Independent Communications Authority of South Africa

350 Witch-Hazel Avenue, Eco Point Office Park
Eco Park, Centurion.
Private Bag X10, Highveld Park 0169
Telephone number: (012) 568 3000/1

2018/2019 Quarter 4:

Voice Quality of Service

Report –

Western Cape Province

Table of Contents

List of Abbreviations

CSFB	Circuit Switched Fall Back
CSSR	Call Setup Success Ratio
DCR	Drop Call Ratio
GSM	Global System for Mobile Communications
ICASA	Independent Communications Authority of South Africa
KPI	Key Performance Indicator
LTE	Long-Term Evolution
R&S	Rohde & Schwarz
MOS	Mean opinion score
POLQA	Perceptual Objective Listening Quality Analysis
UMTS	Universal Mobile Telecommunications Service
VoLTE	Voice over Long-Term Evolution

List of Figures

List of Tables

1. Executive Summary

The Independent Communications Authority of South Africa (ICASA) contracted ATIO Corporation (Pty) Ltd to conduct Quality of Service (QoS) measurements on the networks of mobile operators; Cell C, MTN, Telkom and Vodacom. The measurements were performed to monitor performance of mobile voice services offered by the operators in the Western Cape Province. The measurements were carried out in the period of 25 January 2019 to 12 February 2019, covering a total distance of 3280 kilometres.

The purpose of performing QoS measurements was to monitor and analyse the quality of mobile voice service as experienced by the end-user. The results were later benchmarked against the QoS standard set by the Authority. The measurements were conducted in areas and in circumstances where mobile voice service is likely to be accessed. These areas include towns, townships, farm areas, rural areas, and economic activity nodes.

A vehicle equipped with Rohde and Schwarz Smart Benchmarker II measurement tool including 24 mobile phones which were used to collect data in mobility conditions. The four Key Performance Indicators (KPIs) used to evaluate QoS are Retainability, Accessibility, Call Setup Time and Speech Quality. The Drop Call Ratio (DCR) KPI is used to measure a user's ability to successfully complete a call and Call Setup Success Ratio (CSSR) KPI measures a user's ability to make a phone call.

According to the End-User and Subscriber Service Charter regulations of 2016, DCR should be less than 3% and CSSR should be greater than 98%. Call Setup Time must be less than 20 seconds and the score for Speech Quality must be greater than 3.

Cell C, MTN and Vodacom met the overall CSSR target of more than 98%, whereas Telkom failed to meet the target. MTN and Vodacom are the only operators that met the overall DCR target of less than 3% and thus meeting the Authority's Retainability target. All operators achieved Call Setup Time target of less than 20 seconds according to the End-User and Subscribers Service Charter Regulation of 2016. For the speech quality (Mean Opinion Score) results, all operators except Telkom met the overall speech quality target of score above 3.

2. Introduction

ICASA's mission is to ensure that all South Africans have access to a wide range of high-quality communication services at affordable prices[1]. The Authority ensures the quality of service through its Quality of Service (QoS) monitoring activities. In order to monitor the QoS, ICASA contracted ATIO Corporation (Pty) Ltd to conduct drive testing in selected areas of the Western Cape Province. The test was focused on monitoring the cellular voice telephony service being offered by MTN, Vodacom, Cell C and Telkom within the Western Cape Province of South Africa.

The QoS monitoring was conducted in the following areas within the District Municipalities; Eden, Cape Winelands and West Coast. The selected areas include: George, Malmesbury, Paarl, Saldanha and Worcester. The areas consist of major towns, townships, farm areas, rural areas, major road arteries, economic activity nodes and areas of previous complaints. Figure 1 depicts the routes which were driven in the Western Cape Province.

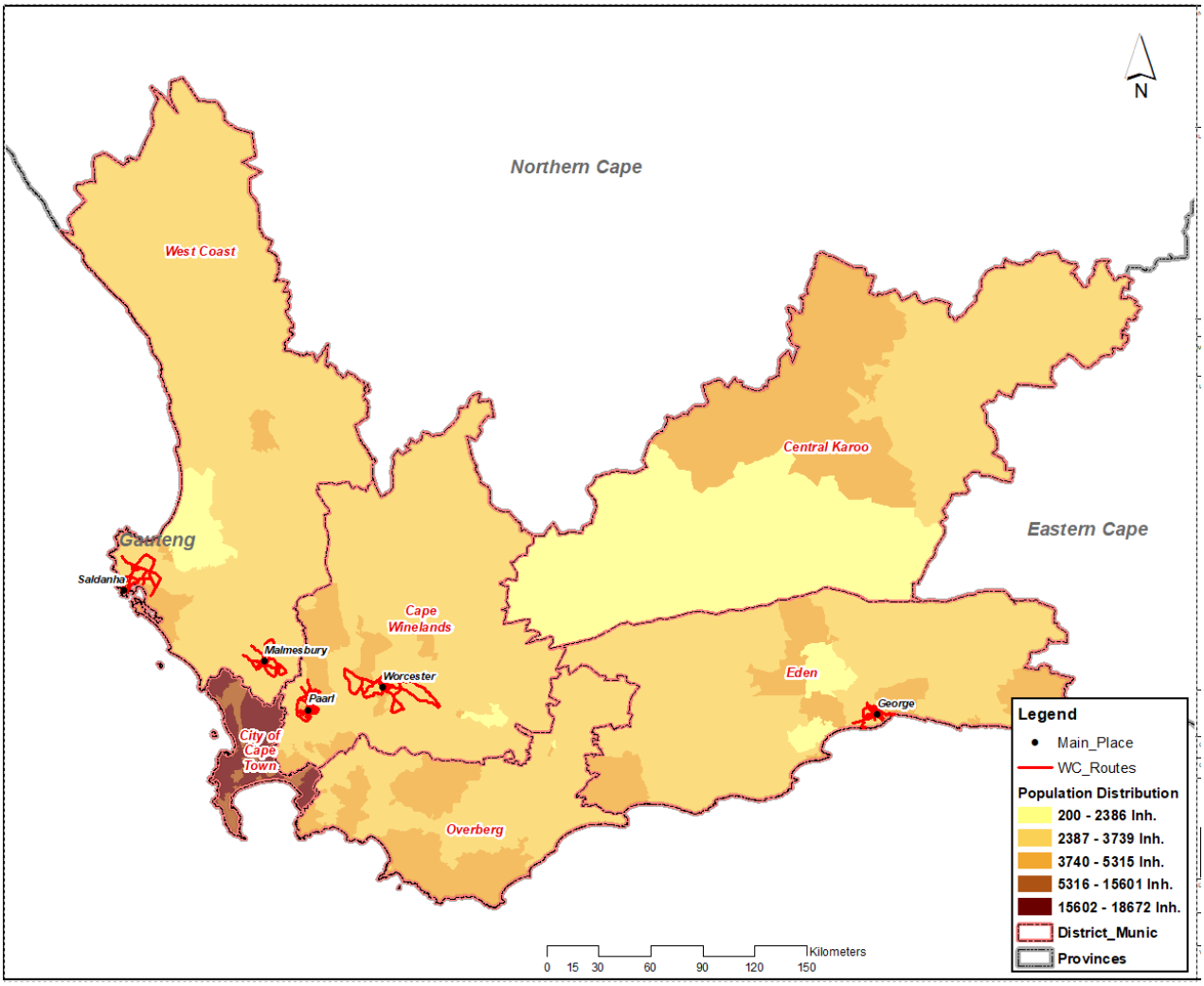


Figure 1. Western Cape Province Route Map

[1] **ICASA Strategic Plan 2016/17-2021**

QoS is defined as the collective effect of service performance that determines the degree of satisfaction a user derives from a service. It provides an indication of what a customer experiences when using a mobile network and is evaluated in terms of Call Accessibility, Call Setup Time, and Call Retainability and Speech Quality parameters. These parameters are described briefly below:

a) Call Accessibility is defined as a percentage and is a measure of the number of times a user is able to successfully establish a call as a percentage of the total calls attempted. It is measured using Call Setup Success Ratio (CSSR).
b) Call Setup Time is the time interval from the instant a user initiates a network connection request until a complete message indicating call disposition is received by the calling terminal. It is measured from the time a user presses the dial button until the user gets connected to the dialled party.
c) Retainability is defined as the ability for a call to stay connected through to a normal call tear-down process, without abnormally disconnecting from the cell site that caries the call. It is measured using Drop Call Ratio (DCR).
d) Speech Quality is the condition of conversational speech without noise and echo interference.

3. Methodology

A minimum of 120 test samples per network operator were collected, except in the areas where services were limited on most parts of the drive test route. A drive-test sampling methodology which provides a snapshot view of the mobile operator's quality of service was adopted. It provides a realistic picture of network performance from a user's point of view. The method adopted provides a snapshot of an operator's network performance on the selected routes and a particular time of the day.

Voice test set-up consisted of two categories which are short call (accessibility) and long call (retainability), and each category required two items of end-user equipment (UE) i.e. call initiating side (A-side) and call receiving side (B-side). This set-up results in four UEs per operator resulting in sixteen UEs for four operators in one drive test vehicle. The Call Window was set up as follows: Call duration + 30 seconds (for the setup and release phases) + 30 seconds (for the minimum pause interval). The default call duration was set at 120 seconds for Long Call and results in 180 seconds call window and call duration for Short Call was set at 10 seconds resulting in 70 seconds call window. The audio quality of speech samples was evaluated using the HD-voice capable and ITU standardized POLQA wideband algorithm.

The devices were set to measure the best available technology and barred from making VoLTE calls, thus in the areas where operators had LTE they performed Circuit Switched Fall Back (CSFB) calls. CSFB allows terminal/mobile phones connected on LTE to use GERAN or UTRAN to connect to the CS domain mainly for voice calls.

Voice testing was done in two phases with a measurement window gap of at least seven days in between both measurements.

3.1. Short & Long Call

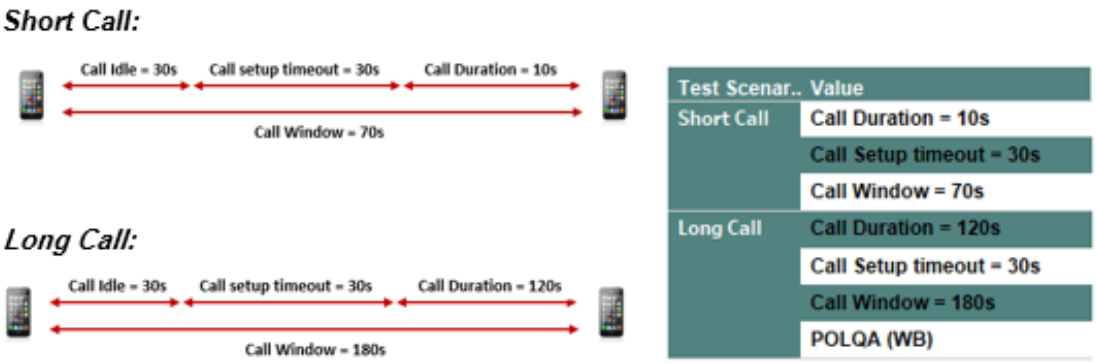


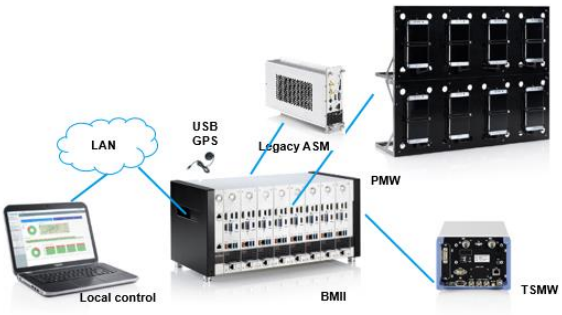
Figure 2. Call Window

Figures 2 depicts the call window for both Short Call and Long Calls scenarios together with call stages.

3.2. Equipment test setup and configuration

3.2.1. System used

The Test Equipment utilised was the R&S SwissQual Benchmarker II platform with Sony XZ Premium smartphones installed inside the car using the R&S Phone Mount Walls.



3.2.2. Device Used

The Sony XZ Premium Smartphone was selected as the measurement UE for Voice and Data Services. It uses the Qualcomm Snapdragon 835 chipset and supports the following technologies; GSM, WCDMA, LTE & LTE-A.

