IMPACT OF 5G ON LOCATION ACCURACY & LAWFUL INTERCEPTION

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Executive Summary

5G will bring new and life changing technology developments that will usher in vast enhancements to mobile technologies and applications. To enable these improvements, data speeds and volume levels will exceed anything we have known before. In fact, 5G has been touted as being one of the advancements that will forever change productivity and economic activities in several industries.

Hand in hand with network improvements, location data and location intelligence have become more sophisticated. Location Services have been key for communication service providers for several reasons. One of which is to adhere to regulatory compliance both for public safety and Lawful Interception (LI).

In 5G, the new Location Services architecture provides more network-based positioning technologies that have significantly advanced and are far more precise. Completely new techniques are used to determine vertical position (i.e., z-axis) and location data has become a much more powerful tool for law enforcement agencies.

Introduction to Location Services

The excitement around 5G's massive bandwidth, super-fast data and low latency, is also spawning new use cases that drive the need for more precise and faster positioning technologies. In the commercial and industrial sectors, autonomous vehicles and low-latency remote control applications demand significant improvements in speed and precision of location technologies.

In the U.S., the most influential government body driving mobile requirements is the Federal Communications Commission (FCC). The FCC has been setting requirements for device location for emergency services since the mid-1990s when it first required the cell phone number and serving cell ID to be reported to the emergency services' operator, or public safety answering point (PSAP). Since then, as mobile devices have become ubiquitous in our society, the FCC has gradually increased their requirement for both accuracy of location and speed at which the mobile device is located.

In fact, per the latest benchmarks and timeline set by the FCC, by April of 2021, "Nationwide providers must achieve 50-meter horizontal accuracy (x/y location within 50 meters) or provide dispatchable location for 80 percent of all wireless 911 calls." Additionally, "In each of the top 25 cellular market areas (CMAs), nationwide CMRS [Commercial Mobile Radio Service] providers shall deploy either dispatchable location or z-axis technology."

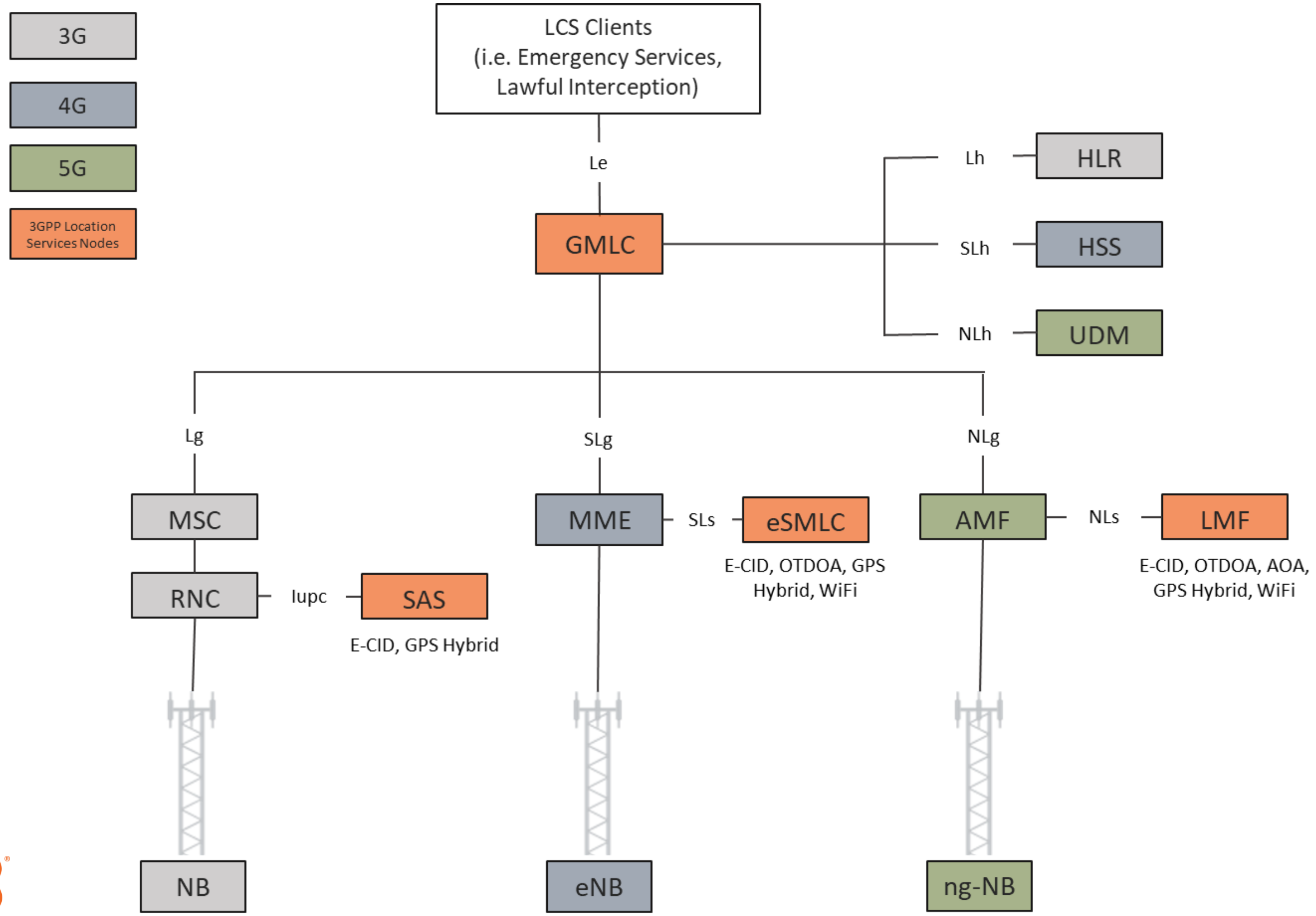
3GPP standards for Location Services (LCS) architecture have evolved in lock step with these ever-changing requirements. With each new network generation, new location methods have been added and previous ones improved.

