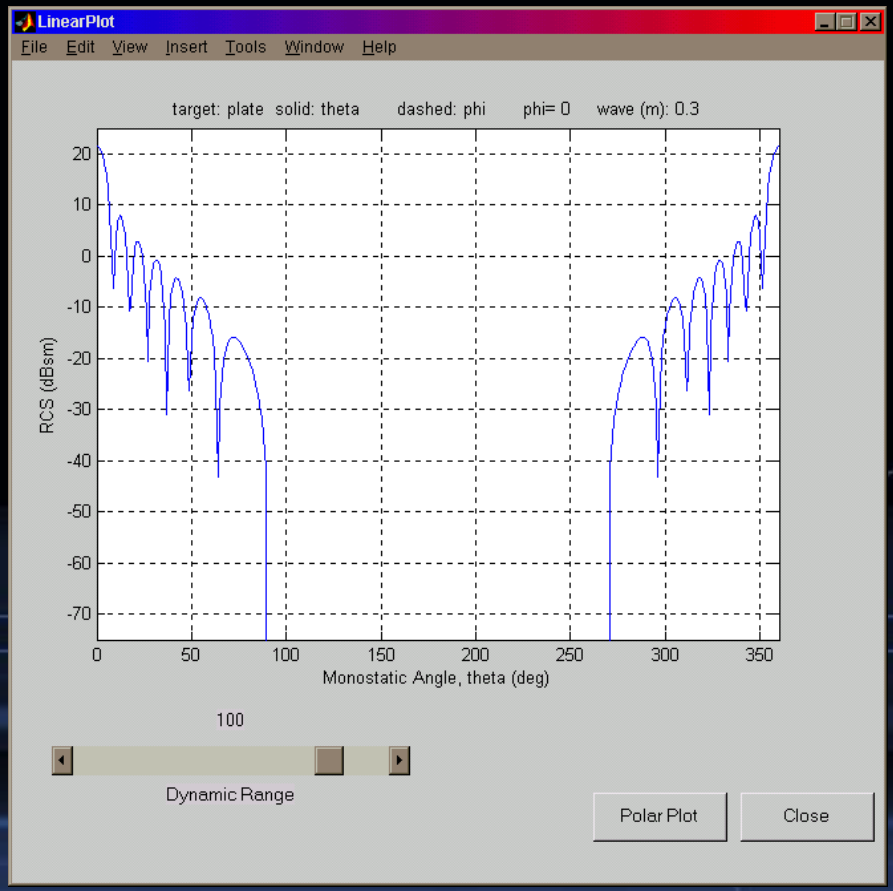
POFACETS 3.0

- NEW FUNCTIONALITIES
  - RCS computations vs Angle or vs Frequency
    - All user input is checked for errors



