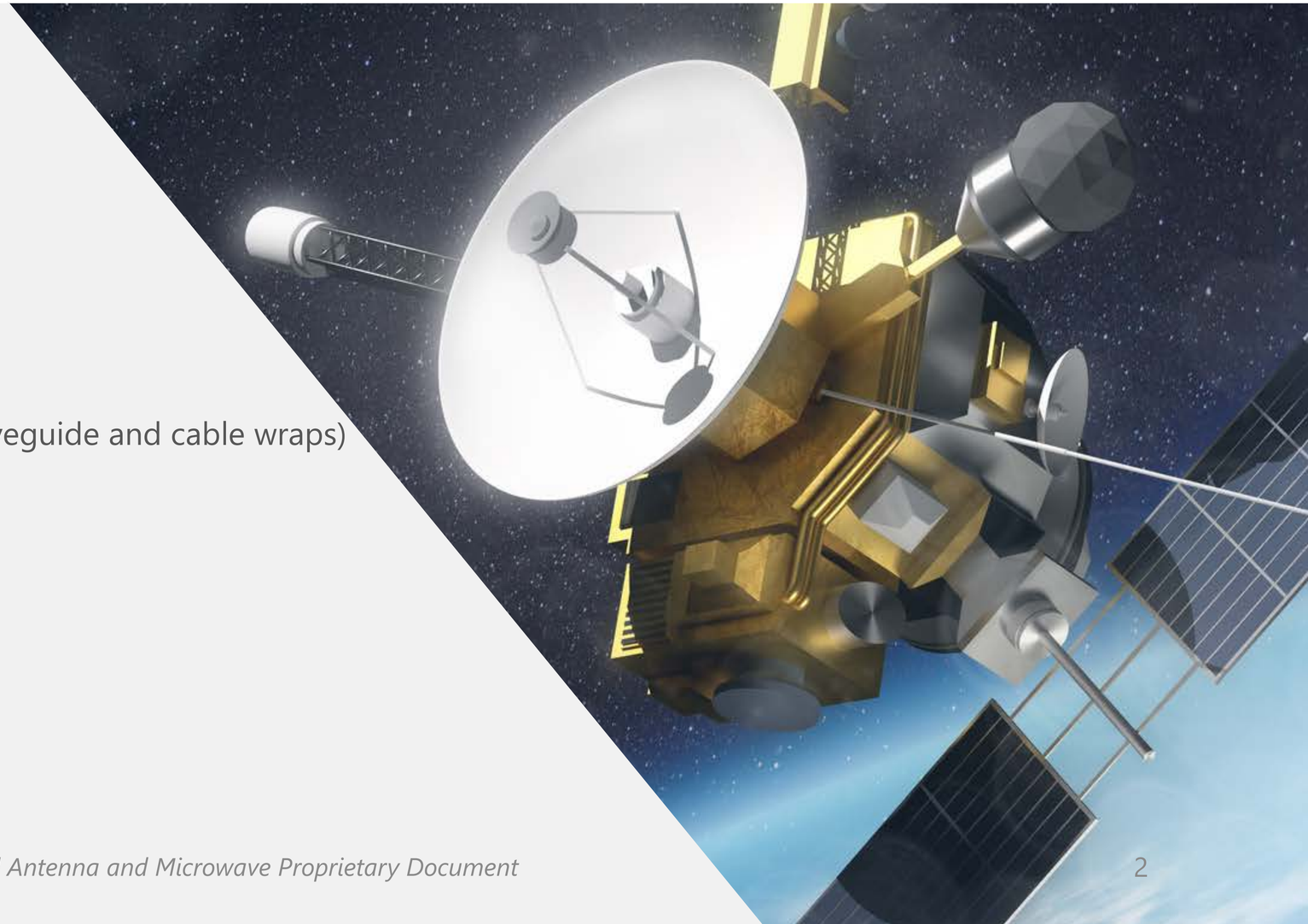
SPACE ROTARY JOINTS OVERVIEW & CAPABILITIES

WHY USE ROTARY JOINTS IN SPACE ?

Product and Mission Reliability

- Long life
- Excellent RF performance
- Design flexibility
- No rotation limits (more reliable than flexible waveguide and cable wraps)
- Stable thermal and vacuum performance
- High multipaction margins
- Very low torque
- Low outgassing materials used



ROTARY JOINT MISCONCEPTIONS

A suitable alternative

Several customers have selected Rotary Joints after test failures of a cable wrap or flexible waveguide.

Misconceptions	Reality
Rotary Joints shouldn't be used for space-flight use	Rotary Joints have been used in Space Applications for decades. Diamond has delivered qualified products to multiple worldwide programs
Poor reliability	Diamond's customers have never experienced a Space product test failure
High torque	Typical ambient temperature torque values are ≤ 4-inch ounces
Rotational RF change	RF change (WOW) with gimbal rotation is typically <.05 in VSWR & Insertion Loss
Cable wraps or flexing a waveguide is a better choice	Why take the chance of a failure? Using RF Rotary Joints is a better choice

BEARING AND LUBRICANT SELECTION

Bearing Selection

- Customers have final approval of bearings and lubricant selected
- Customers may choose to supply bearings as CFE (Customer Furnished Equipment)
- If required, Diamond personnel can perform integration and testing at the customer's location

Lubricant Loss

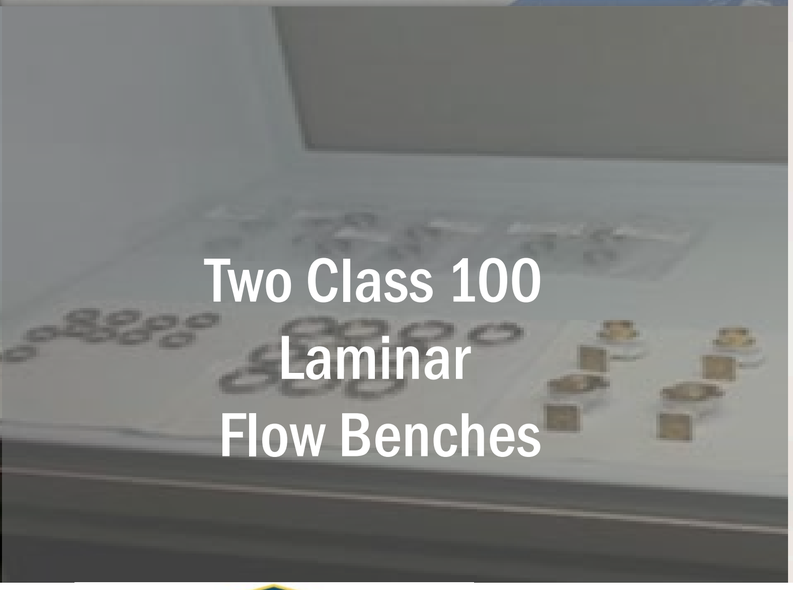
Rotary Joints are designed to minimize lubricant loss through the combination of bearing design, housing labyrinths, and the use of barrier film coating

