Validation of PM Files and Topology Files -LUMITEL (ARCT)

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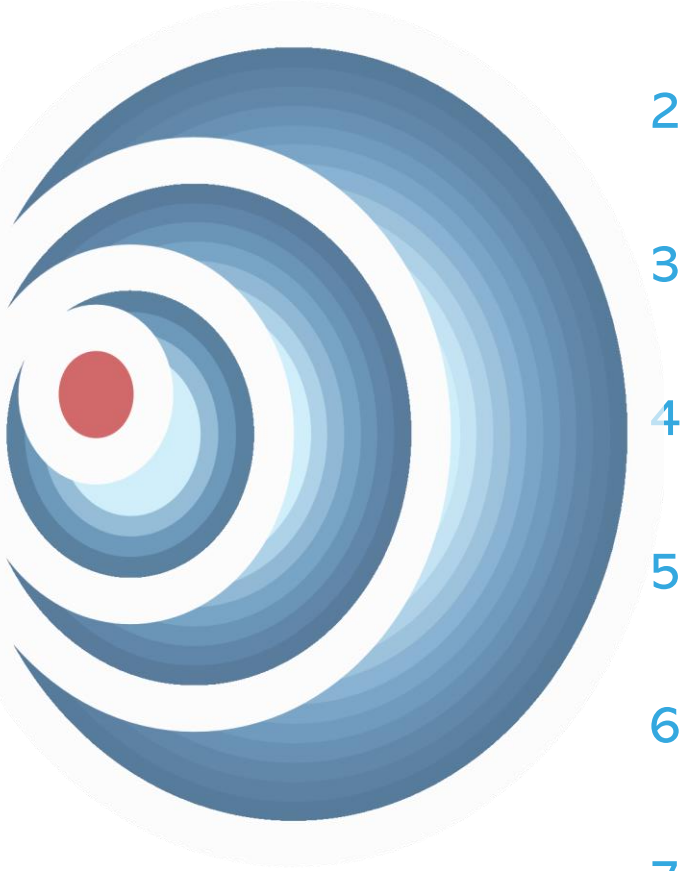
Agenda



1. Brief Overview
2. Objectives
3. Validation of PM files
4. KPI based on ITU-T QoS Category for Serveability
5. PM File Analysis (Ex. Huawei LTE)
6. Verification of Topology Files Adequacy
7. Coverage Map Generation
8. Conclusion

Our References – Telecommunications Regulatory Authorities in Africa

•Benin, Guinea, and Zimbabwe have already implemented the D-QoS application

•Zimbabwe

•Ghana

•Eswatini

•Mozambique

•Rep. Dem Congo-Kinshasa

•Benin

•Senegal

•Sierra Leone

•Guinea - Conakry

•Burkina Faso

•Zambia

•Botswana

•Burundi -2024

Brief Overview – RPM system

•RPM system [Regulators' (QoS) Performance Monitoring System]
The RPM System, designed for QoS performance monitoring by regulators, is an innovative NMS solution that ensures interconnection with all the network monitoring systems of operators and service providers.

• It collects performance data and generates KPI reports that measure a network's performance against the established benchmarks in ARCT QoS Guidelines.

•RPM system dedicated to regulators: Designed for QoS performance monitoring

•Innovative NMS solution: Advanced network management for regulators.

•Interconnection with monitoring systems: Integration passively with mobile operators' monitoring platforms.

•Data collection and aggregation: Calculation of KPIs according to ITU-T QoS evaluation categories with formulas defined by 3GPP and aggregation of these values from the cellular level to the level of municipalities, then provinces, up to the network level.

•Detailed KPI reports: Production of reports for network performance analysis.

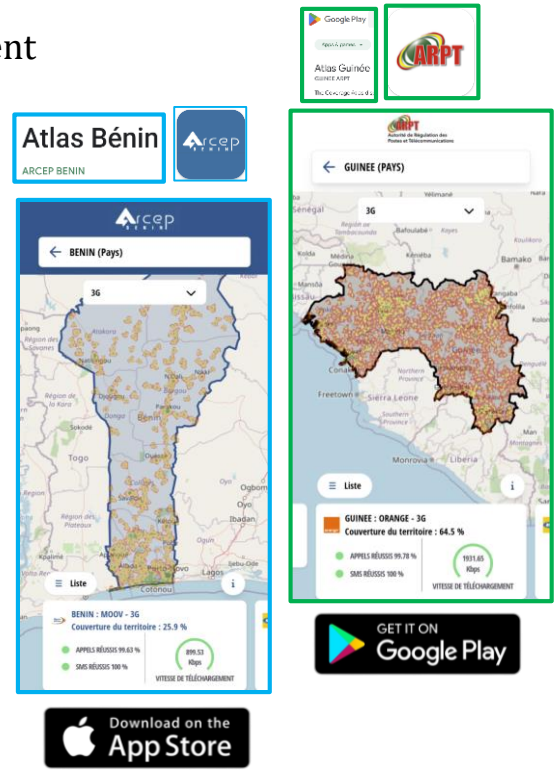
•QoS Enforcement: Tool facilitating the enforcement of QoS standards down to the cellular level..

•Evaluation against the QoS Specifications: Comparison of network performances based on ITU-T QoS evaluation categories and established regulatory thresholds.

Brief Overview : D.QoS mobile application [Atlas de Couverture]

- The D.QoS mobile application (Delivered Quality of Service) acts as an enabling platform for **end-users**, providing them with valuable data on network performance and radio coverage.
- This information allows users to make informed decisions regarding the quality of telecommunication services available in their respective municipalities.
- The D-QoS application allows the ARCT to monitor network performance and improve customer experience in Burundi. It also facilitates the collection of user feedback, which is essential for informed regulatory decisions and the development of telecommunications in the country.

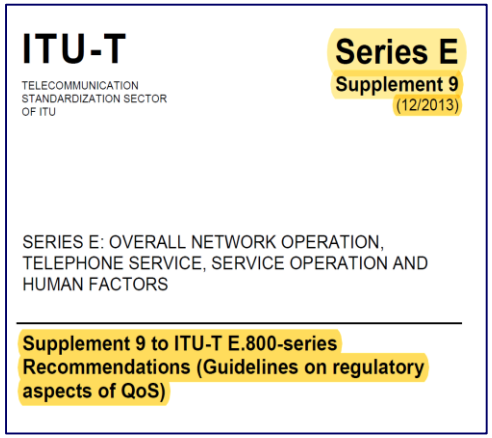
- Display of Radio Coverage: Visualisation de la couverture réseau par les utilisateurs.
- Access to QoS Delivered Data: Accès aux données sur la qualité de service fournie par les opérateurs de télécommunication.
- Reporting of Quality of Experience (QoE) : Detailed reports on user experience..
- Instant Notifications: Real-time alerts on network events.
- Survey Module (Crowdsourcing): User participation in the evaluation of network quality.
- Scalability : The application's ability to scale and adapt to a growing base of users and data.



Background - QoS Monitoring & Enforcement and Radio Coverage

QoS Challenges have been addressed and solutions are given in recommendations as seen in **ITU-T E.800 Sup 9**, **ITU-T E.811** and **ETSI EG 202 057-3**.

