



TECHNICAL SPECIFICATION

**Reconfigurable Radio Systems (RRS);
Radio Interface Engine (RIE);
Part 1: Technical requirements**

Reference

DTS/RRS-0149-1

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Reconfigurable Radio Systems (RRS).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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Introduction

The radio interface engine comprises context information and communication needs to improve both depending on the demands. In ETSI TR 103 587 [i.1] several use cases are identified and described that are used as base for the requirements of the radio interface engine. The concept demands requirements for a future architecture of the radio interface engine. The requirements are split into two categories: the functional and the performance requirements. The functional requirements consist of three groups. These are the radio and hardware processing resources, the functions that are supporting the reconfiguration and the mobile device mobility and connectivity management.

The performance requirements comprise communication as well as context information indicators. Context information includes positioning performance indicators and is proposed in 3GPP R16 where positioning relevant KPIs are identified [i.2]. The context information performance KPIs steer the potential of the radio interface engine to improve and reach the communication performance requirements of the network.

1 Scope

The present document specifies the system requirements for Reconfigurable Radio Systems operating in different environments and bands to apply the concept of the radio interface engine that is introduced in ETSI TR 103 587 [i.1] together with use cases comprising different key performance indicators in radio systems.

The documented key performance indicators are described and followed by the requirements on the wireless systems which are structured in the following requirement categories:

- Requirements for radio and hardware processing resources.
- Requirements for functions supporting the reconfiguration.
- Requirements for mobile device mobility and connectivity management.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI TR 103 587: "Reconfigurable Radio Systems (RRS); Feasibility study of a Radio Interface Engine (RIE)".
- [i.2] 3GPP TR 22.872 (V16.1.0): "Study on positioning use cases (Release 16)", SA WG1.

3 Definition of terms, symbols and abbreviations

3.1 Terms

Void.

3.2 Symbols

Void.

3.3 Abbreviations

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

HPR	Hardware Processing Resources
QoS	Quality of Service
RR	Radio Resources
WD	Wireless Device

4 Requirement Organization and Methodology

4.1 Requirement Organization

The requirements are organized into two categories. Category one defines the function requirements and category two the performance requirements. Both categories are further split up into different groups. Figure 1 visualizes the categories and its enclosed groups.

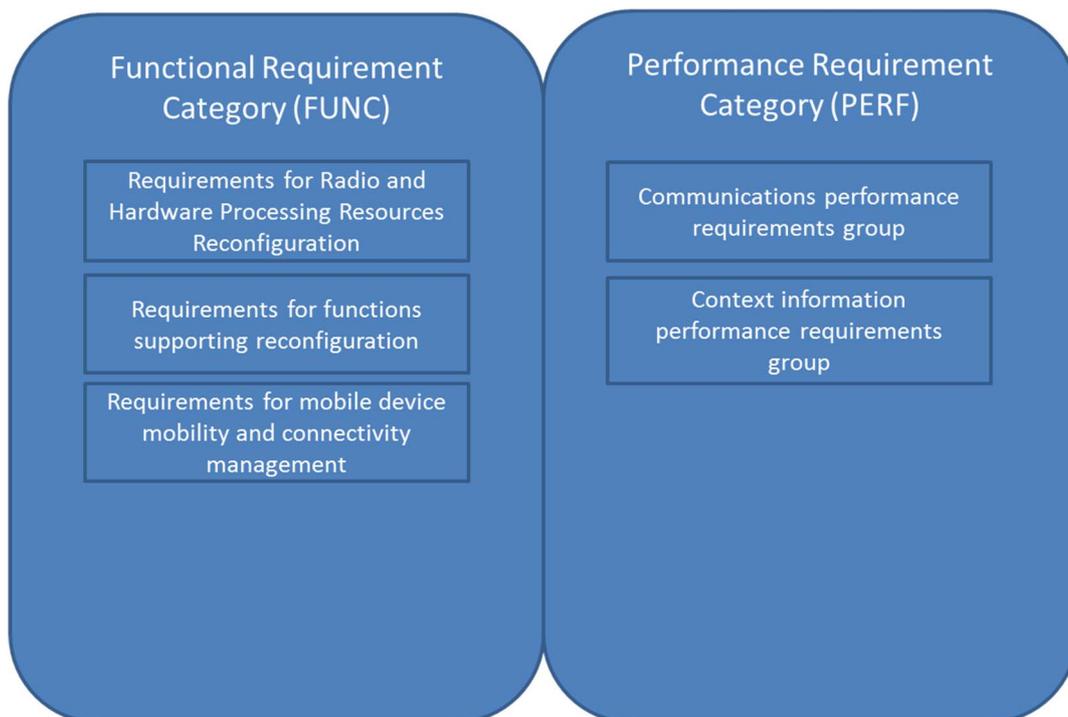


Figure 1: Requirements Operations

4.2 Requirement Format

A letter code is defined to uniquely identify each requirement R<CAT><GROUP><XX>. It is constructed as follows:

- R-:standard requirement prefix.
- <CAT>:

Code	Category
FUNC	Functional aspects
PERF	Performance aspects

- <GROUP>: Requirement group identifier. A three letter code will be used for this identifier.
- <XX>: Requirement identifier within requirement group; range 01 → 99.

EXAMPLE: R-FUNC-RHR-01: Requirements-Function-Radio_and_Hardware_Resources_01.

4.3 Requirement Formulation

A requirement is formulated in such a way that it is uniquely defined. It is built as follows:

- Title: <Title Description>

5 Working Assumptions

The working assumptions described below are based on ETSI TR 103 587 [i.1]. There a radio interface engine is defined to comprise the following use cases which all rely on context information, such as current and predictive location information of the wireless device:

- Decision making based on context information of either the mobile device or the base station identifying if a single or multiple links are best.
- User circumstance trigger context information management that adapts the communication KPIs.
- Considering context information to download and install a different PHY/MAC protocol of wireless devices.
- Tracking context information to decide where the processing unit shall be executed.
- Considering context information to adapt PHY and MAC to improve the location estimation of the WD iteratively further.

Relevant performance indicators are categorized in two groups:

- Communications performance indicators, such as data rate, latency, spectrum and power efficiency.
- Context information performance indicators, such as waveform, location accuracy, integrity of sensor data, and used spectrum for ranging, and outdated sensor data.

6 Functional System Requirements

6.1 Requirements for radio and hardware processing resources

6.1.1 R-FUNC-RHR-01: Reconfiguration for each WD

The system shall support the reconfiguration of both the Hardware Processing Resources (HPRs) and the Radio Resources (RRs) for each supported Wireless Device (WD).

Explanation: The system should be able to perform resource reconfiguration of both the hardware processing resources and the radio resources for each supported WD. The radio resources assigned to each supported WD can be dynamically modified, which includes bandwidth, frequencies, power levels, spectrum masks, etc. Meanwhile, the percentage of hardware processing resources devoted to each supported WD should be dynamically modified. For example, sufficient HPR should be configured to a WD when a new channel is assigned to it.

6.1.2 R-FUNC-RHR-02: Reconfiguration between WDs

The system shall support reconfiguration of both HPRs and RRs between different WDs.

Explanation: The system can reconfigure multiple WDs with flexibility in terms of the percentage of HPRs and RRs between different WDs according to the status of the network.

6.2 Requirements for functions supporting the reconfiguration

6.2.1 R-FUNC-REC-01: Gathering and processing function

The system shall support a gathering and processing function to gather and process radio related metrics and parameters.

Explanation: After having gathered radio related metrics and parameters, the gathering and processing function may process them to make decisions on reconfiguration in order to optimize radio performance. The identification of the radio related metrics and parameters which can be used for reconfiguration purposes may vary according the specific use case. These are expected to include traffic variations, channel bandwidth, interference, transmit power and QoS.

6.2.2 R-FUNC-REC-02: Support of trigger events for reconfiguration

The system shall support trigger events for reconfiguration.

Explanation: Trigger events are described by certain parameters (e.g. thresholds, hysteresis) in order to define the condition under which an event is happening. When one or more events occur, the system starts to evaluate the need for a possible reconfiguration.

6.2.3 R-FUNC-REC-03: Support for reconfiguration function

The system shall support a reconfiguration function to make decisions for radio resource reconfiguration and inform RBSs to perform the reconfiguration e.g. triggered by events in clause 6.2.2.

Explanation: The reconfiguration function shall make radio resource reconfiguration decisions such as, reconfiguration time, reconfigured RATs, frequency bands allocation and adding/dropping carrier frequencies at RBSs.

6.2.4 R-FUNC-REC-04: Support for execution function

The system shall support the execution function in order to perform the reconfiguration.

Explanation: The system WDs should support mechanisms in order to be reconfigured according to the reconfiguration decision of the reconfiguration function.

EXAMPLE: An example is to exchange location estimates between WDs to improve the estimation process on the receiver itself.

