3GPP TSG-RAN WG1 Meeting #122 R1-250nnnn

Bengaluru, India, Aug 25th – 29th, 2025

**Agenda Item: 11.1**

**Title: FL summary#1 on overview of 6GR air interface**

**Source: Moderator (NTT DOCOMO)**

**Document for: Discussion, Decision**

# **1 Introduction**

This document summarizes contributions [3] – [57] submitted to agenda item 11.1 (Overview of 6GR air interface).

Since this is the first RAN1 meeting to discuss this SI [1], RAN1 focuses on the following aspects to make reasonable progress, while keeping open minded.

* Make common understanding among companies on the terminologies
* Establish a finer agenda for future meetings, including the main focus in each meeting

The following sections are categorized according to the following guidance provided by RAN1 chair:

|  |
| --- |
| High level design proposals/principles/target and overall design of 6G air interface to illustrate/address the pain points observed from different angles, e.g., aspects of how to design a single RAT to serve diverse devices, channel bandwidth (at least minimum and maximum), aspects of overall coverage, aspects of initial access and common channel, aspects of MRSS, aspects of service/channel multiplexing/collision, including concurrence of UL transmissions,…..., aspects of concept and operation of bandwidth, aspects of supporting existing and new services, aspects of spectrum utilization and operations, aspects of spectrum efficiency, aspects of all duplex types, as well as concepts and aspects of harmonization of TN and NTN, etc. |

Note: A number of companies provide views on technical details of the following aspects. As per guidance from RAN1 chair, those aspects will be discussed in separate agenda items and/or future RAN1 meetings:

* This RAN1 meeting
	+ Evaluation assumptions for 6GR air interface
		- *Discussions on models, scenarios, parameters, and methodology, metrics/criteria that can be used for evaluating technology proposals, energy efficiency, sensing performance (including potential extension of channel model).*
	+ Waveform
		- *Including proposals for improving spectrum efficiency, power efficiency, coexistence and coverage, etc.*
	+ Frame structure
		- *Including numerology and frame structure (for all duplex types), as well as compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS).*
	+ Channel coding
		- *Including metrics/criteria that can be used for evaluating technology proposals and for down selecting proposals*
	+ Modulation, joint channel coding and modulation
		- *Including metrics/criteria that can be used for evaluating technology proposals and for down selecting proposals*
	+ Energy efficiency
		- *Including discussion of proposal for NW power saving, UE power saving, and joint mechanisms taking both NW and UE into account for power saving, targeting to categorize proposals by RAN1#123. From RAN1#124, proposals will be distributed to respective related agenda.*
	+ AI/ML in 6GR interface
		- *Collecting AI/ML use cases in all potential components in physical layer design, targeting to select some use cases by RAN1#123. From RAN1#124, selected use cases will be distributed to respective related agenda.*
* Future RAN1 meetings
	+ Initial access
		- *Placeholder only and to be broken down. No contributions before RAN1#124. Including synchronization signal and raster, broadcast signals/channel and physical random access channel, etc.*
	+ MIMO operation
		- *Placeholder only and to be broken down. No contributions before RAN1#124.*
	+ Physical layer control, data scheduling and HARQ operation
		- *Placeholder only and to be broken down. No contributions before RAN1#124.*
	+ Duplexing
		- *Placeholder only and to be broken down or adapted based on the discussion in AI 11.1. No contributions before RAN1#124.*
	+ 6GR spectrum utilization and aggregation
		- *Placeholder only and to be broken down. No contributions before RAN1#124.*
	+ NTN
		- *Placeholder only and to be broken down or adapted based on the discussion in AI 11.1. No contributions before RAN1#124.*
	+ Other physical layer signals, channels and procedures
		- *Placeholder only and to be broken down. No contributions before RAN1#124.*
	+ Sensing
		- *Including PHY functions and procedures for sensing technology (e.g., waveform. reference signals, measurement feedback, etc…), aspects of integration with communication services.*
		- *Placeholder only and to be broken down. No contributions before RAN1#124b.*

Similarly, a number of companies provide views on 6G RAN requirements, which is subject to the progress in RANp study for 6G RAN requirements.

# **2 Proposals for Online Sessions**

## **2.1 Proposals for xxxday Online**

To be updated

# **3 How to design a single RAT to serve diverse devices, channel bandwidth (at least minimum and maximum)**

Related to these aspects, the SID states following objectives and Interim Milestone:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
	1. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
	2. Energy efficiency and energy saving: both for network and device.
	3. Enhanced spectral efficiency.
	4. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
	5. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
	6. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
	7. Target scalable and forward compatible design for diverse device types.
	8. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
	9. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
	10. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
	11. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion.1. Physical Layer structure for 6GR,
	1. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
	2. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
	3. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
	4. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
	5. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
	6. MIMO operation [RAN1, RAN4]
	7. Duplexing [RAN1, RAN4]
	8. Initial access [RAN1, RAN2, RAN4]
		* Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		* Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
	9. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
	10. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
	11. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
		1. RAN4 can be involved, if necessary, based on the LS from RAN1

…**TSG#112 (June/2026):** RAN1 to provide interim assessment on the following areas:* Waveform, modulation, channel coding: scope of enhancements beyond NR baseline ((2) a, c)
* Channel bandwidth (min and max), frame structure, numerology ((2) b, d)
* Basic sync signal structure and associated periodicity(ies) ((2) h)

For objectives where RAN4 may be impacted, RAN1 shall coordinate with RAN4 early to enable the above assessment by June 2026. |

Regarding how to design a single RAT to serve diverse devices, quite a few companies mention that common/scalable 6GR should be studied. More specifically, modular/nucleus/scalable design is mentiend by a number of companies and some examples are shown below. Although the details need to be further discussed, the commonality among these concepts is to have a basic feature set / framework commonly applicable to all 6G use cases / device types, as well as add-on features (modules) dedicated to specific use cases / device types.



Modular design in [13]



Modular design in [23]



Scalable design in [46]

These concepts are well aligned with the objectives in the SID, and following proposal can be considered as starting point.

#### Proposal 3.1:

* Study a scalable 6GR design having at least the following aspects:
	+ basic feature set / framework commonly applicable to all 6G use cases / device types
	+ add-on features dedicated to specific use cases / device types

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y | Scalable 6GR design need to address high data rate. It need not address all 6G use cases in the basic feature set. |
| Nokia | Y | In addition, specific device types may have their own basic feature set, with possible add-on features as well. |
| OPPO | Y | If a basic feature set can be applicable to all 6G use cases/device types, it should be based on the low-end IoT, because all use cases needs IoT-like data transfer and all device types can be regarded as a IoT device in low-data working mode. |
| CMCC | Probably OK | The principle seems OK. Features or feature sets are not only RAN1 related. Would this be more appropriate to discuss the principle in RAN plenary? |
| Apple | In principle okay | We are not sure whether add-on features dedicated to specific use cases / device types is absolutely needed, but we are open to study. It might also be better to clarify the meaning of “dedicated”, whether it means the feature is motivated by specific use cases/ device types, or it means the featruer is only applicable (can only be deployed) to specific use cases / device types. In NR, we do have extensive discussion on whether a NR-U feature should be applicable to Uu, a NTN feature should be applicable to TN, etc. Furthermore, we prefer clarification that the use cases are not coupled with the device types. Therefore, we propose the following change * Study a scalable 6GR design having at least the following aspects:
	+ basic feature set / framework commonly applicable to all 6G use cases ~~/~~ and all device types
	+ FFS: add-on features dedicated to specific use cases / device types
 |
| ETRI | Y |  |
| Samsung | Y | We have a clarification question for this proposal. We understand the intention but the current formulation may imply the possibility of introducing massive add-on features dedicated for diversge use cases and device types which is not aligned with a high-level direction of 6GR. We suggest to update as follows* Study a scalable 6GR design having at least the following aspects:
	+ Basic feature set / framework commonly applicable to all 6G use cases / device types
	+ Identify and minimize add-on features dedicated to specific use cases / device types
 |
| CATT, CICTCI | Y | We think the direction is right to go. To better undestand the relationship between basic feature and add-on feature, and also to refine the term ‘scalable’, we have following questions: (1) Does it imply that add-on features are assumed indivitial to each other, and all built on top of basic features?(2) If the basic feature set is designed based on low capability UE, e.g. IoT UE, does it mean some low-hand fruit feature (e.g. 200 MHz BW, 2 layer, Tx switching…) will be addn-on feature and ‘optional’ in general? |

