VoLTE EMERGENCY CALLS

TESTING OF 3GPP COMPLIANCE IN OEM HANDSETS

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Emmett J. Fitch
Jester J.P. Purtteman
Matthew M. Scott
John L. Marakkamveettil

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2 Introduction

About 10 years ago the first packet switched cellular networks were introduced as part of the 4th Generation Long Term Evolution (4G-LTE) standard. With them came a technology known as Voice over LTE (VoLTE). In the coming months and years, packet switched networks will completely replace older circuit switched networks as the 5th Generation networks (5G) come online. To complete this transition some key features of the legacy networks must be replaced in the new packet switched environment.

Prior to digital packet switched networks, federal law required that all mobile handsets be able to reach a 911 emergency Public Safety Answering Point (PSAP). This meant that anyone could reasonably expect any phone they encountered to be able to dial 911 in the event of an emergency. Additionally, a network operator could rely on the fact that the SIM card would fully provision the phone to work on the network.

This paper identifies a significant obstacle to the transition from circuit to packet switched networks. The evidence suggests that a person using a piece of User Equipment (UE) to call emergency services will have a very high failure rate due to inadequate cross-platform testing between handset, radio and network components. In simple terms, handsets will not reliably allow a person to dial 911 and reach a PSAP on these networks. It is vital to the safety of our citizens that this be adequately addressed with utmost urgency.

3 Audience

To understand the technical details of this report an understanding of LTE networks, the 3rd Generation Partnership Project (3GPP) standards, the GSMA (a leading consortium of mobile operators and manufacturers), emergency calling, and VoLTE is recommended. However, the conclusions of this study will be clear to those without the technical background in the subject.

The intent of this document is to inform regulators and lawmakers of a growing problem in our telecommunications network that has now become a public safety concern. During these initial stages of implementing 5G, the discussions regarding Voice over New Radio (VoNR), the next generation of VoLTE, are proceeding without a complete definition of the standard and without adequate effort to ensure complete adoption of the standard. In order to uphold public safety, and promote new technology, standards must be upheld. Regulations adopting 3GPP standards and a process for product testing by a Nationally Recognized Testing Laboratory (NRTL) is needed.

4 Abstract

This study tested VoLTE-based emergency call services on multiple cellular phones across a range of operator provided security information modules (SIM) cards. In testing using a live network 40 out of 70 test cases failed to reliably reach the PSAP when 911 was called. Results of these tests show the need for updated regulations to ensure proper 911 and call functionality in digital and packet-switched telecommunications. Mobile handset vendors expect to complete the phase out of circuit switched technology as early as 2021. At that time, 911 access in an emergency over millions of square miles of the United States will become unreliable or non-existent. This will impact subscribers of the major networks when roaming in rural areas as well as smaller local mobile network operators (MNOs).

5 Background

During the commissioning of its network, as a brand-new LTE and VoLTE-only operator, OptimERA was receiving unexpected results testing 911 calls. This document is the result of a battery of tests performed by OptimERA to help determine the commercial readiness of its network. Results showed that no handset Original Equipment Manufacturer (OEM), i.e. Apple, Samsung, LG…etc., has followed the GSMA guidelines of 3GPP standards implementation, standards designed to ensure compatible mobile UE operation on a mobile network, including VoLTE functionality on a VoLTE-only network.[1]

OEMs do not publish documentation that would allow network operators to troubleshoot problems with handset functionality on their network without the direct aid of the OEMs. Several large OEMs go as far as to lock the handset so that no significant diagnostics are available, and that no changes what-so-ever can be made to their software to permit troubleshooting. Handset OEMs are not required to work with network operators to meet performance or safety metrics. Finally, the OEMs do not rigorously comply with 3GPP standards, including those deemed mandatory by the 3GPP. The end result of this is that conformance testing of a network against a device is virtually, and in many key cases literally, impossible.

Regulations exist for analog mobile phones, specifically stating how an analog mobile phone would handle 911 calls outside of its registered network.[2] Because the regulation specifically identifies analog handsets, it excludes digital communication on packet switched networks.

OEMs offer device customization to carriers as an opportunity to secure large sales contracts. This was used by large carriers early in the rollout of 4G almost a decade ago before the introduction of the IP Multimedia-SIM (ISIM). These customizations allowed the carriers with carrier customizations to forgo having to replace millions of customers SIMs with ISIMs.

Large service providers (AT&T, Verizon, Sprint, T-Mobile, etc.) leverage high volume sales agreements with OEMs to require device customization for not just themselves, but inadvertently for all carriers. As a result, there is less competitive pressure from small carriers because large sales orders get higher priority from OEMs, restricting access to technology for small carriers. One memorable time this tactic was used happened between AT&T and Apple, by locking the iPhone to the AT&T network.[3] Today this is used to restrict device functionality in cases without large service contracts. Because customization has become the standard practice in the United States, handset functionality is inconsistent. Having given the large

[1] ("3GPP TS 31.103 version 14.2.0 Release 14" https://www.etsi.org/deliver/etsi_ts/131100_131199/131103/14.02.00_60/ts_131103v140200p.pdf , "3GPP TS 23.228 version 14.3.0 Release 14" https://www.etsi.org/deliver/etsi_ts/123200_123299/123228/14.03.00_60/ts_123228v140300p.pdf , "3GPP TS 24.229 version 14.3.1 Release 14" https://www.etsi.org/deliver/etsi_ts/124200_124299/124229/14.03.01_60/ts_124229v140301p.pdf , "3GPP TS 33.203 version 14.1.0 Release 14" https://www.etsi.org/deliver/etsi_ts/133200_133299/133203/14.01.00_60/ts_133203v140100p.pdf , "3GPP TS 23.003 version 14.3.0 Release 14" https://www.etsi.org/deliver/etsi_ts/123000_123099/123003/14.03.00_60/ts_123003v140300p.pdf ,

[2] 47 CFR § 22.921 - 911 call processing procedures; 911-only calling mode. https://www.ecfr.gov/cgi-bin/text-idx?SID=089196b1f9ddc42d2f2307df5d91d445&node=pt47.2.22&rgn=div5#se47.2.22_1921

[3] https://www.supremecourt.gov/DocketPDF/17/17-204/59109/20180810115025228_No.%2017-204%20Apple%20v.%20Pepper%20Joint%20Appendix.pdf

networks this customization, the OEMs simply do not follow the GSMA's IR.92[4] in the United States, which lays out the requirements for UEs to be operator agnostic. Furthermore they do not follow TS.32 which provides a mechanism for customization.[5]

Functionality of VoLTE is irregular and unpredictable, because it depends on a combination of the service provider's SIM, the device customization, and the network to which it is connected. Because the device customization is outside of the control of the network operator and/or the OEM's customer, the irregularities must be resolved by the OEMs. Most critically, since 911 will soon be delivered exclusively by packet data only VoLTE networks, Emergency 911 service will be unreliable as well. We have shown this in our testing, a matrix showing the results of our tests can be found as Attachment A to this document.

