

RF Metamaterials

Challenges and Opportunities for Space Applications

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History of Antennas in Space



Explorer 1 (1958)
Two Whip Antennas operating
at 108 MHz. Discovered
Van Allen Radiation Belt

Navstar (1978)
Dish and Patch Antennas
at S and L Band for GPS



Hubble Telescope (1990)
Parabolic dish antenna
at 2.4 GHz

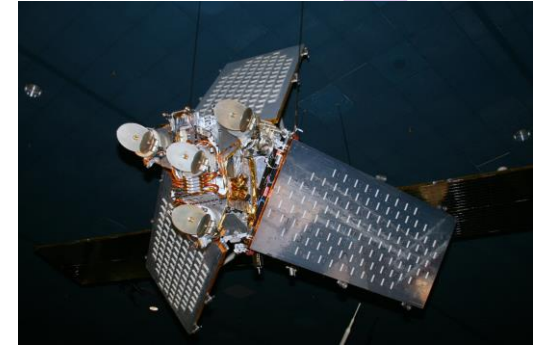


Sputnik 1 (1957)
Four 2.5 m Whip Antennas
operating at 20 MHz.

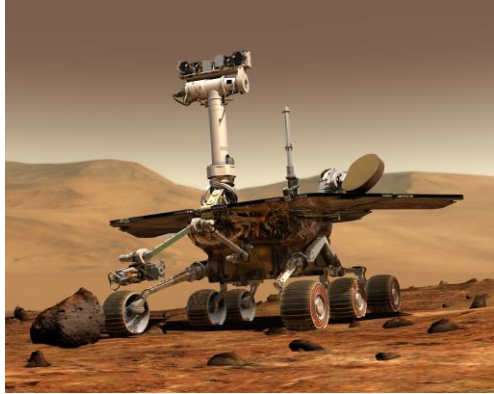
Telstar 1 (1962)
Horn and Whip Antennas
at 1.5 – 4 GHz used for
Transatlantic TV Broadcast



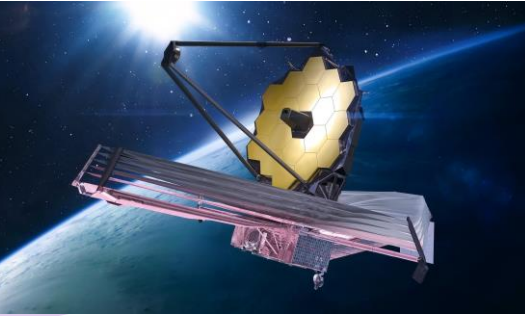
Intl Space Station (1998)
Several dish and whip antennas
at S, Ku and UHF Band



Iridium Satellite Constellation (1997)
Used for global voice and data service
Used dipole antennas at L-band
S-band Phased Arrays introduced
in 2017



Lunar and Mars Rovers
A number of Rovers exploring
other celestial bodies
Use planar antennas and
high gain parabolic dishes



James Webb Space Telescope
Use parabolic reflectors at 25-30 GHz
Use large intelligent surface with 18 primary mirrors