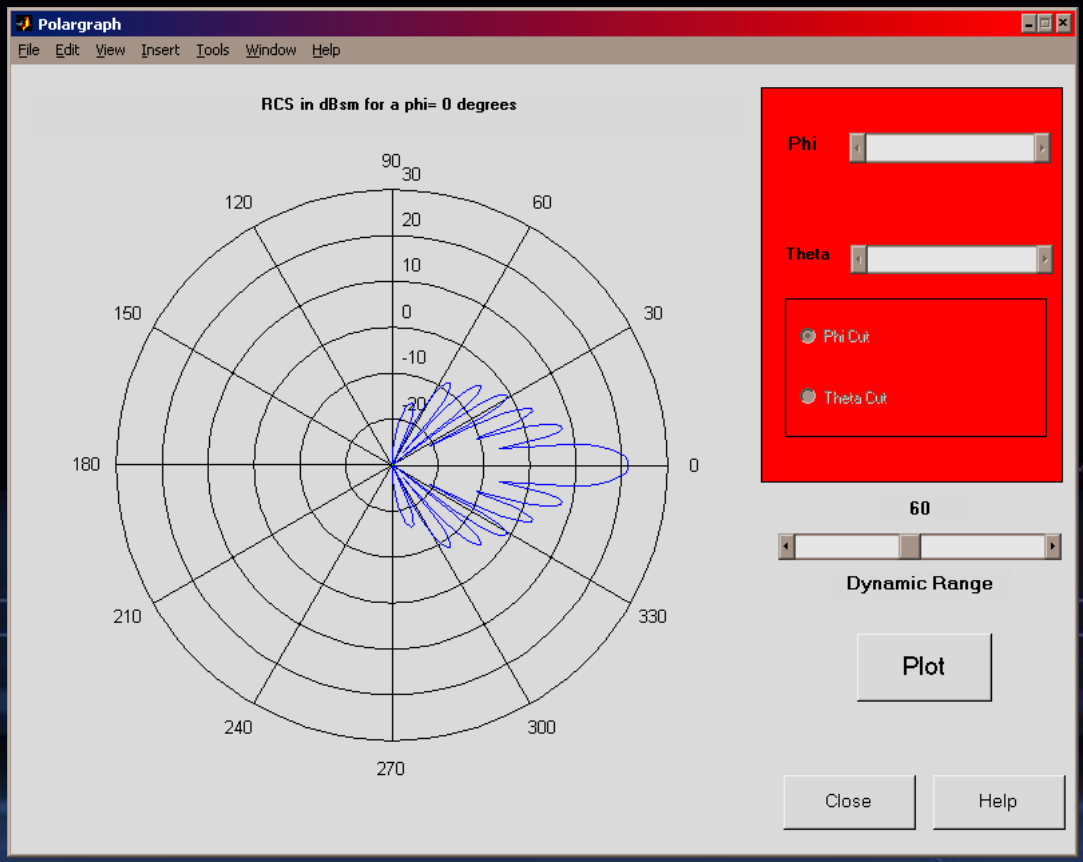
POFACETS 3.0

- NEW FUNCTIONALITIES
  - RCS results display options
    - Standard RCS plot versus angle (1 m by 1 m sphere at 1 GHz)