When a phone is turned on, even if locked by a pin, or when no SIM is inserted, they generally indicate "Emergency Calls Only". We show in the matrix that often even when they say emergency calls only, they will not be able to dial an emergency number. It is impossible for a network operator to control which devices a user may try to use to access the network. Currently, phones and networks have the technology to allow almost any phone to access almost any network. In 2G and 3G networks, phones were completely provisioned by the network operator through the SIM card, all handsets behaved the same and the responsibility was on the network operator to deliver calls and 911 functionality. Due to OEM customization and the OEM not adhering to standards, provisioning in an LTE network is not solely SIM-based.

The latest generation of phones have support for a wide range of spectrum bands and are capable of connecting to nearly any network globally, even in emergency-only status. This, along with the lack of control by the network operator through SIM provisioning, puts responsibility for call functionality and 911 operation within the control of the OEM.

Regulations requiring adoption of 3GPP standards and requiring independent testing of UE and mobile network equipment for conformance and regulated by an NRTL are key to resolving unpredictable and unreliable 911 communications.

6 Test Setup

OptimERA performed tests in an isolated and remote site, away from all the other network service areas. Under the isolated conditions, the UE's behavior was determined by the OEM and the operator sim cards under our LTE/VoLTE network.

The test was preformed using a Parallel Wireless Radio Access Network (RAN), an Athonet Evolved Packet Core (EPC), and a Metaswitch IP Multimedia Subsystem (IMS). The EPC and IMS services where configured with the assistance of Athonet and Digital Communications Consulting LLC (DCC LLC) and the RAN was configured by Parallel Wireless.

[4] (GSM Association Official Document IR.92 - IMS Profile for Voice and SMS)
https://www.gsma.com/newsroom/wp-content/uploads/IR.92-v12.0.pdf
[5] (GSM Association Official Document TS.32 - Technical Adaptation of Devices through Late Customization)
https://www.gsma.com/newsroom/wp-content/uploads//TS.32-v6.0.pdf

The test was to dial 911 using multiple phones, each using multiple SIM cards, and setting the phone to different states (LTE Data On/Off). Attachment A has the test results laid out in a matrix for visual representation.

A few notes regarding the setup:

1. At the time of testing, OptimERA did not have roaming agreements with any carriers, so was unable to perform registered 911 testing for any except OptimERA SIM cards.
2. Due to the lack of regulation regarding handset functionality, OptimERA has only been able to acquire an official "carrier profile" on the Samsung S9. Currently all handset vendors have made it so that you must have a "carrier profile" added to the phone with your "carrier-specific information" on it in order to enable VoLTE. This is in lieu of using the SIM card for configuration. This in violation of GSMA IR.92, "Support for ISIM based authentication in the UE is mandatory."[6]

Definitions:

1. Registration State
    a. *Emergency Calls Only*, is the state when a device cannot register with the network but by law must connect to the network in case of emergency.
    b. *Registered*, means fully registered on the network, shows full bars and that you have service.
2. *LTE Data On/Off*, means whether data was enabled on the phone or if it was only in voice mode. One artifact of OEMs device customization is that some device and SIM combinations did not expose this option to the user.

7 Test Devices

All test devices were bought unlocked with no carrier branding. All devices were updated to ensure they were running the latest firmware version possible at the time of testing. All devices were advertised as VoLTE capable.

1. **Apple iPhone (iOS 13)**
2. **Xiaomi Mi8 (Android 9)**
3. **Huawei Mate SE (Android 8)**
4. **Essential PH-1 (Android 10)**
5. **Samsung S9 (Android 9)**

8 Test SIMs

All test SIMs where procured under the requirement that they be VoLTE (ISIM) cards. Without being able to read the card file structures, it was not possible to confirm that they were all ISIM cards. However, even if the cards where only USIM file structure the 3GPP have provisions regarding how this is handled and so

[6] "GSM Association Official Document IR.92 - IMS Profile for Voice and SMS p.16 Sec. 2.2.2" https://www.gsma.com/newsroom/wp-content/uploads/IR.92-v12.0.pdf

should have been able to make a VoLTE 911 call. All devices should have been able to make a VoLTE 911 call without needing a SIM card.

1. **OptimERA**
2. **Verizon**
3. **AT&T**
4. **Sprint**
5. **GCI**
6. **No SIM**

9 Basic High-Level VoLTE Emergency Call Flow

These diagrams are based on 3GPP specifications, mostly focused on 3GPP TS 23.167 version 14.6.0 Release 14. OptimERA's VoLTE based emergency test cases are based on these standards and technical specifications. The following 5 diagrams (Figure 1 - Figure 5) show the call flow through the network and the two scenarios that were failures during testing.

Several of the component elements at the top and the bottom of the page are technical components. If a term is unfamiliar, please use the glossary at the end of this document to help understand the acronyms in blue, as well as a handful of the terms on the diagrams.