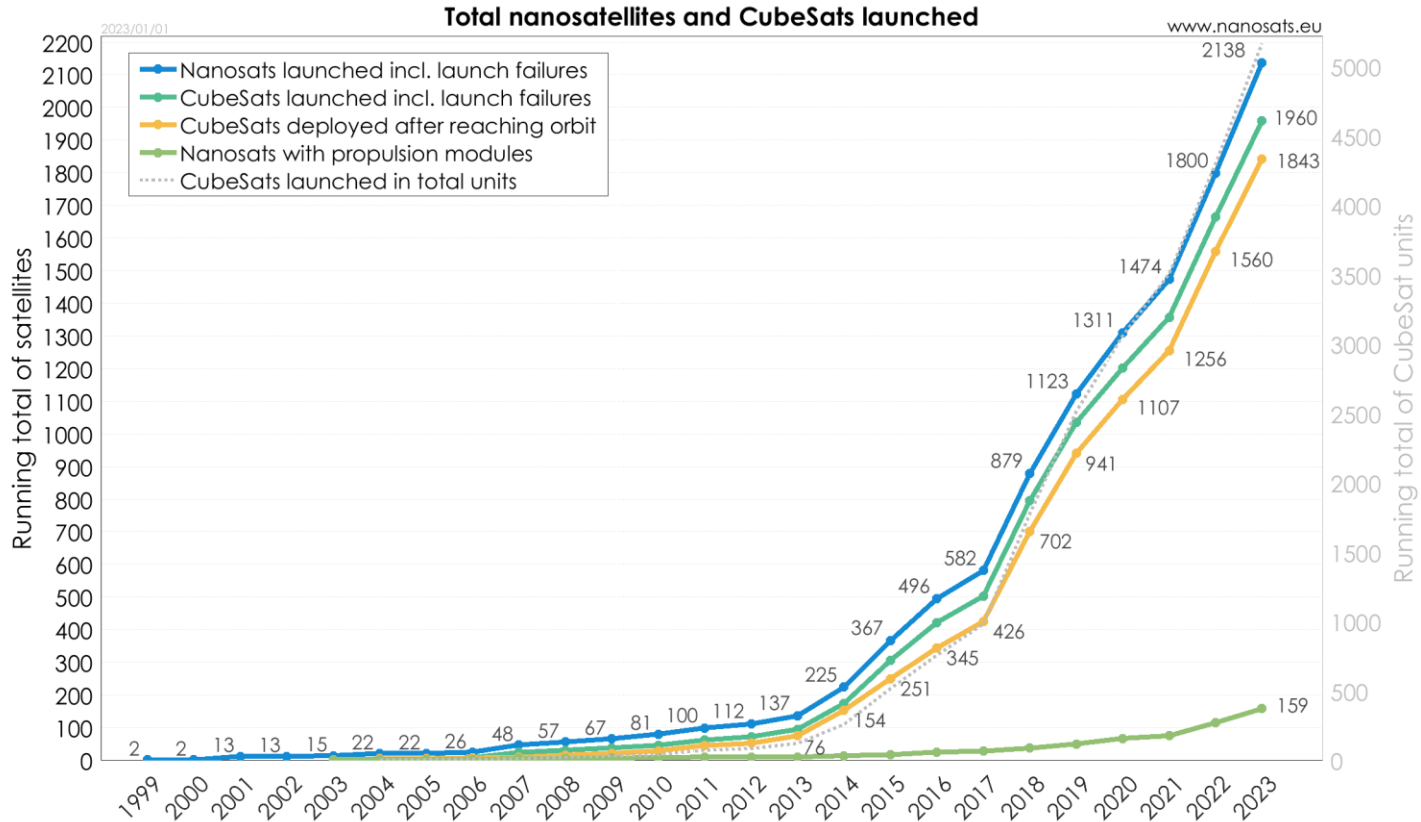
Large Satellite Constellations
Starlink, Amazon Kuiper, and OneWeb
setting large constellations with small satellites
with beam-steering antennas

New Opportunities

Large

They

Such



New Opportunities and Challenges

New Applications:

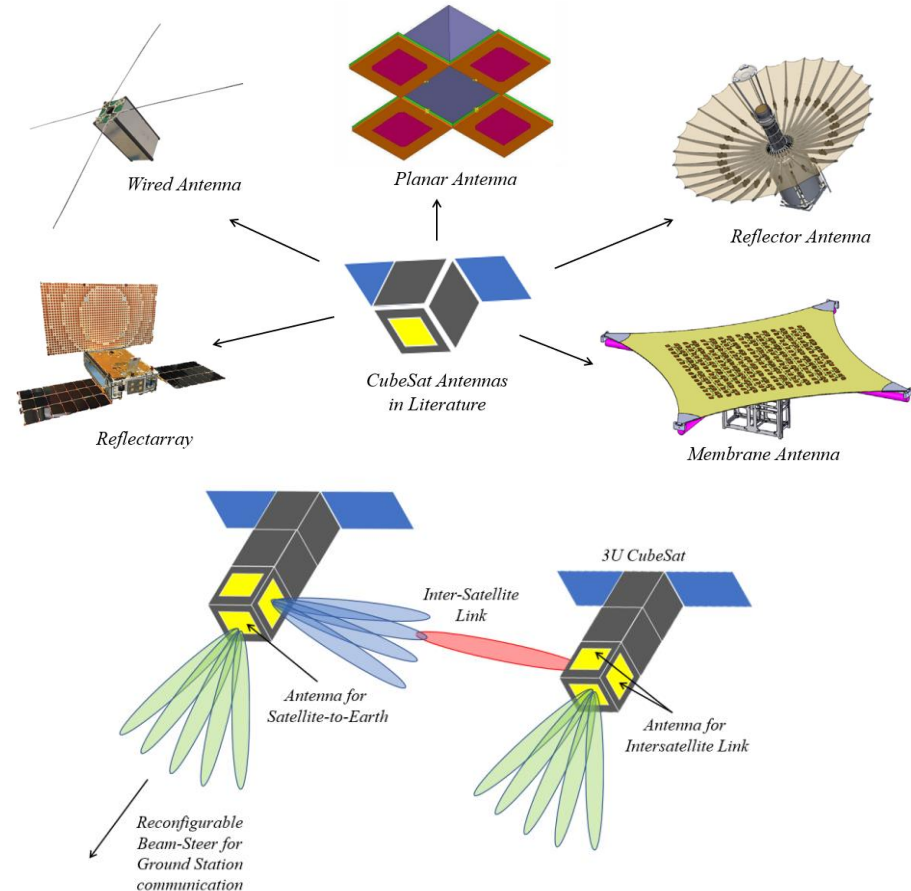
- Telecommunications
- Internet of Space
- Vehicle-to-Everything Network (V2X)
- Interplanetary Research

New Antennas for Satellites and Ground Stations:

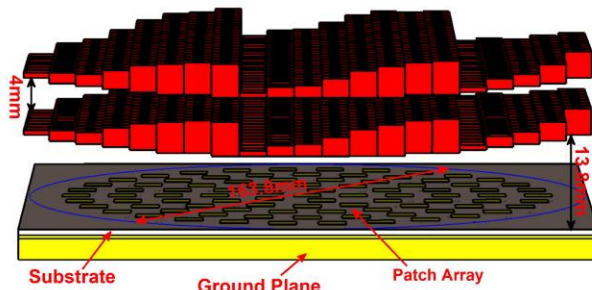
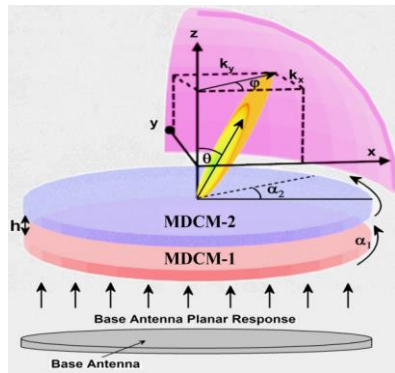
- Reflectarrays
- Membrane Antennas
- Intelligent Metasurfaces

Challenges:

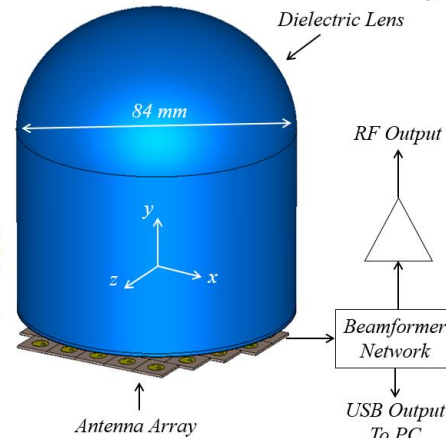
- Small Ground Stations
- Highly directional beams
- Wide Beam-Steering Capabilities
- Active Antennas with Low Power Consumption
- Small Antennas to fit on CubeSat platforms
- No or minimal deployment
- Light weight setup
- Less number of active components



