



Frequency Bands and Carrier Aggregation Systems; Band and Carrier Aggregation

STANDARD PREVIEW
(standards.iteh.ai)
Full standard:
<https://standards.iteh.ai/catalog/standards/sist/4275-bd76-6d2157cfad89/etsi-gr-mwt-015-v1-1-2017-11>

Disclaimer

The present document has been produced and approved by the millimetre Wave Transmission (mWT) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG.
It does not necessarily represent the views of the entire ETSI membership.

Reference

DGR/mWT-0015

Keywords

antenna, FWA, mWT, point-to-point

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2017.

All rights reserved.

DECT™, PLUGTESTS™, UMTS™ and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

3GPP™ and LTE™ are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

oneM2M logo is protected for the benefit of its Members.

GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Contents

Intellectual Property Rights	4
Foreword.....	4
Modal verbs terminology.....	4
Executive summary	4
1 Scope	5
2 References	5
2.1 Normative references	5
2.2 Informative references.....	5
3 Abbreviations	6
4 Bands and Carrier Aggregation concept	6
5 Applications and use cases for Bands and Carrier Aggregation	7
5.0 Introduction	7
5.1 Channels aggregation in low microwave frequency bands (Long Haul application)	7
5.2 Channels aggregation in medium microwave frequency bands	9
5.3 Microwave and mmW channels aggregation	9
5.4 Licensed and unlicensed channels aggregation	11
6 Bands and Carrier Aggregation benefits	11
7 Technological advancements related to Bands and Carrier Aggregation.....	13
7.1 Introduction	13
7.2 Frequency selection.....	13
7.3 Antenna technologies	13
7.4 First results.....	14
8 Deployment and relevant network design	16
8.1 Link planning example: Case of E-Band and traditional microwave band	16
9 Regulatory and licensing: Considerations and proposals.....	18
Annex A: Authors and contributors.....	20
Annex B: Change History	21
History	22

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) millimetre Wave Transmission (mWT).

Modal verbs terminology

In the present document **"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).

"must" and **"must not"** are **NOT** allowed in ETSI deliverables except when used in direct citation.

Executive summary

More and more demanding requirements will challenge the wireless transport in the near future. Therefore it appears necessary to investigate new approaches in order to meet such needs.

"Bands and Carrier Aggregation" (BCA) is one of these possible concepts, as it could be exploited to enhance radio link performance in different aspects.

Combining multiple frequency bands over the same link could in fact provide several benefits, on top of plain throughput increase, leading to an efficient use of the available spectrum. This appears to be one of the most critical point taking into account the ongoing network evolution towards 5G.

BCA could be implemented through different arrangements, depending on the application. For each of these, some new considerations in terms of network design apply, as the propagation aspects can be very different depending on the spectrum options aggregated over the radio link. The overall BCA network design, often providing multiple capacity levels with different availability, will have to fit the variety of services that need to be transported (along with their SLAs).

Another fundamental aspect, when BCA is concerned, is represented by the regulatory and licensing framework: it is indeed important that the benefits provided by such new technology are known and supported in order to boost as much as possible its usage where applicable.

1 Scope

The present document describes the "Bands and Carrier Aggregation" (BCA) concept, along with associated use cases and benefits for transport networks.

A specific clause deals with technological advancements related to BCA, such as multi-band antennas and wideband RF components.

Another aspect is related to possible barriers to the adoption of BCA in the existing standards/regulations or to proposals for incentives and discounts in the frequency licensing when BCA is implemented, due to its benefits in terms of efficient spectrum usage.

It should be noted that the BCA concept described in the present document is not referred to "Channel aggregation" system as described in ETSI EN 302 217-4 [i.3]. In fact BCA represents a much wider scope, only one of the possible BCA arrangements being a "channel aggregation" system.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative 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.

