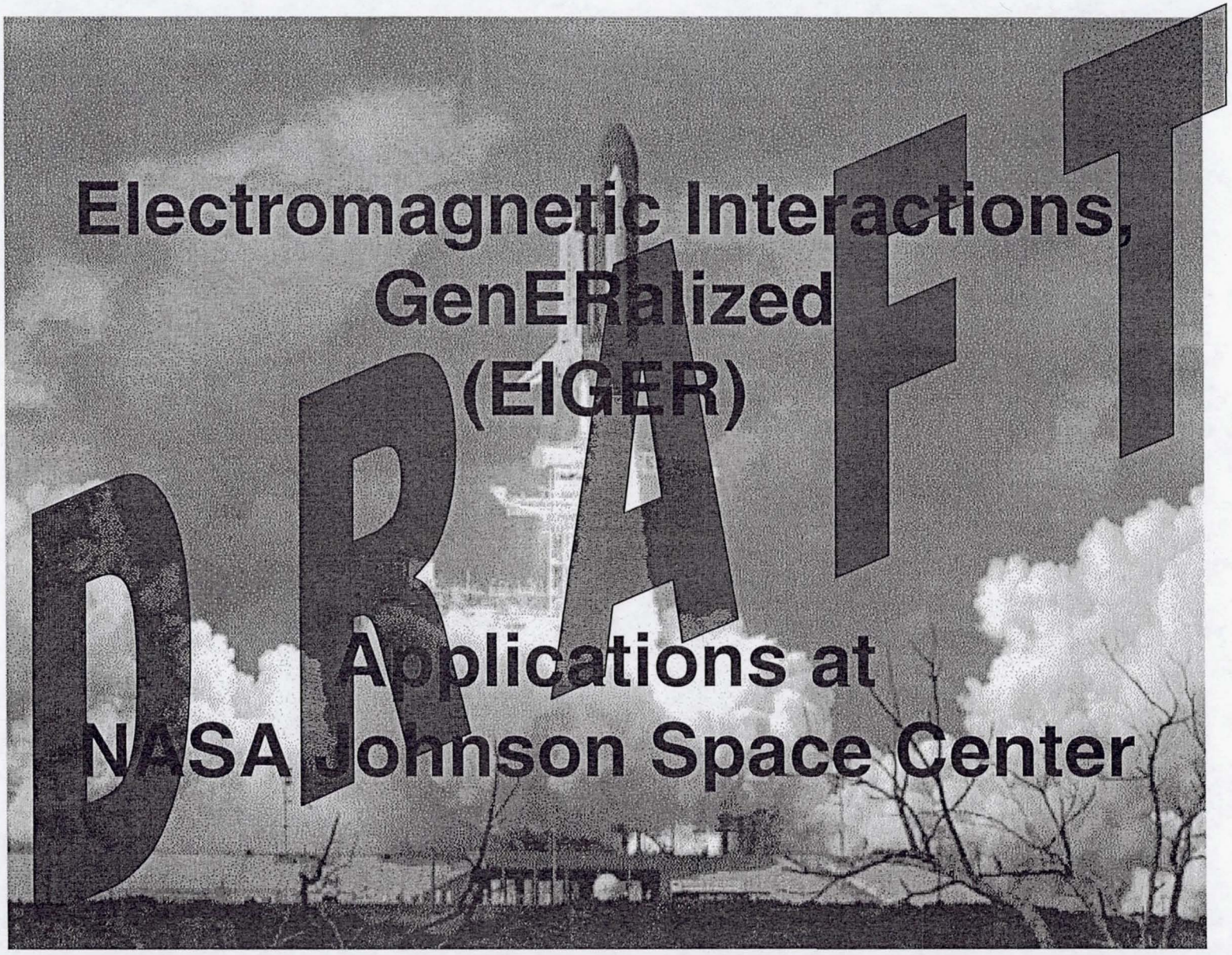


Electromagnetic Interactions, GenERalized (EIGER)

Applications at NASA Johnson Space Center

Contact Information

- Justin A. Dobbins, (281) 483-1498
- Dr. Patrick Fink, (281) 483-0973
- Robert C. Scully, (281) 483-1499

- 2101 NASA Road 1
  Building 14, M/S EV41
  Houston, Texas 77058-3696

Overview

- EIGER Background
- Recent Applications at NASA JSC
  - Antenna Coverage for Small Satellite (Mini-AERCam)
  - EMC/Antenna Analysis for MISSE5 (DoD Payload)
  - EMC and RF Analysis for VASIMR (Research)

EIGER Background

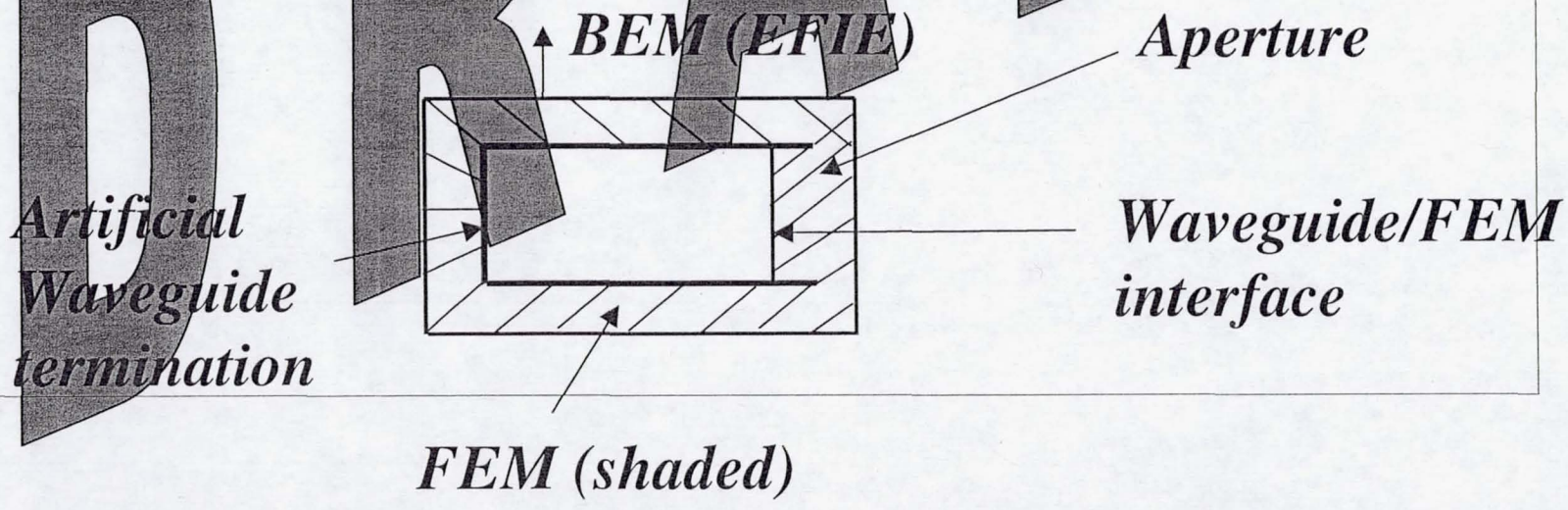
- Electromagnetic Interactions GenERalized
  - Software framework for the analysis and design of complex electromagnetic systems
    - hybrid finite element solutions for wave equations
    - boundary element solutions for integral equation formulations
  - Uses object-oriented design methods to abstract the key analysis components (elements, basis functions, etc.) and implemented in Fortran 90

