Supplementary Downlink (SDL)

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1. Background

Mobile broadband is now rapidly becoming more important as users demand Internet-based services on the move as well as at home and in the office. In addition mobile broadband is now the cost-effective way to deliver the broadband Internet to rural communities in most cases.

New figures released by ITU today indicate that, by end 2014, there will be almost 3 billion Internet users, two-thirds of them coming from the developing world, and that the number of mobile-broadband subscriptions will reach 2.3 billion globally. Mobile broadband is playing an increasingly important role in our daily lives. It is changing the way we are entertained, educated, working and sharing information while improving the quality of our lives. Mobile broadband presents great opportunities for operators in both mature and new markets. To meet the ever-increasing user demands of the mobile broadband experience, networks need to be smart, simple, scalable and deliver superior performance.

For penetration in the broadband market, operators have to satisfy the discerning customer who requires good service when accessing multimedia content and other internet based services.

Mobile broadband devices, such as smartphones and tablets, offer an easier way of using the broadband Internet than traditional PCs. The increasing penetration of mobile broadband devices partly due to their affordability is driving up the consumption of mobile broadband. Industry forecasts suggest mobile data traffic could grow by up to 30 times current levels over the next 5 years.

Most of the traffic on mobile networks is multimedia content (estimates range from 60-80%) – for example applications such as streamed audio and video, real-time broadcasts of big sporting or popular cultural events, video based news, IP radio, video based specialist magazines and clips or long form content (movies, programs, etc).

Mobile data traffic is predicted to increase exponentially over the coming years with a particular evolution towards asymmetrical traffic. This asymmetry of mobile traffic has been confirmed by measurements in today’s networks which show that current data asymmetry ratio in the US, Europe and Japan ranges from 4:1 to even 9:1. Furthermore, internet is going mobile through a variety of connected devices (e.g. e-readers and tablets). Their number is projected to grow significantly in near future amplifying asymmetric mobile data traffic and the increase in mobile multimedia consumption.

2. Introduction-What is SDL

SDL or supplemental downlink allows the bonding of unpaired spectrum with FDD mobile broadband bands, to significantly enhance networks downlink capacity and users experience. It uses unpaired spectrum to enhance the downlink capability of mobile broadband networks by
enabling significantly faster downloads and supporting a much greater number of users with mobile devices. This provides an efficient way of using spectrum because consumption of rich content and other data heavy applications is asymmetric. There is much more traffic on the downlink than on the uplink over mobile broadband networks. Supplemental downlink and carrier aggregation have now been enabled in the HSPA+ Release 9 (and beyond) and LTE Release 10 (and beyond).

The technology represents a significant step forward in traditional spectrum aggregation systems that are already used for HSPA+ and LTE networks by the 3GPP standardization group. Supplemental downlink technology can now be used in the L-Band and could also be considered in other frequency bands. In Release 9, the SDL feature allowed a single carrier in an unpaired band to be used along with the serving cell's paired spectrum. Release 10 provided for up to three supplemental carriers in the unpaired band to be used along with the serving carriers in the paired band. This feature was demonstrated at MWC 2011 by Ericsson using unpaired spectrum from the L-band (1452-1492 MHz) with paired spectrum in the 2.1 GHz band.

3. Benefits of SDL

The two principal benefits of SDL at 1.4 GHz:

- **Reduced costs**: Deployment leads to avoided costs of investment in additional base station and backhaul infrastructure. Once mobile broadband demand exceeds network capacity, networks can be expanded by deploying a 1.4 GHz SDL on existing base station sites rather than building new base station sites and this leads to cost effectiveness. The scale of this benefit depends primarily how soon other spectrum is made available for mobile broadband use and how quickly demand for mobile broadband grows in each country.

- **Better service quality**: Deployment leads to improved services – in particular better in-building coverage, higher downlink speeds and ability to support a greater number of users. The 1.4 GHz SDL when paired with low frequency spectrum behaves like sub-1 GHz

![Figure. SDL](image)
spectrum in terms of propagation characteristics. So a 1.4 GHz SDL offers better in-building coverage than spectrum allocated for mobile broadband use at 2.1 or 2.6 GHz.

The use of 1452-1492 MHz for a supplemental downlink for mobile broadband could generate economic benefits to the society at large and the availability of broadband and the development of e-health services such as telemedicine and mobile healthcare systems should deliver substantial benefits which include improved services and response times, cost savings and better health care.