Then, the next question is how to define diverse device types to be supported by 6GR. A number of companies provide views and some examples are shown below. Although the details need to be further discussed, the commonality among companies are limiting the number of device types to avoid excessive UE capabilities, and having some mandatory capability set in each device type.

Device types in [10]

|  |  |  |  |
| --- | --- | --- | --- |
|  | Device type A | Device type B | Device type C |
| Typical Device/service | Smartphones, immersive eMBB, CPE, | Reduced capability eMBB, e.g., wearable/XR, etc | IoT |
| Downlink peak data rate | ~10Gbps  | 200Mbps ~ 1Gbps | ~10Mbps |
| Uplink peak data rate | ~2Gbps | 50Mbps ~ 200Mbps | ~5Mbps |
| Supported maximum downlink channel bandwidth | At least 200 MHz  | 100 MHz | ~5MHz for FDD~20MHz for TDD |
| Supported maximum uplink channel bandwidth | [100/200] MHz | 100 MHz | ~5MHz for FDD~20MHz for TDD |
| Supported maximum Downlink MIMO layer | At least 4 layers  | 1~2 layers | 1~2 layers |
| Supported maximum Uplink MIMO layer | At least 2 layers | 1 layer | 1 layer |



Device types in [12]



Device types in [26]

These views are well aligned with the objectives in the SID, and following proposal can be considered as starting point.

#### Proposal 3.2:

* Study how to define device types suppored by 6GR, including at least
	+ How to avoid excessive UE capabilities
	+ Mandatory capability set in each device type

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y |  Support the proposal |
| Nokia | Y |  |
| Vodafone | Y |  |
| OPPO | Y | But as a special case, mandatory capabilities of low-end IoT are mandatory for all device types. Suggest change to the proposal:* Study how to define device types suppored by 6GR, including at least
	+ How to avoid excessive UE capabilities
	+ Mandatory capability set in each device type
	+ A basic capability set is mandatory for all device types
 |
| CMCC | Y | On the second bullet, regarding the mandatory capability set for each device type, it is difficult to discuss at this early stage. Some clarification may be needed on the ‘mandatory capability set’ that would be discussed under this agenda. |
| Apple | In principle okay | We prefer to add the following based on the online presention from operators* + How to ensure that the manadatory feature can be IoDT’d

We also believe there is significant performance benefit from both the UE and NW perspective to allow UE to update its capability based on the UE circumstances, therefore, we propose to study the following * + Study the benefit, and how to support event-based UE capability update
 |
| ETRI | Y |  |
| Samsung | N | We are generally ok with intention of proposal 3.2 but we first need to align design principles for device types. Namely, we should identify options such as* How to define UE types, such as form factor, use case, or capability
* How to define/update/signaling of UE capabilities
* Which metrics/features should be included in a capability set

Based on that, we suggest to modify * Study how to define device types suppored by 6GR, including at least
	+ How to define UE types, such as form factor, use case, or capability
	+ How to define/update/signaling of UE capabilities
	+ Which metrics/featues should be included in capability set
 |
| CATT, CICTCI | Y |  |

Regarding the channel bandwidth (at least minimum and maximum), there is in general good alignment among companies for avoiding multiple numerologies for the same band / sub-range, while companies may have different preference on which SCS/numerology to take in each band / sub-range, resulting in different assumptions of the maximum CBW and required FFS size for the SCS as shown in below table. Note that the maximum supported BW for low-tier 6G UE is discussed in Section 9.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **FR** | **Range** | **SCS (kHz)** | **Required FFT size** | **Max CBW (MHz)** | **Min CBW (MHz)** |
| FR1 | 400 MHz – 6.425 GHz | 15, 30 | 4096, 8192 | 20, 100 | 3, 5 (FDD)10, 20 (TDD) |
| 6.425 – 7.125 GHz | 15, 30, 60 | 4096, 8192 | 100, 200, 400 | 20 |
| New FR(s) | 7.125 – X GHz | 30, 60 | 4096, 8192,16384 | 200, 400 | 20 |
| X – 24.25 GHz | 60, 120 | 4096, 8192 | 400, 800 | 20 |
| FR2-1 | 24.25 – 52.6 GHz | 120 | 4096, 8192 | 400, 800 | 50, 100 |

TBD: the value X

Also, the view on max/min CBW can be different due to different situation for the spectrum allocation in each region. As stated in the SID and pointed out by some companies, this issue would need RAN4 involvement in early stage.

As this issue was also discussed in AI11.3.2 (Frame structure), moderators in each agenda coordinated how to avoid overlap. {SCS, required FFT size, Max CBW} are more suitable to be discussed under AI11.3.2 since those would highly affect overall design of frame structure. On the other hand, Min CBW can be discussed in this agenda item since this would not have much impact on overall design design of frame structure, rather related to the maximum supported BW for low-tier 6G UE and the spectrum allocation in each region.

Therefore, following proposal can be considered as starting point for further discussion together with RAN4.

#### Proposal 3.3:

* Study the minimum CBW in each band / sub-range using the following table as starting point
	+ Note: RAN4 involvement is necessary
	+ TBD the value X, including the possibility that this value is not defined, i.e., common values in the new FR(s).

|  |  |  |
| --- | --- | --- |
| **FR** | **Range** | **Min CBW (MHz)** |
| FR1 | 400 MHz – 6.425 GHz | 3, 5 (FDD)10, 20 (TDD) |
| 6.425 – 7.125 GHz | 20 |
| New FR(s) | 7.125 – X GHz | 20 |
| X – 24.25 GHz | 20 |
| FR2-1 | 24.25 – 52.6 GHz | 50, 100 |

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y | Support the proposal. 3 MHz channel BW support is required in 6G. |
| Nokia | Y | Indeed RAN4 involvement is necessary, and the final decisions on min CBW are dependent on the supported SCS for the different channels. The table has some implicit assumptions of what SCS is the baseline for the different bands, which is fine as starting point for discussion though.  |
| OPPO |  | Suggest to discuss in Agenda 11.3.2. |
| CMCC |  | We should not preclude <10MHz for TDD at this moment. We suggest removing the duplex mode for Min CBW.For new spectrum (including U6G and new FR), the minimum CBW can depend on available spectrum and decided by RAN4, for example, in R15, RAN4 decided to define 40MHz as minimum CBW for n79. We can keep TBD for now. Proposal 3.3 (revised):* **Study the minimum CBW in each band / sub-range using the following table as starting point**
	+ **Note: RAN4 involvement is necessary**
	+ **TBD the value X, including the possibility that this value is not defined, i.e., common values in the new FR(s).**

|  |  |  |
| --- | --- | --- |
| **FR** | **Range** | **Min CBW (MHz)** |
| FR1 | 400 MHz – 6.425 GHz | 3, 5  |
| 6.425 – 7.125 GHz | TBD |
| New FR(s) | 7.125 – X GHz | TBD |
| X – 24.25 GHz | TBD |
| FR2-1 | 24.25 – 52.6 GHz | 50, 100 |

 |
| Apple | Y | The proposal looks good to us as starting point |
| ETRI | Y |  |
| Samsung | Y | We are supportive of this proposal. |
| CATT, CICTCI |  | We still have concern on min CBW = 3 MHz, but OK as starting point. We should also list the associated SCS assumption for each Min CBW. Otherwise, we do not know how this CBW comes. For example, 20 MHz min CBW, it is unclear whether 30 kHz or 60 kHz SCS is assumed. |