EIGER Background

- Electromagnetic Interactions GenERalized
  - Multi - Institutional Development
    - Lawrence Livermore National Lab
    - Sandia National Labs
    - University of Houston
    - NASA Johnson Space Center
    - US Navy Space and Warfare Systems Center
    - ANT-S

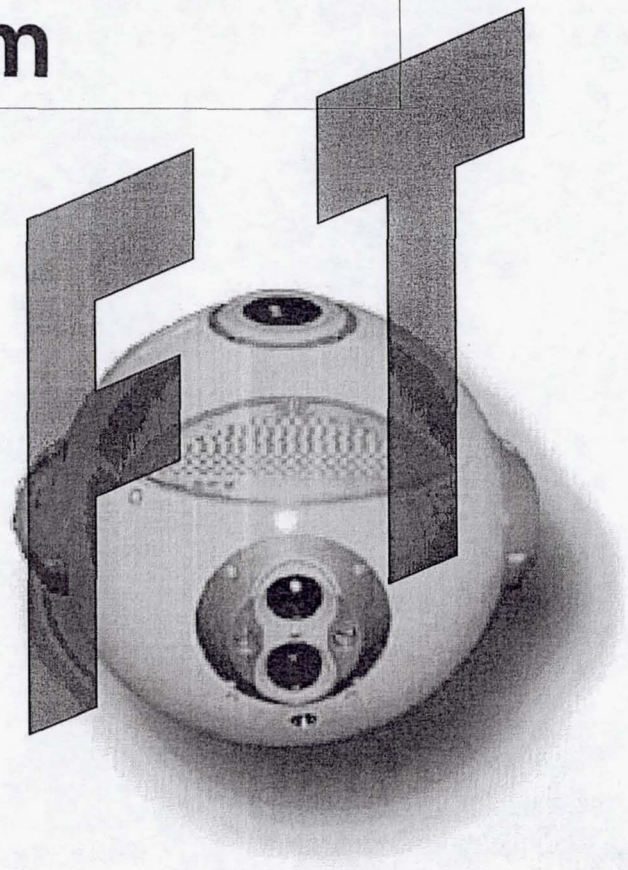
Higher Order Modeling Applied to Antenna Analysis

- Antenna type: open-ended circular waveguide (D=1λ)
  - **Measured data from *Antenna Engineering* (1st edition), Henry Jasik, editor, McGraw-Hill, 1961.**
  - **Modeled with hybrid BEM/FEM formulation by Zuffada, Cwik, Jamnejad (*IEEE AP Trans.*, Vol. 45, 1997)**



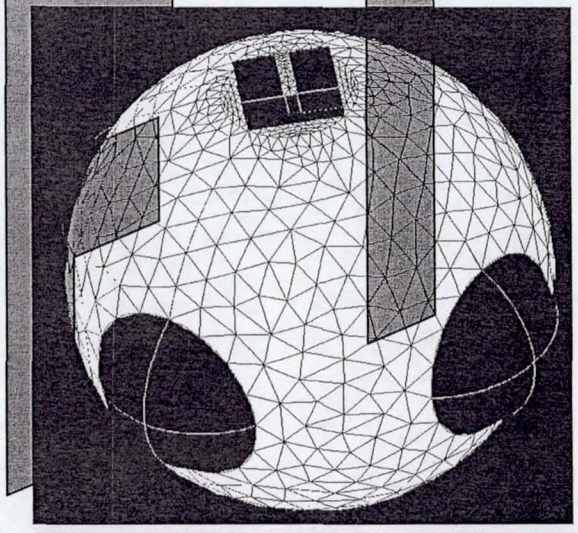
Mini-AERCam

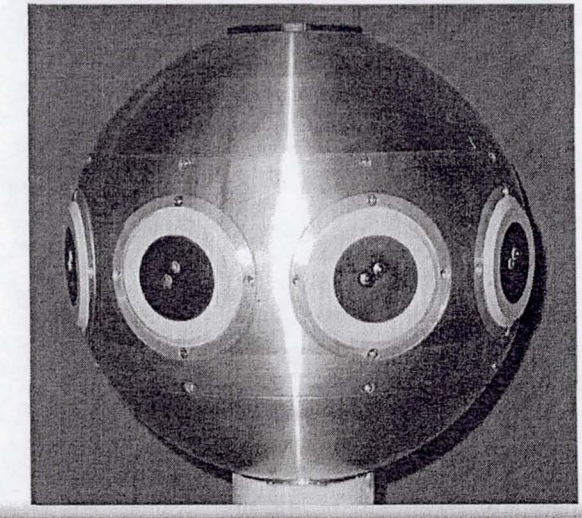
- **Mini-AERCam – free flying vehicle**
  - 7 ½ inch diameter
  - Originally conceived as supporting International Space Station Operations
  - Currently being considered to aid on-orbit inspection of Shuttle tiles
- **Capabilities**
  - Inspection and viewing missions
  - Tele-operation and autonomous control modes
  - Relative GPS positioning
- **POC for Further Information:**
  - Dr. Steven Fredrickson (281) 483-1457



