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| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Radio Access Network;Study on Evolution of NR Duplex Operation(Release 18) |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document captures the results and findings from the study item "Study on Evolution of NR Duplex Operation " [2]. The purpose of this TR is to document the follows for evolution of NR duplex operation:

- applicable and relevant deployment scenarios.

- evaluation methodology and assumptions.

- possible schemes/enhancements, feasibility and performance evaluation results of subband non-overlapping full duplex and dynamic/flexible TDD.

- summary of the regulatory aspects that have to be considered for deploying the identified duplex enhancements in TDD unpaired spectrum.

This activity involves the Radio Access work area of the 3GPP studies and has potential impacts both on the Mobile Equipment and Access Network of the 3GPP systems.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-213591, New SI: Study on evolution of NR duplex operation

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

<ABBREVIATION> <Expansion>

SBFD Subband non-overlapping full duplex

# 4 Introduction

TDD is widely used in commercial NR deployments. In TDD, the time domain resource is split between downlink and uplink. Allocation of a limited time duration for the uplink in TDD would result in reduced coverage, increased latency and reduced capacity. As a possible enhancement on this limitation of the conventional TDD operation, it would be worth studying the feasibility of allowing the simultaneous existence of downlink and uplink, a.k.a. full duplex, or more specifically, subband non-overlapping full duplex at the gNB side within a conventional TDD band.

The NR TDD specifications allow the dynamic/flexible allocation of downlink and uplink in time and CLI handling and RIM for NR were introduced in Rel-16. Nevertheless, further study may be required for CLI handling between the gNBs of the same or different operators to enable the dynamic/flexible TDD in commercial networks. The inter-gNB CLI may be due to either adjacent-channel CLI or co-channel-CLI, or both, depending on the deployment scenario. One of the problems not addressed in the previous releases is gNB-to-gNB CLI.

This study aims to identify the feasibility and solutions of duplex evolution in the areas outlined above to provide enhanced UL coverage, reduced latency, improved system capacity, and improved configuration flexibility for NR TDD operations in unpaired spectrum. In addition, the regulatory aspects need to be examined for deploying identified duplex enhancements in TDD unpaired spectrum considering potential constraints.

# 5 Objectives of study

The objective of this study is to identify and evaluate the potential enhancements to support duplex evolution for NR TDD in unpaired spectrum.

In this study, the followings are assumed:

* Duplex enhancement at the gNB side
* Half duplex operation at the UE side
* No restriction on frequency ranges

The detailed objectives are as follows:

* Identify applicable and relevant deployment scenarios (RAN1).
* Develop evaluation methodology for duplex enhancement (RAN1).
* Study the subband non-overlapping full duplex and potential enhancements on dynamic/flexible TDD (RAN1, RAN4).
* Identify possible schemes and evaluate their feasibility and performances (RAN1).
* Study inter-gNB and inter-UE CLI handling and identify solutions to manage them (RAN1).
	+ Consider intra-subband CLI and inter-subband CLI in case of the subband non-overlapping full duplex.
* Study the performance of the identified schemes as well as the impact on legacy operation assuming their co-existence in co-channel and adjacent channels (RAN1).
* Study the feasibility of and impact on RF requirements considering adjacent-channel co-existence with the legacy operation (RAN4).
* Study the feasibility of and impact on RF requirements considering the self-interference, the inter-subband CLI, and the inter-operator CLI at gNB and the inter-subband CLI and inter-operator CLI at UE (RAN4).
* Note: RAN4 should be involved early to provide necessary information to RAN1 as needed and to study the feasibility aspects due to high impact in antenna/RF and algorithm design, which include antenna isolation, TX IM suppression in the RX part, filtering and digital interference suppression.
* Summarize the regulatory aspects that have to be considered for deploying the identified duplex enhancements in TDD unpaired spectrum (RAN4).

Note: For potential enhancements on dynamic/flexible TDD, utilize the outcome of discussion in Rel-15 and Rel-16 while avoiding the repetition of the same discussion.