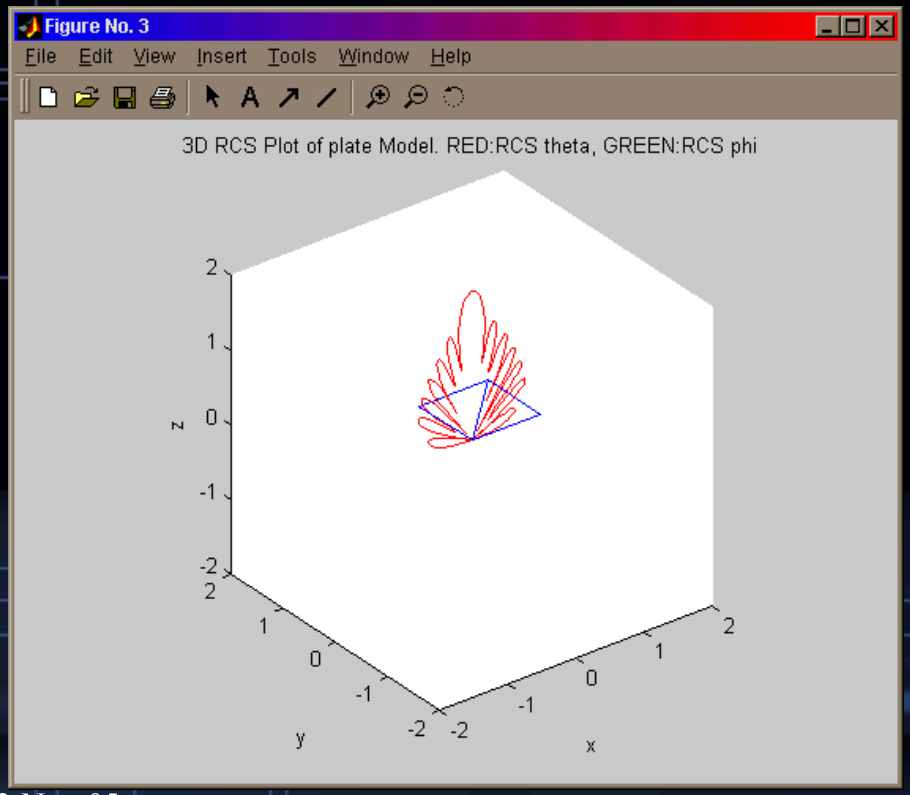
POFACETS 3.0

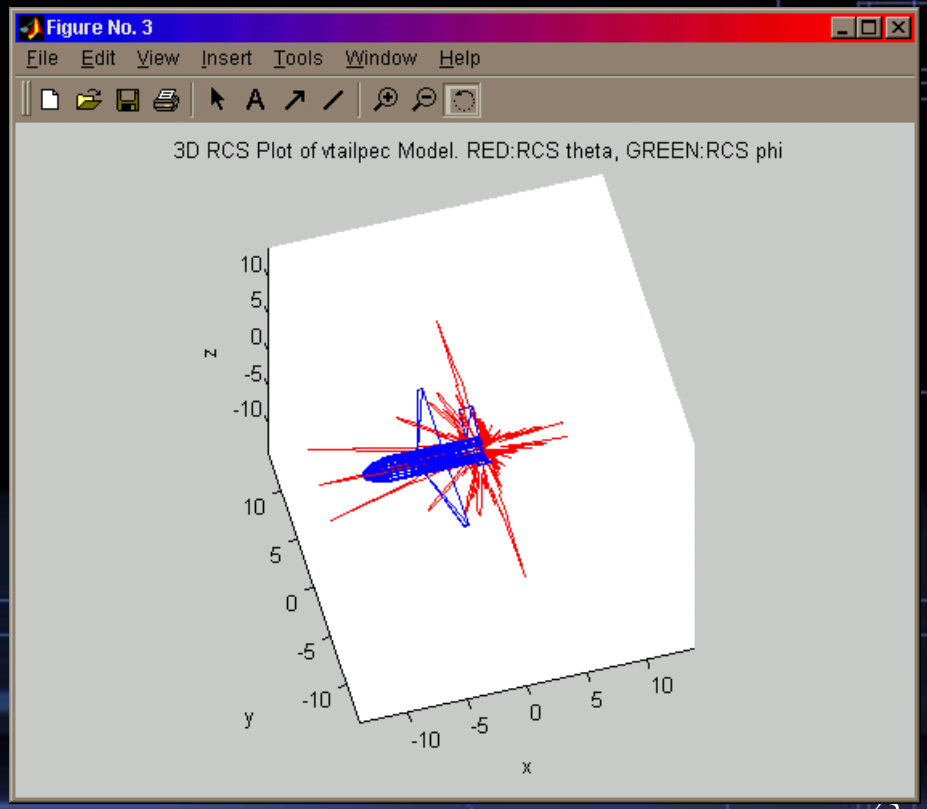
- NEW FUNCTIONALITIES
  - RCS results display options
    - Polar Plot



POFACETS 3.0

- NEW FUNCTIONALITIES
  - RCS results display options
    - Combination Plot





POFACETS 3.0

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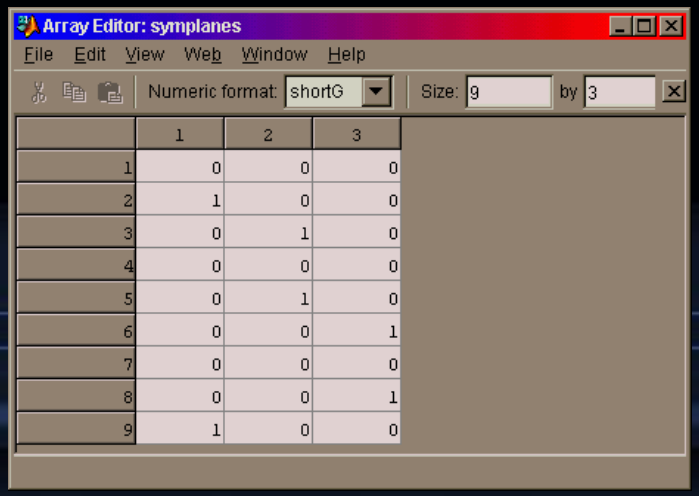
POFACETS 3.0