Mini-AERCam Antenna Coverage

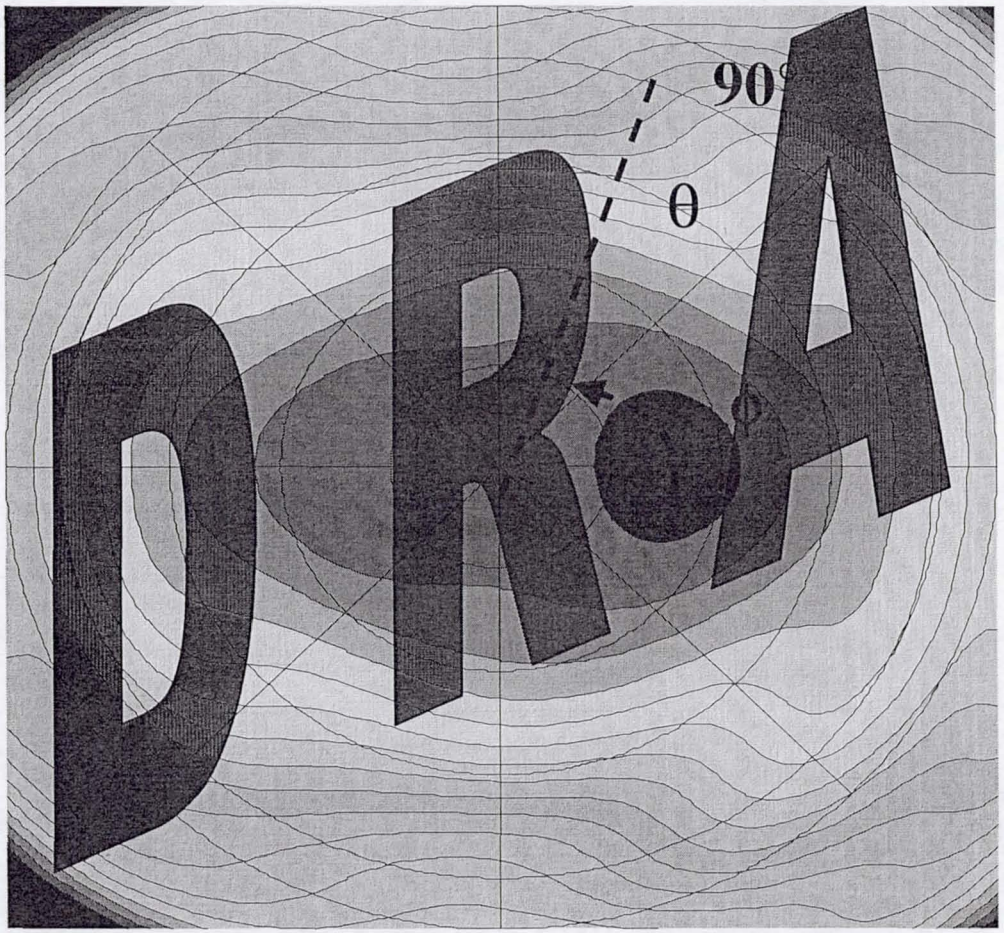
- **Computational Model**
  - ¼ - wave capacitively fed patch antenna (2.33 GHz)
  - 7.5" dia. sphere w/ 4 x PEC thruster pods
  - Method: Hybrid BEM/FEM
- **Test Model**
  - ¼ - wave capacitively fed patch antenna (2.44 GHz)
  - 7.5" dia. sphere w/ 8-element GPS array (1.575 GHz)

