

# View on Integrated Sensing and Communications

# Background

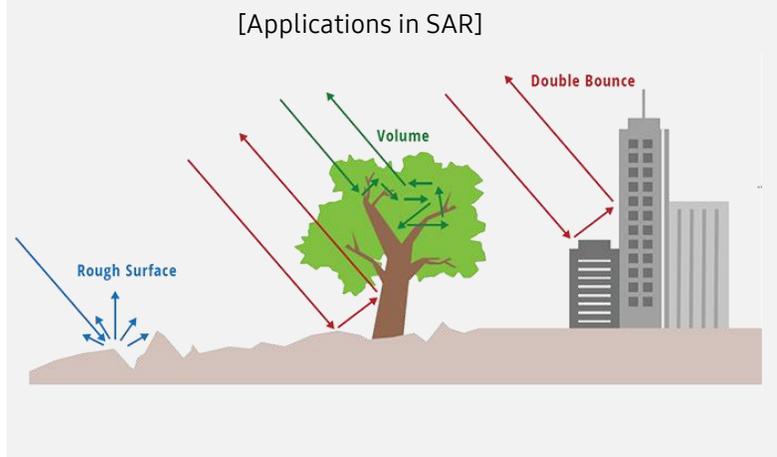
RF sensing has been used for various applications and industries such as sensor and Rader.

- Synthetic Aperture Rader for remote sensing (8 – 12 GHz for high resolution SAR)
- Active Rader or RF sensors in 24, 28, 60, and 76 – 81 GHz for distance, presence, object tracing, and motion detection
- Passive imaging at 94 GHz for RF imaging for climate and miliary

For detection accuracy and resolution, using high-frequency with wideband signal is the key.

## SAR at 8 – 12 GHz

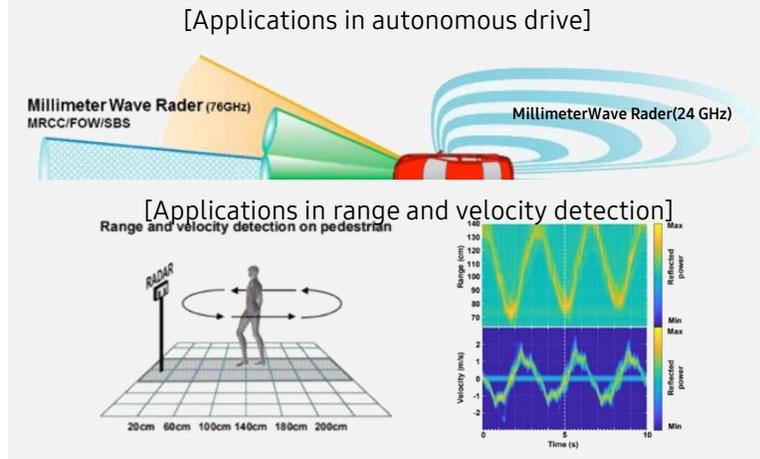
- Method to generate images of the sea surface that can be exploited to extract geophysical information of environmental interest.



What is Synthetic Aperture Radar? | Earthdata (nasa.gov)

## Sensing/Rader at 24, 60, 76 – 81 GHz

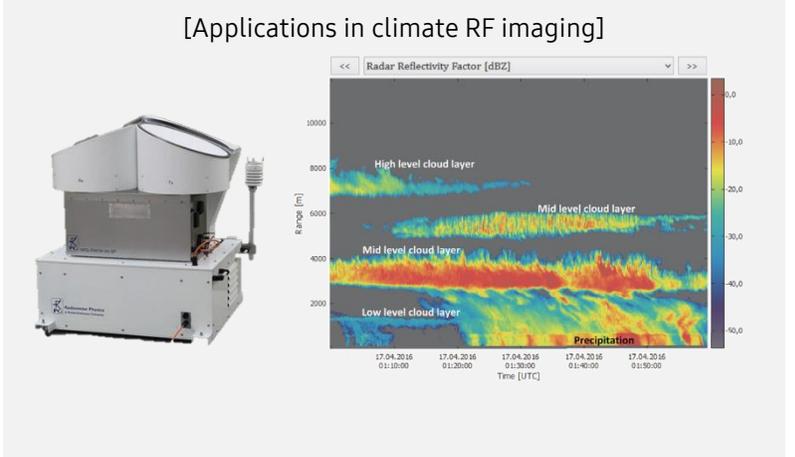
- Method to send Rader signal and received reflected signal to detect distance, proximity, presence, motions, velocity, and more from Doppler or Micro-Doppler, CIR, and others



