

# *Active Radar Sensing Using Joint Communications and RF Sensing*

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*6G Research Visions Webinar Series*

*Localization and Sensing – Technologies, Opportunities and Challenges*

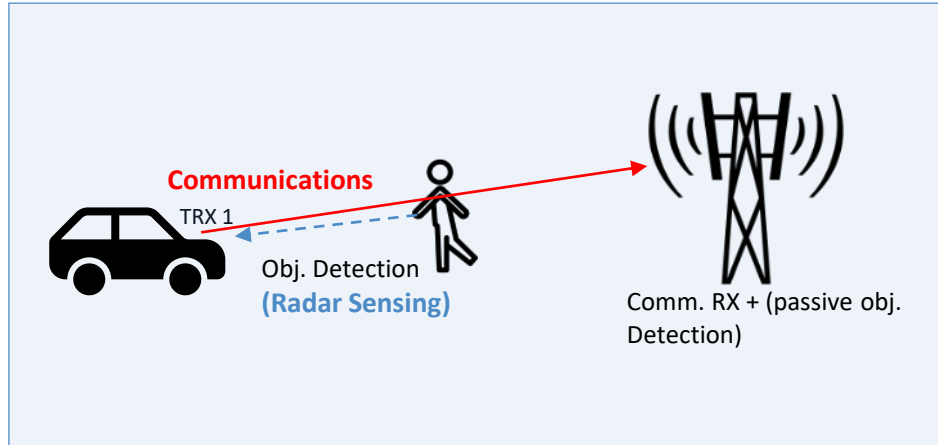
*18 November 2020*

# What is Joint Communications and Sensing (JC&S)?



Both radar and communications rely on the propagation of electromagnetic waves

- Why not do both jointly using same signal/equipment?



- (radar) sensing is likely to be an integral part of 6G

# What do we gain from it?

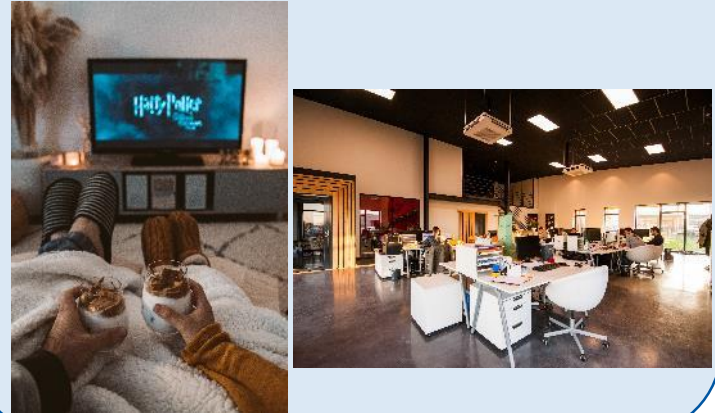
**Spectrum sharing** opportunity between radar and communications

- More spectrum will be needed for 6G
- radar spectrum is underutilized in most places

High Radar Usage



Low Radar Usage



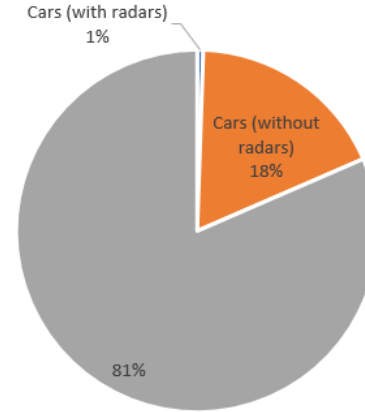
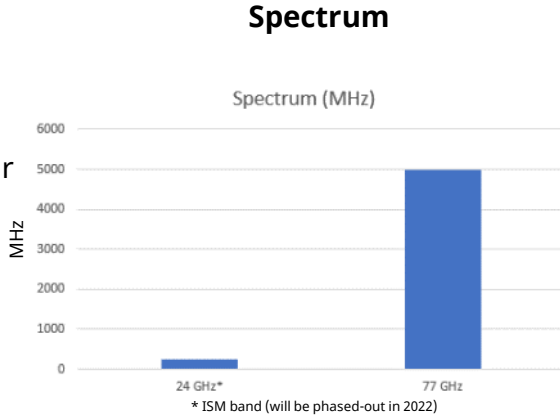
# The spectrum issue