Radio coverage propagation models and prediction methods are given in recommendations **ITU-R P.1411-12**, **ITU-R P.2147** and **ITU-R P.2108-1**

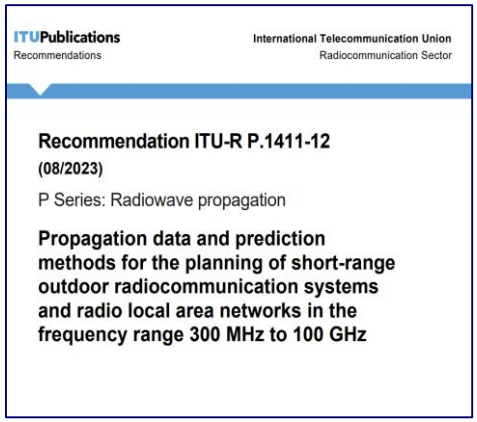

ITU-T

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

Series E
Supplement 9
(12/2013)

SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Supplement 9 to ITU-T E.800-series Recommendations (Guidelines on regulatory aspects of QoS)

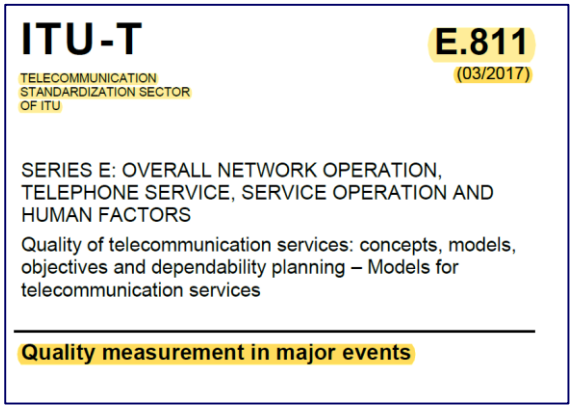

ITUPublications
Recommendations

International Telecommunication Union
Radiocommunication Sector

Recommendation ITU-R P.1411-12
(08/2023)

P Series: Radiowave propagation

Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz


ITU-T

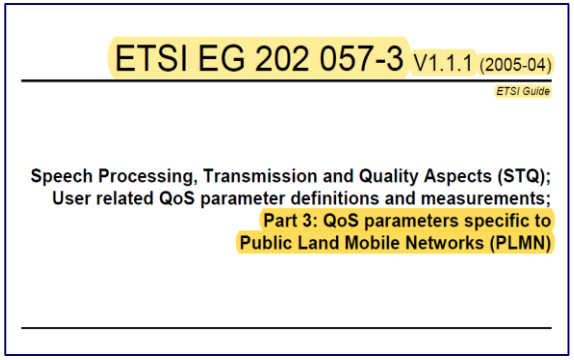
TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

E.811
(03/2017)

SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Quality of telecommunication services: concepts, models, objectives and dependability planning – Models for telecommunication services

Quality measurement in major events


ETSI EG 202 057-3 V1.1.1 (2005-04)

ETSI Guide

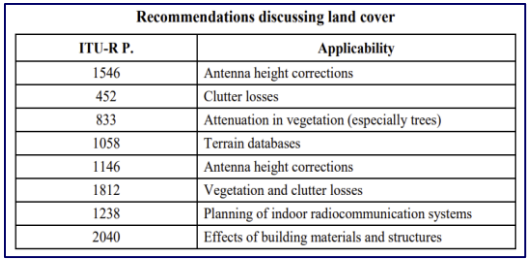
Speech Processing, Transmission and Quality Aspects (STQ); User related QoS parameter definitions and measurements; Part 3: QoS parameters specific to Public Land Mobile Networks (PLMN)


ITU-R
Radiocommunication Sector of ITU

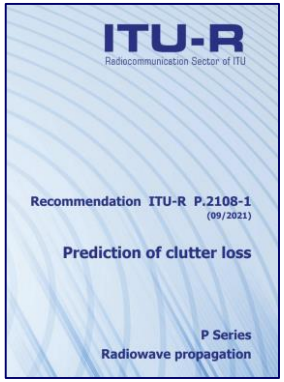
Recommendation ITU-R P.2147-0
(08/2022)

Acquisition, presentation, analysis and use of digital products in studies of radiowave propagation

P Series
Radiowave propagation


Recommendations discussing land cover

ITU-R P.	Applicability
1546	Antenna height corrections
452	Clutter losses
833	Attenuation in vegetation (especially trees)
1058	Terrain databases
1146	Antenna height corrections
1812	Vegetation and clutter losses
1238	Planning of indoor radiocommunication systems
2040	Effects of building materials and structures

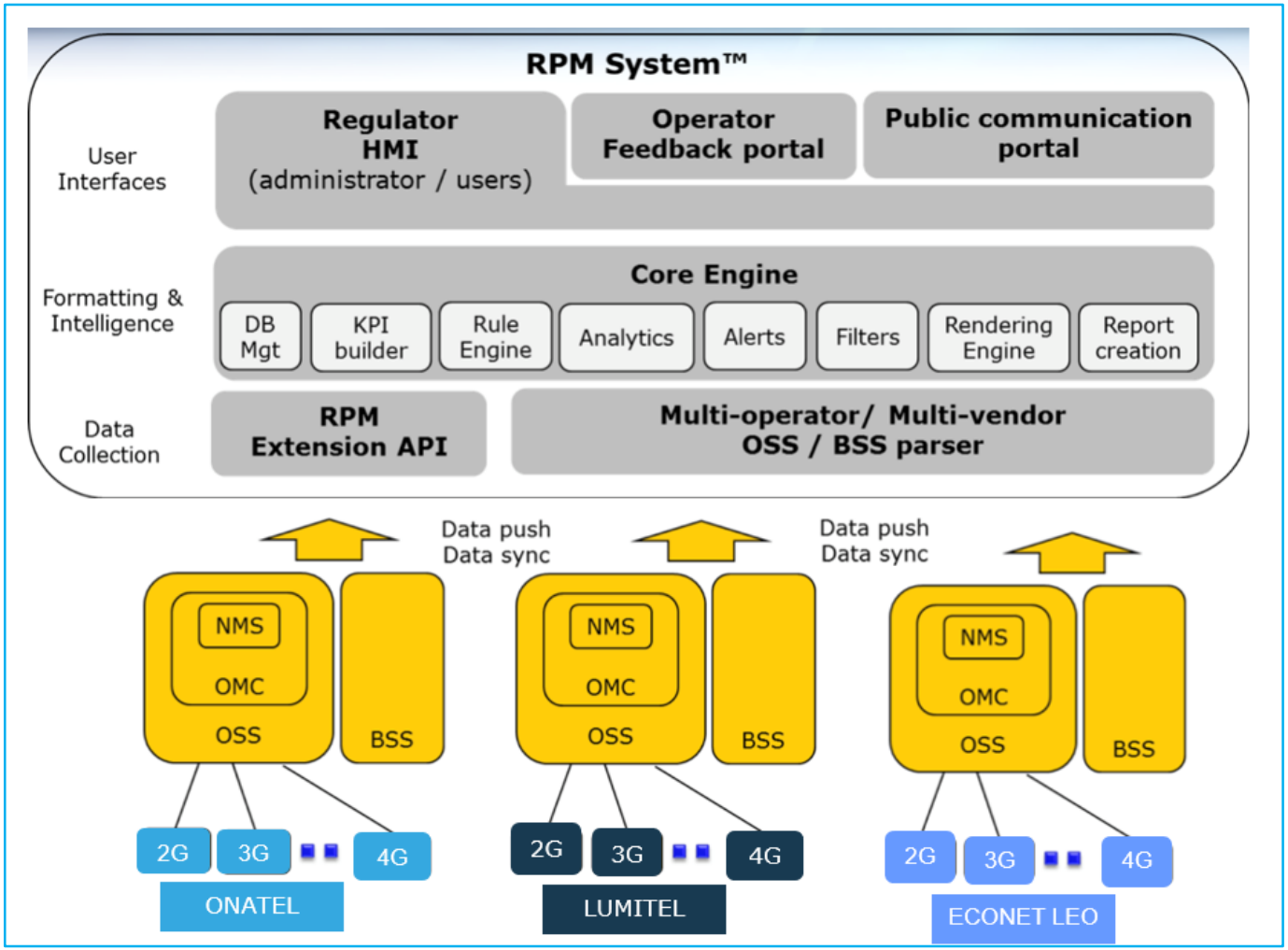

ITU-R
Radiocommunication Sector of ITU

Recommendation ITU-R P.2108-1
(09/2021)

