



**Institute for the Wireless  
Internet of Things**  
at Northeastern University

## **Conquering the Spectrum above 100 GHz for 6G**

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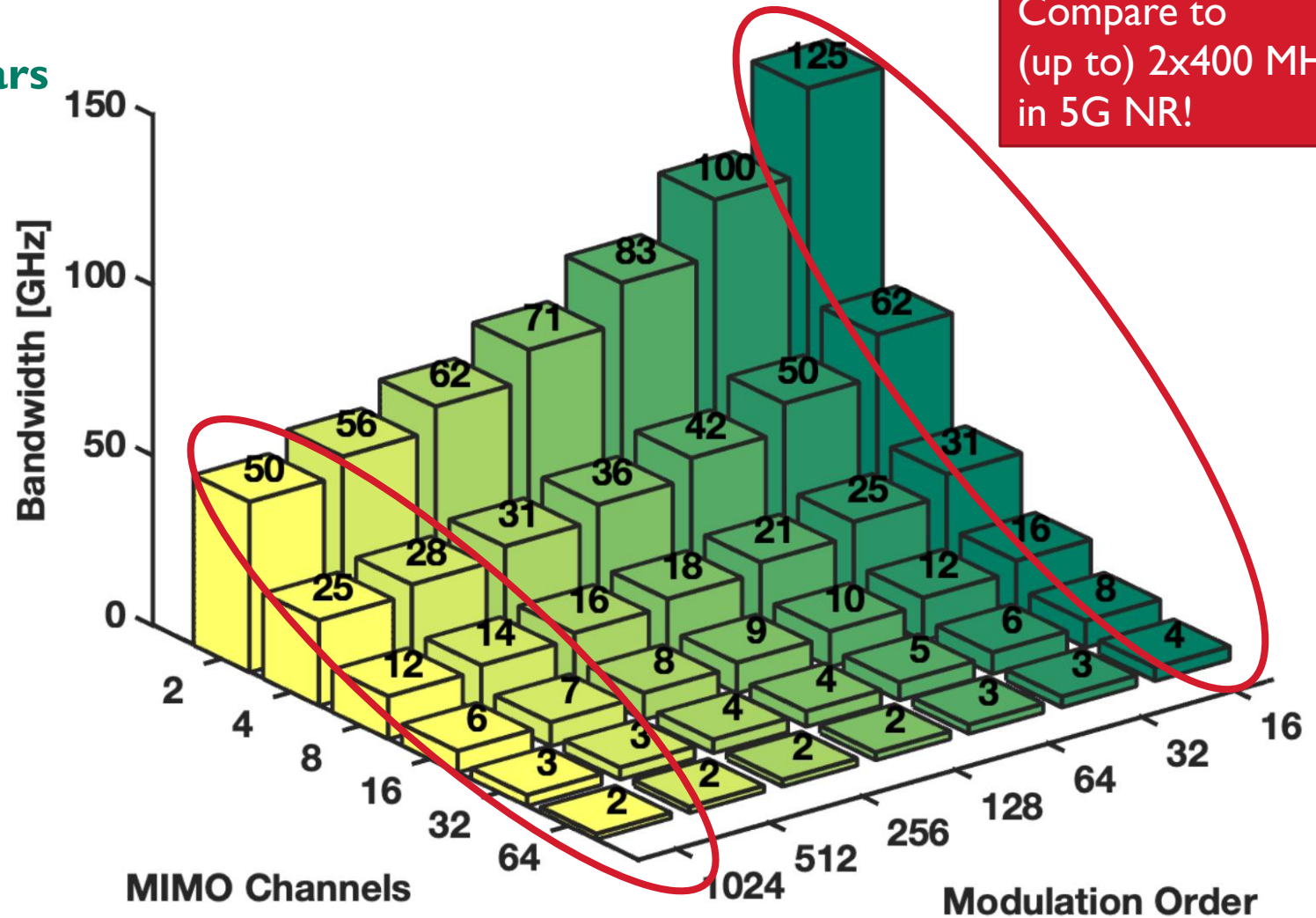
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[www.unlab.tech](http://www.unlab.tech)

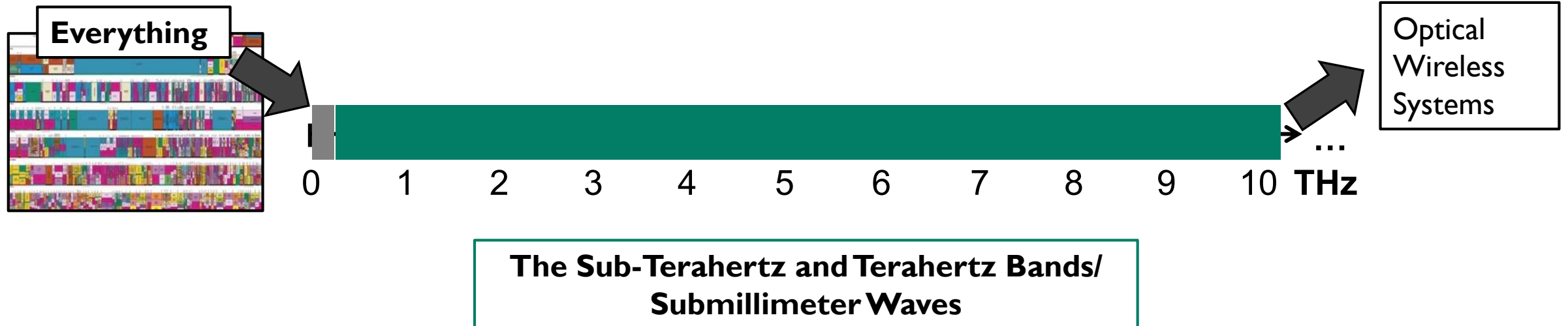
# On the Road to 6G Systems

- 6G is happening within the next **5 years**
- Both academia and industry agree on **1 Terabit-per-second (Tbps)** peak data-rate as a reasonable goal
- **How much bandwidth do we need for this?**
  - It depends on:
    - Modulation order/channel
    - Number of MIMO channels



