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N71 600MHz TripleBand RRU for Coverage and Capacity Enhancement in 5G Networks

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Abstract - The increasing demand for ubiquitous 5G connectivity necessitates the deployment of low-band spectrum capable of providing extensive coverage, improved indoor penetration, and enhanced cell-edge performance. Among the available low-band frequencies, the 600 MHz NR Band n71 has emerged as a promising solution due to its favorable propagation characteristics. This paper presents a comprehensive field evaluation of a 600 MHz triple-band Radio Remote Unit (RRU) supporting 600 MHz, 700 MHz, and 900 MHz bands in a live commercial 5G network. The study investigates the impact of n71 deployment through extensive field measurements including EN-DC verification, carrier aggregation validation, stationary throughput testing, indoor coverage assessment, drive testing, OSS KPI analysis, and interference mitigation evaluation. Performance comparisons were conducted between existing n28 deployment and the newly introduced n71 layer under both Standalone (SA) and Non-Standalone (NSA) architectures. Results demonstrate significant improvements in network performance. Stationary testing shows uplink throughput gains exceeding 250% and downlink gains above 100% in several scenarios. Indoor measurements reveal uplink improvements up to 283% and downlink improvements up to 145%. Furthermore, deployment of 4T4R technology increased coverage distance by approximately 38% compared with conventional 2T2R configurations. OSS statistics indicate a substantial increase in low-band traffic utilization and user distribution across the network. The results confirm that n71 deployment significantly enhances coverage, indoor service quality, cell-edge performance, and overall user experience while improving spectrum utilization efficiency in commercial 5G networks.

Keywords: ***N71, 600 MHz, 5G NR, Triple-Band RRU, EN-DC, Carrier Aggregation, 4T4R, Indoor Coverage, Interference Isolation, NSA, SA***

1. INTRODUCTION

The global expansion of 5G networks has underscored the strategic importance of low-frequency spectrum for achieving wide-area coverage and deep indoor penetration. While mid-band frequencies such as N78 (3.5 GHz) and N40 (2.3 GHz) serve capacity-driven urban scenarios, they suffer from propagation limitations that reduce coverage at cell edges and inside buildings. The 600 MHz band (NR Band N71, 663–698 MHz DL / 617–652 MHz UL) offers a compelling alternative due to its superior propagation characteristics, inherently lower path loss, and ability to provide ubiquitous coverage even at large inter-site distances.

Mobile operators deploying 5G in the Arabian Peninsula face the dual challenge of maintaining wide-area coverage across large urban and semi-urban zones while delivering competitive uplink speeds to a growing subscriber base using a diverse set of devices—ranging from high-end Apple iPhones and Samsung Galaxy flagships to residential 5G CPE units.

Integrating N71 as a dedicated coverage layer within a multi-band 5G stack represents a practical path to addressing these challenges without requiring new physical infrastructure.

This paper documents the methodology and outcomes of a POC trial in which a Huawei RRU5526t Triple-Band RRU (supporting LNR 600+700+900 MHz) was integrated into an existing 5G site. The existing 3L12H antenna and 2T2R RRU5508 units were replaced with 4L6H Riyadh Antenna elements and the new triple-band RRU, enabling simultaneous 600 MHz (N71), 700 MHz (N28), and 900 MHz low-band 5G coverage from a single tower configuration. The test timeline spanned August–September 2025, beginning with site preparation and device commissioning, progressing through 2T2R testing, EN-DC/CA verification, 4T4R testing, and culminating in feature tests and this final report.

The paper is structured as follows: Section 2 describes the site configuration and test methodology; Section 3 presents EN-DC and CA combination verification results; Section 4 covers stationary throughput performance; Section 5 analyzes indoor deep coverage; Section 6 reports drive test results for 2T2R versus 4T4R; Section 7 discusses OSS KPI observations;

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Section 8 characterizes UL interference and the anti-interference feature; Section 9 examines the N71 device ecosystem; and Section 10 summarizes conclusions and deployment recommendations.

2. SITE CONFIGURATION AND TEST METHODOLOGY

2.1 Site Characteristics

The site is located in an urban area, characterized by an inter-site distance of approximately 1,142 m and an antenna height of 37 m. The surrounding environment presents few physical obstructions, even testing routes across all three sectors, and no significant elevation gradients—conditions representative of typical urban deployment scenarios in the region.