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 103 103 (V1.1.1): "Fixed Radio Systems; Point-to-point systems; ATPC, RTPC, Adaptive Modulation (mixed-mode) and Bandwidth Adaptive functionalities; Technical background and impact on deployment, link design and coordination".
- [i.2] ETSI White Paper No. 15: "mmWave Semiconductor Industry Technologies: Status and Evolution".
- [i.3] ETSI EN 302 217-4: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4: Antennas".
- [i.4] ETSI White Paper No. 09: "E-Band and V-Band - Survey on status of worldwide regulation".
- [i.5] ETSI GR mWT 008: "Analysis of Spectrum, License Schemes and Network Scenarios in the D-band".
- [i.6] Contribution to ECC PT SE19 meeting #76 28-30 March 2017: "SE19 (17)11 WI 37&38 BCA concept - NOKIA".
- [i.7] ETSI GR mWT 016: "Applications and use cases of Software Defined Networking (SDN) as related to microwave and millimetre wave transmission".

3 Abbreviations

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

4G	Fourth Generation of Mobile Networks
5G	Fifth Generation of Mobile Networks
ACM	Adaptive Coding and Modulation
ATPC	Automatic Transmit Power Control
BCA	Bands and Carrier Aggregation
ECC	Electronic Communication Committee
PDH	Plesiochronous Digital Hierachy
P-P	Point to Point
RF	Radio Frequency
TCO	Total Cost of Ownership
TDM	Time-Division Multiplexing
W-Band	band from 90 to 114,5 GHz
Wi-Fi	Wireless Fidelity
XPIC	Cross-Polarization Interference Cancellation

4 Bands and Carrier Aggregation concept

The requirements which will challenge the wireless transport evolution depend on the services to be transported and can be very different (and even conflicting) in terms of throughput, latency, QoS, availability, etc.

The radio resource has to provide the capability to satisfy different KPIs for different services in order to meet end to end committed traffic SLAs.

Bands and Carrier Aggregation (BCA) is a concept enabling an efficient use of the spectrum through a smart aggregation, over a single physical link, of multiple frequency channels (in the same or different frequency bands).

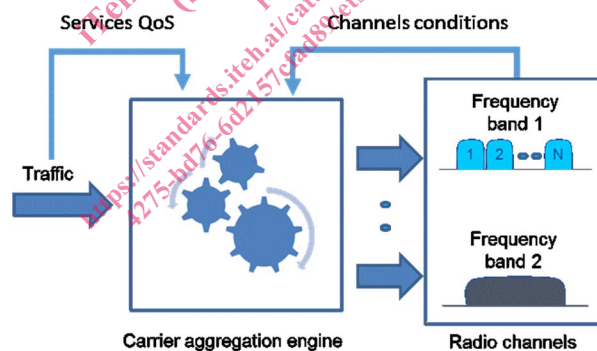


Figure 1: BCA concept

A logical scheme of the BCA includes a carrier aggregation engine and different physical radio channels. Most of the BCA benefits can be obtained thanks to the engine design which takes into account both the required traffic QoS and the conditions of the radio channels.

Radio channels (same or different frequency band) can be different in terms of:

- Channel size.
- Capacity and latency (according to the adopted radio profile).
- Availability - due to different frequency band and different results of the engineered link (solution performance linked to antenna size, system gain, etc.).
- Fixed or adaptive modulation scheme.
- License scheme - subjected to interference-free operation or not.

- License cost fees.

In practice, transmitting multiple channels from different frequency bands over a single physical link can be seen as an additional technique used to increase capacity in wireless domain, on top of traditional ones such as adaptive modulation, XPIC and packet compression.

Spectrum being a critical asset, and it is fundamental to implement methods which can efficiently use the available spectrum without wasting resources and adapt as much as possible radio portions to the input traffic needs.

For most of the different BCA use cases, it is worth noting that when assuming a target with the same level of error performance/availability, the link budget design may result differently than what is obtained in traditional cases without BCA. This will depend on how the traffic is distributed, and it is therefore strictly correlated to the proprietary carrier aggregation engine implementation. As explained in the Long-Haul application and depicted in clause 5.1, in some cases less frequency channels may be needed.