3.2.3. Device Specification

Table 1 depicts device specification:

Table 1: Device Specification

Technology	Info
Data:	LTE-A Pro Cat 16 (1000/150 Mbit/s), HSDPA+ (4G) 42.2 Mbit/s, HSUPA 5.76 Mbit/s, UMTS
GSM:	850, 900, 1800, 1900 MHz
UMTS:	800, 850, 900, 1700/2100, 1900, 2100 MHz
LTE (FDD):	Bands 1, 2, 3, 4, 5, 7, 8, 12, 13, 17, 19, 20, 26, 28, 29, 32
LTE (TDD):	Bands 38, 39, 40, 41
Processor:	Octa-core, 2450 MHz, Kryo 280 and ARM Cortex-A53, 64-bit
System chip:	Qualcomm Snapdragon 835 MSM8998
Qualipoc version:	18.0.0.63

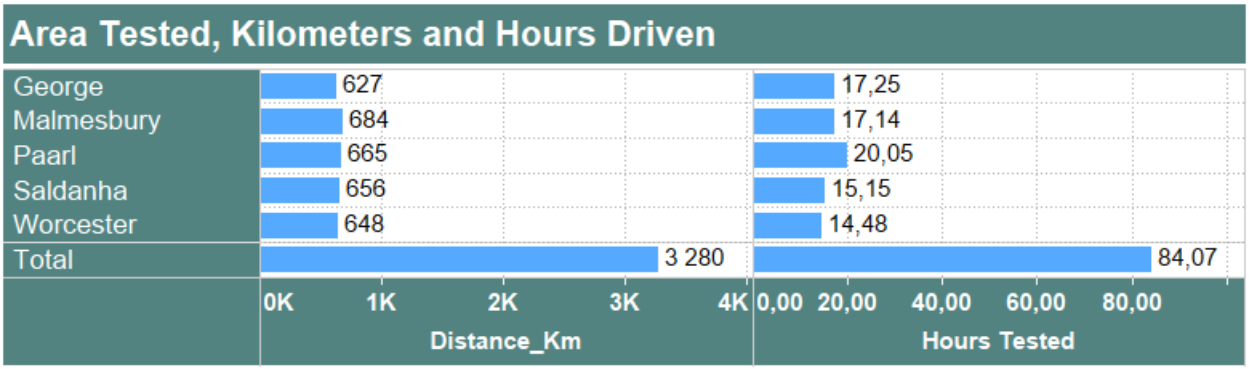
3.3. Route selection

The areas and routes that were tested are shown in Table 2 including the dates driven. The distance travelled, and active measurements time are shown in Table 3:

Table 2: Test timelines for areas covered

Routes and Dates			
District	**Area**	**Date**	**Test Type**
Eden	George	2019/01/25	Phase 1
		2019/02/05	Phase 2
Cape Winelands	Worcester	2019/01/27	Phase 1
		2019/02/07	Phase 2
	Paarl	2019/01/29	Phase 1
		2019/01/30	Phase 1
		2019/02/04	Phase 1
		2019/02/08	Phase 2
West Coast	Malmesbury	2019/01/30	Phase 1
		2019/01/31	Phase 1
		2019/02/11	Phase 2
	Saldanha	2019/02/02	Phase 1
		2019/02/12	Phase 2

Table 3: Area Tested, Kilometers and Hours Driven per area



3.4. Measurement parameters and targets

3.4.1. Targets

According to the End User and subscriber Service Charter Regulations of 2016, the following targets have been set as the measurement parameters for the following services:

1. Call Setup Success Ratio – Average Call Setup Success Ratio must be greater than 98%;
2. Call Setup Time Ratio – Average Call Setup Time must take less than 20 seconds;
3. Drop Call Ratio – Average Drop Call Ratio must be less than 3%;
4. Speech Quality – Average Speech Quality of MOS must be greater than 3.[2]

3.4.2. Call Setup Success Ratio [%]

The Call Setup Success Ratio (CSSR) is the percentage of calls that are successfully set up as a percentage of the total call attempts.

The formula to calculate CSSR is shown below:

CSSR = Y/X *100

Where, Y represents the calls that are call established successfully and X is the total number of call attempts.

3.4.3. Drop Call Ratio [%]

Dropped Call Ratio (DCR) is the proportion of incoming and outgoing calls, which, once correctly established and therefore having been assigned a traffic channel, are dropped or interrupted prior to the deliberate completion by the user.

The formula to calculate DCR is shown below:

DCR= D/S*100

Where, D represents number of dropped calls and S is the number of successful calls established

3.4.4. Call Setup Time [s]

Call Setup Time refer to the time interval from the moment a user initiates a network connection request until a complete message indicating call disposition is received by the calling terminal. It is measured from the time a user presses the dial button until the user gets connected to the dialled party.

3.4.5. Speech Quality (MOS)

Speech quality on call basis is an indicator representing the end-to-end speech transmission quality of the mobile telephony service. This parameter computes the speech quality on the basis of completed calls.

[2] https://www.icasa.org.za/uploads/files/39898_1-4_Icasa.pdf

Measurements made use of the POLQA Algorithm which compares the reference signal received from the transmitting side against an equivalent sample on the receiving side.

4. Results and Analysis

This section provides a summary of the mobile operators' performance results based on the drive test route in the following test areas: George, Malmesbury, Paarl, Saldanha and Worcester.

4.1. Voice KPI Results

Table 4: Overall voice KPI results

		MTN	Vodacom	Cell C	Telkom
Short Call	Call Attempt	4251	4288	4220	4228
	Call Failed	44	66	73	194
	Successfull Attempts	4207	4222	4147	4034
	Call Dropped	0	0	0	0
	Call Complete	4207	4222	4147	4034
	Call Setup Success Rate [%]	98,96	98,46	98,27	95,41
	Call Setup Time [s]	4,44	4,68	4,16	6,88
Long Call	Call Attempt	1699	1708	1756	1778
	Call Failed	34	50	68	178
	Successfull Attempts	1665	1658	1688	1600
	Call Dropped	24	11	58	49
	Call Complete	1641	1647	1630	1551
	Call Drop Rate [%]	1,44%	0,66%	3,44%	3,06%
	POLQA MOS	3,56	3,72	3,29	2,98

Table 4 shows the overall voice measurement results for both Short and Long Calls scenarios. CSSR and Call Setup Time were measured in Short Call scenario. The DCR and POLQA MOS KPIs were measured in Long Call scenario. Results which are coloured in red indicate that the operator did not meet the target set by the Authority. Appendix 1 shows operator results per route per phase tested.

The results in Table 4 show that Telkom failed to achieve the Call Setup Success Ratio target as per regulations. All operators were however, able to achieve the Call Setup Time target and for the Drop Call Ratio target only MTN and Vodacom achieved the target. It can also be observed that MTN, Vodacom and Cell C achieved the speech quality target of above 3 and only Telkom did not achieve the target.

4.1.1. Voice KPIs per Area

Table 5 shows voice call measurement results for each route per operator. In George all the operators met the targets in all the voice KPIs. In Paarl, all the operators failed to meet the CSSR target, and Cell C was the only operator that failed to meet DCR target. In Malmesbury, MTN was the only operator that met CSSR target and for DCR, MTN and Vodacom are the only operators that met the target. For speech quality (MOS) in all of the areas tested, Telkom was the only operator that did not meet the target in Malmesbury and Worcester.

Table 5: Summary of results per Area

		George	Malmesbury	Paarl	Saldanha	Worcester
Call Setup Success Rate - [%]	MTN	99,33%	99,04%	97,95%	99,48%	99,32%
	Vodacom	99,89%	97,75%	97,28%	99,36%	98,23%
	Cell C	99,67%	97,76%	96,35%	99,61%	98,38%
	Telkom	98,12%	92,18%	95,06%	96,12%	95,68%
Drop Call Ratio [%]	MTN	0,88%	2,72%	1,52%	1,31%	0,69%
	Vodacom	0,00%	0,90%	1,53%	0,00%	0,69%
	Cell C	1,44%	7,18%	3,06%	2,27%	3,08%
	Telkom	1,47%	6,77%	1,84%	2,29%	3,24%
Call Setup Time [s]	MTN	5,38	4,24	4,14	4,20	4,19
	Vodacom	4,70	4,57	4,80	4,48	4,84
	Cell C	3,92	4,28	4,22	4,08	4,34
	Telkom	6,73	6,87	7,21	6,45	7,05
POLQA MOS	MTN	3,72	3,51	3,50	3,54	3,50
	Vodacom	3,71	3,70	3,73	3,80	3,68
	Cell C	3,00	3,26	3,50	3,26	3,42
	Telkom	3,01	2,93	3,00	3,03	2,89

4.1.2. Call Accessibility (Short call)

Table 6 shows number of samples collected per area for Short Call scenario.

Table 6: Short Call sample size per Area

		George	Malmesbury	Paarl	Saldanha	Worcester
Call Attempt	MTN	896	832	1 024	765	734
	Vodacom	897	846	1 028	781	736
	Cell C	900	802	1 014	764	740
	Telkom	851	831	1 032	774	740
Call Failed	MTN	6	8	21	4	5
	Vodacom	1	19	28	5	13
	Cell C	3	18	37	3	12
	Telkom	16	65	51	30	32
Call Dropped	MTN	0	0	0	0	0
	Vodacom	0	0	0	0	0
	Cell C	0	0	0	0	0
	Telkom	0	0	0	0	0
Call Complete	MTN	890	824	1 003	761	729
	Vodacom	896	827	1 000	776	723
	Cell C	897	784	977	761	728
	Telkom	835	766	981	744	708

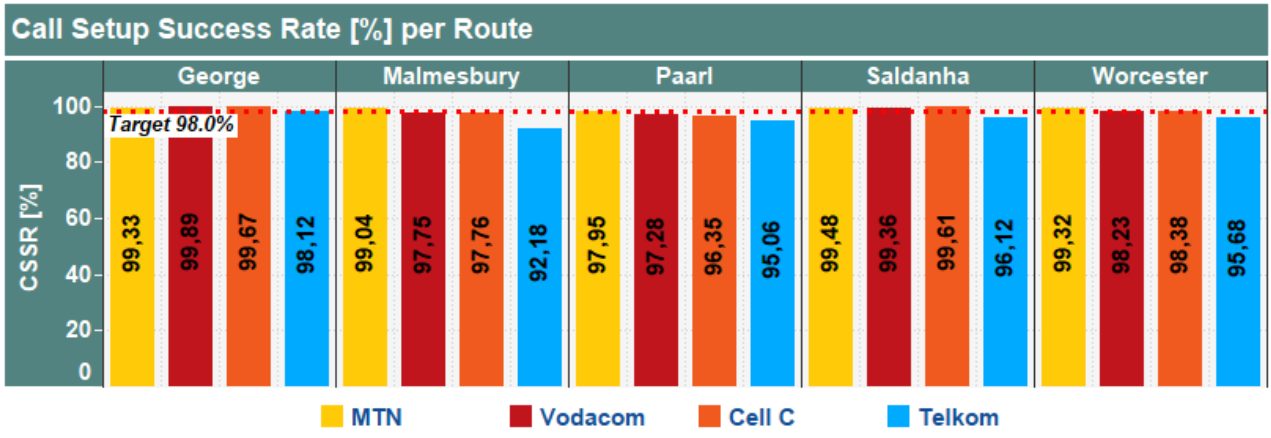


Figure 3. CSSR KPI per Area

Figure 3 shows that all operators met 98% CSSR target in George. Telkom only met the CSSR target in George and failed to meet the target in other areas which were tested. All operators failed to meet the CSSR target in Paarl.

4.1.3. Drop Call Ratio (Long call)

Table 7 shows number of samples collected per area for Long call scenario.

