ADVANCES IN TECHNOLOGIES FOR TRANSMITTERS FOR CUBESATS

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Presentation Overview

- Introduction and Motivation for Developing A New Generation of Transmitters for CubeSats
- Prerequisites and Critical Requirements for CubeSat-based Transmitters
- Technologies and Electromagnetic Spectral Bands for Transmitters
- State-of-the Art and Commercially Available Products
- Advances- Recent and Future
- Examples and Tradeoffs
- Conclusion

Introduction and Motivation for Developing A New Generation of Transmitters for CubeSats

Higher Data Rate, Bandwidth Than Currently Available from Commercial Communication Links/Radios

Reduced SWaP-C (Size, Weight, Power Consumption and Cost)

Performance (Power Use Efficiency, Reliability, ….)

Commercial Availability as COTS Products

Prerequisites and Critical Requirements for CubeSat-based Transmitters

- **Small and compact to fit CubeSat dimensions/form-factor**
- **Lightweight (< 0.5 kg)**
- **Highly efficient (>30% Power-Added Efficiency)**
- **Broadband and highly linear (handle very high data rates)**
- **Availability for frequency bands from 8 to above 76 GHz**
- **Scalable power output levels (1 to 25^{+} Watts)**
- **Highly reliable in Space environment**
- **Modular design with “standardized” modules,**
- **Affordable as COTS items**
- **Mass-producible to meet market demands.**

Electromagnetic Spectral Bands For Space to Earth and Intersatellite Links

Many CubeSats have more than one link

Optical

RF

- VHF/UHF (30-1000 MHz)

Microwave

- S (2-2.5 GHz)
- X (7.1-8.5 GHz)
- Ku (12-16 GHz)

Millimeter waves and Terahertz

- K (17.2-21.2 GHz)
- Ka (25.5-27.5 GHz, 31-33 GHz), 35.5 GHz
- Q (37.5-42.5 GHz)
- E/V/W (71-76, 81-86 GHz, 94 GHz) W-Cube, EIVE)
- Terahertz (Between 100 and 1000 GHz)