# On a Quest for Resources

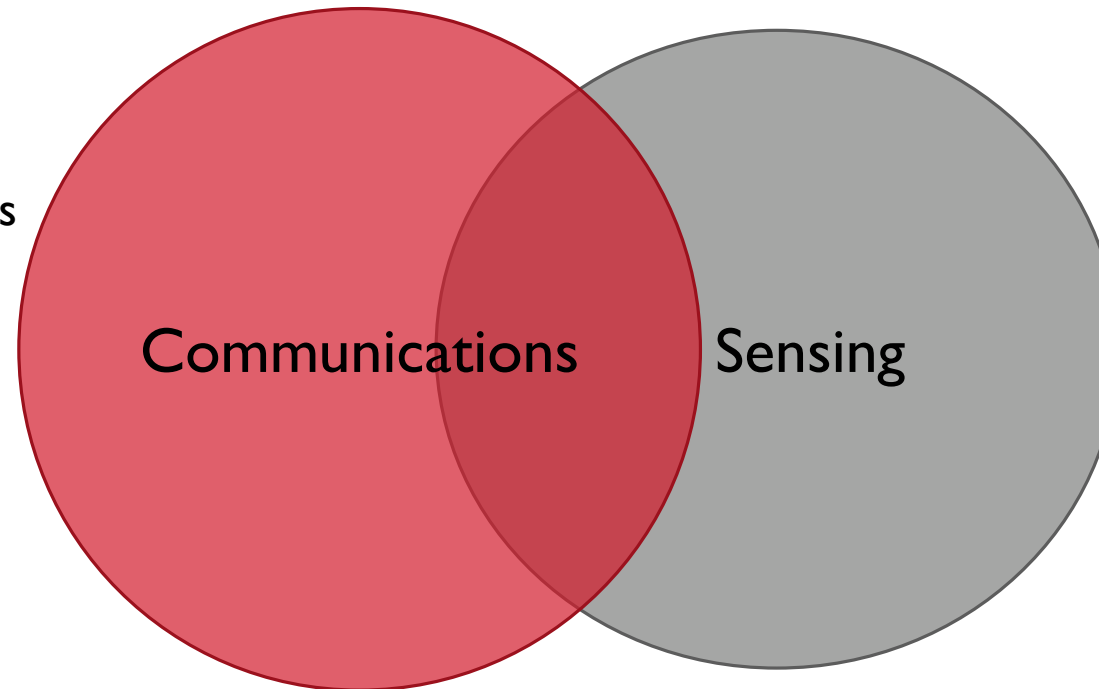
Where do we find such bandwidth?



I. F. Akyildiz, C. Han, Z. Hu, S. Nie, J. M. Jornet "Terahertz Communications: An Old Problem Revisited and Research Directions for the Next Decade" IEEE Transactions on Communications, 2022.

# Opportunities at Terahertz Frequencies

Terabit body and personal networks  
Terabit wireless access  
Terabit wireless backhaul  
Inter-satellite and space networks



High resolution radar/localization  
Non-damaging imaging  
Spectroscopy  
Earth and space exploration