# 6 Subband non-overlapping full duplex (SBFD)

*Editor’s note: More subsections may be added under section 6 depending on the discussion for SBFD*

## 6.1 General aspects of SBFD schemes

Editor’s note: This section captures the general aspects of SBFD schemes except self-interference, inter-gNB and inter-UE CLI handling schemes.

## 6.2 Self-interference handling schemes

## 6.3 Inter-gNB and inter-UE CLI handling schemes

Editor’s note: This section captures the potential inter-gNB and inter-UE CLI handling schemes that are specific for SBFD, and the schemes that are common for both SBFD and dynamic/flexible TDD are captured in 8.2. Specifically, the inter-subband CLI handling schemes are captures in 6.3, and intra-subband CLI handling schemes are captured in section 8.2.

# 7 Feasibility and Performance Evaluation for SBFD

## 7.1 Deployment Scenarios

Editor’s note: This section captures a summary of the identified applicable deployment scenarios for feasibility and performance evaluation, covering both FR1 and FR2, as well as non-coexistence scenarios, co-channel co-existence scenarios and adjacent-channel co-existence scenarios.

### 7.1.1 FR1

### 7.1.2 FR2

## 7.2 Evaluation Methodologies

Editor’s note: This section captures table(s) for evaluation metrics and assumptions of link budget analysis (if needed), link level simulation (if needed) and system level simulation for the identified scenarios. Sub-sections may be added later based on the discussion progress, e.g., Link level methodology, System level methodology.

## 7.3 Feasibility Evaluation Results

Editor’s note: This section captures the results and observations of feasibility evaluation for identified scenarios.

### 7.3.1 FR1

### 7.3.2 FR2

## 7.4 Performance Evaluation Results

Editor’s note: This section captures the results and observations of performance evaluation for identified scenarios.

### 7.4.1 FR1

### 7.4.1 FR2

# 8 Potential enhancements on dynamic/flexible TDD

## 8.1 General aspects of dynamic TDD schemes

Editor’s note: This section captures the general aspects of dynamic TDD schemes except the inter-gNB and inter-UE CLI handling schemes.

## 8.2 Inter-gNB and inter-UE CLI handling schemes

Editor’s note: This section only captures the potential inter-gNB and inter-UE CLI handling schemes including schemes that are specific for dynamic TDD and schemes that are common for both SBFD and dynamic/flexible TDD. Specifically, intra-subband CLI handling schemes are captured in section 8.2.

# 9 Feasibility and Performance evaluation for dynamic/flexible TDD

## 9.1 Deployment Scenarios

Editor’s note: This section captures a summary of the identified applicable deployment scenarios for feasibility and performance evaluation, covering both FR1 and FR2, as well as non-coexistence scenarios, co-channel co-existence scenarios and adjacent-channel co-existence scenarios.

### 9.1.1 FR1

### 9.1.2 FR2

## 9.2 Evaluation Methodologies

Editor’s note: This section captures table(s) for evaluation metrics and assumptions of system level simulation for the identified scenarios.

## 9.3 Feasibility Evaluation Results

Editor’s note: This section captures the results and observations of feasibility evaluation for identified scenarios.

### 9.3.1 FR1

### 9.3.2 FR2

## 9.4 Performance Evaluation Results

Editor’s note: This section captures the results and observations of performance evaluation for identified scenarios.

### 9.4.1 FR1

### 9.4.1 FR2

# 10 Feasibility of and impact on RF requirements

Editor’s note: This section captures the feasibility of and impact on RF requirements considering the self-interference, the inter-subband CLI, and the inter-operator CLI at gNB and the inter-subband CLI and inter-operator CLI at UE, as well as feasibility of and impact on RF requirements considering adjacent-channel co-existence with the legacy operation (RAN4). This section also captures the evaluation assumptions, methodologies and results developed by RAN4.

# 11 Regulatory aspects for deploying the duplex enhancements in TDD unpaired spectrum

Editor’s note: This section captures the summary of the regulatory aspects that have to be considered for deploying the identified duplex enhancements in TDD unpaired spectrum (RAN4).

# 12 Conclusions and recommendations

Annex <A>:
Simulation assumptions

# A.1 Heading

 Annex <Z>:
Change history

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| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-05 | RAN1#109-e |  |  |  |  | Skeleton | 0.0.1 |