



LTE in Unlicensed Spectrum:

Trials, Deployments and Devices

April 2017



This report is the first in a series of quarterly reports tracking the progress of License Assisted Access (LAA, or LTE-LAA) and its future enhancement eLAA, key features of Release 13 and future Release 14 networks as LTE moves towards 5G. The report also includes details of other technologies designed to allow the use of unlicensed spectrum alongside licensed spectrum in 3G and 4G networks – specifically in this report, LTE-U and LWA. Future reports will also cover the status of networks and ecosystems for CBRS (the US shared access spectrum) and LWIP.

GSA summarizes network trials as well as deployments, and the availability of chipsets, modules and devices. GSA welcomes additions to its database of LAA/eLAA, LTE-U, LWA and LWIP being prepared by Innovation Observatory. The database also contains information about spectrum bands and bandwidth used, where available. Please contact gsa@innovationobservatory.com with additional information.

GSA makes no guarantees that the information is complete, but reasonable efforts have been made to be comprehensive and accurate. The next update of this report will be at the end of July 2017.

Technology Context

The idea of using unlicensed spectrum to offer LTE services and improving downlink throughput, has been around for some years, and there are alternative approaches:

- **LAA:** a 3GPP standard finalized in Release 13, (Rel-13) involves a licensed LTE band as the primary carrier and Carrier Aggregation (CA) used to add a carrier in unlicensed 5 GHz (WiFi) spectrum for the downlink only. In Rel-14, eLAA will add uplink support.

High-priority traffic can use the licensed band, while lower priority traffic can use the WiFi channel. The decision on traffic allocation is made by the LAA-enabled base station/small cell, and there is no impact on the core network infrastructure.

TDD and FDD modes are supported in the standard. Fair coexistence in the unlicensed channel is provided by a region-specific listen-before-talk (LBT) capability to ensure channels are clear before transmission. LBT is mandatory in the EU and Japan.

- **LTE-U:** is a pre-Release 13 technology pioneered in the US (notably by Verizon and T-Mobile), and also being trialled in other countries including South Korea.
It is similar to LAA with Carrier Aggregation; no core network changes; decisions on spectrum use made by base station/small cell - except that LTE-U uses Carrier-Sensing Adaptive Transmission (CSAT) rather than LBT to determine when the 5 GHz unlicensed WiFi spectrum is in use to maintain fair coexistence. Development of the industry standard has been led by the LTE-U Forum.

- **LWA:** (LTE Wireless-LAN Aggregation), a 3GPP Rel-13 standardized technology, aggregates carriers at PDCP layer, and uses the Dual Connectivity feature from 3GPP Rel-12.

LWA supports downlink aggregation only; eLWA (a work item for Rel-14) will add uplink support. Separate nodes (a WLAN access point and an LTE base station) are used, and these can be physically separate or collocated in a single unit. The eNodeB makes the decision on activation of LWA and the use of the bearers.

LBT is used to ensure fair coexistence in the unlicensed band. Both 2.4 GHz and 5 GHz unlicensed spectrum bands can be used.

13 operators are trialling or deploying LAA

8 operators are trialling or deploying LTE-U

- **LWIP:** (LTE WAN Integration with IPsec tunnel) is a Rel-13 feature similar to LWA but performing aggregation and switching at the IP layer. It has been designed to require no changes to existing WLAN infrastructure, and in its Rel-13 version can support uplink data transmission as well as downlink.
- **MulteFire** is an approach using WiFi spectrum for LTE, but without aggregating the WiFi carrier with a licensed-spectrum carrier.

Operator Trials and Demonstrations

Note that before March 2016 when 3GPP Rel-13 was finalised, announcements of demos and trials of “LAA” or “LWA” would have referred to pre-standard versions of these technologies. Terms may not have been used consistently in press releases and

other statements, for instance, trials of “pre-standard LAA” in some cases involve what has subsequently become known as LTE-U. Nokia’s “cellular/WiFi boost” technology was a pre-standards version of LWA, for example. Notes in Tables 1, 2 and 3 give appropriate information where possible.