Table 7: Long Call samples per Area

		George	Malmesbury	Paarl	Saldanha	Worcester
Call Attempt	MTN	343	337	418	307	294
	Vodacom	340	340	429	306	293
	Cell C	348	362	439	310	297
	Telkom	354	394	428	330	272
Call Failed	MTN	1	6	22	1	4
	Vodacom	0	8	36	4	2
	Cell C	1	14	47	1	5
	Telkom	13	69	47	24	25
Call Dropped	MTN	3	9	6	4	2
	Vodacom	0	3	6	0	2
	Cell C	5	25	12	7	9
	Telkom	5	22	7	7	8
Call Complete	MTN	339	322	390	302	288
	Vodacom	340	329	387	302	289
	Cell C	342	323	380	302	283
	Telkom	336	303	374	299	239

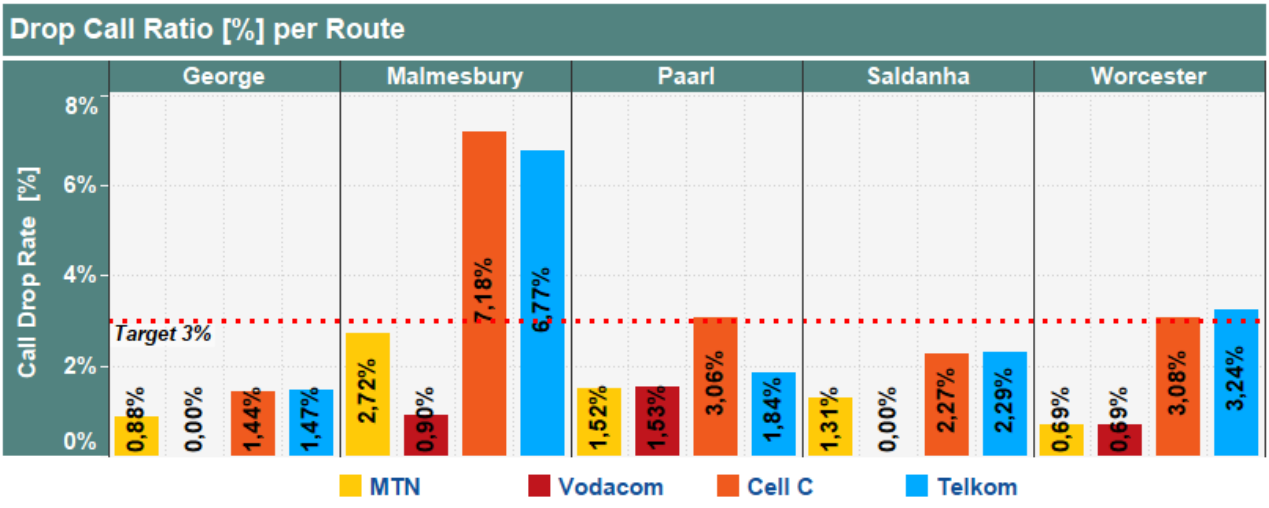


Figure 4. DCR KPI per Area

Figure 4 shows that all operators met the DCR KPI target in George and Saldanha. Vodacom and MTN are the only operators that met the DCR target in Malmesbury and Worcester. MTN, Vodacom and Telkom achieved the DCR target in Paarl; whilst Cell C failed to meet the DCR target.

4.1.4. Voice Call Setup Time (Short call)

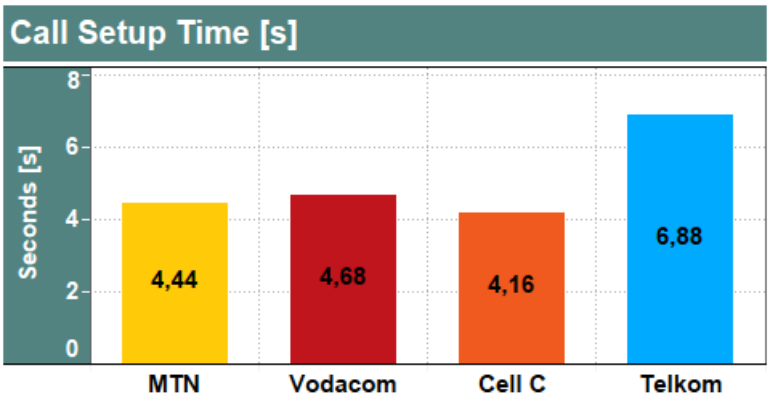


Figure 5. Call Setup Time [s] KPI Overall

Figure 5 shows the overall results for Call Setup Time. Cell C had the lowest overall Call Setup Time, followed by MTN, Vodacom and Telkom in ascending order.

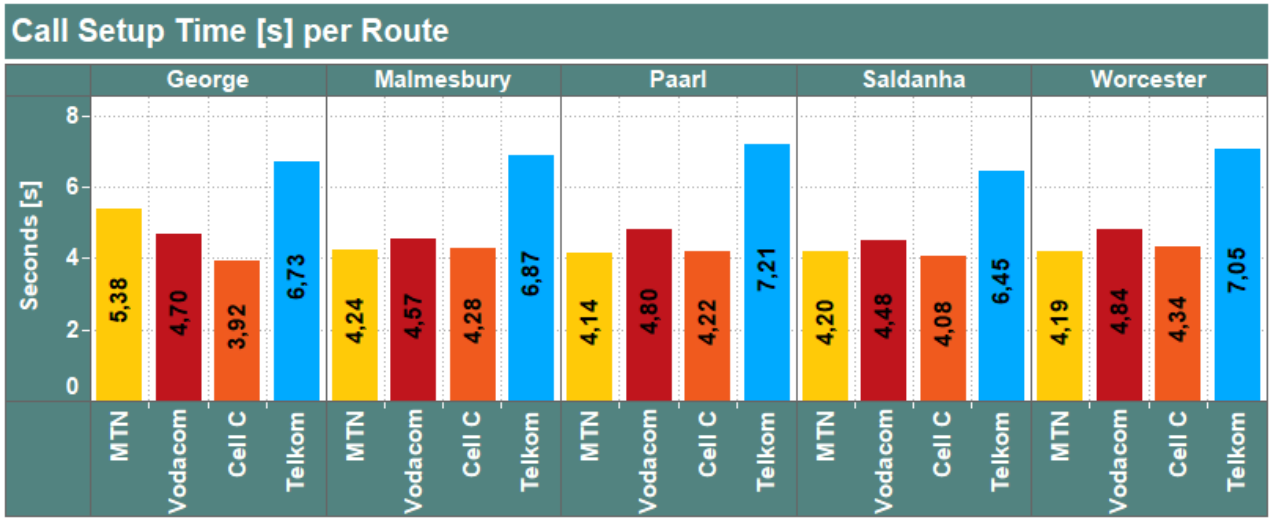


Figure 6. Call Setup Time [s] KPI per area

Figure 6 shows that all operators met the Call Setup Time target of less than 20 seconds as per the End-User and Subscribers Service Charter Regulations of 2016.

4.1.5. POLQA MOS (Long call)

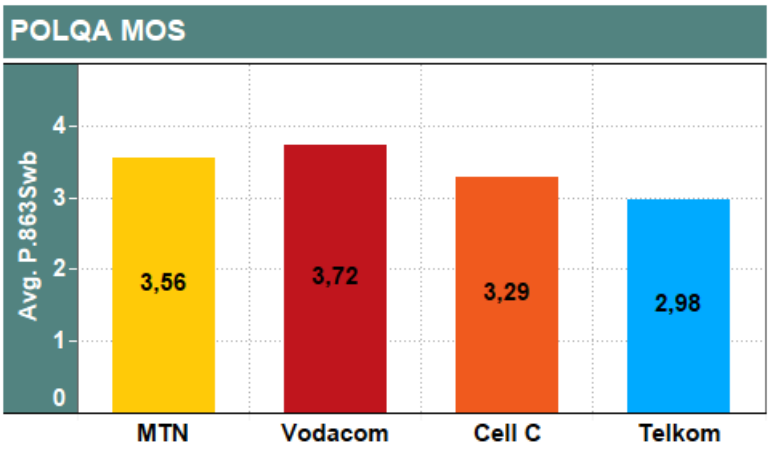


Figure 7. Speech quality overall results

Figure 7 shows that Vodacom achieved the best Speech Quality followed by MTN, Cell C and Telkom in the descending order.

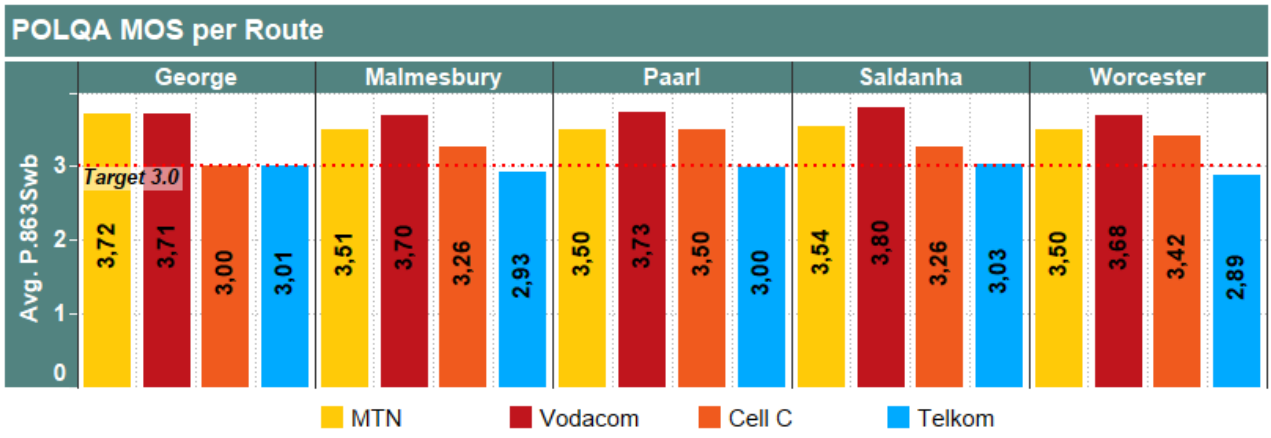


Figure 8. Speech Quality per Area

Figure 8 depicts speech quality results per tested area. All operators achieved an average speech quality (MOS) of over 3 in George, Paarl and Saldanha. MTN, Vodacom and Cell C also met the target for speech quality In Malmesbury and Worcester whilst Telkom failed to meet the target in these areas.

4.1.6. Radio Technology (Long call)

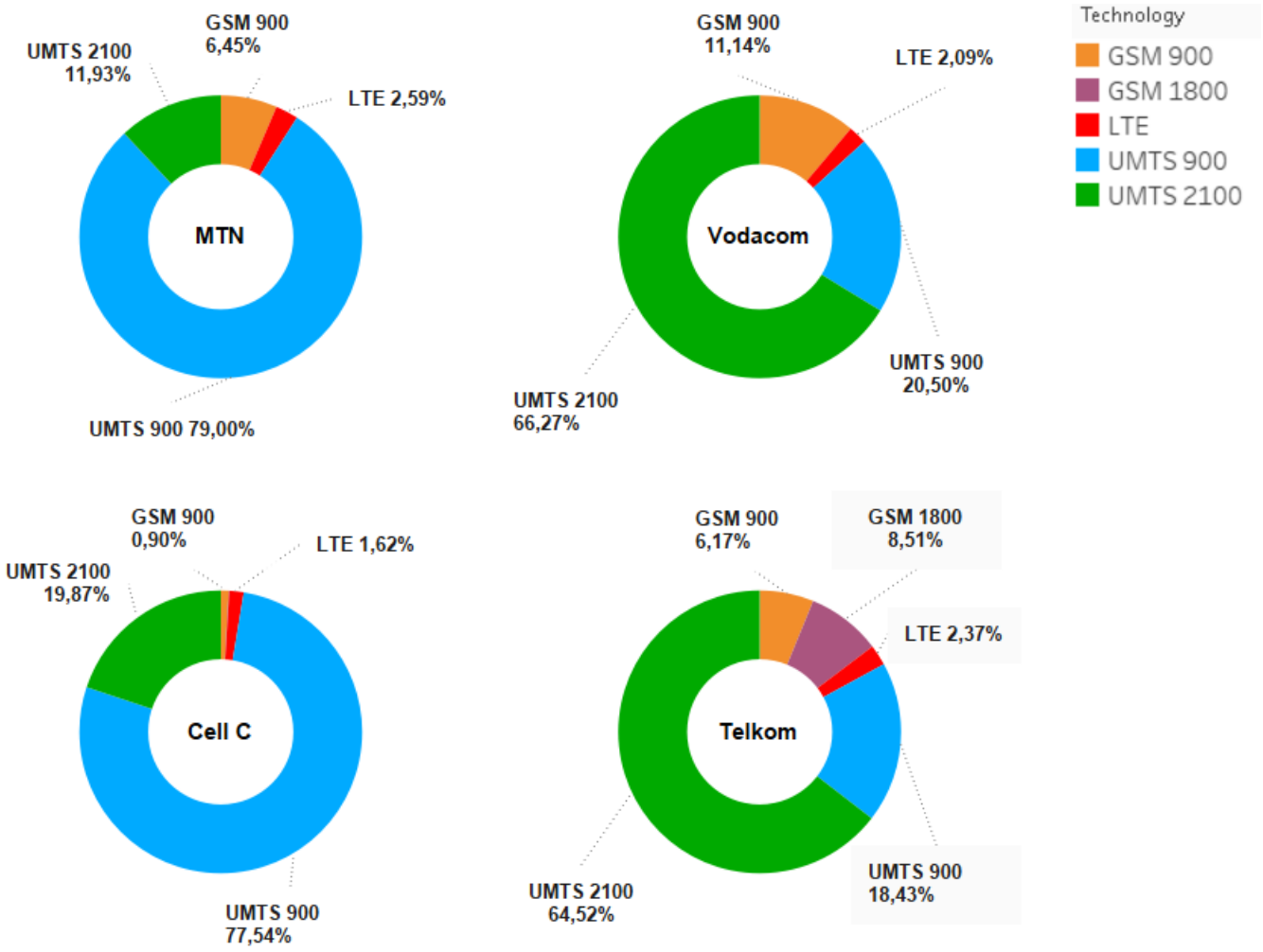


Figure 9. Radio technology

Figure 9 shows the distribution of the serving technology during the drive test. The serving technology distribution is based on the device used and the network parameter configuration which varies with the mobile operators. All operators' serving technology was mainly on UMTS technology, with MTN and Cell C predominantly serving on UMTS900 whilst Vodacom and Telkom are predominantly serving on UMTS2100.