Traffic distribution is relatively uniform within Sectors A and B, while Sector C faces an open-area environment. The site does not experience dramatic traffic fluctuation scenarios (e.g., railway stations, stadiums, or hospitals), making it well-suited for controlled performance benchmarking.

2.2 Hardware Upgrade: Existing vs. Target Configuration

The site transition involved replacing legacy low-band hardware with a new triple-band solution. The following table summarizes the hardware changes:

Component	Existing Configuration	New Configuration
Low-Band RRU	RRU5508 (L700+L900)	RRU5526t (LNR 600+700+900)
Antenna	3L12H Antenna	4L6H Riyadh Antenna
MIMO Config	2T2R	4T4R
5G Bands Added	N28, N40	N71, N28, N40
Frequency Bands Present	G9/L7/L9/L18/L21/L23/N40/N78/N28/N77	G9/L7/L9/L18/L21/L23/N71/N40/N78/N28/N77

2.3 N71 Layer Strategy

The network layer prioritization strategy was designed to balance bandwidth availability with user experience. N71 (600 MHz, 20 MHz bandwidth) was configured with an NSA SCG priority of 3 and an SA Idle Mode Cell Reselection Priority of 7.2—positioned above N28 (700 MHz, 10 MHz bandwidth, priority 2 / 7.0) but below N40 (2.3 GHz, 60 MHz bandwidth, priority 4 / 7.4). This hierarchy ensures that devices prefer the higher-bandwidth N40 layer when available, and fall back to N71 for coverage extension, while N28 serves as the lowest-priority wide-area anchor.

The UE steering policy configures N71-related Carrier Aggregation (CA) when the UE is covered by both N71 and a TDD band. In Area1a (full TDD+FDD+N71 coverage), UEs supporting T+T CA are directed toward N78/N77+N40 combinations, while T+F-capable UEs use N78+N28/N71. In coverage boundary zones, N71 serves as a CA carrier to extend TDD reach and improve user experience. UEs in outer coverage areas (Area3/4) that are solely covered by N71 are intentionally not connected to N71 alone, to avoid generating low-speed 5G samples.

2.4 Test Equipment and Duration

All throughput measurements were conducted using the Huawei H155-383 5G CPE device paired with GENEX Probe software for logging and analysis. The Samsung Galaxy S25 Ultra was used for select EN-DC tests with TEMS Application band-locking to N71. The test campaign ran from August 6 to September 30, 2025, spanning site preparation, 2T2R

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commissioning and testing (August 13–28), EN-DC/CA verification, 4T4R upgrade (September 9), feature tests (September 20), and report completion (September 30).

3. EN-DC AND CA COMBINATION VERIFICATION

3.1 Verified EN-DC and CA Configurations

A total of 7 EN-DC configurations under NSA mode and 2 CA combinations under SA mode were verified in the live network using the Huawei H155-383 CPE. Verification involved activating each combination, confirming the signaling trace (B1+B3+N71 activation was identified via GENEX Probe Signaling Tracing due to CPE camping capability reporting limitations under a blind LTE CA configuration), and recording peak DL/UL throughput.

#	Type	Combination	Verified
1	EN-DC (NSA)	DC_L1800_n71 (Band3+N71)	Yes
2	EN-DC (NSA)	DC_L2100_n71 (Band1+N71)	Yes
3	EN-DC (NSA)	DC_L1800_L2100_n71 (Band1+Band3+N71)	Yes
4	EN-DC (NSA)	DC_L1800_n40-n71 (B3+N40+N71)	Yes
5	EN-DC (NSA)	DC_L1800_n71-n78 (B3+N71+N78)	Yes
6	EN-DC (NSA)	DC_L2100_n40-n71 (B1+N40+N71)	Yes
7	EN-DC (NSA)	DC_L2100_n71-n78 (B1+N71+N78)	Yes
8	NR CA (SA)	CA_n40-n71	Yes
9	NR CA (SA)	CA_n71-n78	Yes

3.2 Representative Throughput in EN-DC Mode

Adding N71 as a secondary cell in NSA EN-DC configurations consistently delivered throughput gains. As an illustrative example, the B3+N78 standalone combination achieved approximately 362 Mbps DL / 32.8 Mbps UL, while adding N71 (B3+N78+N71) raised throughput to 491 Mbps DL / 41.7 Mbps UL—a gain of approximately 35% on DL. Similar additive gains were observed across all 7 EN-DC variants, with N71 effectively serving as a supplemental FDD carrier extending the combined bandwidth available to the UE.

