Integrated Sensing and Communication – Recent advances and the **one6G association** perspective

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Panel: P2. Integrated Sensing and Communications for Industrial Applications

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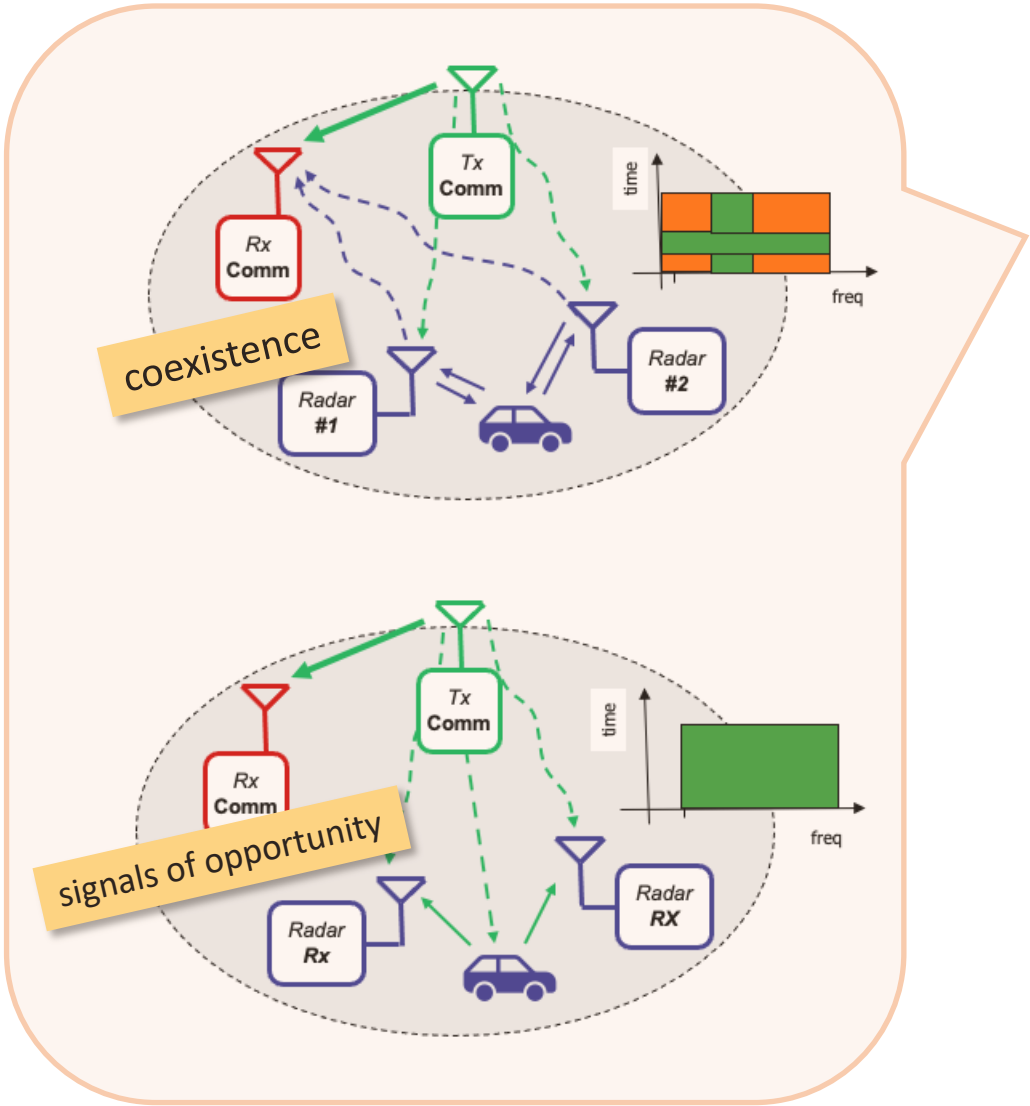
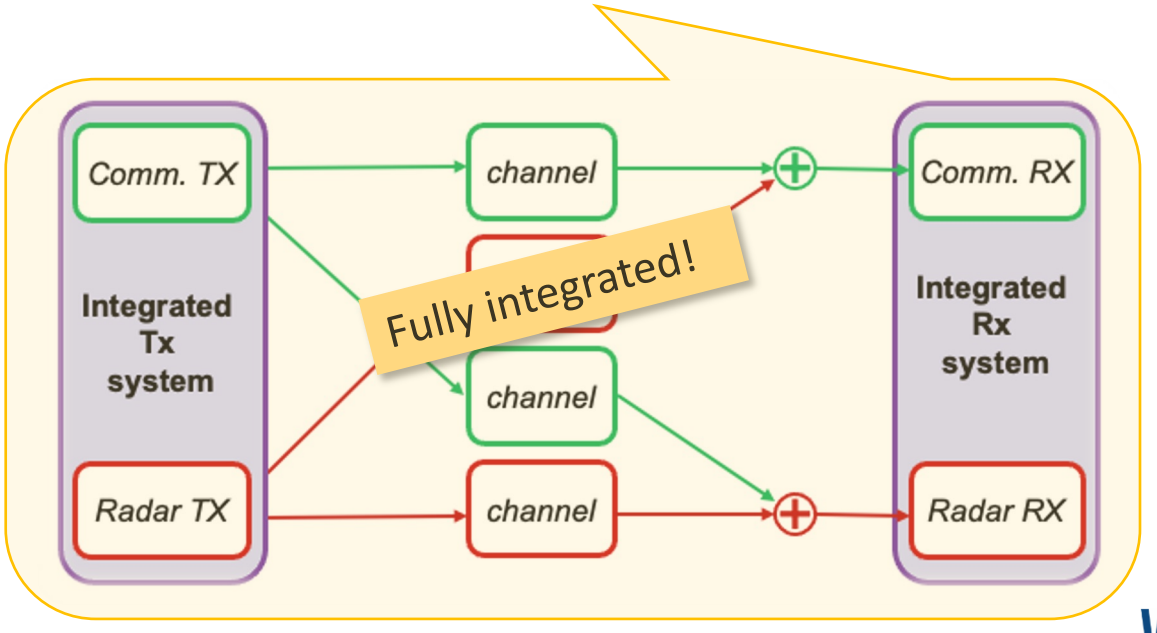
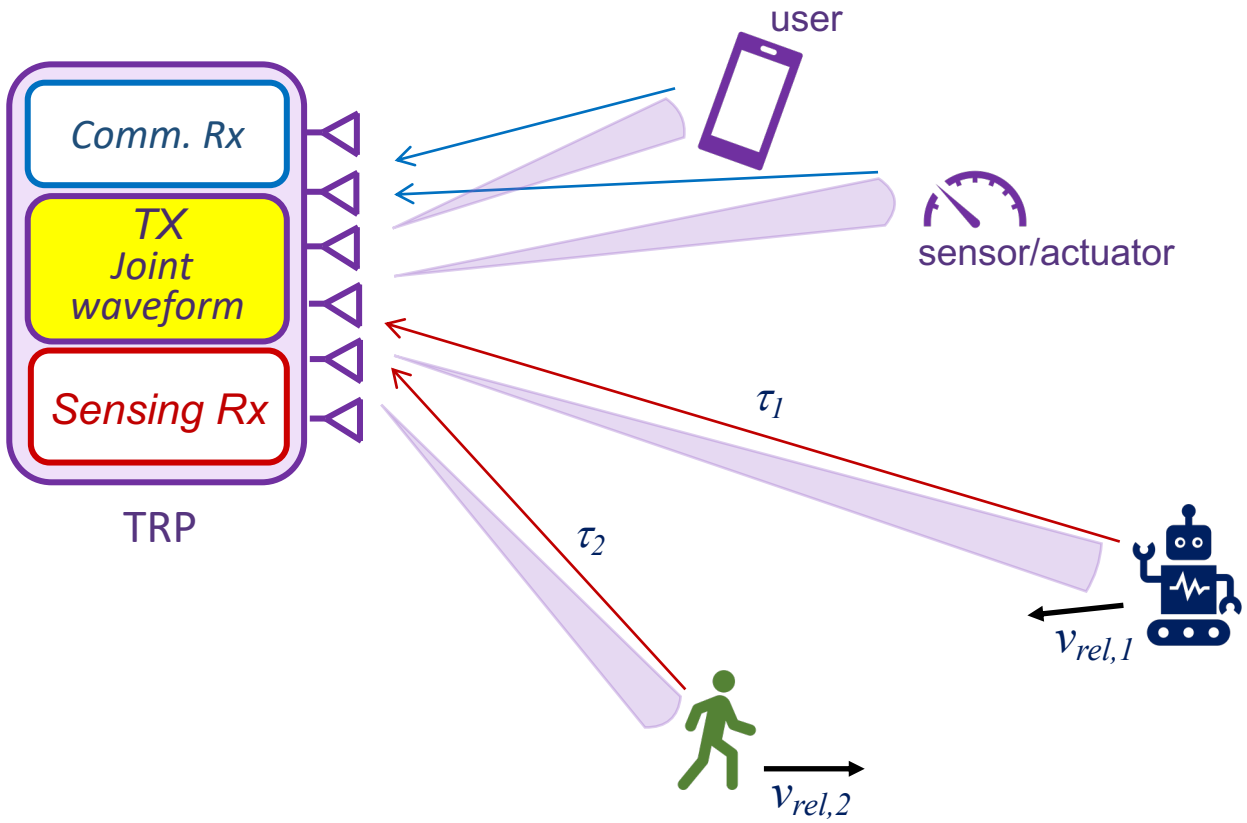
From coexistence to joint comm and sensing (JCAS)



