3GPP TSG RAN WG1 Meeting #126 **R1-2605357**
Maastricht, Netherland, August 24th – 28th, 2026

Agenda Item: 10.8.3

Source: EURECOM

Title: Waveform and frame structure for ISAC

Document for: Discussion and decision

1. Introduction

According to Releases 19 and 20 ISAC, the use cases, channel model and evaluation assumptions are defined as follows:

- Five use cases are studied for ISAC:
  - UAVs
  - Humans indoors and outdoors
  - Automotive vehicles
  - Automated guided vehicles (e.g. in indoor factories)
  - Objects creating hazards on roads/railways, with a minimum size dependent on frequency
- Six sensing modes: transmission reception point (TRP)-TRP bistatic, TRP monostatic, TRP-user equipment (UE) bistatic, UE-TRP bistatic, UE-UE bistatic, UE monostatic are supported in these use cases.
- ISAC channel model is specified in Section 7.9 in TR 38.901.
- Evaluation assumptions and performance metrics are specified in TR 38.765.

A unified design for sensing and communication is required for ISAC use cases.

The following agreements are noted in RAN1#124b:

Agreement:

CP-OFDM waveform as defined for 6GR is the starting point for 6G ISAC waveform study.

Study on enhancements on CP-OFDM or other waveforms is not precluded.

Agreement:

6GR communication frame structure is the starting point for 6G ISAC frame structure study, in at least the following aspects.

- Frame/sub-frame/slot/symbol structure
- CP length
- SCS

Enhancements on frame structure/above aspects are not precluded.

Agreement:

Companies are encouraged to provide views on necessity/pros/cons/metrics of LLS and/or SLS and pros/cons/metrics of theoretical waveform characteristics analysis, for evaluation of ISAC waveform and/or integration with communication, to RAN1#125 meeting.

Agreement:

CP-OFDM is used as the benchmark for evaluating the benefits of sensing waveforms.

The following agreements are noted in RAN1#125:

Agreement:

At least the following potential enhancement directions for CP-OFDM are studied for 6G ISAC.

- Improve PAPR
- Obtain Tx power gain from other
- Improve Ambiguity Function (AF)/Auto-correlation properties (PSLR/ISLR, main lobe width)
    - FFS: details of the definitions, time/frequency/doppler domain, linear correlation vs circular correlation, etc.
- Improve resilience to interference
- Improve sensing resource utilization efficiency
- Improve cross-correlation property
    - FFS: details of the definition

Note: Other enhancements and any combination of multiple enhancements are not precluded.

At least the following aspects are considered for above potential enhancement directions for CP-OFDM for 6G ISAC.

- Impact to ACLR(Adjacent Channel Leakage Ratio)/OOBE(Out-Of-Band Emission)
- Impact to ISI/ICI/self-interference/inter-cell interference
- Impact to Tx/Rx complexity
- Impact to communication (e.g., resource, interference)
- Impact from one enhancement to other enhancements

Agreement:

Companies are encouraged to provide theoretical waveform/RS sequence characteristics analysis for waveform/RS sequence evaluation for 6G ISAC.

Companies are encouraged to provide either LLS or a simplified SLS in addition to the theoretical waveform/RS sequence. It's up to company to select and how to model LLS or a simplified SLS.

Agreement:

For the study of enhancement based on CP-OFDM for signal/RS used for sensing, at least the following methods can be considered.

- Zadoff-Chu sequence enhancement
- Gold sequence enhancement
- LFM/Chirp-like sequence (incl. frequency sweeping/Chirp rate/slope)
- Quasi-complementary sequence set (QCSS)
- Transparent/Non-transparent Tx/Rx time-domain processing and/or frequency-domain processing (e.g., FDSS)
- Pi/2 BPSK for RS
- Non-Linear FM sequence
- Pulse-type waveform/RS generation
- Phase continuity in the sensing resource block considering the guard band
- RS sequence randomization in time and/or frequency domain
- RS sequence spanning across multiple symbols

FFS: whether applicable to dedicated resource and/or shared resource with communication

FFS: The applicable sensing modes.

Note: Not all enhancements directions may be applicable for each of the above methods

Note: Other methods are not precluded.

Agreement:

For waveform/RS sequence evaluation for 6G ISAC, at least the following waveform/RS sequence characteristics are considered as the evaluation metrics.