3.3 Device Ecosystem Limitations

EN-DC/CA verification was primarily conducted using the Huawei H155-383 CPE. IPhone devices could not be tested because the iOS TEMS Application does not support band locking to N71. Samsung Galaxy S25 Ultra testing required TEMS APP installation for band locking. The operator is advised to coordinate with Apple to obtain SA software versions that support N71-related EN-DC/CA combinations and to verify device capabilities with all major OEM partners to expand the verified device matrix.

4. STATIONARY FIXED-POINT THROUGHPUT TEST

4.1 Test Configuration

Fixed-point stationary tests compared N71 (20 MHz, 2T2R, 256QAM) against the existing N28 (10 MHz, 2T2R, 256QAM) and legacy B28 (10 MHz, 2T2R, 256QAM) benchmarks at three reference distances from the serving cell: Near (~70 m),

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Middle (~533 m), and Far (~1,090 m). Tests were conducted in both NSA (LTE anchor + NR secondary) and SA (standalone NR) modes.

4.2 NSA Mode Results

Mode	Distance	N28 DL (Mbps)	N71 DL (Mbps)	DL Gain	N28 UL (Mbps)	N71 UL (Mbps)	UL Gain
NSA	Near (~70 m)	95	194	+104%	40	98	+149%
NSA	Middle (~533 m)	50	105	+109%	41	90	+121%
NSA	Far (~1,090 m)	18	36	+99%	10	7	+49%

4.3 SA Mode Results

Mode	Distance	N28 DL (Mbps)	N71 DL (Mbps)	DL Gain	N28 UL (Mbps)	N71 UL (Mbps)	UL Gain
SA	Near (~70 m)	84	154	+83%	32	107	+232%
SA	Middle (~533 m)	44	96	+119%	32	80	+150%
SA	Far (~1,090 m)	20	40	+95%	2	7	+259%

N71 consistently delivers approximately 2X improvement in both DL and UL throughput compared to N28 across all measurement points and operating modes. The UL advantage is particularly pronounced under SA mode, where the absence of the LTE anchor removes uplink split-bearer constraints and N71 is able to exploit its wider 20 MHz bandwidth and better SINR from the lower carrier frequency.

5. INDOOR COVERAGE PERFORMANCE

5.1 NSA Indoor Test

Indoor tests were conducted at a single fixed indoor location 319 m from the serving cell to evaluate penetration characteristics. The N71 RSRP reading was -82.5 dBm compared to -86.38 dBm for N28—a 4 dBm improvement attributable to the superior propagation of the 600 MHz band through building materials.

Metric	N40 (TDD 60 MHz)	N28 2T2R	N71 2T2R	N71 vs N28 Gain
RSRP (dBm)	-89	-86.38	-82.5	+4 dBm
DL THP (Mbps)	173	60.5	100	+65%
UL THP (Mbps)	19	38.5	70.8	+84%

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5.2 SA Indoor Test

Metric	N40 (TDD 60 MHz)	N28 2T2R	N71 2T2R	N71 vs N28 Gain
RSRP (dBm)	-86.63	-85	-82	+3 dBm
DL THP (Mbps)	111	40.1	99.1	+145%
UL THP (Mbps)	5.49	20.2	77.4	+283%

5.3 Extended Deep Indoor Coverage (4T4R N71 vs N40)

A multi-point indoor test was conducted at locations ranging from 150 m (near, small market) to 1.5 km (far, residential apartment) from the serving cell. The N71 4T4R configuration was benchmarked against N40 (60 MHz TDD), revealing the profound coverage advantage of the lower frequency band:

