
Metrico Wireless Call Performance

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1 EXECUTIVE SUMMARY

This document presents results of a call performance benchmarking study conducted on 4 handset models on a major US-based network. The field tests were performed from May 18th-June 29th, 2009. Approximately 1500 mobile originated calls (approximately 2250 minutes of call time) were placed on each handset tested. The primary research questions the study sought to answer were:

- Are there quantifiable differences in behavior across handset models in their ability to access the network, particularly in marginal areas?
- Are there quantifiable differences in the ability of each handset model to retain calls once successfully initiated on the network?
- Do the push email capable handsets display poorer Call Initiation and Retention performance when subject to email traffic?

The three principal metrics we used to answer these questions were:

- *Percentage of Failed Calls* experienced by the devices making calls
- *Percentage of Dropped Calls* experienced by the devices making calls
- *The relative performance*, based on the measured KPI and the 90% confidence interval range, *against that of a Reference device*

The **principal conclusions** we were able to draw from this study were:

- **Device B** and **Device C** have a **higher dropped call rate** relative to the Reference device.
- **Device B** has **higher call initiation failure rate** relative to the Reference device.
- **Device C** has **slightly higher call initiation failure rate** relative to the Reference device.
- **Device A** has a **lower call initiation failure** and **dropped call rate** compared to the Reference device.

MULTIRAB Performance Conclusions:

- **Device A** experienced a **200% increase in dropped call rate when receiving emails compared to when not receiving emails**.
- **Device B, Device C** and **the Reference device** also experienced a significant increase in **drop call rates** when receiving emails compared to when not receiving emails. However, the increase for these devices was not as high as the **Device A**.

When reviewing the conclusions it should be noted that only one device of each model under test was available, and thus it is inferred that this handset is truly representative of the average performance of that model.

2 TEST METHODOLOGY

2.1 TEST CONFIGURATION

The four handset models were tested simultaneously, placing calls based on a repeating 2 minute cycle on the network. Testing was performed over 6 days, typically between 9am and 5.30pm, yielding an average of approximately 150-200 calls per handset per day. The devices and airtime were acquired by Metrico.

The handsets are mounted in the vehicle along the front and passenger side windows using standard hands free cradles. The phones are placed a minimum of 12 inches apart and rotated around the cradle positions after approximately every 60 minutes of data collection.

The handsets in the drive vehicle were connected via Metrico's NOMAD automated call sequencer solution which places and terminates calls sending Bluetooth commands via standard pairing with the devices. Calls from the devices are placed to Metrico's local audio server which guarantees call termination with no risk of blocking in the PSTN.

Metrico's NOMAD records all users perceived call metrics such as failed calls, dropped calls, and setup time for all devices.

The call model used for the devices making calls was 90 seconds in call, 30 seconds idle for a total call cycle of 120 seconds. The call sequencing is synchronous, meaning all devices dial simultaneously regardless of individual call outcomes. For example, if a device failed to initiate or retain a call for the full 90 seconds, then that device will wait until the next call cycle to dial along with the other handsets.

In these tests only mobile originated calls were used.

Additional logs are also captured with a Motorola NetMon engineering mode handset to characterize the RF conditions on the two drive routes. Maps of the key RF parameters are provided in the results section of this report

2.2 DRIVE ROUTE

The map below shows the drive route used, the loop (drive time approximately 40 minutes) is primarily 3G coverage, with a number of IRAT handovers and “no coverage” areas. Each loop was driven in total 10-12 times a day in the same direction of travel.