9.1 The LTE Core Signaling and Call Flow

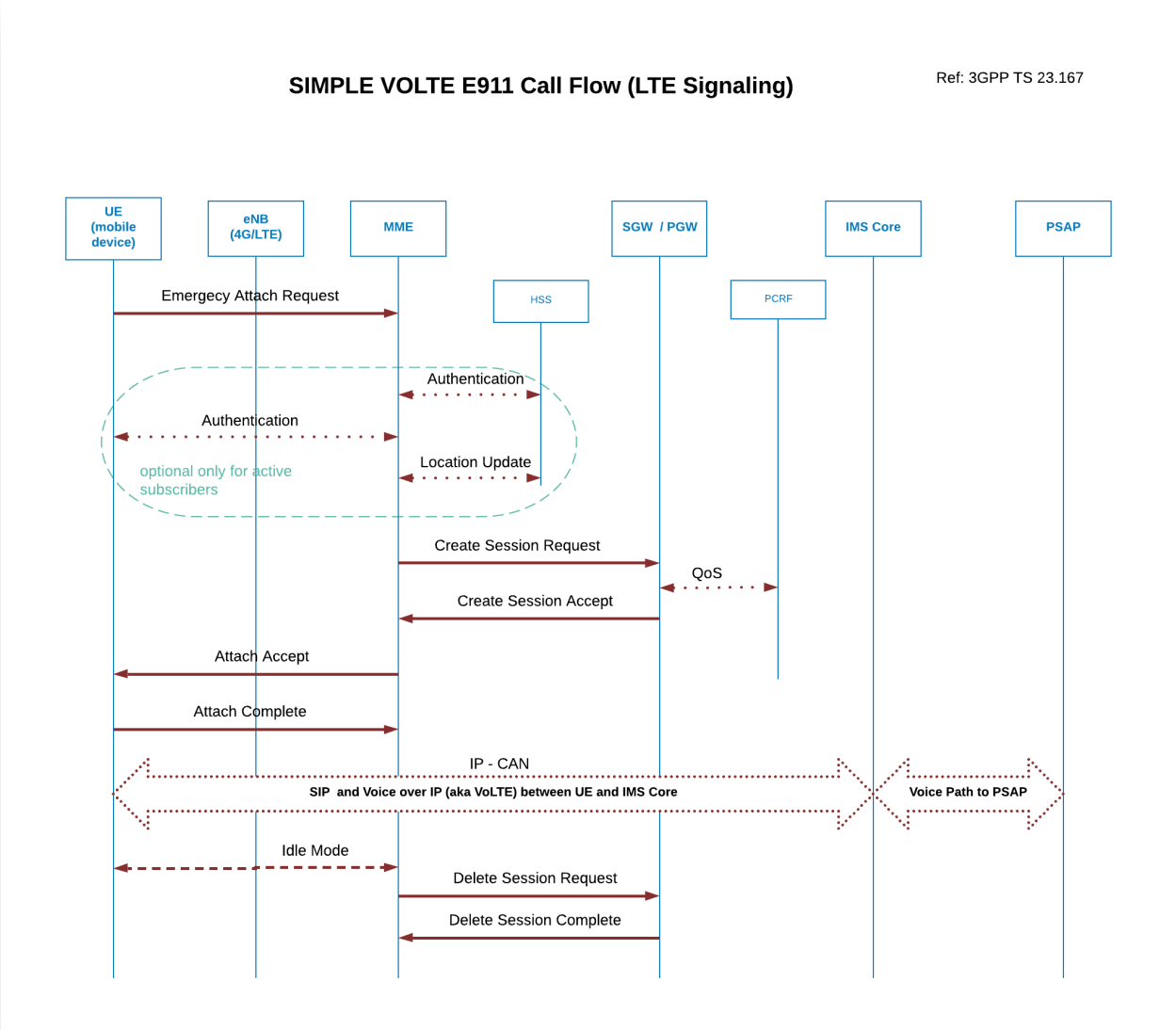

Figure 1. Signaling flow between basic LTE Core nodes and the UE.

