Phased Arrays of Ground and Airborne Mobile Terminals for Satellite Communications

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ABSTRACT

Phased array antenna is begining to play an important role in the arena of mobile/satellite communications. As a ground and airborne terminal antenna, it offers the advantages of beam agility for providing coverage of multiple satellites, conformal mounting ability for aerodynamic consideration and aesthetic appearance, and graceful degradation in performance for better reliability. However, the phased array antenna suffers from high manufacturing cost (especially for commercial application), low power efficiency, and limited beam coverage area. Two examples of mobile terminal phased arrays will be shown. One is the L-band land vehicle antenna and the other is the 20/30 GHz NASA ACTS airborne terminal antenna. Their technical background, challenges, and cost drivers will be discussed. A possible solution to combat some of the deficiencies of the conventional phased array by exploiting the phased reflectarray technology will be briefly presented.

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- **The reasons for higher-gain mobile antennas:**
  - Limited satellite power (approx. 20 W RF)
  - Long communication range for Geo satellites
  - Large propagation losses at higher frequencies
- **Applications:**
  - Mobile phone and video, DBS, military, etc.
- **Types of higher-gain mobile antennas:**
  - Mechanically steered
    - Parabolic reflector
    - Fixed-beam passive or active array
  - Electronically steered
    - Switchable array
    - Phased array

- **Advantages of Phased Arrays**
  - Beam agility for multiple satellites
  - Conformal mounting for aerodynamic consideration, aesthetic appearance and low observable
  - Performance graceful degradation

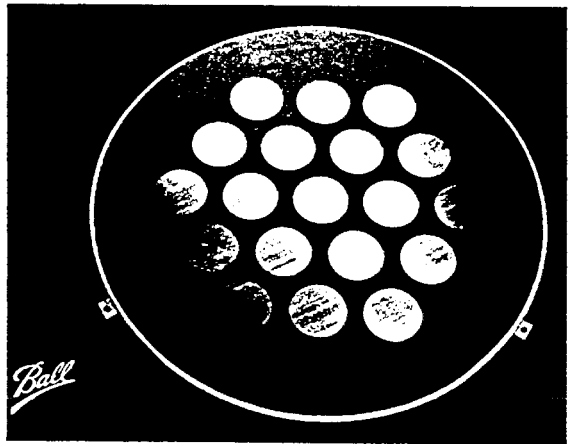
- **Disadvantages of phased array**

  High cost for commercia application
  - Low power efficiency, generally
  - High scan loss with limited beam coverage

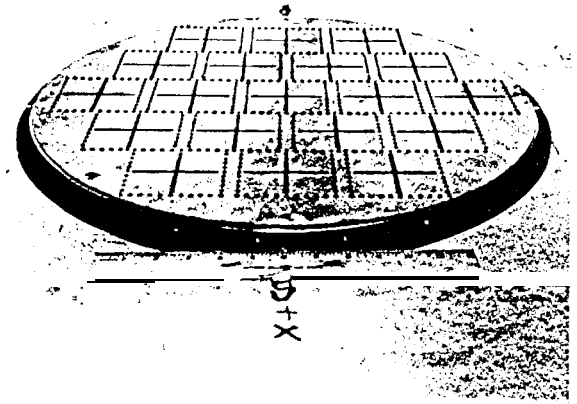
Examples of Mobile Phased Arrays

- L-band land vehicle phased arrays (MSAT and Toyota)
- L-band aircraft phased array (AIRLINK)
- Ka-band MMIC active array (ACTS)
- Ka-band MMIC phased array (ACTS)

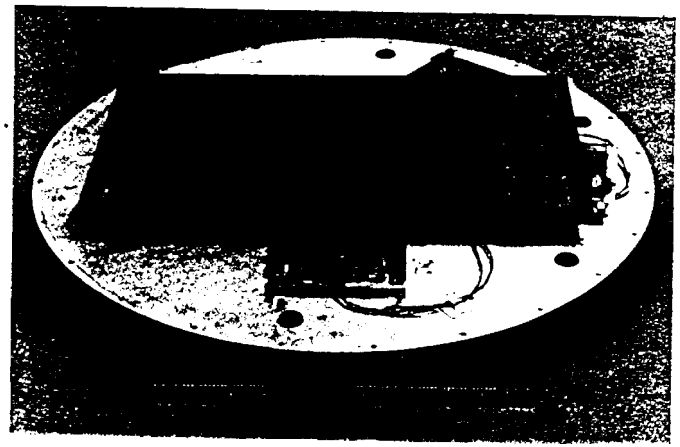
JPL L-BAND MSAT VEHICLE ANTENNAS



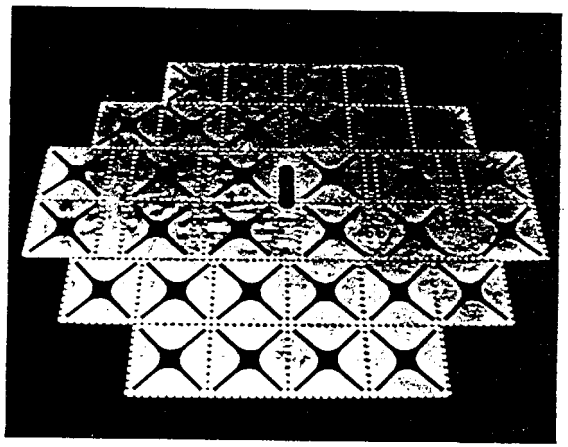
PHASED ARRAY BALL)



PHASED ARRAY (TELEDYNE)