<https://www.import-car.com/making-sense-of-mazdas-i-activesense-adidas/>  
<https://www.elektronikpraxis.de/radar-chip-mit-60-ghz-ueberwacht-kontaktlos-vitalparameter-a-953862/>

## Passive imaging at 94 GHz

- Method to accumulate noise power to measure emissivity and brightness temperature



<https://www.radiometer-physics.de/products/microwave-remote-sensing-instruments/94-ghz-fmcw-doppler-cloud-radar/#tabs-container-0>

L. Yujiri, M. Shoucri and P. Moffa, "Passive millimeter wave imaging," in IEEE Microwave Magazine, vol. 4, no. 3, pp. 39-50, Sept. 2003, doi: 10.1109/MMW.2003.1177

# Integrated Sensing and Communications

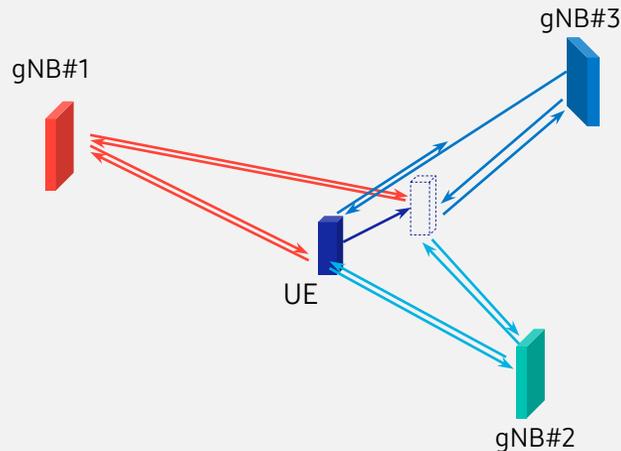
Integration sensing and communications (ISC) may be possible in 6G period considering the trends of industry convergence.

- Mobility/proximity/positioning, CSI, and assistance information from RF sensing might be valuable for network performance
- Indoor scenario seems practically affordable due to less noise and interference sources

Important to understand sensing capability for both non-3GPP based and 3GPP based

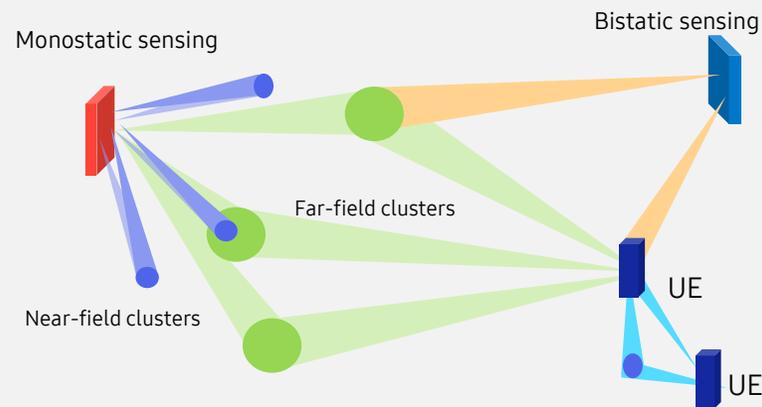
## Mobility/Proximity/Positioning

- Speed and direction detection for mobility / single-cell positioning / Energy saving for proximity