9.2 The IMS Core Signaling and Call Flow

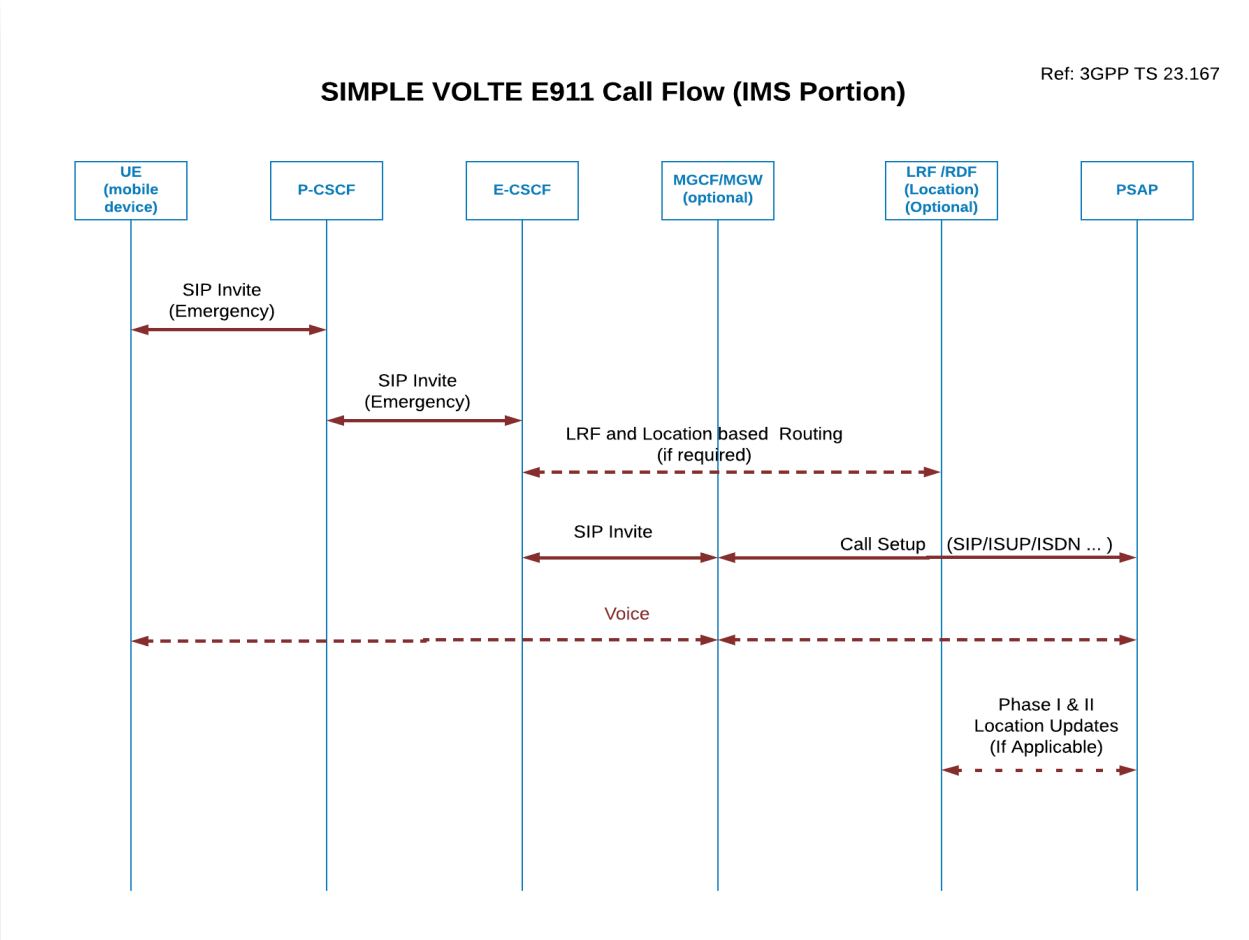

Figure 2. Shows a high level of how the calls are setup under the Session Initiation Protocol (SIP) layer.

Note: In our test cases, we are not using location-based emergency services and hence the call flow is kept to the basic minimum and focused on the UE behavior under an LTE/VoLTE service area.

9.3 LTE Core Signaling and Call flow – Failure of UE Attach

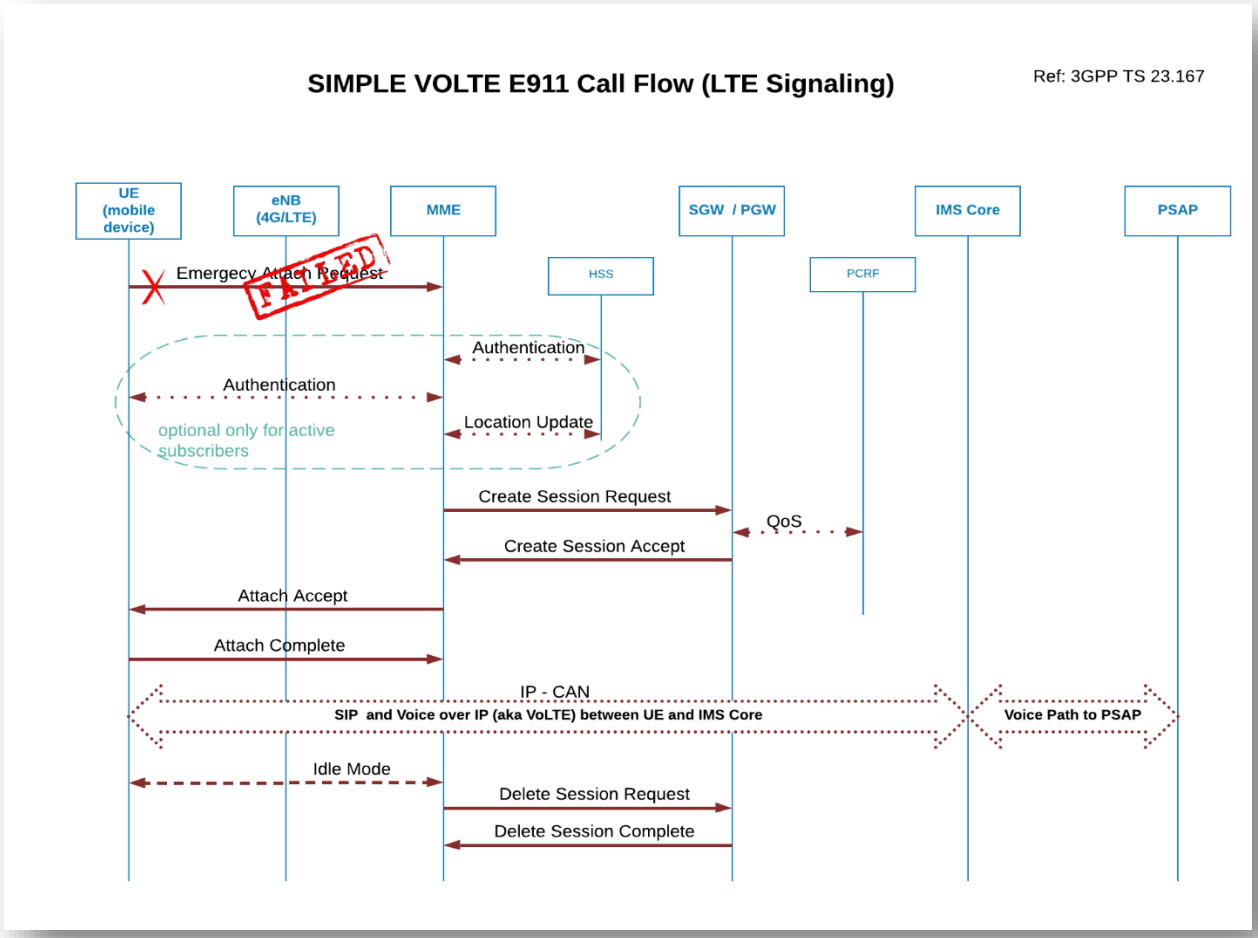

Figure 3. This diagram shows the failure of the UE to attach to the IMS APN of the network for a 911 call to be made. In this state the phone could show “Emergency Calls Only” and maybe “LTE” depending on the OEM + Operator combo but not actually be able to make an emergency call.

In the below test cases, resulting failures will be noted as **Emergency Attach Failure**.