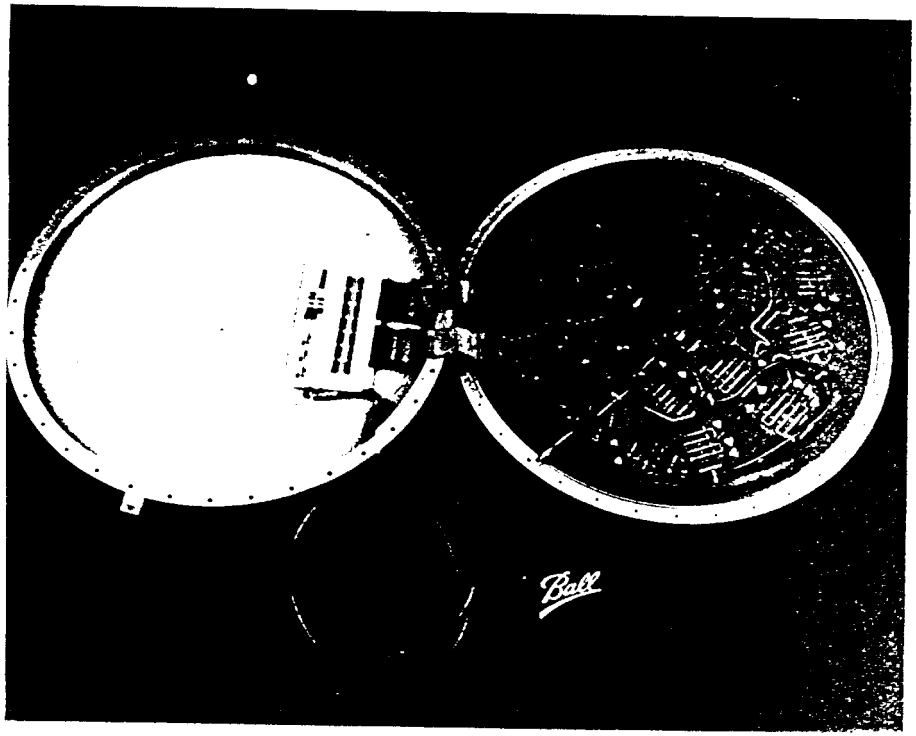
LOW PROFILE MECHANICALLY STEERED ANTENNA



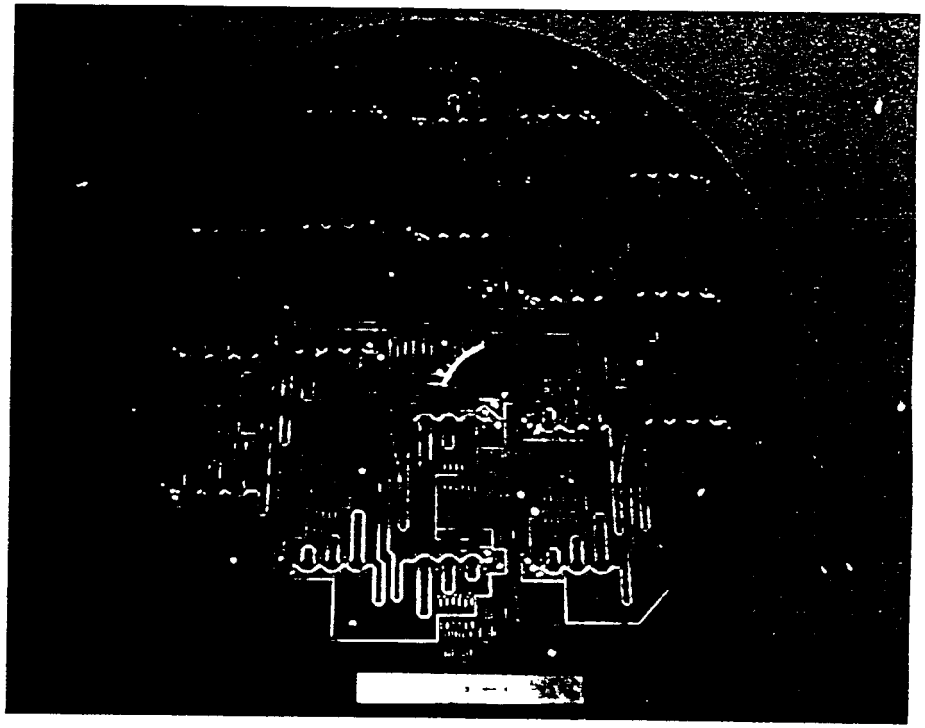
HYBRID ELECTRONIC/MECHANICAL STEERED ARRAY