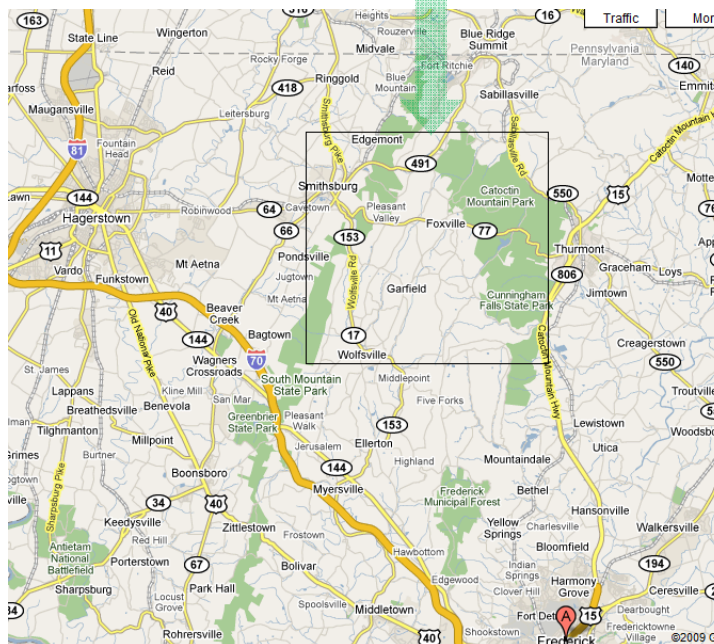
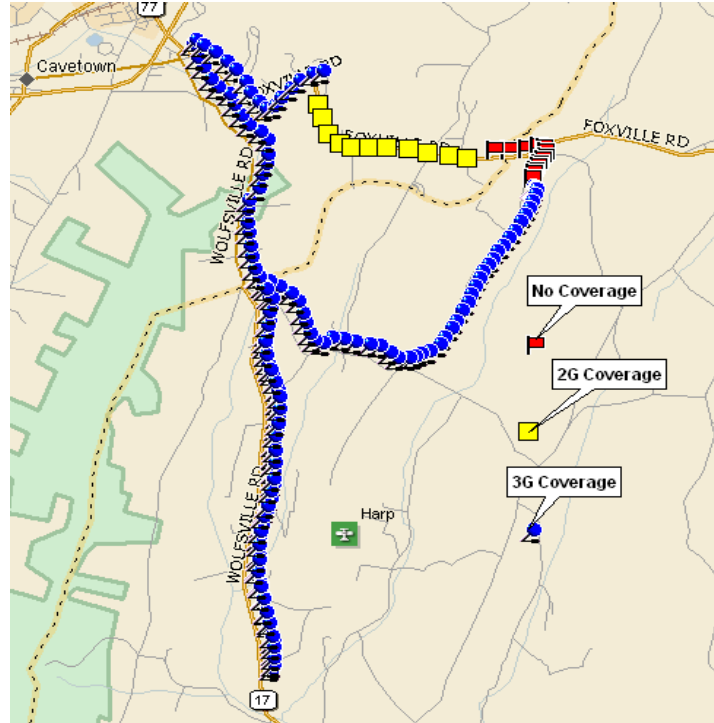


Figure1: Drive Route Loop

The loop was designed to stress the devices in areas of marginal QoS and expose the devices to rapidly changing RF conditions experienced by real world and mobile users. They include a mixture of interference and coverage limited environments and a good volume of IRAT handovers. The methodology can also be extended to include 2nd or minority RAN vendor areas to ensure no interoperability issues impact call performance.

2.3 MULTIRAB TESTING PROCESS

The Test Configuration is the same as described in Section 2.2. The same drive route is used as outlined in Section 2.3. A test email was sent to the email accounts for the above handsets at the rate of 1 email per minute. The size of a test email was less than 1Kb.

2.4 SAMPLE SIZE

A discussion of the sample sizes for each of the metrics is included:

- **Connection Attempts-** The goal was to place 1000 calls for each device, this typically yields a confidence interval of $\pm 1\%$ for the expected failed initiation and dropped call rates. The exact number of connection attempts obtained for each of the test devices was used for calculation of Failed and Dropped Calls percentages. The slight variation in the number of calls placed per device can be attributed to a small number of sporadic Bluetooth connectivity errors, such instances are excluded from the results.
- **Connection Attempts for MultiRAB -**The goal was to place 500 calls for each device, this typically yields a confidence interval of $\pm 1\%$ for the expected failed initiation and dropped call rates. The exact number of connection attempts obtained for each of the test devices was used for calculation of Failed and Dropped Calls percentages. The slight variation in the number of calls placed per device can be attributed to a small number of sporadic Bluetooth connectivity errors, such instances are excluded from the results.
- **Confidence Interval-** A 90% confidence interval was calculated for the failed initiation and dropped call percentages for each device. If the difference between a measured KPI for a device relative to the reference exceeds the confidence bands for two devices then it can be concluded that the results are statistically different.

