GRASP

The globally preferred solution

TICRA

- *The most groundbreaking software of the reflector antenna industry*
- *The globally leading tool for dedicated reflector design*
- *The preferred solution for the major players in the satellite industry world-wide*
- *Recognized for the unsurpassed calculation speed and accuracy*

Credits: ALMA(ESO/NAOJ/NRAO), E. Stenvers.

Welcome

to the world of TICRA

When three young engineers founded TICRA in 1971, with the purpose of developing algorithms and numerical methods for modeling of satellite antennas, the availability of commercial codes for EM modeling was non-existing. The few large players in the field, primarily spacecraft manufacturers, would have their own home-grown reflector antenna design and analysis tools. Their customers, mainly space agencies and a few satellite operators, would also be limited in terms of EM analysis capabilities, and would have to trust the antenna pattern predictions that the supplier offered for their link budgets and margin considerations.

From this scenario grew GRASP, the first commercial reflector antenna code developed and supported by the independent company, TICRA, to become a de facto standard within the reflector antenna community. Through substantial collaboration with the European Space Agency, the capabilities of GRASP increased with the needs of the satellite community. This continuous refinement of the tool has continued ever since, now with more and more input coming directly from the industrial customers, who feed back their requirements to the development team behind GRASP. When the satellite industry implemented polarization-sensitive reflector surfaces to increase the capacity by means of frequency re-use, TICRA implemented analysis capabilities for reflector surfaces that were no longer perfectly conducting, but could have anisotropic characteristics, as found in a metal polarization grid. When the earth-station manufacturer needed to supply flyaway terminals, TICRA were there to enhance the capabilities of GRASP to predict the influence of mis-alignment of the individual reflector panels.

It is this approach that has made GRASP the no. 1 tool for reflector antenna EM modeling world-wide today, trusted and validated by the thousands of antennas built and tested against the GRASP predictions. It is the intimacy with our customers that ensures this to be the case also in the future. We hope you will enjoy reading more about the capabilities of GRASP on the following pages.

Poul Erik Frandsen
Chairman of the Board

Customers say:

I'd like to congratulate TICRA on the development and recent release of GRASP 10! The robust PO engine we have relied on for years now includes a modern GUI, complete with clickable objects in the 3D view expanding to a dialog of all editable dialog properties, plus helpful options such as changing the perspective view type. The new "job" concept is invaluable for maintaining iterations of similar models, with parameters changed, and the results tab provides an easy comparison methodology.

We look forward to continued development of the results area, to incorporate more of the post processor functions within the GRASP framework.

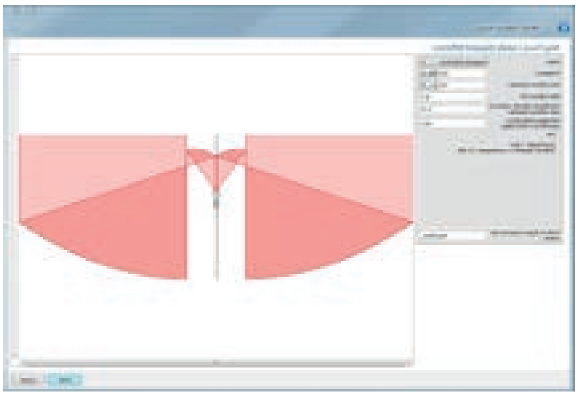
Ken Hersey,
Principal Antenna Engineer
NASA Goddard Space Flight Center

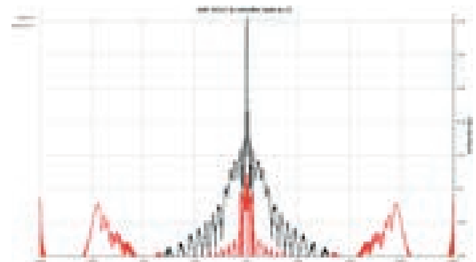
Productivity

enhancement

Using GRASP in it's simplest way is easy. Just start the wizard and define your single or dual reflector system with a minimum of parameters. Then leave the hard work of generating geometric figures and analysis commands to the wizard, hit the "Go" button and inspect your antenna directivity pattern within seconds. For most usage this provides the ideal starting point for continued analysis and investigations. And the wizard is not only capable of setting up single reflector and Gregorian or Cassegrain systems; more advanced configurations such as ring-focus, or axially displaced reflectors, are handled equally well.