SDL provides:

- Increased peak rate
- Improved capacity
- Effective use of existing spectrum

Supplemental Downlink (SDL) is poised to boost the downlink:

- By aggregating unpaired spectrum with typically paired spectrum
  - L-Band standardized as band 32 in 3GPP and harmonized in Europe
  - Band 29 in the US

This new technology will allow network operators to manage the ever-increasing demand for data service on wireless networks and provide improved performance for end users. The following figure, according to simulations carried out by Qualcomm, shows that the downlink data burst rate capacity approximately doubles for fixed number of users with use of SDL. Conversely, the number of data subscribers supported at given bit rate becomes approximately twice with use of SDL.
4. Functioning of SDL

A cell typically consists of two component carriers: uplink and downlink. Supplementary downlink only cells are an exception where there is only a downlink component carrier. This feature allows a carrier aggregation capable UE to use the supplementary downlink only cell as a secondary component carrier.

For HSPA+, since the SDL carrier is not paired with an uplink, it cannot support UEs configured in pre-Release 9 modes (legacy UEs). It can only be used as the secondary serving cell (carrier) by Release 9, or later, UEs. The SDL operation is different from traditional Release 8 DC-HSDPA. In traditional Release 8 DC-HSDPA, both the carriers can support SC UEs as well as DC-HSDPA UEs. Hence, the Radio Network Controller (RNC) can assign an SC UE to either of the two carriers. In contrast, the SDL carrier cannot support single carrier (pre-Release 9) operation.

For LTE Release 10 onwards, the Supplementary Downlink for Carrier Aggregation feature makes it possible to add and unlock an FDD E-UTRAN Cell with a downlink carrier only, no uplink carrier, for example: Band 29. This downlink only cell is utilized as a downlink secondary cell by the Carrier Aggregation feature. When a cell is configured as downlink only, it is barred and incoming S1 and X2 handover are rejected.
The Dynamic SCell Selection and Supplementary Downlink for Carrier Aggregation features can operate together.

The Carrier Aggregation function

Carrier aggregation provides the ability to transmit data to a single UE on more than one carrier simultaneously. A UE configured for carrier aggregation has one Primary Cell (PCell) and one or more Secondary Cells (SCell). The PCell is the cell where the UE is connected and has established the RRC connection. The SCell is configured once the RRC connection is established.

To facilitate UE battery savings, dynamic activation and deactivation of the secondary cell is done on a need basis.

The SCell is only activated when there is DL data demand that could benefit from transmitting on more than just one carrier and if the channel quality is above a certain threshold.

The SCell is deactivated if the DL data demand drops so much that it can be handled by only one component carrier, or when the channel quality of the SCell goes below the threshold for a certain time.
Using a low band as PCell and high band as SCell, it’s possible to leverage the low band UL for boosting DL and thus improve the application coverage. Some use case scenarios showing the benefit of SDL are shown below:

a) F1 and F2 cells are co-located and overlaid. F1 provides sufficient coverage and F2 is used to improve throughput. Mobility is performed based on F1 coverage. A likely scenario is when F1 and F2 are of different bands, e.g., F1=2.1GHz, F2= 1.4GHz SDL band.

![Diagram of F1 and F2 cells co-located and overlaid.]

b) F1 provides macro coverage and on F2 Remote Radio Heads (RRHs) are used to improve throughput at hot spots. Mobility is performed based on F1 coverage. A likely scenario is when F1 and F2 are of different bands, e.g., F1=2.1GHz, F2= 1.4GHz SDL band.

![Diagram of F1 and F2 cells with RRHs at hot spots.]

5. **Proof of Concepts**

Orange, Ericsson and Qualcomm have successfully used L-band frequencies to demonstrate the use of supplemental downlink technology on a mobile network. The world's first live demonstration was carried out on Orange's network in Toulouse, France, on 21 February 2013.

The performance and benefits of this technology have been unveiled during the Mobile World Congress in Barcelona, at a press conference with Orange and Qualcomm on Ericsson's stand.
This initiative was achieved in the context of the recent decision from the CEPT (European Conference of Postal and Telecommunications Administration) to harmonize use of the L-band (1452-1492 MHz), reserving it specifically for supplemental downlink technology.

The trial system, which uses L-band frequencies for testing, was authorized by the French telecom regulator, Arcep, in June 2012. The system combines L-band frequencies in the downlink mode with traditional 2.1 GHz frequencies owned by Orange to boost downlink capacity. The trial network used radio base stations supplied by Ericsson and devices equipped with Qualcomm chipsets.

The live demonstration demonstrated the relevance of this technology for increasing download speed and improving user experience.