2.5 NOTES AND OBSERVATIONS FROM DATA COLLECTION

A number of Bluetooth connectivity errors were seen, primarily on Device A, in such circumstances the call sequencer returns a value 'Device Error' for the call. These errors occurred evenly over the duration of the drive route. Further calls were placed on all devices to ensure that the total numbers for all devices exceeded 1000 once the 'Device Error' calls were removed from the analysis. As a consequence the call volumes for Device A are slightly lower than the other devices.

2.6 EVENT DEFINITIONS

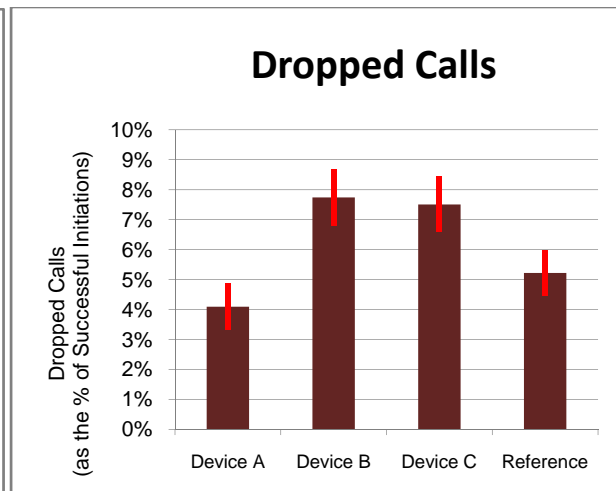
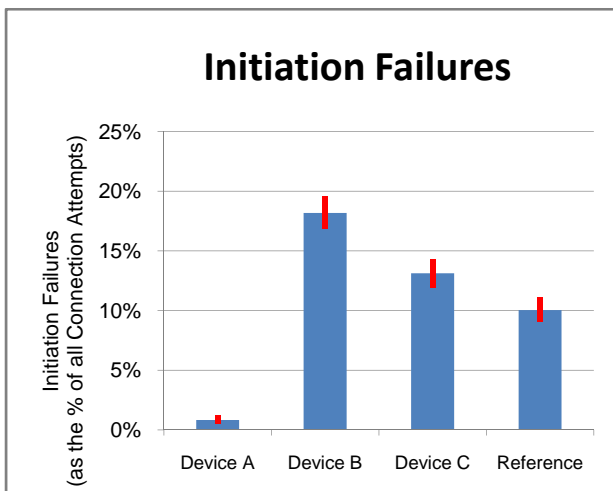
Event	Definition
Successful Initiation	A successfully established call.
Failed Initiation/Call Setup Failures	Any call not successfully established.
Successful Call	A call that is successfully established and which lasts for the expected duration
Dropped Call	A call that is successfully established but which ends before the duration has elapsed.
Call Initiation Failure Rate	The percentage of all connection attempts that result in a call setup failure
Dropped Call Rate	The percentage of all successful initiations which result in a dropped call.
Confidence Interval	$= +/- z(a) * s(p) = 1.282 * s(p)$ where $n =$ connection attempts, $s(p) = \text{SQRT}[(p(1 - p) / (n - 1))]$ $p =$ percentage of failed initiations/drops, $z(a) = z(90\text{th percentile}) = 1.282$

3 TEST RESULTS

3.1 CALL PERFORMANCE SUMMARY (WITHOUT EMAIL)

A summary of the study results are presented below.