Table 1: Trials, Demonstrations and Plans for LAA

Operator	Country	Status	Notes
AT&T	USA	Demo, planned or being deployed	Demo with Ericsson, Qualcomm (Feb 2017); announced plans to deploy in 2H17
China Mobile	China	Trials, planned or being deployed	Trials with Baicells, Radisys (announced Feb, Mar 2016); deployment was planned for 2016
Deutsche Telekom	Germany	Trials	Trials with Qualcomm (announced March 2015)
NTT DoCoMo	Japan	Trials	(Pre standards) trials with Huawei (announced 2014, 2015) involving 'adaptive LBT'
MTS	Russia	Trials	With Ericsson (announced Dec 2015 for 2016) of LTE-U/LAA
Singtel	Singapore	Trials, planned or being deployed	With Ericsson (announced Mar 2016 and Jul 2016); deployment planned for 1H2017
SK Telecom	South Korea	Demo	With Ericsson (announced Feb 2017) involving 'LAA/LTE-U'
SmarTone	Hong Kong	Demo	With Ericsson (announced Jan 2017) involving 'pre-standard LAA'
T-Mobile	USA	Trials	Trials with Ericsson and Nokia (announced Jan 2015) of pre-standard 'LAA' (and LTE-U)
Verizon	USA	Demo	With Ericsson (announced Feb 2015) involving 'LAA/LTE-U'
Vodafone	Netherlands	Demo	With Ericsson (Nov 2015)
Vodafone	Turkey	Planned or being deployed	Deploying Huawei and SpiderCloud small cells for LAA (announced Feb 2017)
XL Axiata	Indonesia	Trial	With Ericsson (announced Nov 2015) involving 'LAA'

Table 2: Trials, Demonstrations and Plans for LTE-U - Note there is some overlap with table 1

Operator	Country	Status	Notes
AT&T	USA	Trial	Trials announced in March 2016 (LAA also being trialed)
China Mobile	China	Trials, planned or being deployed	Trials with Baicells, Radisys (announced Feb, Mar 2016); deployment was planned for 2016
LG U+	South Korea	Trials	Trial using 5.8GHz unlicensed spectrum band (announced May 2015)
MTN	South Africa	Trials	With Ericsson (announced April 2016)
MTS	Russia	Trials	With Ericsson (announced Dec 2015 for 2016) of LTE-U/LAA
Telefonica	Spain	Demo	With Ericsson (announced March 2016)
T-Mobile	USA	Planned or being deployed	Ericsson and Nokia providing equipment for commercial network due to launch "spring 2017"
Verizon	USA	Planned or being deployed	Samsung and Verizon trials started in 2015; Qualcomm and SpiderCloud Wireless also involved in pilots in 2017

Table 3: Trials, Demonstrations and Plans for LWA

Operator	Country	Status	Notes
Chunghwa Telecom	Taiwan	Planned or being deployed	Commercial availability of services expected 2017 (announced Feb 2017); equipment from MediaTek, Sercomm and HTC
M1	Singapore	Trial, planned or being deployed	Trial announced Aug 2016, involving Nokia's Flexi Zone equipment; deployment and commercial services planned for 2017

Live Operator Networks

As far as we know there are no live operator networks with LAA, LTE-U or LWA being used commercially as of March 2017, though several networks are very close to such status. The most significant of these are:

- LTE-U networks being prepared by US operators T-Mobile and Verizon, both of which are expected to go live within 2Q 2017.
- Vodafone Turkey's "LAA-ready" network.
- Chunghwa Telecom's LWA network that the company says will be launched for consumers in 2017 in the Taipei area.
- M1's LWA network scheduled for commercial launch in 2017.

Chipsets and Modules

The silicon required to deliver LTE-U, LAA, LWA and other related network features comes in a number of forms. Key are the

modems and mobile processors that can handle aggregation of carriers in both licensed and unlicensed spectrum, and the bandwidth enabled by such aggregation. Baseband SoCs (System on Chip) also need to be capable of supporting the relevant technologies on the base station.

We do not know of any currently commercially available modules supporting LWA, LTE-U or LAA, but we understand that the next generation of Sierra Wireless's EM and MC pattern modules will include Qualcomm's X16 modem and that LTE-U/LAA will be supported. The modules will be available as samples this year, but a shipping date has not been announced.

Table 4 summarizes known commercial devices in a number of different categories: base station SoC, mobile processor and modem.