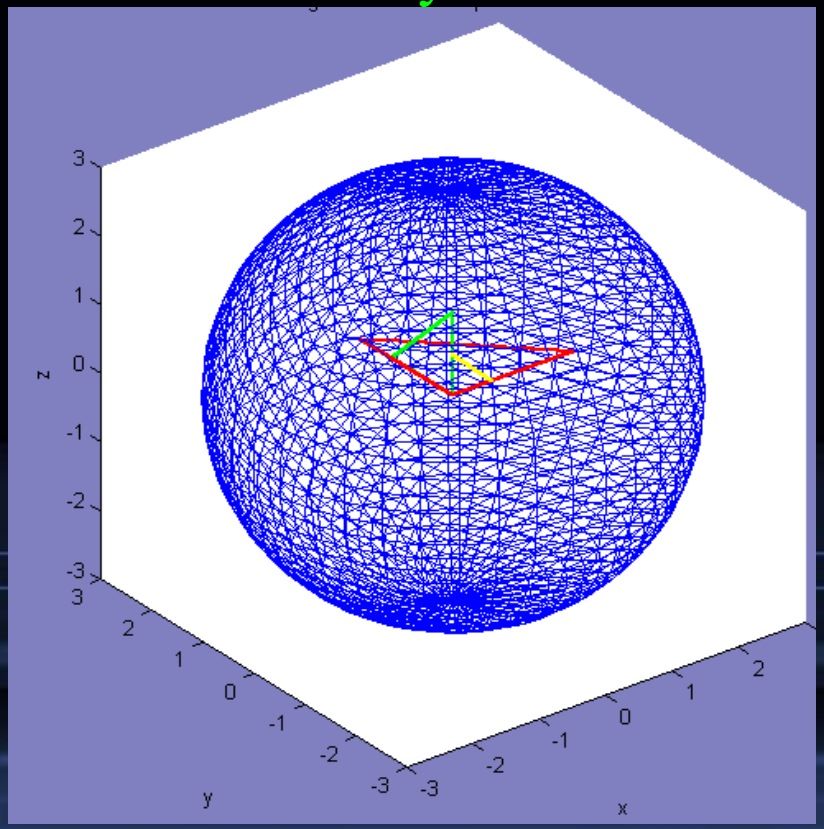
- NEW CAPABILITIES
  - Exploitation of symmetry planes
    - Monostatic RCS is the same for symmetrical angles of incidence
    - Can be exploited to expedite RCS computation time
    - Up to three symmetry planes can be defined



	1	2	3
1	0	0	0
2	1	0	0
3	0	1	0
4	0	0	0
5	0	1	0
6	0	0	1
7	0	0	0
8	0	0	1
9	1	0	0

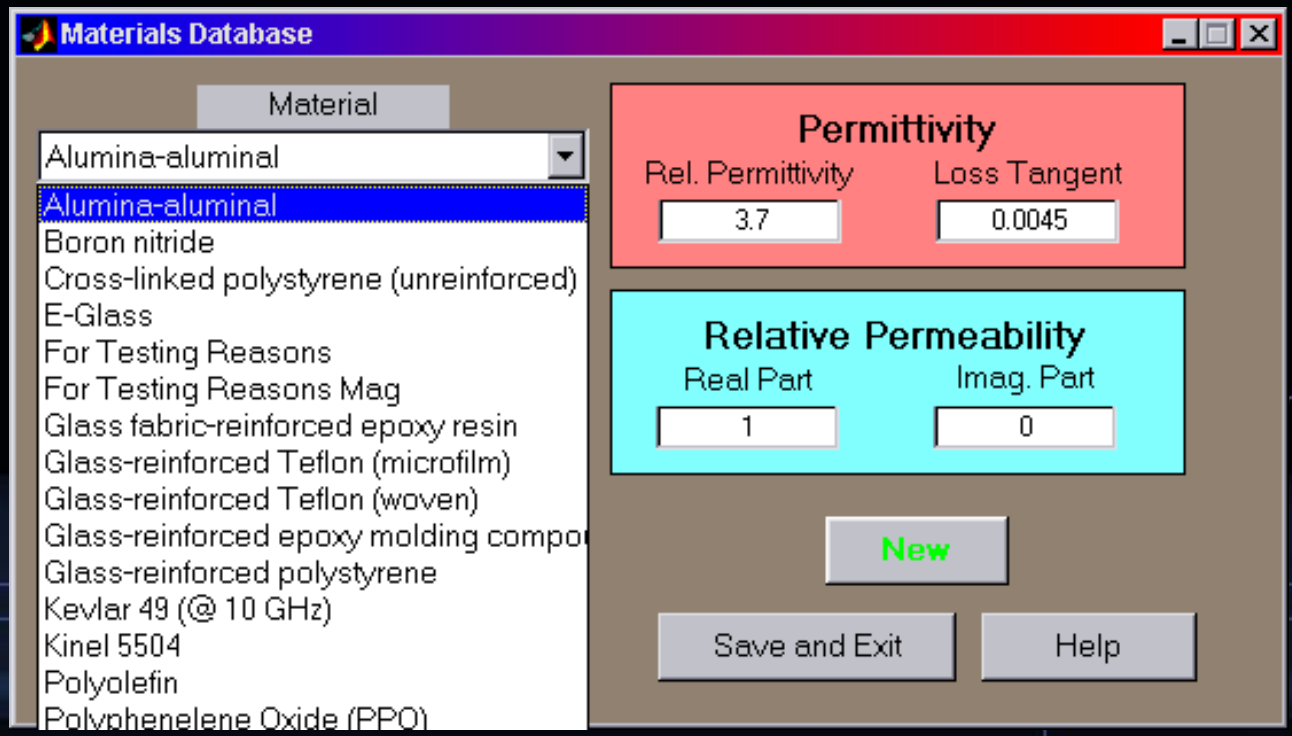
POFACETS 3.0

- NEW CAPABILITIES
  - Exploitation of symmetry planes
    - Program execution for the RCS calculation of this sphere was reduced by 73%