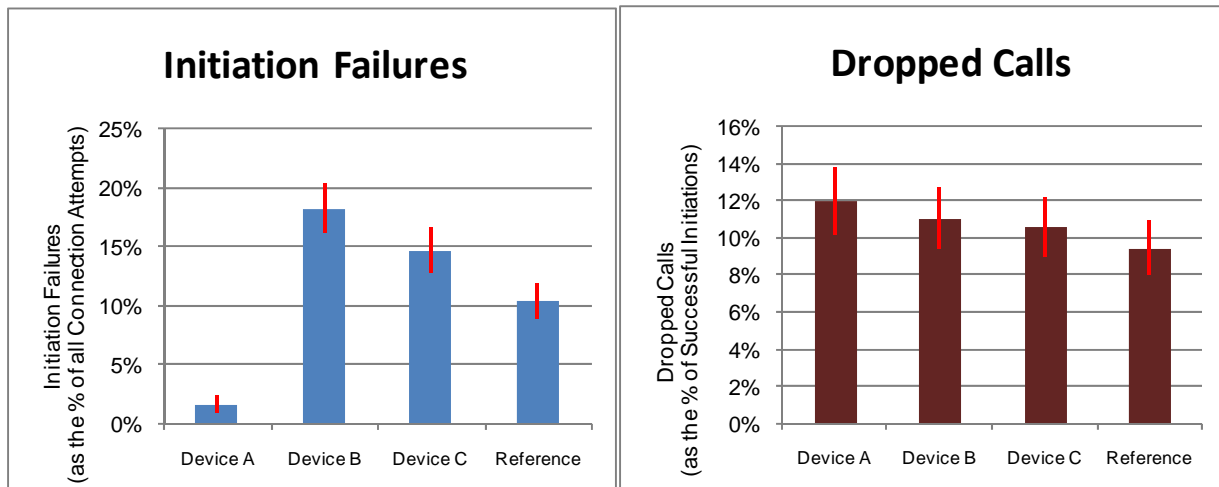
Device Tested	Connection Attempts	Mean Setup Time (s)	Call Initiation Performance		Call Retention Performance	
			Successful Initiations	Failed Initiations	Successful Calls	Dropped Calls
Device A	1083	6.73	99%	1%	96%	4%
Device B	1342	8.33	82%	18%	92%	8%
Device C	1303	8.24	87%	13%	92%	8%
Reference	1384	8.47	90%	10%	95%	5%



- **Device B and Device C** have a **higher dropped call rate** compared to the reference device
- **Device A** has a **lower call initiation failure and dropped call rate** compared to the reference device
- **Device B** has **higher call initiation failure rate** compared to the reference.
- **Device C** has **slightly higher call initiation failure rate** compared to the reference.

3.2 CALL PERFORMANCE SUMMARY (WITH EMAIL – MULTIRAB)

Device Tested	Connection Attempts	Mean Setup Time (s)	Call Initiation Performance		Call Retention Performance	
			Successful Initiations	Failed Initiations	Successful Calls	Dropped Calls
Device A	534	6.74	98%	2%	88%	12%
Device B	564	8.24	82%	18%	89%	11%
Device C	564	8.88	85%	15%	89%	11%
Reference	670	8.88	90%	10%	90%	9%