- PAPR
- Tx power gain
    - PA model used should be reported by company
- Ambiguity function/auto-correlation property

- PSLR / ISLR / main lobe width
    - FFS: details of the definitions, time/frequency/doppler domain, linear / circular correlation, etc.
- Cross-correlation
    - FFS: details of the definition
- Out-of-band characteristics
    - Adjacent Channel Leakage Ratio(ACLR) / Out-Of-Band Emission(OOBE)
    - PA model used should be reported by company
- Resilience to interference
    - Resilience to ISI, ICI, self-interference, inter-cell interference
    - FFS: details of metrics

FFS: whether applicable to dedicated resource and/or shared resource with communication

FFS: applicable metrics per evaluation scenario

Other metrics are not precluded.

Agreement:

For handling of a sensing signal reception beyond the communication CP length, if the necessity is identified, at least the following methods are studied for 6G ISAC without changing frame structure.

- Effective CP length extension based on successive N OFDM symbols
- Effective CP length extension based on frequency-domain comb pattern
- Time gap before/after/within sensing signal
- Effective CP length extension based on phase continuity across successive symbols
- Transmission of RS in successive N OFDM symbols without CP length extension
- RS sequence enhancement across symbols
- By implementation without any spec impact

FFS: applicable sensing modes

FFS: whether applicable to dedicated sensing RS or RS shared with communication

FFS: impact on integration with communication

FFS: resource overhead consideration

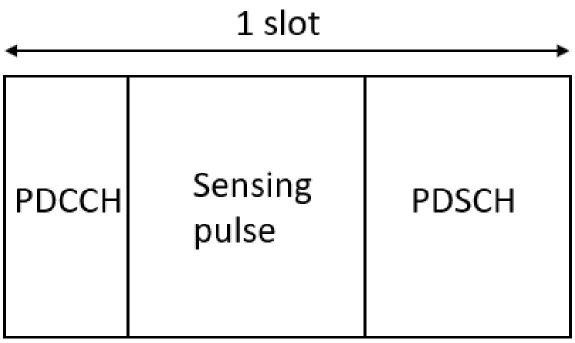
Note: Other methods are not precluded.

Note: RAN1 strives for a solution that has maximum commonality with 6GR communication frame structure and numerology

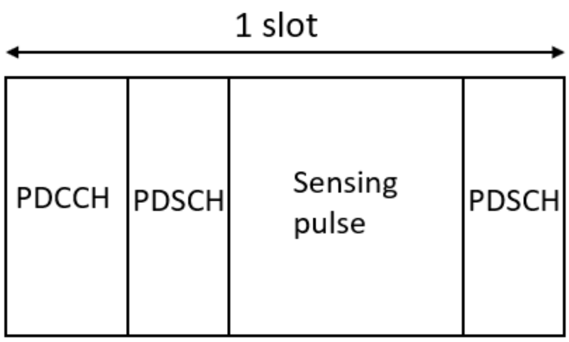
2. Discussion

2.1. Slot structure for sensing and communication

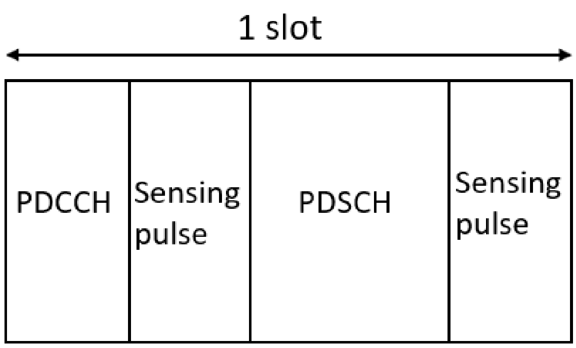
2.1.1. DL slots for ISAC



a. Continuous PDSCH resource



b. Discontinuous PDSCH resource



c. Discontinuous sensing resource

Figure 1: Slot structure for sensing and communication signals in DL

In the use cases such as UAV and automated guided vehicles, the sensing entities need to detect and track high mobility targets. It requires a short repetition interval of sensing signal to achieve high maximum unambiguous velocity.