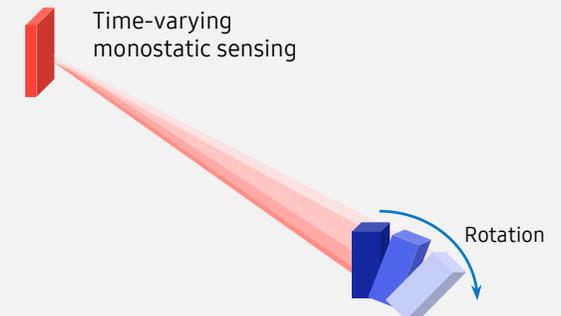
## CSI information

- Accurate cluster measurement/UE-assisted and gNB-assisted measurement for channel and interference channel for MIMO performance



## Assistance information

- UE-rotation, activity, action, motion detection, and other assistance information to help beam management



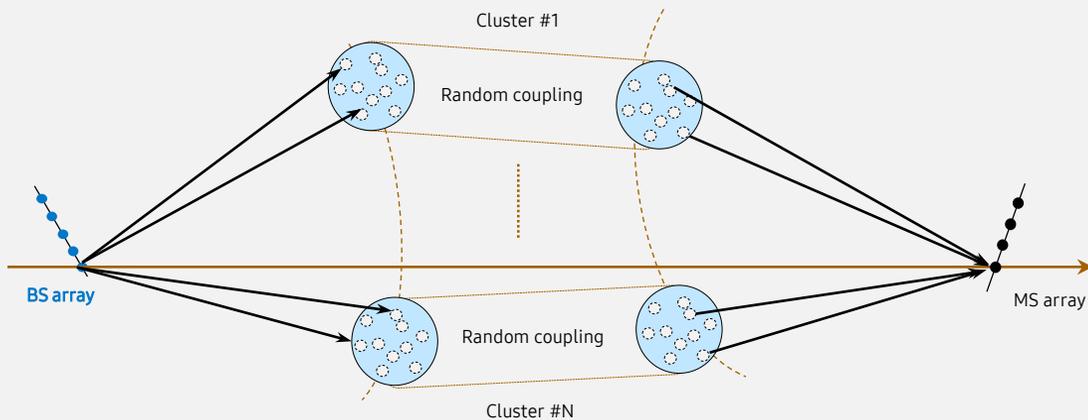
# Necessary for ISC Channel Model

However, there is no methodology to evaluate “sensing” in 3GPP (e.g.,TR38.901)

- Channel model cannot be used for evaluation of sensing performance and data performance based on ISC model
- To have accurate evaluation, a framework for ISC channel model should be design considering monostatic and bistatic sensing
- In TR38.901, both channel model and methodology should be updated with verifications

