

# 5G NR FDD 600 MHz Proof-of-Concept Deployment and Assessment

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**Abstract** - This paper presents a comprehensive performance analysis of 5G New Radio Band 71 (N71, 600 MHz) deployment across a large-scale, multi-region, multi-vendor Proof-of-Concept network spanning six geographically diverse administrative regions. The study evaluates N71 coverage and throughput performance against co-deployed NR bands (N28, N40, N77/N78) through static drive-test measurements, cluster-level OSS key performance indicators (KPIs), crowdsourced Ookla speed-test data, and 5G Standalone cluster validation. Antenna configuration gain from 2T2R to 4T4R is quantified, device ecosystem maturity and carrier aggregation readiness are assessed from an installed base exceeding 34 million terminals, and multi-vendor layering strategies are described for three equipment vendors (Vendor A, Vendor B, Vendor C). Results demonstrate that N71 provides a 2–3 dB RSRP advantage over N28 outdoors, +7 dB versus mid-band layers, and up to +15 dB in deep-indoor scenarios, with uplink throughput exceeding mid-band by more than 90% in low-coverage conditions. In 5G SA mode with N71+N78 carrier aggregation, peak downlink throughput reaches 878 Mbps (CPE) and 1230 Mbps (flagship smartphone), establishing N71 as a viable SA anchor band for VoNR readiness and nationwide 5G coverage extension.

**Keywords** - 5G NR; Band 71; 600 MHz; coverage extension; carrier aggregation; FDD; NSA; 5G SA; VoNR; multi-vendor; drive test; OSS KPI; device ecosystem.

## I. INTRODUCTION

The rapid expansion of 5G services has intensified demand for seamless coverage across diverse propagation environments — urban high-rises, suburban residential clusters, rural areas, and challenging deep-indoor scenarios such as shopping malls, basements, and multi-storey buildings. Mid-band NR deployments on N40 (2300 MHz) and N77/N78 (3500 MHz) deliver the high throughput that defines the 5G user experience, yet their coverage footprint is fundamentally limited by higher path loss. Low-band 5G, particularly the 600 MHz band (NR Band 71), offers a complementary propagation profile that penetrates obstacles more effectively, extends coverage to cell-edge users, and provides an indoor 5G layer where mid-band signals cannot reach.

The November 2024 600 MHz spectrum award in the deployment market made it the first country in EMEA and ITU Region 1 to assign N71 capacity for 5G [1]. The deployment studied here is among the first large-scale N71 live-network PoCs in the region, comprising several hundred sites across six administrative regions with three major equipment vendors. This scale and geographic diversity provide a rare empirical dataset covering NSA and SA operation, four co-deployed NR bands, multiple antenna configurations, and commercially representative device populations.

Prior work on low-band NR performance is limited. Rochman et al. [2] provide a city-wide multi-carrier evaluation covering sub-1 GHz and mid-band NR, finding low-band NR channels typically operate in 2x2 MIMO due to device limitations and that throughput gains are bandwidth- rather than beamforming-driven. Wongprasert et al. [3] investigate low-band 4T4R MIMO reception on commercial smartphones, documenting meaningful RSRP and throughput gains. An indoor 600 MHz field trial [4] reports RSRP floor values and peak throughput in a controlled single-site environment. Shao et al. [5] study uplink CA combining mid-band with n71 on a commercial network, finding n71 contributes meaningfully to CA uplink in coverage-limited conditions. None of these studies

combine NSA performance, 4T4R antenna gain, installed-base device ecosystem analysis, multi-vendor layering strategy, and 5G SA CA validation within a single nationwide PoC framework.

This paper makes the following contributions:

- (1) **Multi-band field comparison** of N71 against N28, N40, and N77/N78 across near, mid, far, and deep-indoor propagation scenarios from a large-scale commercial PoC.
- (2) **Antenna gain quantification** of the 2T2R-to-4T4R upgrade on N71 in terms of RSRP, SINR, and DL/UL throughput at multiple distance ranges.
- (3) **Multi-vendor OSS KPI benchmarking** with pre/post N71 activation comparisons and crowdsourced Ookla validation.
- (4) **Device ecosystem and CA readiness analysis** over an installed base exceeding 34 million terminals, including CA combination gap analysis.
- (5) **5G SA cluster validation** using N71 as the anchor band, reporting N71+N78 CA throughput, NSA vs. SA latency, and VoNR readiness.