Prediction of clutter loss

P Series
Radiowave propagation

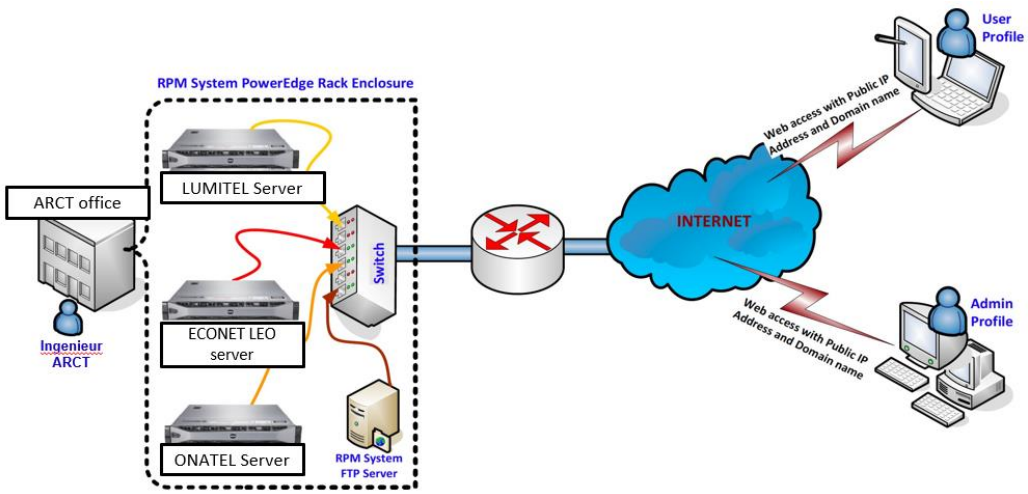
RPM System Overview

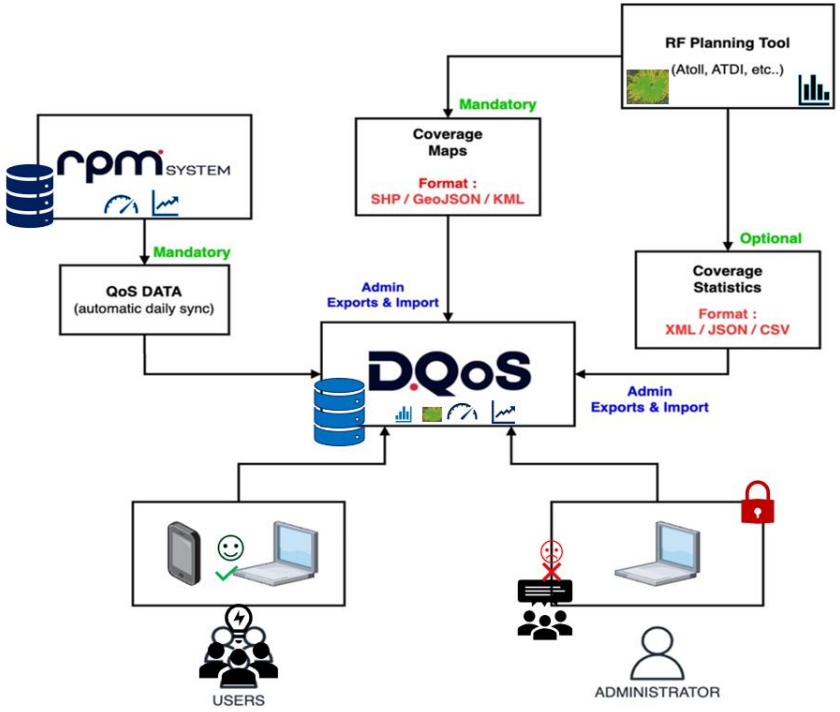


Configuration of ARCT Servers - RPM System & DQoS (+Coverage Maps)

- The ARCT's RPM System tool is configured to monitor the **Quality of Service (QoS) delivered** by mobile operators (MNOs) in Burundi.

- The service quality (QoS) report dashboards can be accessed on the web by MNOs as well as by the public via the D.QoS mobile app.





Objectives

- Validate the PM files shared by LUMITEL to ensure they meet the required 3GPP specifications, confirming that all necessary counters (function setIDs) for computing high-level KPIs are activated on the network.

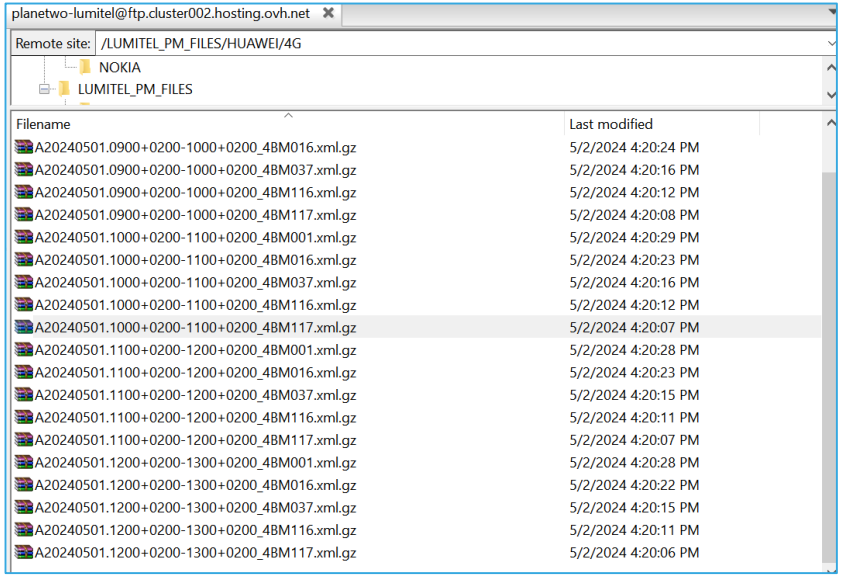
  3GPP TS 32.401

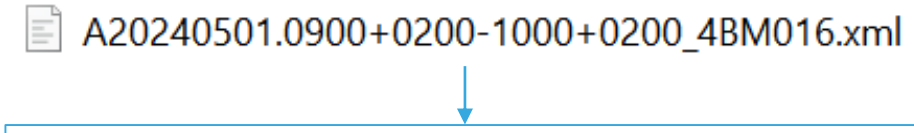
- Confirm the completeness and accuracy of the topology file, ensuring that all required columns are populated. This is essential for generating coverage maps and computing KPIs at both the province and commune levels.

Validation of PM Files: (Example: HUAWEI LTE PM Files)

- **Compliance with 3GPP Standards:** The PM files provided in XML format adhere to the specifications outlined in 3GPP TS 32.401. LUMITEL shared data covering four hours from five eNBs, resulting in a total of 20 PM files. The details of these files are illustrated in the screenshot below.

AYYYYMMDD.HHMM+UTC-HHMM+UTC_enodeBID.xml 4G (1H)





YYYYMMDD =20240501 (1st May 2024)

.HHMM= 0900 (9:00AM start time)

+UTC = Time Zone (Universal Time Cordinated) or GMT +0200 (Burundi)

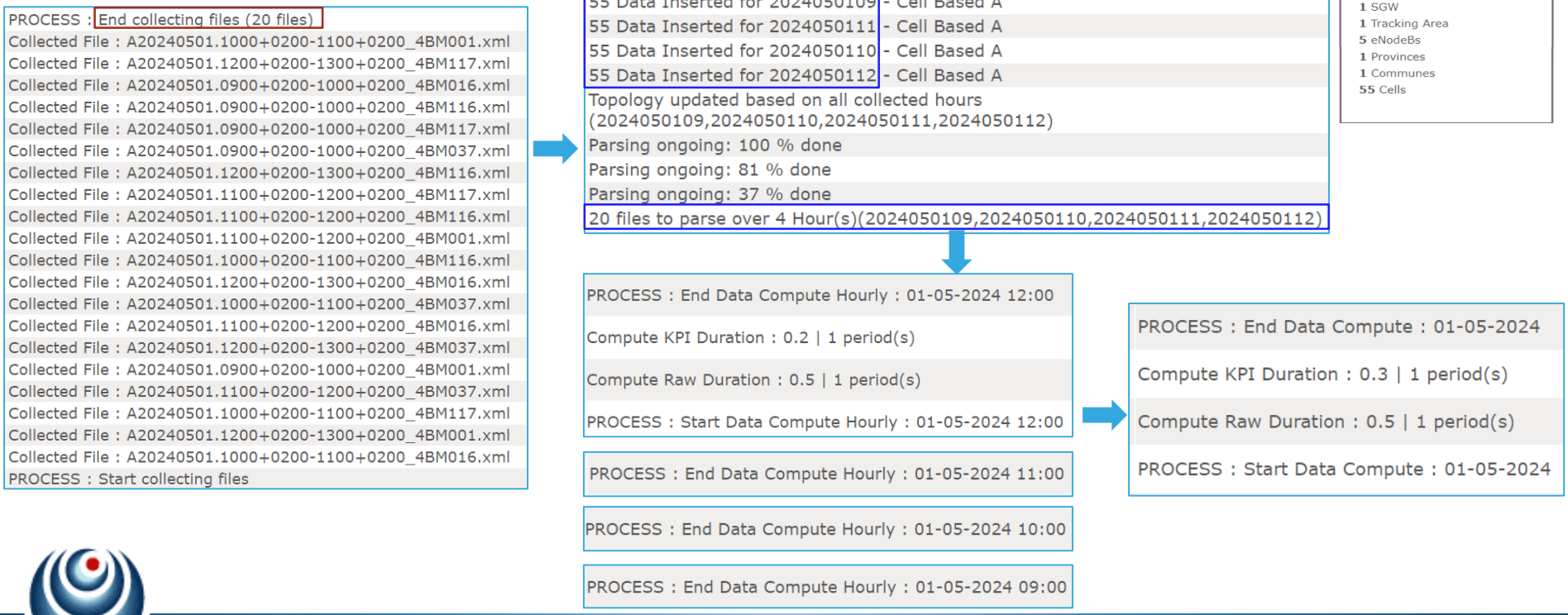
-HHMM=1000(10:00 end time)