# **4 Overall coverage**

Related to this aspect, the SID states following objectives:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
2. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
3. Energy efficiency and energy saving: both for network and device.
4. Enhanced spectral efficiency.
5. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
6. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
7. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
8. Target scalable and forward compatible design for diverse device types.
9. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
10. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
11. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
12. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion. |

Quite a few companies provide the views on coverage target for 6GR, including not only + 5 to 10 dB enhancement from normal coverage (144dB MCL) for cell-edge performance but also overall UL performance improvements in anywhere within the cell coverage. However, the target values need to be discussed and clarified in RANp study for 6G requirements and hence, RAN1 needs to wait for their progress.

While RAN1 does not have exact target value for coverage enhancement, as stated in SID, the 6GR is assumed to support enhanced overall coverage. Therefore, RAN1 can start studying some technical direction for coverage enhancements, including which signals/channels need to be improved, and which UEs/device types need to support features for coverage enhancements. According to the contributions, there is in general good alignment to consider coverage enhancement not only dedicated channels (e.g. scheduled PDSCH/PUSCH) but also common signals/channels during initial/random access (e.g., PRACH, Msg3 PUSCH) from the 1st release, while further discussion would be necessary on the applicable UEs (e.g., MBB and/or IoT, TN and/or NTN). Therefore, following proposal can be considered as starting point for further discussion.

#### Proposal 4.1:

* Study how to enhance overall coverage, including at least
	+ which signals/channels need to be improved, including both cell-common and UE-dedicated signals/channels
	+ which UEs/device types need to support features for coverage enhancements

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom |  | Considering the importance of coverage for us operators, we think 6G DAY-1 needs to pay more attention to this topic. Meantime, we need to learn lessons from 5G to ensure a good coverage at the beginning. Since the coverage target is not determined currently, we think instead of identifying which signals/channels need to be improved (maybe all the channels need to be improved), it’s better to study which technique can improve the coverage and can be supported in 6G, e.g., coverage enhancement solutions studied/specified in 5G. Then, after the target coverage related values are determined, we think evaluation is needed to check if the target can be met for each channel. Thus, we suggest the following proposal instead:* Study potential techniques/solutions for coverage improvement for both downlink and uplink channels.
 |
| Tejas | Y | Support the proposal |
| Nokia | Y | Improvements need to be defined with respect to baseline, so it is important to define the target MCL for 6GR. Generally the coverage enhancement features should be agnostic to device types. UE-type or scenario-specific enhancements may be considered on top at a later stage. |
| Vodafone | Y |  |
| OPPO | Y |  |
| CMCC |  | For the first bullet, which signals/channels need to be improved should based on evaluation, e.g. under agenda 11.2.What can be dicussed under agenda 11.1 is the target for coverage enhancement. Hence, we propose to add another bullet for study:* A unified target for coverage (a MCL target) for all the signals/channels.

Proposal 4.1 (revised):* Study how to enhance overall coverage, including at least
	+ A unified target for coverage (a MCL target) for all the signals/channels.
	+ ~~which signals/channels need to be improved, including both cell-common and UE-dedicated signals/channels~~
	+ which UEs/device types need to support features for coverage enhancements
 |
| Apple |  | We think the right approach is to set a common coverage requirement, e.g., MCL (Maximum Coupling Loss), that covers (1) all channels/signals and PHY procedures in all RRC states, (2) all services, use cases, verticals, (3) all supported device types. Of cousse, MCL should be coupled with the performance requirement, e.g., control channel (e.g, PUCCH/PDCCH) reliability, data channel (e.g., PDSCH/PUSCH) minimum data rate, etc. Then each agenda should ensure that the design meets the coverage requirement in 6G day 1. Therefore, we propose * Study a common coverage requirement, e.g., MCL (maximum coupling loss), for (1) all channels/signals and PHY procedures in all RRC states, (2) all services, use cases, verticals supported at least in 6G day 1, (3) all device types supported at least in 6G day 1 ~~how to enhance overall coverage, including at least~~
	+ Note: the coverage requirement is a combination of the performance requirement and the associated channel condition, e.g., MCL
	+ ~~which signals/channels need to be improved, including both cell-common and UE-dedicated signals/channels~~
	+ ~~which UEs/device types need to support features for coverage enhancements~~
 |
| ETRI | Y | Based on the learning from 5G, at least all UL signals/channels should be improved. The improvement of DL signals/channel can be also considered. |
| Samsung | N | We think the moderator’s approach appears similar to NR, where coverage enhancements were handled release-by-release based on the results of NR deployments; this led to fragmented handling and inconsistent implementation. It is more important to have a common understanding, such as 6GR should consider coverage enhancemenets from the first release and RAN1 should support coverage enhancement schemes, when needed, to all applicable channels and signals.Moreover, channel/signal designs and device types are currently unknown. Therefore, it is too early to conclude on the moderator’s proposal. |
| CATT, CICTCI |  | Agree that overall coverage is important. When we go into details, for the 1st bullet, it is very difficult to study without a clear target, either:* Abosolute target value (and metric such as MCL, MPL, or MIL), or
* Target reference channel (e.g. using which channel as refrence for comparison and bottlenect channel identification)

For the 2nd bullet, we think we can conclude that all UE/devices in 6G need to support features for coverage enhancements☺. |

Regarding ~7GHz band coverage, a number of companies mention larger number of antennas is necessary to achieve the comparable coverage to 5G mid-band (~3.5GHz). This aspect can be discussed in RANp SI for 6G requirement (especially for deployment scenarios) as well as RAN1 6G study AI11.2 for evaluation assumptions.

# **5 Initial access and common channel**

Related to these aspects, the SID states following objectives and Interim Milestone:

|  |
| --- |
| 1. Physical Layer structure for 6GR,
2. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
3. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
4. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
5. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
6. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
7. MIMO operation [RAN1, RAN4]
8. Duplexing [RAN1, RAN4]
9. Initial access [RAN1, RAN2, RAN4]
	* + Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		+ Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
10. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
11. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
12. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
13. RAN4 can be involved, if necessary, based on the LS from RAN1

…**TSG#112 (June/2026):** RAN1 to provide interim assessment on the following areas:* Waveform, modulation, channel coding: scope of enhancements beyond NR baseline ((2) a, c)
* Channel bandwidth (min and max), frame structure, numerology ((2) b, d)
* Basic sync signal structure and associated periodicity(ies) ((2) h)

For objectives where RAN4 may be impacted, RAN1 shall coordinate with RAN4 early to enable the above assessment by June 2026. |

Initial access aspects are planned to be discussed from RAN1#124 (Feb. 2026). Therefore, in general, it is better to wait for RAN1#124 to open the discussion on initial access aspects. However, the Interim Milestone states that RAN1 needs to provide interim assessment on the basic sync signal structure and associated periodicity(ies) by June 2026. Therefore, at least on these aspects, RAN1 should start discussion earlier to provide enough assessment.