9.4 LTE Core Signaling and Call Flow – Failure of UE to request correct Session Parameters

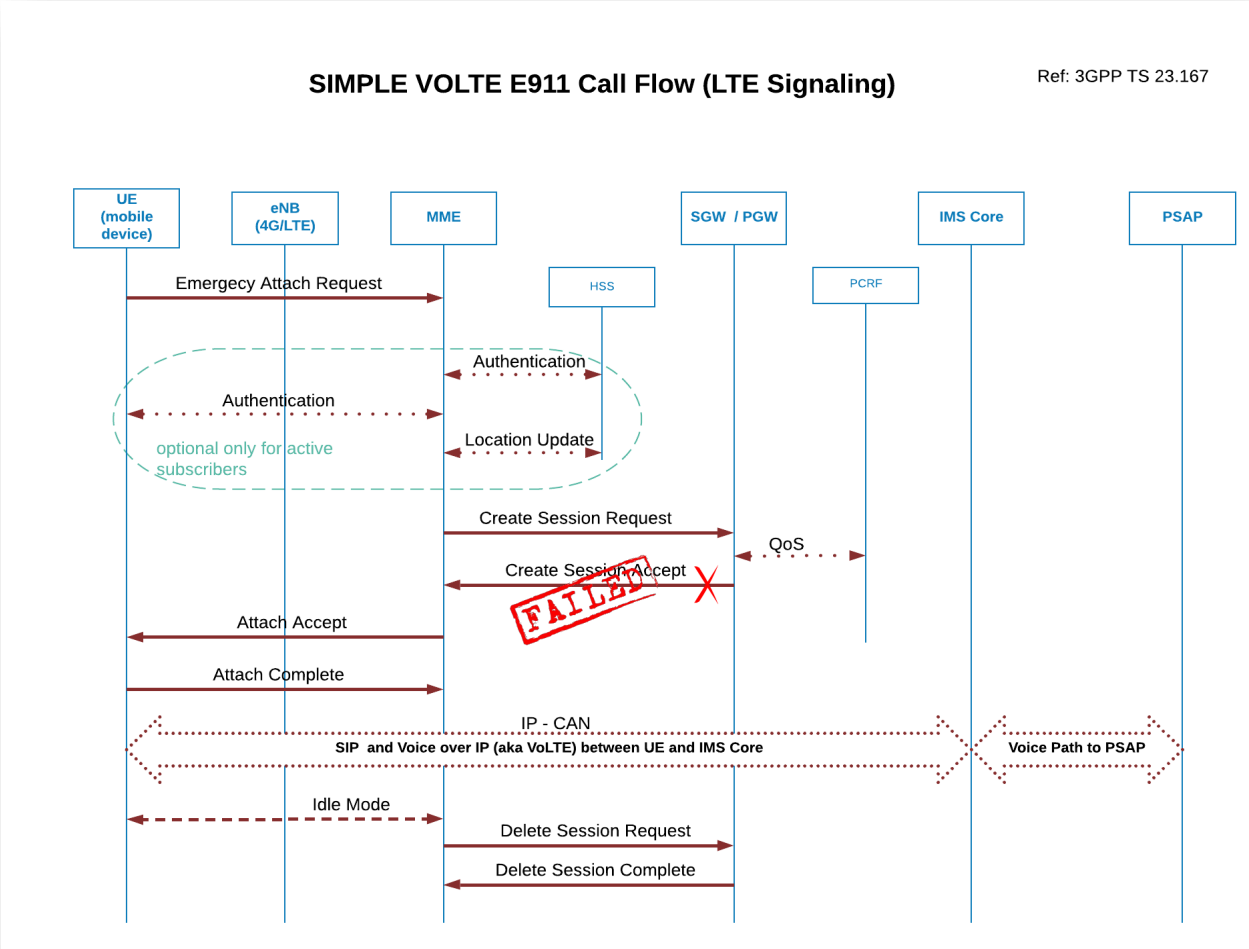

Figure 4. This diagram shows where the call breaks if a UE requests a session parameter that the network is either not capable of doing or is not configured for.

In the below test cases, resulting failures will be noted as **Packet Data Network Failure**.