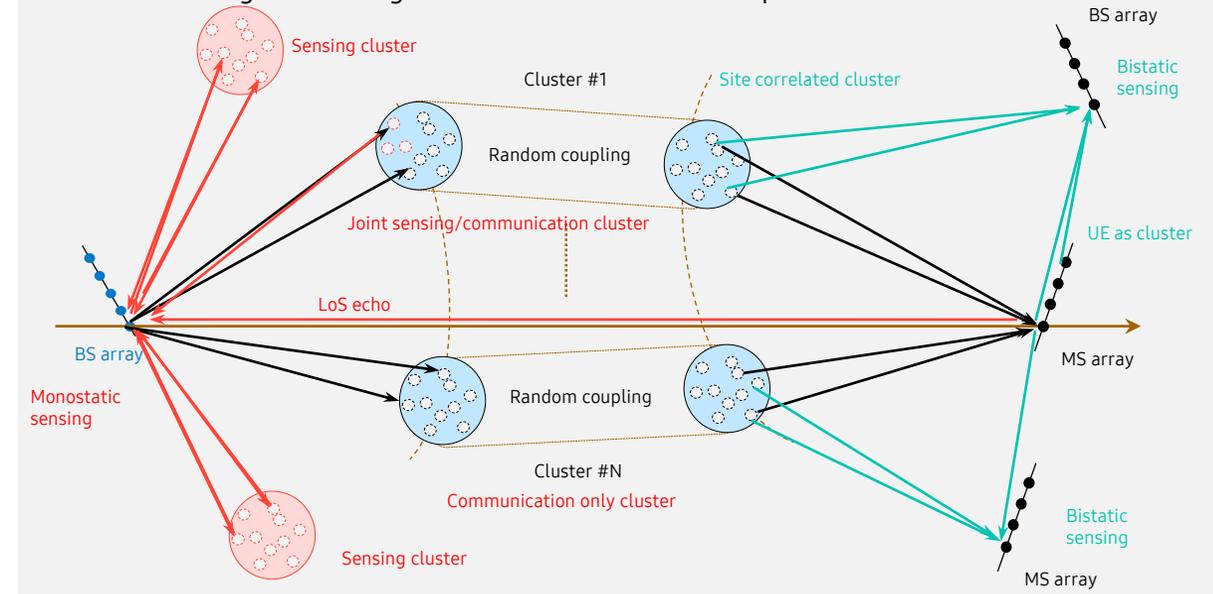
## TR38.901 Channel model

- Clusters are defined between BS array and MS array for MIMO channel



## Expected ISC model

- A lot of missing for sensing channel and understand impact on communications

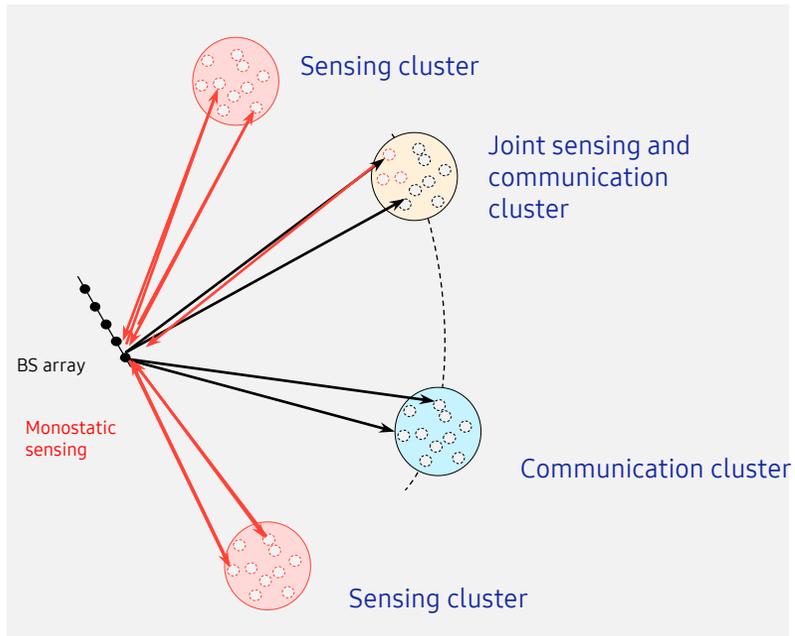


# Necessity of Channel Model Study

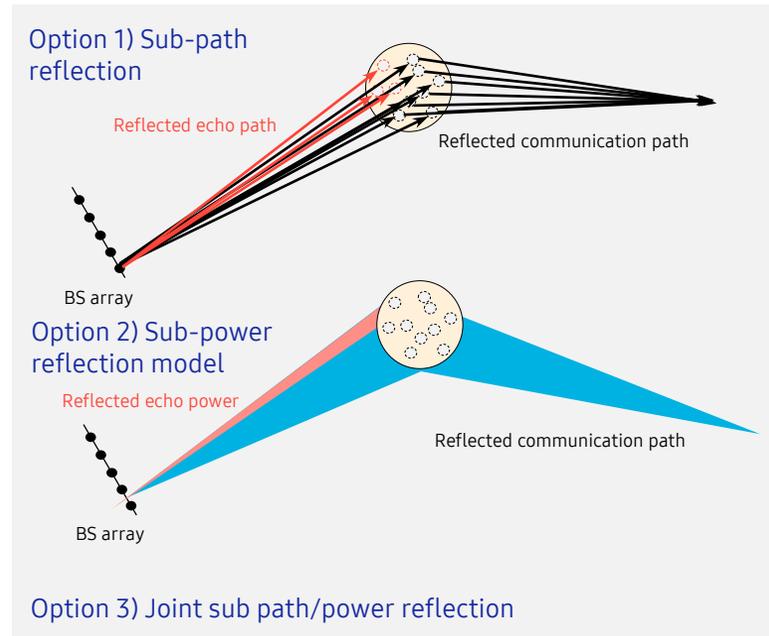
1) Cluster modeling: study how to define cluster, reflection modeling, distance dependency.