By using the wizard you will generate a template that can serve as starting point for your continued and more elaborate investigation of your particular antenna design. This includes changing the surface profile, the rim or edges, the surface material, adding other objects to simulate the antenna environment, investigating near fields and much, much more.





The full-sphere directivity pattern for an 11m C-band dual-reflector is obtained in a matter of seconds on a laptop

A diversity of possibilities

Reflector profiles are selected among a vast supply of models

- Paraboloid, hyperboloid, ellipsoid
- Plane, cone, cylinder and general second order polynomials in x, y and z
- File-defined surface, given as a number of points $z_i = z(x_i, y_i)$
- Rotationally symmetric surface, given numerically as $z_i = z(\rho_i)$
- Pyramidal surface

The most common boundary, or rim, of reflectors is the general ellipse, but numerous other definitions have been introduced over the years to support the needs of antenna engineers:

- Elliptical, including circular
- Rectangular
- Super-ellipse, resembling a rectangle with rounded corners
- Triangular
- General, numerically defined from file input

Real-world

analysis

$$P = \frac{1}{2} \sum_{s=1}^{2} \sum_{n=1}^{N} \sum_{m=-n}^{n} \left| Q_{smn} \right|^2$$

Antenna designs typically start with an idealized representation of the system. But in real life a reflector surface is rarely perfectly conducting; the surface may approach the desired shape, e.g. parabolic, but manufacturing tolerances, thermal and mechanical loading and more will result in deviations from that shape. TICRA continuously upgrade GRASP to cater for all likely non-ideal effects, and can handle as diverse issues as:

- Most commonly encountered types of polarization grids
- Woven mesh
- Surface distortion caused by the ribs in deployable antennas of the "umbrella"-type
- Random surface distortions specified by an RMS value and the correlation distance between errors
- Multiple layers of different dielectric material
- Finite conductivity material and absorbers

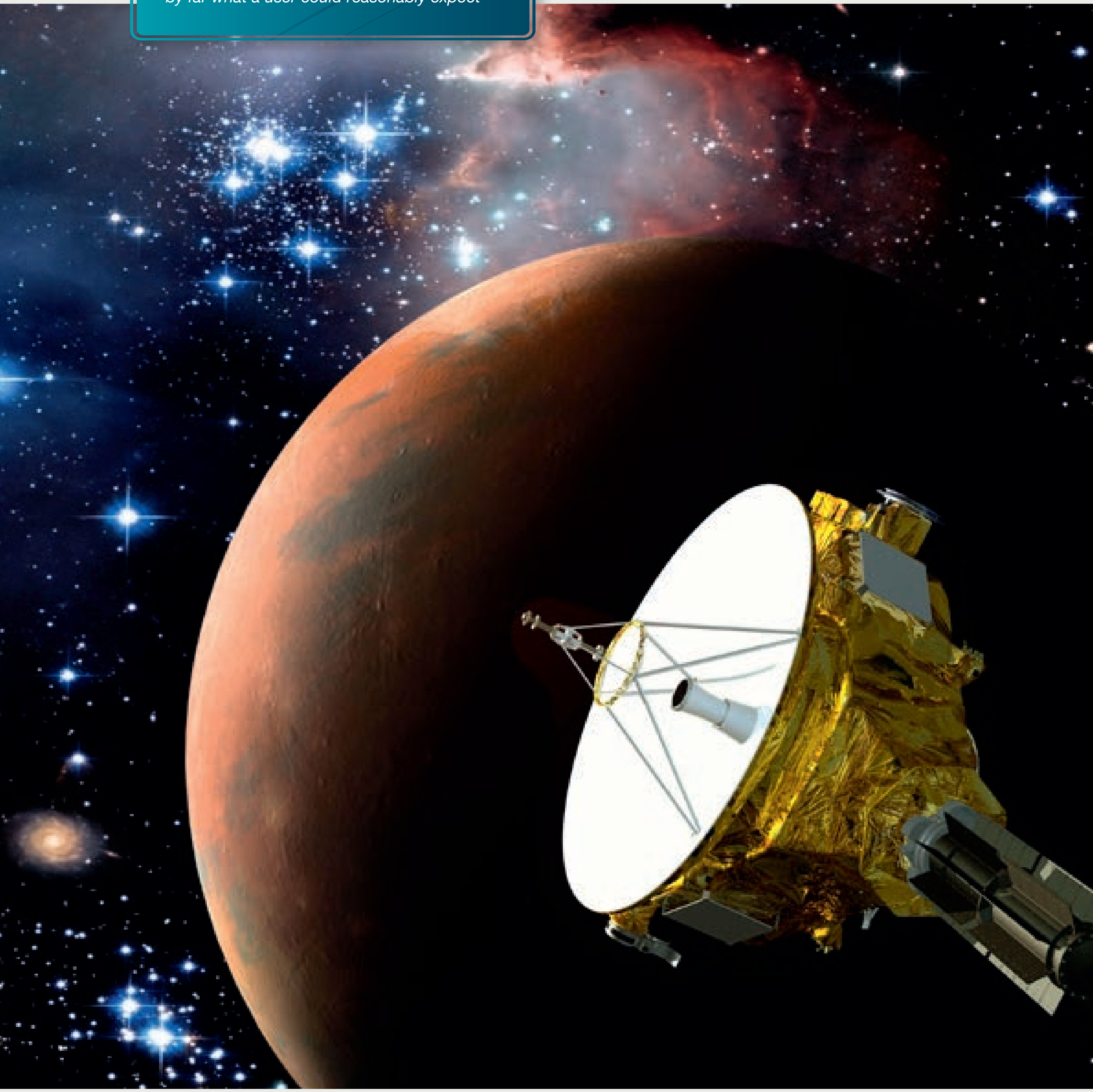
It is of course possible to combine materials, for example placing a polarization grid sandwiched in a dielectric support structure.