## II. DEPLOYMENT SETUP AND METHODOLOGY

### A. Network Architecture and Scope

The PoC was conducted on a live operational network in NSA Option 3x configuration, with LTE FDD serving as the EN-DC anchor layer and multiple 5G NR carriers deployed as secondary nodes. Band N71 was integrated alongside existing N40 and N77/N78, and in approximately 55% of sites with N28 co-location, creating multi-layer configurations of up to five component carriers (CC). Table I summarises the key deployment parameters.

TABLE I. DEPLOYMENT OVERVIEW

Parameter	Value
Deployment Scale	Large-scale multi-region PoC
Deployment Regions	Six diverse regions (urban, suburban, rural)
Equipment Vendors	Three major RAN vendors (A, B, C)
N71 Channel Bandwidth	20 MHz FDD
Architecture	NSA (Option 3x, EN-DC) and 5G SA cluster validation
Antenna Configurations	2T2R and 4T4R
Co-located N28	Approximately 55% of sites
Integration Period	Q4 2025 – Q1 2026

FDD: Frequency Division Duplex; NSA: Non-Standalone; SA: Standalone; EN-DC: E-UTRA NR Dual Connectivity.

### B. PoC Cluster Design

Six dedicated PoC clusters were selected to represent two N71 deployment scenarios: (i) N71 co-located with N28 — three clusters, one served by each vendor (Vendor A, Vendor B, Vendor C); and (ii) N71 standalone without N28 — three additional clusters. This separation enabled direct attribution of N71 traffic and coverage gains in each scenario.

### C. Measurement Methodology

Three complementary measurement methods were employed. Static drive-test (DT) measurements used a Qualcomm Mobile Test Platform (MTP) UE in lock mode to isolate each NR band at four distance/attenuation scenarios: Near (+2 dB relative RSRP advantage for N71 vs. N28), Mid (+1 dB), Far (+2 dB), and Deep Indoor (penetration only N71 sustained). OSS-based KPI monitoring tracked DL/UL user throughput, cell-edge UL throughput, 5G traffic share, and secondary-node addition metrics across each cluster using vendor-specific counters. Crowdsourced Ookla Speedtest data (raw samples filtered to N71 co-location sites) provided independent user-plane validation of pre-deployment (Q4 2025) vs. post-deployment (Q1 2026) performance. For 5G SA validation, a dedicated cluster used CPE and a flagship smartphone as test UEs.

### D. Layering Strategy

Band priority in NSA was configured consistently across vendors: N77/N78 (highest) > N40 > N28 (medium) > N71 (low), with NR A2/B1 release thresholds of -121 dBm for low-band and -124 dBm for mid-band. N71 was assigned low priority because installed-base CA combination support for N71 NSA-DC is limited compared to N28. In 5G SA, N71 is elevated above N28 (priority 5 vs. 4) due to wider bandwidth and better CA support, with N77/N78 (7) and N40 (6) retaining the highest priorities. One vendor deployed an N28 CA blacklist function to eliminate LB+MB CA combinations on N28, effectively elevating N71 to medium priority without impacting total CA traffic.

## III. THEORETICAL BACKGROUND

The propagation advantage of N71 (600 MHz) over mid-band NR is governed by the Friis free-space path loss model. Path loss  $L$  in dB increases with  $\log(f)$ , meaning a doubling of carrier frequency yields approximately 6 dB of additional path loss. Consequently, 600 MHz signals sustain 7–9 dB lower path loss than 2300 MHz (N40) and 14–16 dB lower than 3500 MHz

(N77/N78) at equivalent distances, physically underpinning the coverage-extension measurements reported in Section IV.

Channel capacity is bounded by the Shannon–Hartley theorem:

$$C = B \cdot \log_2(1 + \text{SNR}) \quad (1)$$

where  $C$  is channel capacity (bps),  $B$  is bandwidth (Hz), and SNR is the signal-to-noise ratio. Although N71 at 20 MHz FDD offers lower bandwidth than N40 or N77/N78, its SNR advantage in coverage-limited scenarios — particularly cell-edge and deep-indoor — compensates significantly, especially in the uplink where lower path loss and FDD simultaneous UL/DL transmission are most impactful.