- Need to classify clusters into sensing only, communications only, and joint
- Reflection model is also important to define angular, spatial, and power profiling
- Echo channel characteristics can have different spread in respective of sensing distance

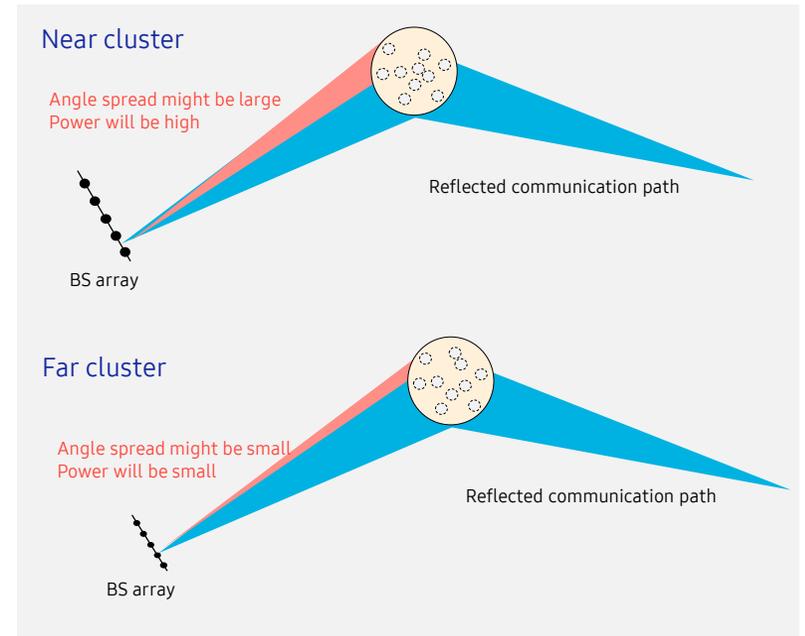
## Cluster classification



## Reflection model



## Distance dependency



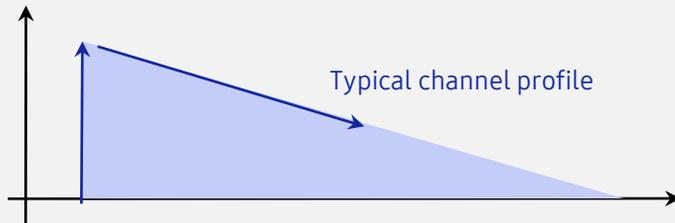
# Necessity of Channel Model Study

## 1) Cluster modeling (cont.): sensing delay profile, multi-reflection, and UE as cluster

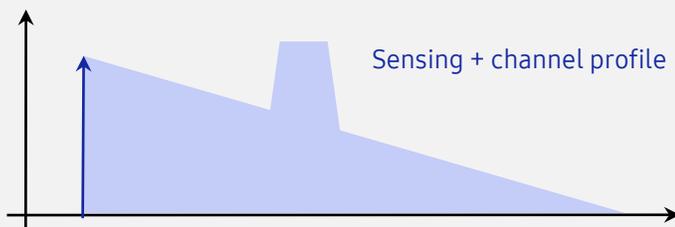
- Sensing cluster will have different profile, but depends on distance
- Multi-reflection cannot be used in TR38.901, but need to verify power contributions
- Clusters in TR38.901 assume buildings or obstacles, not UE, but sensing should use UE or gNB as a cluster