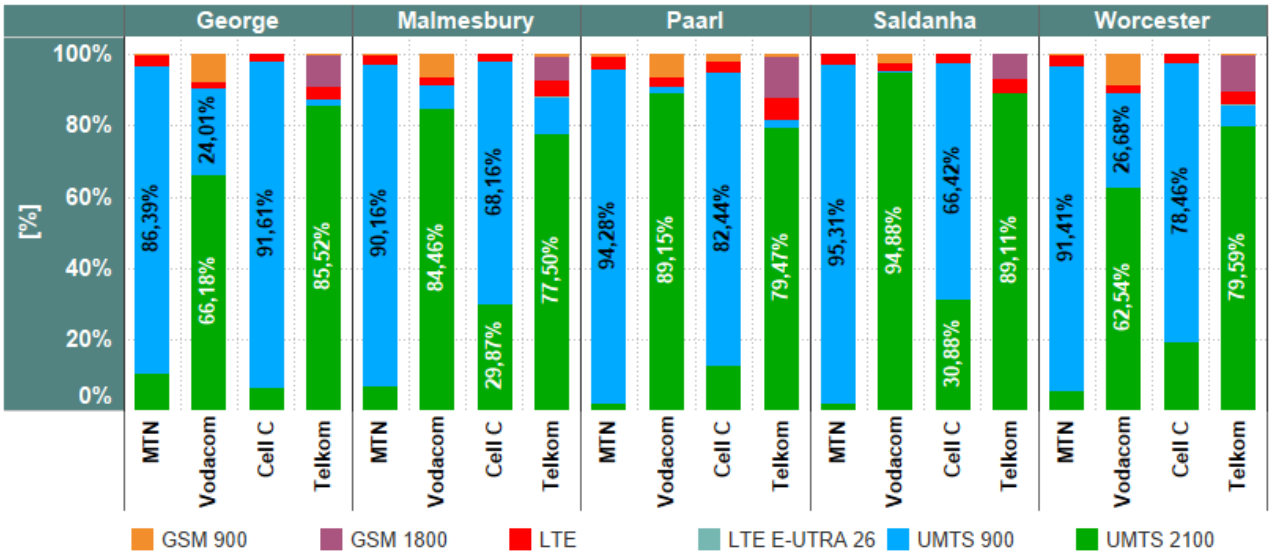


Figure 10. Radio technology per Area

Figure 10 shows the distribution of the serving technology during the drive test per Area.

4.1.7. CSFB (Short call)

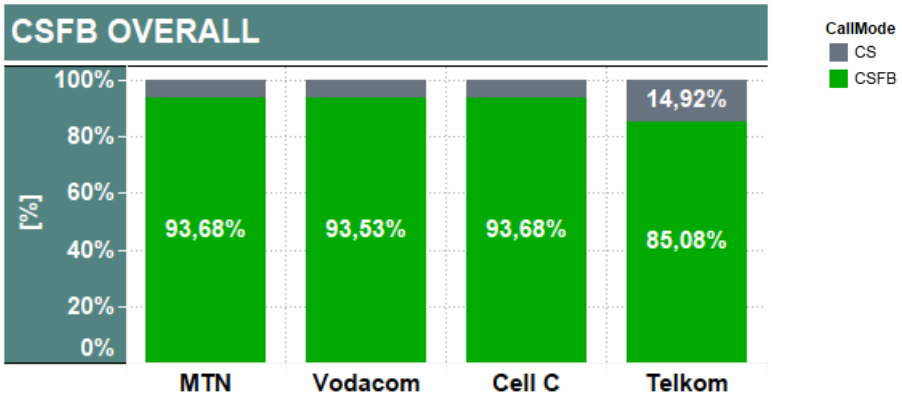


Figure 11. CSFB Overall stats

Figure 11 shows percentage of calls that were attempted on traditional networks (CS Calls) as well as the ones initiated on LTE network and fell back to UMTS or GSM (CSFB Calls).

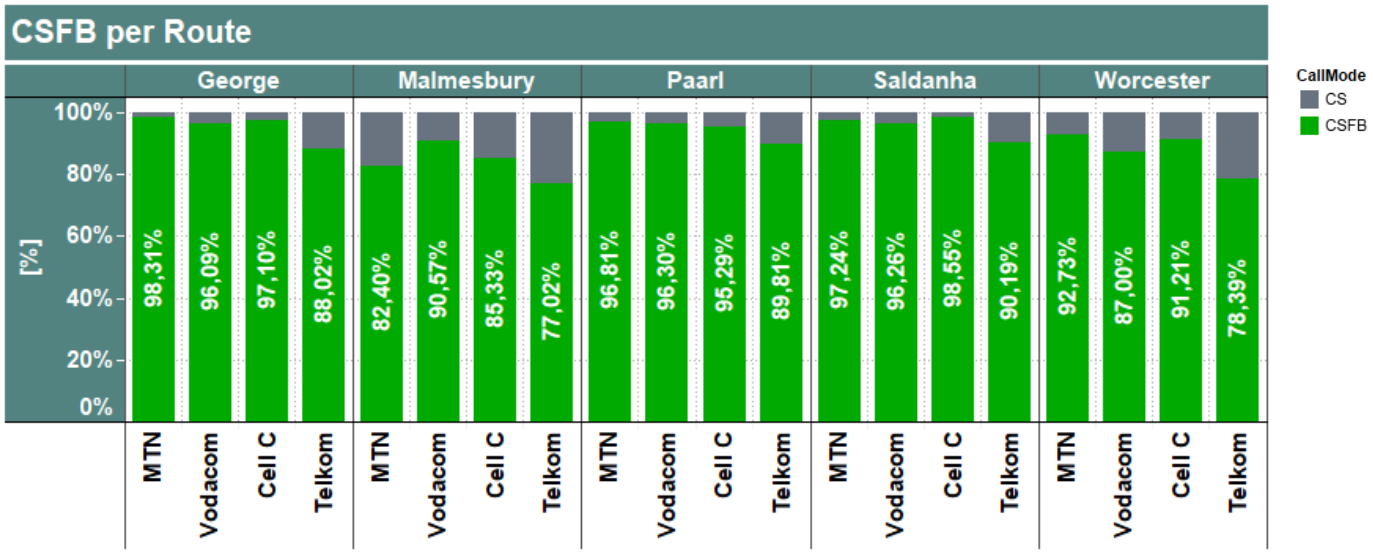


Figure 12. CSFB per Area

Figure 12 shows the breakdown of CS/CSFB calls per Route. All the operators are seen with high percentage of CSFB in all of the areas tested however Telkom had their lowest percentage in Malmesbury and Worcester. This is also an indication that the operators have LTE coverage in these areas.

4.1.8. Roaming statistics (Long call)

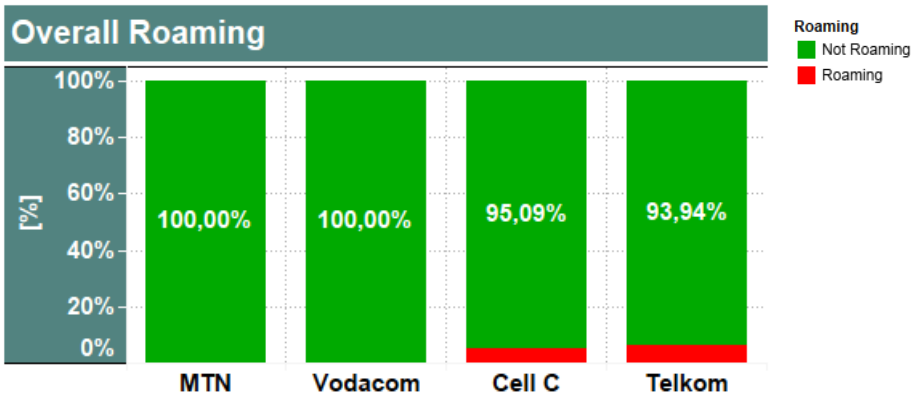


Figure 13. Overall Roaming percentages

Figure 13 shows overall roaming samples for each operator. Cell C and Telkom are observed to have roaming samples with Telkom having the highest percentage of roaming.

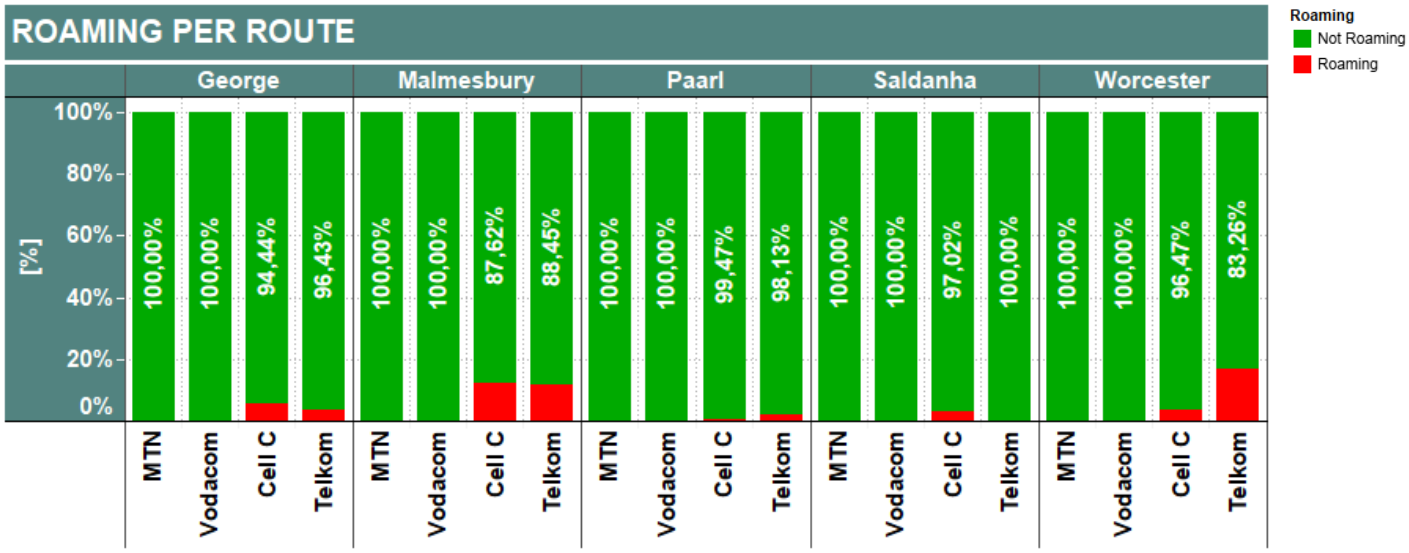


Figure 14. Roaming percentages per Area

Figure 14 shows roaming per operator per route. Cell C and Telkom were observed to have roaming samples in George, Malmesbury, Paarl and Worcester; with Telkom having the highest roaming percentage in Worcester compared with Cell C. Saldanha is the only area where Telkom did not roam.