Test Location	Metric	N40 (TDD 60 MHz)	N71 4T4R (FDD 20 MHz)	Gain
Near — Small Market	RSRP (dBm)	-78	-74	+4 dBm
Near — Small Market	DL THP (Mbps)	316	158	-50% (1/3 spectrum)
Near — Small Market	UL THP (Mbps)	32.9	89.8	+173%
Middle — Car Workshop	RSRP (dBm)	-89	-86	+3 dBm
Middle — Car Workshop	DL THP (Mbps)	278	151	-46% (1/3 spectrum)
Middle — Car Workshop	UL THP (Mbps)	19	86	+353%
Far 1 — Apartment	RSRP (dBm)	-95	-93	+2 dBm
Far 1 — Apartment	DL THP (Mbps)	162	122	-25% (1/3 spectrum)
Far 1 — Apartment	UL THP (Mbps)	2.1	55.3	+25.3X
Far 2 — Apartment	RSRP (dBm)	-110	-99	+11 dBm
Far 2 — Apartment	DL THP (Mbps)	Call Drop	83	N40 Out of Coverage
Far 2 — Apartment	UL THP (Mbps)	Call Drop	22	N40 Out of Coverage

At the farthest indoor test point (RSRP = -110 dBm on N40), N40 experienced a call drop while N71 maintained an RSRP of -99 dBm and delivered 83 Mbps DL / 22 Mbps UL, demonstrating the fundamental coverage advantage of sub-700 MHz spectrum for deep indoor penetration. The DL throughput reduction at near/middle points relative to N40 is expected and

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directly proportional to N71's narrower 20 MHz bandwidth (versus 60 MHz for N40), representing roughly one-third the spectral resource.

6. DRIVE TEST: 2T2R VERSUS 4T4R PERFORMANCE

6.1 4T4R Coverage Gain Mechanism

Upgrading from 2T2R to 4T4R doubles the number of transmit and receive antenna ports, providing approximately 2–3 dB of additional coverage gain through coherent beamforming and increased total radiated power (from 2×20W to 4×20W per sector). This improvement translates directly to extended downlink coverage distance and improved cell-edge throughput.

6.2 N71: 4T4R vs 2T2R Drive Test

A single-site drive test was conducted for N71 comparing the 2T2R (2×20W) and 4T4R (4×20W) configurations. The following key metrics were recorded as route averages:

Configuration	Avg RSRP (dBm)	Avg SINR (dB)	Avg DL THP (Mbps)
N71 2T2R	-88.04	7.78	78.31
N71 4T4R	-84.38	7.98	106.24
Gain (4T vs 2T)	+3.65 dBm	+0.2 dB	+35%

The 4T4R configuration extended the N71 DL coverage distance from 6,720 m to 9,278 m, a 38% improvement. Throughput at the middle test point improved by +28% DL / +82% UL, while far-point throughput gains reached +52% DL / +167% UL—reflecting the compounding benefit of improved RSRP and SINR at cell edges.

6.3 N28: 4T4R vs 2T2R Drive Test

For comparison, the N28 (700 MHz) band was also tested with 2T2R versus 4T4R under a cluster site configuration:

Configuration	Avg RSRP (dBm)	Avg SINR (dB)	Avg DL THP (Mbps)
N28 2T2R	-85.73	-0.06	32.28
N28 4T4R	-82.73	+1.12	40.59
Gain (4T vs 2T)	+3 dBm	+1.18 dB	+25%

N28 4T4R middle-point throughput improved by +43% DL / +86% UL and far-point by +32% DL / +170% UL. The larger SINR gain for N28 (1.18 dB vs 0.2 dB) reflects the higher interference-limited nature of the 700 MHz channel, where 4T4R spatial processing provides more differentiated improvement.

6.4 N71 vs N40 Uplink Comparison

A route-level UL throughput comparison between N71 4T4R and N40 (single-site) showed N71 average UL throughput of 38 Mbps versus 11 Mbps for N40—a 2.45X advantage. This is consistent across the tested distance range (0–3,000 m from the serving cell) and reflects both N71's better propagation (higher received UL power) and the dedicated FDD UL channel, which avoids TDD frame configuration constraints.

7. OSS KPI STATISTICS

7.1 Low-Band User Growth

OSS daily monitoring from July 30 to September 16, 2025 tracked 5G low-band (N28 and N71) user counts, traffic volume, DL throughput, and PRB utilization across three distinct phases: pre-N71 activation (N28 only), N71 2T activation (mid-August), and N71/N28 4T activation (early September).