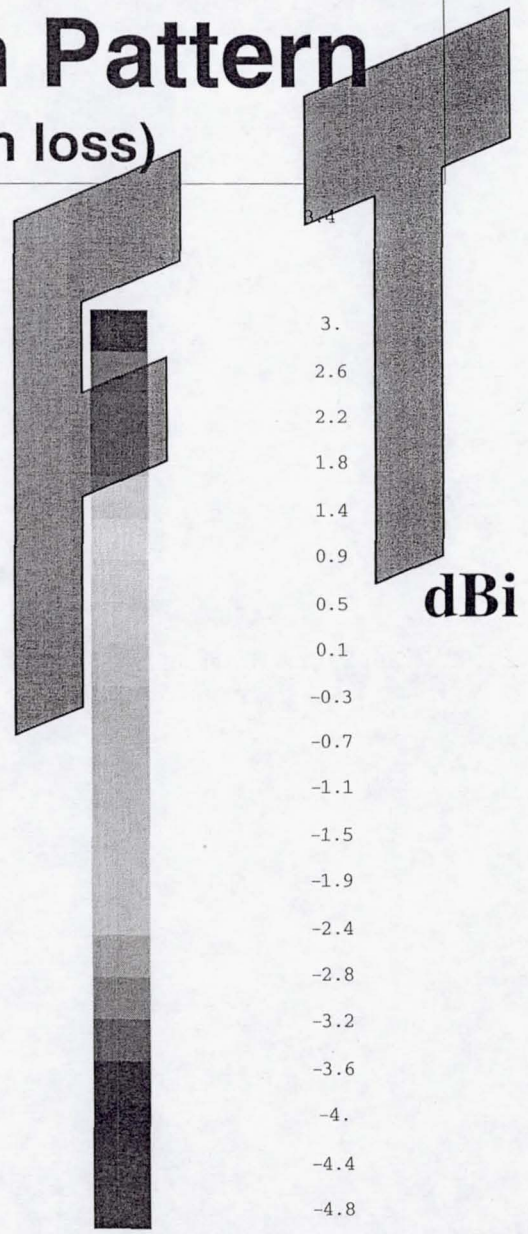




Front Side Radiation Pattern

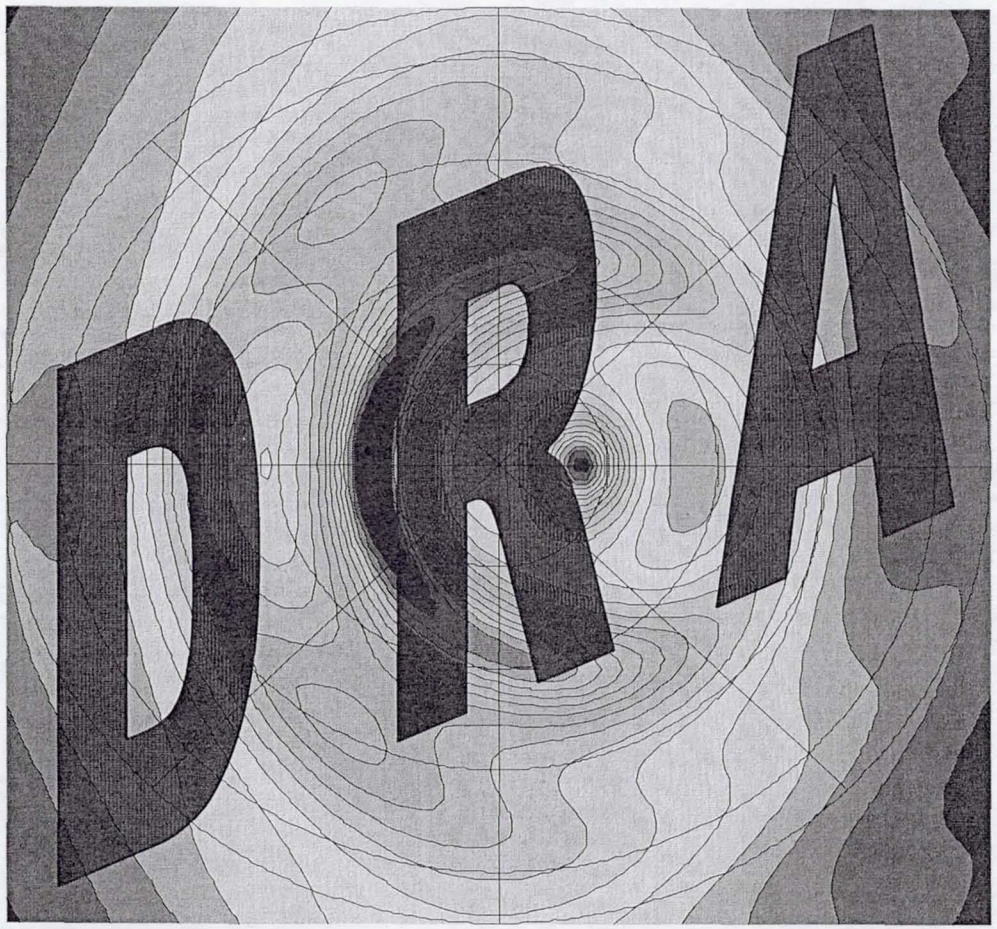
(assumption: no polarization loss)





Back Side Radiation Pattern

(assumption: no polarization loss)