5. Conclusion

This section provides the summary and key findings of all measurements. The results illustrate a snapshot of the mobile network performance and customer experience within the measured time and location context.

The results indicate that the end-user's quality of service and operators' network performance varies significantly per tested area. The overall voice KPI results per area tested shows that all operators met the Call Setup Success Ratio target in George and all failed to meet the target in Paarl. Telkom only met the CSSR target in George and failed to meet the target in other tested areas. Cell C, MTN and Vodacom met the overall CSSR target of more than 98%, whereas Telkom did not.

All operators met the Drop Call Ratio target of less than 3% in both George and Saldanha. MTN and Vodacom are the only operators that met the overall DCR target of less than 3% and thus meeting the Authority's Retainability target. All operators achieved Call Setup Time target according to the End-User and Subscribers Service Charter Regulation of 2016.

For the speech quality (MOS) results, all operators achieved an average score of over 3 in George, Paarl and Saldanha. All operators except Telkom met the overall speech quality target of score above 3.

It was observed that Vodacom had a high number of GSM samples compared to the other operators, followed by MTN, Telkom and Cell C in descending order.

Telkom and Cell C had roaming samples in George, Malmesbury, Paarl and Worcester with Malmesbury having highest percentage of roaming for Cell C and Telkom having their highest percentage in Worcester.

6. Appendices

6.1. Appendix 1: Detailed test results by Phase

Table 8: Call Setup Success Rate (CSSR) per Area – Phase 1 & 2

		George		Malmesbury		Paarl		Saldanha		Worcester		Total
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
Call Attempt	MTN	446	450	384	448	477	547	373	392	340	394	4251
	Vodacom	445	452	398	448	478	550	375	406	339	397	4288
	Cell C	447	453	377	425	476	538	365	399	345	395	4220
	Telkom	405	446	384	447	482	550	372	402	345	395	4228
Call Setup	MTN	442	448	380	444	461	542	372	389	338	391	4207
	Vodacom	445	451	387	440	457	543	373	403	332	391	4222
	Cell C	444	453	366	418	449	528	363	398	338	390	4147
	Telkom	401	434	356	410	445	536	358	386	326	382	4034
Call Setup Success Rate [%]	MTN	99,10%	99,56%	98,96%	99,11%	96,65%	99,09%	99,73%	99,23%	99,41%	99,24%	98,96%
	Vodacom	100,00%	99,78%	97,24%	98,21%	95,61%	98,73%	99,47%	99,26%	97,94%	98,49%	98,46%
	Cell C	99,33%	100,00%	97,08%	98,35%	94,33%	98,14%	99,45%	99,75%	97,97%	98,73%	98,27%
	Telkom	99,01%	97,31%	92,71%	91,72%	92,32%	97,45%	96,24%	96,02%	94,49%	96,71%	95,41%

Table 9: Drop Call Ratio (DCR) per Area – Phase 1 & 2

		George		Malmesbury		Paarl		Saldanha		Worcester		Total
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
Call Complete	MTN	167	172	149	173	178	212	146	156	133	155	1 641
	Vodacom	168	172	156	173	175	212	146	156	134	155	1 647
	Cell C	167	175	152	171	173	207	146	156	132	151	1 630
	Telkom	165	171	139	164	164	210	145	154	129	110	1 551
Call Dropped	MTN	2	1	4	5	4	2	2	2	2	0	24
	Vodacom	0	0	0	3	4	2	0	0	2	0	11
	Cell C	3	2	13	12	6	6	2	5	6	3	58
	Telkom	3	2	11	11	4	3	4	3	5	3	49
Drop Call Ratio [%]	MTN	1,18%	0,58%	2,61%	2,81%	2,20%	0,93%	1,35%	1,27%	1,48%	0,00%	1,44%
	Vodacom	0,00%	0,00%	0,00%	1,70%	2,23%	0,93%	0,00%	0,00%	1,47%	0,00%	0,66%
	Cell C	1,76%	1,13%	7,88%	6,56%	3,35%	2,82%	1,35%	3,11%	4,35%	1,95%	3,44%
	Telkom	1,79%	1,16%	7,33%	6,29%	2,38%	1,41%	2,68%	1,91%	3,73%	2,65%	3,06%