# Joint THz Communications and Sensing

Ultrabroadband  
Ultra-directional Links



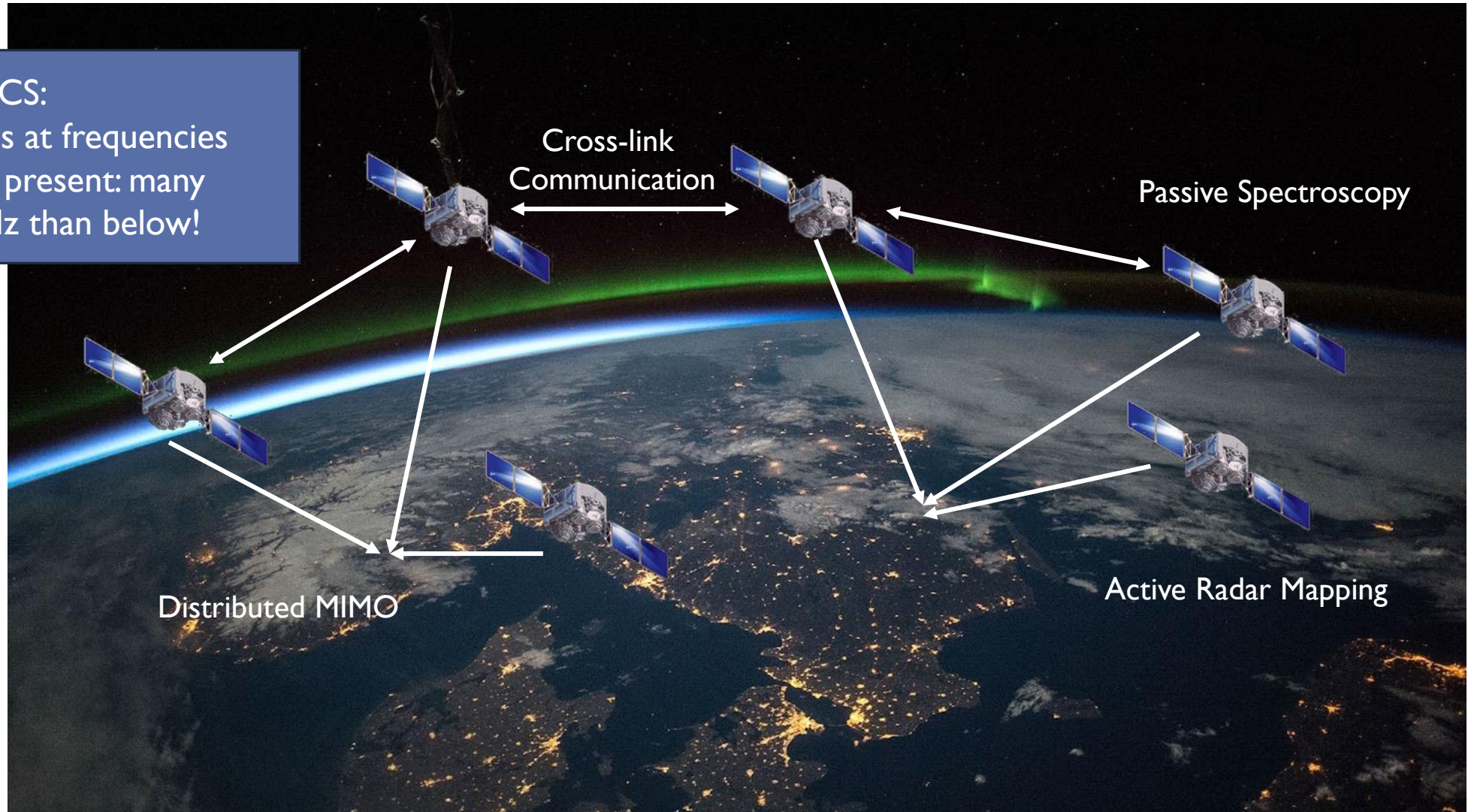
Intelligent  
Reflecting  
Surfaces

Uniqueness of THz JCS:  
- Not only target detection and tracking, but also **target classification**  
- All while characterizing air quality

Room occupancy: 70%  
Air quality: Acceptable

# Joint THz Communications and Sensing

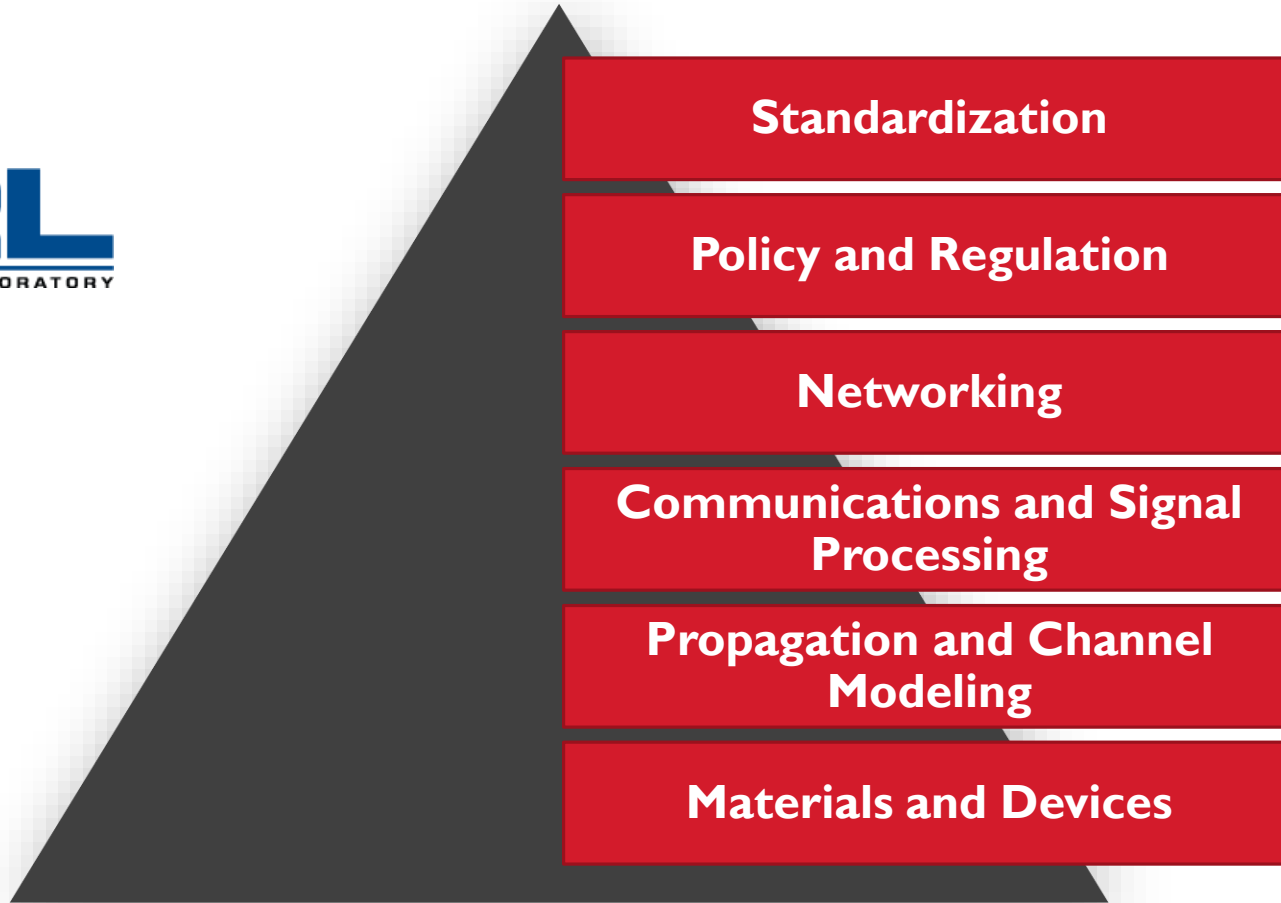
Uniqueness of THz JCS:  
- You can only do this at frequencies where absorption is present: many more above 100 GHz than below!



S. Aliaga, A. Al Qaraghuli, J. M. Jornet  
**“Joint Terahertz Communication and Atmospheric Sensing in Low Earth Orbit Satellite Networks: Physical Layer Design,”**  
in Proc. of the 2<sup>nd</sup> IEEE WoWMoM Workshop on NTN for 6G, 2022. (Best Paper Award)

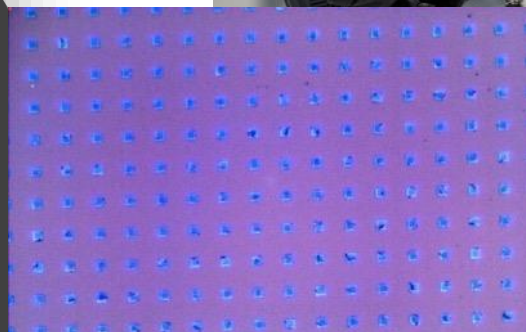
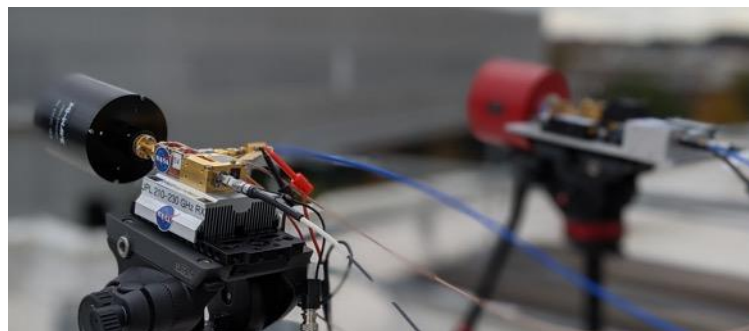