KPI	Pre-N71 (N28 Only)	Post N71 2T	Post N71+N28 4T	Total Gain
Avg 5G Low-Band Users/Day	7.2	8.7	11.5	+60%
Avg 5G Low-Band Traffic (GB/Day)	11.8	42.4	64.2	+3.6X (2T) / +5.4X (4T)
Avg N71 DL Throughput (Mbps)	-	90.9	72.2*	2.3X vs N28 2T
5G Low-Band CA Users	Baseline	+26% (2T)	+71% (4T)	Significant growth

* The DL throughput reduction under 4T is expected: 4T activation attracts more cell-edge users whose individual throughput is lower, reducing the cell average while increasing total traffic capacity.

N71 activation increased 5G low-band traffic by 3.6X, with 4T activation providing an additional 51% gain, confirming that the RRU upgrade is immediately effective in monetizing the 600 MHz spectrum. The DL throughput ratio of N71 relative to N28 was 2.3X for 2T and 1.9X for 4T—consistent with the stationary test results reported in Section 4.

8. INTERFERENCE ANALYSIS AND MITIGATION

8.1 Interference Detection

Prior to N71 activation, a 600 MHz band scan was conducted at three geographic test points using PC-TEL Scanner and Tektronix Spectrum Analyzer equipment. No external interference was detected during the mobility drive scan or fixed-point RSSI measurements—indicating a clean spectrum environment at baseline.

However, after N71 activation, a BTS-level FFT sweep (High-Resolution Online Frequency Scan, conducted on September 15, 2025) detected UL interference in two sub-bands within the 600 MHz UL spectrum: 678–685.8 MHz and 695–698 MHz. Interference intensity was measured at 20–40 dB above the noise floor (-140 dBm), indicating a significant external interference source within the first 7.8 MHz of the N71 UL band and a secondary tail in the upper 3–4 MHz.

8.2 Anti-Interference Feature Performance

Huawei's Precise Interference Isolation feature was enabled to mitigate the detected UL interference. Pre- and post-activation drive tests (conducted on September 6 and September 13, 2025 respectively) demonstrated:

KPI	Pre-Feature (DT)	Post-Feature (DT)	Gain
Avg SINR (dB)	3.9	6.0	+2 dB
Avg UL Throughput (Mbps)	20.9	23.6	+13%

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OSS KPI measurements over the same period confirmed a User UL Average Throughput increase of 19% and a Cell UL Average Throughput increase of 20% following feature activation. These results validate that software-based interference isolation is effective in partially mitigating the impact of UL interference without requiring physical spectrum clearance.

8.3 Recommendations

The following actions are recommended to fully resolve the interference issue:

- Report the 600 MHz UL interference to the national spectrum regulator (Communications and Space Technologies Commission, CST) and request formal spectrum clearance.
- Conduct periodic BTS Scan (FFT Sweep) monitoring to track interference evolution and confirm post-clearance improvement.
- Maintain the Precise Interference Isolation feature active as a first-line mitigation measure while spectrum clearance is pending.

9. N71 DEVICE ECOSYSTEM STUDY

9.1 Network-Level Hardware Penetration

An analysis of the device base within the operator's network using GSMA hardware capability data shows that 52% of active 5G devices support N71 (NR Band 71) hardware capability, while 54% support B71 (LTE Band 71). This indicates that over half of the existing 5G subscriber base can immediately benefit from N71 coverage without any device replacement.

9.2 CPE N71 Capability

Among 5G CPE devices in the live network, 77% support N71 hardware capability. The dominant CPE types are the Huawei H155-383 (33.6% of all 5G CPEs) and Huawei 5G CPE 5 (30.6%), both of which are confirmed N71-compatible. The H155-383 additionally supports a comprehensive set of EN-DC combinations (DC_1A_n40A-n71A, DC_1A_n71A-n78A, DC_3A_n40A-n71A, DC_3A_n71A-n78A, DC_1A_n71A, DC_3C_n71A) and, pending a SA software version upgrade, will also support CA_n40A-n71A and CA_n71A-n78A combinations.