FDD operation in N71 provides dedicated, simultaneous uplink and downlink sub-bands, unlike TDD systems (N40, N77/N78) where the UL slot ratio is constrained. This yields a structural uplink advantage per unit time, directly contributing to the superior UL throughput observed in low-coverage scenarios in Section IV-B.

For MIMO antenna configurations, the theoretical array gain from 2T2R to 4T4R is approximately 3 dB in RSRP, with a proportional increase in spectral efficiency through spatial multiplexing or diversity gain depending on channel rank. At low-SINR operating points (typical in far and indoor scenarios), diversity gain dominates, yielding substantial UL throughput improvements quantified in Section IV-C.

When N71 is combined with mid-band carriers in CA, the effective capacity sums over all component carriers:

$$C_{\text{total}} = \sum_i B_i \cdot \log_2(1 + \text{SNR}_i) \quad (2)$$

In 5G SA with N71+N78 CA, N71 contributes coverage reach while N78 contributes high-rank spatial multiplexing and bandwidth, explaining the peak throughput reported in Section VII.

## IV. COVERAGE AND DRIVE TEST RESULTS (NSA)

### A. Multi-Band Static Point Comparison

Table II presents static-point field measurement results comparing RSRP, uplink throughput, and downlink throughput across N71, N28, N40, and N77/N78 at four propagation scenarios. All measurements were obtained in lock mode on a live network site (N28 configured at 5 MHz) using a Qualcomm MTP device.

TABLE II. STATIC POINT MULTI-BAND COMPARISON

Scenario	Metric	N71	N28	N40 / N77-78
Near (+2dB)	RSRP (dBm)	-73	-75	-78.1 / -78
	UL Thp (Mbps)	107	15.1	66.5 / 73.7
	DL Thp (Mbps)	150.1	37.8	317 / 338.6
Mid (+1dB)	RSRP (dBm)	-90.8	-91	-94 / -96.4
	UL Thp (Mbps)	19.1	5.0	17.1 / 30.3
	DL Thp (Mbps)	95.8	20.1	283 / 266.9
Far (+2dB)	RSRP (dBm)	-103	-105	-108.8 / -110.7
	UL Thp (Mbps)	13.3	4.5	0.06 / 0.11
	DL Thp (Mbps)	53.7	10	3 / 8
Deep Indoor	RSRP (dBm)	-112	N/A	N/A
	UL Thp (Mbps)	0.5	—	—
	DL Thp (Mbps)	38.7	—	—

Shaded cells indicate the best value per row. N71 deep-indoor results are unique — mid/high-band layers had no measurable signal at RSRP -112 dBm.

The results confirm three key coverage properties of N71. First, N71 consistently provides 2 dB better RSRP than N28 in near and far scenarios and 1 dB in the mid scenario, validating the propagation advantage despite the bandwidth asymmetry. Second, N71 outperforms mid-band layers by +7 dB in outdoor far scenarios, where N40 and N77/N78 drop to impractical UL values (0.06 Mbps) while N71 sustains 13.3 Mbps. Third, in the deep-indoor scenario at RSRP -112 dBm, only N71 maintained connectivity at 38.7 Mbps DL and 0.5 Mbps UL — a +15 dB advantage relative to mid-band. As expected from Shannon's theorem, mid-band layers outperform N71 in DL throughput in near and mid scenarios owing to their wider bandwidth.

Geolocation heat-map analysis across two cluster sites corroborates the field measurements. In one cluster, N71 achieved an average tile RSRP of -95.5 dBm vs. -95.8 dBm for N28 outdoors, and -98.61 dBm vs. -99.07 dBm indoors. In a second cluster, N71 yielded -89.6 dBm vs. -98.6 dBm for N28 — a 9 dB advantage. Despite fewer session-start counts on N71 (reflecting its lower priority), the traffic volume carried by N71 was comparable to or higher than N28, confirming absorption capacity.

#### B. Uplink Performance in Low-Coverage Conditions

A key differentiator of N71 is uplink performance in coverage-limited areas. At the far point, N71 delivers 13.3 Mbps UL versus 4.5 Mbps (N28), 0.06 Mbps (N40), and 0.11 Mbps (N77/N78) — a 90%+ UL advantage over mid-band, consistent with the FDD structural advantage described in Section III. Lock-mode testing further validates this: N71 UL throughput exceeded N40 by +163% and N78 by +95.4% across cluster drive routes.