6.2.5 R-FUNC-REC-05: Support of learning function

The system shall support a learning function to improve and optimize the reconfiguration decisions.

Explanation: For example, the learning capability may consist in monitoring the performance of the system after each reconfiguration and verifying whether the decisions meet or not the reconfiguration target. Another possibility is to learn about the causes that trigger a particular reconfiguration by memorizing the situation; if such causes happen again, the reconfiguration that should be performed is already known.

6.2.6 R-FUNC-REC-06: Support of information provisioning function

The system shall support an information provisioning function to provide updated network configuration information to the appropriate system devices.

Explanation: After a reconfiguration, the information related to the new network configuration and policies, are expected to be efficiently provided to the system devices (only the ones affected by the reconfiguration) in order to minimize the control plane overhead due to the reconfiguration.

6.3 Requirements for mobile device mobility and connectivity management

6.3.1 R-FUNC-MOB-01: Mobility management of the WDs

The system shall guarantee the mobility management of the WDs.

Explanation: Network reconfiguration (e.g. change of WD in currently used band or starting operations in a new band using a WD already deployed or a new WD) may imply the change of radio parameters, such as neighbour cells relation information (e.g. the neighbour cells IDs, the neighbour cells operating frequency, etc.) affecting the cell selection/reselection of WDs in idle mode. The mobility management is guaranteed by providing such updated information to the WDs.

6.3.2 R-FUNC-MOB-02: Connectivity management of the WDs

The system shall manage the connectivity of the WDs during the reconfiguration.

Explanation: When a WD is in connected mode and operating on radio resources that may be reconfigured, an appropriate decision has to be evaluated by the system in order to maintain the connectivity of the involved WDs. In the following, different examples of approaches are depicted according to the WDs capabilities:

In order to support connectivity of WDs that are only able to operate on WD "a" in band "x", sufficient radio resource in band "x" may be maintained for WD "a" in band "x". In order to support WDs capable of operating on WD "a" or WD "b" in band "x" and which are in connected mode on WD "a" in band "x", it may be evaluated if the connectivity currently provided to the WDs on WD "a" could be provided also on WD "b" performing handover from WD "a" to WD "b" before the reconfiguration from WD "a" to WD "b" on band "x".

In order to support WDs capable of operating only on WD "a" in band "x" and band "y" and which are in connected mode on WD "a" in band "x", the WDs may be handed over to band "y" before the reconfiguration of the radio resources that refer to band "x".

6.3.3 R-FUNC-MOB-03: Scalability of connections of the WDs

The system shall consider scalability of the potentially active mobile WDs that are either managed by the network or a central unit.

EXAMPLE: Mobile WDs may operate in a peer-to-peer mode and demand resources (spectrum, power) in a predictive manner. Therefore, scalability is supported by the predictive demand of the mobile WD.

6.3.4 R-FUNC-MOB-04: Support of authentication

The system shall support authentication methods to provide traceable and trustable data sources from WDs.

Explanation: If data is exchanged between WDs that is used for determining the context information it is relevant that an authenticated source that can be trusted provides the information. Therefore, the risk of changing context information by spoofing location relevant data is reduced.

7 Key Performance Requirements

7.1 Key Performance Indicators for Communications

7.1.1 R-PERF-KPI-COM-01: Selecting the best PHY/MAC of the communication system

The system shall select the best PHY/MAC protocol depending on context information such as network and user requirements.

EXAMPLE: A given WD, e.g. a WiFi node, is using a certain MAC protocol, which provides a certain QoS under the current environment conditions. However, at a certain point in time, an external structured quasi-periodic and impulsive interference appears, e.g. due to an LTE-U transmission in the same band, which decreases the achievable QoS. Since the interference is impulsive and quasi-periodic, it can be easily predicted and, if known, it would be trivially avoided by MAC protocol operation. Rather than a priori designing a MAC protocol so as to integrate support for avoidance of such structured interference, which would create a significant overhead in situations where there is no interference, the WiFi node can use the context information to detect if, in the current environment, there is an active interference and which is its pattern, and then download and switch to a MAC protocol specifically designed for avoiding that specific pattern.

7.1.2 R-PERF-KPI-COM-02: Reliability of the communication link

The system shall perform predictive handover to keep the transmission reliable.