JPL

PHASED ARRAY ANTENNA
PHASE SHIFTER AND POWER DIVIDER LAYER

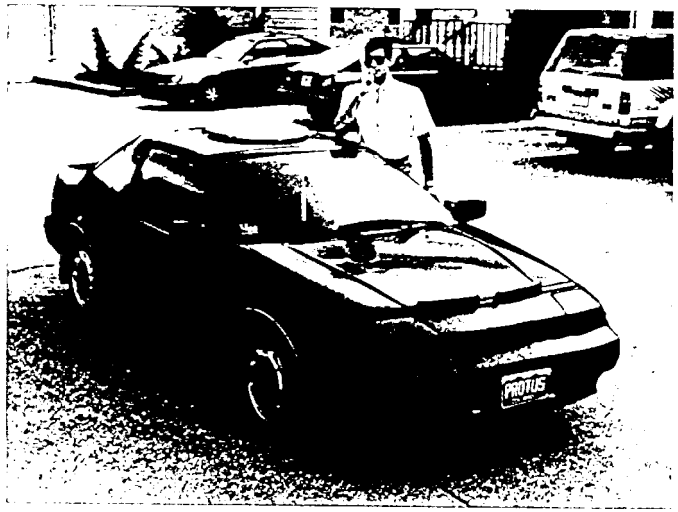


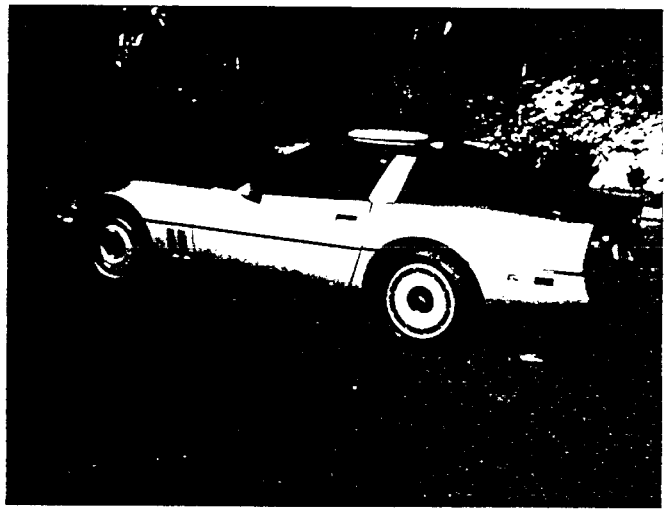
BALL



TELEDYNE

JPL MSAT-X PHASED ARRAY ANTENNAS





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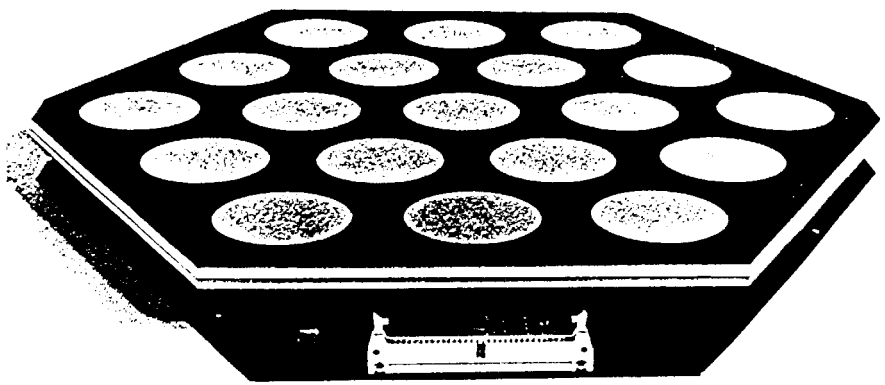
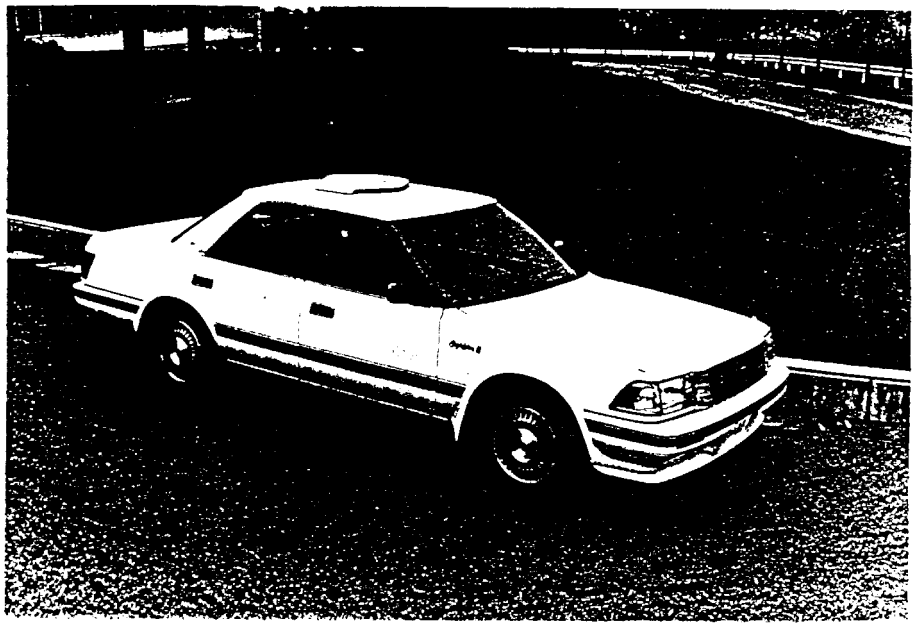
Toyota Central R&D Labs
L-Band Mobile Phased Array





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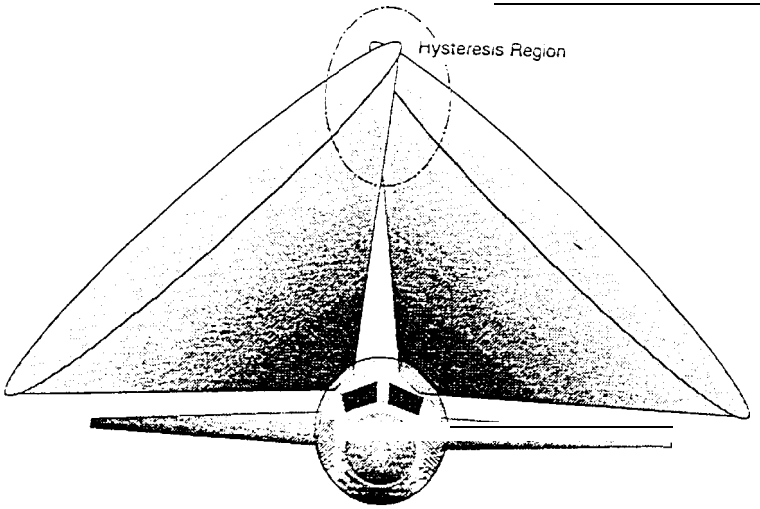
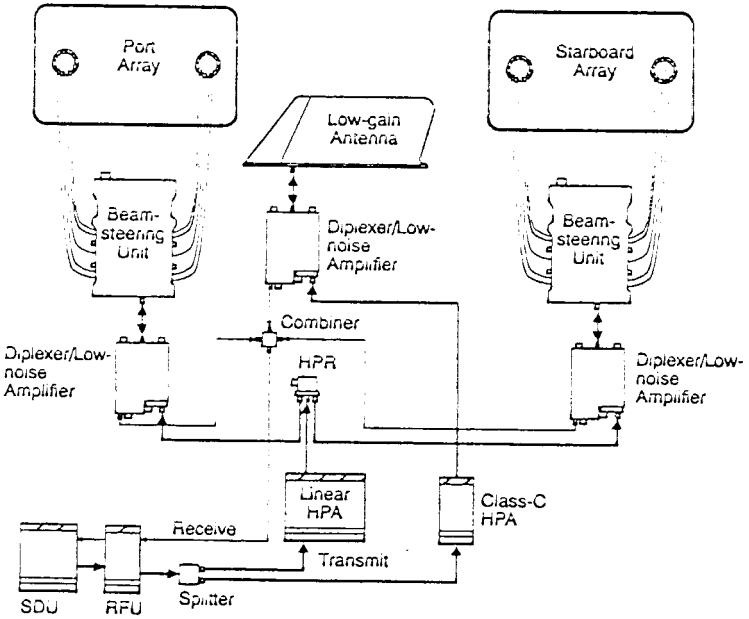
AIRLINK by Ball Corp
L-Band Aircraft Phased Array