The reality is that Global Navigation Satellite System (GNSS) and LTE-based hybrid location technologies are becoming insufficient to meet increasing location demands and regulatory requirements. Thus, the push for greater precision and options for positioning.

Indoor location is becoming a particularly important FCC requirement. This is an area where GNSS is unreliable, and LTE-based positioning methods are not quite as accurate or able to provide z-axis position.

Figure 1

Evolution of Location Services Technology in Communication Networks



Location Services Network Acronyms	
AMF	Access & Mobility Management Function
AOA	Angle of Arrival
E-CID	Enhanced Cell ID
eNB	Evolved NodeB
eSMLC	Evolved Serving Mobile Location Center
GMLC	Gateway Mobile Location Center
A-GNSS	Assisted Global Navigation Satellite System
HLR	Home Location Register
HSS	Home Subscriber Server
LMF	Location Management Function
MME	Mobility Management Entity
MSC	Mobile Switching Center
NB	NodeB
ng-NB	Next generation NodeB
OTDOA	Observed Time Difference of Arrival
RNC	Radio Network Controller
SAS	Standalone SMLC
UDM	Unified Data Management

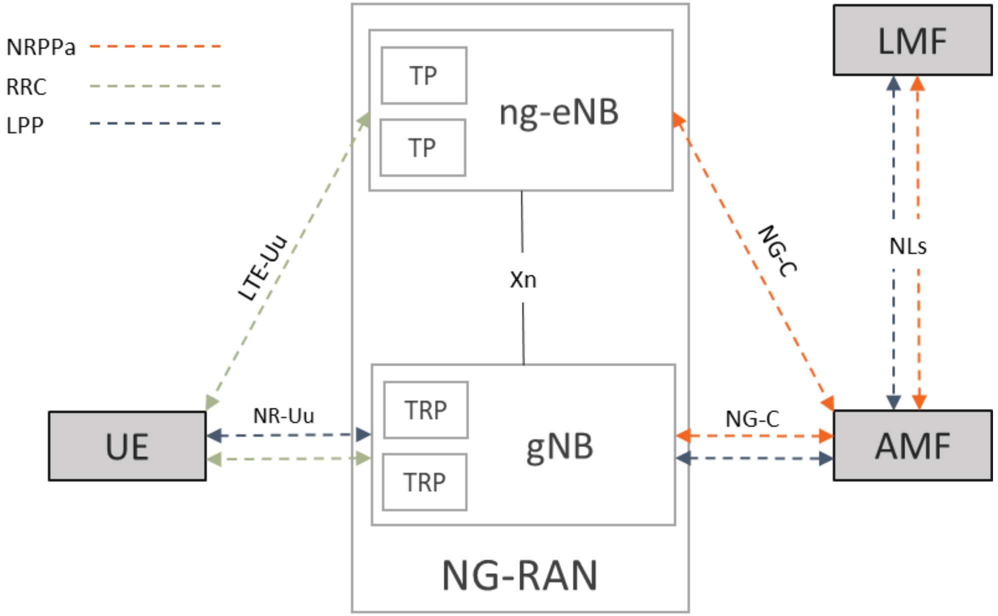
5G Location and Positioning Methods

The new entity, location management function (LMF), is central in the 5G positioning architecture. The LMF receives measurements and assistance information from the next generation radio access network (NG-RAN) and the mobile device, otherwise known as the user equipment (UE). The transmissions occur via the access and mobility management function (AMF) over the NLs interface to compute the position of the UE.

Due to the new next generation interface between the NG-RAN and the core network, a new NR positioning protocol A (NRPPa) was introduced. This protocol is to carry the positioning information between NG-RAN and LMF over the next generation control plane interface (NG-C).

Figure 2

User Equipment Positioning Architecture Applicable to NG-RAN (3GPP TS 38.305)



5G Location Architecture & Positioning Acronyms			
AMF	Access & Mobility Management Function	NR	Next Generation Radio
gNB	Next Generation NodeB	NRPPa	NR Positioning Protocol A
LMF	Location Management Function	RRC	Radio Resource Control
LPP	Location Positioning Protocol	TP	Transmission Point
ng-eNB	Next Generation eNB	TRP	Transmission-Reception Point
NG-RAN	Next Generation Radio Access Network		

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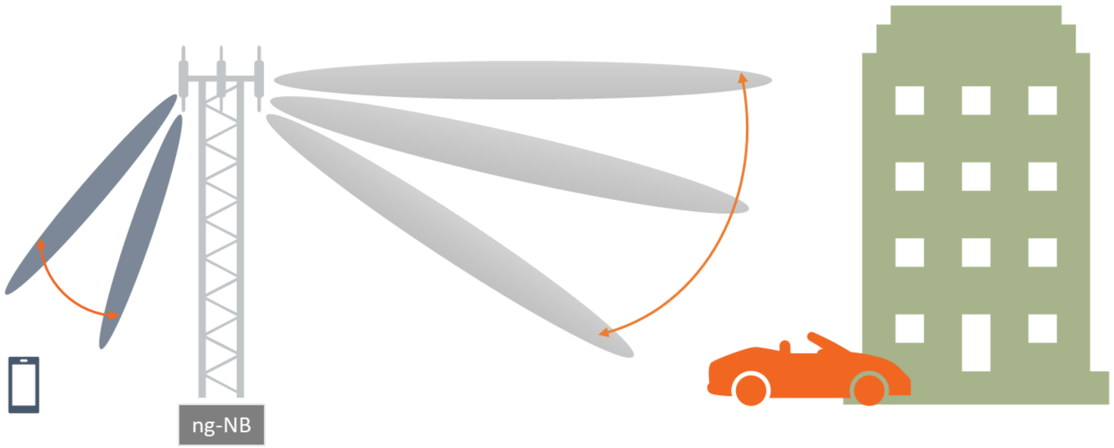
Figure 3
5G Antenna Beamforming Technology