At frequency of 5 GHz, in monostatic sensing, the repetition interval must be smaller than 340 μs so that the sensing entity can track the target moving at 160 km/h. With SCS of 15 kHz and 30 kHz, the repetition interval is smaller than one slot. To satisfy the transmission of sensing signal with small repetition interval, a mini-slot structure for communication and sensing signal are needed. As shown in Figure 1, sensing signal and communication signal (PDSCH) are multiplexed in one slot.

With an interval smaller than 340 μs, a sensing signal might be repeated in the middle of a slot that interrupts a communication transmission carried by PDSCH. In this case, as shown in Figure 1b, PDSCH communication can be interrupted in the middle by a sensing transmission. In other words, PDSCH transmission stops and resumes in a slot due to sensing transmission.

The aNB can preconfigure the time and frequency resources in a slot for sensing signal then inform the receiver allowing it to detect the sensing signal in those resources. The aNB sends downlink control information (DCI) contained in PDCCH or radio resource control (RRC) signaling to the UE in order to indicate time and frequency resources of sensing signal. PDCCH used to indicate sensing resource can be transmitted in the same or different CORSET as PDCCH used to indicate communication resource.

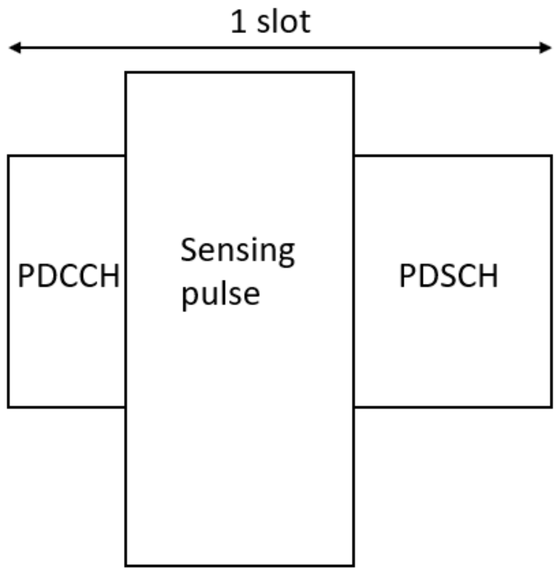
In this slot structure, sensing signal and communication signal have the same SCS.

Proposal 1: In a DL slot, mini-slot structure is used to multiplex sensing signal and communication signal. Mini-slots in a slot contain sensing signal or communication signal.

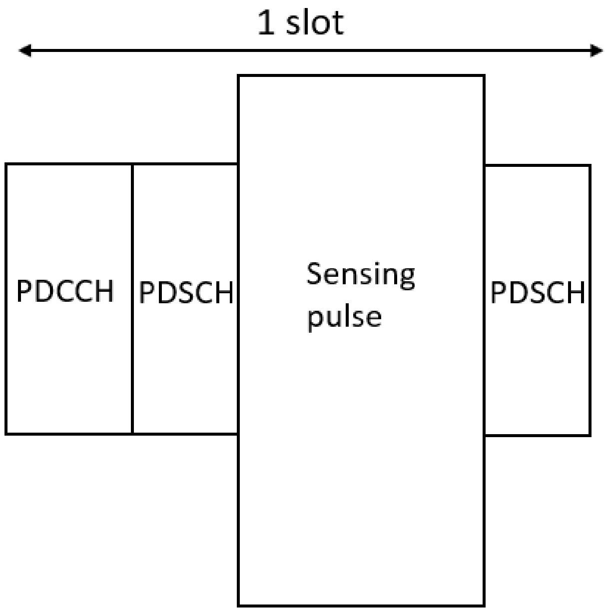
Proposal 2: In a DL slot, communication signal can stop before a sensing transmission the resume after the sensing transmission.

Proposal 3: PDCCH used to indicate sensing resource can be transmitted in the same or different CORSET as PDCCH used to indicate communication resource.

Proposal 4: Sensing SCS and communication SCS are the same.



a. Continuous PDSCH resource



b. Discontinuous PDSCH resource

Figure 2: DL slot structure with higher bandwidth for sensing signal

For sensing signals, a higher bandwidth allows greater sensing accuracy with improved range resolution. In the applications with strict sensing accuracy requirement, more frequency resources are allocated to transmit sensing signal. In a slot, bandwidth of sensing resource is increased while the other parameters such as bandwidth of communication resource are kept the same. In

Continuous **PDSCH resource**

c. Discontinuous PDSCH resource

Figure 2, sensing resources are increased in terms of frequency while bandwidth of communication resource for PDCCH and PDSCH is kept the same.