# From Materials to Standards

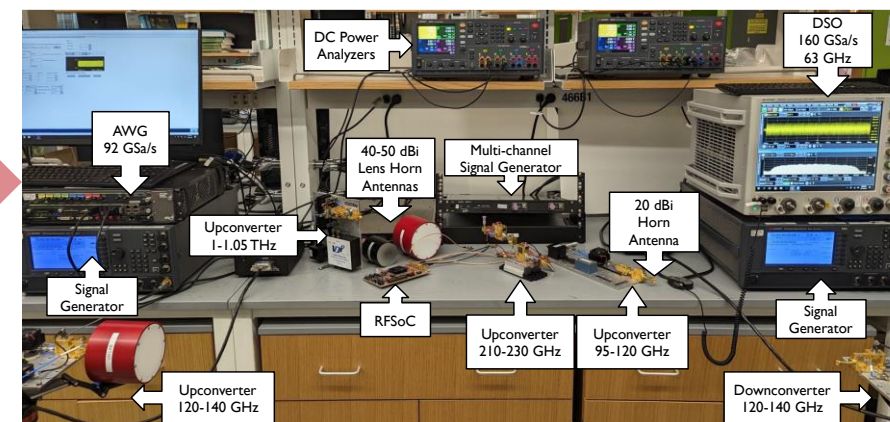


# Conquering the Spectrum above 100 GHz

From Devices...



...To Platforms



Materials, Devices and Testbeds

Closing the terahertz technology gap with electronic, photonic and plasmonic front-ends, antenna arrays and metasurfaces, and ultrabroadband DSP engines

P. Sen, V. Ariyaratna, A. Madanayake, J. M. Jornet, **“A Versatile Experimental Testbed for Ultrabroadband Communication Networks Above 100 GHz,”** Elsevier Computer Networks, vol. 193, July 2021.

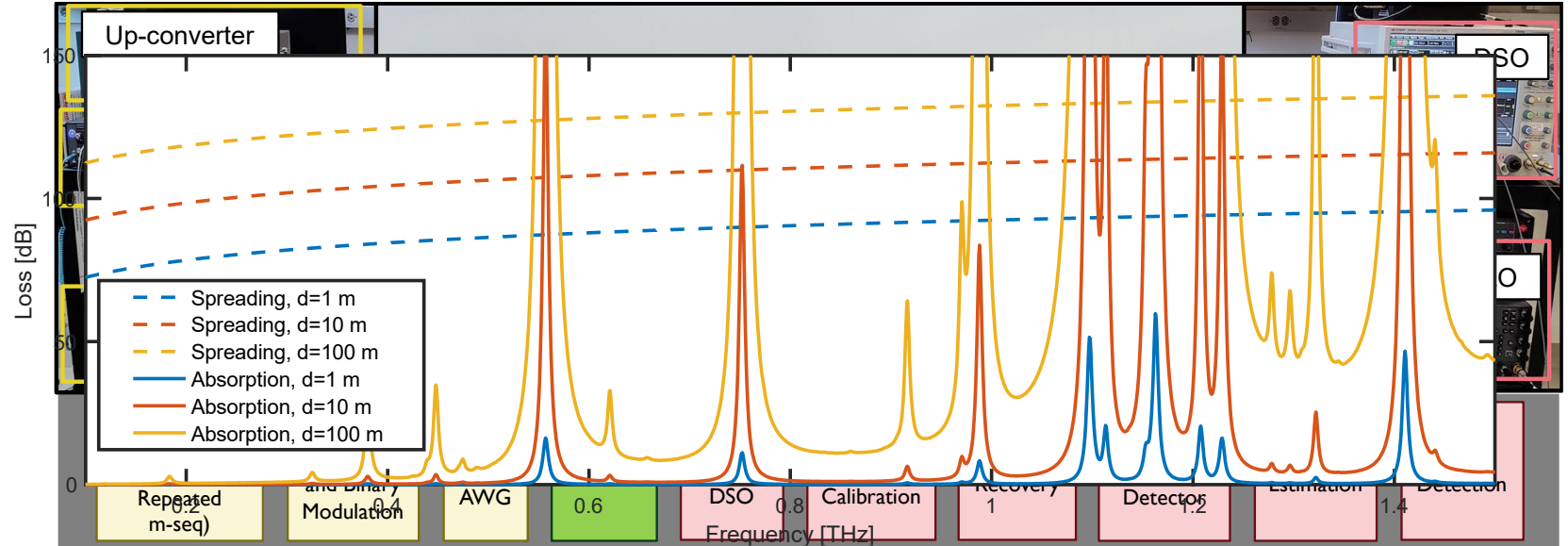


# Our Next Platform? At an Altitude of 400 km!

- With the support of the NASA CubeSat Launch Initiative Program, we are **launching two satellites to test terahertz communications in space**
  - Timeframe: 2024-2027