Regarding the basic sync signal periodicity, quite a few companies provide views to introduce longer SSB periodicity than that assumed for NR initial access (i.e., 20ms) from NES perspective. The candidate values vary from 40ms to 320ms and it was pointed out by some companies that RAN1 needs to consider the trade-off between NES gaing and UE complexity. As this aspects highly related to AI11.5 for Energy efficiency, moderator suggest discussing SSB periodicity in AI11.5.

Also, it is interesting to note that multiple operators have similar concept to minimize always-on signals (including SSB/SI) for the case of multi-carrier operation, and some examples are shown below. The commonality among these concepts is that the initial cell search is done only on a specific carrier and hence, the always-on signals can be minimized on other carriers. This aspect can be discussed in Section 10 as well.



Elastic cell concept in [39]



Perch/anchor/data concept in [48]

Regarding the basic sync signal structure, the design needs to consider at least following aspects:

* NES: Reduced number of sync raster, which can be obtained by narrower SSB BW
* Low-tier 6G device: maximum supported BW for complexity reduction, which is discussed in Section 9
* Detection performance: If narrower SSB BW is considered, more OFDM symbols would be required to maintain the NR performance

At the same time, not a few companies mention NR SSB structure should be the baseline. Unlike the periodicity, the structure design include multiple aspects (not only NES), and hence, moderator suggest discussing SSB sturcure in this AI. Following proposal can be considered as starting point for further discussion. Note that this aspect also needs early RAN4 imvolvement.

#### Proposal 5.1:

* Study the basic sync signal structure considering at least following aspects:
	+ NR SSB as baseline
	+ Whether to reduce SSB BW considering at least NES and low-tier 6G device
	+ Whether to increase the number of OFDM symbols considering at least detection performance
	+ Note: RAN4 involvement is necessary

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom | Y | For SS structure, we support to take NR SSB as a baseline, for the 2nd and 3rd bullet, we think they can be treated as kinds of optimization. If we follow the principle that only high level design is considered for this agenda, we suggest to make it simple as follows:Proposal 5.1:* Study the basic sync signal structure considering at least following aspects:
	+ NR SSB as baseline
	+ Wheter optimization is needed
	+ ~~Whether to reduce SSB BW considering at least NES and low-tier 6G device~~
	+ ~~Whether to increase the number of OFDM symbols considering at least detection performance~~
	+ Note: RAN4 involvement is necessary
 |
| Tejas | Y | In addition to this, we would like to include the what should be KPI should be used for 6G SSB. More number of symbols to improve the detection performance & study whether new services can signalled in the initial access. |
| Nokia | Y | Support as a starting point, with the implicit assumption that this means pursuing a basic sync signal structure that is NES-friendly and that it does not prevent us from pursuing alignment between different scenarios, e.g. NTN, if possible. Also we would like to clarify that we need to define a performance target for 6GR, taking into account the different devices types and the overall target of TN/NTN harmonization, as well as the coverage aspects raised in Proposal 4.1, which might have implications on the overall design. |
| Vodafone | Y |  |
| OPPO |  | Suggest to discuss in Agenda 11.3.2, 11.5 and 11.7. |
| CMCC |  | We prefer to not have “NR SSB as baseline” at this moment, which put unnecessary restriction on the study. Also, we think increasing number of OFDM symbols for sync signal need to be discussed based on evaluation and it may be more appropriate to be discussed under initial access agneda.Proposal 5.1 (revised):* Study the basic sync signal structure considering at least following aspects:
	+ ~~NR SSB as baseline~~
	+ Whether to reduce SSB BW considering at least NES and low-tier 6G device
	+ ~~Whether to increase the number of OFDM symbols considering at least detection performance~~

Note: RAN4 involvement is necessary |
| Apple | In principle okay | In principle we are okay. But we feel the main driving factor for reduced SSB BW is the spectrum holding of the operators, e.g., 3MHz, therefore we propose the following change* + Whether to reduce SSB BW considering at least minimum CBW ~~NES and low-tier 6G device~~
 |
| ETRI |  | Generally fine with NR SSB structure, however different number of RBs for PSS/SSS and PBCH should be revisited. We prefer to align the number of RBs for all signals and channels for 6GR SSB |
| Samsung | N | The meaning of “NR SSB as baseline” is unclear/premature. As many companies mentioned in tdocs, when considering the NES impact with longer SSB periodicity, we first need to identify which parts of NR design must be modified to achieve 6GR requirements. We suggest the following revisions.* Remove the word “basic”, which is ambiguous.
* The most essential motivation for reducing SSB bandwidth is for reducing the number of sync raster entries and save UE complexity in initial cell search, which is missing from the current proposal.
* We also propose to study whether to support more than one SSB structures for 6GR, for example, different SSB structures can be used for NES mode and non-NES mode, or different SSB structures can be used for cell-defining SSB and non-cell-defining SSB, or different SSB structures can be used for always-on SSB and on-demand SSB.
* Study the ~~basic~~ sync signal structure considering at least following aspects:
	+ ~~NR SSB as baseline~~
	+ Whether to reduce SSB BW over NR SSB considering at least the number of sync raster entries, NES and low-tier 6G device
	+ Whether to increase the number of OFDM symbols over NR SSB considering at least detection performance
	+ Whether to support more than one sync signal structures, e.g., different structures for regular operation vs network energy saving operation, cell-defining vs non-cell-defining, always-on vs on-demand
	+ Note: RAN4 involvement is necessary
 |
| CATT, CICTCI |  | OK with most of the contents. However, we have concern in 2nd bullet (reducing SSB BW) since:* It is unclear the min CBW so far, which impacts SSB BW.
	+ Even if min CBW is smaller, SSB can still be larger than min CBW and work by puncturing
* It looks like opening the door for different SSB designs for several aspects, e.g. IoT v.s. MBB UE.
 |

# **6 MRSS**

Related to this aspect, the SID states following objectives:

|  |
| --- |
| 1. Physical Layer structure for 6GR,
	1. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
	2. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
	3. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
	4. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
	5. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
	6. MIMO operation [RAN1, RAN4]
	7. Duplexing [RAN1, RAN4]
	8. Initial access [RAN1, RAN2, RAN4]
		* Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		* Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
	9. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
	10. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
	11. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
		1. RAN4 can be involved, if necessary, based on the LS from RAN1

…1. Migration from 5G NR to 6GR as well as interworking and mobility between 5G NR and 6GR:
2. 5G-6G Multi-RAT Spectrum Sharing for migration [RAN1, RAN2, RAN4, RAN3]
3. Study if any additional migration mechanism is necessary. [RAN] [RAN2, RAN1, RAN3, RAN4]NOTE: the start of this study objective (b) should be triggered by RAN plenary in time to guarantee proper completion of the WG study.
4. Mobility between 5G NR and 6GR [RAN2, RAN3, RAN4]
 |

Not only the frame structure as stated in the SID, a number of companies mention that 5G compatible design should be ensured for MRSS, including waveform, modulation, numerology, channel coding and so on. All these aspects are discussed in other AIs in RAN1, and hence, moderator suggest considering MRSS aspects when discussion the above topics in other AIs 11.3.1, 11.3.2, 11.4.1, 11.4.2.

When considering the coexistence with NR signals/channels on MRSS carrier, in general there are following two directions and companies view are split, and hence, further discussion is necessary to clarify the pros/cons for each direction.

* NR/6GR resources are split via TDM/FDM, including rate-matching
* 6GR shares NR signals/channels

Another aspect is whether “5G-6G MRSS” includes LTE as well as NR, since LTE Rel-15 or later are also considered as 5G. Some companies mention that coexistence with eMTC/NB-IoT should be ensured, which needs further discussion.