Common Lubricants for Space Bearings

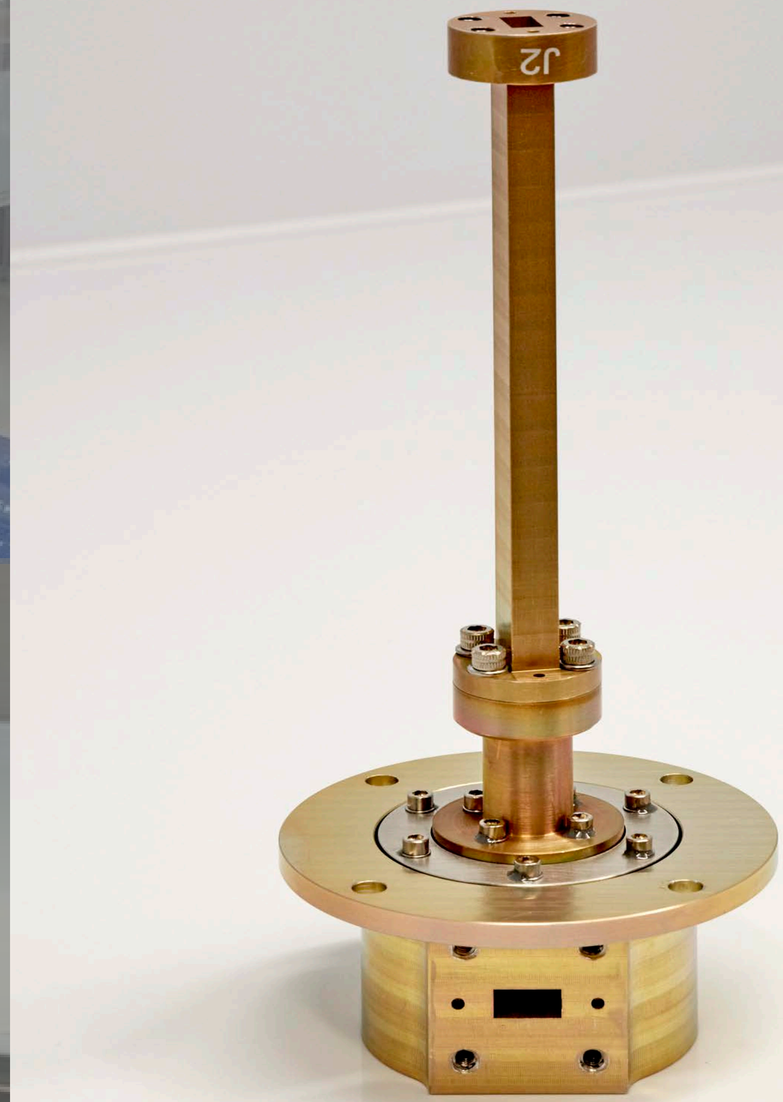
- Penzane
- Rheolube Family
- Moly Disulfide (MOS_2) Dry Film
- Braycote 601EF
- Customer Proprietary Lubricant

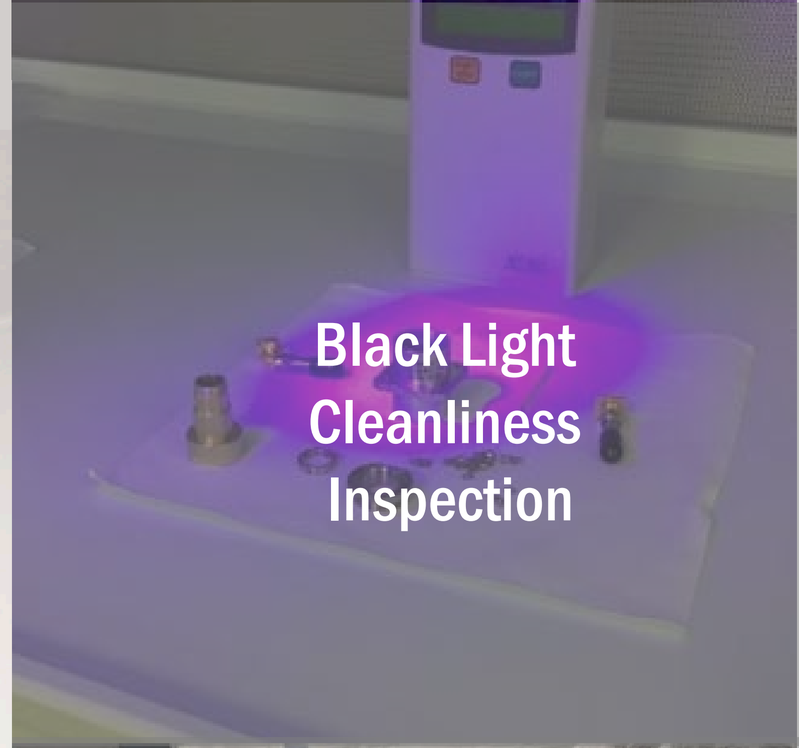
SPACE ASSEMBLY AREA

Class 10,000
Clean Room



Two Class 100
Laminar
Flow Benches





Black Light
Cleanliness
Inspection

RF Testing
in Clean Room

DIAMOND ROTARY JOINT DESIGN PROCESS

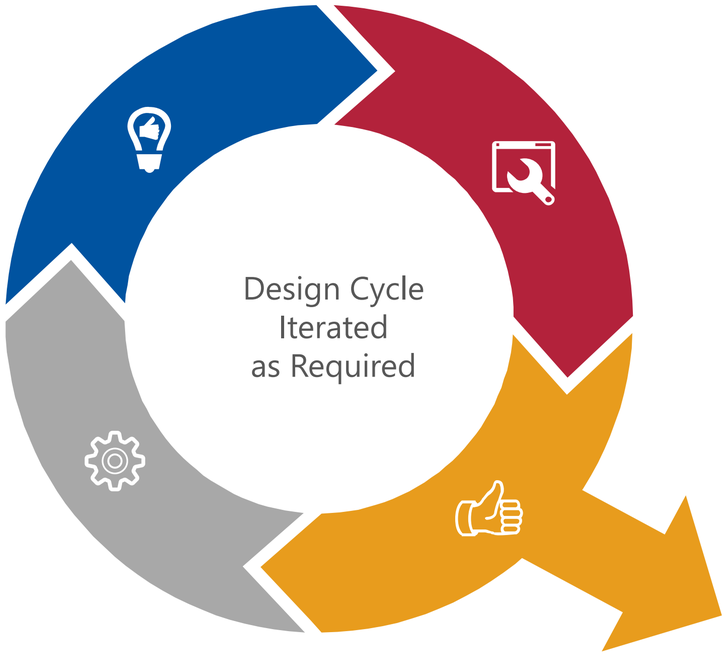
TYPICAL

Rotary Joint RF Modeling Design

Mechanical Assembly Model and Analysis Period

Mechanical Manufacturing Package

RF Modeling Verification



RF Modeling of Transient, Frequency, Thermal and Mechanical Deformation Solvers Available