Table 4: Silicon Supporting LAA, LTE-U and LWA

Vendor	Product type	Name	Technology status			Notes
			LAA	LTE-U	LWA	
Intel	Base station SoC	Transcede T3K	Shipping	Shipping		Available since 3Q 2014
Qualcomm	Base station SoC	FSM9955	Shipping	Shipping		Available since February 2016
TI	Base station SoC	KeyStone II TCI6630K2L	Shipping			Available since 2015
TI	Base station SoC	KeyStone II TCI6630K2H	Shipping			Available since 2015
MediaTek	Mobile processor	Helio X30		Shipping	Shipping	Includes WorldMode modem; used in Vernee Apollo 2 smartphone
Qualcomm	Mobile processor	Snapdragon 820		Shipping	Shipping	Announced September 2015
Qualcomm	Mobile processor	Snapdragon 821		Shipping	Shipping	Available since July 2016
Samsung	Mobile processor	Exynos 8895	Shipping			May be used in Samsung Galaxy S8/S8+ outside US
Mediatek	Modem	WorldMode		Shipping	Shipping	Announced March 2017
Qualcomm	Modem	Snapdragon X16	Shipping	Shipping		Announced February 2016
Qualcomm	Modem	Snapdragon X12		Shipping	Shipping	Supports LTE-U with WTR3950 transceiver, and LWA with QCA6174A chipset

In addition

- Intel's XMM7560 modem, announced in February 2017, is at pre-commercial stage. It will support LAA.
- Qualcomm's X20 modem, announced in February 2017, is at pre-commercial stage. It will support LAA and LTE-U.
- Qualcomm's Snapdragon 835 mobile processor, announced in February 2017, is at pre-commercial stage. It will support LAA and LTE-U.
- MediaTek's Helio P10 mobile processor is used in HTC's U Play smartphone; Chunghwa Telecom states this device is LWA-capable (possibly after a firmware upgrade), but we have not been able to confirm the details.
- We expect MediaTek's Helio X35 mobile processor, currently pre-commercial (announced November 2016) will support relevant technologies, but details have not been released.

Devices

Table 5 summarizes known commercial devices now available (or with a confirmed shipping date in 2Q 2017) in a number of different categories: base station software, indoor small cells, outdoor small cells and smartphones. Other categories will be added to the database as devices become available.

In addition to those devices listed in Table 5, Cisco resells SpiderCloud's entire portfolio of small cell products; Cisco is not separately marked as a vendor of those products in our database.

Ericsson confirmed in March 2017 that its Radio Dot System is being developed for LAA (but not LTE-U); that the Radio 2205 outdoor small cell will be available from 3Q 2017 with LAA capability (it can also be deployed indoors), and that the Vault Radio concept will also have similar capabilities to the Radio 2205.

We understand that Nokia's Femtocell Multiband SoHo uses a Qualcomm chipset (FSM99xx) that can be enabled for LAA/LTE-U, but Nokia has not confirmed that the product supports those features. It has confirmed that it is developing LWA capability for its AirScale WiFi base station (announced March 2017).

Several smartphones are expected to be announced with LTE-U capability as the US operators T-Mobile and AT&T roll-out and switch on their LTE-U capability during 2017 and LAA networks near commercial readiness. The devices listed below contain silicon capable of supporting the features covered in this report:

- Sony's Xperia XZ Premium smartphone will use Qualcomm's Snapdragon 835 mobile processor and may support LAA/LTE-U when it is launched - potentially 2Q 2017.
- LG's G6 smartphone will use Qualcomm's Snapdragon 821 processor and may support LTE-U or LWA when it is launched.
- Vernee's Apollo 2 smartphone, which is expected to ship in May 2017, will feature the MediaTek WorldMode modem that supports LTE-U and LWA, but it is not clear if these features will be enabled out-of-the-box in the Apollo 2.

Note that we understand the Samsung Galaxy S8/S8+ may use Samsung's Exynos 8895 mobile processor in markets outside the US.

Finally, Ericsson confirms that its Network Software 16a supports LAA and LTE-U.