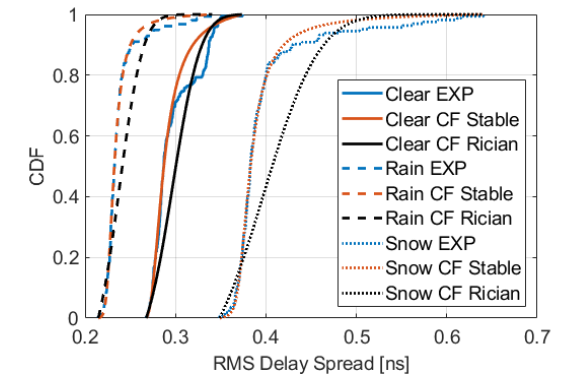
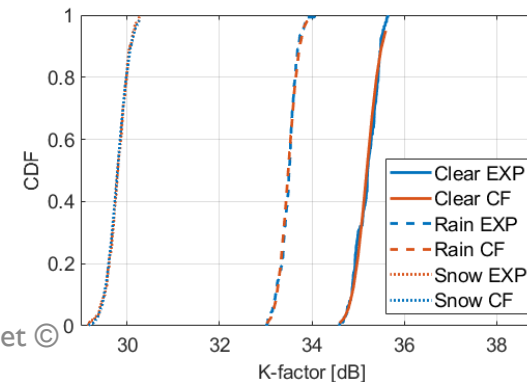
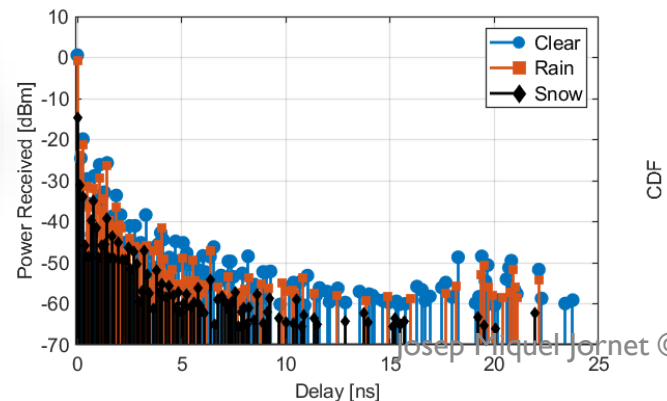


# Conquering the Spectrum above 100 GHz



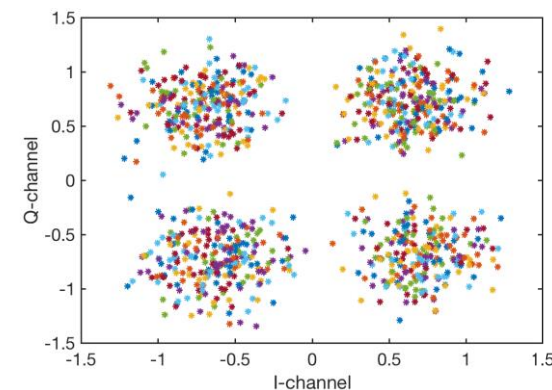
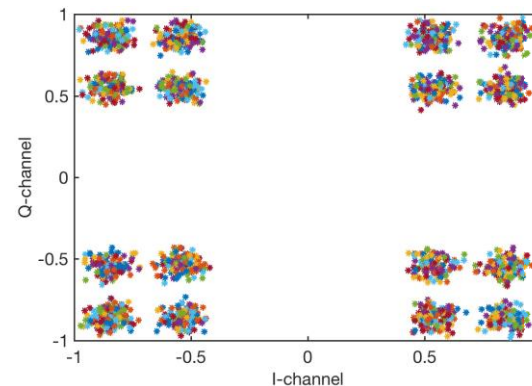
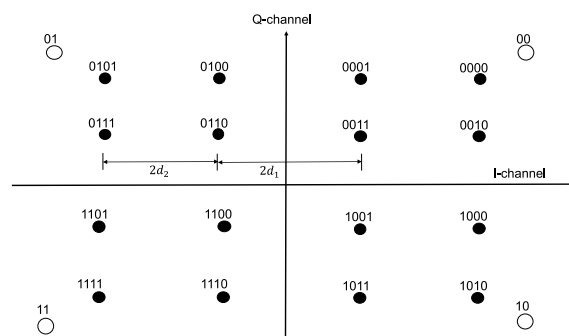
## Propagation and Channel Modeling

From studying the physical phenomena affecting the propagation of terahertz waves to experimentally characterizing, collecting and sharing channel data



# Conquering the Spectrum above 100 GHz

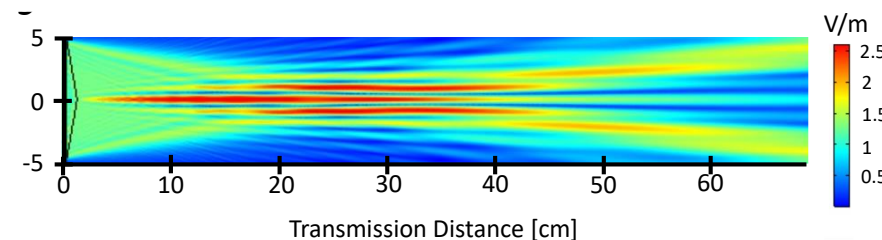
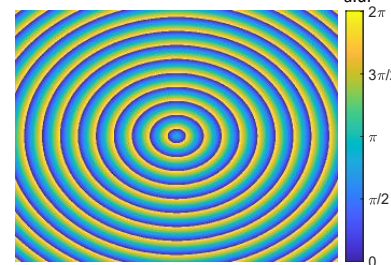
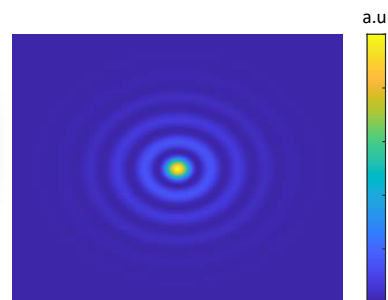
## From Waveforms ...