6.2. Appendix 2: Coverage maps

6.2.1. Technology Maps

6.2.1.1. George

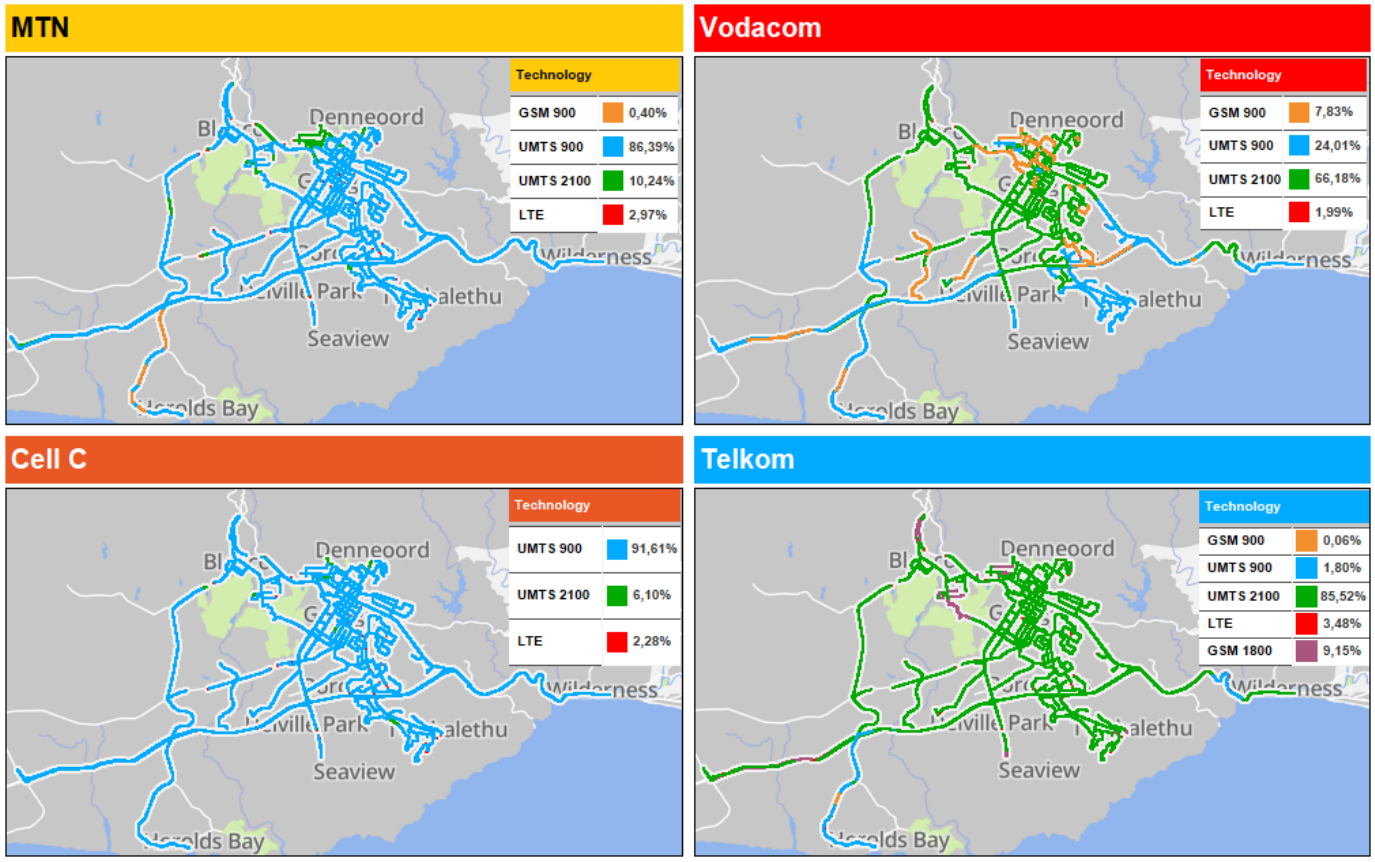


Figure 15. George Technology Map

6.2.1.2. Worcester

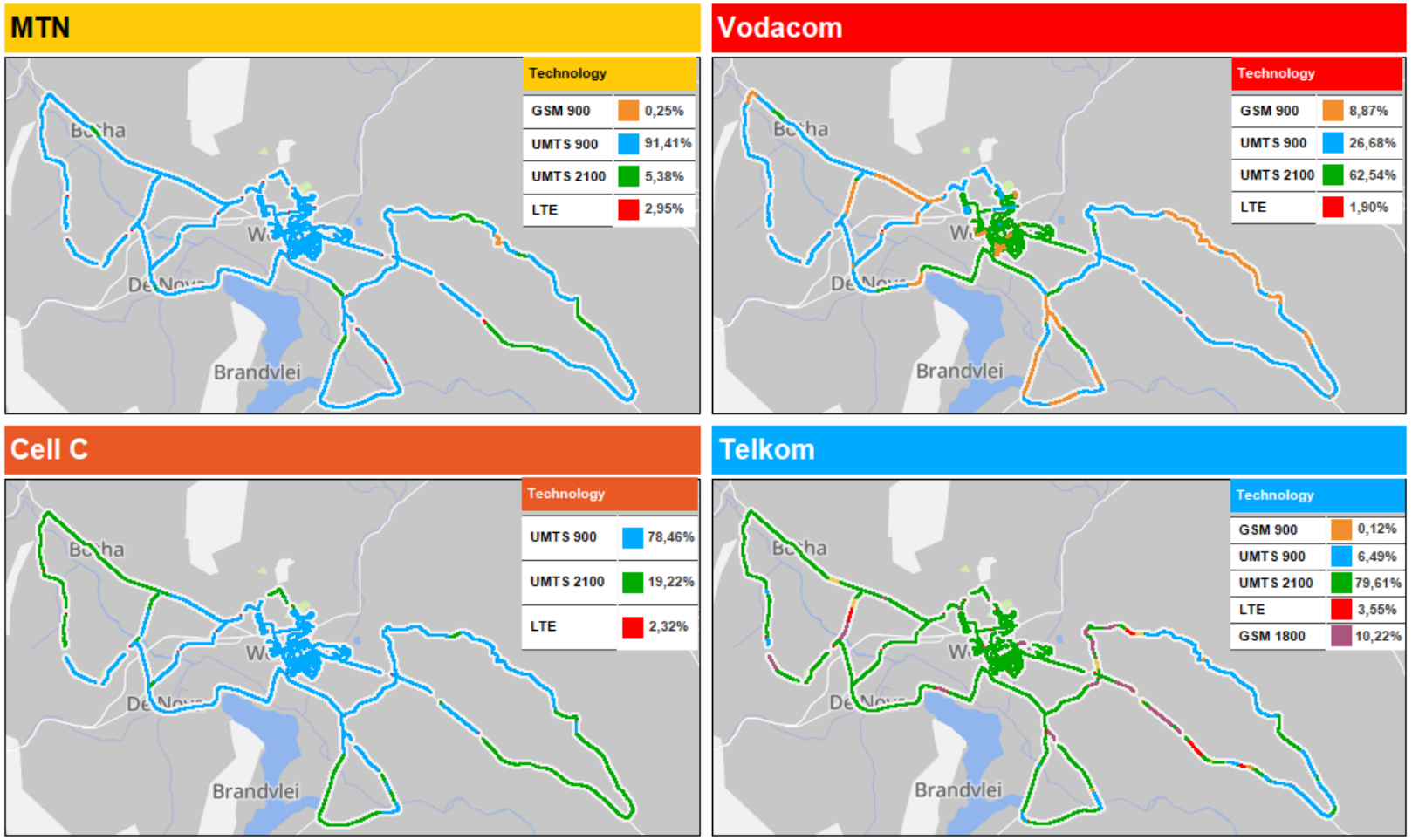


Figure 16. Worcester Technology Map

6.2.1.3. Paarl

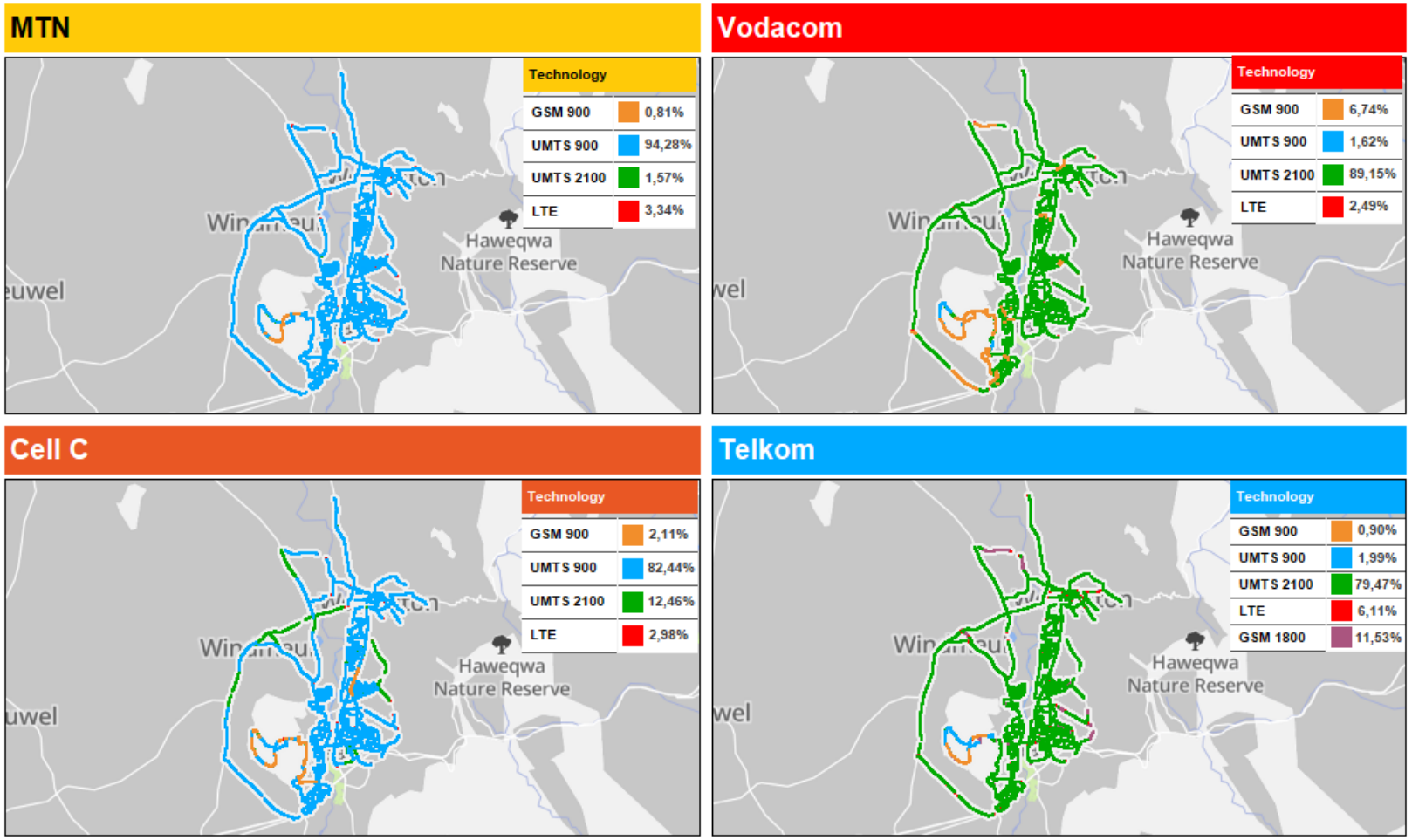


Figure 17. Paarl Technology Map

6.2.1.4. Malmesbury

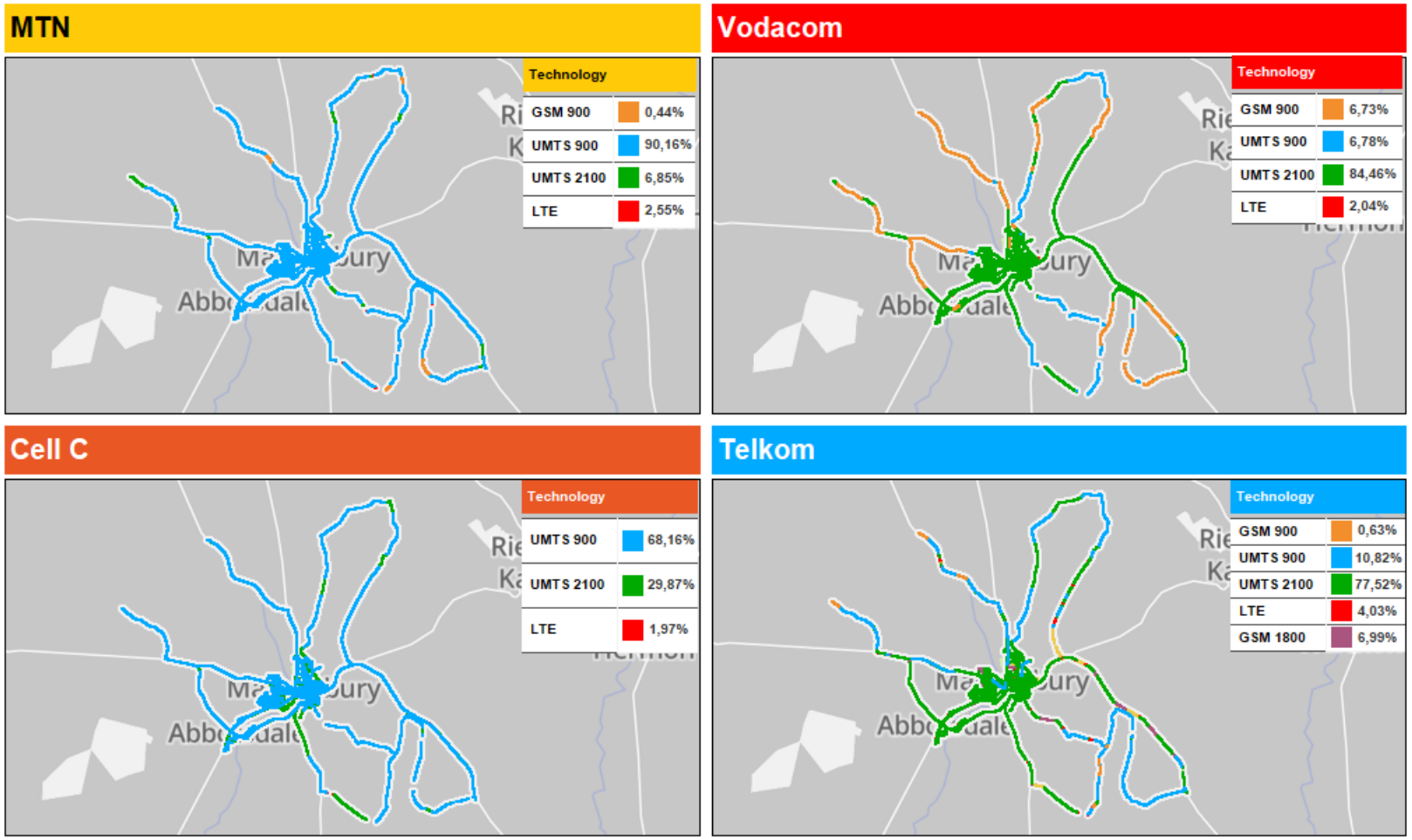