Some basic indications for the link budget, mainly in term of availability, are provided in following pages, case by case.

In the next clauses of the document it will be explained why BCA is a smart method to achieve such objectives.

5 Applications and use cases for Bands and Carrier Aggregation

5.0 Introduction

BCA is mainly applicable to mobile backhaul/fronthaul applications and to wireless transport in general (including Fixed Broadband Access transport connectivity).

Main use cases applicable to BCA are listed here.

5.1 Channels aggregation in low microwave frequency bands (Long Haul application)

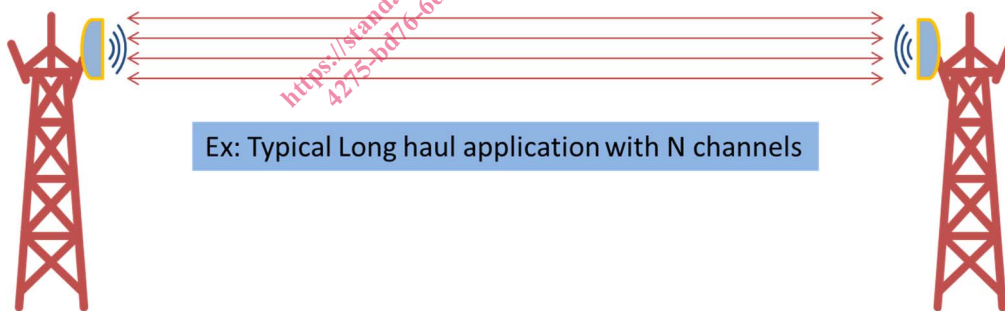


Figure 2: BCA in low microwave bands

In long haul transport, aggregation of multiple channels over a single antenna and radio link is a known technology. Those channels can be in the same frequency band or in different frequency bands, increasing the protection towards selective fading which is in fact the main impairment applicable to low frequencies. A typical case, widely used by some operators, is aggregation of 6 GHz or 7 GHz and 11 GHz, but also other combinations are possible.

Historically this kind of application has been serving SDH multi-hop transport for long distances (up to 150 km). More recently a smooth migration from TDM transport to full Ethernet and an increasing request for capacity has led to higher demand for carrier aggregation systems reaching multi-Gbit/s transmission.

This migration requirement has corresponded to a shift from traditional N+1 transmission scheme (with one dedicated spare channel) to N+0 configuration.

Microwave N+1 protection mechanisms had a rigid association between the SDH/SONET container (for example, STM1/OC3) and the related radio channel. The resulting traditional N+1 protection mechanisms had N channels used to transport NxSTM1/OC3 flows, and a spare protection channel that, when idle, could be used to carry low priority SDH/SONET traffic.

With the introduction of LTE, mobile backhaul networks are smoothly shifting from TDM-based networks to Ethernet and IP packet networks. Due to this shift, it is getting more difficult and inefficient to reliably scale microwave links with traditional microwave N+1 approaches. Packet microwave solutions based on N+0 and a smart carrier aggregation engine can provide better availability than N+1 (considering the same reference throughput).

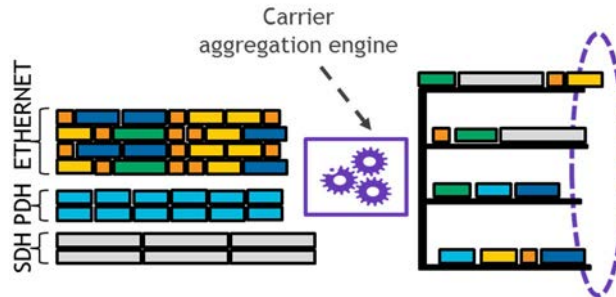


Figure 3: Distribution of traffic flows in BCA

Basically N+0 implements a BCA system in which a carrier aggregation engine distributes traffic flows over a bundle of radio channels (all active), which may have different frequency bands, polarizations and/or channel spacing. The radio channels are dynamically changing their bandwidth thanks to Adaptive Modulation, following propagation impairments.

