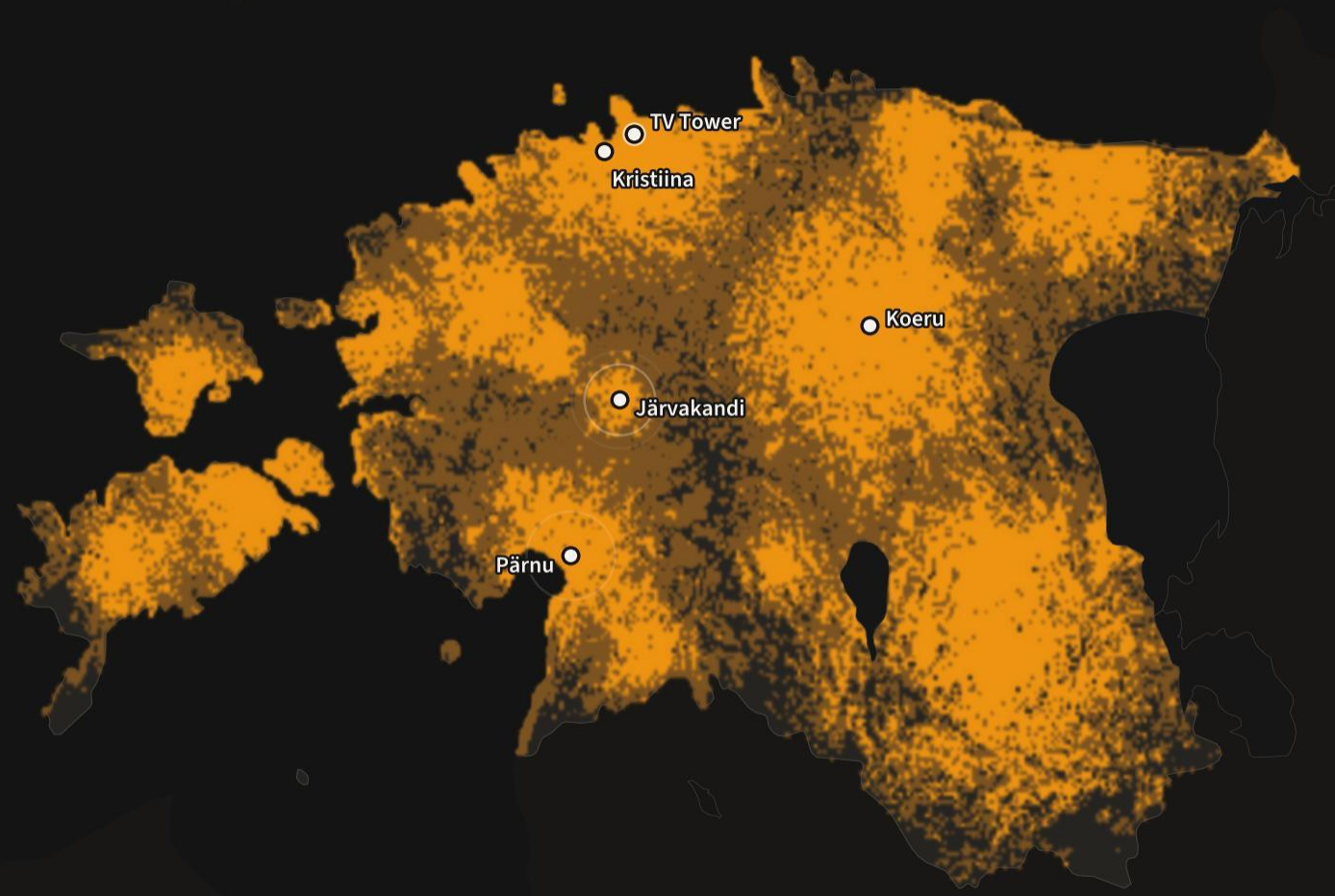
POCKET SIREN
5G BROADCAST

POCKET SIREN FORUM · 22 OCTOBER 2026

5G BROADCAST FOR PUBLIC WARNING



Technical results of the Estonian pilot, 2025–2026

Kristo Kaasan · Levira

levira · Tredess · NAKOLOS · TAL TECH · Republic of Estonia Ministry of the Interior · Co-funded by the European Union · Investing in your future

INNO FOND

Commissioned by the Government Office of Estonia. Funded by Funded by the Public Sector Innovation Fund from EU Cohesion Cohesion Policy 2021–2027 resources.

24-MONTH PILOT · 2025-2026

THE PILOT AT A GLANCE

5

transmitters on air: 3 high-power towers towers and 2 fillers, SFN and MFN

5

test days with authorities and end users, July 2025 – October 2026

101 794

drive-test records in 2025 and 2026 used to calibrate the coverage model

79.3%

of indoor log points detected the network in 13 shopping centres

20

transmitter sites in the nationwide plan, all on existing broadcast masts

96%

of the population reached by alerts with the 20-site network (84% of land area)

01

THE SOLUTION

One broadcast carrier that delivers public warnings, TV and radio to radio to phones, independently of mobile networks.