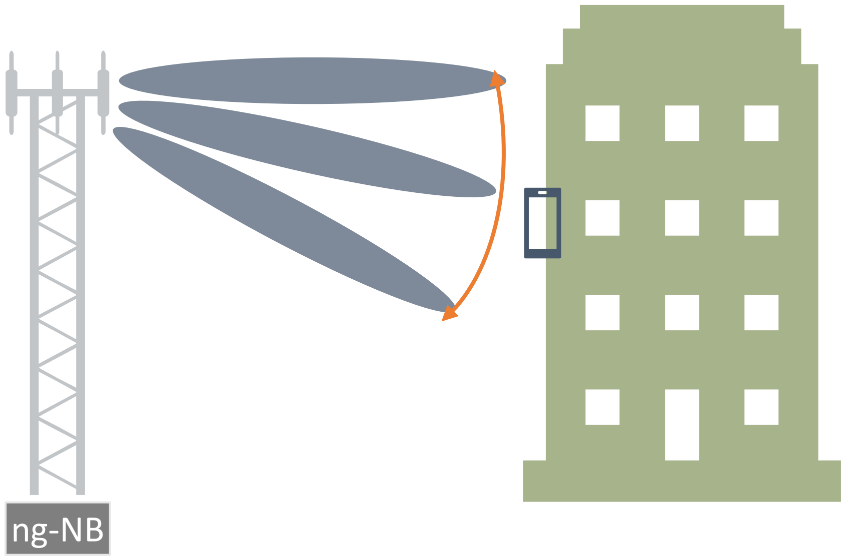


5G Location and Positioning Methods Continued

But what makes positioning in 5G so compelling, starts with its inherent architecture. Generally, it is expected that the new network density will play an important role in achieving the demanding requirements of 5G networks (i.e. high capacity, low-latency). The inter-site distance of gNBs (or access nodes) in such ultra-dense networks could range from a few meters up to a few tens of meters.

Furthermore, these 5G gNBs are expected to be equipped with smart antenna solutions, such as antenna arrays supporting multiple-input multiple-output (MIMO) techniques and beamforming. Such antenna technologies are suitable for effective communications. As well as accurate direction of arrival (DoA) estimation, which in turn allows for high-accuracy positioning.

Figure 4
5G Antenna Beamforming Technology for Z Axis



5G Location and Positioning Methods Continued

3GPP allows support for more than ten standard positioning methods in NG-RAN, not including A-GNSS. The various methods leverage other existing technologies (such as Bluetooth beacons, WiFi APs, etc.), but also add new methods that leverage NR technologies.

In LTE, the base station knows what sector a user is in, and the E-SMLC may be able to compute an approximate location of the user using the arc intersections of the neighboring cells (using their respective reported signal strengths). 5G antenna beamforming technology slices base station transmissions into many spatial components just a few degrees apart, providing far greater location accuracy. And these beamforming antennas are not just horizontal but, are also two-dimensional arrays of antenna elements.

By identifying which vertical beam a user is occupying, we can also determine vertical z-axis positioning. Additionally, higher frequencies allow for higher resolution of beamforming. With 5G deployments into millimeter Wave (mmWave) frequencies (28GHz and higher), a gNB sector will be divided into many beams that are even fewer degrees apart, resulting in even greater accuracy in both horizontal and vertical dimensions.

Impact of 5G Architecture on Public Safety

One objective with 5G standards was to improve positioning accuracy and to provide methods that rival A-GNSS in reliability. This is critical as we are now almost 100% dependent on wireless connectivity, which means it is also our primary means of communication when indoors.

A-GNSS is not reliable indoors, especially in dense urban areas or deep underground. In an emergency call, the PSAP is expecting the network and device to report the most accurate position possible for the caller's device, in the quickest time possible. If the caller is outdoors, there is a high degree of probability that a GNSS-based position will be reported in about 30 seconds or less. If indoors, however, the UE may require more time to generate GNSS measurements for position calculation, if able to do so at all.

If it cannot, the network fallback location methods (such as Enhanced Cell ID, or just plain Cell ID) may not produce a dispatchable location if the error radius is too large (i.e., several city blocks).

Impact of 5G Architecture on Public Safety Continued

5G reduces the dependency on A-GNSS for precise location. With 5G, a caller can be located without A-GNSS (if unavailable) to a precise level, and if located in a high-rise building, potentially identify the floor level (with an acceptable level of confidence).