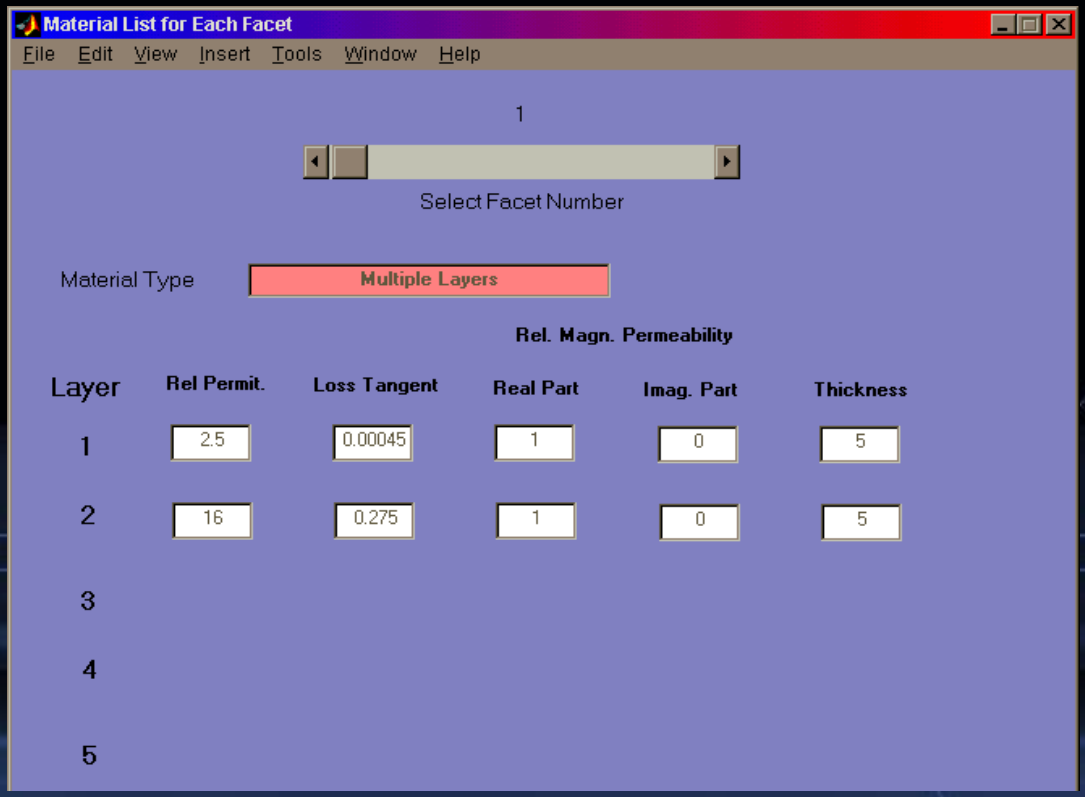
POFACETS 3.0

- NEW CAPABILITIES
  - Effects of Materials on RCS
    - A user-updateable database of materials was created