6. SDL Spectrum Regulations

The L-band 1452-1492 MHz is currently allocated by the ITU on a co-primary basis to the Mobile, Broadcasting and Fixed Services which enables the use of this spectrum for supplemental mobile downlink to deliver convergent services. The 1.5 GHz band offers a unique opportunity to deploy supplemental downlink (SDL) for the delivery of enhanced multimedia services IMT/IMT-Advanced networks. It also helps governments in achieving their broadband targets by providing additional mobile broadband downlink capacity.

The ECC Decision is required to provide guidance and certainty to the industry so that the UMTS/HSPA (3GPP specification Release 9 and beyond) standard and LTE-Advanced (3GPP specification Release 10 and beyond) standard, that are capable of aggregating multiple downlink channels in multiple bands, thus allowing the use of an unpaired spectrum for SDL, specify the 1452-1492 MHz band as a SDL band to be implemented in chipsets, devices and equipment.

CEPT in October 2012 decided to harmonize the frequency band 1452-1492 MHz (L-band) for mobile communications Supplemental Downlink (SDL). The L-band (1452-1492 MHz) has earlier been a broadcasting band (terrestrial and satellite DAB) in Europe, and in order to allow countries wishing to continue terrestrial DAB operation in part of the band, a solution that avoids having mobile devices transmitting in the band was required.

In addition to the above Region 1 status, in Japan, downlink frequency 1475.9 - 1495.9 MHz is allocated and operated as Band 11 DL, and it would be possible to utilize SDL L-band not only in Region 1 but also in Japan by extending the upper edge of the band by 4 MHz covering up to 1496 MHz. This enables the use of the L-Band for SDL in Region 1 and Japan, which will drive economies of scale while ensuring compliance with regional regulatory requirements (i.e. use of SDL in 1452-1492 MHz only in Europe and 1475.9 - 1495.9 MHz in Japan). This approach will be beneficial not only to UE vendors but also to operators who are trying to make use of the band more globally.
6.1 L-band Standardization Work in EU:
The progress made by the in Europe towards standardization of this concept is as follows-

Frequency Management (FM) group of Electronic Communications Committee (ECC) approved
the draft ECC Report on SDL.

The ECC Decision which cancels the use of satellite in L-band within CEPT in favor of SDL
was approved for public consultation by the last WG FM in February 2013.

FM also decided to proceed with the harmonization of the band for SDL in Europe, as concluded
by the ECC Report.

The ECC Decision on L-Band SDL harmonization enables optimal SDL deployment, increasing
the value of this spectrum. It encompasses

1) higher in-band SDL power to match 800/900 MHz coverage,
2) a harmonized downlink-only (no TDD) band plan
3) technology neutral rules enabling both HSPA+ and LTE and
4) unconstrained out-of-band SDL emissions limits for the compatibility with services in
adjacent bands.

The ECC Decision includes the technical rules for the harmonized use of band for SDL (band
plan, spectrum mask, cross border coordination etc.). FM tasked two project teams, SE7 and
PT1, to assist FM50.

The completion of the technical studies lead to an approval of the final ECC Decision. With this,
countries can then start auctioning the band later in 2013 / beginning 2014.

As concluded in the ECC Report, FM also decided to withdraw ECC Decision (03)02, which
currently harmonizes part of the band for satellite digital radio in Europe.

ECC Plenary in November 13 has published the following Decision, as given in ECC DEC
13/(03) report:

1) This ECC Decision harmonises the use of the 1452-1492 MHz band for terrestrial
mobile/fixed communications networks supplemental downlink (MFCN SDL) while
allowing individual countries to adapt to specific national circumstances in part of the
band for terrestrial broadcasting and other terrestrial applications. It provides the
harmonised technical conditions for the deployment of MFCN SDL within CEPT.
2) This ECC Decision contains annexes defining the harmonised frequency arrangement and
applicable least restrictive technical conditions for the use of the band by MFCN SDL
within CEPT.
CEPT started liaising with 3GPP in February 2013 to prepare the ground for the inclusion of L-band SDL in the standard.