The availability of feed models also reflects the real-life requirements: while the initial design of an antenna will typically assume a simple Gaussian-beam type feed radiation, it soon becomes important to change this, for example by utilizing the results of other modeling programs such as CHAMP by TICRA. A simple, non-proprietary data format for feed data given as either cuts or spherical wave expansions ensures a simple interface with most other vendors' code.

- Whether the feed is chosen among the built-in analytic models or is provided as data in a file, GRASP has the capability of computing not only the far field from the feed but also, by means of a spherical expansion, the true near field. This is extremely important when illuminating e.g. a sub-reflector in a dual-reflector system.

Customers say:

"You guys have the best support, it exceeds by far what a user could reasonably expect"



Largest selection

of analysis methods

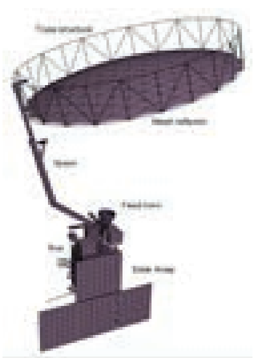
Physical Optics is a straightforward, versatile, fast and accurate method for analyzing the scattering from reflector antennas by means of the induced current concept. And so it is the method of choice in GRASP, where years of effort have been invested to develop the most advanced and efficient algorithms to compute and integrate the PO currents. With the PO approach it is possible to predict the entire pattern from very large antennas in a matter of seconds.

The GRASP implementation is supplemented by PTD which accounts better for edge effects than the PO currents. When the reflector, or scatterer, size is small in terms of wavelengths the PTD effects become more pronounced.

In all, GRASP offers several different analysis options:

- PO/PTD
- GO/GTD, one reflector
- PWE, Plane Wave Expansion
- GO/GTD, multiple reflectors (optional)
- Method of Moments, MoM (optional)

The optional GTD package's primary usage is for large systems of reflector antennas where the mere size of the antennas makes standard PO analysis very time consuming. The full-wave MoM implementation is intended for analysis of interaction between reflector, feed or structure elements that are typically smaller in terms of the wavelength.



Jet Propulsion Lab's GRASP model of the full Soil Moisture Active Passive spacecraft using the method of moments add-on.

Quasi-optical systems

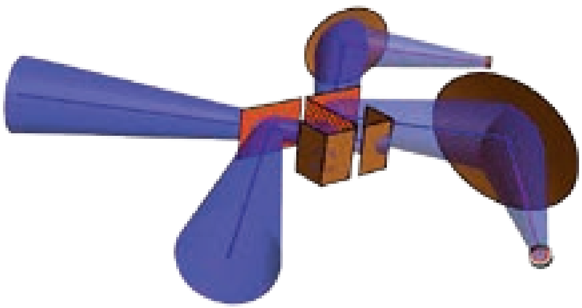
(Optional capability enhancement package)

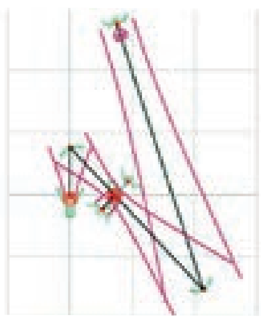
The QUAST add-on module extends the well-known GRASP analysis methods by Gaussian beam analysis and accelerated PO, and includes a large number of new components to speed up beam waveguide design while maintaining high accuracy.

