3GPP TSG RAN Meeting #101
Bangalore, India, September 11-15, 2023
Agenda item: 8A.2.11
RP-232217

Discussion on Rel-19 Channel Modeling

CMCC

Endorsed RAN chair's summary in RWS-230488: Channel Modeling (& possibly additional aspects e.g. for ISAC) for further evolution

- Strong interest in exploring study in new areas (RAN plenary invovlement?)
  - **Very strong interest in channel modeling for integrated sensing and communication (ISAC), and also interest in other possible areas (e.g., use cases, scenarios, key performance metrics (KPIs), potential spec impact, etc.)**
  - Reasonable interest in exploring study in new spectrum, such as 7-24GHz
    - Channel modeling study only?
  - **Reasonable interest in RIS (Reconfigurable Intelligent Surface) related study**
    - **Channel modeling study only?**
- Very challenging if study is to be carried out for all the above items
  - Which one(s) should be the focus? Necessity for future standard evolution?

Commonality of channel modeling study on ISAC and RIS

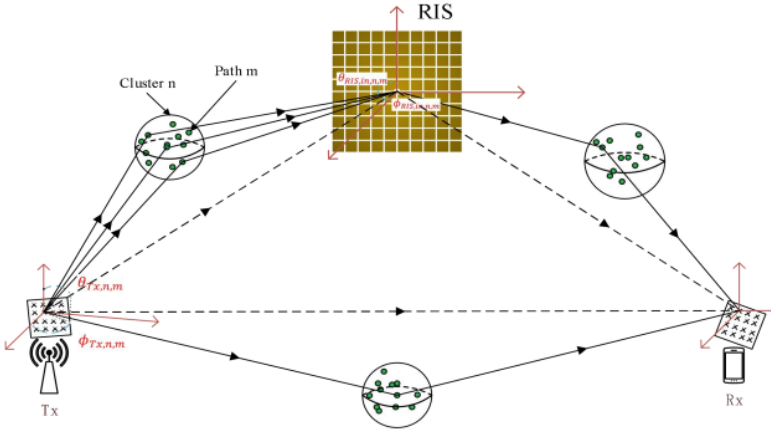


Figure 1, channel modelling of RIS [1]

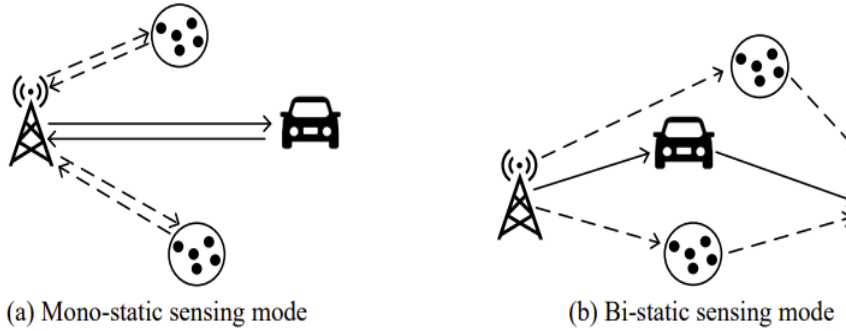


Figure 2, two typical sensing modes [2]

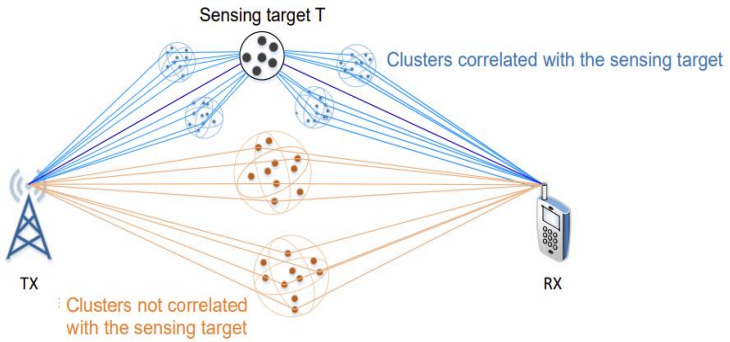


Figure 3, channel modeling of bi-static sensing mode [2]

