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| **Change Request** | | | | | | | |
| **Document** | **O-RAN.WG4.CUS.0** | **ver** | **10.00** | **CR** | **QCM-0045** | **rev** | **2** | |

|  |  |  |  |
| --- | --- | --- | --- |
| ***Title:*** | Add change to allow use of a non-rectangular antenna model or one with ordered elements | | |
| ***Source to WG:*** | QCM | | |
| ***Target WG :*** | **WG4** | | |
| ***Category:*** | **B** | ***CR Creation Date*** | 2022.08.11 |
|  | *Use one of the following* ***categories****:* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* ***F*** *(correction)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | |

|  |  |
| --- | --- |
| ***Reason for Change:*** | The existing antenna model only accommodates rectangular antenna panels with elements in a specific order (bottom to top, left to right). This is inflexible. |
| ***Summary of change:*** | A change is made to various sub-clauses within clause 12 to allow use of an antenna model comprising an ordered list of antenna element coordinates, thereby allowing non-rectangular and even non-planar antenna panels whose elements may be specificed in any desired order. |
| ***Consequences if not aproved:*** | Non-rectangular antenna panels cannot be supported, or would be supported in some non-optimal fashion by approximating the panel using rectangularly-defined elements. |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Clauses affected:*** | 10.2, 12.5.1, 12.5.4, 12.5.6 | | | | |
|  | **Y** | **N** |  | |  |
| ***Other specs*** | **X** |  | Other core specifications: | YANG model PR-296 | |
| ***affected:*** |  | **x** | Test specifications: | <fill in related CRs if “Y”> | |
| ***(show related CRs)*** |  | **X** | O&M Specifications: | <fill in related CRs if “Y”> | |
| ***Supporting material:***  ***Other comments:*** |  | | | | |

**< differences between v01 and v02 of this CR are marked with blue-highlighted material >**

### \*\*\*Change #1\*\*\*

Table 10.2‑1: O-RAN mandatory and optional features

| Category | Feature | O-DU support | O-RU support | Additional information |
| --- | --- | --- | --- | --- |
| <many other table entries> | | | | |
| **Other features** | **LAA LBT O-DU congestion window mgmt** | **Conditional Mandatory** | **Conditional Mandatory** | Mandatory only for O-DUs and O-RUS supporting LAA. |
| LAA LBT O-RU congestion window mgmt | Optional | Optional |  |
| UL gain correction per eAxC | Optional | Optional | See clause 8.1.3.2.3. |
| DL reference level adjustment | Optional | Optional | See Reference\_Level in clause 8.1.3.3. |
| FS adjustment | Optional | Optional | See FS\_Offset in clause 8.1.3. |
| Ordered transmission | Optional | Optional | See clause 4.6.3. |
| Uplink traffic management using M-Plane | Optional | Optional | See clause 4.6.4. |
| Uplink traffic management using C-Plane | Optional | Optional | See clause 4.6.4. |
| Uniformly distributed transmission | Optional | Optional | In accordance with clause 4.6.2. Requires support of uplink traffic management (using M-Plane or C-Plane). |
| Independent U-Plane transmission window control | Optional | Optional | According to clause 4.6.4. Requires support of uplink traffic management (using M-Plane or C-Plane). |
|  | C-Plane Message processing O-RU limits | Optional | Optional | As specified in clause 7.8.2 and M-Plane specification [7], clause 15.8. |
|  | beam-update-contention-control | Optional | Optional | See clause 12.4.3 |
|  | Provision of beam-context-gap-period | N/A | Optional | See clause 12.4.3 |
|  | Free-form antenna model | Optional | Optional | See clause 12.5.4.2 |

### \*\*\*Change #2\*\*\*

12.5.1 Overview

Knowledge of O-RU antenna model is critical for certain types of beamforming. The following model is applicable for O-RU with one or more antennas, where each antenna has array of elements that are

* uniform (all elements have same properties) and
* organized into rectangular array (with rows and columns) that is planar (flat).
* Alternatively and optionally, non-rectangular and non-planar arrays, referred as “free-form arrays”, with elements in any order (see clause 12.5.4.2)

O-RU shall expose via the M-Plane a logical model of the O-RU consisting of one or more arrays composed of one or more array elements. An array element represents an independently controllable entity including one or more radiating elements and related RF processing elements (here, an RF processing element is an entity that processes RF signal and is not related to processing element defined in M-Plane). RX and TX are in general independently controllable for that in the model tx-arrays and rx-arrays are described as separate entities. If the O-RU supports beamforming, then beamforming is realized within each array separately i.e., a beamforming weight vector is applicable within one array. One or more arrays can occupy same physical location e.g., rx-array and tx-array that use same set of radiators.

Optionally, non-rectangular and non-planar arrays (“free form arrays”) may be reported by the O-RU to the O-DU using specific M-Plane parameters. This allows the O-DU to operate the antenna array elements in any order, not just the normal order described in clause 12.5.4.1). This also allows the O-DU to support irregular antenna arrays such as those wrapping around a pole or with a non-rectangular arrangement (e.g. hexagonal array or “sunflower” pattern). This capability is governed by the O-RU feature ANTENNA-ARRAY-BY-COORDINATES; if this feature is supported by O-RU then the free-form antenna array may be used, otherwise the rectangular-array shall be used.