Manufacturing Documentation Package Release

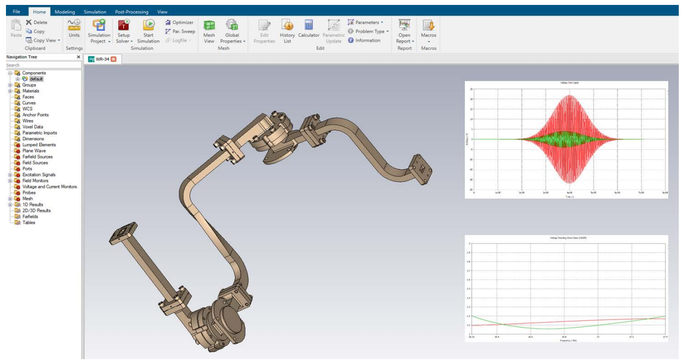
RF DESIGN SOFTWARE

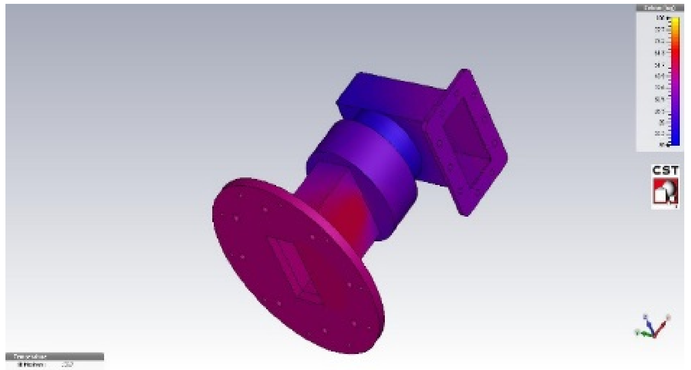
MICROWAVE STUDIO

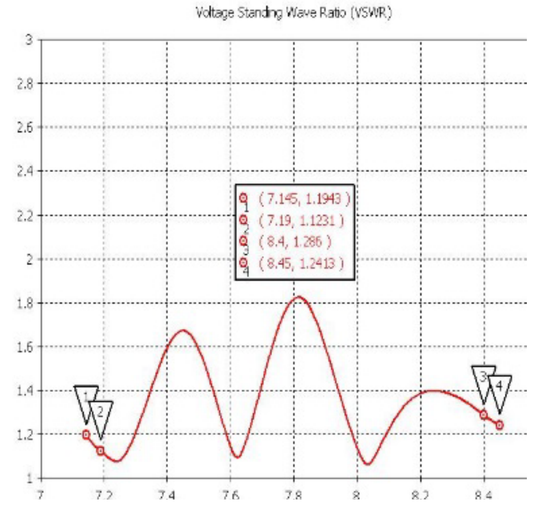
MODELING CAPABILITY

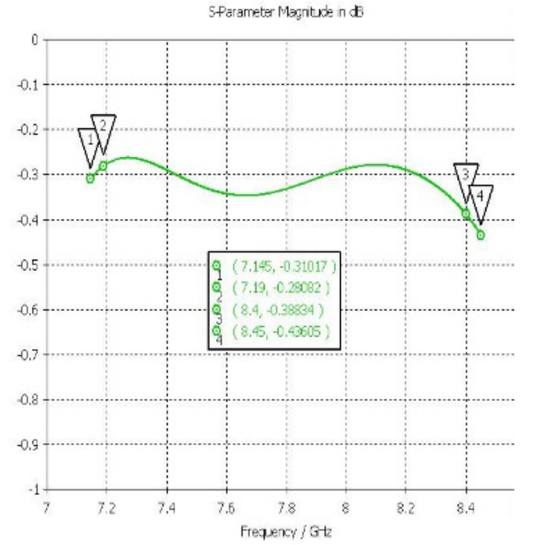
- Virtual Prototypes
- Full RF Analysis
- High Power
- Thermal Analysis
- Mechanical Distortion Analysis
- Multipaction Analysis
- Ionization Analysis