_enodeBID.xml = 4BM016 (eNB on LUMITEL LTE Network)

Granularity = .HHMM – HHMM: 0900-1000 = 1H

Validation of PM Files: (Example: HUAWEI LTE PM Files)

- **Successful Parsing of PM Data:** Due to the files being 3GPP specified, they were successfully parsed by the RPM system without any issues. The effectiveness of this process is demonstrated in the screenshot below, serving as evidence of the files' compatibility and proper integration into the RPM systems.



KPIs

High-Level QoS KPIs

- High-level key performance indicators intended for audit reports and status reports, based on ITU-T service quality evaluation categories, namely: NA (network availability), SA (service accessibility), SR (service retainability), and SI (service integrity), monitored by radio access technology (RAT).

4G (Data Service only)

ITU-T QoS Category	LICENSE KPI NAME	TRA KPI NAME
NETWORK AVAILABILITY	Downtime for Radio Access	CELL DOWNTIME (H)
	Uptime for Radio Access	CELL AVAILABILITY (%)
		CELL UPTIME (H)
		DATA SERVICE AVAILABILITY (%)
SERVICE ACCESSIBILITY	DATA SERVICE ACCESS FAILURE RATE	DATA SERVICE ACCESS FAILURE (%)
	DATA SERVICE ACCESS SUCCESS RATE	DATA SERVICE ACCESS SUCCESS RATE (%)
SERVICE RETAINABILITY	DATA SERVICE DROP RATE	DATA SERVICE DROP RATE (%)
SERVICE INTEGRITY	DOWNLOAD DATA SPEED	DATA DL THROUGHPUT (Mbps)
	UPLOAD DATA SPEED	DATA UL THROUGHPUT (Mbps)

2G (Voice Service only)

ITU-T QoS Category	TRA KPI NAME
NETWORK AVAILABILITY	CELL DOWNTIME (H)
	CELL AVAILABILITY (%)
	CELL UPTIME (H)
SERVICE ACCESSIBILITY	TCH CONGESTION RATE (%)
	SDCCH CONGESTION RATE (%)
	CALL SUCCESS RATE (%)
	CALL SETUP SUCCESS RATE (%)
SERVICE RETAINABILITY	CALL DROP RATE (%)
	CALL COMPLETION RATE (%)

3G (Voice and Data Services only)

ITU-T QoS Category	TRA KPI NAME
NETWORK AVAILABILITY	CELL DOWNTIME (H)
	CELL AVAILABILITY (%)
	CELL UPTIME (H)
SERVICE ACCESSIBILITY	VOICE BLOCK CALL RATE (%)
	VOICE CALL SETUP SUCCESS RATE (%)
	VOICE CALL SUCCESS RATE (%)
	DATA ACCESS SUCCESS RATE (%)
SERVICE RETAINABILITY	VOICE CALL DROP RATE (%)
	VOICE CALL COMPLETION RATE (%)
	DATA DROP RATE (%)
SERVICE INTEGRITY	DATA DL HS THROUGHPUT (Kbps)

ITU-T QoS Model

The International Telecommunications Union - Telecommunications (ITU-T) has described a general model for Quality of Service (QoS) from an end-user perspective to use in mobile networks.

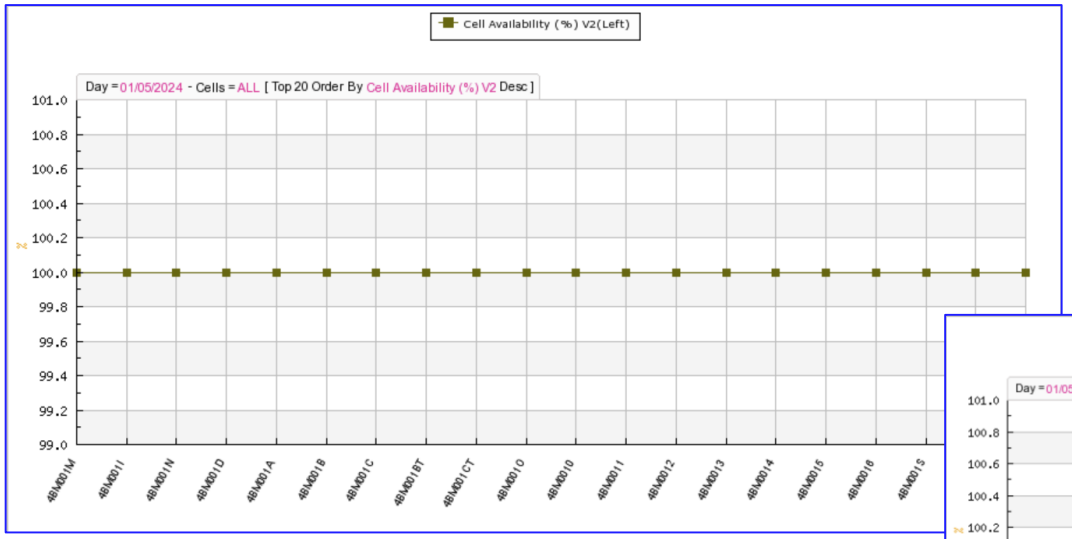
The QoS categories for Serveability are:

PM Files Analysis: (Example: HUAWEI LTE PM Files)

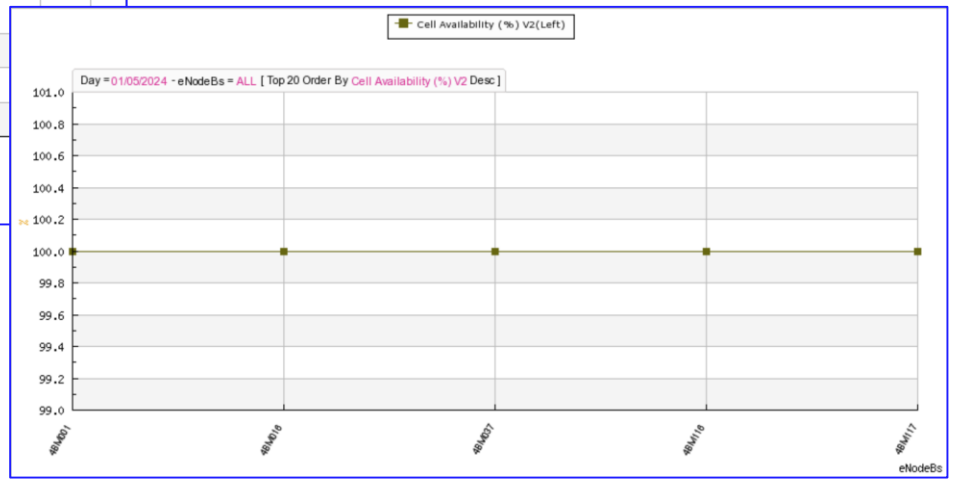
- Below is a summary of the ITU-T QoS categories along with their corresponding KPIs:
  Network Availability (NA): The key performance indicator for this category is Cell Availability, which measures the proportion of time that the cell is available for use.

Legend Label	KPI/RAW Counter Name	KPI/RAW Counter Label	Product	Family	Formula	Comment
Cell Availability (%) V2	*KPI* : CELL_AVAILABILITY_	CELL AVAILABILITY '	Huawei LTE	Cell Based A	100 * (L_Cell_Avail_Dur / capture_duration)	KPI is calculated based on the measurement hours observed in the available PM files.