- **Different systems and bands** – Integration at the higher layers. Sensing and communications systems exchange information to aid operation in some way.
- **Different systems and shared bands** – E.g., integration by multiplexing in time, frequency, and space, enabling the two functions to share the spectrum.
- **Full integration (Joint Comm & Sensing)** – Same band, same waveform, shared hardware.



Joint Comm And monostatic Sensing with multibeam technology

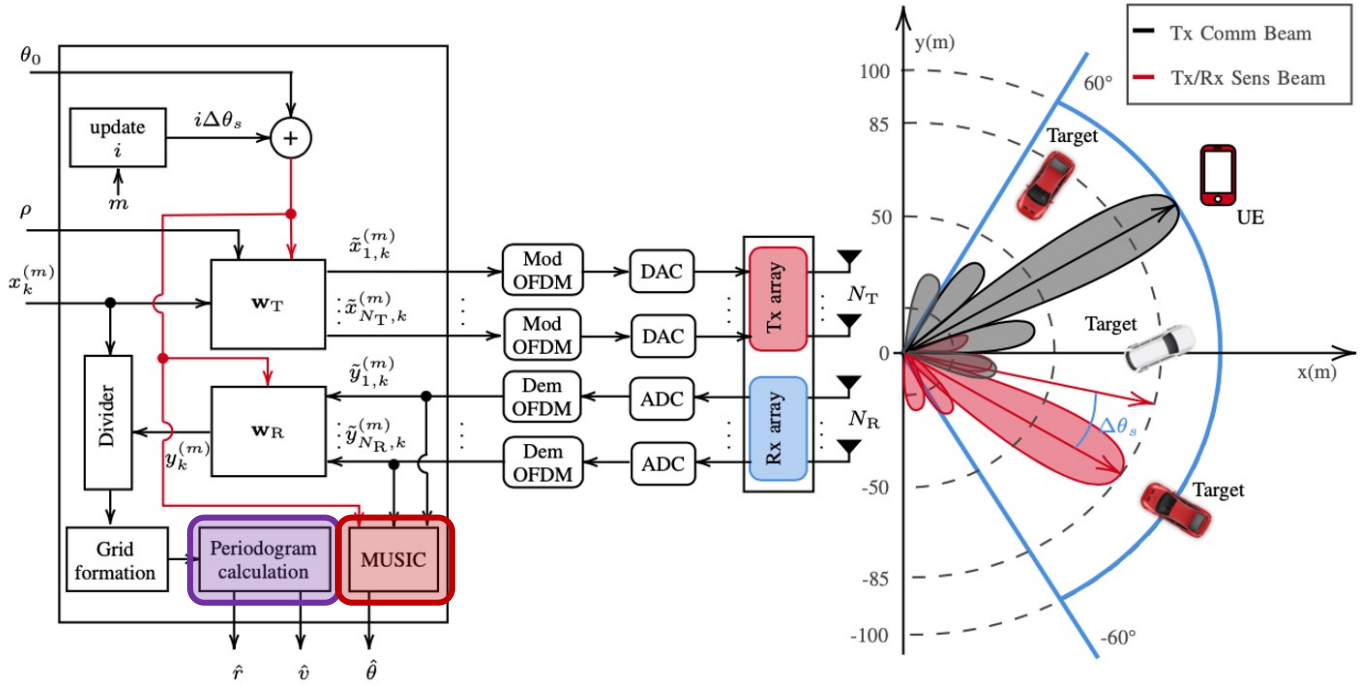


- Object detection
- AoA, range, velocity estimation
- Tracking
- Object recognition

- Stand alone solution
- Full duplex required!

L. Pucci, et. al., "System-Level Analysis of Joint Sensing and Communication based on 5G New Radio," IEEE J. on Sel. Areas in Comm. (JSAC), 2022.

System-level analysis of JCAS system based on OFDM



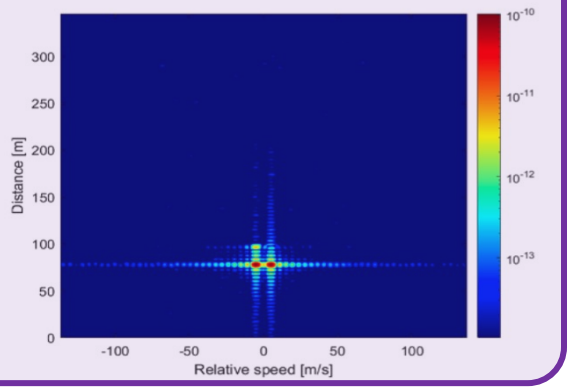
From received OFDM symbols (time-frequency matrix)

$$g_k^{(m)} = \sum_{l=1}^{L} \alpha_l e^{j2\pi m T_s f_{D,l}} e^{-j2\pi k \Delta f \tau_l} \Upsilon(\theta_{T,s}, \theta_{R,s}, \theta_l) + \nu_k$$

via periodogram in both directions

$$\mathcal{P}(q,p) = \left| \sum_{k=0}^{K_p-1} \left(\sum_{m=0}^{M_p-1} g_k^{(m)} e^{-j2\pi \frac{mp}{M_p}} \right) e^{j2\pi \frac{kq}{K_p}} \right|^2$$