Based on the above, following proposal can be considered as starting point for further discussion.

#### Proposal 6.1:

* For NR-6GR MRSS support, study the following options for the coexistence with NR signals/channels on MRSS carrier
	+ Opt1: NR/6GR resources are split via TDM/FDM, including rate-matching
	+ Opt2: 6GR shares NR signals/channels
	+ FFS: whether/how to support LTE-6GR MRSS

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom |  | Opt 2 is not clear to us, does it mean 6GR has the same signals/channels as NR on MRSS carrier? From our perspective, we think the collision between NR/6GR resources should be avoided. For LTE-6GR MRSS, we don’t think it is needed, but we can live with the FFS. |
| Tejas | Y | We also want to include whether 6GR can use new waveform and can coexist with 5G NR |
| Nokia | Y | Opt1 is the baseline together with SDM, but investigate the feasibility and potential benefits of Opt2 for NR-6GR MRSS. We do not see a need to support LTE-6GR MRSS. |
| Vodafone | Y | As long as handover from 6G to 4G is specified MRSS between LTE-6GR may not be needed. Important however to ensure coexistence between 6GR and NB-IoT |
| OPPO |  | Suggest to discuss in Agenda 11.11. |
| CMCC |  | Before discussing whether to share or split, we need first to discuss the MRSS use cases, e.g. which signal/channel are going to be shared/rate mated. Once these are identified, detailed solution of MRSS can be discussed and evaluated under dedicated agendas.Proposal 6.1 (revised):For NR-6GR MRSS support, study necessary MRSS use cases, e.g. which signal/channel are going to be shared/rate mated. |
| Apple |  | We are okay, but we propose to delete the FFS* + ~~FFS: whether/how to support LTE-6GR MRSS~~

In 6G WG SID RP-251881, below is the quote regarding LTE/6G coexistence*Note: Inclusion of LTE/6G interworking/coexistence aspects may be further discussed based on the requirement from RAN plenary*Hence, we believe the RAN1 study of LTE/6G spectrum sharing needs to be triggered by new RAN plenary guidance |
| ETRI |  | At least for the data region, it is preferred that 5G and 6G be separated by TDM or FDM, while certain signals and channels may still be shared for resource efficiency. Therefore, both Option 1 and Option 2 can be considered together. |
| Samsung | N | We are unsure whether Option 1 and Option 2 are intended to be the same level. Regardless of TDM/FDM splitting, whether and how to support sharing can be discussed separately and is design-dependent. Whether NR signals/channels can be shared will depends on decisions for the design of those 6G channels/signals. Morever, how the NR/6GR resources are shared can be transparent to the UE – e.g., may even be in spatial domain. Therefore, we suggest:* For NR-6GR MRSS support, study the following ~~options~~ for the coexistence with NR signals/channels on MRSS carrier
	+ ~~Opt1:~~ NR/6GR resources are split via TDM/FDM, including rate-matching patterns
	+ ~~Opt2: 6GR shares NR signals/channels~~
	+ FFS: whether/how to support LTE-6GR MRSS
 |
| CATT, CICTCI |  | OK for further study, but we have strong concern on Opt2, which largely limit the 6G NW planning, common signal/channel design, and high-layer information design.We also think MRSS with 4G is unnecessary. |

# **7 Service/channel multiplexing/collision, including concurrence of UL transmissions**

The SID does not have text explicitly mentioning this aspect. However, according to companies’ contributions so far, companies have high interest in improvement/simplification of the Service/channel multiplexing/collision, including PUSCH/PUCCH transmissions, UCI multiplexing/prioritization, common RS for communication/sensing/positioning, and so on. Since these aspects are highly related to other agenda items to be discussed in RAN1 (e.g., “Physical layer control, data scheduling and HARQ operation”, “Other physical layer signals, channels and procedures”, and “Sensing”), moderator suggests discussing the above aspects in other RAN1 agenda items. Following is open question to hear companies’ view.

#### Question 7.1:

* Companies are invited to provide views on whether to discuss any features which contribute to improvement/simplification of service/channel multiplexing/collision, other than the features (to be) discussed in other agendas in RAN1. If yes, please elaborate which features need to be studied in this agenda.

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y | We would like to study on simplifying UCI multiplexing |
| Nokia | N | We believe the topics can be covered in the dedicated AIs, as mentioned by the moderator above. |
| OPPO |  | Suggest to discuss in Agenda 11.9. |
| CMCC | N |  |
| Apple | N | We think the current scope in FL summary is a good starting point. We do not see strong need to discuss other features.  |
| Samsung | N | Suggest to discuss in Agenda 11.9  |
| CATT, CICTCI |  | Fine to discuss these issues in dedicated agenda (11.9). In 6G overview agenda, if discussion continuous, we think we can collect pain points and high-level guidance on study directions, rather than technical/performance discussion. |

# **Concept and operation of bandwidth**

The SID does not have text explicitly mentioning this aspect. However, according to companies’ contributions so far, companies have high interest in improvement/simplification of NR BWP framework, which is fundamental unit of BW for UE transmissions/receptions, including but not limited to

* SCS switching
* Association with CORESET/Search space
* BWP switching delay
* RRC configuration overhead
* BWP types
* Frequency location between DL and UL
* Discuntiguous frequency resources within BWP
* Combined with TCI framework
* Support diverse device types

Since the potential scope for the improvement/simplification of NR BWP framework is quite broad, following proposal can be considered as starting point for further discussion. Note that the aspects on BW from multiple carrier perspectives can be discussed in Section 10.

#### Proposal 8.1:

* Study how to improve/simplify BWP framework for 6GR

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom | Y | Support. |
| Tejas | Y | We support the study. |
| Nokia | Y | Robust operation of BWP is important for 6GR. To a large extent it should be covered under dedicated AIs though. RF-related aspects of BWP configuration and operation need RAN4 involvement. Regarding SCS switching, it is only relevant in case there is a possibility of having different SCS for control and data. In case we manage to converge on single SCS per band this is clearly not needed, but in any case our assumption is that we should have a single SCS per carrier in 6GR. Perhaps this is a discussion for the numerology AI, but we just wanted to highlight the connection here. |
| Vodafone | Y | Probably important to also study the need to have NCD-SSB in 6GR BWP operation |
| OPPO |  | Suggest to discuss in Agenda 11.3.2, 11.9, 11.11. |
| Apple | Y | We are okay with the proposal |
| ETRI | Y | Simplfied BWP framework, e.g., reducing the number of BWPs should be studied |
| Samsung | Y | Need to also discuss the scope/ultility of BWPs in 6GR and what aspects from NR regarding BWP operation are to be kept/disarded in 6GR. |
| CATT, CICTCI | Y |  |

# **9 Supporting existing and new services**

Related to these aspects, the SID states following objectives and Interim Milestone:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
2. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
3. Energy efficiency and energy saving: both for network and device.
4. Enhanced spectral efficiency.
5. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
6. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
7. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
8. Target scalable and forward compatible design for diverse device types.
9. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
10. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
11. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
12. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion. |

As stated in the SID, the scope of this SI is limited to the “agreed” existing and new services, while no requirements of existing and new services have been agreed/captured in the RANp SI TR38.914 v0.1.0 yet. Companies provide views on whether/how to support existing and new services, including low-tier device (e.g. IoT, LPWA, RedCap), XR, voice, FWA, positioning, broadcast/multicast, sidelink, unlicensed spectrum, HRLLC, NW for AI, sensing, and so on. Especially on sensing, quite a few companies provide some details on how to support sensing for 6GR. However, this is to be discussed in other agenda items in RAN1 from RAN1#124bis (Apr. 2026) after the use cases and the associated requirement are clarified in RANp study for 6G requirements. Similar to this, moderator does not see any urgency to start discussion on how to support the “agreed” existing and new services in this meeting, except for Low-tier device.

