

Low SNR, Interference & Illegal Transmissions in Uganda's Wireless Networks

1. Technical Metrics in Uganda/East Africa

- **Signal Quality at Cell Edges:** Rural and edge-of-network users often operate near the minimum SNR for connectivity. For example, an LTE link can maintain ~95% throughput at roughly (-1 dB SNR) using robust QPSK coding, whereas higher-order modulations demand >10 dB SNR ¹ ². This means cell-edge devices frequently fall back to low-rate modulation when SNR dips near zero, limiting data speeds.
- **Interference-Driven Errors: Uganda Communications Commission (UCC)** QoS surveys show that "poor signal quality" (i.e. degraded SNR due to interference) is a leading cause of network failures. In late 2019, over (70 %) of MTN and Airtel call failures were attributed to *in-network interference* (same-frequency radios causing self-interference), resulting in dropped/blocked calls ³ ⁴. By contrast, Africell and UTL saw more failures from outright coverage gaps ⁵, highlighting how noise vs. signal paucity both impact rural service.
- **Modulation Classification Under Noise:** Cognitive radio studies confirm that heavy noise severely impairs automatic modulation recognition. One report finds even advanced classifiers barely achieve (~30% accuracy) at extreme low SNR (-20 dB) ⁶. In practice, accuracies remain poor until SNR improves by an order of magnitude – e.g. an 8-PSK signal requires ~8 dB SNR to reach about (90 % classification accuracy) ⁷. This drop-off underscores the challenge of identifying signals under Uganda's noisy spectrum conditions.
- **Rural Link Performance Figures:** Field trials in the region quantify the impact of distance and interference on link quality. For instance, a TV White Space pilot in Malawi (UHF band) reported an average SNR of (~24.7 dB) over a **7.5 km** link, yet throughput was only ~0.42 Mbps with ~118 ms latency ⁸. This modest data rate, despite a healthy SNR, reflects constraints like limited channel bandwidth and ambient interference in real deployments. Likewise, in Uganda's high-traffic areas, UCC observed call block rates spiking to (34 %)+ in towns like Jinja ⁹ (vs. a 2% target), correlating with low signal levels and local interference issues.

2. Documented Service Impacts

- **Mobile Network Outages & Quality Degradation:** UCC's investigations have linked illegal transmitters to service disruptions. In **Oct 2024**, UCC revealed that unauthorized 3.5 GHz point-to-point radios on Kampala rooftops were *interfering* with licensed LTE bands (used by MTN/Airtel), degrading connectivity downtown ¹⁰. An enforcement operation was launched to dismantle ~8 such links causing these disruptions ¹¹. Earlier, **mid-2023**, UCC had similarly shut down dozens of illicit signal repeaters ("boosters") after *complaints from operators* that these devices were injecting noise and crippling local cell reception ¹² ¹³. Several offenders faced prosecution as the interference was directly undermining mobile voice and data quality in the affected areas.
- **Dropped Calls & Data Failures:** High interference translates to tangible user impact in Uganda's networks. UCC's QoS drive tests (Sept–Nov 2019) found call drop and block rates far above

acceptable levels in multiple regions, largely due to low SNR. Notably, Airtel users in Jinja experienced a blocked-call rate of **34%** (meaning over one-third of call attempts failed) ⁹, while cities like Lira, Mbale, and Moroto saw 12–15% call blocking – all vastly exceeding the 2% QoS threshold. UCC traced this to signal interference and congestion causing “degradation in the quality of the network signal” and has since pressed operators for remedial plans ⁴ ¹⁴. Such interference-induced outages also jeopardize services like **mobile money** which rely on a stable mobile network.

- **Aviation Communication Risks:** The **Uganda Civil Aviation Authority (UCAA)** has cautioned that traditional aeronautical radio channels suffer reliability issues due to coverage gaps *and interference*. In Sept 2024, UCAA noted that over oceanic and remote continental airspace “voice/radio communication is less reliable... due to limited coverage and interference,” which can lead to miscommunication ¹⁵ ¹⁶. To mitigate this safety risk, Uganda adopted a data-link system (text-based air-ground communication) less vulnerable to noise. The move came after recognizing that high radio noise floors were impeding clear voice links with pilots, underscoring how illegal transmissions or ambient RF noise can even impact critical services like aviation and air traffic control.
- **Enforcement and Monitoring Lapses:** Until recently, Ugandan authorities lacked robust spectrum monitoring, allowing some illegal operators to persist. UCC has since acquired new monitoring equipment and, in 2024, jointly with police, intensified crackdowns on pirate broadcasters and unlicensed radios ¹⁷ ¹⁸. For example, numerous “bizindaalo” (outdoor megaphone community radios) were seized for broadcasting without licenses and *causing harmful interference* to legitimate FM stations and even public safety communications ¹⁹ ²⁰. In one sweep, **30+** illegal radio setups were dismantled nationwide ²¹. These incidents illustrate that unregulated transmitters not only break the law but also degrade the overall RF environment – prompting UCC to invest in continuous spectrum surveillance to detect and address interference sources in real time.