## Market Penetration (World Pop. 7,8 bill. = 100%)

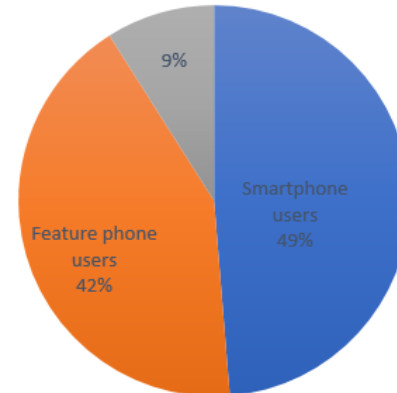
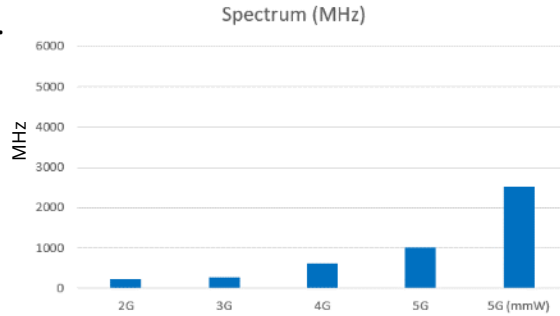
### Spectral Efficiency

(Automotive) Radar



$\sim 2 \times 10^{-7}$  bps/Hz  
(50ms cycle, 1GHz BW,  
10 „bit“-resolution)

Cellular Comms.



>20 bps/Hz (5G-NR)

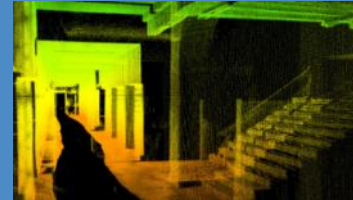
# What else do we gain from it?

- Communication enables new Radar functionality and vice versa

Radar Coordination /  
Interference  
Management

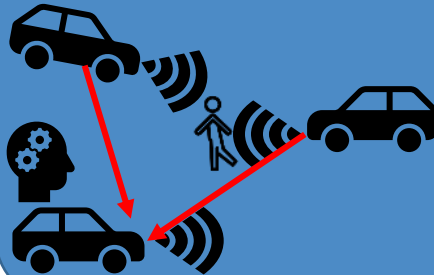


Improved Radar/ THz  
Imaging

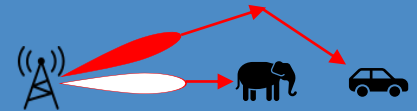


Picture by Huitl et al., TUMindoor

Sensor Fusion



Beam Management  
using Radar Info



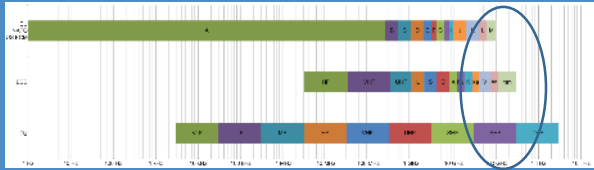
Among possibly many others

# Why Joint Radar Sensing/Comms Now?

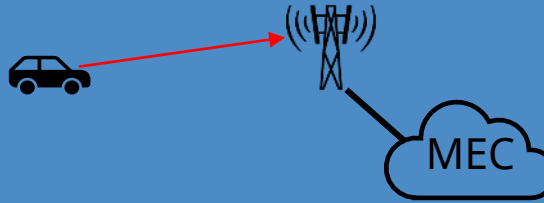
## Enablers



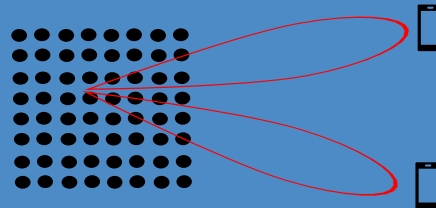
New frequency bands (with higher bandwidth)