### Beamforming methods that use dynamic beamforming with beamforming weights conveyed in C-Plane message (in contrast to predefined beams) require the O-DU to know the antenna properties of the O-RU. Different beamforming methods require knowledge of different subsets of antenna properties.

### \*\*\*Change #3\*\*\*

12.5.4 Identification and ordering of array elements

#### 12.5.4.1 Rectangular Antenna Array

In many applications there is a need to assign to array element a number k such that 0 ≤ k < *K* (see K in clause 12.5.3). One example is mapping position (represented by k, such that 0 ≤ k < *K*) of a beamforming weight in beamforming vector to an array element. Other example is identification of an array elements in the antenna model.

For purpose of identification and ordering a number k is assigned to each element of array by the function *f*(*m,n,p,q*):

𝑓(𝑚,𝑛,𝑝,𝑞) = 𝑞 ∙ 𝑃 ∙ 𝑀 ∙ 𝑁 + 𝑝 ∙ 𝑀 ∙ 𝑁 + 𝑚 ∙ 𝑁 + 𝑛

where:

*m - row (bottom to top), 0≤m<M*

*n* - column (left to right, view from the front of array), 0 ≤ *n* < *N*

*p* - polarization index, 0≤p<*P*; polarization value of polarization index p is ψp (see ψ in clause 12.5.2)

*q* - array-layer, 0 ≤ q < *Q*

*N, M, P, Q* are defined in clause 12.5.3

NOTE: For a rectangular array, the function f(m,n,p,q) can be inverted allowing to determine a "tuple" (m,n,p,q)of k-th element.

#### 12.5.4.2 Free-Form Antenna Array

In the case of a free-form antenna array (when the O-RU feature ANTENNA-ARRAY-BY-COORDINATES is supported), the x,y,z,p coordinate of each antenna element is explicitly provided as an O-RU capability report via the M-Plane as an ordered list of array elements. Here, it is assumed a reasonable and realistic representation of a 3D antenna array is a possibly-curved “sheet” of antenna elements with each antenna element pointed in a direction normal to the “sheet”; it is not assumed antenna elements may be oriented in any random direction. The outward direction of RF radiation for the array “sheet” is indicated by the “normal-vector-direction” YANG parameter. In this manner, any antenna array topology may be reflected in the antenna model. Specifically, the array element numbers k are reflected by the M-Plane-detected ordered list of array element positional coordinates (x,y,z,p). In this case, the following M-Plane reported parameters are to be ignored:

* number-of-rows
* number-of-columns
* number-of-array-layers
* horizontal-spacing
* vertical-spacing

New parameters will be reported by the O-RU per tx-arrays or rx-arrays as follows:

* number-of-array-elements
* antenna-elements-ordered-list [antenna-element-index]
  + antenna-element-index
  + x-coordinate
  + y-coordinate
  + z-coordinate
  + polarization

Observe that the following M-Plane reported array parameters are still operative:

* normal-vector-direction
  + azimuth-angle
  + zenith-angle
* leftmost-bottom-array-element-position
  + x
  + y
  + z
* polarisations [p]
  + p
  + polarisation

The units of x-coordinate, y-coordinate, and z-coordinate are the same as the units of x, y, z under “leftmost-bottom-array-element-position, being 1E-5 meter (or 1/100 of a mm). The parameter polarization is the same as the value of p under “polarizations”.

### \*\*\*Change #4\*\*\*

### 12.5.6 Model usage

The O-RU antenna model reported by the O-RU consists of rx-arrays and tx-arrays. rx-arrays and tx-arrays represent a capability for transmitting/receiving RF signal related to an eAxC and - if beamforming is supported by O-RU on given array - beamforming capability. In this clause examples are presented: red and green bars represent array elements of different polarizations, grey box represents physical device, white rectangles represent arrays reported by O-RU.

<skipped figures and text which are unchanged, then the following text is appended at the end of the clause>

When using the free-form antenna array (see clause 12.5.4.2) the same principles apply as described elsewhere in this clause, except that the antenna element arrays are not regular and rectangular, but conform to the x,y,z,p coordinates as provided by the M-Plane O-RU tx-arrays and rx-arrays reports. As stated above, an O-RU may comprise multiple tx-arrays and rx-arrays to support different capabilities such as an array with just one polarization or a sub-array comprising a fraction of the total available array elements; in these cases separate tx-arrays and rx-arrays would be defined as separate ordered lists of x,y,z,p array element coordinates. In this manner, the function of the O-RU is not changed when using the free-form antenna model, simply the method of defining the physical location of the array elements is changed.

Figure 12.5.6-1 shows an example of use of a non-regular rectangular array with a custom ordering of antenna elements, ordered in four quadrants to match a specific antenna panel design.



Figure 12.5.6‑1 : Example of free-form antenna usage

Figure 12.5.6-2 shows an example of use of a 3-dimensional antenna array, being a cylinder of radius 1000mm, with four dual-polarization elements in a horizontal row arranged 15° and 45° on either side of a normal (x-direction) outward-pointing vector, and four vertical dual-polarization elements separated by 200mm in the vertical direction.



Figure 12.5.6‑2 : Example of free-form antenna usage