Over Cells on 01/05/2024



Over eNodeB on 01/05/2024

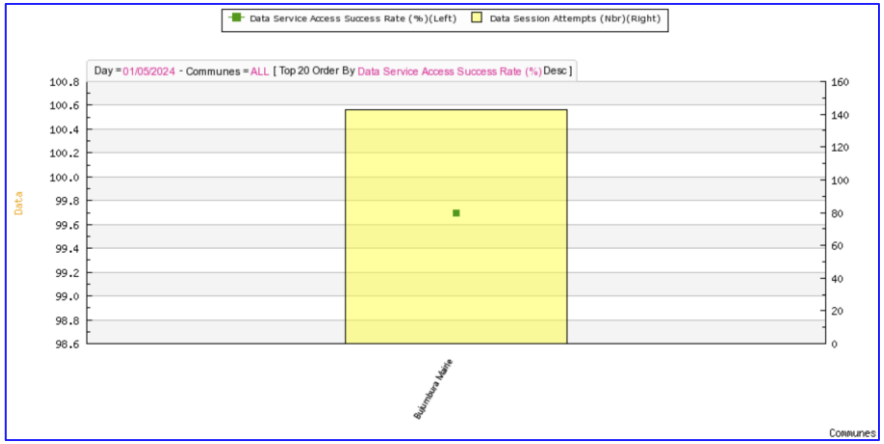


PM Files Analysis: (Example: HUAWEI LTE PM Files)

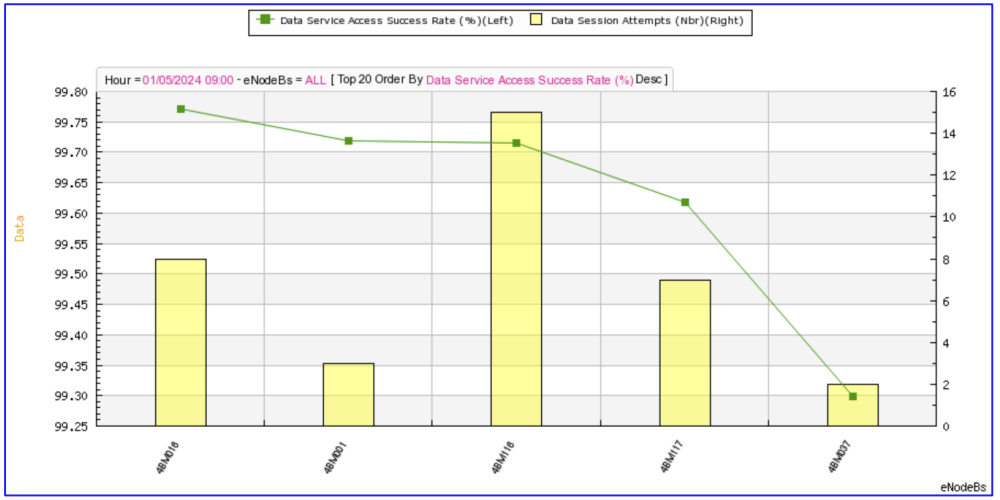
- Service Accessibility (SA): For this category, the Data Service Access Success Rate is the crucial KPI, reflecting the percentage of successful attempts to access the data service.

Legend Label	KPI/RAW Counter Name	KPI/RAW Counter Label	Product	Family	Formula
Data Service Access Success Rate (%)	***KPI*** : DATA_SERVICE_ACCESS_SUCCESS_RATE	DATA SERVICE ACCESS SUCCESS RATE	Huawei LTE	Cell Based A	100 * (L_RRC_CONNREQ_SUCC / L_RRC_CONNREQ_ATT) * (L_S1SIG_CONNEST_SUCC / L_S1SIG_CONNEST_ATT) * (L_E_RAB_SUCCEST / L_E_RAB_ATTEST)

Over Communes on 01/05/2024



Over eNodeB at 9AM on 01/05/2024

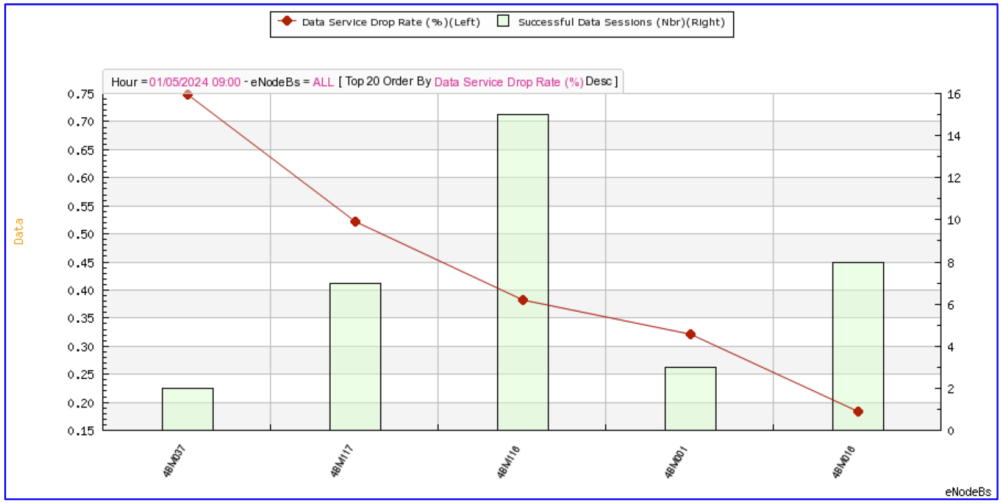


PM Files Analysis: (Example: HUAWEI LTE PM Files)

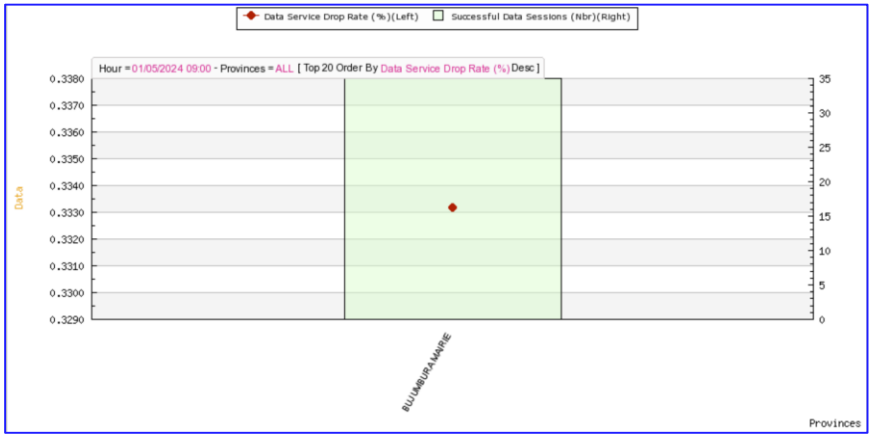
- Service Retainability (SR): The Data Service Drop Rate serves as the primary KPI here, indicating the percentage of data sessions that were unexpectedly terminated before completion.