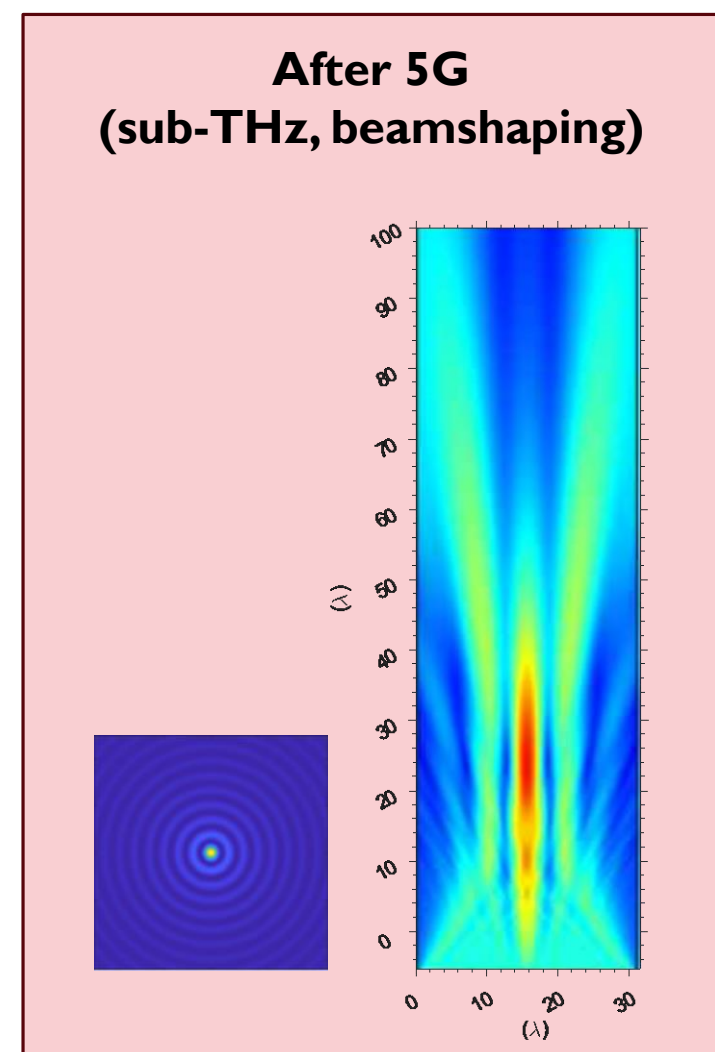
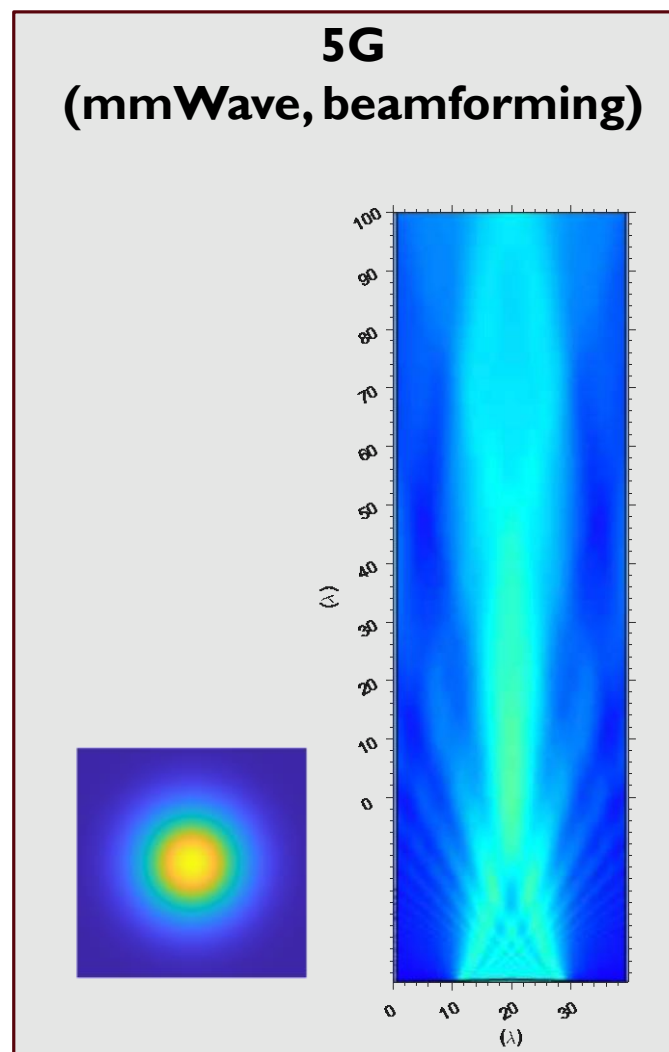
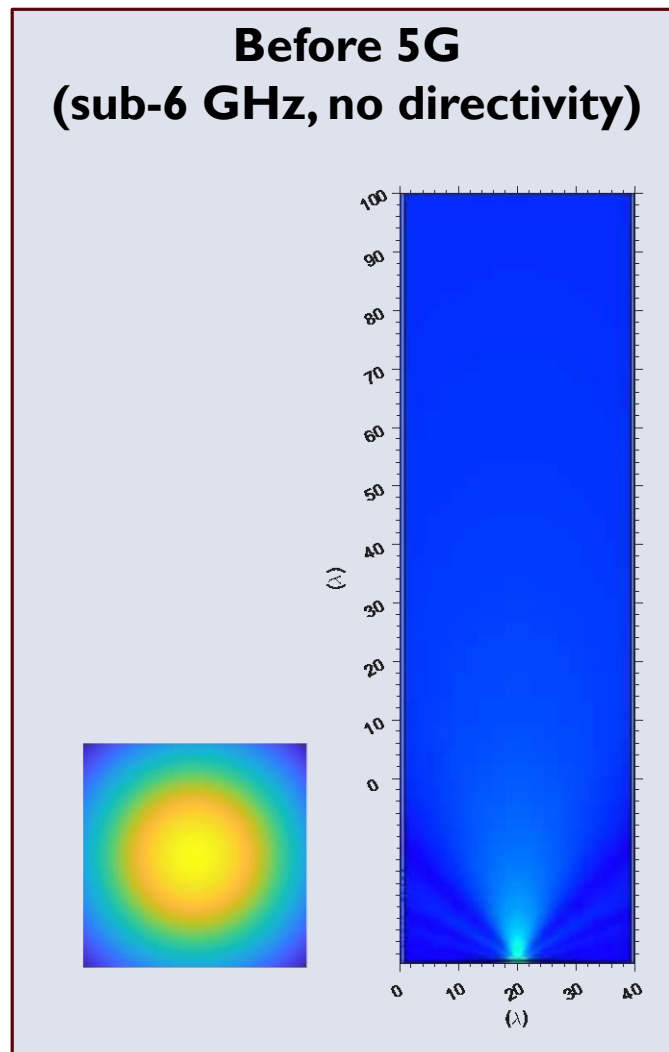
Communications and Signal Processing