Range-Doppler map



From received OFDM symbols

$$\hat{\mathbf{R}} = \frac{1}{KM_s} \sum_{m=0}^{M_s-1} \sum_{k=0}^{K-1} \tilde{\mathbf{y}}_k^{(m)} \tilde{\mathbf{y}}_k^{(m)\dagger} = \mathbf{U}\Lambda\mathbf{U}^\dagger$$

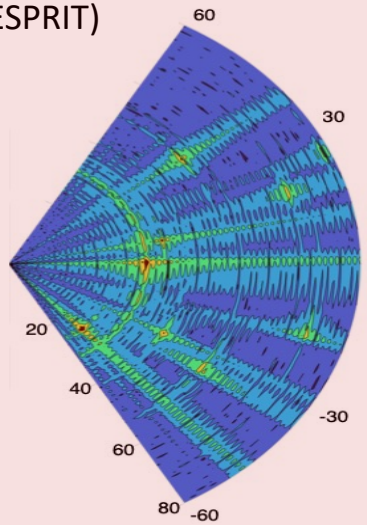
Estimation of the number of targets via MDL

$$\mathrm{MDL}(s) = -\ln\left(\frac{\prod_{i=s+1}^{N_R} \lambda_i^{1/(N_R-s)}}{\frac{1}{N_R-s}\sum_{i=s+1}^{N_R} \lambda_i} \right)^{(N_R-s)KM_s} + \frac{1}{2} s(2N_R - s)\ln(KM_s).$$

MUSIC (root-MUSIC, ESPRIT)

$$f_m(\theta) = \frac{1}{\left\| \tilde{\mathbf{U}}^\dagger \mathbf{a}(\theta) \right\|_2^2}.$$

Range-Angle map

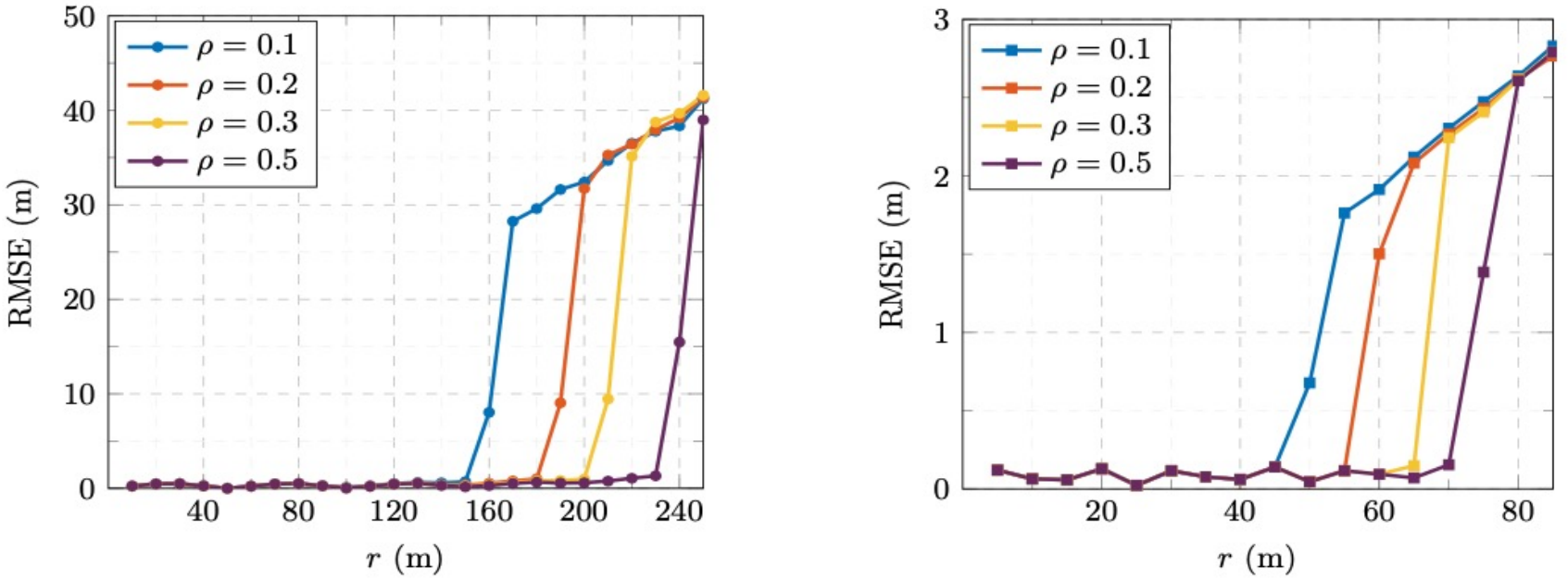


Sub-6GHz vs mmWave

- Position RMSE as a function of comm/sensing **power ratio**
- **Sub-6GHz** vs **mmWave**

TABLE I: JSC system parameters

5G specification →	NR 100	NR 400		
f_c [GHz]	3.5	28		
Δf [kHz]	30	120		
Active subcarriers K	3276	3168		
OFDM symbols per frame M	280	1120		
OFDM symbols per direction M_s	112	112		
Number of antennas $N_T = N_R$	10	10	50	100
Array beamwidth $\Delta\Theta$ [°]	27	27	5.3	2.6



(a) *Position RMSE at* $f_c = 3.5\,\text{GHz}$, $N_R = 10$

(b) *Position RMSE at* $f_c = 28\,\text{GHz}$, $N_R = 50$

Fig. 3: Target localization performance as a function of the sensor-target distance varying the fraction of power ρ reserved for sensing.