Legend Label	KPI/RAW Counter Name	KPI/RAW Counter Label	Product	Family	Formula
Data Service Drop Rate (%)	***KPI*** : DATA_SERVICE_DROP_RATE	DATA SERVICE DROP RATE	Huawei LTE	Cell Based A	100 * (L_E_RAB_ABNORMREL / (L_E_RAB_ABNORMREL + L_E_RAB_NORMREL))

Over eNodeB at 9am 01/05/2024



Over PROVINCE at 9am 01/05/2024

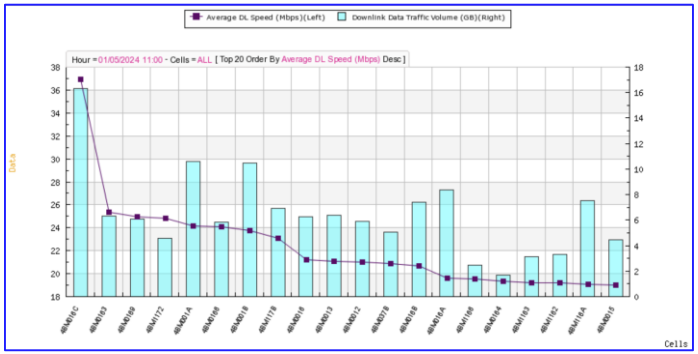


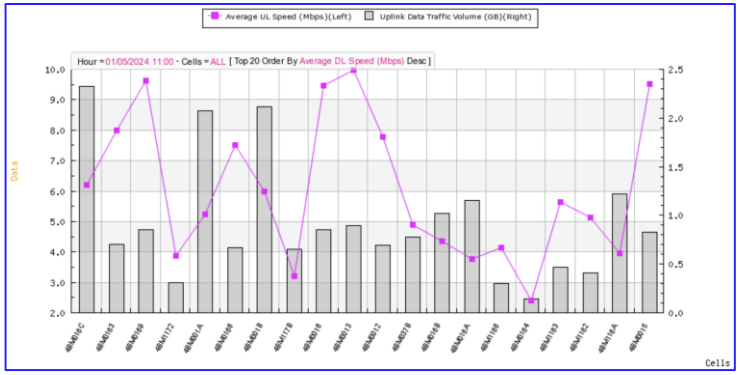
PM Files Analysis: (Example: HUAWEI LTE PM Files)

- Service Integrity (SI): This category is evaluated by the Download and Upload Data Speeds, which measure the throughput performance in Mbps.

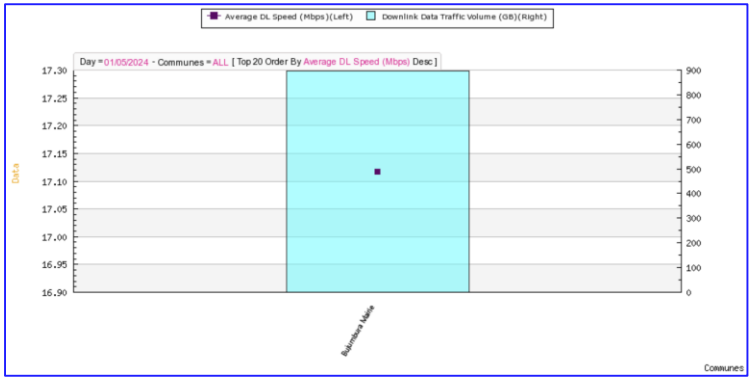
Legend Label	KPI/RAW Counter Name	KPI/RAW Counter Label	Product	Family	Formula
Average DL Speed (Mbps)	***KPI*** : DL_SPEED	DL SPEED (Mbps)	Huawei LTE	Cell Based A	(L_THRP_BITS_DL / L_Thrp_Time_Cell_DL_HighPrecision) / 1000
Average UL Speed (Mbps)	***KPI*** : UL_SPEED	UL SPEED (Mbps)	Huawei LTE	Cell Based A	(L_THRP_BITS_UL / L_Thrp_Time_Cell_UL_HighPrecision) / 1000

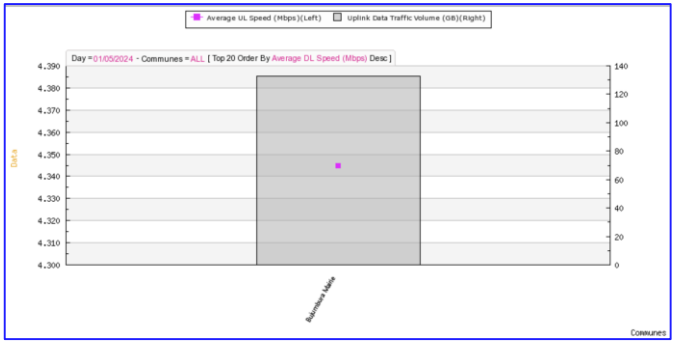
Over Cells at 11am 01/05/2024





Over Communes for day 01/05/2024





PM Files Analysis: (Example: HUAWEI LTE PM Files)

- Required List of "functionsetIDs(measInfoId)" to be activated in Huawei 4G XML PM files submitted should be: "152xxx" group.

```
+ <measInfo measInfoId="1526726657">
+ <measInfo measInfoId="1526726659">
+ <measInfo measInfoId="1526726660">
+ <measInfo measInfoId="1526726661">
+ <measInfo measInfoId="1526726662">
+ <measInfo measInfoId="1526726664">
+ <measInfo measInfoId="1526726665">
+ <measInfo measInfoId="1526726666">
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+ <measInfo measInfoId="1526726708">
+ <measInfo measInfoId="1526726709">
+ <measInfo measInfoId="1526726710">
+ <measInfo measInfoId="1526726712">
+ <measInfo measInfoId="1526726722">
```

ALL Radio Network Related Measurements Function Set IDs- **Present**

•Minimum List that MUST be activated

Family	Function Set IDs	Import
eNodeBCell	1526726657	YES
eNodeBCell	1526726659	YES
eNodeBCell	1526726660	YES
eNodeBCell	1526726661	YES
eNodeBCell	1526726662	YES
eNodeBCell	1526726664	YES
eNodeBCell	1526726700	YES
eNodeBCell	1526726705	YES
eNodeBCell	1526726706	YES
eNodeBCell	1526726708	YES
eNodeBCell	1526726709	YES
eNodeBCell	1526726719	YES
eNodeBCell	1526726722	YES

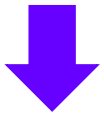
Day	CELL AVAILABILITY	CELL DOWNTIME	CELL DOWNTIME (H)	CELL UPTIME (H)	DATA SERVICE ACCESS FAILURE RATE	DATA SERVICE ACCESS SUCCESS RATE	DATA SERVICE AVAILABILITY	DATA SERVICE DROP RATE	DL SPEED (Mbps)	DL TRAFFIC VOLUME (GB)	INITIAL ERAB ESTABLISHMENT ATTEMPTS	S1 SIGNALING SUCCESS RATE	TOTAL DATA TRAFFIC VOLUME (GB)	UL SPEED (Mbps)	UL TRAFFIC VOLUME (GB)	UL USER THROUGHPUT (Mbps)	Cell	eNodeB	Province	Commune	Vendor
20240501	100	0	0	4	1.03416	98.9658	98.996	0.790051	9.5203	10.7157	16089	99.9676	12.4745	2.54849	1.75875	2.45653	4BM001I	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.49631	99.5037	99.6441	0.892531	7.4396	9.37403	10727	99.8591	10.8746	2.17092	1.50056	1.96678	4BM001M	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.295222	99.7048	99.728	0.967395	8.46163	6.4167	20625	99.9768	7.91476	2.29132	1.49806	1.83524	4BM001D	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.32354	99.6765	99.692	0.183546	25.4683	44.8334	100593	99.9844	53.5764	5.6084	8.74294	2.52655	4BM001A	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.0838399	99.9162	99.9178	0.0706484	23.2671	39.9529	218044	99.9984	48.6415	6.34292	8.68656	4.44566	4BM001B	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.116831	99.8832	99.8911	0.361903	13.7597	11.0731	25981	99.992	12.7448	2.85912	1.67171	3.13259	4BM001C	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.194627	99.8054	99.8124	0.783046	12.3074	14.2445	30114	99.993	16.4148	3.51337	2.17029	4.23492	4BM001BT	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.326755	99.6712	99.6964	0.944713	10.5329	12.8425	40441	99.9747	14.9667	2.90228	2.12421	2.86276	4BM001CT	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.37421	99.6258	99.6747	0.728305	7.60999	11.2926	21068	99.9509	13.5276	3.11659	2.23503	3.34599	4BM001N	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei
20240501	100	0	0	4	0.109977	99.89	99.8974	0.183011	10.129	3.28833	13864	99.9926	3.78254	2.8841	0.494218	2.74251	4BM0010	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	Huawei

All KPIs are computed because all function setIds required are activated

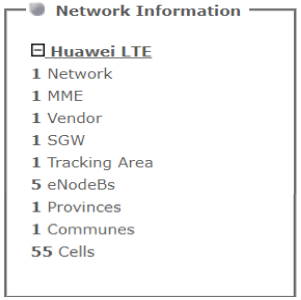
Verification of Topology Files Adequacy

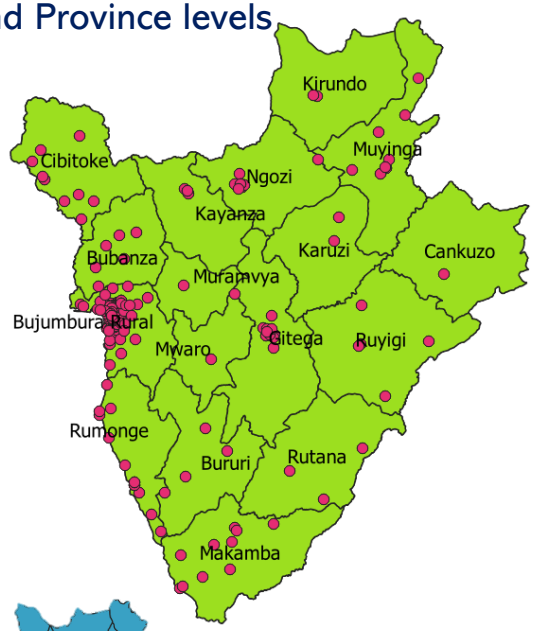
- The topology data lacked specific details such as TX Power and Antenna Gain, but was still sufficient for updating the RPM system with the topology for Commune and Province levels using the Burundi geojson file.