#### C. 2T2R vs. 4T4R Antenna Configuration

The impact of upgrading the N71 antenna configuration from 2T2R to 4T4R was evaluated through cluster drive tests with distance-binned throughput analysis (Table III).

TABLE III. 2T2R VS. 4T4R ON N71

Configuration	RSRP (dBm)	SINR (dB)	Avg DL Thp (Mbps)
2T2R	-85.73	-0.06	32.28
4T4R	-82.73	1.12	40.59
Delta	+3 dBm	+1.18 dB	+25%

Distance-zone deltas: DL +28% at mid-point, +52% at far-point; UL +82% at mid-point, +167% at far-point.

The 4T4R configuration yields +3 dBm RSRP and +1.18 dB SINR on average, translating to a +25% average DL throughput gain. The gain is strongly distance-dependent: at the far point, where the channel operates in a diversity-dominant mode, DL improvement reaches +52% and UL improvement reaches +167%. This confirms the theoretical prediction of diversity-gain dominance at low SINR and validates 4T4R as the recommended antenna configuration for N71 where coverage-depth improvement is the primary objective.

### V. OSS KPI ANALYSIS: MULTI-VENDOR BENCHMARKING

OSS-based KPI analysis was performed independently for each vendor's PoC cluster. Table IV consolidates the per-vendor KPI uplift observed following N71 activation.

TABLE IV. MULTI-VENDOR OSS KPI SUMMARY — N71 VS. N28

KPI	Vendor A	Vendor B	Vendor C
DL User Thp N71 vs N28	+95% (19→37)	+149% (18→44)	+194% (10→30)
UL User Thp N71 vs N28	+63% (2.7→4.4)	+16% (5.7→6.6)	+9% (2.9→3.2)
Cell Edge UL Thp	+79% (0.14→0.57)	N/A	N/A
5G Traffic Share Δ	+2.5%	+5.0%	+2.0%

Pre/Post comparison period Nov 2025–Apr 2026. Concurrent network activities may affect Vendor B cluster absolute values.

Across all three vendors, N71 delivers substantial DL user-throughput gains relative to N28: +95% (Vendor A), +149% (Vendor B), and +194% (Vendor C). The larger gains at Vendor B and C sites reflect proportionally narrower N28 bandwidth there. UL gains are more modest (+9% to +63%) but consistently positive, confirming the FDD uplink advantage even in OSS-aggregated data across all UE types. Vendor A demonstrates the most significant cell-edge UL gain (+79%, from 0.14 to 0.57 Mbps), validating N71's coverage-depth improvement at cluster boundaries.

The 5G traffic-share increase of 2–5% per cluster is lower than throughput gains alone would suggest, primarily due to the low-priority layering strategy and the 62% device ecosystem maturity of N71 (Section VI). Non-N28 clusters showed higher N71 traffic share (1.5–2% vs. 0.5–1% in co-N28 clusters), confirming that N71 serves as an effective gap-filler where N28 is absent.

Ookla crowdsourced data cross-validates the OSS findings (Table V).

TABLE V. OOKLA CROWDSOURCED PRE/POST PERFORMANCE

Metric	Pre	Post	Delta	Source
DL (Mbps) Aggregated	364	390	+7.1%	Raw
UL (Mbps) Aggregated	36.4	38	+4%	Raw
Latency (ms) Aggregated	83.4	74.4	-11%	Raw
DL – Cluster w/ N28	368	373	+1%	Dash
DL – Cluster w/o N28	265	294	+11%	Dash

Aggregated raw samples from N71 co-location sites. Pre: 18–31 Jan 2026; Post: 1–14 Apr 2026.

The 7.1% aggregate DL improvement and 11% latency improvement in the cluster without N28 are particularly significant, as they represent user-experienced gains in areas previously served only by LTE or weak mid-band coverage. The more modest +1% improvement in the co-N28 cluster reflects the marginal gain of N71 over an already-present N28 layer.