L. Pucci, et. Al., "Performance Analysis of Joint Sensing and Communication based on 5G New Radio," Globecom 2021 Workshop – ANLN, Madrid, Spain, Dec. 2021.

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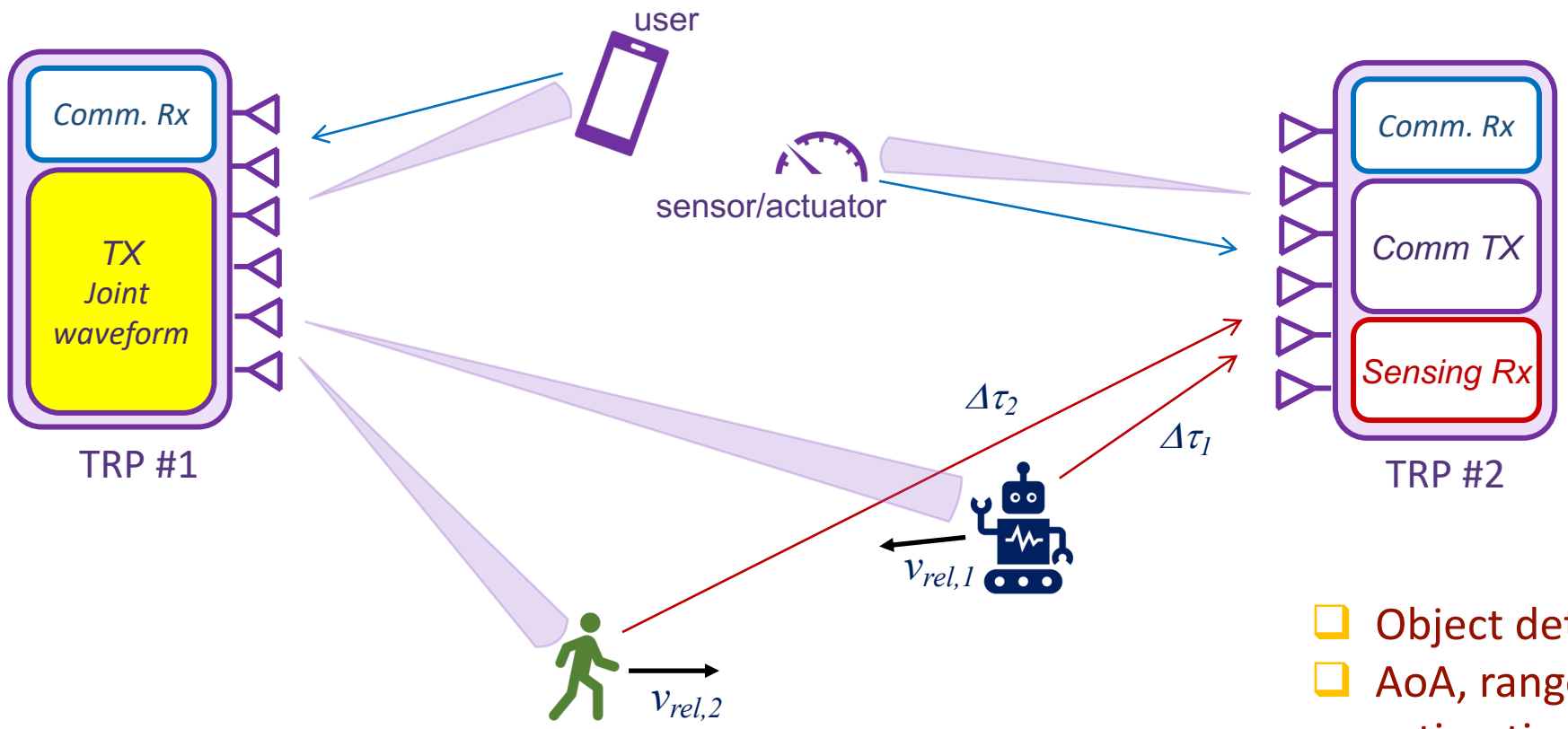
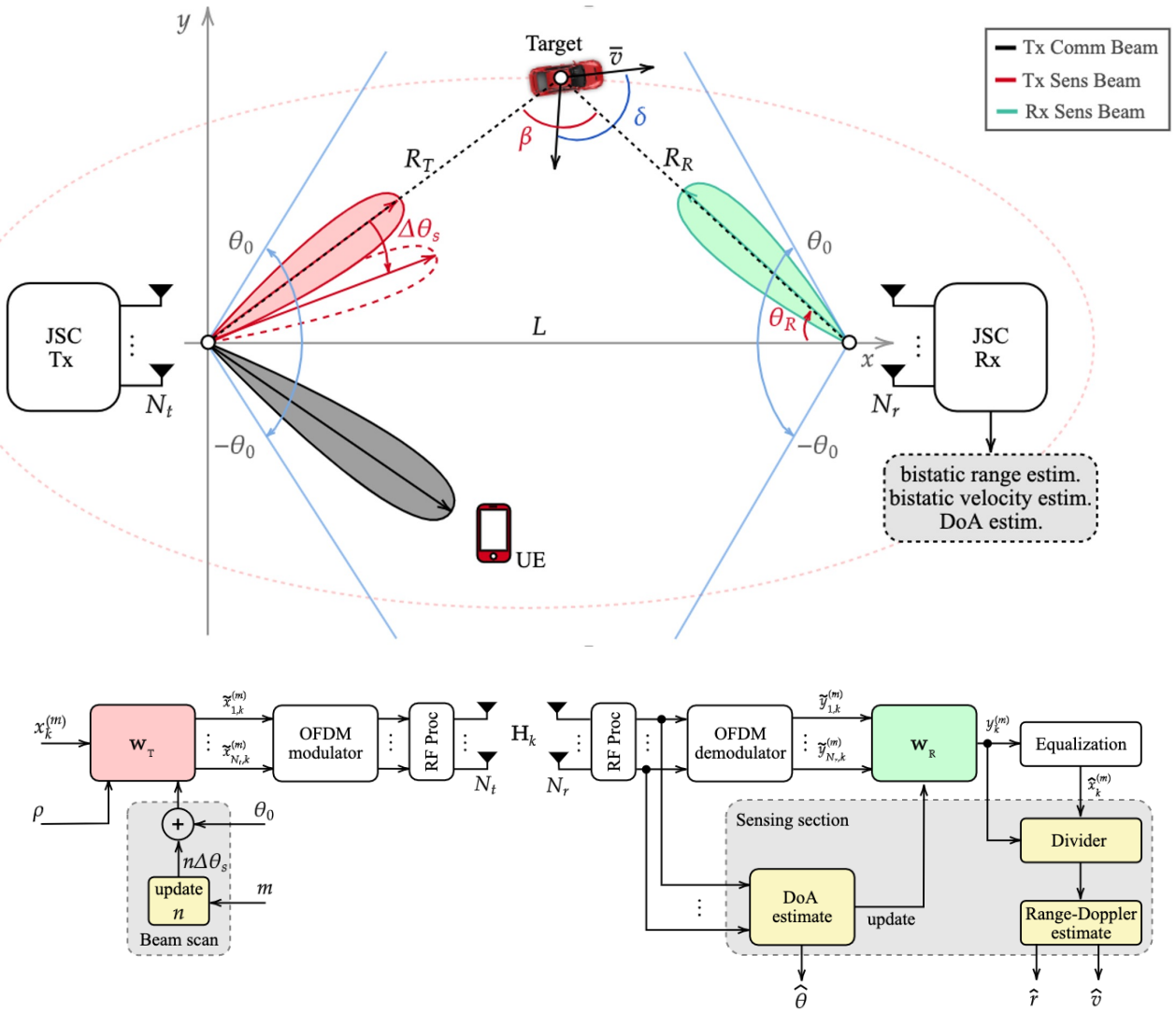
Joint Comm And bistatic Sensing with multibeam technology