In a IEEE whitepaper, researchers determined that with dense antenna distribution and using a signals direction of arrival (DoA), they could determine the device's location to a sub-2-meter accuracy 90% of the time. This was previously unattainable without the use of A-GNSS positioning, even in the best of cases. In a dire situation, an Emergency Services operator's ability to accurately locate a caller quickly and with high confidence could mean the difference between life and death.

Impact of 5G Location on Lawful Interception

Just like in location information used for public safety, the accuracy of location information plays a critical role in the area of lawful interception. Mobile Network Operators must respond to legal law enforcement requests for information regarding a suspect of interest's communication records. Both 3GPP and ETSI have standards established for Lawful Interception that define the interfaces for mediation nodes and the communication data that can be intercepted.

In addition to communication content for example, a law enforcement agency (LEA) can also request the current geographic location information of the suspect. Such information could therefore include what location the suspect was when telecommunications activity occurred.

The Standards allow for "Privacy Overrides" in cases of emergency or lawful interception location requests. However A-GNSS, or other device-based positioning methods, can still be blocked by the UE (depending on implementation) at all times. The only exception being during an emergency call. Outside of such a scenario, law enforcement must depend on the network-based positioning methods to locate the device.

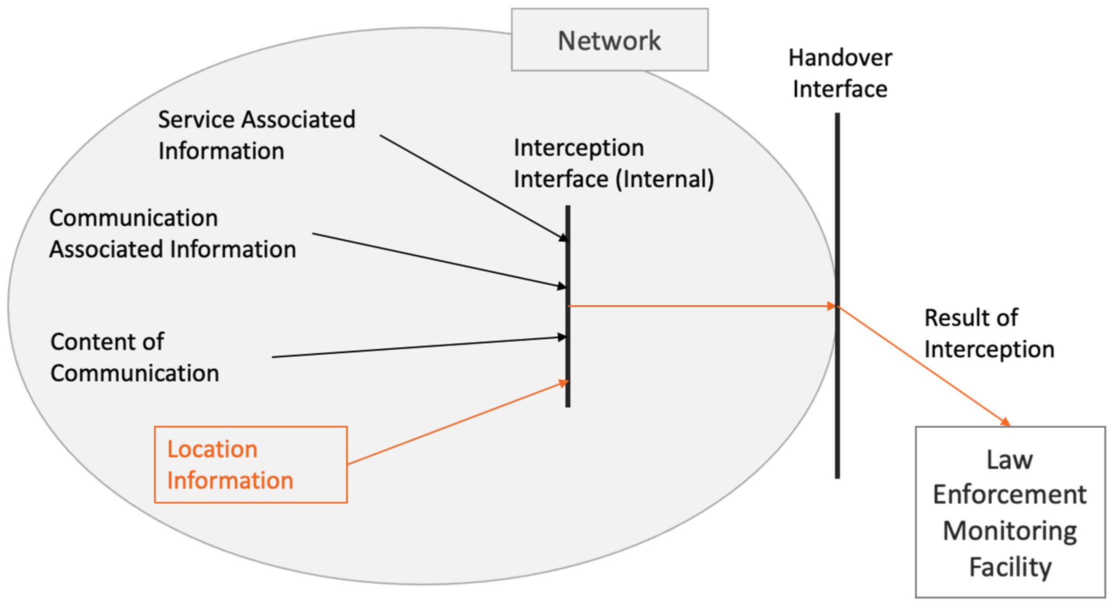
Impact of 5G Location on Lawful Interception Continued

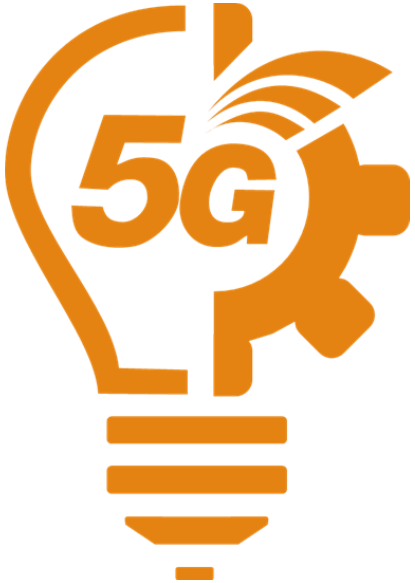
As previously mentioned, the legacy networks did not provide highly accurate positioning methods outside of A-GNSS. And because the list of positioning methods available in 5G is so numerous, several options are still available if for example, an operator has not deployed beam forming technology throughout its network.