Therefore, in case of N+0, capacity is not statically assigned to a channel but is spread over different radio channels exploiting high order modulation schemes. This allows the possibility to transmit the same level of capacity than traditional N+1 at the same or better availability, thus saving one radio channel (and its associated cost). This saving is granted by a packet microwave system, especially if some TDM traffic has to be transported to support a smooth migration to full Ethernet/IP, while for hybrid systems in such case an N+1 transmission scheme is more appropriate.

From availability point of view, in this case, where the major propagation impact derives from multipath, all channels can typically be planned with the same degree of availability (for the relevant reference modulation). Planning/licensing procedures are not different from channel to channel. Therefore, channel behavior differences are linked only to the variable capacity versus availability due to the use of adaptive modulation.

Summarizing, the main benefits of a BCA system based on N+0 are:

- The capability to bundle heterogeneous radio channels increasing granularity.
- The capability to transport different traffic types (PDH, SDH and Ethernet) in the same radio pipe.
- The possibility to avoid the need to duplicate traffic flows (e.g. TDM) on air to provide protection, thus saving also spectrum/bandwidth.
- The increased availability (considering same capacity).
- The possibility to send a single big pipe (e.g. 1 or more Gbit/s) on multiple channels.

5.2 Channels aggregation in medium microwave frequency bands

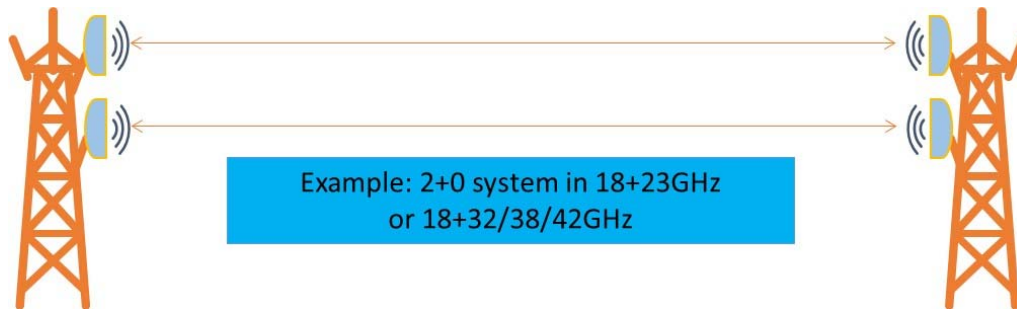


Figure 4: BCA in medium microwave bands

Channels in traditional microwave frequencies can be aggregated over the same or different bands in order to increase capacity (and over 1 Gbit/s) and to address spectrum limitations. In many cases in fact the required bandwidth cannot be found in a single band due to spectrum congestion: a given operator may not have the sufficient number of channels in a given band to reach the required capacity to cover backhaul need in a specific area.

Thanks to BCA a link can be engineered to provide the required QoS for the transported traffic, with maximum achievable distance depending on the bands which have been aggregated. For instance, an interesting aggregation is the one involving low/medium adjacent frequency bands, providing capacity increase with a link length in sub-urban environment (e.g. 10 km), combining over the same link frequencies in the range 15 - 23 GHz.

From the point of view of availability, in this case, where the major propagation impact derives from rain, the higher band channel could be planned with the same degree of availability (possibly playing with different reference modulation and or antennas) only when the bands are contiguous or close-by (e.g. 18 + 23 GHz case). When the band gap is higher (e.g. 18 + 38 GHz), this is no longer possible (unless in a very dry territories) and the higher band channels would offer a lower availability (depending on the rain zone and hop length) than the one of lower band channel. Consequently, planning/licensing procedures may be the same or be different (in term of availability target) from band to band.

5.3 Microwave and mmW channels aggregation

Figure 5 shows an example where a dual band antenna combines a dual polarization at 18 GHz with one E-Band feed (i.e. composing a 3+0 system).