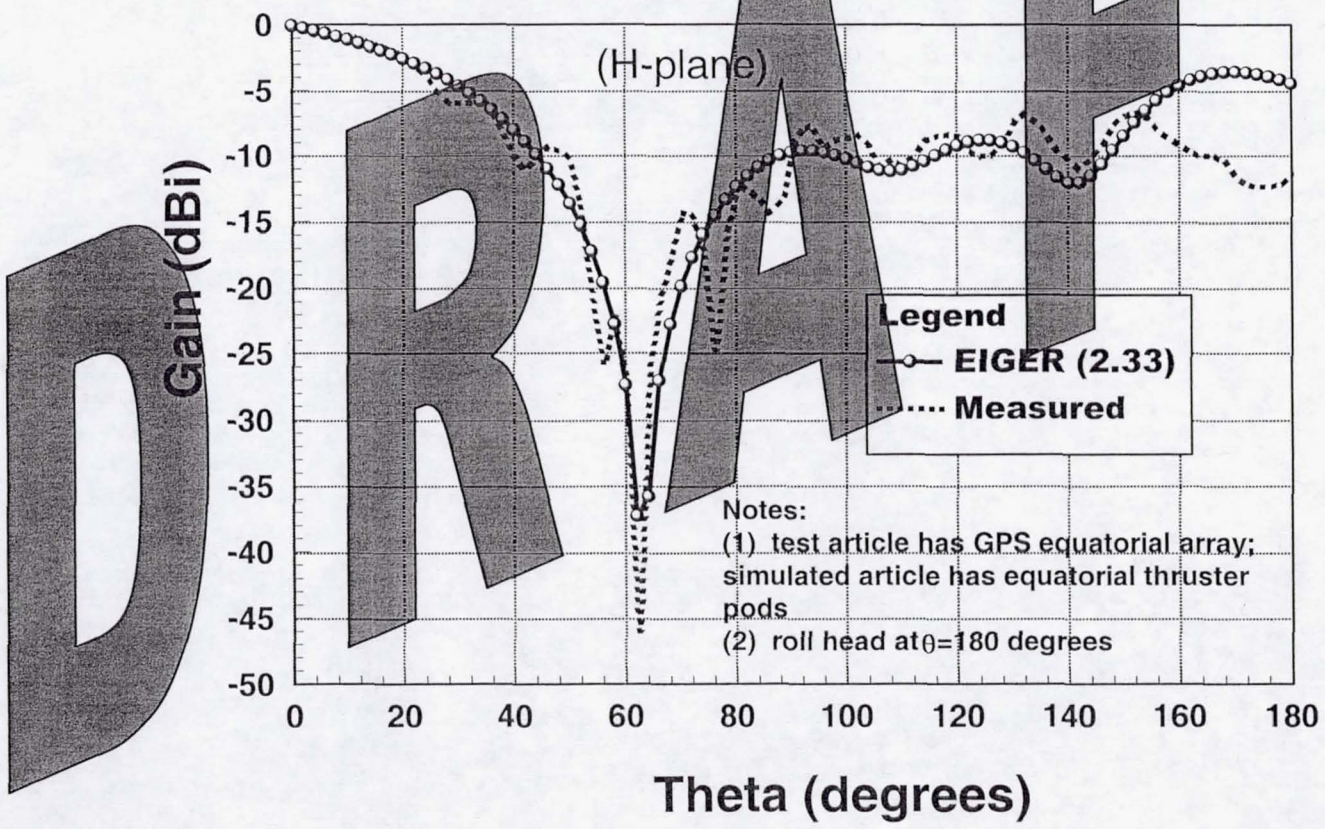


Peak Gain : 1.9

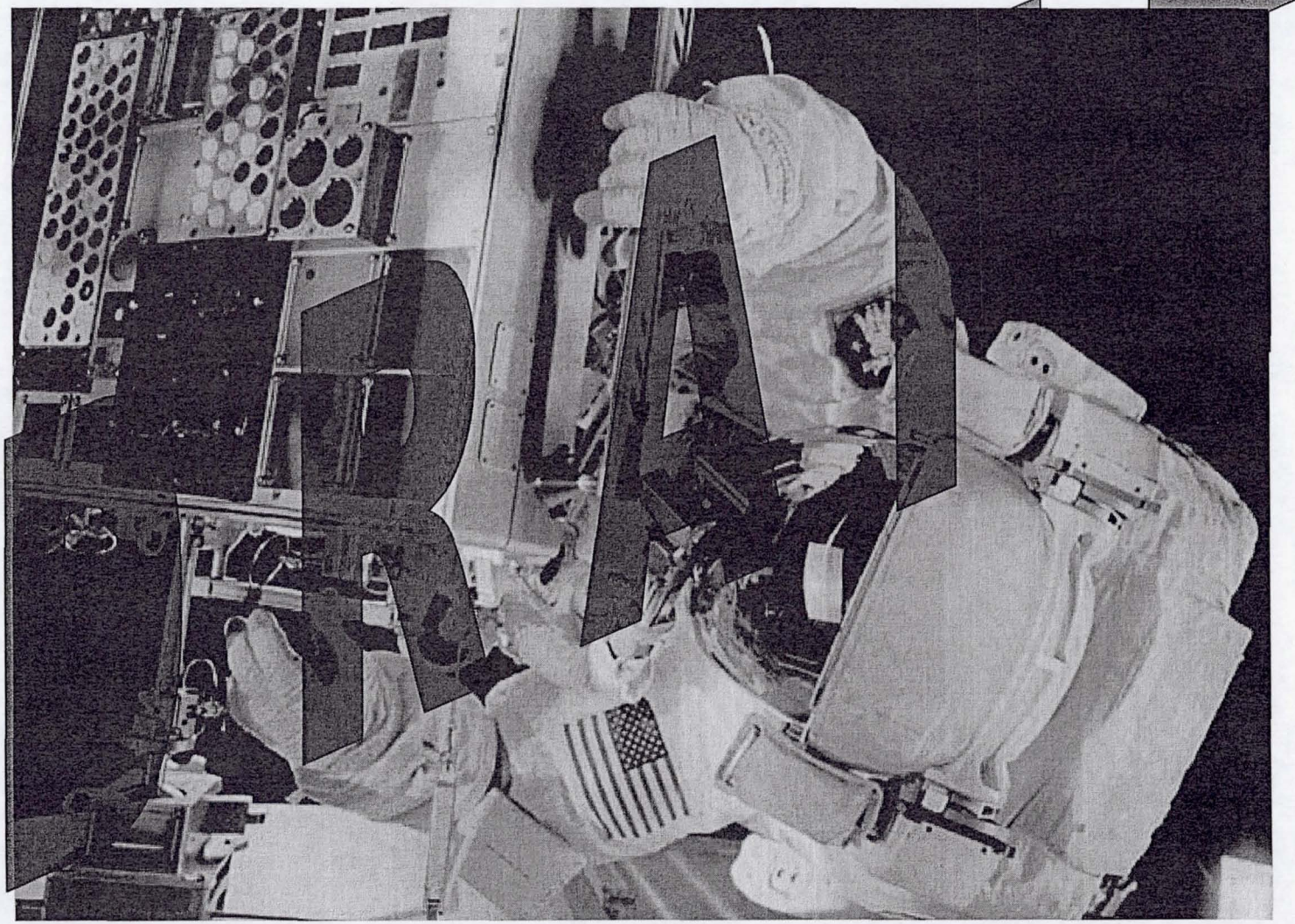
1.1
0.4
-0.3
-1.1
-1.8
-2.5
-3.3
-4.
-4.7
-5.5
-6.2
-6.9
-7.7
-8.4
-9.1
-9.9
-10.6
-11.3
-12.1
-12.8

dBi

Simulated and Measured Responses (R/H Circular Polarization)