The density of deployments of 5G access nodes simply will allow much more precise E-CID position than in previous generation networks. This alone improves the location accuracy by several orders of magnitude.

Figure 5

Lawful Intercept Location Data Handoff to Law Enforcement Agencies





Conclusion

Location data has become increasingly important as communication networks have evolved, and 5G is no exception.

If correctly implemented, 5G networks and their location platforms will expedite the interception and delivery of location data, while at the same time improving its accuracy. For example, first responders will know the exact floor where a victim is located, while law enforcement agencies will have real-time visibility into a criminal's movements.

From the perspective of Public Safety, 5G location is a significant step in the right direction. Because 5G will be more accurate, dependable, and relies less on the hit-or-miss handset-based location technologies, it will improve efficiency when dispatching a first responder and increase the reliability of location data used by intelligence agencies.

For more information regarding SS8's mediation and interception products, please visit www.ss8.com or email us at info@ss8.com. Additionally, you can follow @SS8 on Twitter or https://www.linkedin.com/company/ss8/ on LinkedIn.

Next Steps

While 5G technology is still evolving and at various levels of implementation globally, it brings benefits and challenges. To determine if your Location Services platform is ready for 5G, we recommend the following:

- Spend time with leading providers of LBS and Location Services platforms to understand the new technologies available, as well as the emerging solutions.
- Review your network architecture today, its various ng-NB deployment options, and your country's regulatory compliance obligations.
- Evaluate various Lawful Interception providers and the differences between their technology, ability to adhere to the standards and regulations appropriate to your country of operation, and how they can leverage your 5G network to meet those regulations.

5G will change the future and how CSPs handle Lawful Interception requirements. CSPs need to take the first steps toward understanding the impact and solutions available to assure consistent compliancy.

About the Author

As SS8's lead Location Solutions Architect, Michael Gebretsadik plays an integral role in the company's strategic go to market direction, product design and implementation decisions. With nearly 20 years of experience in telecommunications and location technology, he has thorough understanding network architecture, design and wireless location tracking technologies. Michael can be reached at mgebretsadik@ss8.com and LinkedIn at https://www.linkedin.com/in/michael-gebretsadik

About SS8 Networks, Inc.

SS8 provides Lawful Intelligence platforms. They work closely with leading intelligence agencies, communication providers, law enforcement agencies and standards bodies. Their technology incorporates the methodologies discussed in this blog. Xcipio® is already proven to meet the very high demands of 5G and high volumes of intercepts and provides the ability to transcode (convert) between lawful intercept handover versions and standard families. Intellego® natively supports ETSI, 3GPP and CALEA handovers, as well as national variants. Both product portfolios are used worldwide for the capture, analysis and delivery of data for the purposes of criminal investigations.

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Resources

1. Indoor Location Accuracy Timeline and Live Call Data Reporting Template https://www.fcc.gov/public-safety-and-homeland-security/policy-and-licensing-division/911-services/general/location-accuracy-indoor-benchmarks
2. High-Efficiency Device Positioning and Location-Aware Communications in Dense 5G Networks https://arxiv.org/abs/1608.03775v3
3. 3rd Generation Partnership Project "Technical Specification Group Services and System Aspects: Release 16" July 3, 2020. https://www.3gpp.org/release-16
4. 3rd Generation Partnership Project "5G System (5GS) Location Services (LCS); Release 16" 3GPP TS 23.273 v16.5.0 (2020-12)
5. 3rd Generation Partnership Project "User Equipment (UE) Positioning in NG-RAN (Rel 16)" 3GPP TS 38.305 v16.3.0 (2020-12)
6. 3rd Generation Partnership Project "Lawful Interception Architecture and Functions (Rel 16)" 3GPP TS 33.107 v16.0.0 (2020-07)
7. ETSI Technical Specification "Lawful Interception (LI); Requirements of Law Enforcement Agencies" ETSI TS 101.331 v1.6.1 (2020-10)