Figure 18. Malmesbury Technology Map

6.2.1.5. Saldanha

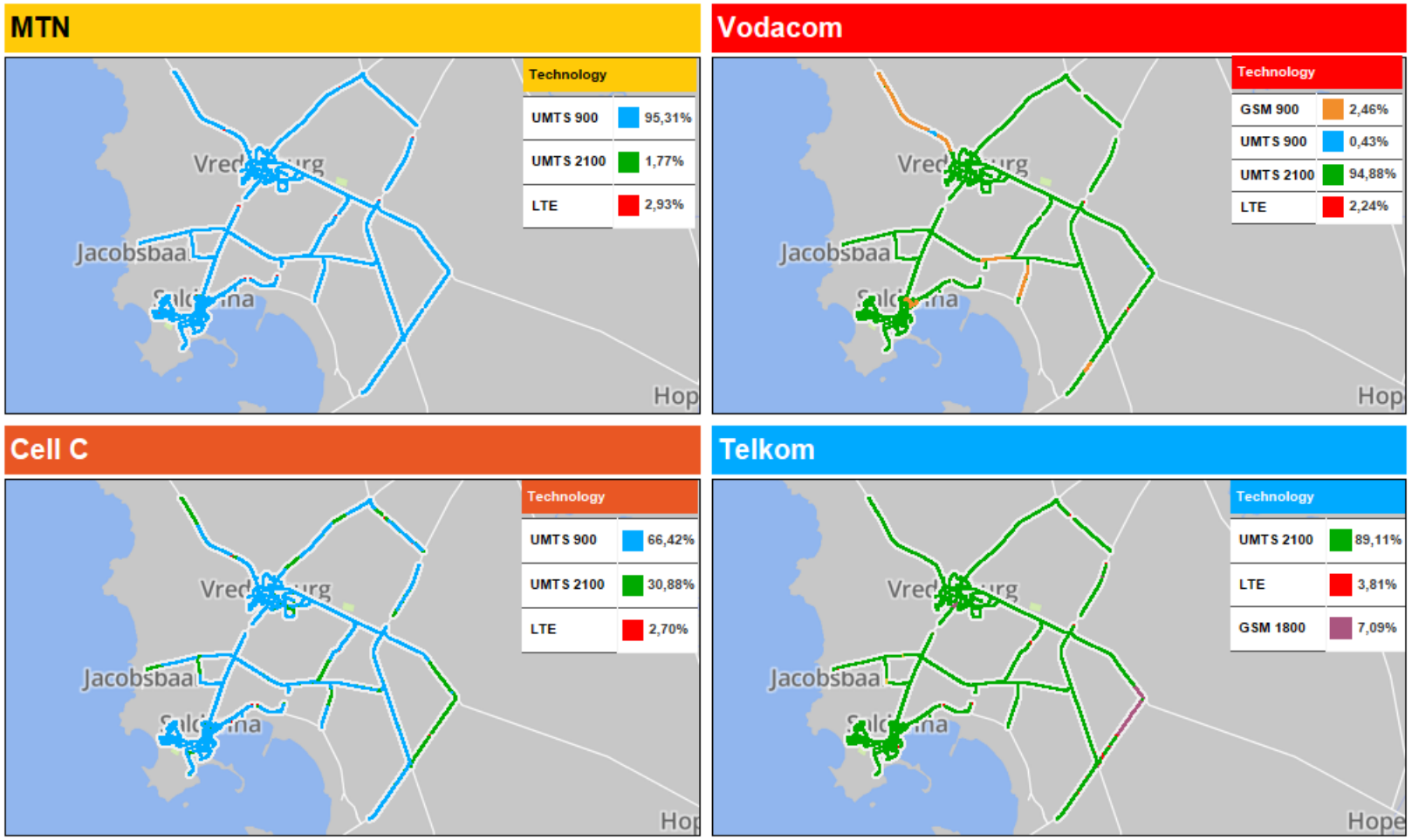


Figure 19. Saldanha Technology Map

6.2.2. Call Failures

6.2.2.1. George

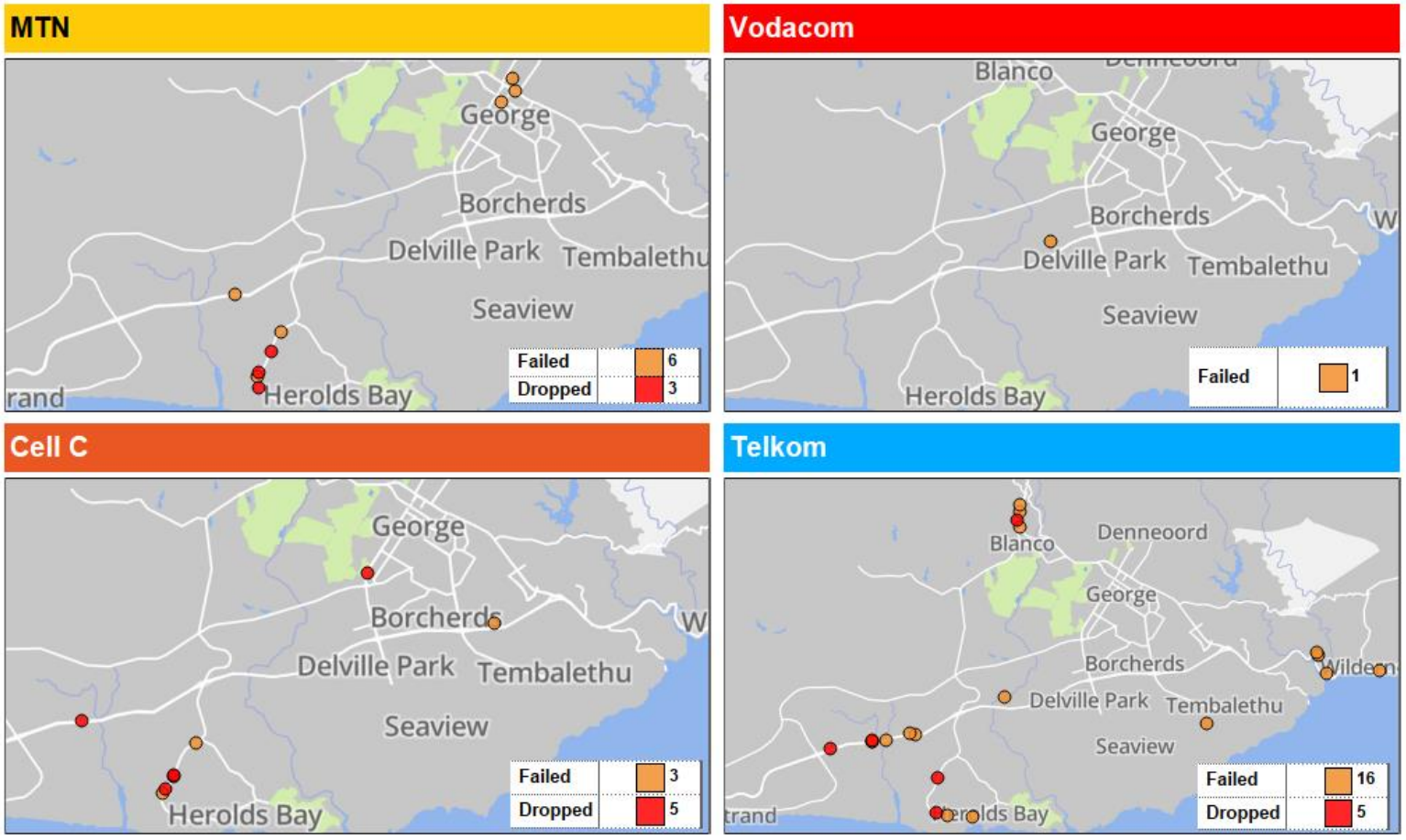


Figure 20. George Call Failures

6.2.2.2. Worcester

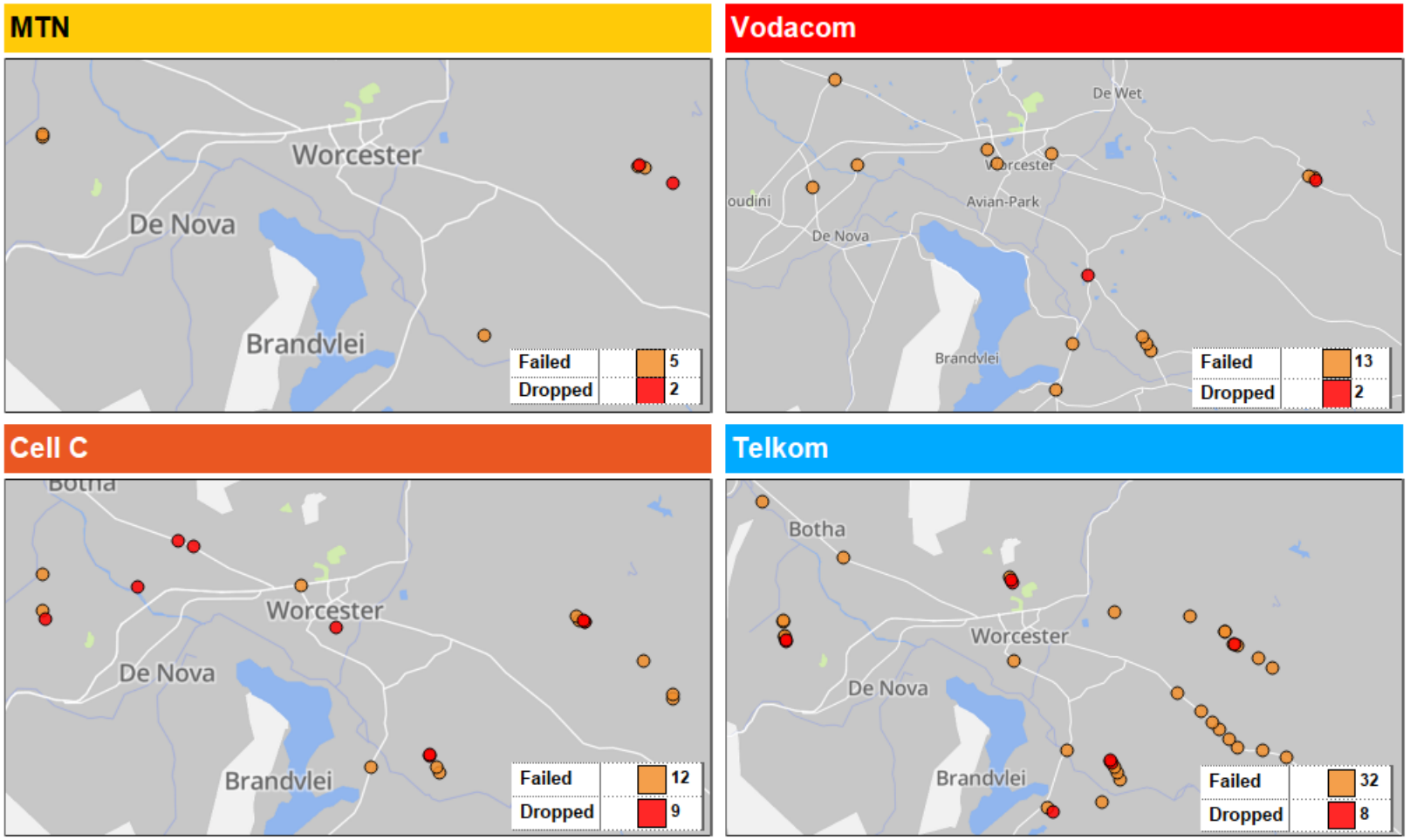
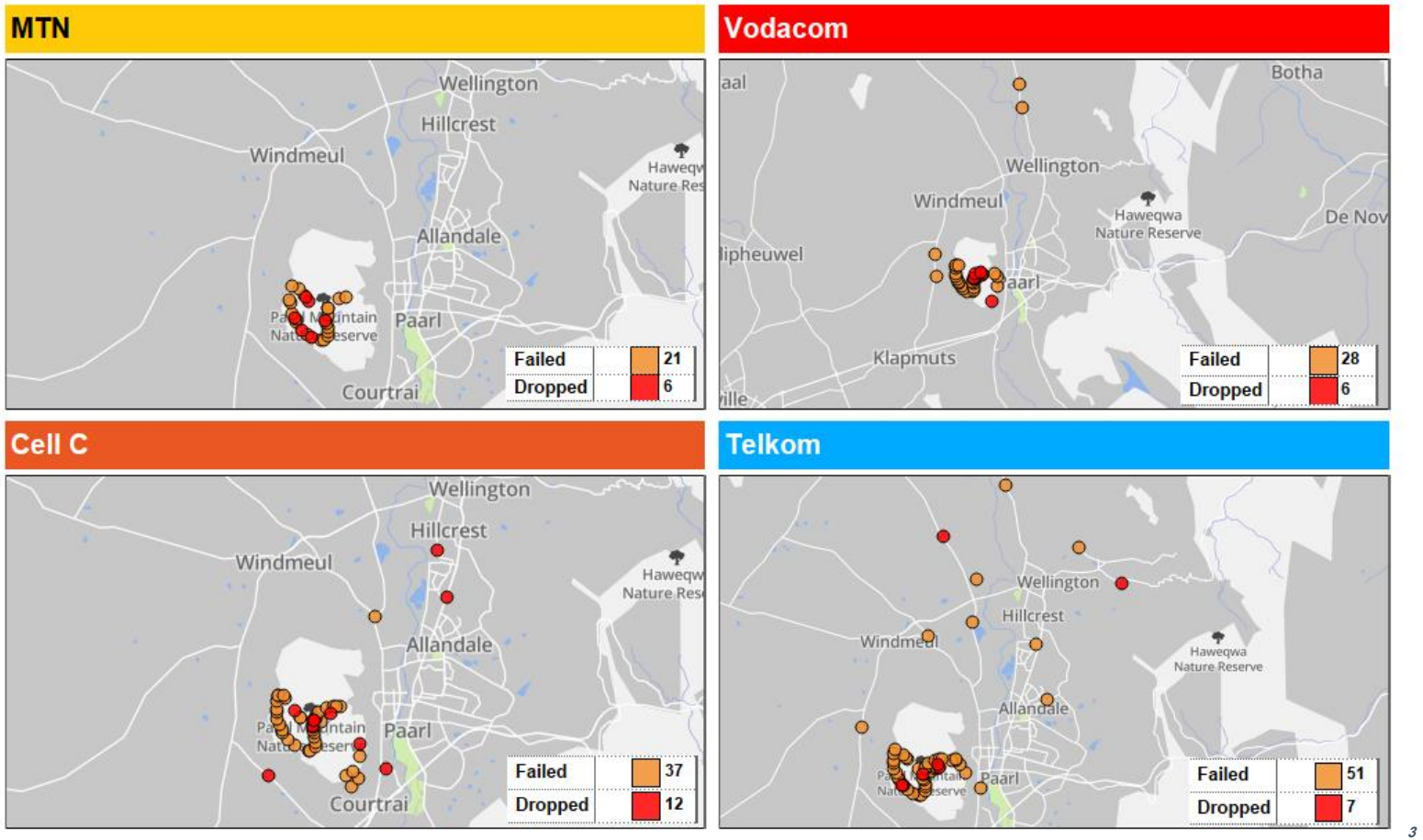


Figure 21. Worcester Call Failures

6.2.2.3. Paarl



[3]