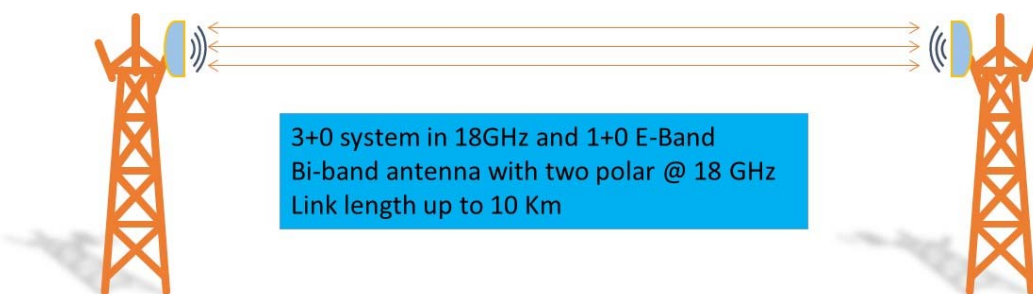


Figure 5: BCA in medium microwave bands plus E-Band

- As first example mmW seen as complement of high microwave bands to increase capacity, addressing spectrum congestion (e.g. 38 GHz + 80 GHz).
- As second example mmW seen as complement of medium microwave bands to increase capacity and extend link distance. In such case microwave band would serve most critical services at highest availability, while mmW band would serve data-hungry applications for the majority of time.

From the point of view of availability, also in this case, the major propagation impact derives from rain. The band distance is very high (e.g. 18 + 80 GHz) and the higher band channels would offer a relatively significant lower availability than that of the channel in the lower band. Nevertheless, the far larger channel size/capacity in the higher band still renders this case very attractive for Ethernet payload transport. Consequently, planning/licensing procedures are different (in term of availability target) from band to band.

The most interesting combination is between microwaves in the range 15 - 23 GHz (main bands used to cover distances up to 7 - 10 km) with the E-Band. This can be derived considering that the BCA value is coming from its capability to exploit at maximum each single frequency band which is part of the aggregation. In fact lower frequency bands (≤ 13 GHz) are able to transmit over longer distances. Therefore:

- BCA over longer distance would reduce the E-Band traffic availability and even make the E-Band link unfeasible.
- It would be more efficient to exploit these bands in terms of link length: taking into account the increasing capacity requirements in view of 5G higher frequency bands would not guarantee a good minimum traffic availability (e.g. $> 99,995$ %) over such link distance (7 - 10 km).
- Solutions using dual band antenna, due to its inherent dimension dictated by E-Band, will penalize too much the lower band antenna gain, resulting in a poor antenna class as well.

Here an example is provided to show a high level guidance, with the following assumptions:

- 300 Mbit/s to be transported over traditional microwave.
- 1 - 2 Gbit/s to be transported over E-Band.
- 2 ft antennas.
- Rain rate 42 mm/h.

The corresponding maximum link distance that could be achieved considering the above microwave bands and 99,995 % availability would be:

15 GHz	18 GHz	23 GHz
11,5 km	8,5 km	6 km

This is in fact compatible with the objective to guarantee around 99,9 % availability in the E-Band (1 - 2 Gbit/s) over the same link distance. In order to provide a rough estimation, the maximum distance for such capacity in the E-Band would be around 7 km. This is almost in the middle between 18 GHz and 23 GHz maximum distance and a bit stretched for the 15 GHz case, even if this is just an indication while in reality there could be different combinations of required throughput vs target link distance.

In the future also higher mmW bands (e.g. W-Band and D-band) could be complemented with a traditional microwave band in order to deliver more throughput over reasonable distances. For reference see the use case table in ISG mWT ETSI GR mWT 008 [i.5], where link distance up to 2 km is envisioned for future 5G macro cell backhaul use case.

Considering that such BCA systems can provide a wide range of traffic availability associated to different steps of capacity (due to ACM and different propagation), this well meets the need to provide, more and more in the future, different level of availability depending on the service (also linked to network slicing concept treated in ETSI GR mWT 016 [i.7] for network slicing clause).