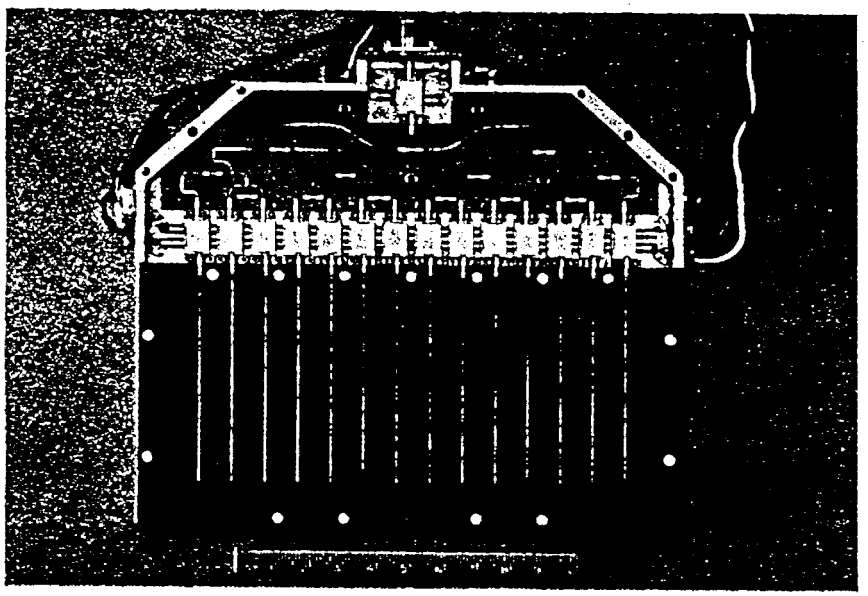
Ka-Band MMIC Active Array

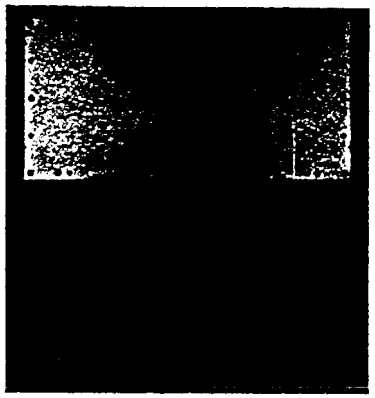
ACTS NI06TTETETEMINAT

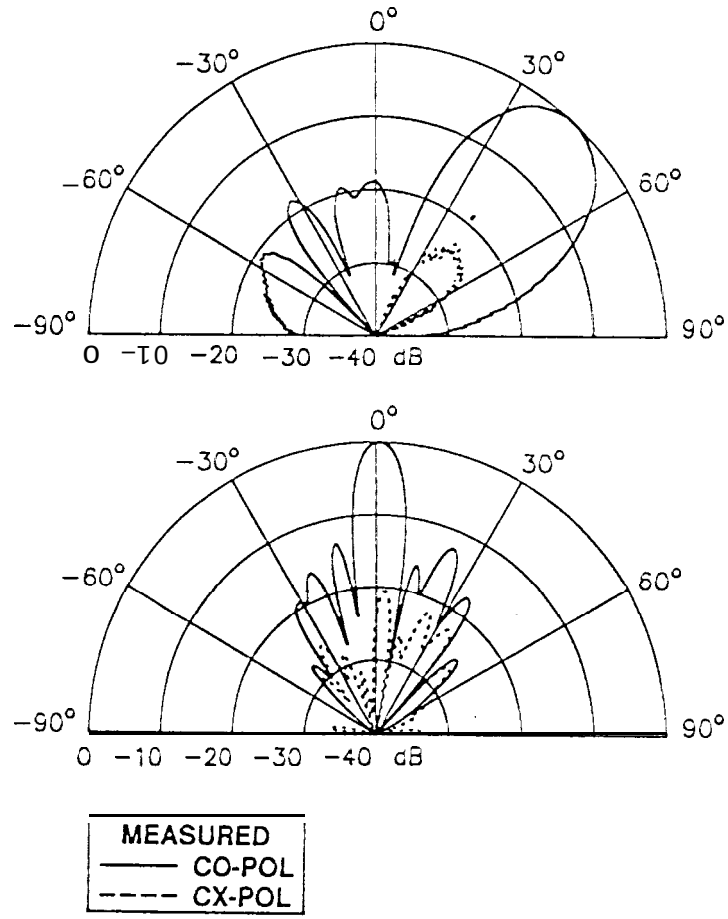
JPL

ACTIVE RECEIVE SLOT ARRAY

- FREQUENCY: 20 GHz, POLARIZATION: VERTICAL
- COMPACT DESIGN APPLICABLE TO FUTURE ULTRA-SMALL SATETTTTEE0NIMIJNTEAIION TERMINALS WITH GOOD HIGH VOLUME PRODUCTION POTENTIAL
- MEASURED G/T: –6.4 dB/K