- To evaluate the performance of RIS, the RIS node or the RIS array can be explicitly modeled in the channel (Figure 1).
  - The channel between gNB and RIS, RIS and UE, and the cascaded channel of gNB-RIS-UE can be modeled.
- To evaluate the performance of ISAC, mono-static and bi-static mode sensing are identified as two typical sensing mode.(Figure 2)
  - In the bi-static sensing model, the targeted sensing objective can be also explicitly modeled. (Figure 3)
  - The channel between gNB-target T, target T- UE and the cascaded channel of gNB-target T-UE can be modeled.
- ➔ Great commonalities can be observed for RIS channel model and ISAC channel model of bi-static sensing mode.
  - Details can be observed in appendix.

- **Proposal 1:**
  - **Considering that channel models will be used in the following multiple Releases (like 38.901 is used from Rel-15 to Rel-19), both ISAC and RIS channel models can be considered for the integrity.**
- **Proposal 2:**
  - **To reduce the further efforts of channel modeling, the study of channel model of ISAC and RIS can be combined considering the commonality of two models.**

[1] Reconfigurable Intelligent Surface Technology White Paper. (http://www.risalliance.com/en/riswp2023.html)
[2] Channel Modeling Methods of 5G-Advanced Integrated Sensing and Communication, IMT-2020 (5G) Promotion Group, 5G-Advanced Sensing Task Group

Content

- Channel modeling for ISAC
- Channel modeling for RIS

Scenarios and Requirements of ISAC

Scenarios and Requirements

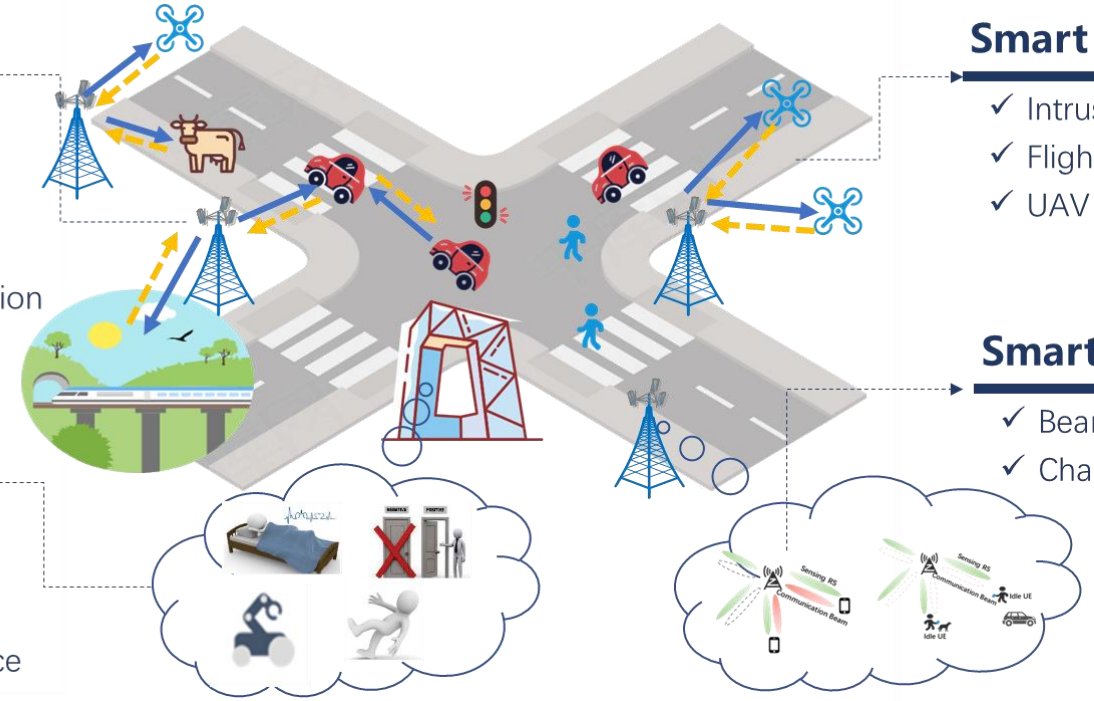
- **ISAC is expected to be a promising native feature in 6G**
  - Support low-cost, high-precision, seamless and ubiquitous sensing capability through joint design of new radio and network architecture, reuse of software and hardware equipment, and spectrum resource sharing.
- **32 use cases have been studied in SA and captured in TR 22.837. Based on the requirements from government and industries, the use cases with higher priority include:**
  - Transportation: Sensing at crossroads with/without obstacle, pedestrian/animal intrusion detection on a highway
  - UAV: intrusion detection
  - Indoor: intrusion detection