### Sensing delay profile

Typical channel profile



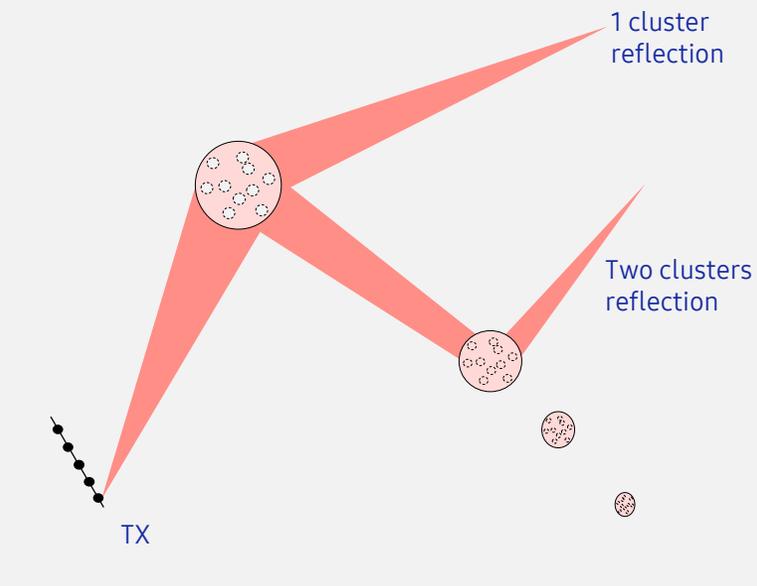
ISC channel profile



Z. Zhang et al., "A General Channel Model for Integrated Sensing and Communication Scenarios," in IEEE Communications Magazine, doi: 10.1109/MCOM.001.2200420.

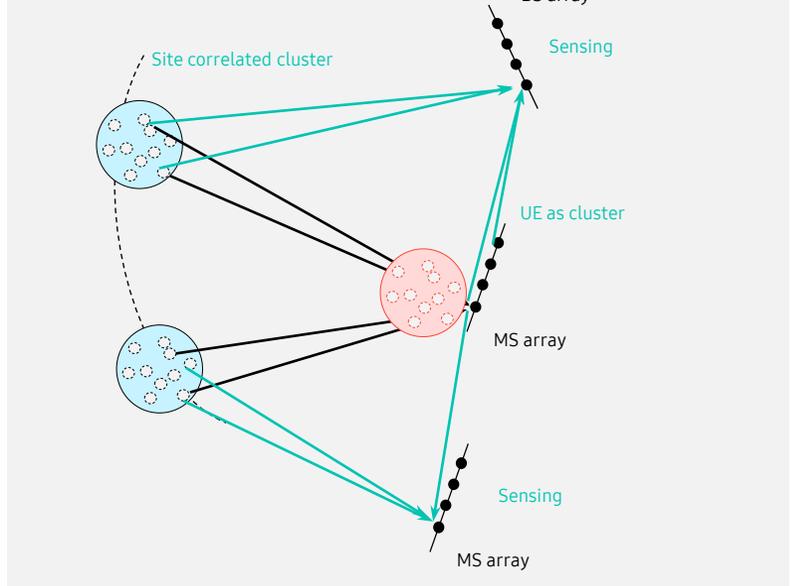
### Multi-reflection

How many reflections do we assume?



### Node as cluster

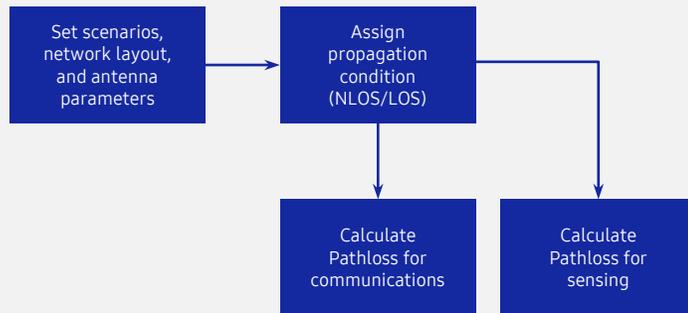
How to model UE as cluster?