Defining ultrabroadband terahertz communication solutions, e.g., new waveforms that leverage absorption, ultra-massive MIMO, self-healing wavefronts

## ... to Wavefronts



# An Evolution of How We Think of Radiation



Near-field region

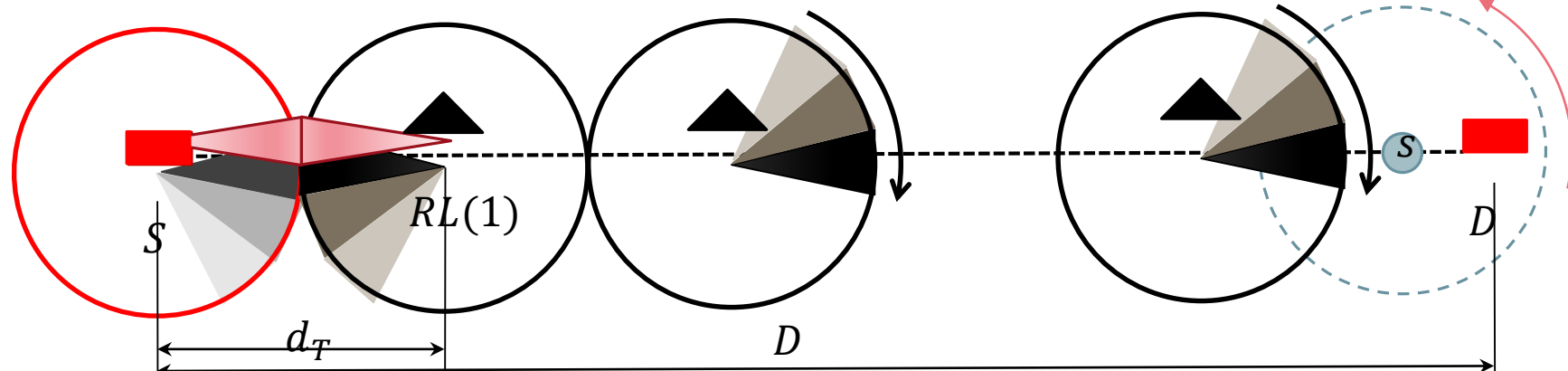
<10cm

Josep Miquel Jornet ©  
1-5m

10-100+m

# Conquering the Spectrum above 100 GHz

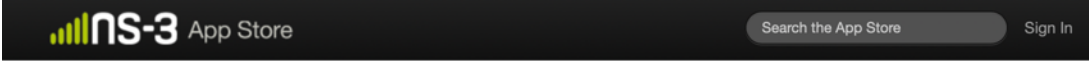
Ultra-directional beam management (discovery, tracking, relaying)



**Networking**

Conceive protocols to ensure end-to-end connectivity in networks that are highly disconnected (also in extreme environments, e.g., planes & satellites).

Building open-source tools for the networking community to embrace the terahertz band



[← Go back to home](#)

**TeraSim**  
TeraSim is the first module for the simulation of Terahertz (THz)-band communication networks which captures the capabilities of THz devices and the peculiarities of the THz channel.

★★★★☆ 3.72/5 (302 reviews)

0 downloads



# Conquering the Spectrum above 100 GHz



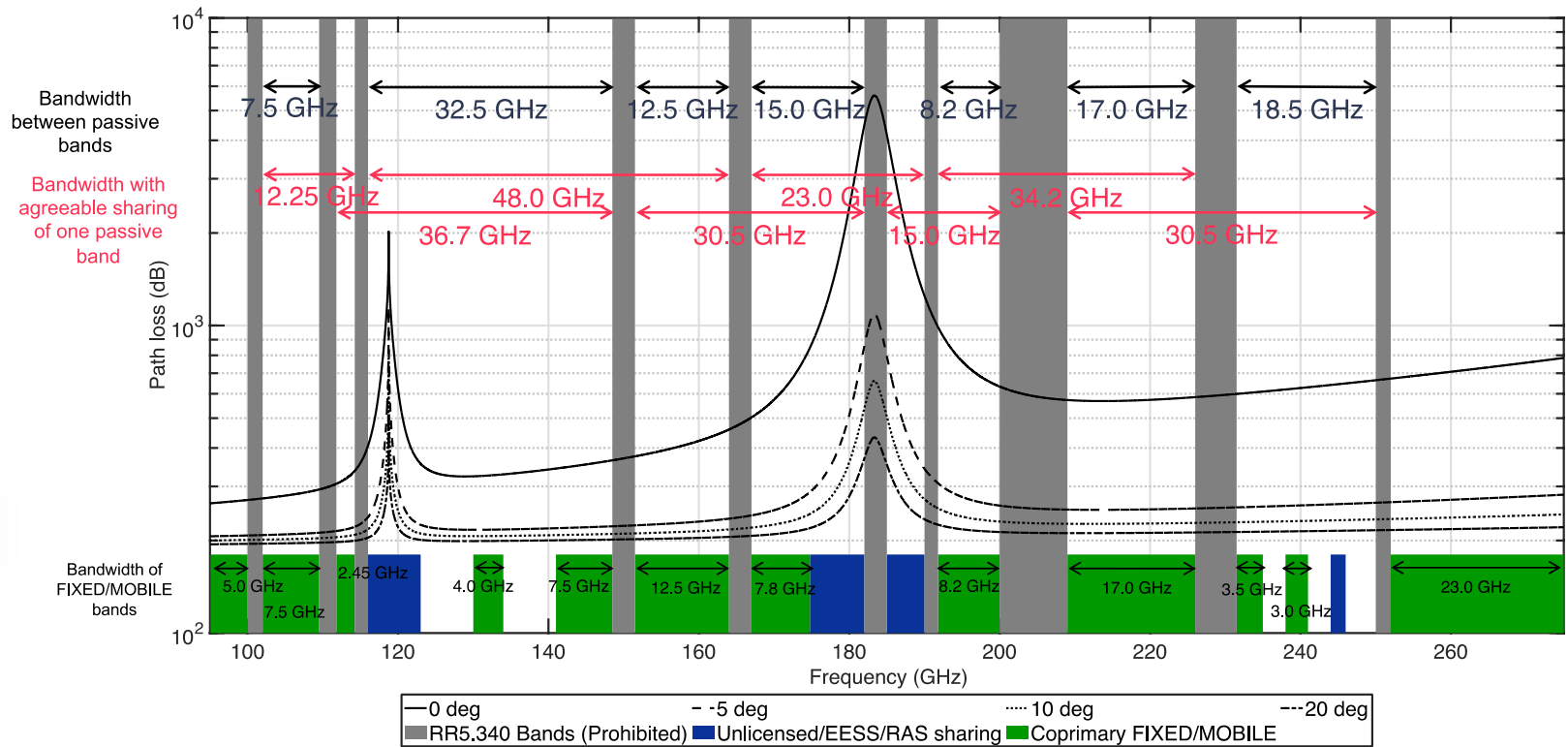
**Document :** ITU-R WP1A Contribution 46  
**Title :** Proposal to initiate work under Resolution 731 (Rev.WRC-19)  
**Date :** 2020-11-13  
**Source :** United States of America  
**Access :** Restricted to TIES users [ITU-R]