In addition to curved and flat mirrors, QUAST provides lenses, beam splitters, polarization grids, aperture stops, rooftop mirrors and interferometers.

The fast and accurate quasi-optical analysis exhibits the following features:

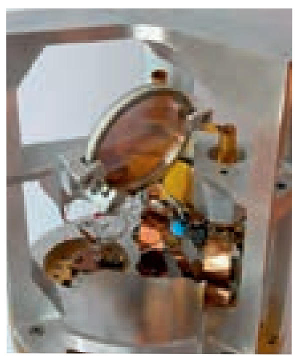
- Physical Optics (PO), with automatic determination of the number of PO current samples, is automatically chosen for most components of the beam waveguide.
- Fast multi-mode Gaussian beam analysis, i.e. Gauss-Laguerre, can be launched for preliminary investigations, where only the beam shape and the cross-polarization are calculated.
- The accuracy of PO computations can be increased by performing a plane wave expansion of the field incident on the component of interest. This is highly recommended for beam splitters and interferometers, whose electrical properties are normally described by reflection and transmission coefficients for an incident plane wave.





QUAST Frame drawing of Band 7 of the front end of the ALMA telescope: one of the feeds, mirrors M1 and M2 and polarization grid.

QUAST OpenGL plot of Band 7 of the front end of the ALMA telescope: feeds with mirrors M1 M1R M2, polarization grid and cryostat windows.



Band 7 cold optics of the front end of the ALMA telescope: mirrors M1 and M1R at the top partly hidden, circular polarization grid in the middle and mirror M2R at the bottom (IRAM, France).

COUPLING

(Optional capability enhancement package)

The COUPLING add-on extends the capabilities of GRASP from computing radiation patterns, near- or far-fields, to calculate the transmission from one antenna to another. Based on the Lorentz reciprocity theorem an algorithm is implemented which calculates the complex coupling ratio between transmitting and receiving antennas.

Interference

between independent antennas due to the environment

A common application of the coupling module is to calculate the interference between two antennas on a spacecraft by means of reflection and diffraction in the satellite body, the solar panels, other antennas and structural elements. Spurious signals generated in the transmit antenna may significantly disturb the receiving antenna because of the high transmission power and sensitivity of the receivers. A broadband radiometer can be disturbed by a telemetry antenna even if they are mounted on completely different faces of the satellite.

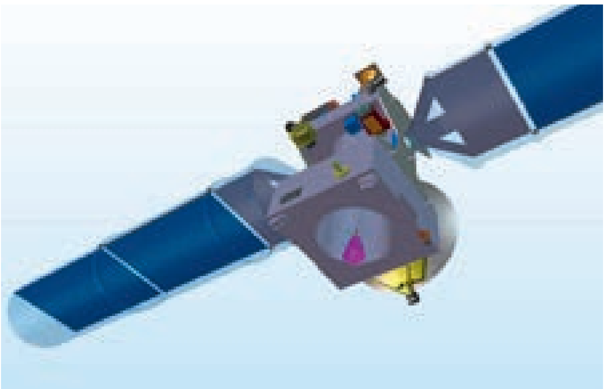
All the standard analysis tools in GRASP are available for the coupling analysis, and they are often supplemented by the Multi-GTD add-on.

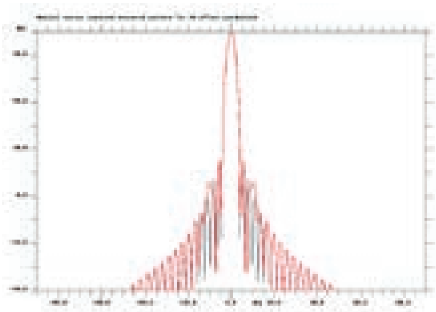
Determination

of the true, measured antenna pattern in a compact test range.