Applications of CubeSat Transmitters

Communications

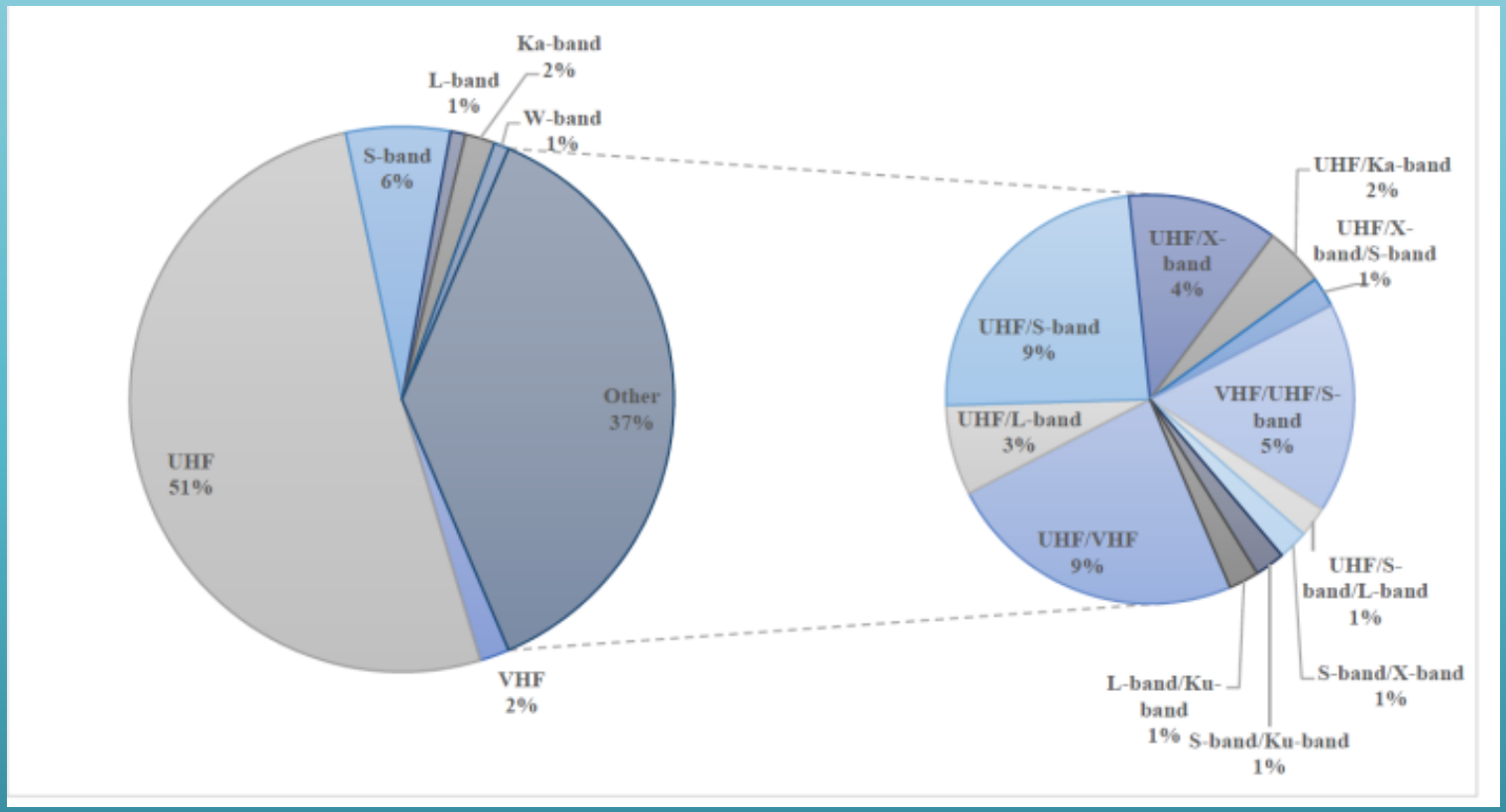
Data Transport

Inter-Satellite Links (ISL)

Sensor/Radar

Other emerging uses

Frequency Bands Used in Most CubeSats



Tradeoffs and Design Options

- Available Space (volume/form-factor)
  - -TWTA-based Transmitters Not Suitable
- Prime Power Consumption
  - - Gallium Arsenide (GaAs) and CMOS Not Efficient Enough
- Data Rates
  - - High Data Rates Require Greater Bandwidth and Linearity
- Atmospheric Attenuation
  - - Higher Frequencies Experience Higher Attenuation and Effects
- Antenna-related Considerations
  - - Higher frequencies Offer Smaller Size or Greater Gain

Gallium Nitride (GaN) Technology-based Power Amplifiers -Challenging Tube-based Amplifiers (TWTA)

Offer exceptional transmitter power and efficiency compared to other device technologies, thus reducing the size, mass and power consumption with reduced heat removal requirement.

Can operate at higher device junction temperature reliably

Typical devices can offer transmit power from a few Watts to more than 50 Watts, with Power-Added Efficiency from 20% to 50%

Advanced thermal design using innovative cooling techniques and materials

Unique products and/or methods have emerged with direct applicability to transmitters for CubeSats.

These include- Oscillating Heat Pipes, synthetic graphite, and novel thermal design of PC Boards. These facilitate very efficient heat removal from power amplifiers within the transmitters, resulting in significantly increased efficiency, output power and lifetime.

Surface-mountable devices (SMD) for printed circuit board-based implementation

Recent availability of high-frequency devices in SMD package for use in PC boards leading to compact, low-cost, large-scale production of transmitters at higher frequencies.

Multi-function SMD packages Available for Millimeter-wave Frequencies

Active Electronically Scanned Arrays provide new possibilities

Additive Manufacturing (3-D Printing Technology) for Manufacturing Transmitter Structure

AM offers potential for producing RF modules for CubeSats at very low cost and high production rates with performance comparable to conventional structures.

Many functions and structures already implemented using Additive Manufacturing

Use of COTS EEE Components

Recent trends in extensive use of COTS parts for Space equipment has potential for dramatic reduction in cost and manufacturing time without appreciable impact on reliability or performance.

Standardization and Modularity

The design and manufacture of these transmitters uses formats that fully conform to established standards for CubeSats, thus permitting perfect integration with the satellite payload.

New Space's Qualification and Testing Philosophy

This approach eliminates formal qualification and detailed testing of custom transmitters by CubeSat integrators or users since the manufacturer carries this out.

Conclusions

Thank you for your attention!