

A Simple Tool for Design and Analysis of Multiple-Reflector Antennas in a Multi-Disciplinary Environment



Tom Cwik, D. Katz, A. Borgioli, C. Fu, W. Imbriale, V. Jamnejad, P. Springer*

Jet Propulsion Laboratory

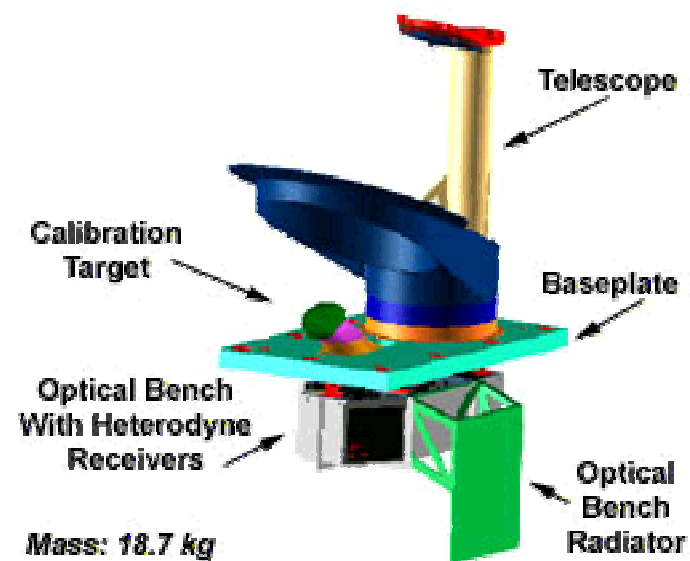
**University of California at Santa Barbara*

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MOTIVATION

- * For the foreseeable future, JPL is proposing, designing and building microwave and millimeter wave instruments
 - Beamwidth, sidelobes
 - Pointing
 - Gain
- * Instruments meet design criteria obtained from science mission goals
 - Fluctuating thermal (deep space and earth orbiting)
 - Mechanical due to thermal load
- * Design criteria are functions of space environment
 - Fluctuating thermal (deep space and earth orbiting)
 - Mechanical due to thermal load
- * Software design tools and environments maturing and becoming integrated



MIRO Instrument (JPL)
www.miro.jpl.nasa.gov

Current Design Tools and Process

* Disciplines/Tools:

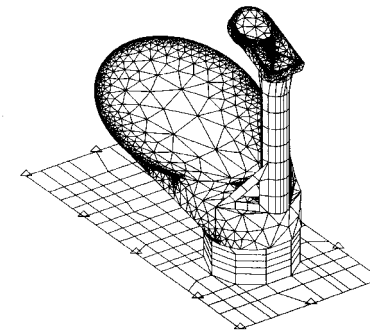
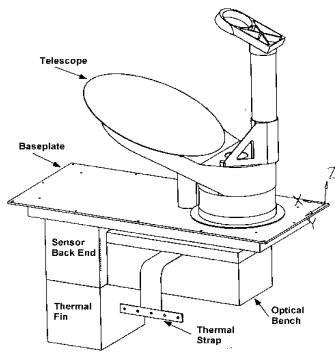
- CAD
 - Pro/Engineer*
 - CV*
 - IDEAS*
- Meshing
 - FEMAP*
- Structural
 - NASTRAN*
- Thermal
 - TRASYS*
 - SINDA*
- Antenna/Optics
 - MACOS*
 - POPO*

* Each tool is used by an analyst/designer, who works in one discipline

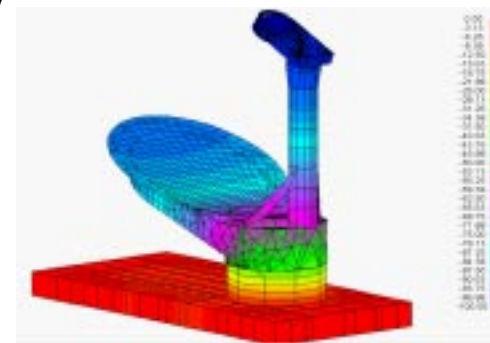
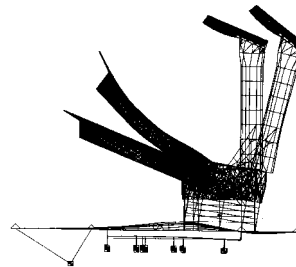
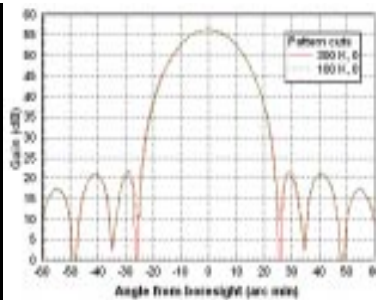
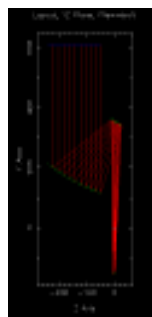
* When one analyst completes a model, it is passed to the next