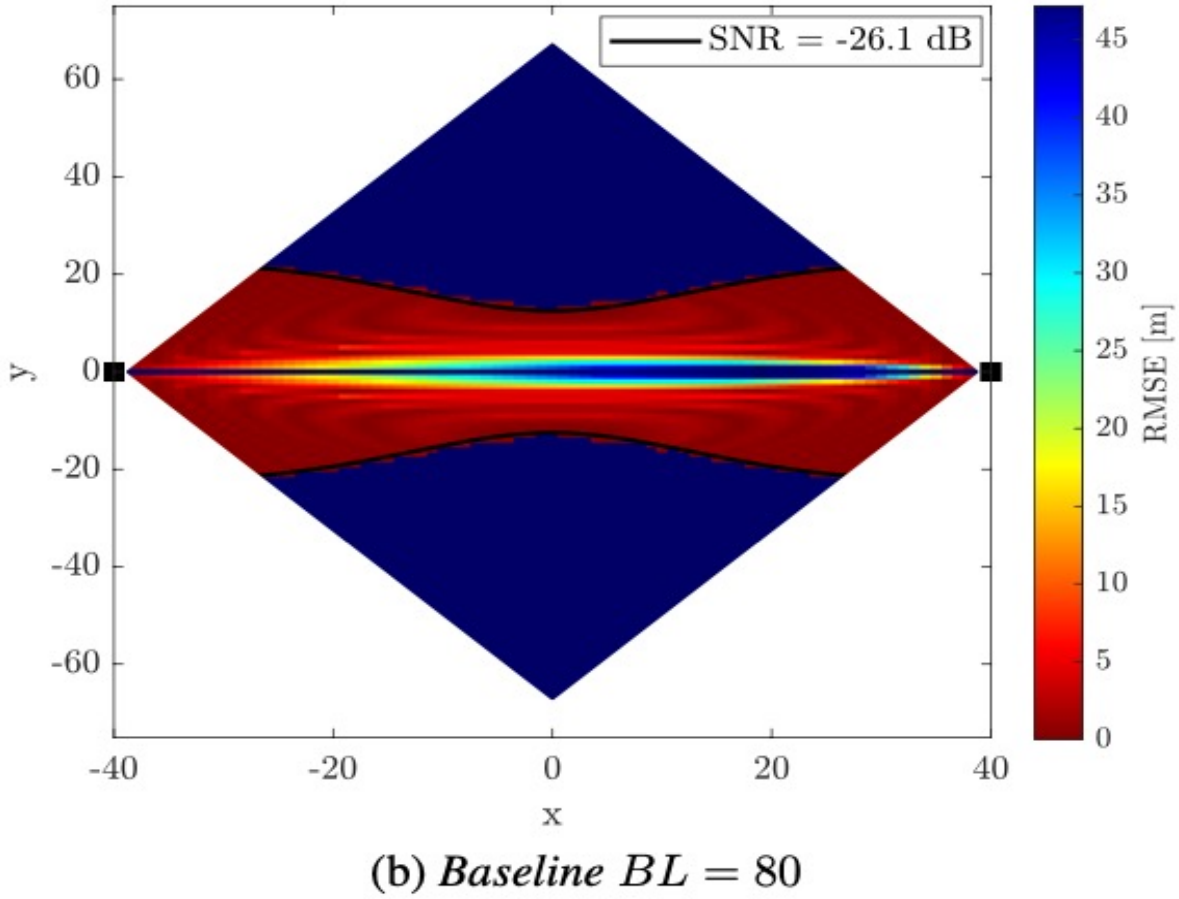


- Evolving towards network-based sensing
- No full duplex!

- Object detection
- AoA, range, velocity estimation
- Tracking
- Object recognition

JCAS with bistatic setup: system-level analysis





(b) *Baseline* $BL = 80$

L. Pucci et.al. "Performance Analysis of a Bistatic Joint Sensing and Communication System," IEEE Int. Conf. on Comm. (ICC), May 2022.

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ONE6G VERVIEW

DRIVE 6G RESEARCH AND INNOVATION EFFORTS

Launched in March 2021, one6G is a non-profit and membership fee free association offering an open collaborative framework to explore how to move beyond current communication networks technologies and business.

EMPOWERING SMART CONNECTIVITY FOR A BETTER FUTURE

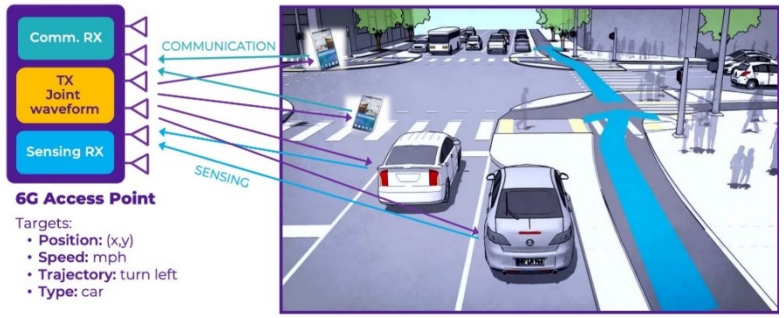
- ✓ Help unlock the full potential of both public and private organizations in the digital decade, empowering international co-creation.
- ✓ Foster participation of visionary researchers from academia and industry, global operators, major market players in selected verticals, regulatory agencies, market analysts, as well as innovative SMEs.
- ✓ On-board major players from several vertical industries to be engaged from the beginning.
- ✓ Promote cutting-edge technologies through joint initiatives, working groups, pre-standardization efforts, testbeds, user engagement, trials, demonstrations, dedicated liaisons and other activities.

MEMBERS

As of July. 2022 (80)