Regarding the low-tier device (e.g. IoT, LPWA, RedCap), as discussed in Section 3, in general companies have aligned view that common/scalable 6GR framework should be studied for diverse device types, including the low-tier device. Toward this, it would be better to clarify the maximum supported BW for the low-tier device in early stage, so that some fundamental aspects discussed in this agenda (minimum CBW in Section 3, SSB BW in section 5) can make progress. Companies have split views on the maximum supported BW; 5MHz BW has the highest interest, while some other candidates, such as 3MHz, 10MHz, and 20MHz are also mentioned. Since too narrow UE BW may cause negative impact to the overall 6GR design, the pros/cons for those options need further study.

Other aspects for low-tier device, including the target use cases, complexity reduction (peak data reduction, reduced# of antennas, HD-FDD, and so on), UE power savings, coverage enhancements, and so on, can be discussed in RANp study for 6G requirements at first, and can be refined in RAN WGs.

#### Proposal 9.1:

* For low-tier device support by common/scalable 6GR framework, study following options for maximum supported UE BW
	+ Opt1: 3MHz
	+ Opt2: 5MHz
	+ Opt3: 10MHz
	+ Opt4: 20MHz

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y | Option1 of 3MHz also needs to be studied (This should be minimum supported UE Bandwidth) |
| Nokia | N | Opt1 is not necessary, minimum UE BW should be 5MHz for FDD (15kHz SCS), even if system BW may be 3MHz for some specific bands and sync raster points. Opt4 is only necessary in case 60kHz SCS is introduced for TDD, otherwise it is not needed. Hence, the baseline should be Op2 (for FDD, 15kHz SCS) and Opt3 (for TDD, 30kHz SCS) in our view.  |
| Vodafone | Y |  |
| OPPO |  | Suggest to discuss in Agenda 11.3.2. |
| CMCC |  | It is better to add a note: this should be equal to the minimum CBW in proposal 3.3..Proposal 9.1 (revised):* For low-tier device support by common/scalable 6GR framework, study following options for maximum supported UE BW
	+ Opt1: 3MHz
	+ Opt2: 5MHz
	+ Opt3: 10MHz
	+ Opt4: 20MHz

**Note: this BW should be equal to the minimum CBW in proposal 3.3** |
| Apple | Y | We are okay with the proposal |
| Samsung | Y | We are okay to study listed options. We support **Opt4 (from UE perspective) for RF bandwidth.** |
| CATT, CICTCI |  | We think the max UE BW of low-tier device highly depend on the FR, band and SCS. Otherwise, it is quite confusing how could it be possible to support some cases like “3 MHz with SCS=30 kHz”. Some suggestions:* For low-tier device support by common/scalable 6GR framework, study following options for maximum supported UE BW and also the associated SCS, for each 6G FR (FR1 FDD, FR1 TDD, FR2-1, new FR around 7 GHz)
	+ Opt1: 3MHz
	+ Opt2: 5MHz
	+ Opt3: 10MHz
	+ Opt4: 20MHz
 |

# **10 Spectrum utilization and operations**

Related to these aspects, the SID states following objectives:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
2. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
3. Energy efficiency and energy saving: both for network and device.
4. Enhanced spectral efficiency.
5. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
6. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
7. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
8. Target scalable and forward compatible design for diverse device types.
9. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
10. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
11. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
12. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion.1. Physical Layer structure for 6GR,
2. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
3. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
4. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
5. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
6. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
7. MIMO operation [RAN1, RAN4]
8. Duplexing [RAN1, RAN4]
9. Initial access [RAN1, RAN2, RAN4]
	* + Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		+ Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
10. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
11. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
12. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
13. RAN4 can be involved, if necessary, based on the LS from RAN1
 |

As discussed in Section 5, multiple operators have similar concept to minimize always-on signals (including SSB/SI) for the case of multi-carrier operation. The commonality among these concepts is that the initial cell search is done only on a specific carrier and hence, the always-on signals can be minimized on other carriers.

In addition, companies provide views on how to improve the spectrum utilization and operations, including Flexible DL/UL pairing, DL/UL decoupling, flexible carrier switching, fast SCell activation/deactivation, single cell multi-carrier operation, and so on. Some examples are shown below:

****

Single cell multi-carrier operation in [10]



DL/UL decoupling in [20]

Although the technical details on the above aspects can be further discussed in other agenda items to be discussed in RAN1 (e.g., “Initial access”, “Physical layer control, data scheduling and HARQ operation”, and “6GR spectrum utilization and aggregation”), it wold be better to discuss some high-level direction on how to improve the spectrum utilization and operations in this agenda items, because this issue has impact on multiple agenda items. Following proposal can be considered as starting point for further discussion.

#### Proposal 10.1:

* Study how to improve the spectrum utilization and operations for multi-carrier operations
	+ Note: the study under this agenda item should be kept on high-level directions, and the technical details can be studied under other agendas in future RAN1 meetings

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom | Y | Support the mainbullet. But we’re not sure what “high-level directions” will be like for this part. From our perspective, we support to study: Single cell multiple carriers, Flexible UL DL carrier association and Flexible carrier switching. We wonder whether the above three aspects can be high-level directions? |
| Tejas | Y |  |
| Nokia | Y | This is a relevant topic, though more specific discussion is expected to take place in dedicated AIs in the near future. |
| Vodafone | Y |  |
| OPPO | Y | High-level design principle for spectrum utilization can be discussed in this agenda, e.g., requirements from operators, needs of single cell with multiple carriers (SCMC), etc.Details should be dicussed in Agenda 11.11. |
| Apple | In principle okay | We propose to focus on the carrier aggregation * Study how to improve the spectrum utilization and operations for carrier aggretation, including single carrier, ~~multi-carrier~~ operations

In 6G WG SID RP-251881, below is the quote for DC*RAN plenary to make a decision on additional 6G-6G aggregation beyond 6G CA: 6G-6G DC. RAN plenary will task relevant RAN WGs for any specific technical analysis, as needed.*Hence, we think the study of DC needs to the tasked by RAN plenary, if needed.  |
| ETRI | Y | At least virtual handling of fragmented multiple carriers should be studied |
| Samsung | Y | We are generally OK with Proposal 10.1 but want to clarify whether “multi-carrier opertaitons” include both multi-carrier in same band and in different-bands. As reflected in several tdoc, layered (high-band and low-band, anchor carrier/non-anchor, coverage/capacity cell) approaches depend on carrier utilization with accros different bands. It would be helpful for the proposal to state this scope explicitly. |
| CATT, CICTCI | Y | Fine with the proposal. Just to confirm the understanding: ‘multi-carrier operation’ is a high-level description, so the examples listed above (e.g. DL/UL decoupling) is not precluded.  |

# **11 Spectrum efficiency**

Related to these aspects, the SID states following objectives:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
2. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
3. Energy efficiency and energy saving: both for network and device.
4. Enhanced spectral efficiency.
5. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
6. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
7. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
8. Target scalable and forward compatible design for diverse device types.
9. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
10. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
11. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
12. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion.1. Physical Layer structure for 6GR,
2. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
3. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
4. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
5. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
6. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
7. MIMO operation [RAN1, RAN4]
8. Duplexing [RAN1, RAN4]
9. Initial access [RAN1, RAN2, RAN4]
	* + Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		+ Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
10. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
11. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
12. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
13. RAN4 can be involved, if necessary, based on the LS from RAN1
 |

Quite a few companies provide the view related to the improvement of spectrum efficiency, and most of them can be fall into MIMO and AI/ML related features, which are (to be) discussed in other agenda items in RAN1. Therefore, moderator does not see any aspects to be discussed in this agenda item related to the improvement of spectrum efficiency. Following is open question to hear companies’ view. Note that in RANp study for 6G requirements, only a few target values for spectrum efficiency has been agreed yet, and RAN1 needs to wait for further RANp progress to see how much spectrum efficiency improvement 6GR aims to achieve.