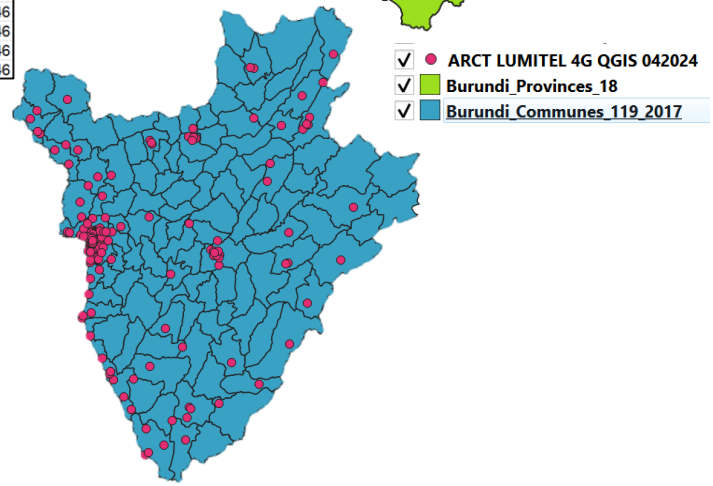
VENDOR	MME ID	SGW NAME	Tracking Area	eNodeB NAME	CELL NAME	eNodeB ID	Local Cell ID	PCI	CHANNEL	AZIMUTH	LONGITUDE	LATITUDE
Nokia	MME1	SGSN1	4001	4BB003	4BB003A	803	21	199	1452	40	29.41922	-3.2668
Nokia	MME1	SGSN1	4001	4BB003	4BB003B	803	22	236	1452	230	29.41922	-3.2668
Nokia	MME1	SGSN1	4001	4BB003	4BB003C	803	23	237	1452	340	29.41922	-3.2668
Nokia	MME1	SGSN1	4001	4BB005	4BB005A	805	21	446	1452	70	29.3426	-3.1224
Nokia	MME1	SGSN1	4001	4BB005	4BB005B	805	22	356	1452	170	29.3426	-3.1224
Nokia	MME1	SGSN1	4001	4BB005	4BB005C	805	23	357	1452	285	29.3426	-3.1224
Nokia	MME1	SGSN1	4001	4BB007	4BB007A	807	21	6	1452	50	29.3043	-3.19789
Nokia	MME1	SGSN1	4001	4BB007	4BB007B	807	22	18	1452	160	29.3043	-3.19789
Nokia	MME1	SGSN1	4001	4BB007	4BB007C	807	23	24	1452	320	29.3043	-3.19789



Network	Vendor	eNodeBs	eNodeBs label	Provinces	Communes	Cells	Cells label	azimuth	longitude	latitude
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_100	4BM001I	280	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_1	4BM001M	30	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_20	4BM001D	280	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_21	4BM001A	30	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_22	4BM001B	150	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_23	4BM001C	270	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_25	4BM001BT	150	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_26	4BM001CT	270	29.37137	-3.38046
LUMITEL	Huawei	100001	4BM001	BUJUMBURA MAIRIE	Bujumbura Mairie	100001_2	4BM001N	150	29.37137	-3.38046



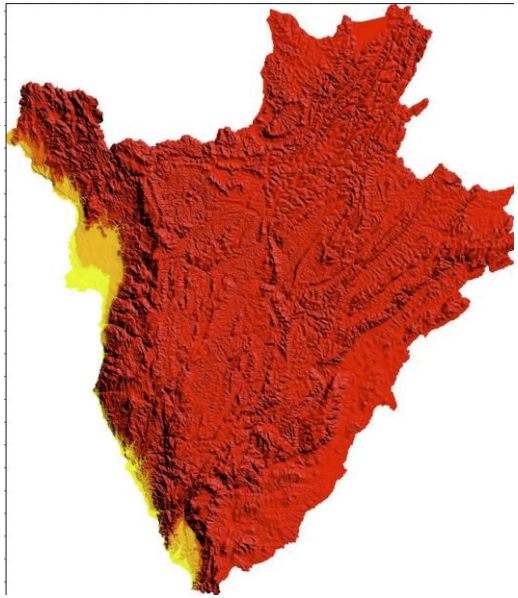




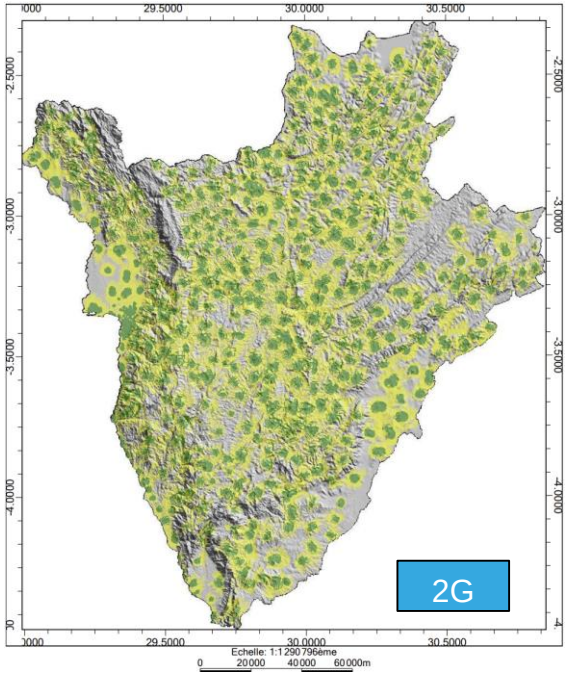
Coverage Map Generation

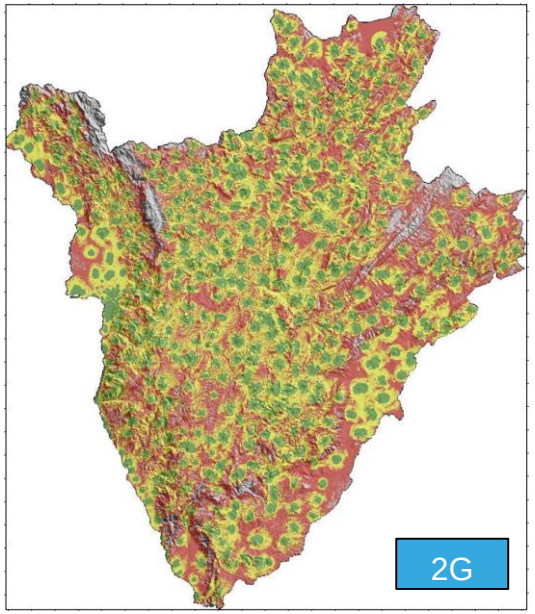
- Although the topology data lacked specific details such as TX Power and Antenna Gain. However, for accurate coverage mapping, we defaulted to using standard antenna TX power(43dBm) and antenna gain(17dBi) values in accordance with ITU-R recommendations, combined with DTM with 5m spatial resolution, to generate the coverage maps effectively.