* This work focuses on antenna electromagnetic design, and how it is connected to the other disciplines through a common digital geometry

MODTool (Millimeter-wave Optics Design Tool)



Common Geometry



MODTool Goals


- * Develop new code only if necessary
 - Try to use/reuse:
 - Commercial applications*
 - Previously developed JPL applications*
 - Try to develop code so that it can be used for other future projects
 - Use standard packages/tools*
 - Always think beyond this project*
- * Ensure users on multiple platforms can easily use tool (client-server)
 - Client written in Tcl/Tk
 - Freely available over the web*
 - Available for Unix, PC, Mac*
 - Server also written in Tcl/Tk, but on a specific type of machine
 - Uses compiled C code using Unix libraries for user authentication*

COMMON GEOMETRY

- * Much of the underlying effort was spent in defining a common geometry that can be used by structures, thermal and electromagnetic design
 - Thermal: 100s of mesh points (degrees of freedom)
 - Structures: 1000s of mesh points
 - Electromagnetic: 10,000s of mesh points

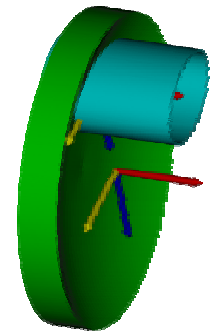
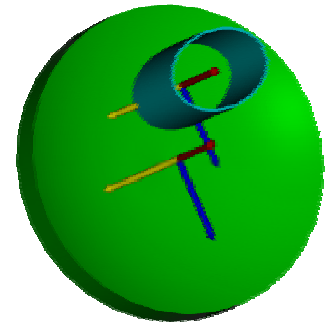
- * A common analytic description of the antenna surfaces was defined, and any distortions produced from structural/thermal analysis codes were interpolated and added to analytic description
 - Struts, backup structure, spacecraft structures models used in structural/thermal analysis; data stripped for use with electromagnetic analysis

Interface and Functionality

- * Designer starts client code on designer's machine (**The Application Interface**)
 - Designer must enter username and password
 - Designer must select existing or new project on which to work
 - * Client opens socket to server (**Automatic and Invisible**)
 - Server validates username and password
 - Server creates local work directory
 - * Designer may then work in one of six modes:
 - Design
 - Prescription
 - Geometric Optics Analysis
 - Physical Optics Analysis
 - Submitting a Mesh
 - Submitting a Load
- |  Interface to thermal and structural design

Design Mode

- * Allows designer to create or modify a design
- * A design is the description of a set of antenna elements
 - Conic sections:
paraboloids, hyperboloids, ellipsoids, flat plates, all cut by an elliptical cutting cylinder
 - Feed location and output coordinate system definitions
- * The elements are shown graphically, and the values which control the elements are shown as a table
 - Either the data in the table or the graphical data may be varied
 - The two displays are linked - changes in one are reflected in the other



Design Mode (Cont'd)

File Edit Mode Help

MOD Tool 1.0.3

	Name	Vx	Vy	Vz	F1 x	F1 y	F1 z
Feed Loc 1	mirr_feed						
Feed Loc 2	src_feed						
Flat 1	mirror6	-140.0	0.0	-251.415	-130.431	-2.92371	-251.415
Ellipse 1	mirror5	-98.1021	-81.7998	-251.415	-126.831	-43.6171	-251.415
Ellipse 2	mirror4	-209.401	43.3384	-251.415	-157.751	33.2160	-251.415
Ellipse 3	mirror3	-272.64	0.0	-327.961	-231.631	0.0	-251.415

Project: MIRD
 Design case: baseline
 Prescription: (none)
 Mode: Design

Working Plane: XY Z = -251.415
 Length Units: mm
 Canvas Range: Min Max
 X: -343.958 538.7137
 Y: -265.958 488.1648