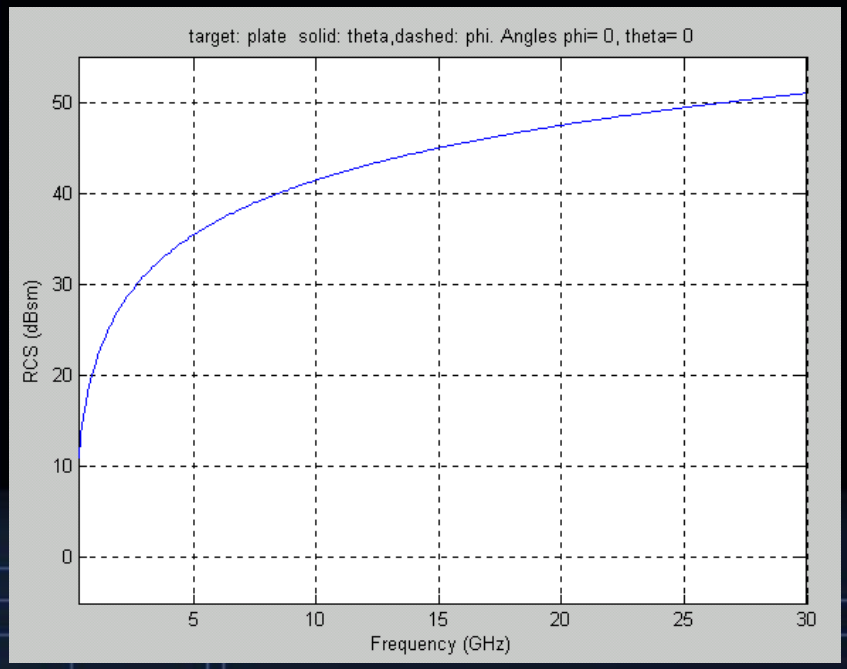
POFACETS 3.0

- NEW CAPABILITIES
  - Effects of Materials on RCS
    - Materials can be applied to each facet of a model in one or more layers

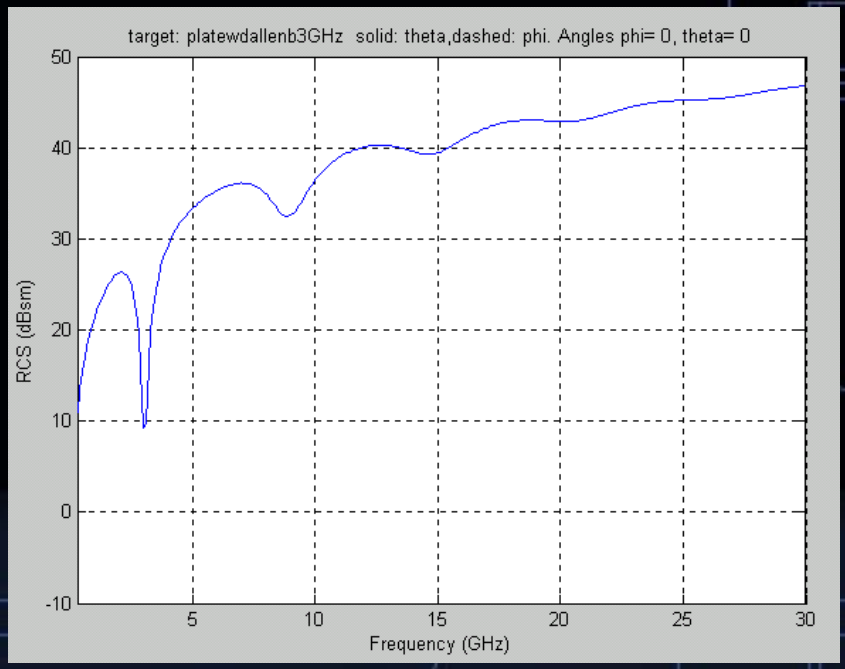


POFACETS 3.0

- NEW CAPABILITIES
  - Effects of Materials on RCS
    - Example of a 1 m by 1 m plate (normal incidence)



Perfect Electric Conductor (PEC)



6.25 mm Composite Layer on PEC (ε_r=16)