Federal Communications Commission FCC 19-19  
 Before the Federal Communications Commission Washington, D.C. 20554  
 In the Matter of )  
 Spectrum Horizons ) ET Docket No. 18-21  
 James Edwin Wheebbee Petition for Rulemaking to ) RM-11795  
 Allow Unlicensed Operation in the 95-1,000 GHz ) (Proceeding terminated)  
 Band )  
**FIRST REPORT AND ORDER**  
 Adopted: March 15, 2019 Released: March 21, 2019

## Policy and Regulation

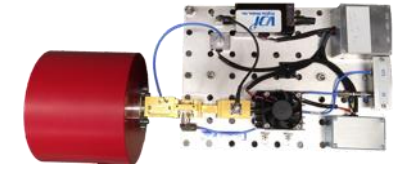
From “no man’s land” to spectrum sharing and coexistence between active communication users and passive sensing services



# Spectrum Sharing and Coexistence

- **An example:** we designed, built and tested a dual-band system able to switch between 120/240 GHz
  - Dynamically reconfigurable in real-time to avoid interference
  - Automated tracking of passive satellites

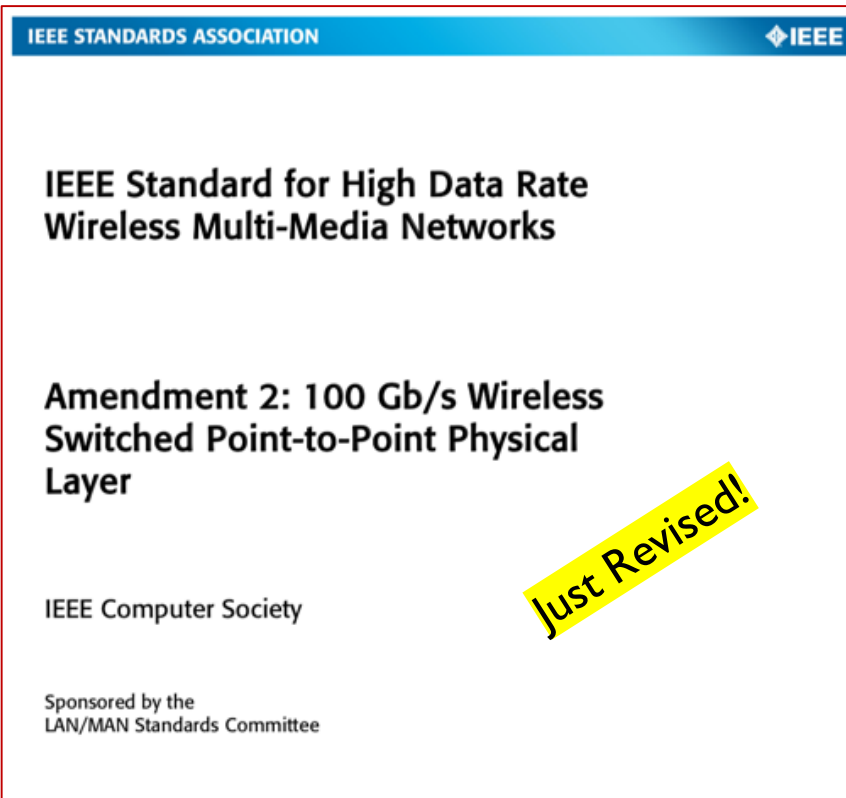
M. Polese, X. Cantos-Romana, A. Singha, M. J. Marcus, T. J. Maccarone, T. Melodia, and J. M. Jornet, **“Coexistence and Spectrum Sharing Above 100 GHz,”** in *Proceedings of the IEEE*, vol. 111, no. 8, pp. 928-954, Aug. 2023.




# Conquering the Spectrum above 100 GHz

## Standardization

From the first IEEE Standard for terahertz Communications (2017, revised 2023) to the NextG Alliance, 3GPP



IEEE STANDARDS ASSOCIATION 

**IEEE Standard for High Data Rate  
Wireless Multi-Media Networks**

**Amendment 2: 100 Gb/s Wireless  
Switched Point-to-Point Physical  
Layer**

IEEE Computer Society

Sponsored by the  
LAN/MAN Standards Committee

**Just Revised!**





# Thank you!



# Want to Be in the Loop?



The image shows a screenshot of a website banner. At the top left is the IEEE logo and the text 'ComSoc RCC'. At the top right is a navigation menu with links: 'Home', 'About SIG', 'Officers', 'Core Members', 'Selected Readings', 'SIG Seminars', and 'Activities'. The main content of the banner features a background of colorful, flowing light trails in shades of blue, green, yellow, and red. The text on the banner reads: 'Welcome to the IEEE ComSoc Radio Communications Committee (RCC)', 'Special Interest Group (SIG) on:', and 'TeraHertz Communications' in large white font.



Join us!!!