Smart Transportation

- ✓ Assisted automotive maneuvering and navigation
- ✓ Intrusion Detection
- ✓ Traffic monitoring
- ✓ Tourist/sports hotspot detection
- ✓ Car parking

Smart City

- ✓ Intrusion Detection
- ✓ Health monitoring
- ✓ Weather forecast
- ✓ AMR/AGV collision avoidance



Smart UAV

- ✓ Intrusion Detection
- ✓ Flight trajectory tracing
- ✓ UAV collision avoidance

Smart Communication

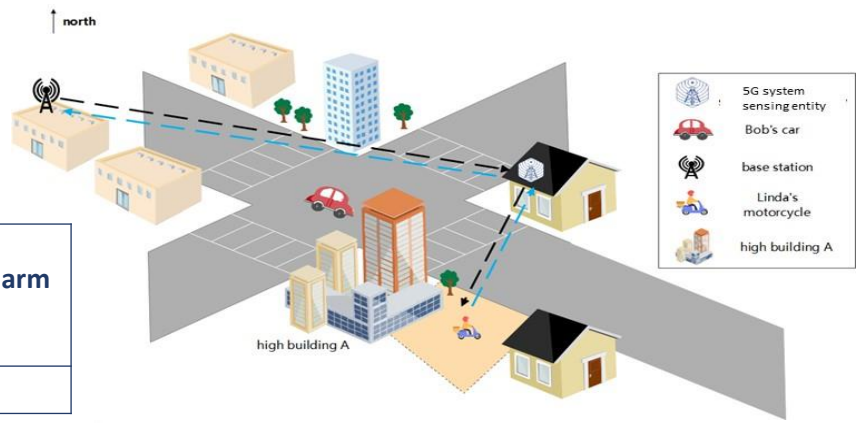
- ✓ Beam management
- ✓ Channel estimation

ISAC Enables Smart Transportation

Sensing at crossroads with/without obstacle

- ✓ Pedestrians suddenly rush to the road from the invisible place.
- ✓ Sensing information to fill the blind points.

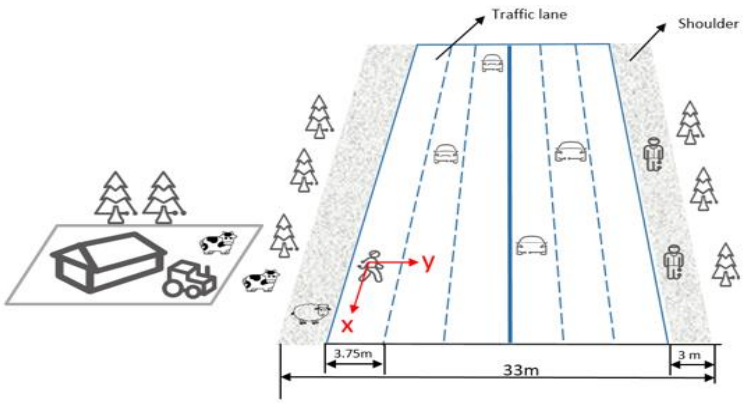
Sensing service area	Confidence level [%]	Accuracy of positioning		Max sensing service latency [ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
		Horizontal [m]	Vertical [m]				
Outdoor	95	≤1	N/A	≤100	≤ 0.1	≤5	≤5



Intrusion detection

- ✓ Road safety, management of road traffic
- ✓ Low cost, all-day, wide area seamless coverage for intrusion detection.