# Necessity of Channel Model Study

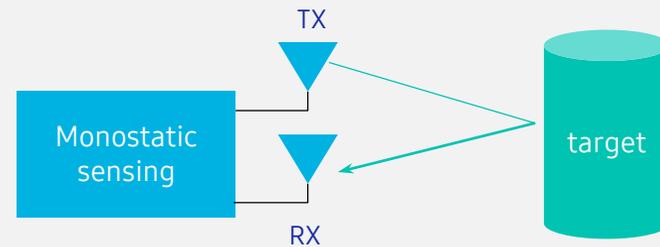
- 2) Echo pathloss: long-term pathloss of echo path
- 3) Interference model for sensing operation: self CIR cancellation capability
- 4) Moving target modeling: Macro/micro-Doppler sensing is required to support use cases in TR22.837

## Echo pathloss model



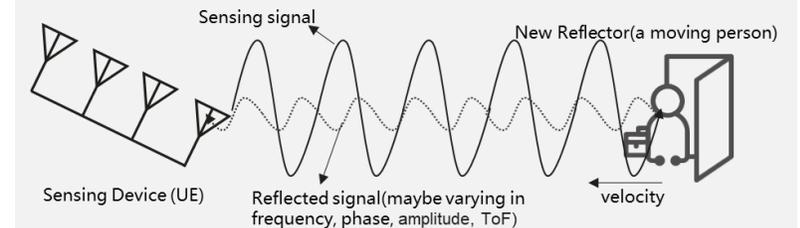
Pathloss in TR38.901 is long-term fading between TX and RX. However, for monostatic sensing, unclear whether current long-term fading is reasonable to use

## Self-Interference model



Full duplex operation is essential in monostatic sensing. Self CIR cancellation at RX to have clean sensing CIR at the gNB. However, there should be residual interference for cancel. Note: Bistatic sensing does not require self cancellation.

## Moving target



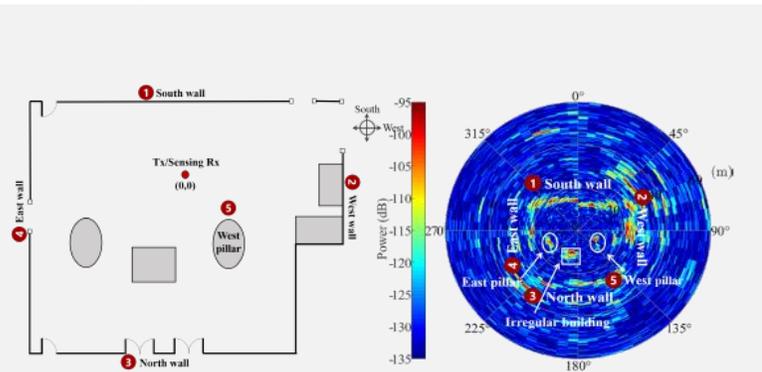
By analysing and collecting the sensing information such as Doppler frequency shift, amplitude change and phase change, the behaviour of indoor object or human could be detected as shown in following figure (in TR22.837)

# Validation of ISC channel model

## Full measurement campaign for ISC channel model is not easy work

- Measurement procedure is not simple since massive measurement points are necessary for modeling clusters.
- Model validation is essential but should be realistic (e.g., ray-tracing based modeling with real-world measurement for selected test points)
- Sensing performance is also important since spatial, delay resolutions are highly correlated with BW, sequence design, and frequency band.
- Methodology can be updated on top of processes depicted in Figure 7.5-1 (TR38.901).