Highly Accurate RF Prediction





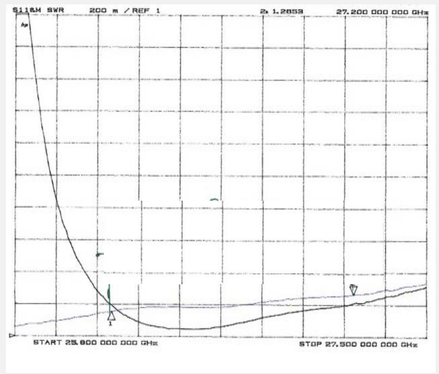




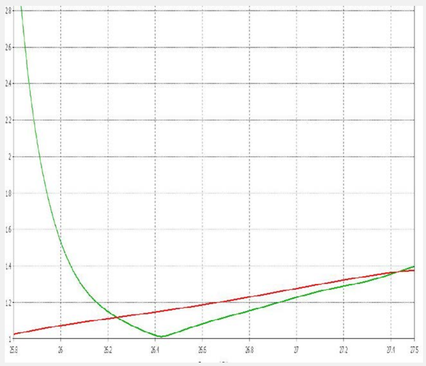
RF MODELING ACCURACY

Waveguide Design Example

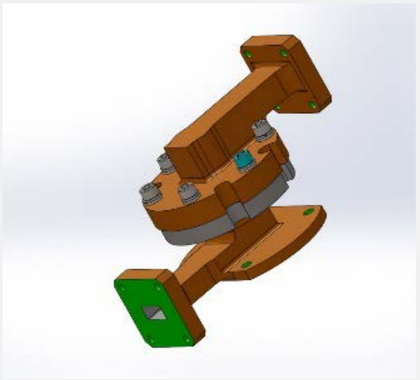
Initial Measured Actual VSWR



VSWR Model Prediction



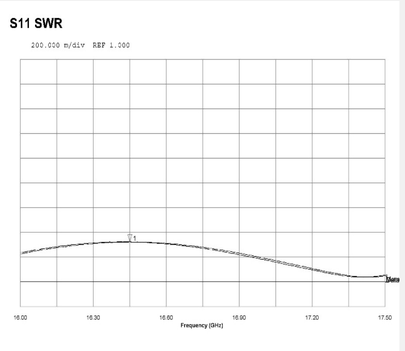
Waveguide Example No Tuning Needed



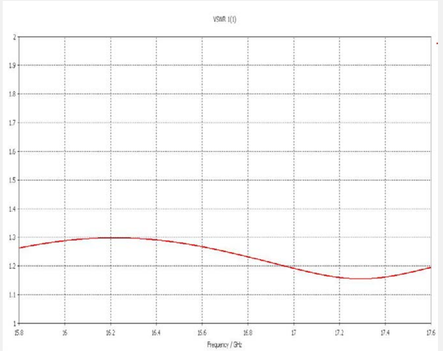
RF MODELING ACCURACY

Coaxial Design Example

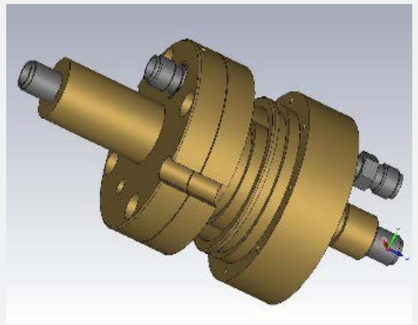
Initial Measured Actual VSWR



VSWR Model Prediction



Coaxial Example No Tuning Needed



TYPICAL PROGRAM SUBCONTRACT DATA REQUIREMENTS LISTS (SDRL'S)

SDRL's and analyses typically comprise a significant portion of a contract's value. Proper selection can improve schedule and reduce costs.

Quality / Program Related

- MIP / KIP Plan
- Quality Plan
- PA Conformance Plan
- PID Document
- Configuration Control Plan
- Cleanliness Control Plan
- Critical Item List
- Risk Management Plan
- Risk Register
- Schedule & WBS
- Product Tree
- Progress Reports

Meetings

- Kickoff Meeting
- Preliminary Design Review
- Critical Design Review
- Manufacturing Readiness Review
- Test Readiness Review
- Pre-Ship Review
- Weekly Progress Meetings

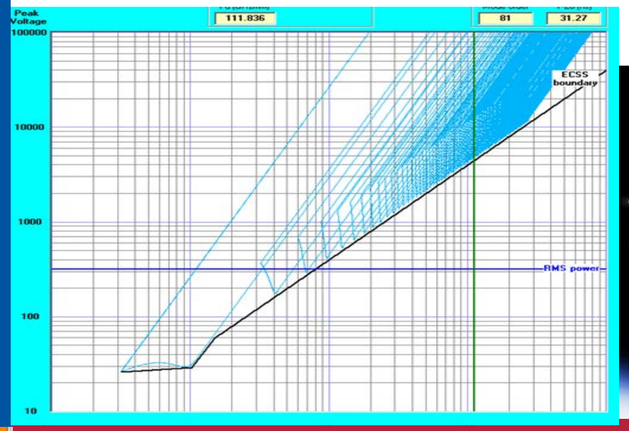
Documentation

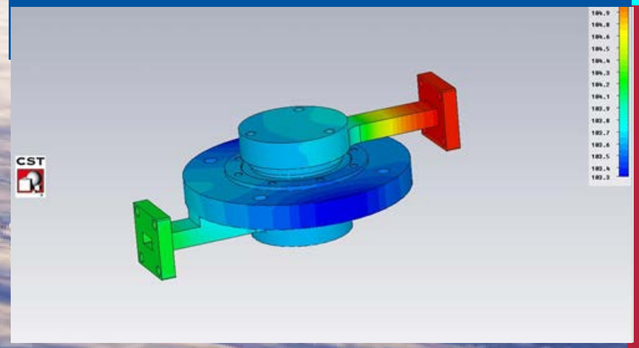
- Materials / Process List
- Logbooks
- Assembly Travelers
- Photographic Inspection
- Verification Test Plan
- End Item Data Packages
- Test Procedures
- Test Reports
- Technical Analysis

TYPICAL RF & MECHANICAL ANALYSES

RF ANALYSES

- RF Design Modeling
- High Power Thermal Rise
- Multipaction
- EMI
- PIM
- RF Data Trending
- Worst Case Dimensional





MECHANICAL ANALYSES

- Bearing
- Structural (Vibration/Shock)
- Thermal
- Thread Engagement
- FMEA
- Reliability
- Lubrication Loss
- Life
- Reliability