Mobile Edge Cloud (MEC)



Massive MIMO (beamforming)



Machine Learning



# Radars as a Service

- Radar Sensing may become just another service in wireless RF systems
- 6G will be a set of different RF-based services!
  - Broadband Connectivity (Communications)
  - uRLLC
  - mMTC
  - **Radars sensing**
  - **Localization**



# Possible application Scenarios



## Automotive

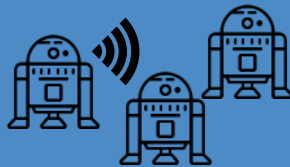
Radars already extensively used for adaptive cruise control, lane change assistant, cross traffic alert  
Usage (and interference) will increase with autonomous vehicles



## Drones



## Robotics



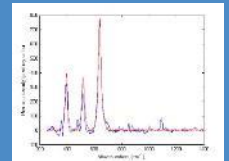
## Gesture Recognition



## Health Monitoring



## Spectroscopy



and many others to come...



## Different Approaches for the problem



### Existing Approaches

#### Coexistence

Two different systems (radar and comms) share the same spectrum – cognitive radio

#### RadComm

A radar system with embedded communication capabilities (to exchange short messages)

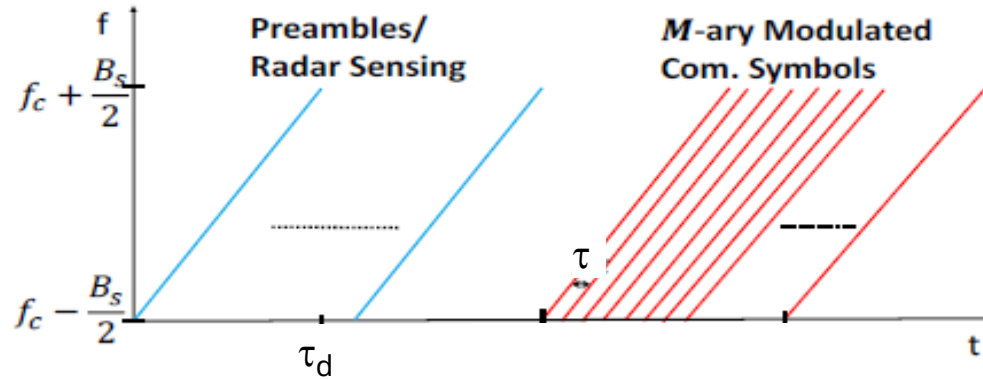
#### Passive Radar / CommRad

Use existing comm. systems and waveforms, detect reflections and objects opportunistically

### Joint Communications and Radar

- One waveform that can be employed for both communications and radar
  - **Co-design** instead of just coexistence
- Flexible allocation between both purposes

# One Possible chirp-based waveform



## Why Chirps?

- good ambiguity properties for radar
- Low-complexity radar transmitters and receivers
- Can easily modulated and detected for communications

S. Dwivedi et al., *Secure Joint Communications and Sensing using Chirp Modulation*, 6G Wireless Summit 2020

M.T, Pham, *Efficient Communications for Overlapped Chirp-based Systems*, IEEE Wireless Comm. Letters, 2020



## Research Challenges in Joint Communications and Sensing

- How to define comparable metrics and theoretical limits
  - E.g., what's the “capacity” or “spectral efficiency” of radar?
- Finding a waveform (and processing algorithms) suitable for both applications
  - OFDM/ chirp-based / other
  - In view of high bandwidths, shall we move towards the power-limited regime?
- Managing interference / resources
  - Increasing usage will increase interference (already an issue with automotive radar)
  - how to allocate efficiently resources
  - A new JC&S MAC layer is needed!
- Designing cost- and power-efficient transceivers
  - Very high bandwidth (with possible low spectral efficiencies)
  - Can we avoid full duplexing?
- Unified consistent channel model

Join us at the 1st IEEE Symposium on Joint Communications & Sensing  
Virtual Event, 23/24 February 2021

[www.jcns-symposium.org](http://www.jcns-symposium.org)