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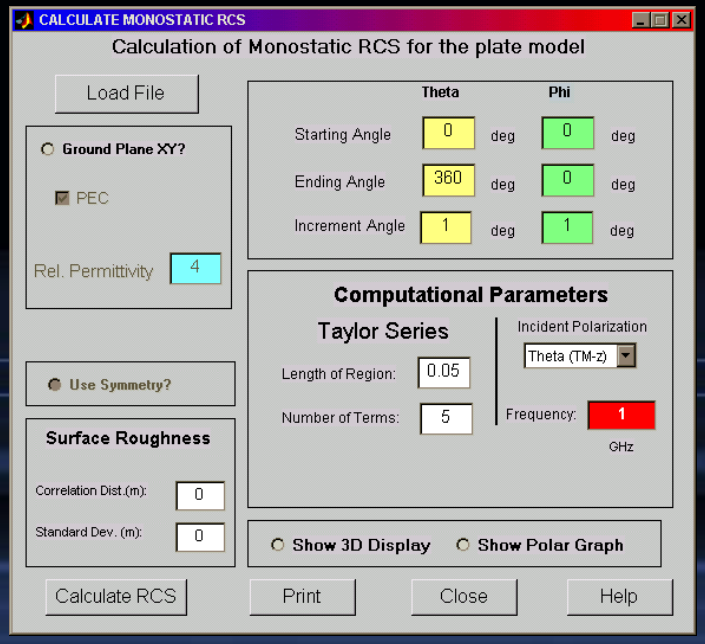
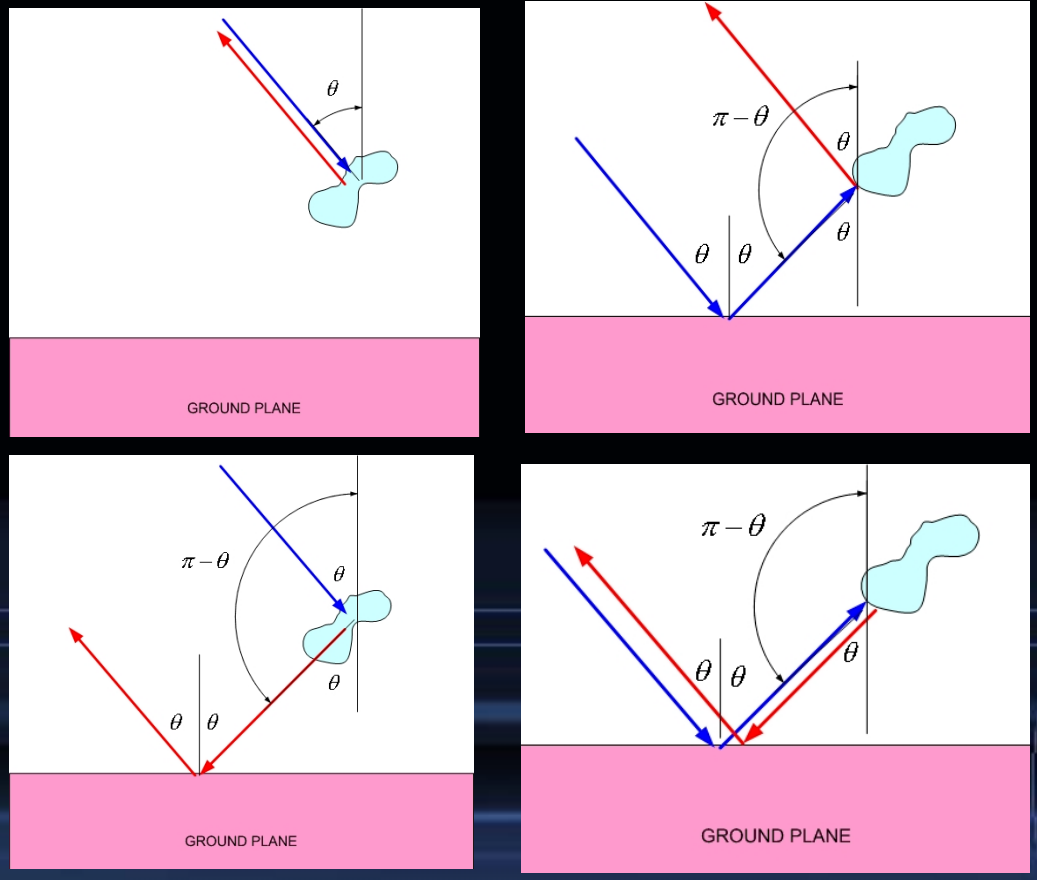
- NEW CAPABILITIES
  - Effects of Infinite Ground Plane
    - Ground effects must be considered for ground targets, naval targets and low–flying airborne targets
    - Option to include or exclude ground effects
    - Ground characteristics can be specified