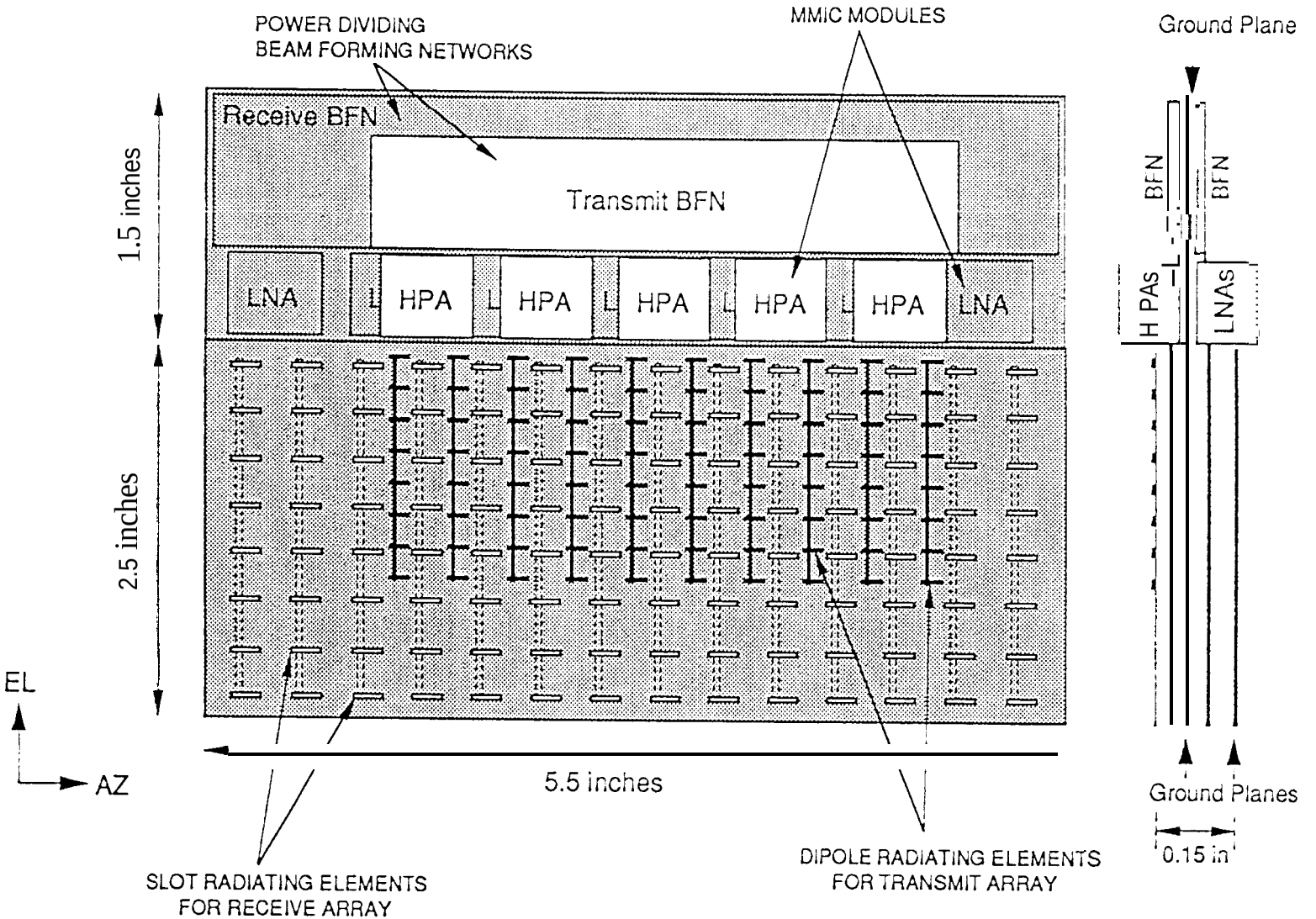




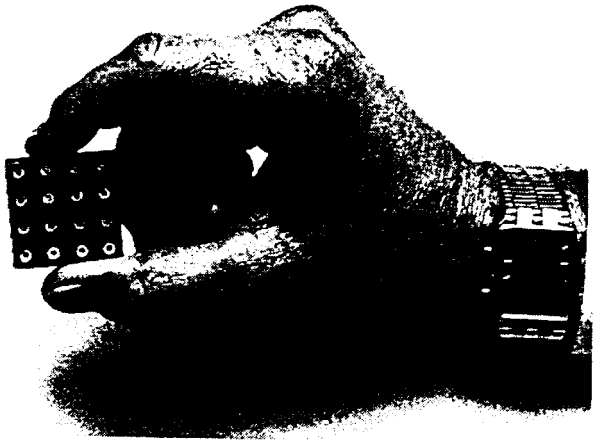


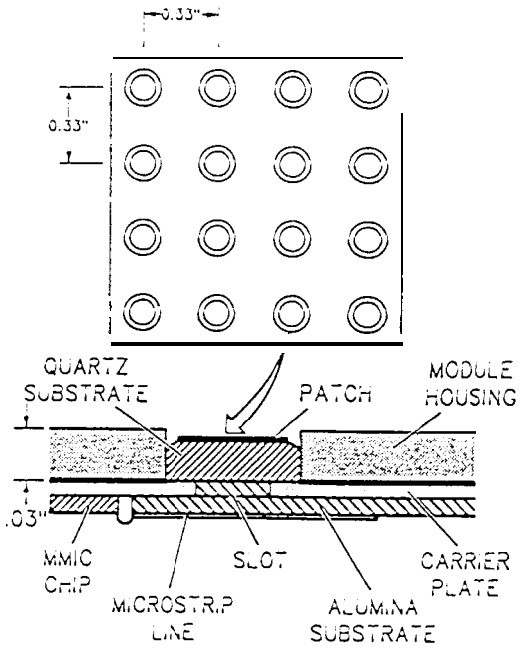
Ka-Band Active Array for ACTS Mobi e Termina