Figure 23. Paarl Call Failures

[3] **Most failures recorded around Nature reserve area due to coverage issues**

6.2.2.4. Malmesbury

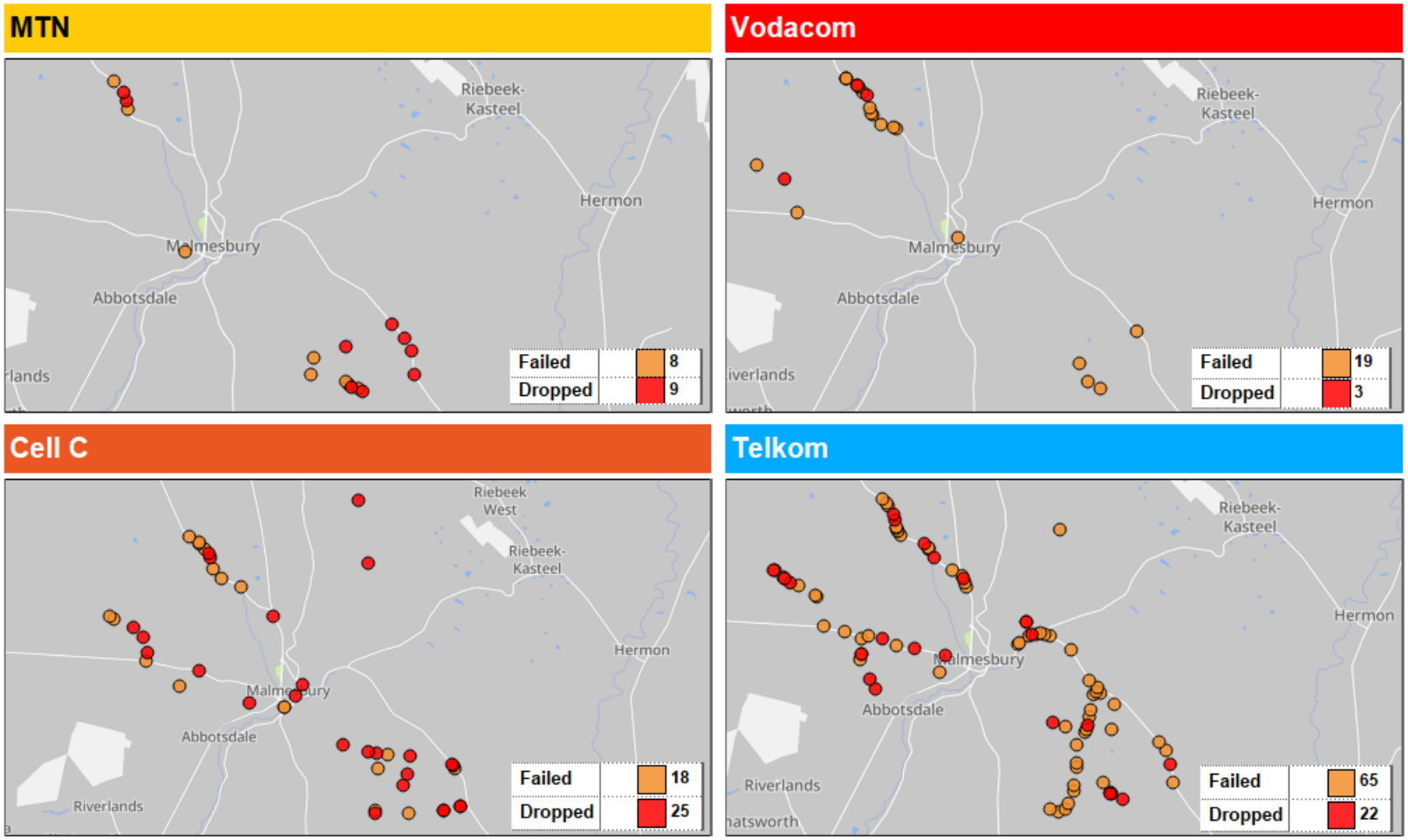


Figure 23. Malmesbury Call Failures

6.2.2.5. Saldanha

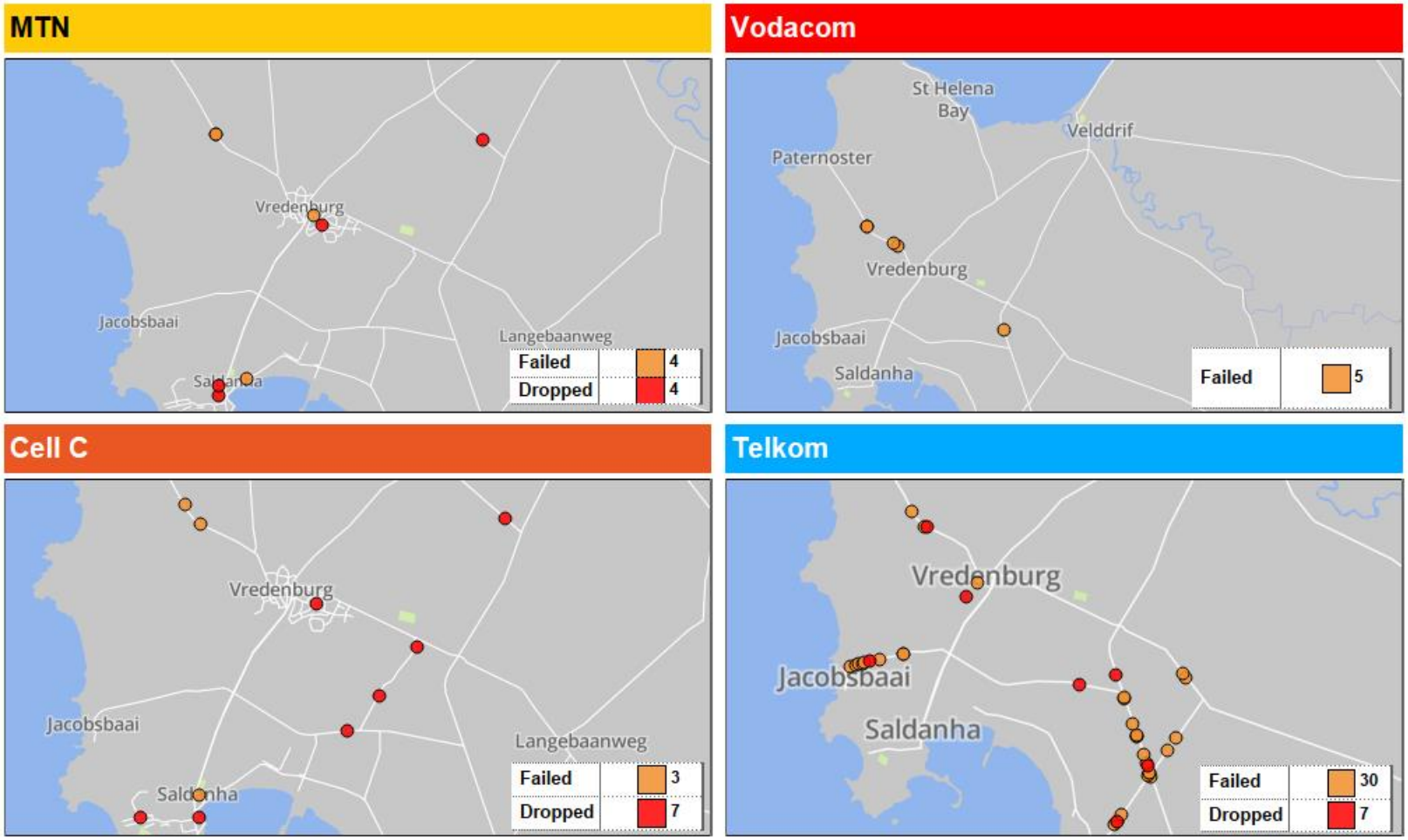


Figure 22. Saldanha Call Failures

6.2.3. Roaming (Long call)

6.2.3.1. Cell C

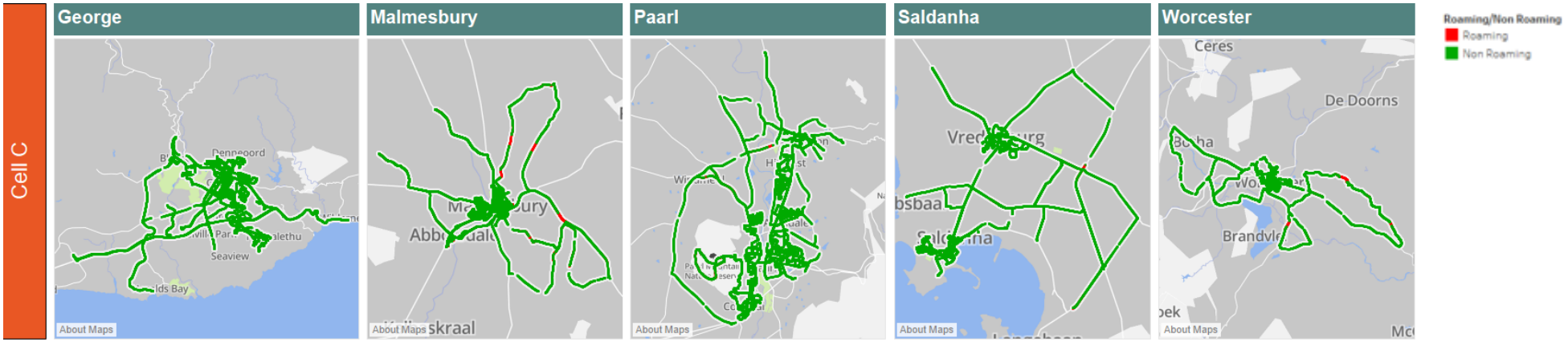


Figure 23. Cell C Roaming (Long Call)

6.2.3.2. Telkom

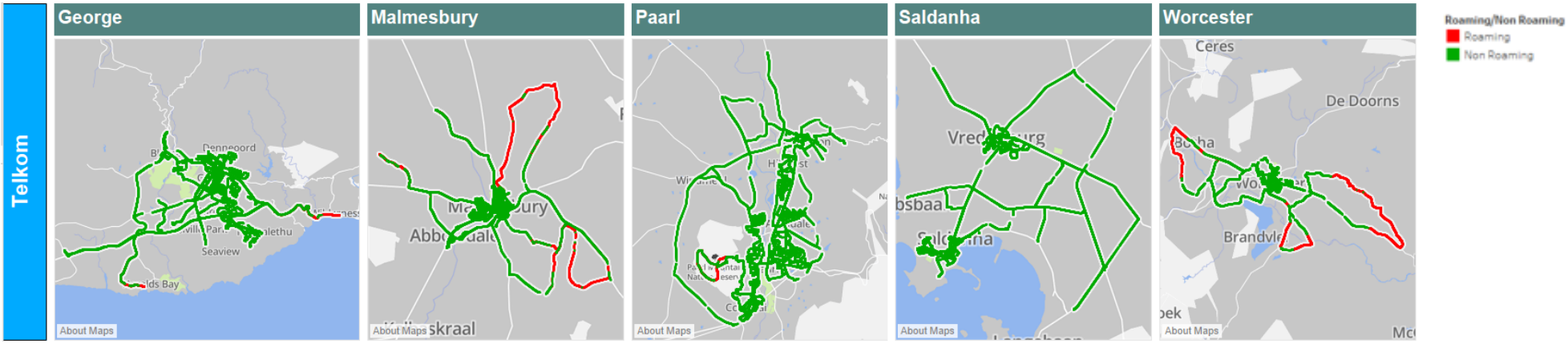


Figure 24. Telkom Roaming (Long Call)

6.3. Appendix 3: Mobile operators' feedback on the report

The detailed report was shared with the affected mobile operators in order for them to share their plans and remedial action to address issue of poor performance. The improvement plans and remedial actions are provided below.

6.3.1.Vodacom

Vodacom provided feedback and network improvement plans that are in place for the areas that were identified to be negatively affecting customer experience by the Authority's QoS monitoring report and shared the following plans and remedial actions:

- Paarl route - An additional sector on the serving site will be added to focus in the problem area. UMTS 900 will also be implemented to improve 3G coverage penetration in this area. Optimisation will be initiated on the serving cells and retrialing will be scheduled to ensure that the problem has been resolved.
- Malmesbury route - All soft changes such as Parameter optimisation and Neighbour additions have been completed for this area. Regional team will re-test this area to ensure that all issues are resolved.

Furthermore, there are challenges in securing new sites in the areas around Paarl Nature reserve since it is zoned as "Green" according to the Environmental Impact assessment policies.

6.3.2.MTN

MTN provided feedback and network improvement plans that are in place for the areas that were identified to be negatively affecting customer experience by the Authority's QoS monitoring and shared the following plans and remedial actions:

- Paarl route – New site planned in the area
- Malmesbury route – Plan to deploy three new sites builds in the next twenty-four (24) months to address poor coverage issue.
- Worcester route – Plan to deploy a new site in the next twenty-four (24) months to improve coverage. Further network optimisation will be conducted.

Furthermore, MTN remains committed to continual investment in the improvement of the network quality thereby improving the end user mobile voice service experience.

6.3.3.Cell C

Cell C attributes poor performance to their major network optimising project which took place at the end of 2018 and the mountainous terrain. However, Cell C's plans and remedies to improve the low performance areas include the following:

- Constant engagement with its national roaming partner to improve coverage in the tested areas,
- Plan to conduct frequent optimisation and upgrade in initiatives to improve on its existing infrastructures. The optimisation challenges have been resolved by 22 February 2019 and further optimisation was completed in the first week of March 2019,
- Future plans which are to rollout more sites.

6.3.4.Telkom

Telkom views the test results as very significant and uses them as additional input to further improve the quality of the mobile network. Most call failures on the Telkom network were due to inadequate network coverage. This is being addressed by building additional sites in the tested areas to provide a more contiguous network coverage. Telkom's deployment plan within these areas are set out below:

- Malmesbury – Plan to deploy 4 sites
- Saldanah – Plans to build 7 sites.
- Paarl – Plans to build additional 22 sites.
- Worcester – Plans to build 3 additional sites.
- George – Plans to build additional 15 sites.

Network quality will be further improved through our roaming agreement with Vodacom and building of additional sites in these areas. In addition to building additional sites, other initiative to improve network and service quality is underway including LTE Carrier Aggregation, reframing of 2100 MHz spectrum for LTE, UMTS R99 parameter optimization, 256QAM modulation, etc.