#### Question 11.1:

* Companies are invited to provide views on whether to discuss any features which contribute to spectrum efficiency improvements, other than the features (to be) discussed in other agendas in RAN1. If yes, please elaborate which features need to be studied in this agenda.

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Tejas | Y | Relook at Guardband & Guard-time and reduced rolloff in conjuction with RAN-4 |
| Samsung | N | We think this is mainly to use more aggressive MU-MIMO, higher modulation order, and other areas. We may consider spectrum efficiency in agenda’s other than 11.1 as moderator suggested. |
| CATT, CICTCI | Y | UE centric system design (including spectrum reuse improvement, dynamic interference management, on demand access control, etc.) can be a candidate for study. |

# **12 All duplex types**

Related to this aspect, the SID states following objectives:

|  |
| --- |
| 1. Physical Layer structure for 6GR,
2. Waveforms (OFDM-based) and modulations. 5G NR Waveforms and modulation should be considered for 6GR and is also the benchmark for other potential proposals. [RAN1, RAN4]
3. Frame structure, including compatibility with 5G NR to allow for efficient 5G-6G Multi-RAT Spectrum Sharing (MRSS). [RAN1]
4. Channel coding, using LDPC and Polar Code as baseline, considering applicable extensions to satisfy 6G requirements and characteristics with acceptable performance/complexity trade-off [RAN1]
5. Channel Bandwidth (at least minimum and maximum), Numerology, avoiding multiple numerologies for the same band / sub-range (e.g., enabling synergies among frequency bands in the ~7GHz range) [RAN1, RAN4]
6. Physical layer control, data scheduling and HARQ operation [RAN1, RAN2]
7. MIMO operation [RAN1, RAN4]
8. Duplexing [RAN1, RAN4]
9. Initial access [RAN1, RAN2, RAN4]
	* + Studies on synchronization signal and raster, broadcast signals/channel and physical random access channel [RAN1, RAN4]
		+ Studies on initial access procedure, random access procedures, system information and paging [RAN2, RAN1, RAN4]
10. 6GR spectrum utilization and aggregation. [RAN1, RAN2, RAN4]
11. Other physical layer signals, channels and procedures [RAN1, RAN2, RAN4]
12. Evaluate performance of at least energy efficiency, spectrum efficiency, and coverage compared to 5G NR, and deliver the initial result at the end of study [RAN1].
13. RAN4 can be involved, if necessary, based on the LS from RAN1
 |

Since the dedicated agenda item on duplexing is planned to be started from RAN1#124, technical details can be discussed there. However, as also stated by RAN1 chair, the 6GR frame structure is discussed for “all duplex types”, it would be better to clarify what “all duplex types” means. It is moderator’s understanding that the frame structure will be studied for the agreed duplex types for study. In this sense, this agenda discusses which duplex types are to be studied in 6GR at first.

There is sufficient support from companies to consider at least following duplexing types,

* FD-FDD
* Semi-static TDD
* gNB semi-static SBFD

while companies may have split views on whether to consider following duplexing types

* HD-FDD, subject to the support for low-tier 6G device
* Dynamic TDD, especially on whether to support SFI
* gNB dynamic SBFD
* UE SBFD
* gNB FD

Based on the above, following proposal can be considered as starting point for further discussion.

#### Proposal 12.1:

* On 6GR duplexing study, RAN1 considers at least following duplex types
	+ FD-FDD
	+ Semi-static TDD
	+ gNB semi-static SBFD
* FFS whether to consider following duplexing types
	+ HD-FDD
	+ Dynamic TDD
	+ gNB dynamic SBFD
	+ UE SBFD
	+ gNB FD

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom | Y | We think gNB FD can also be studied for 6G as the evolution of SBFD. |
| Tejas | Y | HD-FDD is required for NTN at higher frequencies, hence we suggest to include HD-FDD. gNB dynamic SBFD and gNB full duplex will increase spectral efficiency and should be considered for 6G duplex study. |
| Nokia | Y | Support the 3 first duplex types as the baseline, however we believe Dynamic TDD should be confirmed as one of the duplex types for further study as well. |
| Vodafone |  | Agree that FD-FDD, Semi-static TDD and gNB semi-static SBFD should be studied. We also want to include HD-FDD in the study as it is a main consideration for 6G IoT device for many companies and it is important for it to be considered in 6G scheduler implementation since its start. UE (semi-static) SBFD can also be considered for the study |
| OPPO | Y |  |
| CMCC |  | We see no technical reasons to preclude HD-FDD and dynamic TDD, which has already been specified in 4G and 5G.Proposal 12.1 (revised):* On 6GR duplexing study, RAN1 considers at least following duplex types
	+ FD-FDD
	+ Semi-static TDD
	+ gNB semi-static SBFD
	+ HD-FDD
	+ Dynamic TDD
* FFS whether to consider following duplexing types
	+ gNB dynamic SBFD
	+ UE SBFD
	+ gNB FD
 |
| Apple | In principle okay | We are okay with the proposal.We assume “gNB semi-static SBFD” only covers non-overlapping sub-band full duplex.  |
| ETRI | Y | We think HD-FDD for RedCap UEs can be considered together with the other basic duplex types. |
| Samsung | N | Some clarifciaiton is be needed on whether “duplexing” is to be interpreted from the NW perspective only or both NW perspective and UE perspectives. If this includes both sides (UE and NW), we think HD-FDD should be in the main bullet. If we support 6G IoT (LPWA) in a single RAT, it is obvious to support HF-FDD for cost reduction offor low-cost UE types. Regarding the second bullet, we do not recommend studying those items in Rel-21 6GR. Based on lessons from NR (and even LTE in some cases) and on considering the gNB/UE complexity, we suggest to focus on the first 3 items and include support of HD-FDD.  |
| CATT, CICTCI | Y |  |

# **13 Harmonization of TN and NTN**

Related to this aspect, the SID states following objectives:

|  |
| --- |
| 1. Single technology framework based on a stand-alone architecture (Note1) to support the agreed existing and new services, and to satisfy the usage scenarios, requirements, deployment scenarios and design principles with acceptable performance/complexity trade-off, as determined by the RAN requirements in [RP-250810] and [TR38.914], including: [RAN1], [RAN2], [RAN3], [RAN4]
2. Ensuring appropriate set of functionalities, minimize the adoption of multiple options for the same functionality, avoid excessive configurations, excessive UE capabilities and UE capabilities reporting.
3. Energy efficiency and energy saving: both for network and device.
4. Enhanced spectral efficiency.
5. Enhanced overall coverage, focus on cell-edge performance and UL coverage.
6. Wider channel bandwidth (at least 200MHz) support for 6G deployments at least above 2 GHz, around 7 GHz.
7. Re-use of existing 5G mid-band (~3.5GHz) site grid for 6G deployments in at least around 7 GHz and targeting comparable coverage to 5G mid-band.
8. Target scalable and forward compatible design for diverse device types.
9. Improved spectrum utilization and operations taking into account diverse spectrum allocations.
10. Aim at using common 6G Radio design, which meets mobile broadband service requirements as high priority, to also meet vertical needs.
11. Aim at a harmonized 6G Radio design for TN and NTN, including their integration.
12. System simplification, including reducing configuration complexity, enabling more efficient Cell/UE management, etc.