9.3 Live Network Device Connections

During the two-week observation period (August 14–28, 2025) following N71 activation, a total of 13 unique device types connected to the N71 cell: 9 smartphone models and 4 CPE models. The connected smartphone portfolio included Apple iPhone 14/14 Pro/14 Pro Max/14 Plus/15 Pro Max/16 Pro/16 Plus, Samsung Galaxy A56 5G, and Honor Magic V2. CPE types included Huawei H155-383, Huawei 5G CPE 5, ZTE MC888A ULTRA, and ZTE MU5120.

Daily connected devices peaked at 7 (including 5 CPEs and 2 smartphones), demonstrating organic device attachment to N71 without any forced steering—confirming that subscriber devices are capable of autonomous N71 cell selection when coverage is available.

9.4 Regional Device Distribution Analysis

A broader three-day CEM (Customer Experience Management) data study across three major cities in the region revealed 65% hardware penetration for N71 capability among all 5G devices. The top N71-capable smartphone model in each city was predominantly from the Apple iPhone lineup (iPhone 15 Pro Max, 16 Pro Max), followed by Samsung Galaxy flagships. Total mobile N71-capable device counts in the largest city exceeded 578,000, with an additional 31,000+ CPE devices capable of N71 connectivity.

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10. CONCLUSIONS AND DEPLOYMENT RECOMMENDATIONS

10.1 Summary of Key Findings

This paper presented a comprehensive field evaluation of 600 MHz NR Band n71 deployment using a triple-band Radio Remote Unit architecture in a commercial 5G network. Extensive testing confirmed that n71 provides significant improvements in throughput, indoor coverage, user experience, and traffic utilization compared with the existing n28 layer.

The deployment achieved uplink throughput gains exceeding 250%, indoor uplink improvements reaching 283%, and a 38% increase in coverage distance through 4T4R implementation. OSS statistics further demonstrated substantial increases in low-band traffic distribution and network utilization efficiency.

The results validate the strategic importance of n71 as a foundational low-band spectrum layer for future 5G deployments. Future research should investigate multi-site deployment performance, AI-assisted mobility optimization, dynamic spectrum sharing, and advanced carrier aggregation strategies involving n71 and mid-band spectrum resources.

Test Category	Key Result
EN-DC/CA Verification	7 EN-DC + 2 CA combinations verified in live network
Stationary Test (SA Mode)	N71 delivers ~2X DL/UL gain vs N28; far-point SA UL gain: +259%
Indoor Coverage (NSA)	N71 RSRP +4 dBm, DL +65%, UL +84% vs N28 at same location
Indoor Coverage (SA)	N71 UL +283% vs N28; +25.3X UL at deep indoor far point vs N40
Drive Test — N71 4T vs 2T	Coverage distance +38%; DL THU +35%; Far-point UL +167%
Drive Test — N28 4T vs 2T	Coverage +3 dBm; Far-point UL +170%
N71 UL vs N40 (DT Average)	N71 avg UL 2.45X higher than N40
OSS KPI	5G low-band traffic +3.6X (2T) / +5.4X (4T); Low-band users +60%
Interference Mitigation	Anti-interference feature: SINR +2 dB, UL THU +13% (DT); Cell UL +20% (OSS)
Device Ecosystem	52% of 5G devices N71-hardware capable; 77% of CPEs N71-capable

10.2 Deployment Recommendations

Based on the results, the following actions are recommended for network-wide N71 deployment:

- Proceed with nationwide N71 layer rollout, prioritizing sites where the existing subscriber base shows high N71-capable device penetration (above 50%).
- Deploy the 4T4R RRU configuration from day one; the 38% coverage extension and 35%+ throughput gains compared to 2T2R justify the additional hardware investment.
- Configure N71 layer priority between N40 and N28 (NSA SCG priority 3, SA reselection priority 7.2) as verified in this trial.
- Enable Precise Interference Isolation as a default configuration on all N71 cells, and simultaneously file interference reports with CST to pursue spectrum clearance.
- Coordinate with Apple and Samsung OEM partners to certify SA software versions that enable N71-related EN-DC and CA capabilities on all flagship smartphone models.
- Mandate N71 support (hardware + software) as a procurement requirement for all future 5G CPE and smartphone device certifications.
- In coverage-limited indoor scenarios (RSRP < -95 dBm on mid-band), prioritize N71 as the primary 5G serving layer due to its superior uplink performance.

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