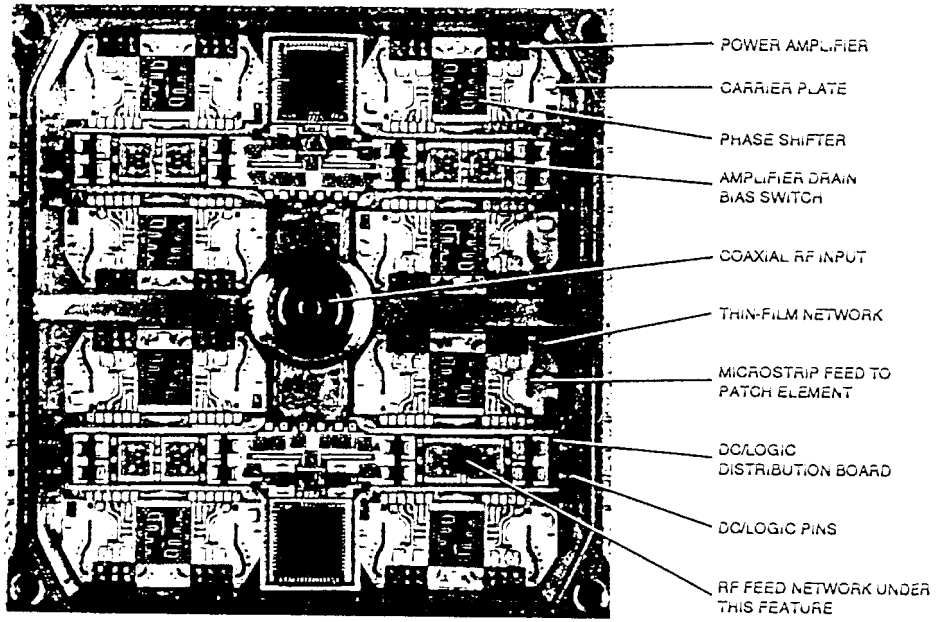
Dual-Frequency Shared Aperture Multilayer Printed Dipoles and Slots



Ka-Band MMIC Phased Array for ACTS Mobiel Terminal
by Texas Instrument/NASA Lewis