9.5 The IMS Core Signaling and Call Flow – Failure to Connect Audio

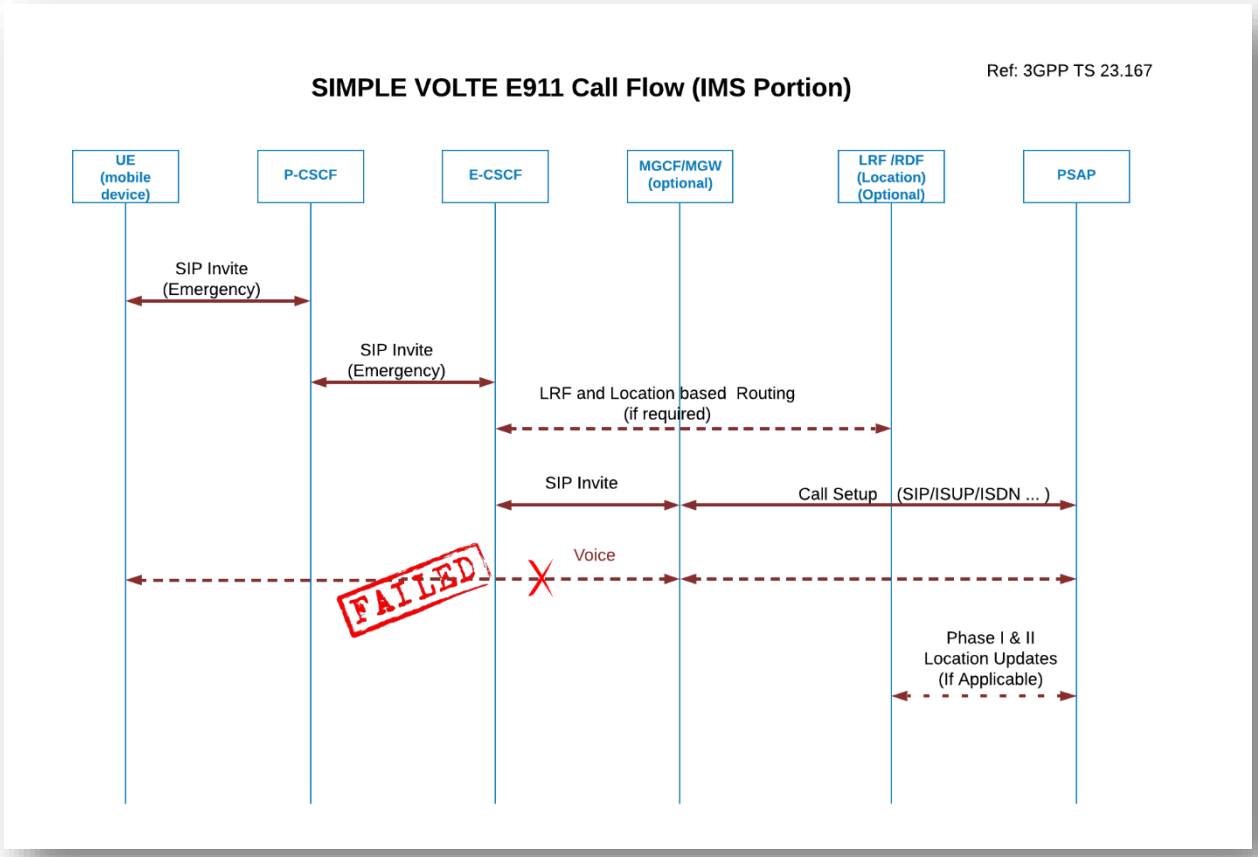

Figure 5. This diagram shows where the SIP/VoLTE audio was not fully connected between the end points, such as the UE and the PSAP. Either the audio was one-way or there was no audio at all after both ends shows connected.

In the below test cases, resulting failures will be noted as **Voice Path Failure**.

10 Test Cases with Samsung Galaxy S9

Software version: .....Android 9 (PPR1.180610.011.G960U1UEU6CSH7) ACG Test Build
IMEI: 354267098848507
Model: SM-G960I1
Serial Number: .....N/A

10.1 OptimERA SIM Card with Active subscription

IMSI: 313 380 000 000 000

Test Result: Pass

Details of the Result: Caller information was passed on to PSAP with appropriate call back number. The SIP Invite from the UE contained MSISDN in the contacts field.

10.2 OptimERA SIM Card without Active subscription

IMSI: 313 380 000 000 028

Test Result: Pass

Details of the Result: There was no caller information to PSAP. The SIP invite did not contain any information pertained to the caller.

10.3 Verizon SIM Card without Active Subscription or Roaming

IMSI: 311480301222432

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail.

10.4 AT&T SIM Card without Active Subscription or Roaming

IMSI: 310410135887801

Test Result: Fail - **Emergency Attach Failure**

Details of the Result: In this case, we did not observe the UE trying to do VoLTE. There was no RRC setup from the UE for any sort of emergency calling to the LTE network. The call failed on LTE layer.

10.5 GCI SIM Card without Active Subscription or Roaming

IMSI: 311370000889218

Test Result: Fail - **Emergency Attach Failure**

Details of the Result: The failure was similar to an AT&T SIM, the diagram shown above, that the UE or Device did not originate a VoLTE 911 call. The phone appeared to continue "calling . . .". Later when we took the phone to a GSM/UMTS network coverage, it completed the call over the circuit switched network.

10.6 Sprint SIM Card without Active Subscription or Roaming

IMSI: 312530201238934

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail.

10.7 No SIM Card in the Device

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMEI as the caller detail.

10.8 Factory reset or brand-new out of the box Device

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMEI as the caller detail.

11 Test Cases with Apple iPhone X

Software version: ..... iOS 13.1.3
IMEI: 354852094382591
Model: MQA82LL/A
Serial Number: F2LWX4F1JCL6

11.1 OptimERA SIM Card with Active subscription

IMSI: 313 380 000 000 000

Test Result: Fail - **Emergency Attach Failure**

Details of the Result: In this test case, the SIM card had active subscription, and was registered on the LTE network. But the device did not register on the IMS network. Hence the phone was unable to originate any calls. Devices can only perform data services over internet. The IMS services were not activated and voice call functions were disabled. Upon dialing an emergency call, the phone did not originate any calls to VoLTE network. In this specific call scenario, OptimERA took the UE to the normal coverage area where a 2G/GSM and 3G/UMTS network coverage was available. The phone was still attached to OptimERA's LTE network, but not VoLTE. Once the Emergency call was dialed, it completed the call using another carrier's GSM network. The PSAP received anonymous caller ID. The conclusion of this test case is that, even though the OptimERA's network is VoLTE capable, the UE in this case, decided not to use it, thereby ignoring 3GPP Technical Specifications #36.331, and #36.508.

11.2 OptimERA SIM Card without Active subscription

IMSI: 313 380 000 000 028

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail. The device acted as a limited service mode and used the VoLTE network to complete the call.

11.3 Verizon SIM Card without Active Subscription or Roaming

IMSI: 311480301222432

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail.

11.4 AT&T SIM Card without Active Subscription or Roaming

IMSI: 310410135887801

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail.

11.5 GCI SIM Card without Active Subscription or Roaming

IMSI: 311370000889218

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMSI as the caller detail.

It was observed that, the SIP invite contained additional parameters which caused the calls to fail in OptimERA's VoLTE network, but our engineering team adapted the changes to accept the additional parameters and the calls to complete.

11.6 Sprint SIM Card without Active Subscription or Roaming

IMSI: 312530201238934

Test Result: Fail – **Packet Data Network Failure**

Details of the Result: The Device was requesting an IPv6 IP address, which is not supported by OptimERA VoLTE network at this time. The PGW in the EPC rejected the PDN request as unsupported request.

11.7 No SIM Card in the Device

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMEI as the caller detail.

11.8 Factory reset or brand-new out of the box Device

Test Result: Pass

Details of the Result: The caller information was not accurate, but it was presented to the PSAP. The SIP invite contained the IMEI as the caller detail.

12 Test Cases with Xiaomi MI 8

Software version: ..... Android 9 PKQ1.180729.001
IMEI: .....867252038439674 / 682
Model: ..... MI 8
Serial Number: .....N/A

12.1 OptimERA SIM Card with Active subscription

IMSI: 313 380 000 000 000
Test Result: Pass (with PS Data Turned off)
Test Result: Fail (with PS Data Turned on).

Emergency Attach Failure. The device seems to not activate the SOS Access Point Name (APN) when the PS data is turned off.