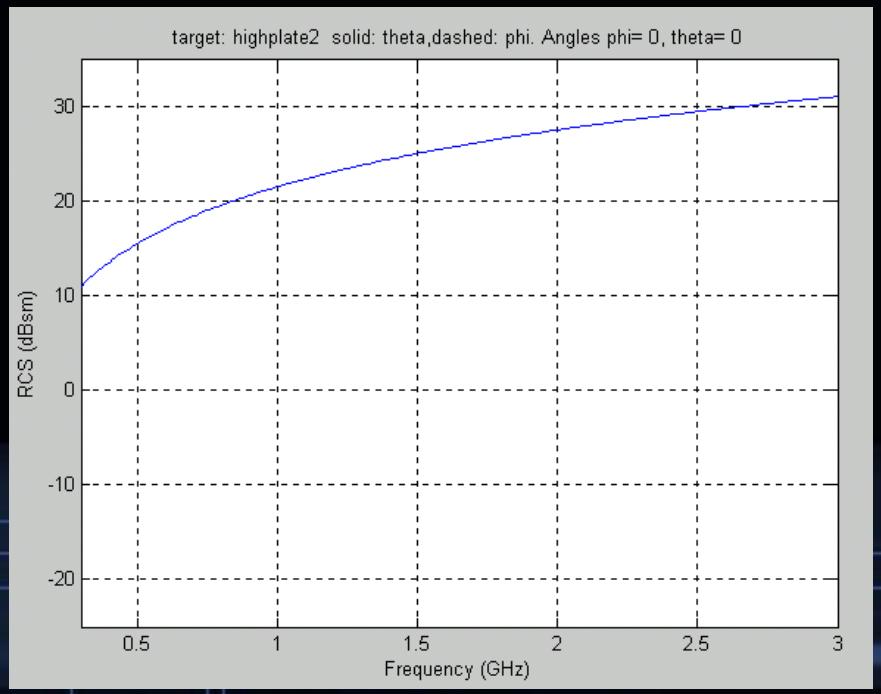
POFACETS 3.0

- NEW CAPABILITIES
  - Effects of Infinite Ground Plane
    - Four cases are taken into account

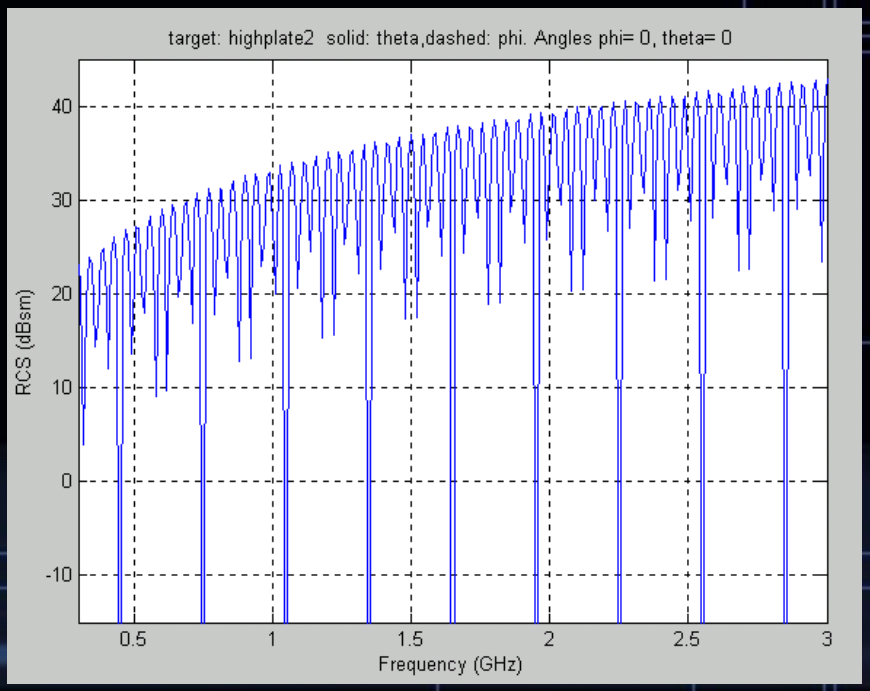


POFACETS 3.0

- NEW CAPABILITIES
  - Effects of Infinite Ground Plane
    - 1 m by 1 m plate 9.25 m above PEC ground, normal incidence



Ground Effects Excluded



Ground Effect Included

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POFACETS 3.0

- CONCLUSIONS
  - User friendly program
    - Use of standard GUI components
    - Minimization of errors in user input
  - Complex models can be handled
    - Combination of models
    - Model Import/Export from/to CAD software
  - New computational capabilities had minimal effect on execution time. Exploitation of symmetry planes can drastically reduce run–time

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- CONCLUSIONS
  - Added Versatility
    - RCS versus Angle and versus Frequency
    - Options for displaying RCS results
    - RCS prediction and RCS analysis can be performed
  - Closer to "real–world" RCS problems
    - Use of ground plane
    - Use of materilas
  - POFACETS 3.0 can be used as an instructional tool and as a "first –cut" approach to RCS prediction and analysis

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POFACETS 3.0

- FURTHER IMPROVEMENTS
  - Capability to import models from:
    - Other RCS software
    - Other CAD software, especially AUTOCAD
  - Overcome Physical Optics limitations by including other scattering mechanisms:
    - Diffraction
    - Double Reflections
    - Surface Waves
    - Shadowing

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Questions ?