Latest info please refer to: https://one6g.org/members/

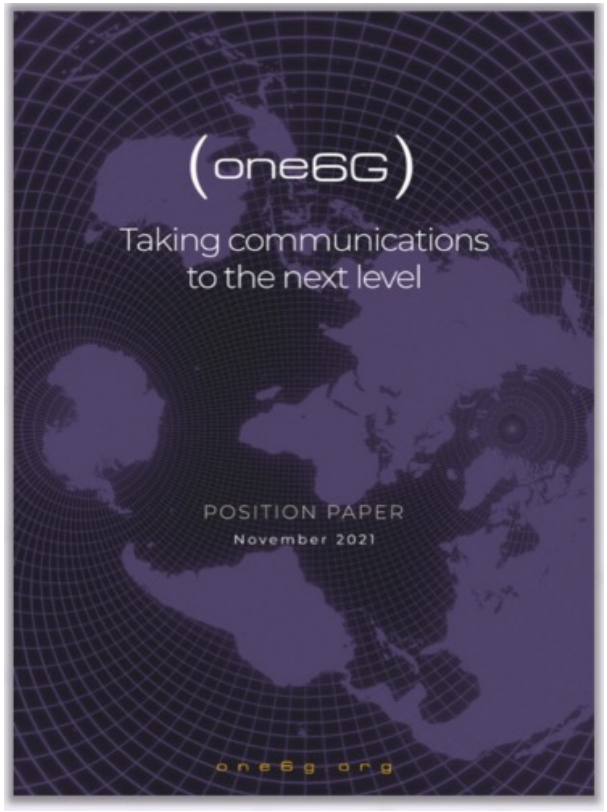
CURRENT WORK ITEMS



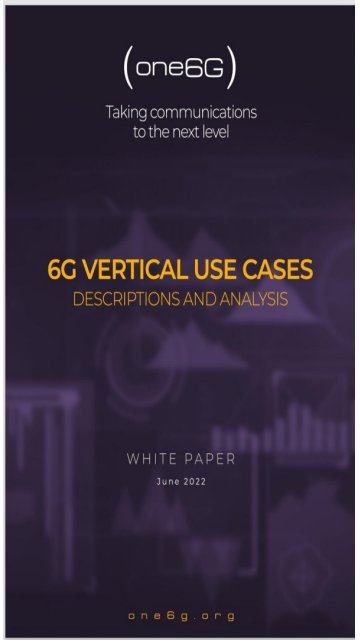
	Work Items	Scope of the WGs
WG1 Use cases, KPIs, and Future Market and Business Scenarios	WI 101 - Collection of 6G-related Use Cases and Related Scenarios （completed and in the maintenance mode）	• Consolidate vision • Use case and requirements analysis • Streamline terminology, etc.
WG2 Enabling Technologies and System Architecture	**WI 204 -** Higher Frequencies **WI 205 -** 6G Radio Access **WI 207 -** Intelligent User Plane, In-Network Computing **WI 208 -** Distributed/Federated AI **WI 209 -** Next-generation MIMO **WI 210 -** Integrated Sensing and Communication **WI 211 -** Flexible Programmable Infrastructures	• Research of key enabling technologies, concepts, etc. • Evaluation and selection of most promising ones • Integration thereof into a coherent architecture
WG3 Communication & Dissemination	**WI 301 -** 6G position paper (completed) **WI 302 -** Dissemination: web page, social media, newsletter, one6G internal and external events, webinars	• Liaisons and partnership management • Marketing and promotional activities • Preparation of workshops, conferences, etc.
WG4 Evaluation, Testbeds, and Pilots	**WI 210 -** (cross WG2/WG4) Integrated Sensing and Communication **WI 402** – Definition of the evaluation guidelines for simulation/emulation	• Aspects of testing and evaluation • Test procedures and verification • Testbeds, prove of concepts and trials, etc.

ONE6G POSITION PAPER

one6G organization published the 1st position paper to lay out its vision and work plan in Nov 2021.



one6G published 2 white papers during EuCNC2022 and ITU-R June meeting time period.



6 Use cases families with 25 use cases analyzed:

- Manufacture: 7
- Automotive: 5
- Health: 5
- Telecom (MBB/Resiliency): 4
- Agriculture: 3
- Transportation (railway):

Use case#22
AI-as-a-service for industrial robots: Learning to be collaborative

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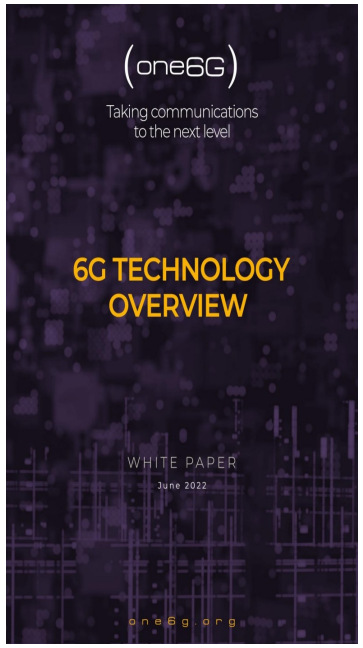

7 technologies identified:

- THz Frequencies
- 6G Radio Access (6GRA)
- Next Generation MIMO
- Integrated Sensing and Communication (ISAC)
- Distributed Federated AI
- Intelligent User Plane, In-Network Computing
- Flexible programmable infrastructures

ONE6G OPEN LECTURE

one6G establishes 5 open lectures in 2022, and aims to provide an open 6G knowledge sharing forum

May 5, 2022 - 14:00 CEST
Lecture 1
6G Network AI

July 7, 2022 - 14:00 CEST
Lecture 2
Integrated Sensing and Communication

Sept. 15, 2022 - 14:00 CEST
Lecture 3
6G testbed/simulation

Oct. 6, 2022 - 14:00 CEST
Lecture 4
Channel Modeling

Dec. 1, 2022 - 14:00 CEST
Lecture 5
Flexible Programmable Infrastructures

CONTACT US TO LEARN MORE

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