3. Policy and Regulatory Mandates

- **Quality of Service & Coverage Goals:** Uganda’s national strategies explicitly prioritize improved signal quality and interference management as part of expanding broadband. The **Third National Development Plan (NDPIII 2020/21–2024/25)** acknowledges that broadband infrastructure still has “significant quality of service challenge,” with most rural areas underserved ²². NDPIII and the **National Broadband Policy (2018)** set ambitious targets for universal access (e.g. minimum 4 Mbps countrywide) and call for investments to extend reliable coverage to **100%** of districts. Indeed, Uganda’s new **Digital Transformation Roadmap (2023–2028)** aims for (90 % broadband coverage) by 2040, stressing “*strengthened infrastructure and wider connectivity*” to bridge the urban–rural divide ²³ ²⁴. These policies create a mandate for regulators and operators to improve SNR at cell edges, adhere to QoS thresholds, and reduce outages caused by noise or interference.
- **Spectrum Management & Interference Mitigation:** Ugandan law and regulations empower UCC to enforce strict anti-interference measures. The **Uganda Communications Act 2013** (Sections 5, 22, 26–27) forbids operating any radio/transmitter without a license or in violation of technical rules. UCC’s *Radio Spectrum Management Guidelines* (2017) explicitly instruct that “*Any interference reported or observed shall be investigated and addressed.*” Offending users face penalties “including fines, withdrawal of spectrum and other penalties” for unauthorized or non-compliant transmissions ²⁵. In practice, this has led UCC to issue public warnings (e.g. in 2021 against unapproved signal boosters ²⁶) and to mount enforcement operations as noted. The Commission also runs an **Intelligent Network Monitoring System** to continuously sample QoS and detect anomalies ²⁷,

aligning with ITU best practices. In short, Uganda's regulatory framework mandates proactive interference monitoring and swift enforcement to protect licensed services' SNR and bit error rates.

- **Dynamic Spectrum Allocation Initiatives:** National policy supports innovative spectrum sharing to alleviate congestion and noise. The **Digital Uganda Vision 2040** and Broadband Policy encourage “optimal utilization of spectrum resources” through technologies like dynamic access ²⁸. In 2021, UCC rolled out a **TV White Space (TVWS) usage standard** for the 470–694 MHz band – allowing secondary rural broadband use of vacant TV channels under a geolocation database system ²⁹ ³⁰. This framework permits multiple services to share spectrum without interference, reflecting Uganda's commitment to modern spectrum management. Similarly, the regulator has discussed opening unlicensed or lightly-licensed bands for community networks and Wi-Fi offload as long as devices meet technical parameters to avoid harmful interference ¹⁰ ³¹. These policy moves (guided by NDPIII and the Broadband Infrastructure Blueprint) underscore that mitigating interference is not just reactive; it's built into Uganda's future spectrum planning via smarter allocation and **spectrum sharing** mechanisms.
- **Mandated QoS and Monitoring:** Uganda's National Broadband Policy and UCC regulations also set **quantitative QoS thresholds** that indirectly target interference issues. For mobile networks, UCC requires <2% call drop/block rates and adequate signal strength in all covered areas ¹⁴. The *Quality of Service Regulations (2019)* define metrics like **signal-to-noise ratio (SNR)** and **bit error rate (BER)** that operators must meet, and empower UCC to audit performance ³². For example, UCC's 2022 public QoS report compared year-on-year data drop rates and signaled that operators must improve radio signal levels in regions falling short ³³. Furthermore, Uganda's **National Broadband Plan** emphasizes resilience against “signal interference with other licensed operators” ²⁰, aligning policy with the need for on-the-ground enforcement. In sum, through a mix of development plans, policies, and technical standards, Uganda's government has mandated: (a) expansion of reliable, interference-free communications nationwide, (b) adoption of dynamic spectrum tools to maximize SNR and reduce illegal use, and (c) continuous monitoring with penalties to ensure compliance with interference mitigation and QoS norms.

Data Gaps: While the above sources give concrete interference cases and some SNR/accuracy figures, **localized BER measurements** in Uganda's rural deployments remain scarce in public literature. For instance, no specific bit-error-rate statistics for UCUSAF-funded tower sites were found in connected sources. Future field studies (e.g. drive tests on UCUSAF base stations or SDR spectrum sensing in villages) may be needed to quantify BER under real interference conditions. Similarly, detailed modulation-classifier performance data in Uganda's context are limited – current figures are mostly from lab simulations. These gaps suggest an opportunity for on-site measurements and trials to further inform **dynamic spectrum management** and investment in interference mitigation technologies.

Sources: See the inline citations for titles, authors, dates, and URLs of the referenced reports, regulations, and articles.

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