VENDOR	BSC NAME	BSC ID	BTS NAME	BTS ID	CELL NAME	CELL ID	LAC	AZIMUTH	LONGITUDE	LATITUDE	CHANNEL	RANGE	NTENNA HEIGHT (m	M-TILT	E-TILT	ANTENNA NAME	ANT GAIN (dBm)	TX POWER (dBm)	TX LOSSES (dBm)	Province
Nokia	BUBC05	BUBC05	BB0003	523	BB00031	46031	11076	40	29.41922	-3.2668	18		55	0	4	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0003	523	BB00032	46032	11076	230	29.41922	-3.2668	27		55	0	6	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0003	523	BB00033	46033	11076	340	29.41922	-3.2668	33		55	0	6	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0003B	103	BB00034	46034	11076	40	29.41922	-3.2668	769		55	0	4	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0003B	103	BB00035	46035	11076	230	29.41922	-3.2668	792		55	0	6	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0003B	103	BB00036	46036	11076	340	29.41922	-3.2668	782		55	0	6	APX15GV				Bubanza
Nokia	BUBC02	BUBC02	BB0004	526	BB00041	46041	11016	110	29.2687	-3.11292	23		60.5	0	7	APX15GV				Bubanza
Nokia	BUBC02	BUBC02	BB0004	526	BB00042	46042	11016	180	29.2687	-3.11292	25		60.5	0	4	APX15GV				Bubanza
Nokia	BUBC02	BUBC02	BB0004	526	BB00043	46043	11016	340	29.2687	-3.11292	30		60.5	0	7	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0005	529	BB00051	46051	11076	70	29.3426	-3.1224	22		49.5	0	4	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0005	529	BB00052	46052	11076	170	29.3426	-3.1224	27		49.5	0	5	APX15GV				Bubanza
Nokia	BUBC05	BUBC05	BB0005	529	BB00053	46053	11076	285	29.3426	-3.1224	32		49.5	0	5	APX15GV				Bubanza
Nokia	BUBC02	BUBC02	BB0006	1732	BB00061	46061	11016	50	29.31985	-3.05717	21		44	0	6	APX15GV				Bubanza



Digital Terrain Model (5m spatial resolution)





Conclusion

In summary, all PM file samples and Topology Files shared have been validated and are satisfactory for our needs. Despite the absence of TX power and antenna gain data, the topology file remains sufficient for operational purposes. Moving forward, ARCT expects LUMITEL will continue to update the topology file monthly and ensure it is shared.

Next step, we are preparing to deploy a 1U form factor server at LUMITEL OSS premises. This equipment will facilitate automatic retrieval of PM files from the OSS, streamlining the QoS monitoring process for ARCT Burundi. This setup will ensure that we maintain near- real time network performance monitoring.

POWEREDGE R240

Compute made simple

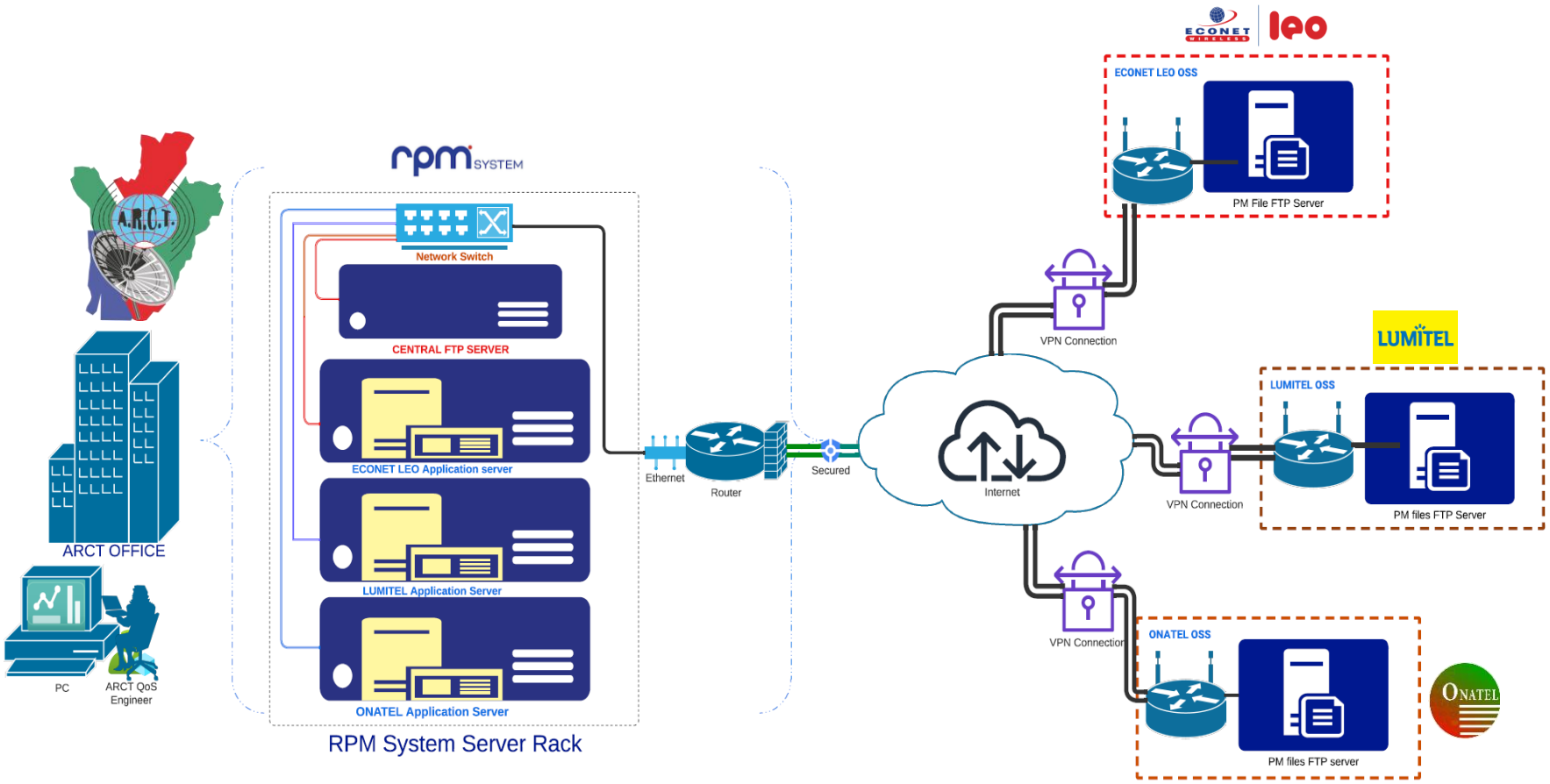
The Dell EMC PowerEdge R240 is an affordable single-socket 1U rack server designed for small businesses and service providers.

Form Factor 1U—19”

Specification of the FTP server on the MNO's premises.

Fonctionnalité	Caractéristiques techniques
Processeur	Un processeur Intel Xeon série E-2300 avec jusqu'à 8 cœurs
Mémoire	• 4 logements DIMM DDR4, prise en charge max. de 128 Go UDIMM, vitesses allant jusqu'à 3 200 MT/s • Prend en charge uniquement les barrettes DIMM DDR4 ECC sans registre Remarque : pour le processeur Pentium, la vitesse de mémoire maximale prise en charge est de 2 666 MT/s.
Contrôleurs de stockage	• Contrôleurs internes : PERC H345, H355, H755, HBA355i, S150 • Démarrage interne : module SD interne double, USB ou Boot Optimized Storage Subsystem (BOSS-S1) : 2 disques SSD M.2 HWRAID • Adaptateurs HBA externes (non RAID) : HBA355e
Baies de disque	Baies avant : • Jusqu'à 4 disques (durs/SSD) SAS/SATA de 3,5 pouces max. 30,72 To • Jusqu'à 2 disques (durs/SSD) SAS/SATA/NVMe de 3,5 pouces, max. 15,36 To • Jusqu'à 4 disques (durs/SSD) SAS/SATA de 3,5 pouces max. 30,72 To
Blocs d'alimentation	• 450 W Bronze 100-240 VCA, câblé • 450 W Platinum 100-240 VCA, câblé
Options de refroidissement	Refroidissement par air
Ventilateurs	• Jusqu'à sept ventilateurs câblés
Dimension	• Hauteur : 42,8 mm (1,68 pouce) • Largeur : 482 mm (18,97 pouces) • Profondeur : 598,64 mm (23,56 pouces) avec panneau 585 mm (23,03 pouces) sans panneau
Format	Serveur au format rack 1U

ARCT-MNO Connectivity / VPN Connection



THANKS

Planet Network International