### VI. DEVICE ECOSYSTEM AND CA READINESS

A critical constraint on N71 utilization in NSA is device ecosystem maturity. Table VI summarises band support and CA user/traffic percentages across all deployed NR bands, extracted from an analysis of the full installed-base terminal population (approximately 34 million registered terminals at the network level).

TABLE VI. NR BAND ECOSYSTEM MATURITY AND CA READINESS

Band	Maturity	CA User %	CA Traffic %	Apple NSA	Samsung NSA
N71	62%	6%	11%	8	1
N28	92%	37%	24%	15	7
N40	94%	20%	33%	—	—
N77/78	98–100%	37%	33%	—	—

CA percentages from OSS counters. Apple/Samsung NSA combos reflect distinct CA combination entries per 3GPP UE capability signalling (flagship reference devices).

N71 ecosystem maturity stands at 62%, below N28 (92%), N40 (94%), and N77/N78 (98–100%). However, the 62% coverage includes the dominant high-volume device models: all recent flagship smartphones, which individually account for the highest data consumption per user. The CA capability gap is more pronounced: only 6% of N71 OSS sessions involve CA versus 37% for N28, reflecting the limited number of NSA EN-DC CA combinations certified for N71 at the time of measurement. Flagship NSA support reaches 8 N71-containing combinations vs. 15 for N28 on one device family, and only 1 vs. 7 on another. In 5G SA, the CA landscape is more favorable: 8–9 N71 combinations are supported, a key driver of the SA performance results in Section VII.

Despite ecosystem constraints, N71 CA user share post-activation in one cluster increased by 4.76%, validating measurable absorption of CA users onto N71. As device firmware updates propagate more N71 CA combinations to the installed base, utilization is expected to grow substantially.

## VII. 5G STANDALONE VALIDATION WITH N71 AS ANCHOR

### A. SA vs. NSA Radio KPI Comparison

A dedicated 5G SA cluster validation compared N71 and N28 radio KPIs in SA mode during drive testing (Table VIII).

TABLE VII. N71 VS. N28 RADIO KPIS IN 5G SA

Indicator	N71	N28
RSRP (dBm)	-81.0	-82.0
RSRQ (dB)	-12.9	-12.7
SINR (dB)	4.5	4.3
DL Throughput (Mbps)	129.0	24.0
UL Throughput (Mbps)	66.0	14.0

SA & CA combination FOTA updates pending on commercial devices at time of measurement.

In SA mode, N71 provides superior performance on all metrics: +1 dBm RSRP, +0.2 dB SINR, and dramatically higher throughput — 129 Mbps DL (vs. 24 Mbps for N28) and 66 Mbps UL (vs. 14 Mbps). The DL ratio of ~5.4× reflects N71's wider bandwidth (20 MHz) relative to the 5 MHz N28 configuration at the test site, combined with SA protocol efficiency that removes the LTE anchor overhead present in NSA.

### B. N71+N78 Carrier Aggregation in 5G SA

Table VII presents throughput from 5G SA CA testing using N71 as the primary cell and N78 as the secondary cell, compared with N71+N28 CA and UL-only CA.

TABLE VIII. 5G SA CARRIER AGGREGATION THROUGHPUT

Parameter	CPE DL (N71+N78)	CPE DL (N71+N28)	CPE UL (N71+N78)	S25U DL (N71+N78)
Max Physical Thp (Mbps)	878	346	224	1230
Avg Physical Thp (Mbps)	606	222	206	—
Ookla Ping (ms)	17	14	—	15
Ookla DL (Mbps)	826	218	—	929

CPE: Customer Premises Equipment. S25U: flagship smartphone. SA & CA combination firmware update pending at time of measurement.

N71+N78 SA CA delivers 878 Mbps average physical DL throughput (CPE) with a peak of 1230 Mbps on the flagship

smartphone — demonstrating that N71 as the SA anchor paired with N78 as the high-bandwidth SCell achieves Gbps-class performance. This exceeds the N71+N28 combination (346 Mbps max) by 2.5×, validating N78 as the preferred SCell pairing. Ookla DL results of 826 Mbps (CPE) and 929 Mbps (smartphone) confirm the gains extend to the user plane. Latency (Ookla ping) is 15–17 ms, with N71+N28 achieving the lowest (14 ms) owing to its shorter SA control-plane path.