Sensing service area	Confidence level [%]	Accuracy of positioning		Max sensing service latency [ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
		Horizontal [m]	Vertical [m]				
Outdoor (Highway)	95	≤1	N/A	≤5000	≤ 0.1	≤5	≤5



*3GPP TR 22.837 Feasibility Study on Integrated Sensing and Communication (Release 19)

ISAC Enables Smart UAV and Smart City

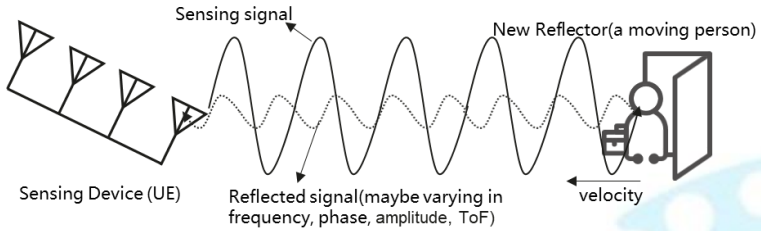
UAV intrusion detection

- ✓ Non-cooperative UAVs intrude some no-fly zone
- ✓ Low cost, wide area seamless coverage for both supervision and non-cooperative UAV intrusion detection.

	Sensing service area	Confidence level [%]	Accuracy of positioning		Sensing resolution		Max sensing service latency [ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
			Horizontal [m]	Vertical [m]	Range resolution [m]	Velocity resolution [m/s x m/s]				
Level 1	Outdoor	95	≤10	≤10	10	[5]	[≤1000]	[≤1]	≤5	≤5
Levle 2	Outdoor	95	≤5	≤5	10	[5]	[≤1000]	[≤1]	≤5	≤5

Intruder detection in home/factory/office

- ✓ Ensure people at home/factory/office feel comfortable and secure
- ✓ Monitor locations without line-of-sight and to monitor wider areas



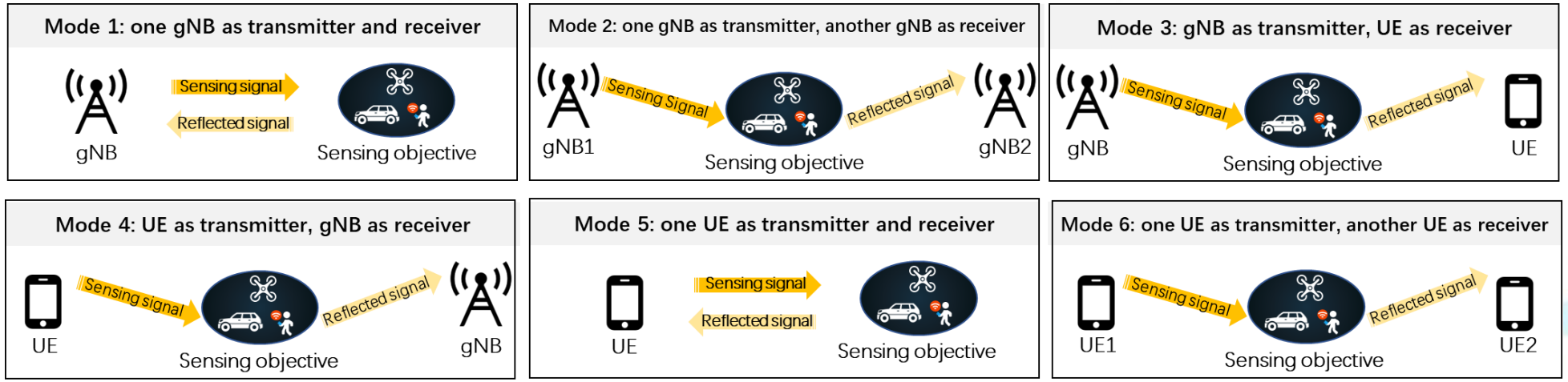
Sensing service area	Confidence level [%]	Accuracy of positioning		Max sensing service latency [ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
		Horizontal [m]	Vertical [m]				
Indoor	95	≤10	≤10	<1000	<1	<5	<2

*3GPP TR 22.837 Feasibility Study on Integrated Sensing and Communication (Release 19)