12.2 OptimERA SIM Card without Active subscription

IMSI: 313 380 000 000 028
Test Result: Fail - **Voice Path Failure**

12.3 Verizon SIM Card without Active Subscription or Roaming

IMSI: 311480301222432
Test Result: Fail - **Emergency Attach Failure**

12.4 AT&T SIM Card without Active Subscription or Roaming

IMSI: 310410135887801
Test Result: Fail - **Emergency Attach Failure**

12.5 GCI SIM Card without Active Subscription or Roaming

IMSI: 311370000889218
Test Result: Pass

Call connected with two-way audio, but with no caller ID from the device, with no IMSI or IMEI info, so the PSTN inserted a dummy number impertinent to the T1/DS1 line.

12.6 Sprint SIM Card without Active Subscription or Roaming

IMSI: 312530201238934

Test Result: Fail - **Emergency Attach Failure**

12.7 No SIM Card in the Device

Test Result: Fail - **Emergency Attach Failure**

12.8 Factory reset or brand-new out of the box Device

Test Result: Fail - **Emergency Attach Failure**

13 Test Cases with Huawei Mate SE

Software version: ..... Android 8.0.0 (EMUI 8.0.0 BND - L34 8.0.0.358 (c567))
IMEI: ..... 867892031466776 / 94786
Model: ..... BND-L34 (Mate SE)
Serial Number: 4AV7N18614001172

13.1 OptimERA SIM Card with Active subscription

IMSI: 313 380 000 000 000
Test Result: Fail - **Emergency Attach Failure**

13.2 OptimERA SIM Card without Active subscription

IMSI: 313 380 000 000 028
Test Result: Fail - **Emergency Attach Failure**

13.3 Verizon SIM Card without Active Subscription or Roaming

IMSI: 311480301222432
Test Result: Fail - **Emergency Attach Failure**

13.4 AT&T SIM Card without Active Subscription or Roaming

IMSI: 310410135887801
Test Result: Fail - **Emergency Attach Failure**

13.5 GCI SIM Card without Active Subscription or Roaming

IMSI: 311370000889218
Test Result: Fail - **Emergency Attach Failure**

13.6 Sprint SIM Card without Active Subscription or Roaming

IMSI: 312530201238934
Test Result: Fail - **Emergency Attach Failure**

13.7 No SIM Card in the Device

Test Result: Fail - **Emergency Attach Failure**

13.8 Factory reset or brand-new out of the box Device

Test Result: Fail - **Emergency Attach Failure**

14 Test Cases with Essential PH-1

Software version: ..... Android Version 10 (Qp1A.190711.148)
IMEI: 990010041388548
Model: PH-1
Serial Number: PML1LHMA7C1301969

14.1 OptimERA SIM Card with Active subscription

IMSI: 313 380 000 000 000
Test Result: Fail (with PS Data on). Resulted in one-way audio. **Voice Path Failure**
Test Result: Pass (with PS Data off). Connected with audio, *but there was no ring back*

14.2 OptimERA SIM Card without Active subscription

IMSI: 313 380 000 000 028
Test Result: Pass (with PS Data off). Connected with audio, *but there was no ring back*

14.3 Verizon SIM Card without Active Subscription or Roaming

IMSI: 311480301222432
Test Result: Fail - **Emergency Attach Failure**

14.4 AT&T SIM Card without Active Subscription or Roaming

IMSI: 310410135887801
Test Result: Fail - **Emergency Attach Failure**

14.5 GCI SIM Card without Active Subscription or Roaming

IMSI: 311370000889218
Test Result: Pass (Connected with audio, there was no ring back)

Call connected with two-way audio, but with no caller ID from the device, with no IMSI or IMEI info, so the PSTN inserted a dummy number impertinent to the T1/DS1 line.

14.6 Sprint SIM Card without Active Subscription or Roaming

IMSI: 312530201238934
Test Result: Fail - **Emergency Attach Failure**

14.7 No SIM Card in the Device

Test Result: Fail (Connected, but there only one-way audio). **Voice Path Failure**

14.8 Factory reset or brand-new out of the box Device

Test Result: Fail (Connected, but there only one-way audio). **Voice Path Failure**

15 Summary

Mobile Telephone Handsets are exhibiting inconsistent behavior depending up on the SIM card used.

For example, an AT&T SIM card if inserted in an Apple iPhone X, the Emergency calls were successful in limited services mode (a.k.a. emergency calls only mode) whereas if inserted into a Samsung S9, would not even try to connect to VoLTE for emergency calls.

A Sprint SIM card inserted in a Samsung S9 would successfully complete emergency calls over VoLTE using IPV4, where an Sprint SIM in an Apple iPhone X would require IPV6 for it to complete the same (both in limited services mode)

A GCI (General Communications Inc) SIM card in Apple iPhone X would perform E911 with extra set of SIP parameters, whereas in a Samsung S9 would not even try to connect to VoLTE for making emergency calls in limited services mode.

An OptimERA SIM card in Samsung S9 would do successful emergency calls in both active and limited services mode SIM card, whereas if used in an Apple iPhone X, would only perform successful emergency call in limited services mode. When there is no VoLTE registration in the Apple iPhone X device, but has an LTE registration, the device is looking for a circuit switch network for completing emergency calls.

A Verizon SIM card in both Samsung S9 and an Apple iPhone X would successfully complete the emergency calls in limited services mode.

Both Samsung S9 and Apple iPhone X would perform a successful emergency call when it is brand-new out of the box or right after a full factory reset of the device. But When a SIM card is removed before a reset was performed, they retain the old profile from the previous SIM cards and call behavior is based on that profile. Such as an AT&T SIM card that was preventing VoLTE emergency call in a Samsung S9, once the SIM card is removed, the device continued to behave like as before and will not perform a VoLTE emergency call. This is same for an Apple iPhone X when a Sprint SIM card was removed, it continued to request IPV6 for IP Connectivity hence continue to fail in IPV4 only networks.

Most of the non-Samsung devices in the list failed almost all emergency calls, with a few exceptions. Huawei device would do normal voice calls over VoLTE, but it failed to attach to the SOS APN for VoLTE based emergency calls. The Xaiomi and Essential phones would not connect audio successfully in some cases where the calls show connected on both ends resulting in no audio or one-way audio.