### C. NSA vs. SA Latency Analysis

Far-point latency comparisons at three packet sizes (32, 640, 1240 bytes) reveal that 5G SA achieves marginally lower latency than NSA at most operating points: 29.6 vs. 30.0 ms (32-byte), 38.0 vs. 39.4 ms (640-byte), and 42.4 vs. 51.0 ms (1240-byte). The 1240-byte improvement is the most significant (-17%), attributable to SA eliminating the LTE backhaul path in the user-plane anchor. Stable SA latency is strongly coverage-dependent: adequate N71 RSRP is a prerequisite for latency gains, making the coverage improvements of Section IV directly relevant to SA performance.

### D. VoNR Readiness

N71 in SA mode forms the propagation foundation for Voice over New Radio (VoNR). The combination of wide-area low-band coverage, FDD simultaneous uplink capability, and lower SA far-point latency satisfies the coverage and latency prerequisites for stable VoNR operation. Relative to N28 SA, N71's higher bandwidth provides greater headroom for simultaneous data and VoNR bearer operation. Formal VoNR benchmarking requires 5G SA project alignment and commercial device firmware updates; these results establish the N71 SA layer as technically ready for VoNR enablement pending ecosystem completion.

## VIII. DISCUSSION

The results collectively establish N71 as a strategically important coverage layer in a multi-band 5G network. Its propagation advantage (+7 dB vs. mid-band, +15 dB indoor) translates into measurable user-experience improvements: +7.1% aggregate Ookla DL improvement, +11% DL gain in areas without N28, and a 90%+ UL throughput advantage at cell-edge. These gains were delivered without degrading existing network KPIs — accessibility, retainability, and mobility indicators remained stable across all vendor clusters following N71 activation.

The primary constraint on N71 utilization remains device ecosystem maturity. At 62% band support and only 6% CA user share, N71's current contribution to overall traffic is limited (1.3–2% traffic share). However, this is an evolving baseline: CA user numbers increased by 4.76% post-activation in one cluster, and SA CA combination support is notably richer than NSA. As firmware updates propagate N71 CA capabilities, utilization is expected to grow — particularly in SA mode where N71 is the preferred anchor band.

Compared with the closest prior single-cluster, single-vendor N71 study, this work adds multi-vendor (three vendors), multi-region (six regions), multi-cluster (six PoC clusters) coverage, head-to-head N28 vs. N71 comparison, 4T4R analysis, ecosystem/CA readiness analysis over 34 million terminals, and

5G SA cluster validation — extending the evidence base for N71 from a controlled pilot to a nationally representative PoC.

From a deployment-strategy perspective, the results support differentiating N71 priority by co-location scenario: in areas without N28, N71 should be elevated to medium priority immediately; in co-N28 areas, elevation should proceed as device CA capabilities expand. The 4T4R configuration should be prioritized for N71 where hardware supports it, given the disproportionate UL and far-point DL gains in coverage-limited conditions.

## IX. CONCLUSION

This paper presented the results of a large-scale, multi-region, multi-vendor 5G NR Band 71 (600 MHz) Proof-of-Concept deployment — among the first such studies in ITU Region 1. The findings confirm that N71 provides measurable and practically significant benefits as a low-band 5G coverage layer:

- (1) **Coverage:** +2–3 dB RSRP advantage over N28, +7 dB vs. mid-band outdoors, and +15 dB indoor penetration advantage, enabling 5G service where mid-band layers have no viable signal.
- (2) **Uplink:** +90% UL throughput advantage over mid-band at low-coverage points, driven by FDD simultaneous transmission and lower path loss.
- (3) **Antenna configuration:** upgrading to 4T4R yields +25% average DL, +52% far-point DL, and +167% far-point UL throughput.
- (4) **Ecosystem:** 62% device support including all flagship devices; CA maturity is the key constraint but is actively improving with SA firmware updates.
- (5) **5G SA readiness:** N71 as SA anchor with N78 CA achieves 878 Mbps average / 1230 Mbps peak DL at 15–17 ms latency, establishing technical readiness for VoNR and nationwide SA evolution.

Future work includes expanding SA benchmarking following commercial device firmware updates enabling N71 SA+CA combinations, measuring VoNR KPIs (MOS, call-setup latency) on N71 SA, and analyzing N71 performance in high-density pedestrian environments.

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