PO Status: unknown
 GO Status: not running
 Transfer Status: idle

```

Info: 137.78.73.41:51128, You are connected to the softtool server.
Info: It is now Fri Jul 9 15:28:08 PDT 1999
Info: Server: getting project list
Info: Server: sending back project list
Info: Login for dsk succeeded
Info: Server: getting case list for MIRD
Info: Server: returning list of cases
Info: Server: reading design data for MIRD:baseline
  
```

Prescription Mode

- * Allows the user to create or modify a prescription
- * A prescription is an ordered list of a subset of the optical elements from the design
 - Determines which elements should be analyzed and in what order
 - Needed because instruments can have multiple “optical” paths
 - Instrument will be used at multiple frequencies*
 - Instrument has multiple modes of operation*
- * Elements may be modified in location or orientation from the base elements as stored in the design
 - Used for tolerancing analysis

Prescription Mode (Cont'd)

File Edit Mode

MOD Tool

Current mode is: Prescription

Current design file is: /home/dsk/modtool/miro.des

Current prescription file is: /home/dsk/modtool/miro.sm.pre

Load Prescription File

Save Prescription File

Choose Prescription from Design Data

Frequency: GHz Length Units:

Feed File:

Distance into feed of Rotation Point:

	g/l	dx	dy	dz	rx	ry	rz
<input type="button" value="sm_feed"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="mirror5"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="mirror6"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="mirror3"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="mirror2"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="mirror1"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>
<input type="button" value="output_sys"/>	<input type="text" value="G"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>	<input type="text" value="0.0"/>

GO Analysis Mode

- * Allows the user to perform geometric optics analysis on a design and prescription
- * These files are converted to a MACOS input set
 - MACOS provides computationally efficient general ray-trace, differential ray-trace, and scalar-diffraction calculation capabilities
 - Developed at JPL, starting in 1989
 - Commercial and U.S. Government versions are available
- * The files must be on the server, which does the conversion, and runs MACOS
 - Only the general ray-tracing capabilities of MACOS are currently supported through MODTool

GO Analysis Mode (Cont'd)

File Edit Mode

MOD Tool

Current mode is: Geometric Optics Analysis
Current design file is: /home/dsk/modtool/miro.des
Current prescription file is: /home/dsk/modtool/miro.sm.pre

First Element: Last Element: Plane:

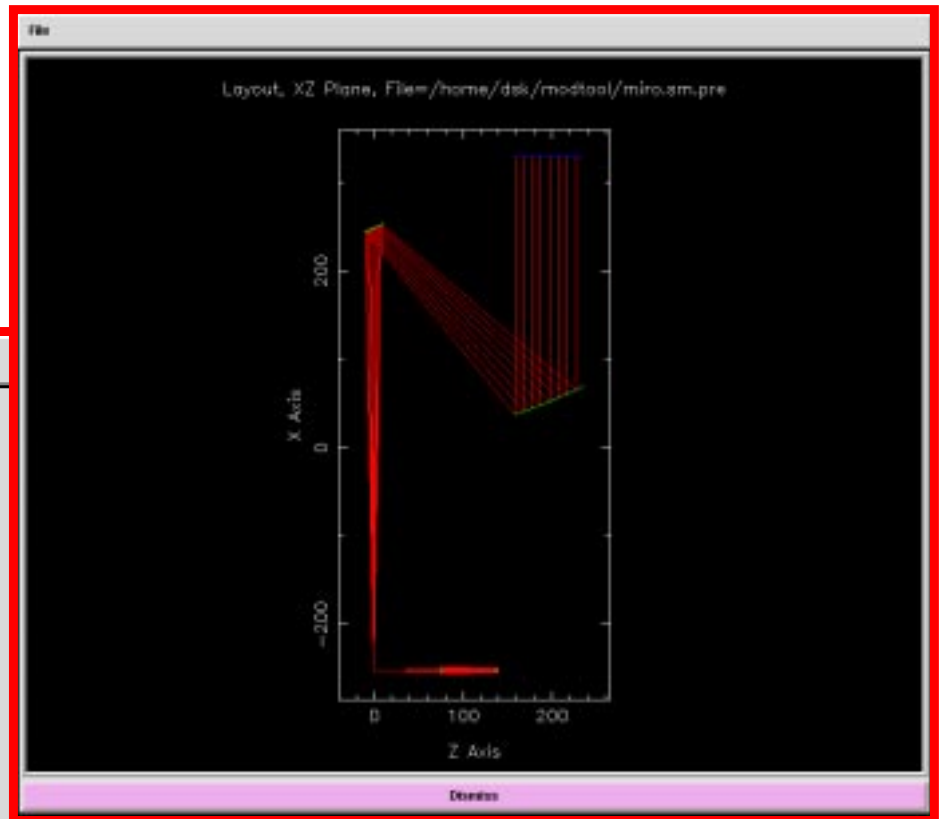
on Element:

on Element: Show as:

next image in new window

Aperture percentage: Aperture value (deg): 8.5700000000000003

Status: MACOS idle



Physical Optics Mode

- * Physical Optics (POPO) code
 - Developed at JPL over a long period of time (1971 - present)
 - Versions exist for PCs, workstations, Cray J90, T3D, Beowulf
- * Can analyze surfaces from design and prescription mode
- * Can also add deformations from load file before analyzing
 - Done using MATLAB to read mesh and load data, and to calculate coefficients for a bipolynomial (or other) surface approximating the deformation
 - MATLAB is run on the server, where the design, prescription, mesh and load files are stored
- * POPO code is run on supercomputers
 - Using username and password for that machine supplied by user
 - Ensures correct accounting and time-charging
 - Expect is used between the server and the supercomputer

PO Mode (Cont'd)

MOD Tool 1.02

Machine to use for Physical Optics Analysis: Server (Sun at JPL)
Neptune (HP-SPP2000 at Caltech)

Far Field Sweep Parameters:
 Phi start: 0.0 Phi stop: 180.0 dPhi: 15.0
 Theta start: -30.0 Theta stop: 30.0 dTheta: 0.60
 Load: (none)

List of Output Plots on server:
(double click to view a plot)

plot1.dat	phi = 0	Thu Jun 08 12:49:14 Z 1933
plot2.dat	phi = 15	Thu Jun 08 12:49:14 Z 1933
plot3.dat	phi = 30	Thu Jun 08 12:49:14 Z 1933
plot4.dat	phi = 45	Thu Jun 08 12:49:14 Z 1933
plot5.dat	phi = 60	Thu Jun 08 12:49:14 Z 1933
plot6.dat	phi = 75	Thu Jun 08 12:49:14 Z 1933
plot7.dat	phi = 90	Thu Jun 08 12:49:14 Z 1933
plot8.dat	phi = 105	Thu Jun 08 12:49:14 Z 1933
plot9.dat	phi = 120	Thu Jun 08 12:49:14 Z 1933
plot10.dat	phi = 135	Thu Jun 08 12:49:14 Z 1933
plot11.dat	phi = 150	Thu Jun 08 12:49:14 Z 1933
plot12.dat	phi = 165	Thu Jun 08 12:49:14 Z 1933
plot13.dat	phi = 180	Thu Jun 08 12:49:14 Z 1933

Info: Server: returning list of prescriptions
 Info: Server: reading prescription data for VERIFY:SSMA:new.pr
 Info: Server: returning PO status
 Info: Server: sending data for plot1.dat
 Info: Server: sending data for plot1.dat
 Info: Server: sending data for plot1.dat
 Info: Server: sending data for plot1.dat
 Info: Server: sending data for plot13.dat
 Info: Server: sending data for plot1.dat

Project: VERIFY
Design case: SSMA
Prescription: SSMA/new.pr
Mode: Physical Optics

Choose Load
Start PO Analysis
Update PO Status

PO Status: analyzing mirror 100%
GO Status: not running
Transfer Status: none

MOD Tool: server: plot1.dat

1st Component Magnitude

2nd Component Magnitude

1st Component Phase

2nd Component Phase

Dismiss

Mesh and Loads

- * Used by structural, thermal and electromagnetic engineers
 - * Submits a mesh of an instrument from a client to the server
 - Currently, meshes must be FEMAP neutral files
 - One layer is used for the elements that make up each optical element
 - * Validates that mesh and the “analytic” design are the same geometry
 - * Used with the load data for physical optics analysis of loaded instruments
-
- * Deformations come from structural or thermal loads
 - How the instrument will change from the original design when it is in its operating environment
 - * The load data must be logically tied to a set of mesh data
 - * This data is used in the physical optics analysis, with the corresponding mesh data

- * Adding ZEMAXS 3D optical software as addition to Design input mode
- * Interfacing to tool set in JPL TEAM I (Instrument) a concurrent engineering center
Ocean-Salinity Soil-Moisture Integrated Radiometer-Radar Imaging System
(OSIRIS) E. Njoku-JPL (Proposal)