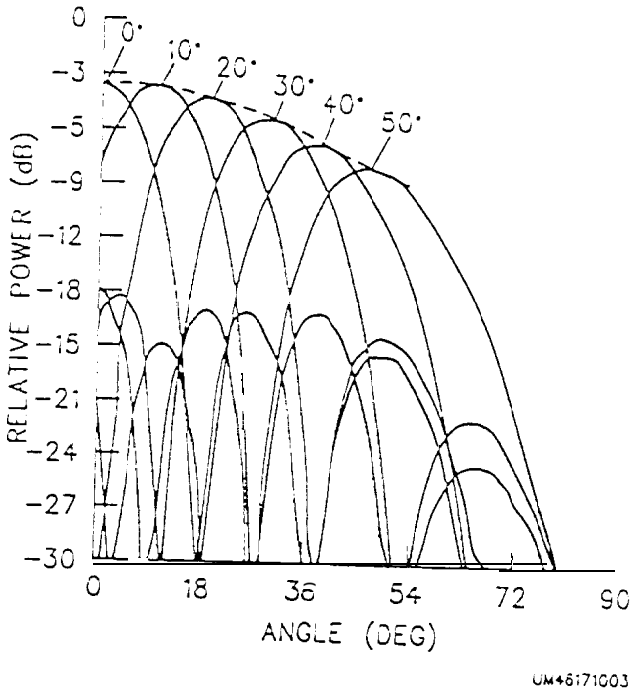




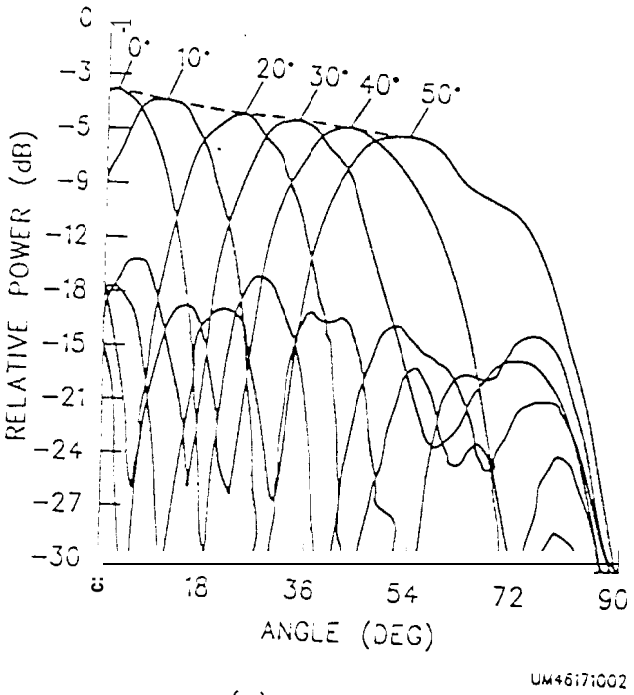


Ka-Band MMIC Phased Array for ACTS Mobile Terminal
by Texas nstrument NASA Lew s

Measure 4x4 Subarray Beam-Scan Patterns



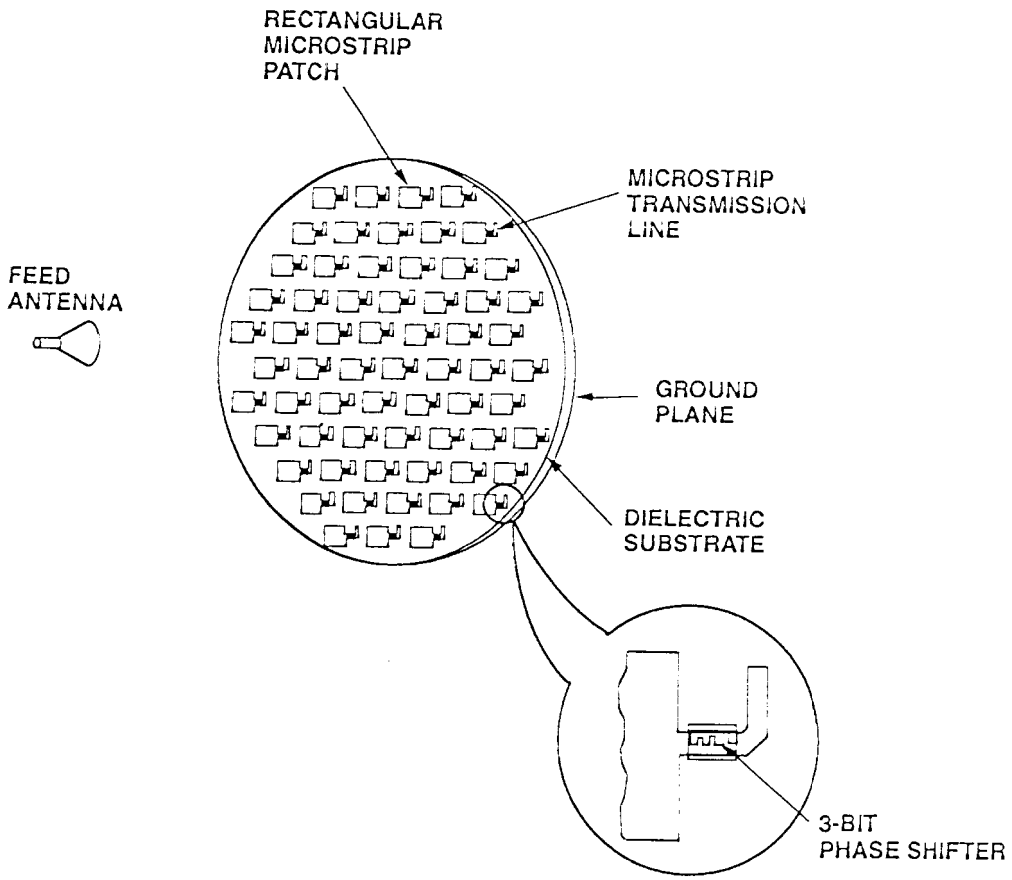
(a) H-Plane

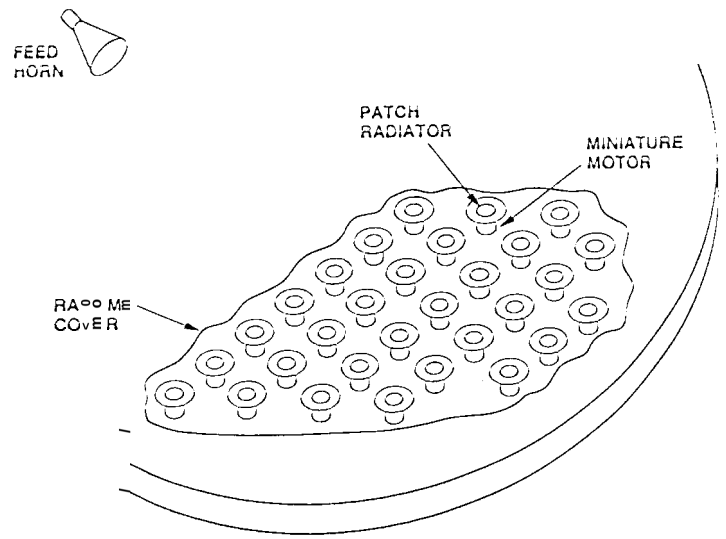


(b) E-Plane

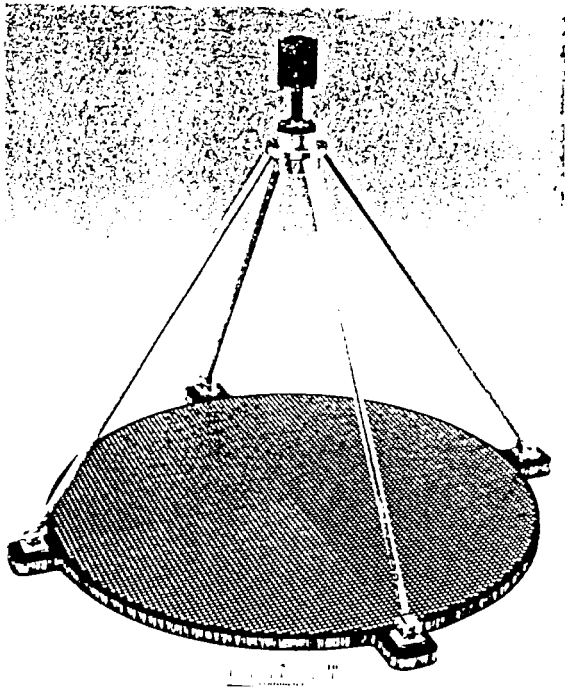
Phased Reflectarray

Beam scanning by micro-machined phase shifters or motors

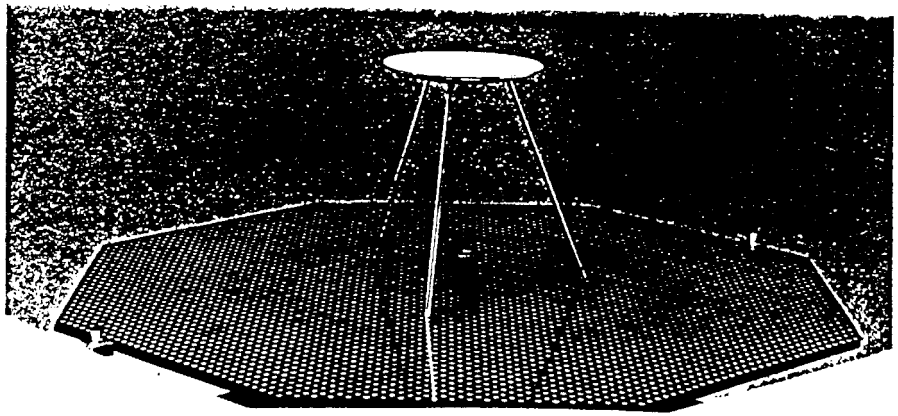




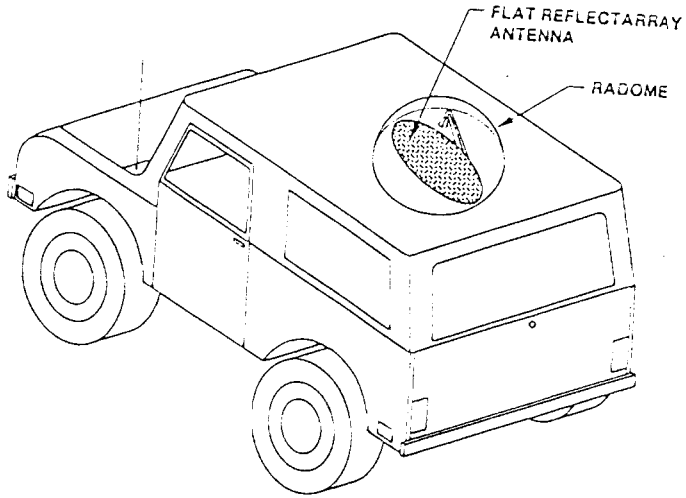
Phased Reflectarray
Application for Mobile Terminals