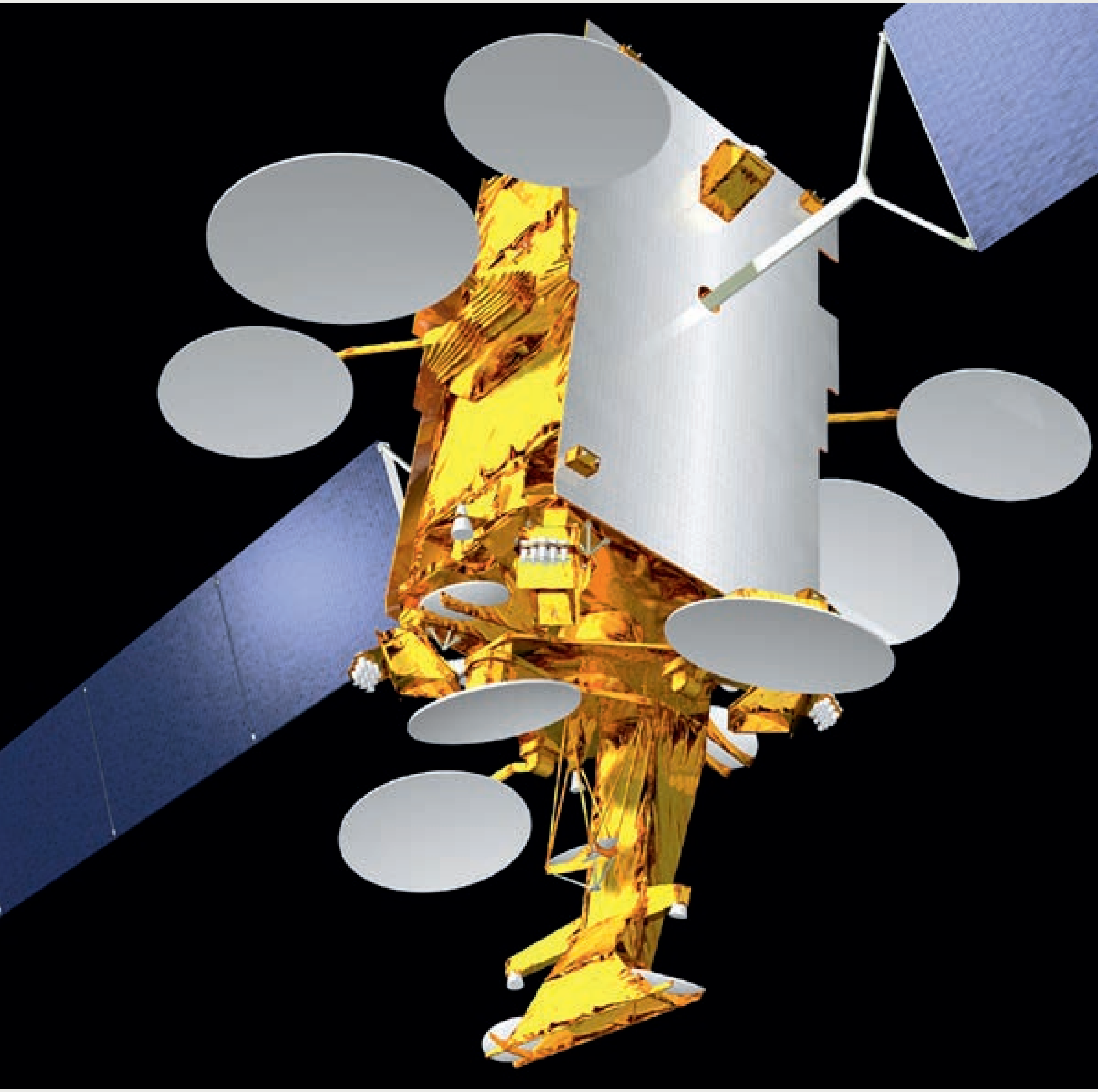
An antenna can be measured under simulated far-field conditions by placing it in the aperture field from a parabolic reflector antenna. The aperture field approximates a plane wave with a quality that depends on both the reflector and the feed.

GRASP can be used to predict the quality of the quiet zone by performing a standard near-field analysis of the field from the chamber reflector to generate amplitude and phase patterns. But how does that really affect the AUT measured pattern? COUPLING can compute the field that is coupled from the range reflector to the antenna under test. This pattern will deviate from the ideal, nominal antenna far-field patterns, and it is this pattern that one should expect to see on the range if the antenna is perfect.





Coupling analysis of an antenna in a compact test range. The measured pattern will deviate from the theoretical pattern in a predictable way.



Credits: ESA/EADS-ASTRIUM.