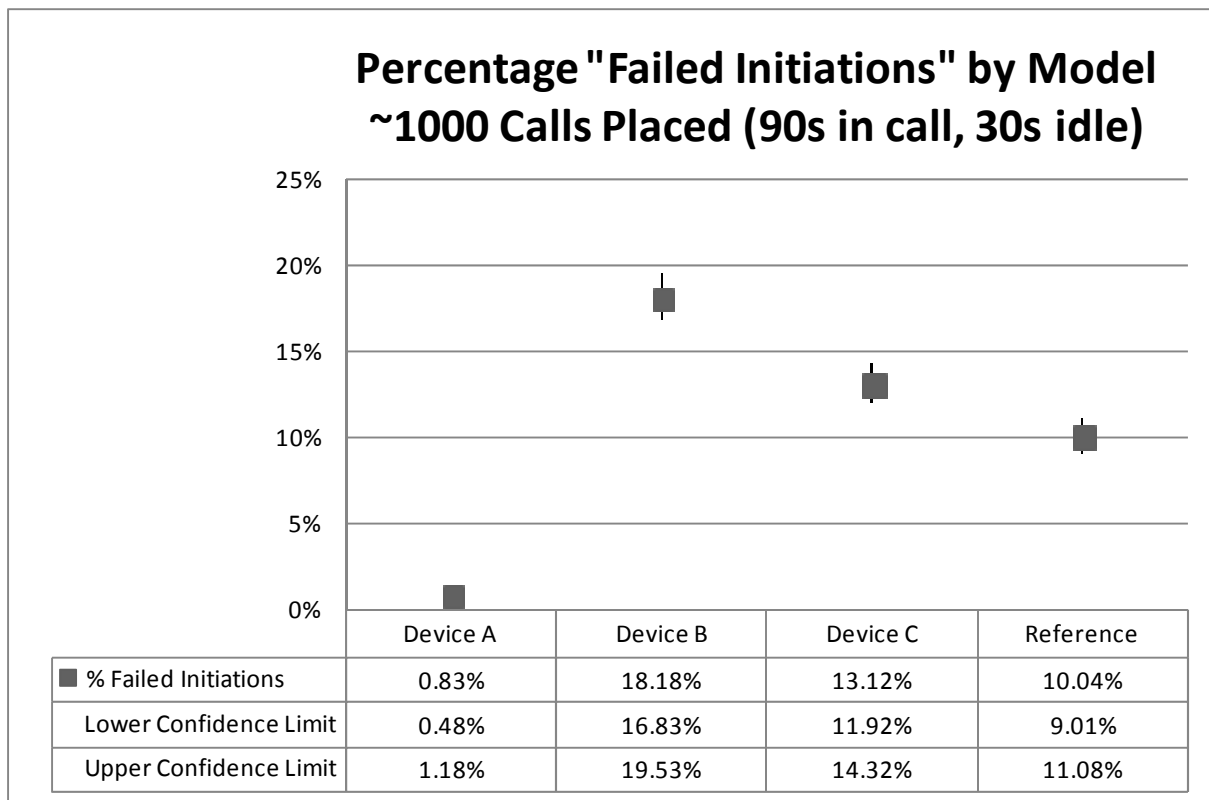


- **Device A has 8% higher DCR (Drop Call Rate) when receiving emails compared to when not receiving emails.**

3.3 CALL INITIATION PERFORMANCE (WITHOUT EMAIL)

The results of the failed initiation analysis are shown below. The 'low' and 'high' values represent the upper and lower ranges of the confidence interval

Test Device	Mean Setup Time (s)	Connection Attempts	Successful Initiations	Initiation Failures					
				Failed Attempts	No Service	Access Timeout	Voicemail	Busy	Fast Busy
Device A	6.73	1083	99%	1%	0%	0%	0%	0%	0%
Device B	8.33	1342	82%	11%	8%	0%	0%	0%	0%
Device C	8.24	1303	87%	13%	0%	0%	0%	0%	0%
Reference	8.47	1384	90%	0%	10%	0%	0%	0%	0%