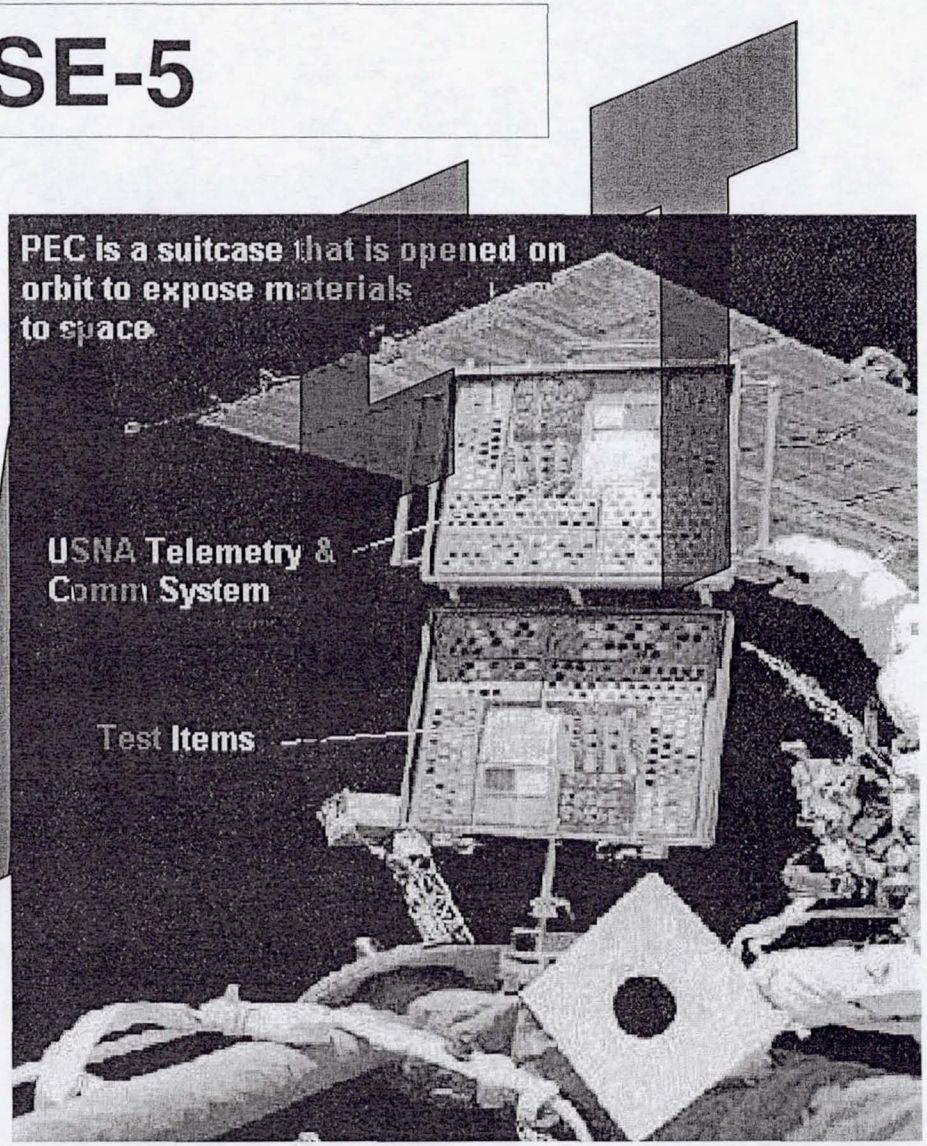


MISSE-5



MISSE-5

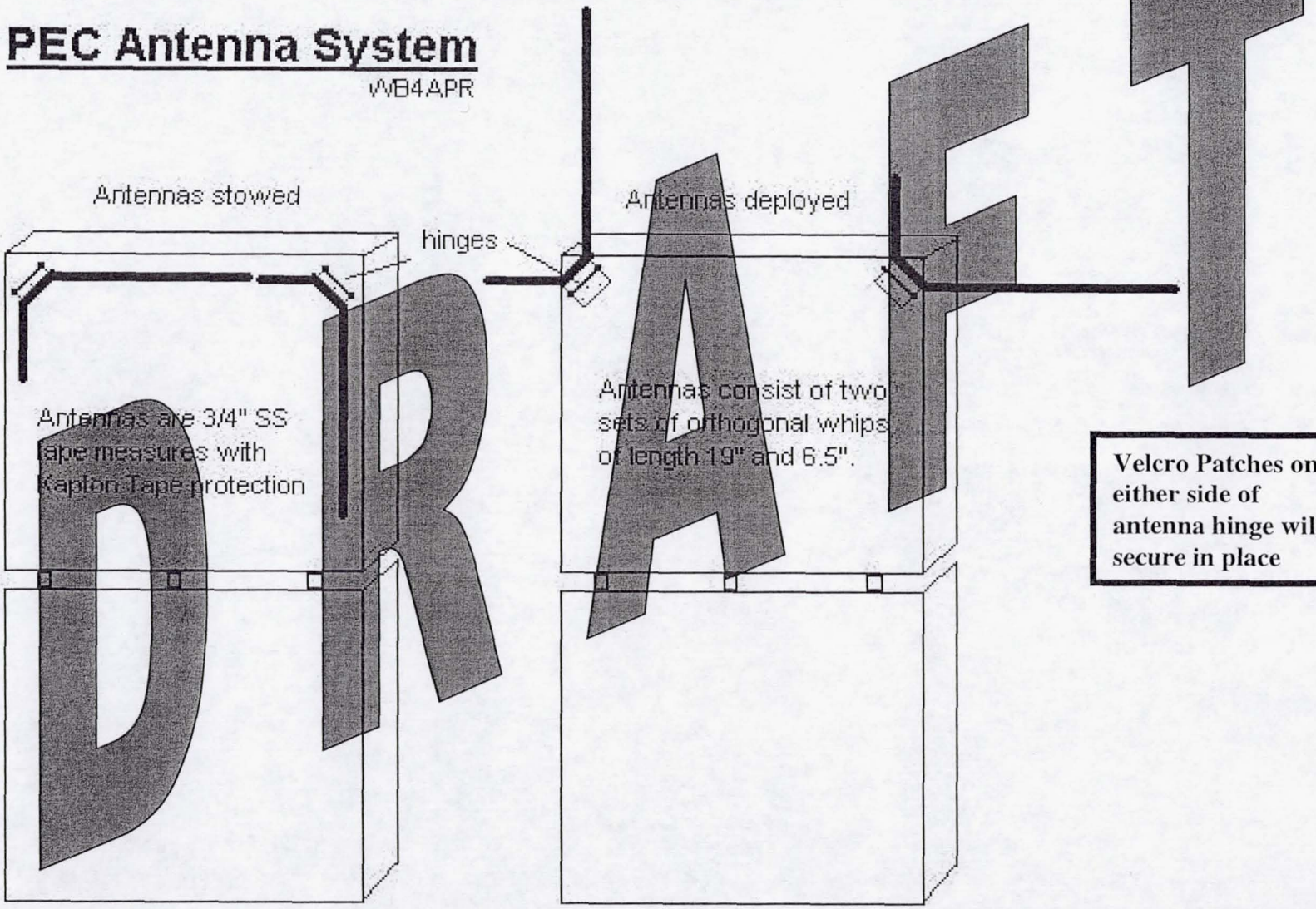
Materials International Space Station Experiment (MISSE) uses a Passive Experiment Container (PEC) to fly space environment samples to space and back. It has flown 4 times including a year on MIR as MEEP. It is attached to the exterior of the ISS during an EVA to expose its samples to space. For MISSE5, these samples are high-tech DOD solar cells on the side of MISSE that faces the sun. On the back side, the Naval Academy has an opportunity to add an Amateur Satellite Communications system similar to what it is flying on PCsat as an external ARISS payload.