TYPICAL FINITE ELEMENT ANALYSES

Sinusoidal Vibration

Random Vibration

Shock

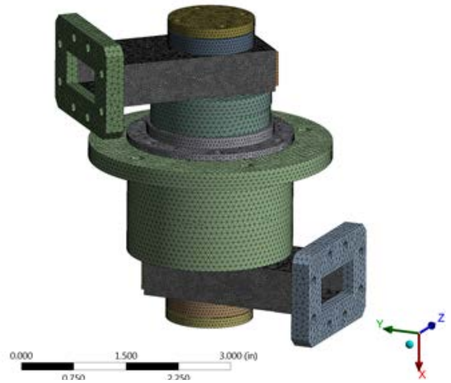
Quasi-Static

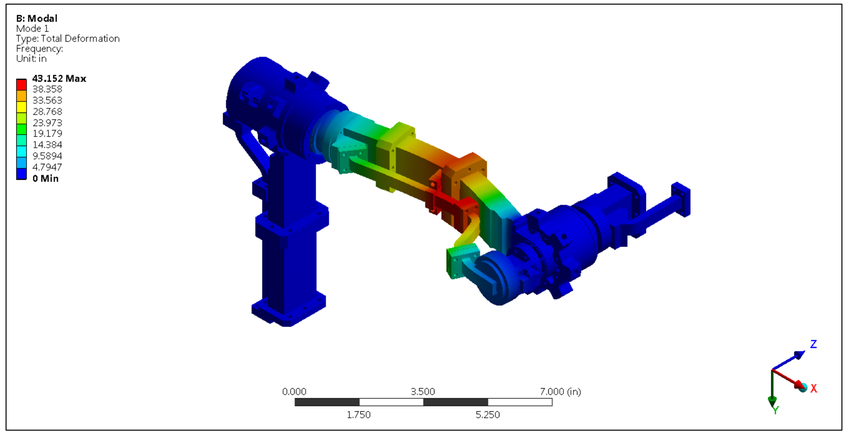
Thermal Loads

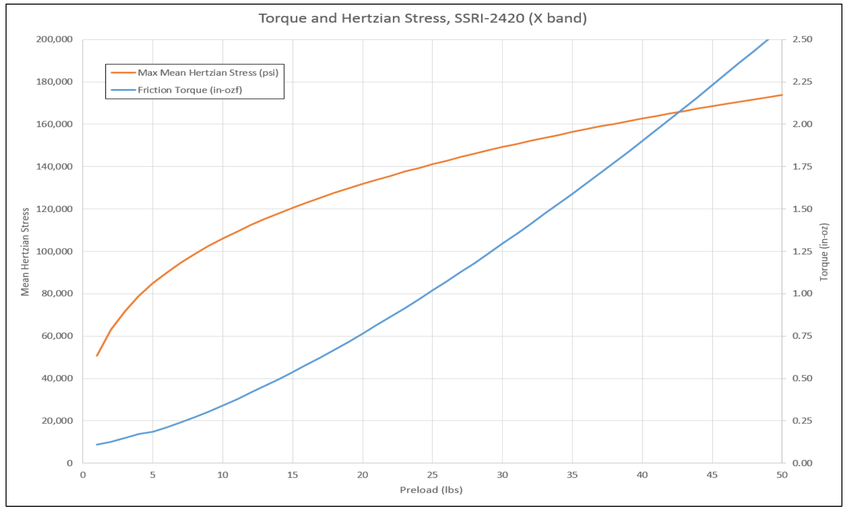
Bearing & Life

Bolted Joints

Lubricant Loss







TYPICAL RF ANALYSES

RF Analysis

Average Power

Peak Power

Multipaction

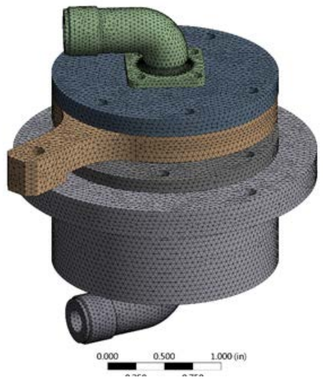
Ionization

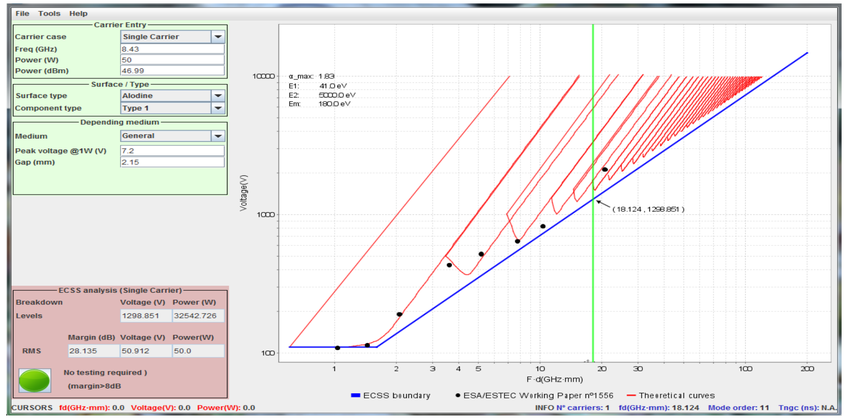
Thermal Effects on RF

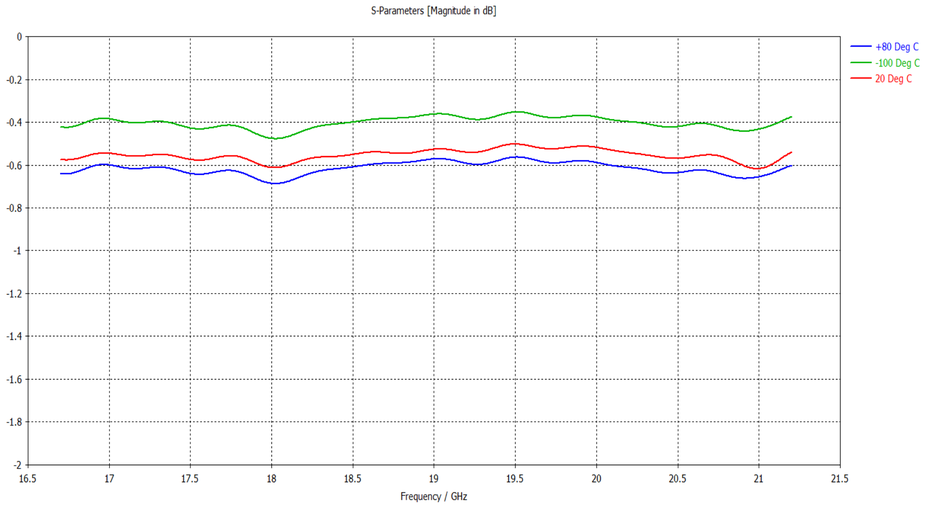
Worst Case Analysis

Distorted Geometry

RF Leakage







DIAMOND ANTENNA SPACE HERITAGE

Customer Satisfaction

Leading worldwide supplier

Exceptional customer service

Many repeat orders

Other vendor product refurbishment

Design and Manufacturing Experience

Diamond performs 100% of the required activity (Prog Mgt, QC, Design, Assy, Test, Shipment)

Core team has worked together for over 15 years, with more than 100 years of combined Engineering experience