Full-wave analysis

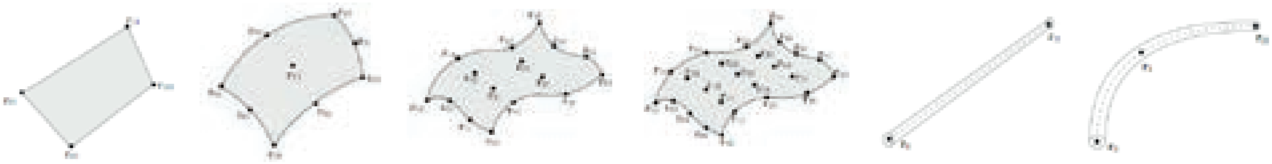
– Method of Moments (MoM) add-on

Extend the analysis capabilities of GRASP to cover an even wider range of scattering problems.

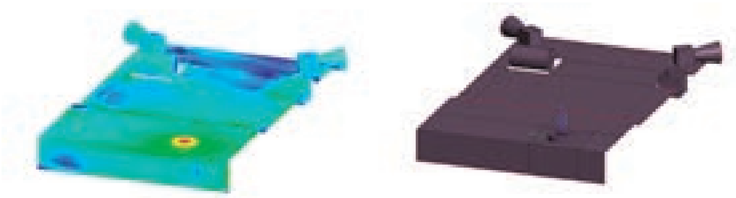
Admitted, there are certain EM problems, even for reflector antennas, where the pre-requisites of Physical Optics are not fulfilled. To ensure that you can also predict the accurate performance in these cases, TICRA offers an advanced implementation of a moment-method solver. The choice of higher order basis functions to represent the currents, combined with up to fourth order curved patches for surfaces and second-order curves for wires, guarantees minimum memory requirement and maximum computation speed compared to other, more traditional solvers.

- Current expansion in hierarchical polynomial basis functions adaptively matched to the size of the patches minimizes the number of unknowns
- Generalized quadrilateral surface patches of polynomial shape up to fourth order provide for an efficient meshing of typical curved surfaces encountered in reflector problems
- Perfect electric conductors (PEC), homogeneous dielectrics, thin, dielectric sheets and lossy conductors
- Import of arbitrary meshed geometries
- Monopoles and dipoles are modeled as generally curved wires
- Computation of S-, Z- and Y-parameters
- Voltage sources
- Automatic meshing of all GRASP reflector types, with the possibility of exporting the mesh
- Seamless integration with GRASP, using the same commands to perform full-wave analysis as PO, just replacing the command input

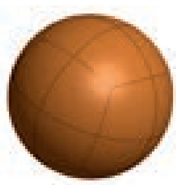
The MoM add-on also provides a productivity-enhancement tool for collecting individual scatterers in groups, thus simplifying the analysis of complex system. This tool can even be utilized in PO computations.



Using higher-order basis functions and curved surface patches reduces computation time and memory requirements significantly.



Full-wave analysis of the Exomars UHF antenna with the MoM add-on. The potential scattering in the scientific instruments on board is considered, including a major part of the satellite body. (Courtesy: Thales Alenia Space and RYMSA)



A spherical body is meshed extremely accurate with very few curved patches

Ray analysis of complex systems

– Multi-GTD add-on

Perform fast computations on systems of electrically large reflectors, and inspect the ray paths visually.

Radio astronomy in the far infra-red band relies on telescopes that may operate at 1 THz frequencies and could be thousands of wavelengths in diameter. At such frequencies it is possible to characterize the individual antennas quite well by using PO, but other tools are needed when investigating the scattering between many reflectors and structures. This applies equally well to large, ground-based telescopes and space-borne equipment.

The Multi-GTD add-on implements the Uniform Geometrical Diffraction Theory (UGTD) that describes the scattering mechanisms by means of rays. Reflection and diffraction points are found by a combination of numerical and analytical techniques and the efficient algorithms ensure very fast response time.

- Automatic determination of possible ray paths
- User can select which scatterers should be considered
- Objects may be specified not to block the rays, so a project may contain reflectors that are not considered in the analysis
- PEC as well as non-perfectly conducting surfaces (polarization grid, dielectrics)

Multi-GTD is used extensively on scientific-mission satellites, anechoic chambers and spaceports with multiple large ground station installations.

Customers say:

"Having GRASP in my tool box is my job security"… another satisfied antenna engineer in our defense customer segment

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