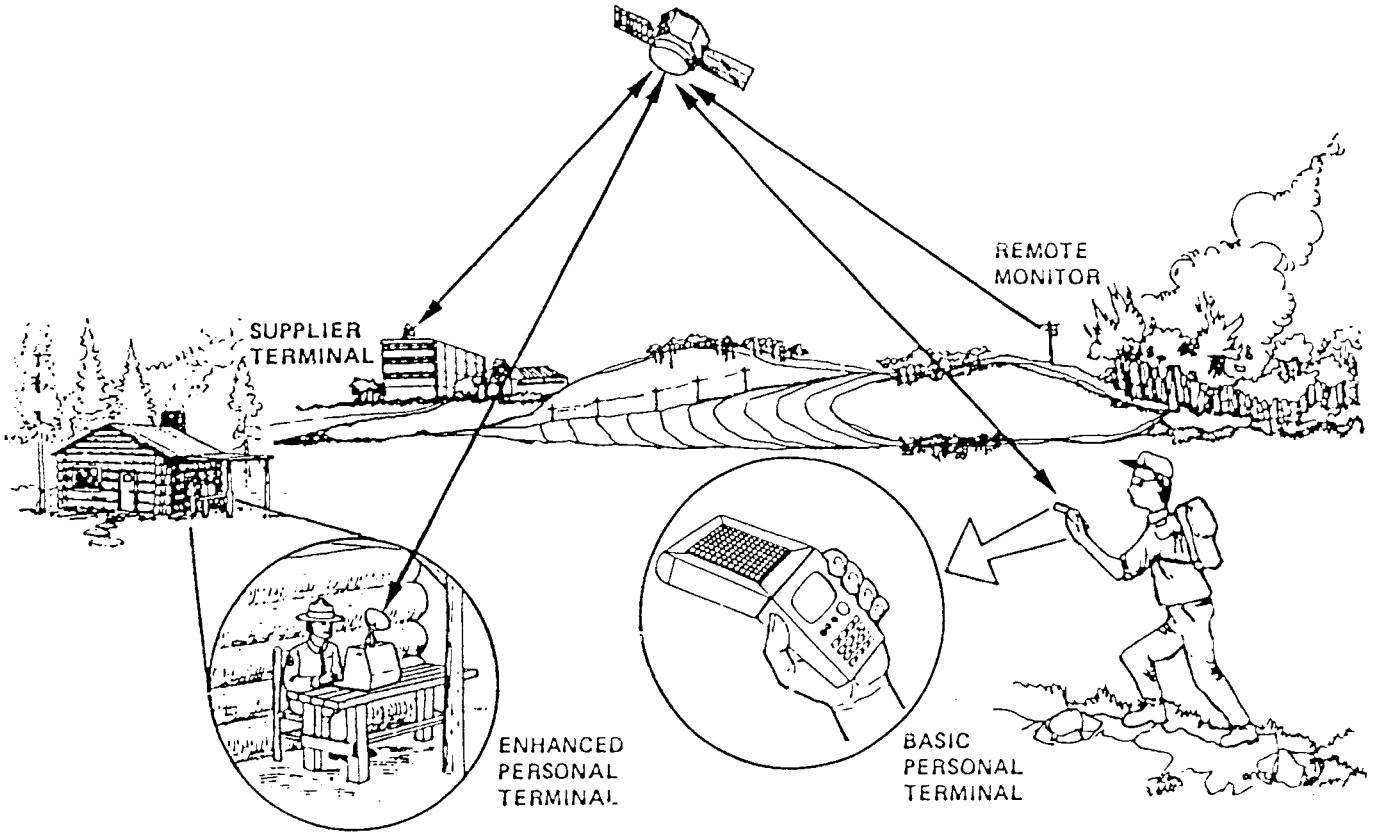
Ka-band 0.5m microstrip reflectarray



Cassegrain microstrip reflectarray

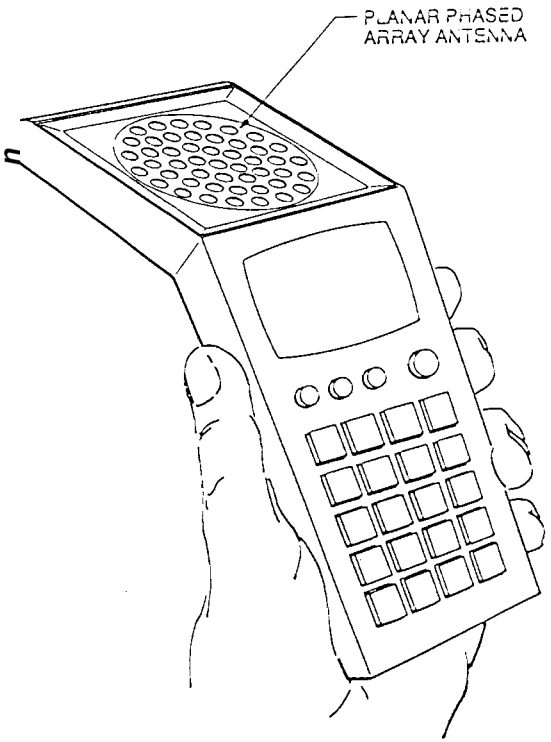


Personal Access Satellite System User Terminals



Futuristic Phased Array Systems

HAND-HELD PHASED ARRAY



HEAD-MOUNTED PHASED ARRAY