International Customer Base

North America

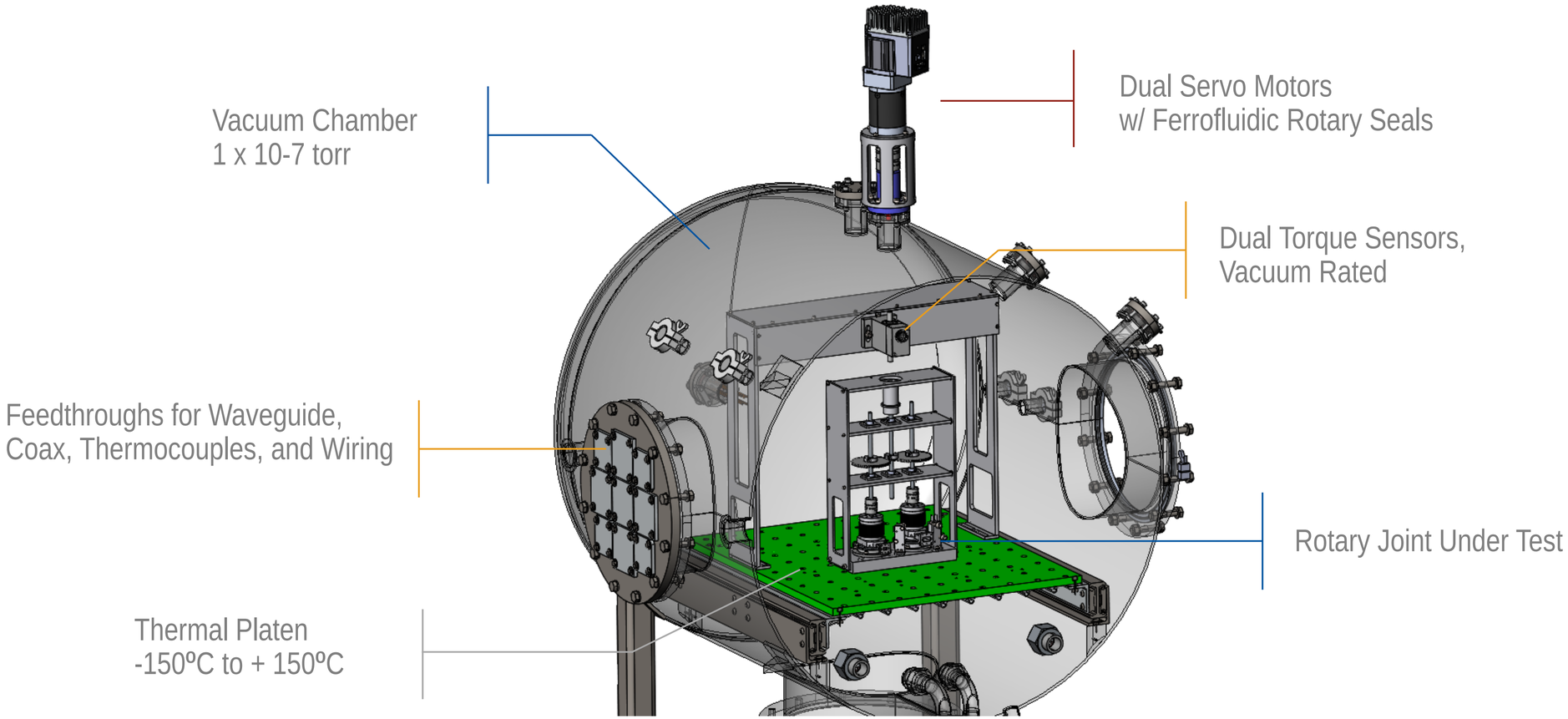
Europe

Asia Pacific

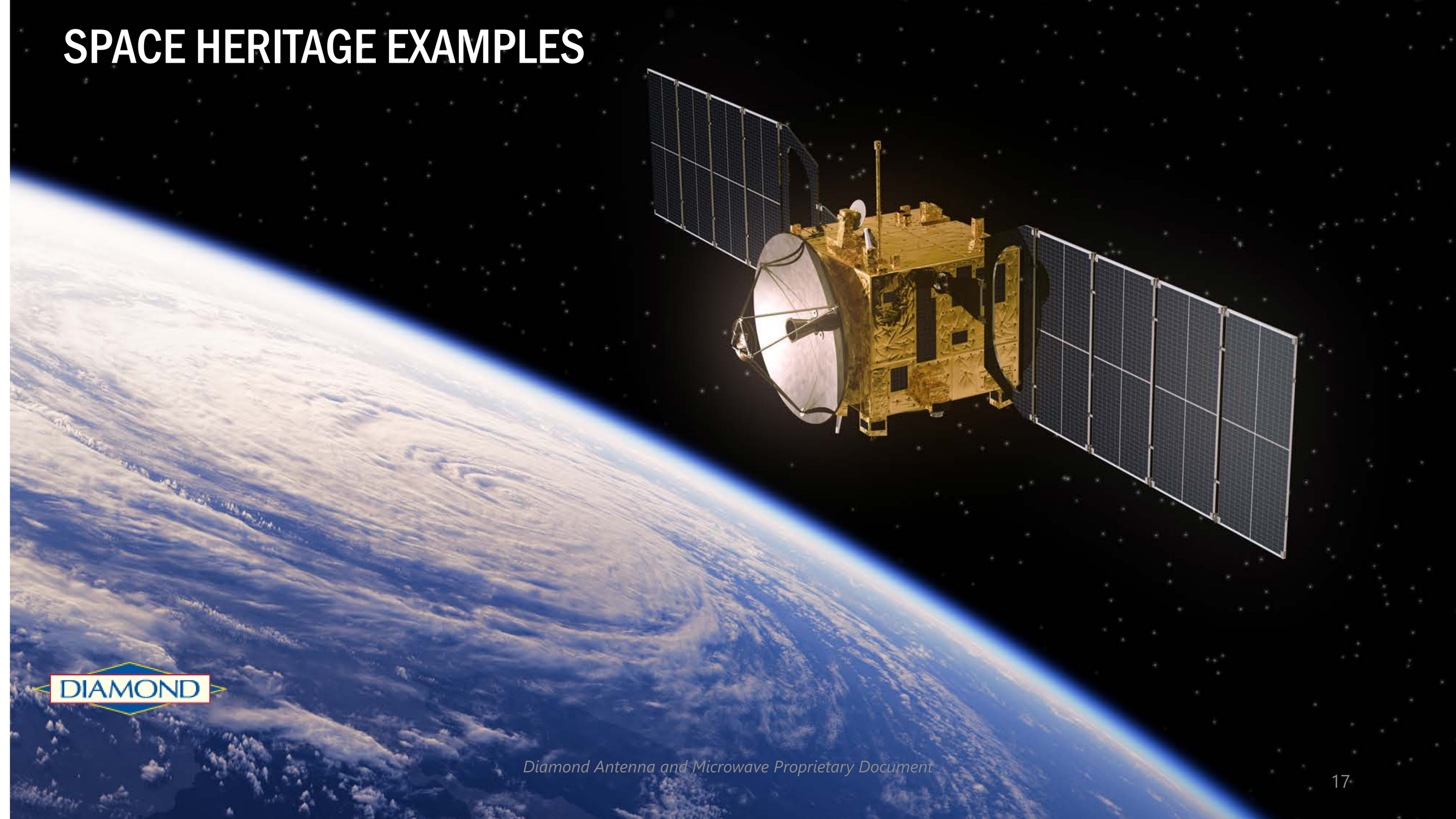
THERMAL VACUUM CHAMBER

IN-HOUSE TEST CAPABILITY

THERMAL VACUUM CHAMBER



SPACE HERITAGE EXAMPLES



SPACE FLIGHT HERITAGE

ROTARY JOINTS: (Past Programs)

Mars Observer: X-Band WR-90 Waveguide

DSCS-3: X-Band WR-90 Waveguide

Land Sat 5: X-Band Coaxial

Land Sat 7: X-Band Coaxial

CRSS: X-Band Coaxial

Earthwatch: X-Band Coaxial

Orbview: X-Band Coaxial

Quickbird: X-Band Coaxial

Stereo: X-Band Coaxial

ROTARY JOINTS: (Current Programs)