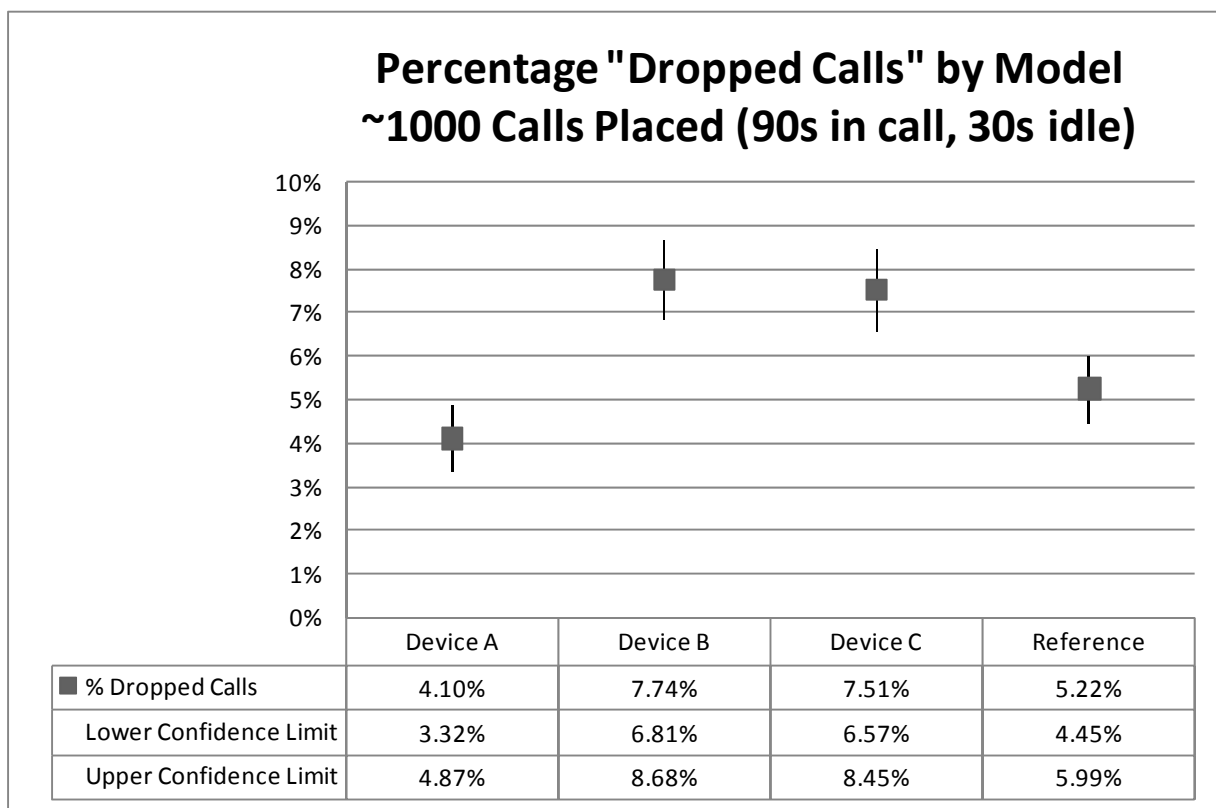


- **Device B** has **higher call initiation failure** rate compared to the reference.
- **Device C** has **slightly higher call initiation failure** rate compared to the reference.
- **Device A** has a **lower call initiation failure** rate compared to the reference device

3.4 CALL RETENTION (WITHOUT EMAIL)

The call retention results are shown below. The 'low' and 'high' values represent the upper and lower ranges of the confidence interval.

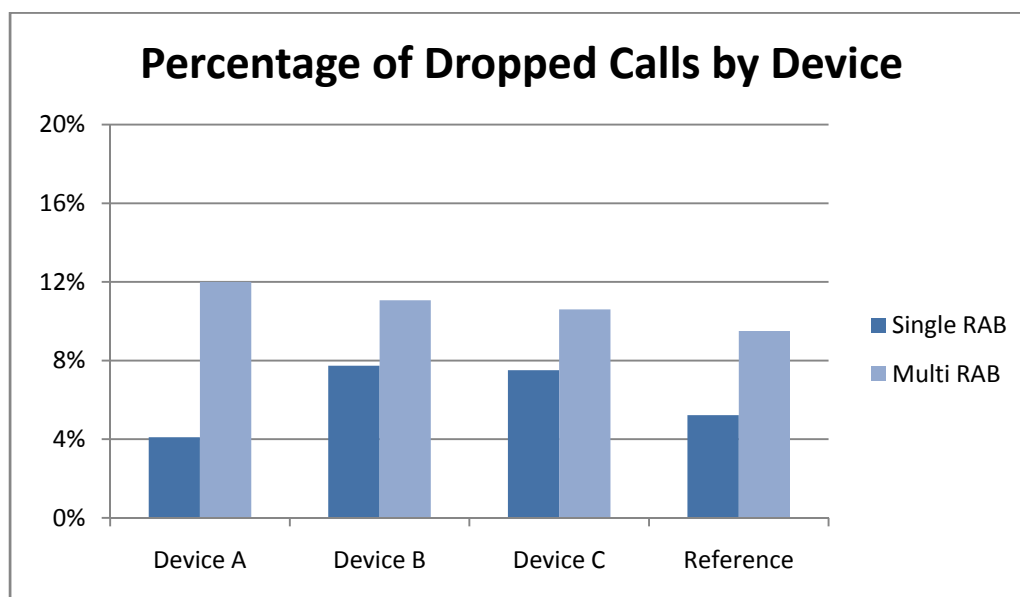
Test Device	Connection Attempts	Successful Initiations	Dropped Calls	Dropped Call Rate (%)	Confidence Interval
Device A	1083	1074	44	4%	0.8%
Device B	1342	1098	85	8%	0.9%
Device C	1303	1132	85	8%	0.9%
Reference	1384	1245	65	5%	0.8%