MISSE-5

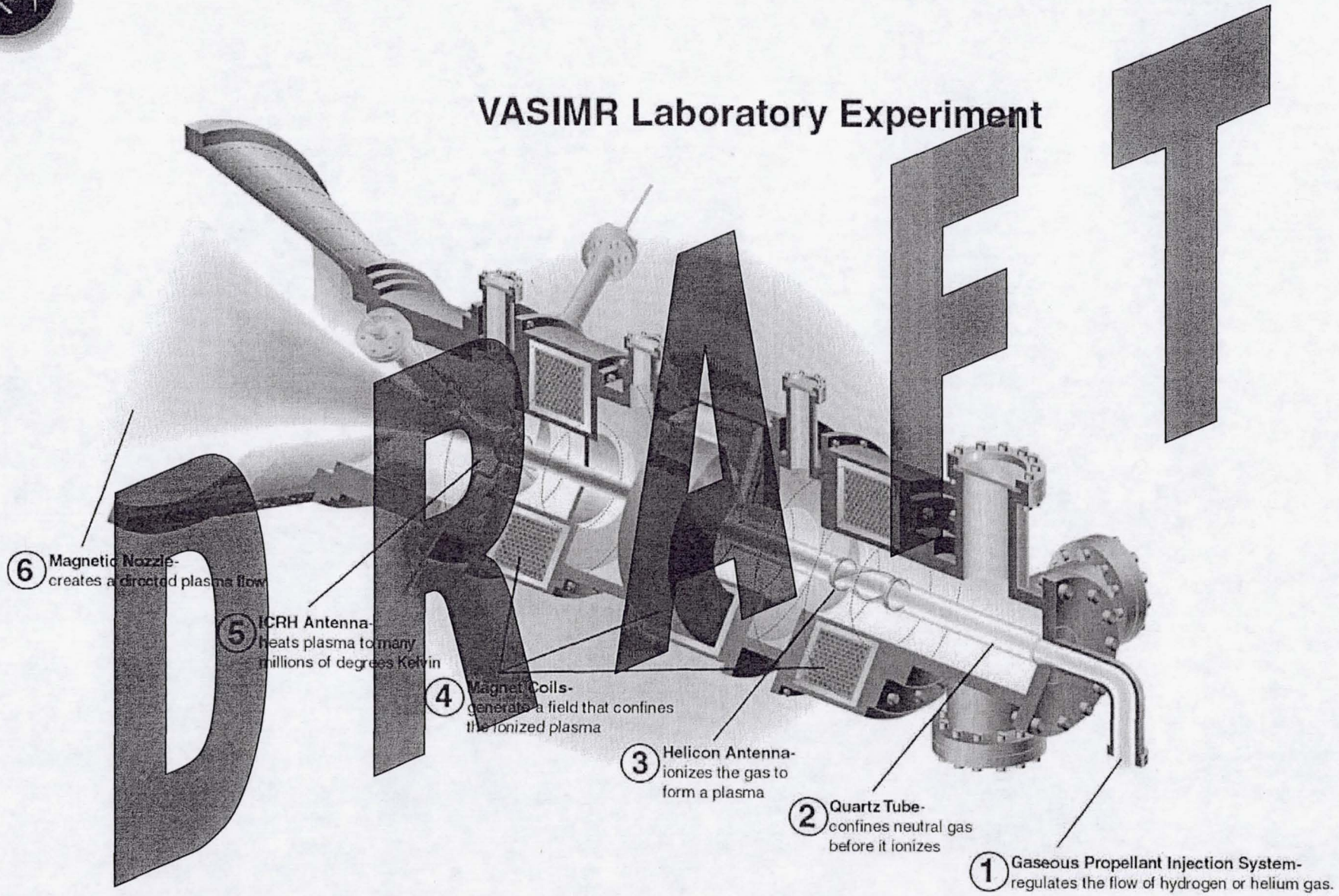
PEC Antenna System

VWB4APR



Velcro Patches on either side of antenna hinge will secure in place

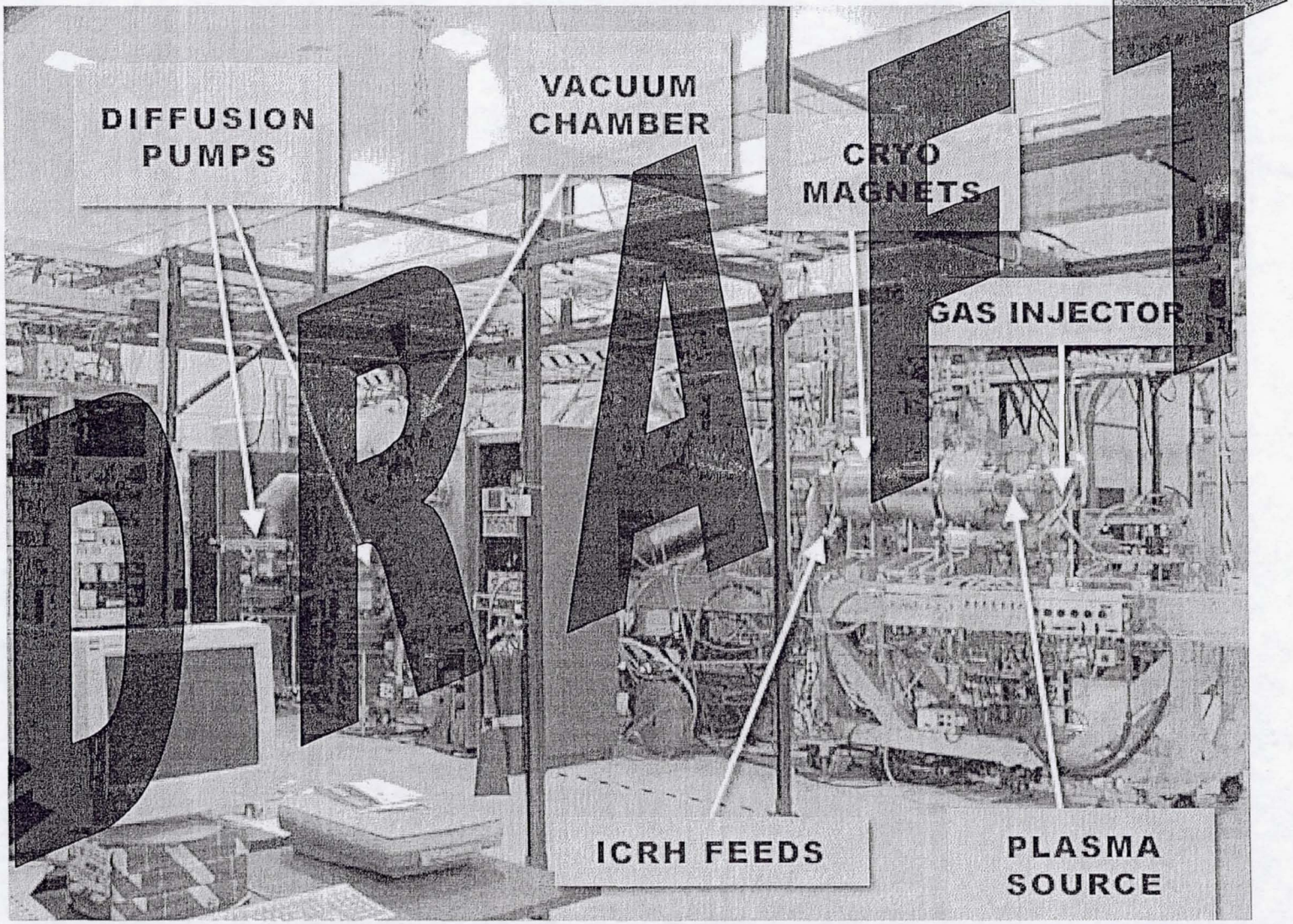
MISSE-5


VASIMR Laboratory Experiment
DRAFT
6 Magnetic Nozzle- creates a directed plasma flow
5 ICRH Antenna- heats plasma to many millions of degrees Kelvin
4 Magnet Coils- generates a field that confines the ionized plasma
3 Helicon Antenna- ionizes the gas to form a plasma
2 Quartz Tube- confines neutral gas before it ionizes
1 Gaseous Propellant Injection System- regulates the flow of hydrogen or helium gas.

VASIMR

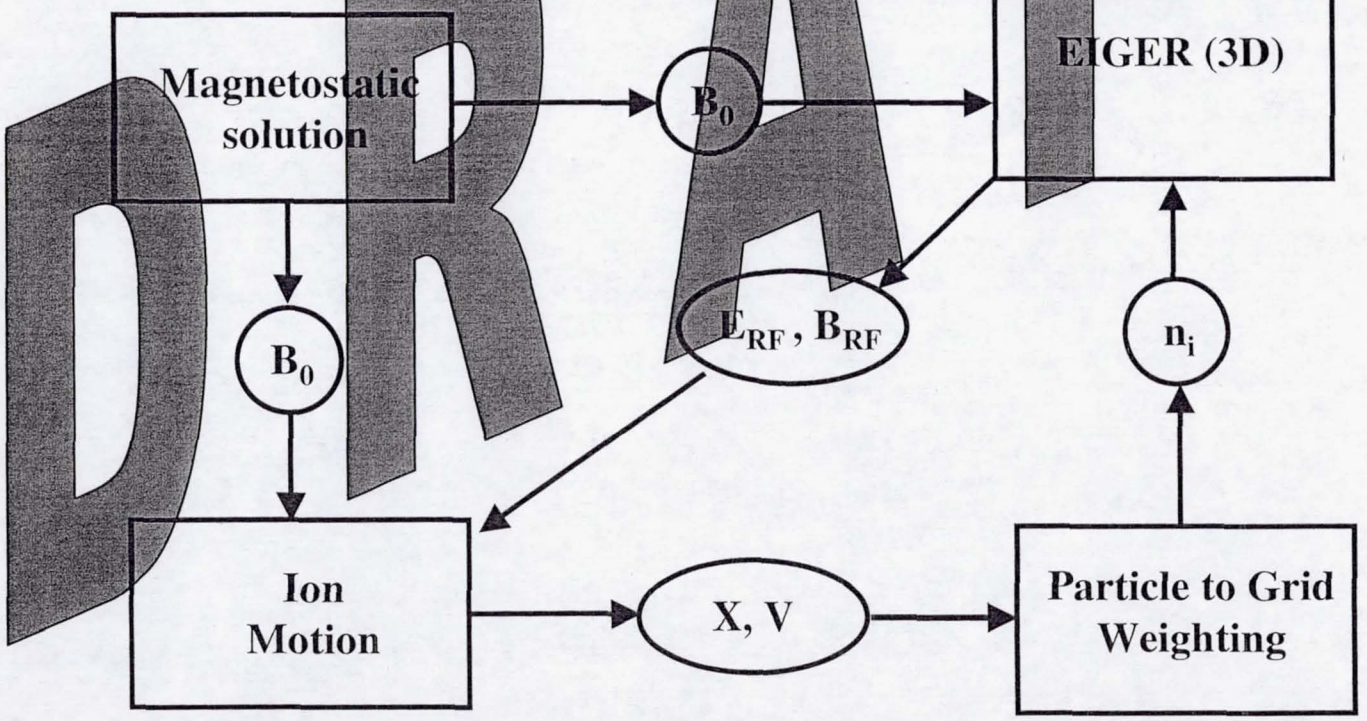
- VAriable Specific Impulse Magnetoplasma Rocket
  - Advanced Engine Uses Plasma to Provide Thrust
- Three Stages
  - Plasma Generation
    - 25 MHz or 50 MHz @ 3 kW < P > 6 kW
    - Uniform Magnetic Flux Density, approx 0.1 Tesla
  - Heating/Acceleration
    - 1.5 MHz < f > 3.0 MHz, @ 6 kW (10 kW in near term)
    - Strong Magnetic Flux Density
      - Two electromagnets
        - approx 1.0 Tesla
        - approx 0.5 Tesla
  - Magnetic Nozzle
    - Contains and Directs Superheated Plasma

VASIMR


DIFFUSION PUMPS
VACUUM CHAMBER
CRYO MAGNETS
GAS INJECTOR
ICRH FEEDS
PLASMA SOURCE
DRAFT

VASIMR

- **EIGER May Be Used to Model the Ion Cyclotron Resonant Heating Stage**
  - Cavity & Antenna Element Currently Being Modeled
  - Higher Order Elements and Basis Fns Will Be Employed



VASIMR

- Because of the interrelationship of the high power RF, the strong magnetic flux density, and the resultant potential for interference, the Antenna and EMC Groups will be working very closely to achieve a smooth transition to higher power scenarios desired by the Project.

VASIMR

- POC for Further Information:
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    (281) 792-5673
  - Dr. Andrew Ilin
    (281) 792-5675
  - Andrew Petro
    (281) 792-5676