NASA Program:	WR-34 Single Channel Waveguide
NASA Program:	WR-34 Single-Axis
Military Program:	WR-51 Multi-Axis Waveguide
Military Program:	X-Band Coaxial Single Channel
WR-51 Program:	WR-51 Dual Channel
ESA Program:	WR-112 & WR-28 Dual Channel, Dual-Axis
Military Program:	Coaxial Single Channel
WR-51 Program:	WR-51 Single Channel, Dual Axis

Military Program:	Dual Channel Coaxial
Military Program:	WR-51 & WR-22 Single Channel
NASA Program:	WR-34 Single Channel, Dual-Axis
Military Program:	WR-28 Single Channel, Dual Axis
Military Program:	Dual Channel Coaxial
NASA Program:	WR-112 Single Channel
Mars 2020:	X-Band Coax Single Channel Refurbishment
NASA Program:	WR-34 Single Channel / TNC Single Channel

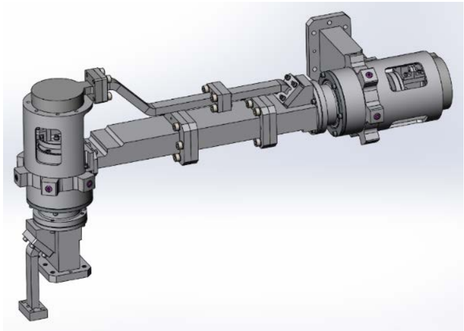
DUAL AXIS WR-112 / WR-28

Dual Channel Dual Axis Waveguide Rotary Joint

Dual Channel (WR-112 / WR-28) with Integrated Waveguide

Severe Vibration and Shock Environment

+ 200° C to -80° C Temperature Range

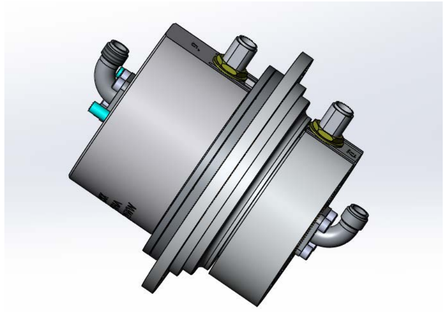


DUAL CHANNEL SMA

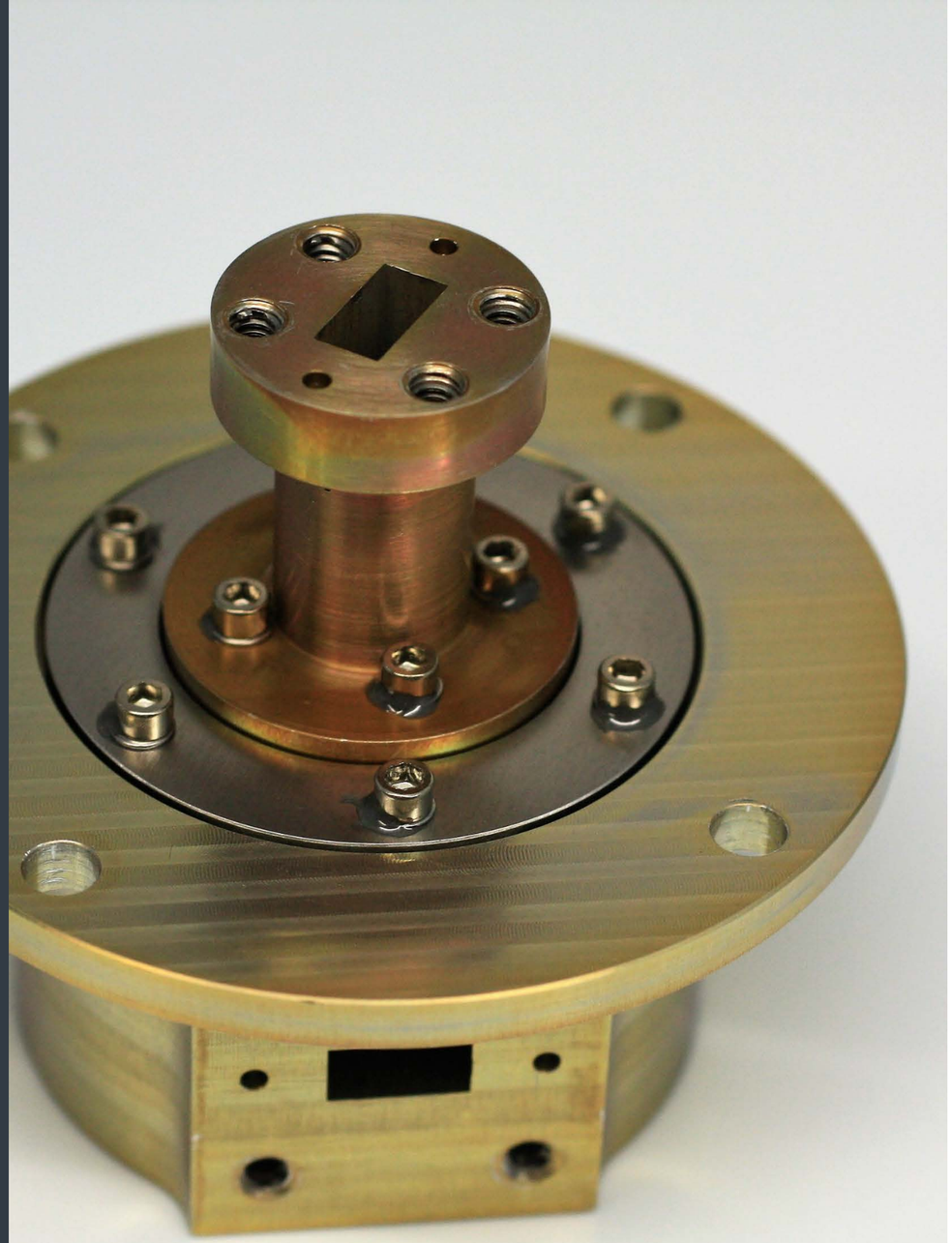
Dual Channel Coaxial Rotary Joint