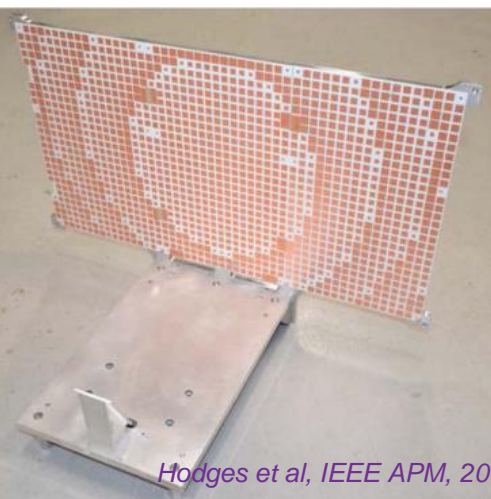
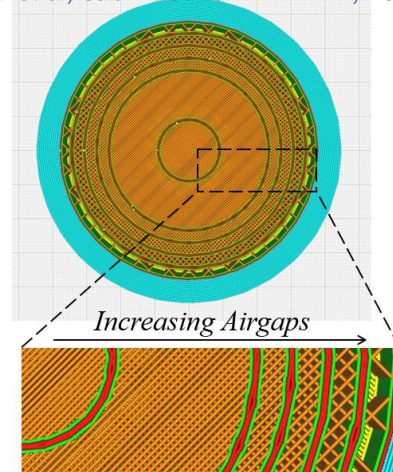
Examples



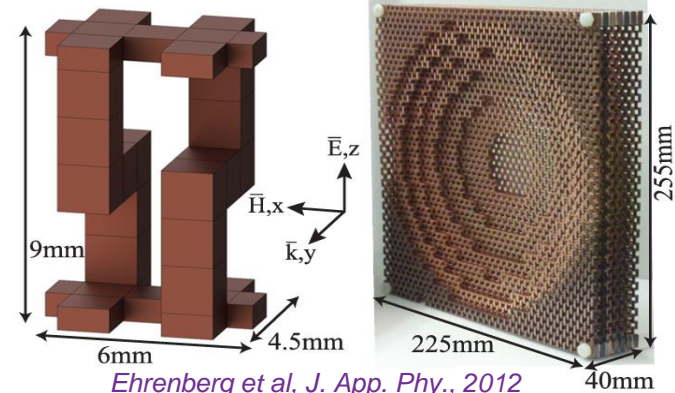
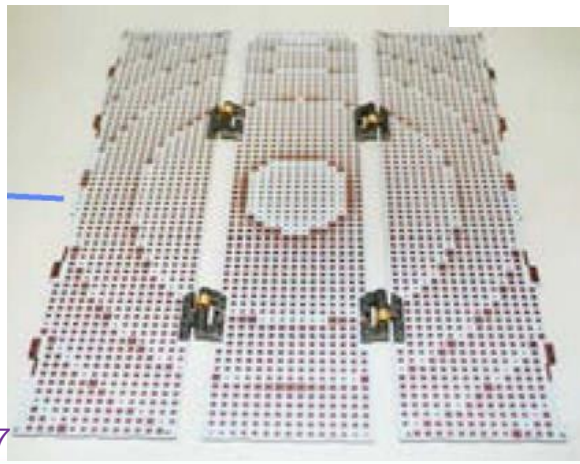
Ahmed et al, IEEE OJAP 2023



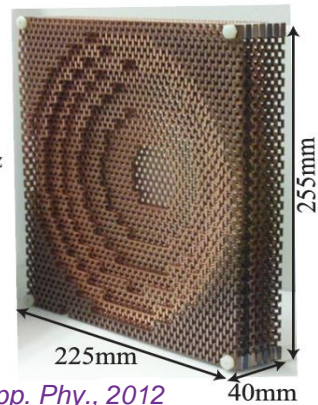
Bansal et al, submitted to IEEE TAP, 2023



Hodges et al, IEEE APM, 2017



Ehrenberg et al, J. App. Phys., 2012



Thank you!



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