The slot structures in

Continuous PDSCH resource

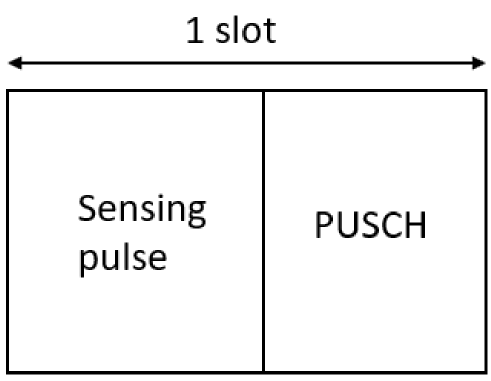
d. Discontinuous PDSCH resource

Figure **2** are configured by the aNB based on the requirements of sensing applications through DCI or RRC signaling. The aNB defines the new bandwidth of sensing resource and the number of slots where new bandwidth is used for sensing. Then after the last slot defined by the aNB, bandwidth of sensing resource in the next slots returns to match bandwidth of communication resource as shown in Figure 1 to serve the applications with lower sensing accuracy requirement.

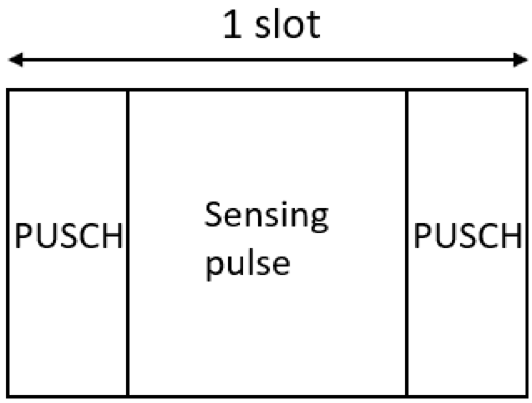
Proposal 5: The aNB dynamically increases the bandwidth of the sensing resource through DCI or RRC signaling to serve the sensing applications with high sensing accuracy requirement while still keep the bandwidth of communication resource in the same DL slot unchanged.

Proposal 6: The aNB indicates to the UE through DCI or RRC signaling the number of slots where an increased bandwidth of sensing resource is applied.

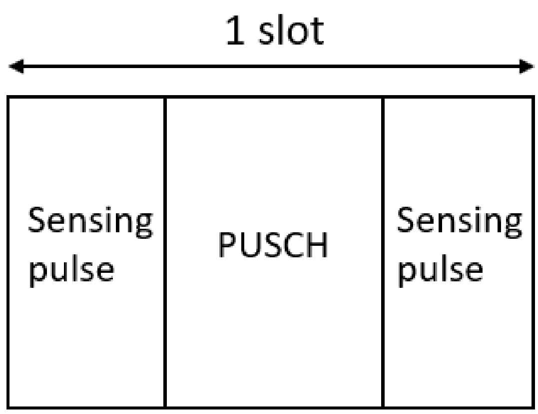
2.1.2. UL slots for ISAC



a. Continuous PUSCH resource



b. Discontinuous PUSCH resource



c. Discontinuous sensing resource

Figure 3: Slot structure for sensing and communication signals in UL

In UL slot, sensing signal and communication signal are also multiplexed in a slot following a mini-slot structure as DL slot as shown in Figure 3. Communication signal carried by PUSCH can stop before a sensing transmission and resume after a sensing transmission in a slot as shown in Figure 3b.

In one mode, sensing resources are preconfigured to the UE by the aNB through DCI or RRC signaling. The period of sensing resources is indicated by DCI or RRC signaling. In another mode, the UE requests the aNB to configure sensing resource through uplink control information (UCI) when it needs to carry out a sensing task then the aNB configures sensing resource through DCI.