Table 5: Devices Supporting LAA, LTE-U and LWA

Vendor	Product type	Name	Technology status			Notes
			LAA	LTE-U	LWA	
Radisys	Base station software	CellEngine TOTALeNodeB+	Upgrade-able	Commercial	Upgrade-able	Available since May 2016; design based on Intel Transcende T3K chipset
Radisys	Base station software	CellEngine 5G RAN v1.0	Commercial			Available since February 2017
Nokia	Indoor small cell	Flexi Zone Multiband Indoor Pico BTS	Commercial	Commercial	Commercial	Available since September 2016
SpiderCloud Wireless	Indoor small cell	SCRN-320	Commercial	Commercial		Available since February 2017
Airspan	Indoor small cell	AirVelocity			Commercial	Announced February 2016
Baicells	Indoor small cell	Light4G solution	Upgrade-able	Commercial		Announced March 2016; uses Intel TranscendeT3K chipset and Radisys software
Ericsson	Indoor small cell	RBS6402	Upgrade-able	Commercial		LAA-upgradeability announced March 2016
Huawei	Indoor small cell	AtomCell	Commercial			Support for LAA features announced November 2015
Huawei	Indoor small cell	Lampsite 2.0 / 3.0	Trial use	Trial use		Announced November 2016
Samsung	Indoor small cell	LTE-U eFemto	Upgrade-able	Commercial		Uses Qualcomm FSM9955 chipset
Sercomm	Indoor small cell	SCB107Ev2			Commercial	Available since February 2017
ZTE	Indoor Small cell	Qcell Plus	Commercial		Commercial	Available since February 2016
Nokia	Outdoor small cell	Flexi Zone Multiband Micro BTS		Commercial		Available since September 2016
HTC	Smartphone	U Play			Upgrade-able*	Announced February 2017
Samsung	Smartphone	Galaxy S8/S8+	Commercial	Commercial		Available April 2017; uses Qualcomm's Snapdragon X16 modem (in US)

* The HTC U Play is a smartphone that Chunghwa Telecom states is compatible with its pre-commercial LWA network, but advised a firmware upgrade is recommended.

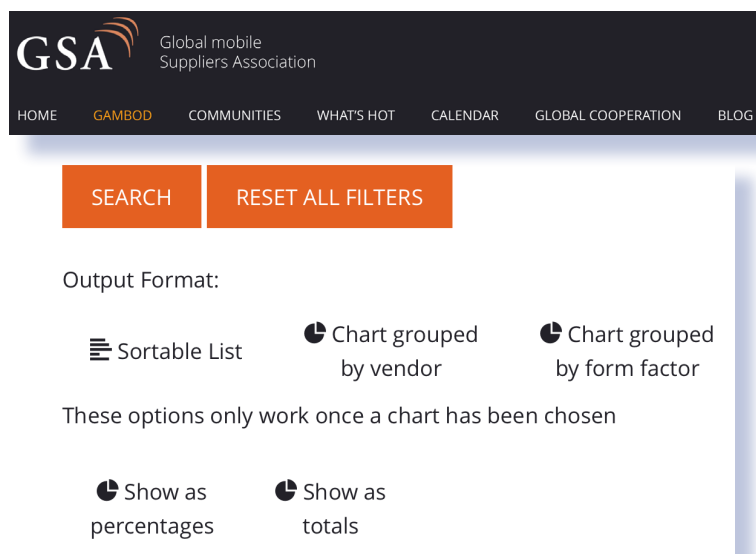
Conclusion

Global ecosystems for a number of technologies supporting the use of unlicensed spectrum for LTE services are building, and commercial services using these technologies are very close to being launched. The GSA is committed to tracking this important market; the next in this series of reports will be published at the end of July 2017.

GAMBoD Database

The GSA Analyser for Mobile Broadband Devices - to be renamed GSA Analyser for Mobile Broadband Database - will continue to track 3GPP standards based devices and during 2017 will expand to include commercially announced Operator Networks, Technologies (including LAA/LTE-U etc.), Spectrum, Network Speeds, will be fully searchable by different categories and will output charts or lists as required.

GAMBoD is a GSA resource available to all GSA Member companies, Operators and GSA Associates. For more information on accessing GAMBoD please contact GSA at - info@gsacom.com



About GSA

GSA (the Global mobile Suppliers Association) is a not-for-profit industry organisation representing companies across the worldwide mobile ecosystem engaged in the supply of infrastructure, semiconductors, test equipment, devices, applications and mobile support services.

GSA actively promotes the 3GPP technology road-map – 3G; 4G; 5G – and is a single source of information resource for industry reports and market intelligence. GSA Members drive the GSA agenda and define the communications and development strategy for the Association.

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