6.2 L-band Standardization Work in 3GPP:
The objective of the Work Item in 3GPP (3GPP TR 37.814 V0.5.0 (2014-05) is to:

- Specify the band numbering and RF characteristics of the L-band for UTRA, E-UTRA and MSR.
  - E-UTRA channel bandwidths 5, 10, 15 and 20 MHz.
  - The L-band is restricted to be used on CA configuration for E-UTRA or dual band configuration for UTRA
- Specify the UE RF requirements for frequency range of L-band as 1452 – 1496 MHz based on assumption that UE Rx filter is optimized for 1452 – 1492 MHz
- Specify the RF requirements for the support of E-UTRA Carrier Aggregation between Band 20 + L-band (1452- 1496 MHz):

<table>
<thead>
<tr>
<th>E-UTRA band / channel bandwidth</th>
<th>CA Configuration</th>
<th>E-UTRA Bands</th>
<th>1.4 MHz</th>
<th>3 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>15 MHz</th>
<th>20 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA_20A-xA</td>
<td>20</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

The requirements should be based on the functionality currently defined for DL-only carrier Aggregation.

- Specify the RF requirements for the support of UTRA dual band for the band combinations of Band I (2.1 GHz) + L-band (1452- 1496 MHz).

The requirements should be based on the functionality currently defined for DB-DC HSDPA and 4C-HSDPA:

<table>
<thead>
<tr>
<th>UTRA SDL Configuration</th>
<th>Anchor Band (DL and UL)</th>
<th>Supplemental Band (DL only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band</td>
<td>Bandwidth</td>
<td>Band</td>
</tr>
<tr>
<td>1a</td>
<td>I (2.1 GHz)</td>
<td>5MHz</td>
</tr>
<tr>
<td>1b</td>
<td></td>
<td>5MHz</td>
</tr>
<tr>
<td>1c</td>
<td></td>
<td>10 MHz</td>
</tr>
</tbody>
</table>
It is important to note that quality uplink is critical for maintaining the QoS. The right mix of UL and DL spectrum in different frequency bands will be critical to reach higher levels of QoS in the future. The supplemental downlink for traffic asymmetry is being considered at 3GPP for following frequency bands in chunks of 5 MHz-

**UTRA:**
- Band I (2.1 GHz) + L-band (SDL)
- Band VIII (900 MHz) + L-band (SDL)

**E-UTRA:**
- Band 8 (900 MHz) + L-band (SDL)
- Band 3 (1800 MHz) + L-band (SDL)

3GPP TS 36.104 V12.4.0 (2014-06) has included L Band as Band 32, which is likely to be frozen this year.

7. **Conclusion**

In India, the adoption of mobile broadband is also growing at fast pace because of adoption of smartphones with their affordability and ease of use. The Government spending on e-governance projects and SWAN initiatives is likely to drive the growth of the networking market further. Going forward, advanced wireless technologies like 3G and 4G are expected to pace up the broadband growth in India.

Wireless broadband also has attractive elements, particularly in a market like India’s, which lacks a fixed network of any credible size. Mobile broadband is relatively easy to roll out and offers increasingly acceptable speeds. Wireless for last-mile connectivity in rural India and growth in broadband penetration will drive market growth and eventually help India transition to a fully networked economy.

Looking at the spectrum crunch and the demand from operators for more spectrum to support increased number of users and to provide better quality services, SDL in L band is a good technology option for faster downloads.

It is expected that with freeze of 3GPP Release 12 in October/November 2014, L band will be standardized as Band 32 and carrier aggregation involving Band 1/III/VIII with Band 32 will be approved for HSPA+ and LTE-A. Since carrier aggregation band combinations are a release independent feature, the commercial availability of products can be expected from 2015 onwards. It is also noted that the ITU-R is also actively discussing the implementation of SDL in the L Band.
Use of SDL requires support in handset and network side:

i) HSPA+: Handsets and network elements that support Release -9 and higher releases

ii) LTE-A: Handsets and network elements that support Release -10 and higher releases

The use of SDL depends on the commercial availability of handsets that can support this feature and also on availability of spectrum in the L-Band.

8. **Recommendation**

The band 1452-1492 MHz, which is being used by Mobile, Broadcasting and Fixed Services on co-primary basis, needs to be made available for SDL in India. It is understood that at present the band has been allocated for fixed services. With the objective of making it ready, it is recommended that the current allocations in this band may be reviewed in time for possible auction for the use of SDL application.
9. References

1) ECC Decision (13)03: The harmonised use of the frequency band 1452-1492MHz for Mobile/Fixed Communications Networks Supplemental Downlink (MFCN SDL), Approved 8 November 2013

2) 3GPP TR 37.814 v0.5.0 (2014-05): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; L-band for Supplemental Downlink in E-UTRA and UTRA; (Release 12)

3) 3GPP TS 36.104 V12.4.0 (2014-06): Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception

4) Plum Consulting Report: The economic benefits from deploying 1.4 GHz spectrum for a mobile broadband supplemental downlink in the MENA region (October 2012)