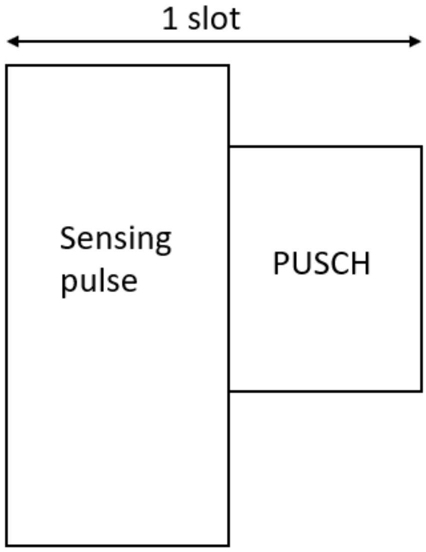
PDCCH used to indicate sensing resource can be transmitted in the same or different CORSET as PDCCH used to indicate communication resource.

Proposal 7: In an UL slot, mini-slot structure is used to multiplex sensing signal and communication signal.

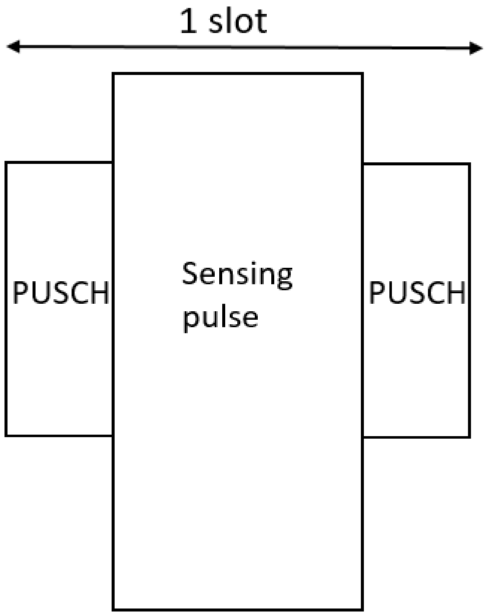
Proposal 8: In an UL slot, communication can stop before a sensing transmission then resume after the sensing transmission.

Proposal 9: In one mode, sensing resources are preconfigured to the UE by the aNB through DCI or RRC signaling. The period of the sensing resources is indicated by DCI or RRC signaling.

Proposal 10: In another mode, the UE requests the aNB to configure sensing resource through UCI when it needs to carry out sensing task then the aNB configures sensing resource through DCI.



a. Continuous PUSCH resource



b. Discontinuous PUSCH resource

Figure 4: UL slot structure with higher bandwidth for sensing signal

In the applications with strict sensing accuracy requirement, more frequency resources are allocated to transmit sensing signal. In an UL slot, bandwidth of sensing resource is increased while the other parameters such as bandwidth of communication resource are kept the same as shown in Figure 4.

Proposal 11: In an UL slot, bandwidth of sensing signal can be increased to be bigger than bandwidth of communication signal to serve the applications with strict sensing requirements.

3. Conclusion

Proposal 1: In a DL slot, mini-slot structure is used to multiplex sensing signal and communication signal. Mini-slots in a slot contain sensing signal or communication signal.

Proposal 2: In a DL slot, communication signal can stop before a sensing transmission the resume after the sensing transmission.

Proposal 3: PDCCH used to indicate sensing resource can be transmitted in the same or different CORSET as PDCCH used to indicate communication resource.

Proposal 4: Sensing SCS and communication SCS are the same.

Proposal 5: The aNB dynamically increases the bandwidth of the sensing resource through DCI or RRC signaling to serve the sensing applications with high sensing accuracy requirement while still keep the bandwidth of communication resource in the same DL slot unchanged.

Proposal 6: The aNB indicates to the UE through DCI or RRC signaling the number of slots where an increased bandwidth of sensing resource is applied.

Proposal 7: In an UL slot, mini-slot structure is used to multiplex sensing signal and communication signal.

Proposal 8: In an UL slot, communication can stop before a sensing transmission then resume after the sensing transmission.

Proposal 9: In one mode, sensing resources are preconfigured to the UE by the aNB through DCI or RRC signaling. The period of the sensing resources is indicated by DCI or RRC signaling.

Proposal 10: In another mode, the UE requests the aNB to configure sensing resource through UCI when it needs to carry out sensing task then the aNB configures sensing resource through DCI.

Proposal 11: In an UL slot, bandwidth of sensing signal can be increased to be bigger than bandwidth of communication signal to serve the applications with strict sensing requirements.