Dual Channel SMA (non-contacting) U-Style

7.9 – 8.5 GHz



SINGLE CHANNEL WR-34



Single Channel Waveguide Rotary Joint

WR-34 L-Style

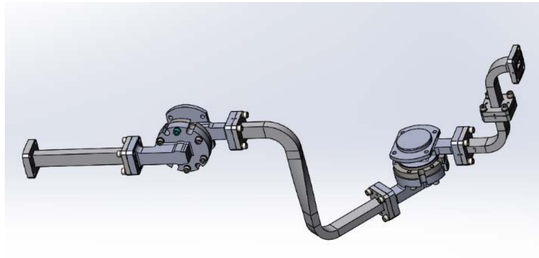
25.5 – 27.5 GHz

SINGLE CHANNEL - DUAL AXIS WR-34

Single Channel Dual Axis Rotary Joint

Dual Axis WR-34 with Integrated Waveguide

26.5 to 26.8 GHz

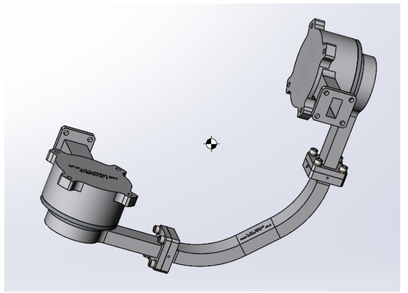


SINGLE CHANNEL DUAL AXIS WR-51

Single Channel Dual Axis Rotary Joint

Dual Axis WR-51 with Integrated Waveguide

20.2 to 21.2 GHz

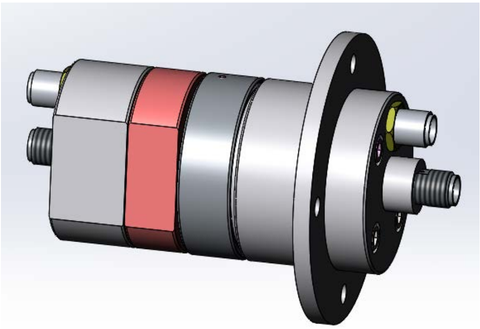


DUAL CHANNEL COAXIAL

Dual Channel Coaxial Rotary Joint

Dual-Channel SMA X-band Inline

7.9 – 8.5 GHz

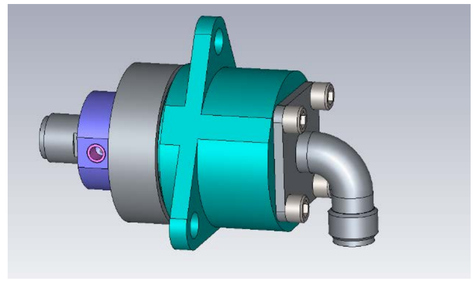


SINGLE CHANNEL COAXIAL

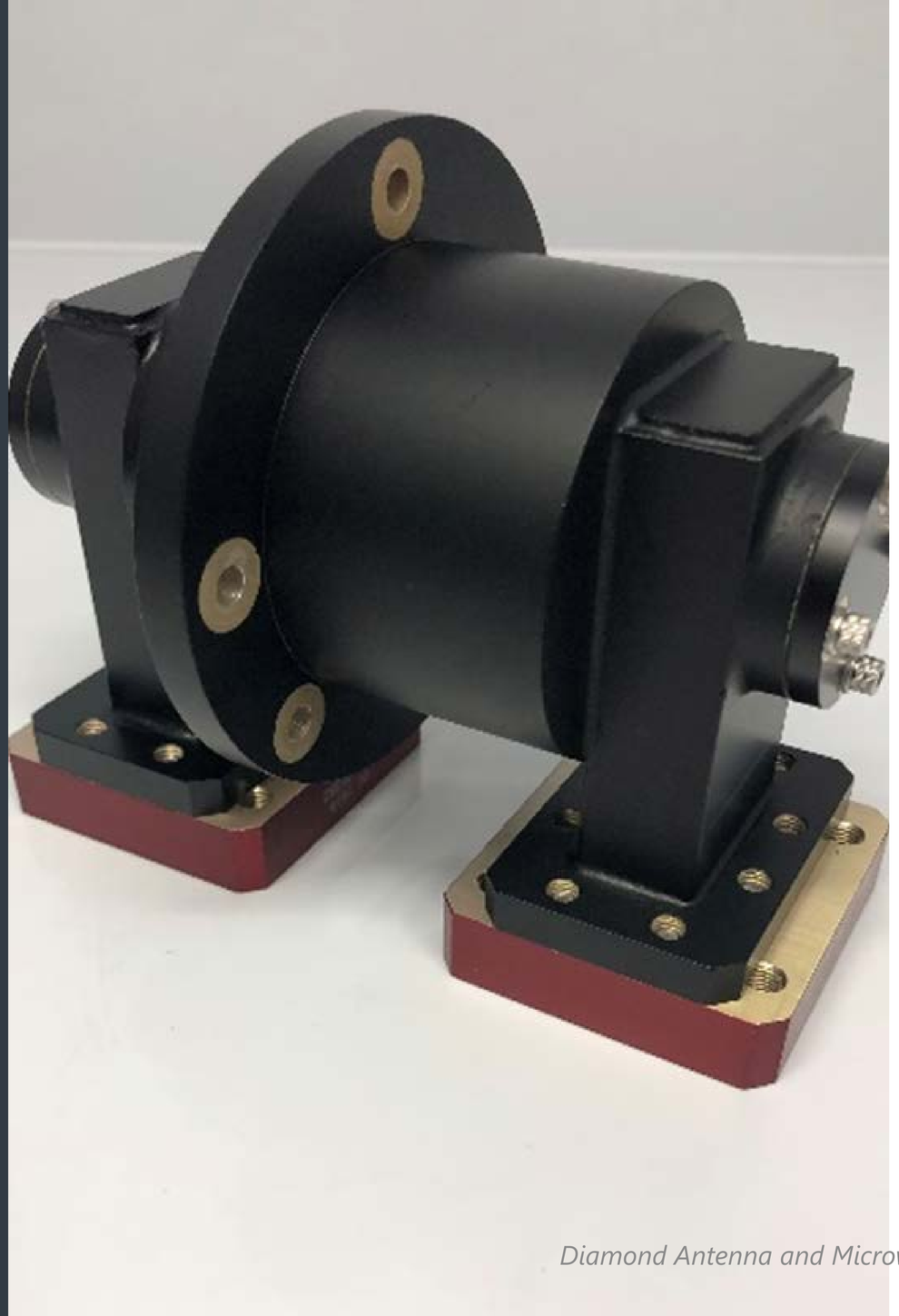
Single Channel Coaxial Rotary Joint

SMA L-Style Non-Contacting

7.9 – 8.5 GHz



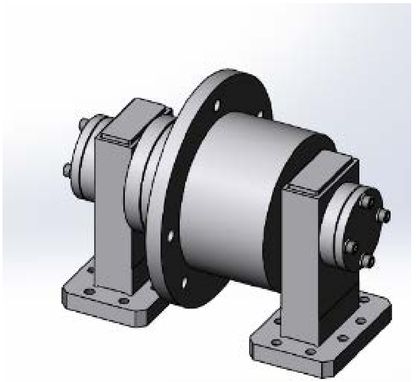
SINGLE CHANNEL WR-112



Single Channel Waveguide Rotary Joint

WR-112 U-Style

7.9 – 8.5 GHz



DESIGN OR PROGRAM QUESTIONS?

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Or visit our Space Products page

https://diamondantenna.com/market/space/