- **Device B** and **Device C** have a **higher dropped call rate** compared to the reference device
- **Device A** has a **lower dropped call rate** compared to the reference device

3.5 CALL RETENTION PERFORMANCE COMPARISON (WITH EMAIL – MULTI-RAB vs. WITHOUT EMAIL)

Test Device	No EMAIL traffic	With EMAIL traffic (1 per min)	MultiRAB Effect
Handset Models	Dropped Call Rate (%)	Dropped Call Rate (%)	% INCREASE in DCR
Device A	4.1%	12.0%	192.9%
Device B	7.7%	11.1%	42.9%
Device C	7.5%	10.6%	41.2%
Reference	5.2%	9.5%	82.0%



- **Device A** experienced a **200% increase in dropped call rate (DCR) when receiving emails as compared to when not receiving emails.**
- **Device B, Device C and the Reference** experienced **significantly lower increase in drop call rates** compared to **Device A** when receiving emails compared to when not receiving emails.

3.5.1 Statistical Considerations:

Comparison between Call Performance Results for testing performed without email (Single RAB) and testing performed with email (MultiRAB) can be made because of the repeatability of the individual tests.

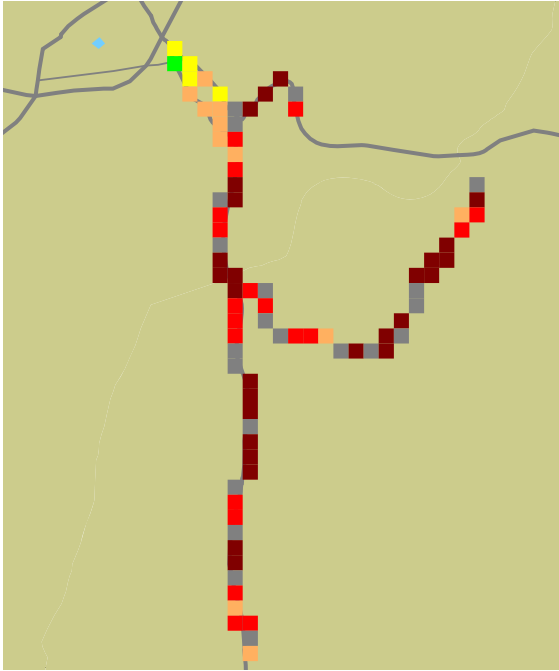
The repeatability of the tests is an outcome of the test design which calls for a statistically significant sample size collection. A Confidence Interval of +/- 1% of the results is obtained at 90% Confidence with the sample size collected for the respective tests.

The statistically similar results for Call Initiation Failure rates across the 2 experiments for all test devices is a evidence of the repeatability of the tests.

4 ENGINEERING DATA

4.1 ENGINEERING DATA (3G COVERAGE)

RSCP



EcNo