EXAMPLE: The acquired context information is exploited in order to identify the best possible working point for a concerned Wireless Equipment. For this purpose a combination of instantaneous observations together with historical (averaged) data is used in order to enable predictive decision making. Depending on the choice of the decision making entity (e.g. Network centric decision making, Wireless Equipment centric decision making, hybrid decision making split between Network and Wireless Equipment), the context information needs to be transported (and accumulated from various sources) to the decision making entity.

7.1.3 R-PERF-KPI-COM-03: Selection of power compliant processing units

The system shall switch to a low power consuming unit if the context information identifies relevant changes.

EXAMPLE: The WD is serving an outdoor park; the cell load will be directly related to the weather conditions. For situations where the load is high (good weather conditions) and many users need to be served, the most time consuming operations of the protocol stack (e.g. PHY processing) are executed in high performance devices (like FPGAs). In the situation where the weather is likely to change, as predicted by humidity, temperature, and pressure sensors, which provide the context information, the cell load will tend to decrease rapidly. Thus, under the new circumstance of low cell load, the decision making entity selects a less performant less energy consuming processing device (e.g. GPP) to perform the PHY processing, with the purpose of serving the reduced number of users at lower energy consumption and power radiation with a QoS target.

7.1.4 R-PERF-KPI-COM-04: Preselecting relevant sensor data

The system shall preselect data that is maybe no longer relevant because it is outdated to improve the net-throughput. The decision can be done at the WD.

EXAMPLE: The WD is sharing relevant correction data for ionospheric effects to improve GNSS based location estimation. If this data is outdated but will be used it could lead to a higher location error.

7.2 Key Performance Indicators for Context Information

7.2.1 R-PERF-KPI-CON-01: Accuracy of the localization estimation

The system shall assess the accuracy. Such an assessment may be performed by known ground truth points, or estimating the noise level, or the bias due to non-line-of-sight conditions.

EXAMPLE: A set of known fixed ground truth points act as a reference points. Distance measurements depending on the reference points together with the geometrical distribution and knowledge about past measurements allow assessing the accuracy of the estimate of the location.

7.2.2 R-PERF-KPI-CON-02: Integrity of the localization performance

The system shall assess the integrity of the estimated localization performance.

EXAMPLE: Known reference points allow to establish an integrity level to derive a confidence level of exploitable context information. Other methods could be location measurement units share their integrity measurements to be prepared to detect either spoofing or jamming.

7.2.3 R-PERF-KPI-CON-03: Geometric constellation of WD

The system shall assess the geometrical constellation of all active and passive WDs to decide how the location estimation process is affected, and therefore the resources are reasonably invested.

EXAMPLE: Two WDs that support the localization process are placed in line behind each other. Using both devices in such a constellation will bring no benefit, but requires resources such as spectrum and power.

7.2.4 R-PERF-KPI-CON-04: Sensor reliability

The system shall assess the reliability of sensors that assess data to be integrated as context information (such as pressure and humidity) and provide the measurement data.

EXAMPLE: Sensor information such as humidity or pressure could predict a change of the weather. Therefore rain could harm the transmission at certain carrier frequencies, such as mmWave. Additional sensors could foresee such a weather change to adapt the wireless link to a more robust carrier frequency.

7.2.5 R-PERF-KPI-CON-05: Spectrum requirements

The system shall adapt the spectrum depending on the current accuracy requirements, especially in the context of a second WD.

EXAMPLE: Broader spectrum allows estimate the ranging performance more accurately. However, depending on the requirements this is not necessary and could allow a second WD to estimate with its own spectrum the range.

7.2.6 R-PERF-KPI-CON-06: Waveform adaptations

The system shall adapt the applied waveform to optimally choose the current waveform on scenarios with line-of-sight or non-line-of-sight conditions.

EXAMPLE: The waveform determines the performance with a given spectrum. This is of interest in simultaneously ranging between WDs that are collocated.

7.2.7 R-PERF-KPI-CON-07: Location methods

The system shall adapt its location methods depending on the performance requirements, available sensor data, update rate and potential power consumption.

EXAMPLE: Different location methods exist with constraints in respect to complexity, latency and used sensor data. The key constraints limit the power consumption and therefore, only a simple location method is applied with a low update rate and using only limited sensor data.

7.2.8 R-PERF-KPI-CON-08: Horizontal and vertical accuracy performance

The system shall differentiate between the horizontal and vertical accuracy performance.

EXAMPLE: Human addressed use cases exploit location information only on a single floor (in the horizontal dimension). Therefore, the performance requirements shall be different between the horizontal and vertical dimension.

History

Document history		
V1.1.1	March 2019	Publication