Diversity Modes to Enable Variable Scenarios for ISAC

Diversity Modes

- **Six modes have been discussed for ISAC, Mode 1 and Mode 2 are more suitable for V2X, UAV and indoor intrusion detection use cases, to provide low cost, all-day, wide area seamless coverage sensing, and enable higher sensing accuracy with high transmission power and large antenna array.**
  - Mode 1: one gNB as transmitter and receiver. Mode 2: one gNB as transmitter and another gNB as receiver.
    - Pros: high transmission power and large antenna array to enable high sensing accuracy.
    - Cons: isolation between transmitter and receiver for Mode 1, synchronization between gNB for Mode 2.
  - Mode 3: gNB as transmitter and UE as receiver. Mode 4: UE as transmitter and gNB as receiver.
    - Pros: compatibility with 5G system.
    - Cons: sensing of non-cooperative UE.
  - Mode 5: one UE as transmitter and receiver. Mode 6: one UE as transmitter and another UE as receiver.
    - Pros: scenarios without LOS from gNB or even out of coverage of gNB.
    - Cons: isolation between transmitter and receiver, low transmission power and small antenna array of UE.



Channel modeling study on ISAC (1)

Motivations

- To enable ISAC for V2X, UAV and indoor intrusion detection use case with higher requirements from government and industries, potential enhancement may include signal design, resource allocation, measurements based on existing waveform and reference RS, and sensing architecture for supporting sensing application.
  - The detailed design of potential solutions require a reliable and comprehensive understanding of sensing channel. **Adequate channel model representing the multipath of sensing signal is very important for performance evaluation for different sensing modes and different scenarios.**

Potential Objectives

- **Identify prioritized use cases and corresponding requirements from TR 22.837 [RAN1]**
- **Study the channel modeling for integrated sensing and communication for both FR1 and FR2 [RAN1]**
  - Large-scale fading modeling includes pathloss modeling, RCS modeling, and LOS probability
  - Small-scale fading modeling

Channel modeling study on ISAC (2)

Large-scale fading modeling

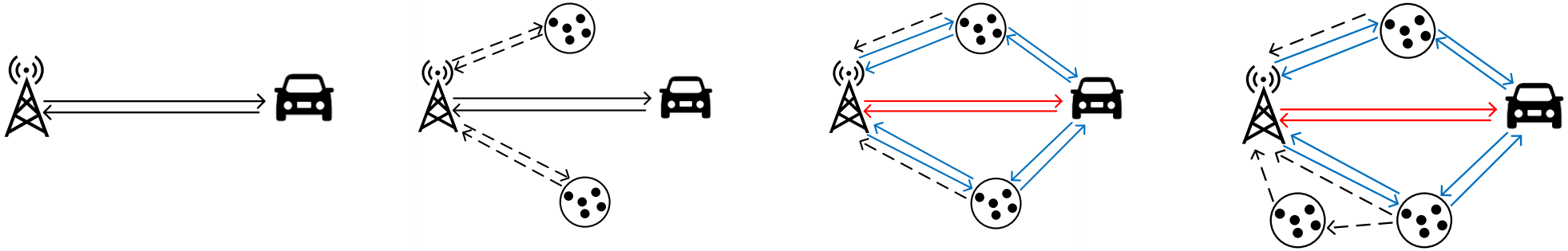
- **Study the large-scale fading modeling for both FR1 and FR2, at least includes:**
  - **Pathloss modeling:** “double-link” pathloss from point A to sensing target, and from sensing target to point B.
    - Modification of height of point A, sensing target, and point B.
  - **RCS modeling:** RCS may be considered to characterize the power loss caused by reflecting on sensing target.
    - Typical values, uniform distribution, Gaussian distribution, or other methods.
  - **LOS probability:**
    - For mono-static sensing, the LOS probability only needs to be determined once using channel reciprocity
    - For bi-static sensing, the LOS probability may be separately determined for the “double-link”

$$PL_s\left(d_1,d_2\right)=PL\left(d_1\right)+PL\left(d_2\right)+10\log_{10}\left(\frac{\lambda^2}{4\pi}\right)-10\log_{10}\left(\sigma_{RCS}\right)$$

Channel modeling study on ISAC (3)

Small-scale fading modeling

- **Study the small-scale fading modeling for both FR1 and FR2, at least includes:**
  - **Small-scale fading modeling:** sensing target LOS only, sensing target LOS and environment LOS, sensing target LOS+NLOS and environment LOS, sensing target LOS+NLOS and environment LOS+NLOS (low priority)