16 Conclusion

Handset behavior is not consistent with outgoing 911 calls. This absolutely must be standardized to make VoLTE the new telephony standard of the 21st century. Based on the results of the test, there is need for oversight of the OEM handsets. Without requiring OEM handset manufacturer's to be held to standards, and comply with GSMA, 3GPP, ATIS and ITU standard for operation, we will have an increase in failed 911 attempts as the country finalizes its transition to VoLTE. Given the test results, it is reasonably likely that 911 failures due to handset VoLTE interoperability problems are already happening.

5G is the next generation of communications, but VoNR (5G Voice) is already shaping up to be fraught with major concerns. In the 10 years VoLTE has been standardized, it hasn't been able to be fully realized because of a lack of standards compliance. Regulation and oversite of how handsets function is needed in order to ensure a smoother transition to 5G voice and keep our national security and emergency response systems intact.

There are currently over 60 Mobile Network Operators (MNOs) in the United States serving millions of customers spread across millions of square miles. These operators (as well as the large operators) rely on an array of products from many vendors in an enormous array of combinations of EPC, RAN, and IMS. Add to that dozens of handset vendors releasing a handful to dozens of products each, and the monumental challenge of interoperability becomes quite clear. This enormous diversity of hardware and software combinations is why adherence to standards is so vital to our communications network. The fact that our very lives often depend on the ability to reach out for help justifies that a fully independent 3rd party testing and certification process by an NRTL is established. Reiterating from the abstract, it is vital to the safety of our country that this be addressed with the utmost urgency.

17 Glossary

APN – Access Point Name, a string of characters (usually letters) used to identify the type of data session requested by a device when connecting to an LTE network. For example, a phone requesting internet access should, per the standard, request the "internet" APN, or for a voice call should use "ims". The APN requested is used by the EPC to determine what features to apply to a given data session, most critically priority.

ACG – Associated Carrier Group, is an industry association of US CDMA cellular network operators.

E-CSCF – Emergency Call Session Control Function, The E-CSCF in the IMS core network that handles certain aspects of emergency sessions, e.g. routing of emergency requests to the correct emergency center or PSAP.

eNB – E-UTRAN Node B, also known as Evolved Node B, is a node in the LTE network that wirelessly connects the mobile handsets to the LTE and VoLTE network.

EPC – Evolved Packet Core, the "network switch" for a mobile network.

HSS – Home Subscriber Server, the user database that contains the identifying security details to permit authentication of devices on the network.

IMSI – International Mobile Subscriber Identity (IMSI) is a unique number, usually fifteen digits, associated with 3GPP network mobile phone users. The IMSI is a unique number identifying a subscriber.

IMEI – International Mobile Equipment Identity, is a unique number identifying a mobile device or a cellular telephone usually in the 3GPP supported networks.

IMS – IP Multimedia Core Network Subsystem, a system required for SMS, MMS, voice, video and other types of communications protocols on a packet switched network.

LRF – Location Retrieval Function. In the 3GPP IMS, the LRF retrieves location information for users that have initiated an emergency session. This location information is provided to the E-CSCF (Emergency CSCF) in order to facilitate routing of the call to a suitable PSAP (Public Safety Answering Point)

MGCF – Media Gateway Controller Function is a SIP endpoint that does call control protocol conversion between SIP and ISUP/BICC and interfaces with the SGW over SCTP. It also controls the resources in a Media Gateway (MGW) across an H. 248 interface

MGW – Media GateWay is a translation device or service that converts media streams between disparate telecommunications technologies such as old telephony networks, IP, TDM (such as T1s).

MME – Mobility Management Entity. MME is responsible for initiating paging and authentication of the mobile device

MSISDN – Mobile Subscriber ISDN Number, also known as Mobile Directory Number, the telephone number associated with a SIM card or a User Device.

P-CSCF – Proxy Call Session Control Function, is a SIP proxy that is the first point of contact for the IMS terminal. In some network deployment, a P-CSCF also functions as SBC (Session Boarder Controller), which acts as a gateway into the SIP/VoIP network.

PCRF – Policy and Charging Rules Function, a software node that provides real time policy decisions for the network.

PDN – Packet Data Network

PGW – Packet Data Network Gateway, the network element that provides connectivity form the UE to the external packet data networks (e.g. the Internet)

PSAP – Public Safety Answering Point, sometimes called "public-safety access point" is a call center where emergency calls (like police, fire brigade, ambulance) initiated by any mobile or landline subscriber are terminated.

RDF – Routing Determination Function, combined with LRF, it determines which PSAP the emergency call be routed to.

SIM – Subscriber Identity Module, a smart card inside a mobile phone, carrying an identification number unique to the owner, storing personal data, and preventing commercial access to a network if removed.

SGW – Serving Gateway, the network element that routes and forward data to the UE on a mobile network

SIP – Session Initiation Protocol, refers to a TCP/IP-based network protocol which can be used to establish and control communication connections of several subscribers. SIP is often used in Voice-over-IP telephony to establish the connection for telephone calls

SOS APN–A very specialized APN which must be present in all networks that all phones must connect to according to the 3GPP standards. When triggered properly, the APN ensures the highest priority on a network, giving the emergency call pre-emption over non-emergency phone calls and data sessions.

UE – User Equipment, often simply a mobile phone. In the Universal Mobile Telecommunications System (UMTS) and 3GPP specification for Long Term Evolution (LTE), user equipment (UE) is any device used directly by an end-user to communicate. It can be a hand-held telephone, a laptop computer equipped with a mobile broadband adapter, or any other device.

18 Attachment A

Below Table shows the test results matrix.

Pass Fail N/A

	Phone	Apple iPhone X		Samsung S9		Xiaomi - Mi 8		Huawei - Mate SE		Essential - PH-1	
	LTE Data on/off	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Provider SIM	**Registration State**										
OptimERA	Registered										
	Emergency Calls Only										
Verizon	Registered										
	Emergency Calls Only										
AT&T	Registered										
	Emergency Calls Only										
Sprint	Registered										
	Emergency Calls Only										
GCI	Registered										
	Emergency Calls Only										
No SIM	Registered										
	Emergency Calls Only										

1. Registration State
    a. “Emergency Calls Only” is the state when a device cannot register with the network but by law must connect to the network in case of emergency.
    b. “Registered” means fully registered on the network, shows full bars and that you have service.