Note1: the term stand-alone architecture does not imply any particular Core network architecture, which is up to SA2 discussion. |

Since the dedicated agenda item on NTN is planned to be started from RAN1#124, technical details can be discussed there. Howerver, for the harmonized 6GR design for TN and NTN, it would be better to identify which technical areas the NTN aspects need to be considered in early stage. In this sense, this agenda discusses to identify the affected technical areas for the harmonized 6GR design for TN and NTN.

According to the contributions, the potentially affected areas by NTN are quite broad. There is a joint contribution from satellite companies [52] and another contribution from another satellite company [53]. It would be good to start from their proposal as starting point to reflect the industry’s view. Other aspects can be included through discussion.

Note that the orbit type and payload type will be discussed in RANp study for 6G requirements.

#### Proposal 13.1:

* For harmonized 6GR design for TN and NTN, RAN1 studies to identify the technical aspects affected by NTN characteristics, including at least
	+ a) GNSS-resilient operation
		- Further discuss how to avoid duplication with Rel-20 5G-A NR-NTN study
	+ b) PAPR reduction for NTN DL
	+ c) Frame structure
	+ d) Coverange enahncements
	+ e) Duplex types
	+ f) Propagation impairments
	+ g) Long propagation delay
	+ h) Grant free access
	+ i) Beam hopping and longer SSB periodicity
	+ j) Positioning/Location
	+ k) NTN/TN mobility
	+ l) DC/CA
	+ m) Coexistence with IoT-NTN/NR-NTN
	+ n) Beam-specific signal/channel design
	+ o) Interference management for TN-NTN, inter-orbit, and inter-satellite cases

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| China Telecom |  | We are a bit confused here. For example, for Frame structure part, since there is an agnenda being discussed in parallel, then how to deal with the relationship between them? |
| Tejas | Y | Dual connectivity of TN and NTN should be considered as well. |
| Nokia | N | In this early stage, the main questions to be addressed is whether the waveform, frame structure, and numerology under study for TN can be utilized by NTN as well. From that point of view, mainly topics b), c), d), e), f) are relevant for this AI. In addition, topic l) DC/CA should not be addressed in RAN1 without prior indication from RAN Plenary. Some of the topics (i.e. m) and o)) seem to fall into the domain of RAN4 and should not be discussed as part of the RAN1 discussions. Topic k) is additionally more in the RAN2 domain and should not be discussed here either. Other topics can be discussed under dedicated AI in the near future. In general we should avoid significant deviations in the design, especially on essential functionalities, e.g. related to cell discovery and initial access signals and procedures. |
| OPPO |  | Details should be studied in Agenda 11.12. But in 11.1, we can discuss a general design principle for 6GR:Step 1: 6GR Baseline design is identified considering requirement of 6G TN communication (i.e. MBB and IoT).Step 2: Design for 6G verticals (e.g. Sensing, NTN) can be studied based on the 6GR baseline design. Strive for reusing the 6GR baseline design (e.g. waveform, frame structure, channel coding, modulation) for 6GR verticals. But Sensing-specific and NTN-specific designs can be studied. |
| CMCC |  | For Duplex type, TDD spectrums can be considered as addtiaonl resources to FDD spectrum providing more candidate spectrum resources fro deployments.When TDD is supported for NTN, the round trip time needs to be covered by the GP between DL and UL slots. With the consideration of this, longer periodicity for TDD-UL-DL periodicity can be considered. It needs further clarification on Grant free access. There would be some pre-conditions for the Grant freee access, such as GNSS with high accuracy of timingfor uplink transmission. Legacy PRACH procedure still can be considered as baseline behavior for UE initial access. After the design of initial access, we can discuss the grant free access. In addition, it seems some aspects listed may not purely RAN1 scope, for example, NTN/TN mobility, DC/CA, and some fuctions also require RAN SI discussion.  |
| Apple |  | For us, the scope of the study is to large and may not fit into 6G day 1, we are mostly interested in * + a) GNSS-resilient operation
		- Further discuss how to avoid duplication with Rel-20 5G-A NR-NTN study
	+ d) Coverange enahncements
	+ e) Duplex types
	+ g) Long propagation delay
	+ i) Beam hopping and longer SSB periodicity
	+ k) NTN/TN mobility
	+ m) Coexistence with IoT-NTN/NR-NTN
 |
| ETRI | Y | We assume that “b) PAPR reduction for NTN DL” covers the waveform discussions as well. |
| Samsung | N | We appreciate the effort to identify NTN-specific aspects. However, the current proposal is overly detailed with many specific examples, and it does not fully account for the potential side impacts on TN operation. The study should instead focus on an integrated TN-NTN design between TN and NTN from the initial stage of the 6GR specifications, under the premise that such integration will not introduce any adverse impact, complexity, or limitation on TN operation.Accordingly, we would like to suggest the following updated proposal:Proposal: For a harmonized 6GR design for TN and NTN, RAN1 should study the technical aspects affected by NTN characteristics, underwith the clear principle that such studies shall not cause any degradation, complexity, or limitation to TN performance and operation. |
| CATT, CICTCI | Y | In additionl to the above list, we propose the following directions:* **Numerology** (since it is unclear whether NCP is sufficient in some NTN band)
* **MIMO transmission** (NTN terminals may have left-hand circular polarization and right-hand circular polarization to form multi-layer transmission)
* **Satellite related system information broadcasting**
 |

# **14 Other aspects**

Other than the aspects discussed in the above sections or other agenda items (including those planned in future RAN1 meetings), some companies mention the aspects related to PHY security, NW resilience, and so on. It is moderator’s understanding that neither of other aspects can be discussed in RAN1 without any progress in RANp study on 6G requirements. RAN1 cannot discuss any features without justification on the target/motivation, which need to be clarified in RANp study at first. Following is open question to hear companies’ view.

#### Question 14.1:

* Companies are invited to provide views on whether to discuss any features, other than those (to be) discussed in other sections in this summary or in other agendas in RAN1. If yes, please elaborate which features need to be studied in this section.

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Vodafone |  | Important to have close alignment between SA3 (with early input being desired) and the RAN groups to ensure that any new security requirements on lower layers are delivered. Any new procedure/mechanism on L1 security should consider and study the additional payload to DCI/UCI control signalling  |
|  |  |  |
|  |  |  |

# **15 Conclusions**

Following agreements were made in this meeting:

To be updated

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|  |  |  |  |
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| [51] | [R1-2506326](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506326.zip) | Discussion on Overview of 6GR air interface | China Unicom |
| [52] | [R1-2506327](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506327.zip) | Overview of 6GR air interface | THALES |
| [53] | [R1-2506335](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506335.zip) | Views on 6GR air interface | CSCN |
| [54] | [R1-2506358](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506358.zip) | Overview of 6G Air Interface | CEWiT |
| [55] | [R1-2506365](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506365.zip) | Overview of 6GR air interface | KDDI Corporation |
| [56] | [R1-2506368](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506368.zip) | Views on 6GR air interface design criteria | NICT |
| [57] | [R1-2506394](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_122/Docs/R1-2506394.zip) | Views on 6G PHY choices | BT, Orange, Vodafone, Deutsche Telekom, Turkcell, KPN |

# **RAN1 agreements**

### **RAN1#122**

To be updated