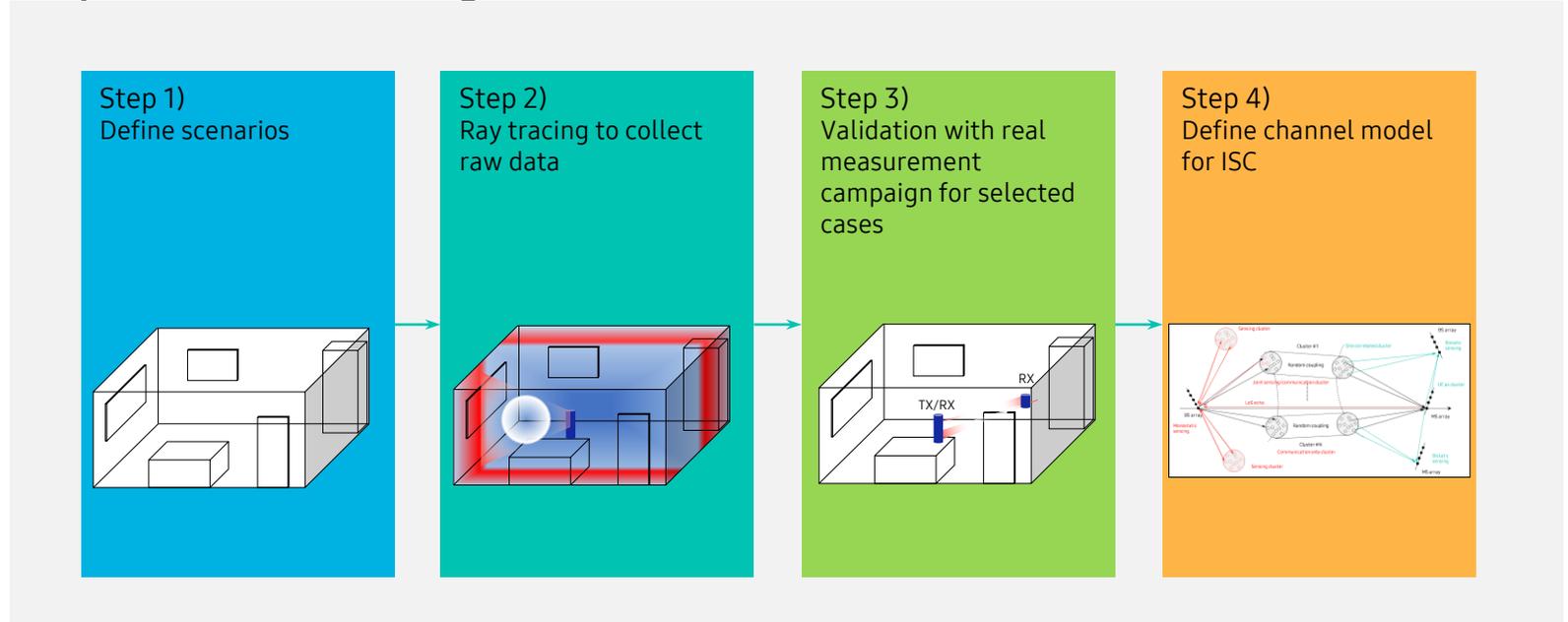
## Sensing measurement example



To understand correlation between sensing and communications, measurement cases should be exponentially increased to consider both TX and RX surroundings

Also, to measure moving target, massive snapshots should be measured in all grid positions in the scenarios

## Steps to validate sensing channel model



# Conclusion

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## **If there is a high need for ISC, “channel model study” should be the first step in Rel-19**

- Channel model in TR38.901 cannot evaluate ISC performance
- Channel model study should include the following aspects:
  - Identify RF sensing method, scenarios for channel model study
  - Study channel characteristics such as reflected PDP, angular, and spatial information, Doppler and Micro-Doppler, reflectivity/transmittance, and noise temperature
  - Study how to validate ISC channel (e.g., ray tracing and/or real measurement campaign, or hybrid)
  - Develop channel model of long-term and short-term fading for ISC (e.g., common cluster model, ... )
  - Develop methodology for channel generation for ISC evaluation