  - **Concatenation-based channel modeling:** cascade of the “double link” fast fading from point A to sensing target and from sensing target to point B
  - **Non-concatenation-based channel modeling:** sensing target is modeled as a cluster in TR 38.901

RAN side sensing architecture for ISAC

Motivations

- Additionally, based on sensing signal, it is important to **process the sensing measurements at RAN side to satisfy low latency requirement of the use cases, such as ≤100ms for V2X.**

Potential Objectives

- **Study of RAN side sensing architecture, including functional interfaces, protocol, and procedures, e.g. measurement processing is within RAN node, or measurement data is directly delivered from RAN node to non-3GPP entity [RAN3]**

Content

- Channel modeling for ISAC
- Channel modeling for RIS

Channel modeling study on RIS

Motivations

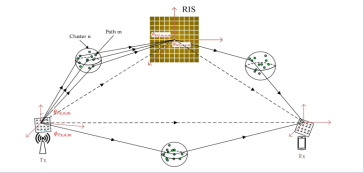
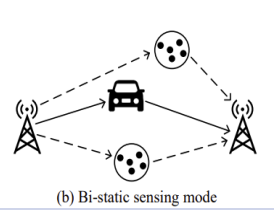
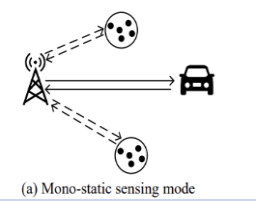
- Reconfigurable Intelligent Surface (RIS), as a low cost and lower power consumption technology, draw a large attention and strong interests from industry.
- RIS with large arrays can provide the coverage enhancements (especially over the coverage hole) and capacity improvement.
- Additional gain can be achieved through the adjustment of the reflective coefficient of the surface.
- Evaluation methodologies and channel modeling are not clear.
  - TR 38.901 cannot support the modeling of RIS node.
  - The channel modeling between gNB and RIS, RIS and UE, and the cascaded channels of gNB-RIS-UE are not supported.
- It is observed that, the channel modeling of RIS and that of ISAC have commonalties, especially in the sensing cases, “gNB A ➔ gNB B”, “gNB A ➔ UE”, “UE ➔ gNB A”
  - Details can be observed in the appendix.

Potential Objectives

- **Study the use case, deployment scenarios and evaluation methodologies.**
- **Study the channel modeling of RIS**
  - Including gNB-RIS, RIS-UE and the cascaded channels of gNB-RIS-UE
    - Pathloss modeling, RCS modeling, LOS probability, and small-scale fading modeling
    - Explicit modeling of RIS

THANK YOU !

Channel modeling study on ISAC and RIS

The necessary channel modeling components	RIS Whether the component is needed ?	ISAC (bi-static sensing mode) Whether the component is needed ?	ISAC (mono-static sensing mode) Whether the component is needed ?
Modeling the following links: 1) gNB-X, 2) X-Y➔ 3) gNB-X-Y cascaded channels (based on 1 and 2) 4) gNB-Y 5) X-gNB 6) gNB-X-gNB cascaded channels (based on 1 and 5) Object X={RIS, sensing target} Object Y = {UE, gNB B}	3) (cascaded based on 1 and 2), 4), X= RIS, and Y= UE 	3) (cascaded based on 1 and 2), 4), X=sensing target, Y=gNB B Same as RIS  (b) Bi-static sensing mode	6) (cascaded based on 1 and 5) X = sensing target  (a) Mono-static sensing mode
Pathloss, LOS probabilities	Need The LOS probability and PL of gNB-X(RIS) and X(RIS)-UE should be considered	Need The LOS probability and PL of gNB-X(sensing target) and X-Y(gNB B) should be considered Same as RIS	Need The LOS probability and PL of gNB-X(sensing target) should be considered
Explicitly modeling of the response of Object X (RIS, sensing target)	Need The RIS beamforming gain or the array gains should be modeled and evaluated	Need The gain or loss due to reflection of the sensing target is modeled as RCS (Radar Cross Section) The RCS will at least impact the calculation of PL between TX and RX. Similar as RIS	Need The gain or loss due to reflection of the sensing target is modeled as RCS (Radar Cross Section) The RCS will at least impact the calculation of PL between TX and RX.
Large scale and small-scale parameters	Needed	Needed Same as RIS	Needed