01 · SOLUTION

END-TO-END ARCHITECTURE

ALERT SOURCE

EE-ALARM

National warning system sends a CAP message with area polygon, category and and languages

HEAD-END

NAKOLOS core

Converts CAP to CMAS cell broadcast, multiplexes alerts alerts with TV and radio, controls the network

TRANSMITTERS

TRedess, 5 sites

ETSI TS 103 720 on UHF channels E40 and E41, GNSS-GNSS-locked for single-frequency operation

RECEIVERS

Phones

Android devices with FeMBMS FeMBMS on band n71 (600 (600 MHz); no SIM card or subscription needed

~5 s

repetition interval until the alert expires

1 carrier

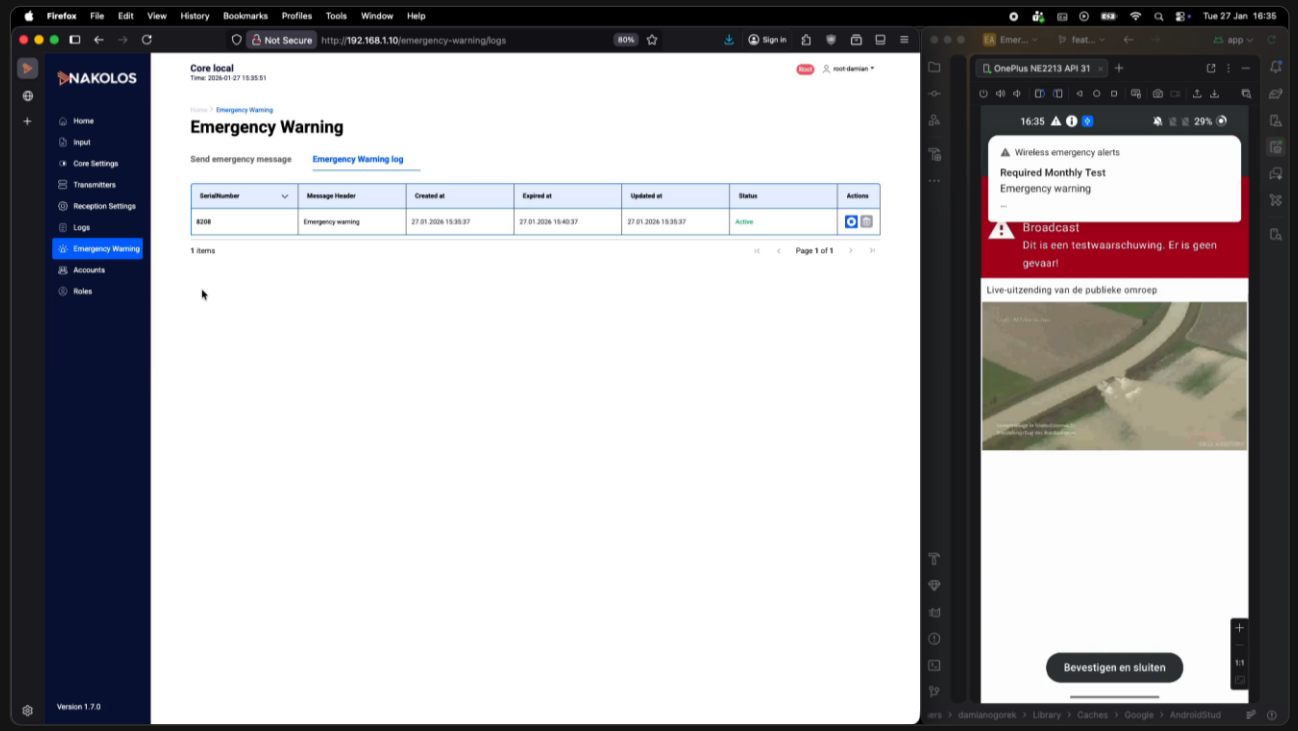
for alerts, 2 TV and 2 radio programmes

0 load

on mobile networks, however many receive

01 · SOLUTION

ALERTS AND MEDIA ON ONE CARRIER



Screen recording: a warning composed in the NAKOLOS console arrives on the phone

TELEVISION

ETV and ETV+, about 700 kbps each

RADIO

Vikerraadio and Raadio 4, about 200 kbps each each

WARNINGS

CMAS cell broadcast, categories 4370–4380, up to 1 up to 1 350 characters

ON THE PHONE

Pocket Siren app with NAKOLOS middleware, no firmware changes

02

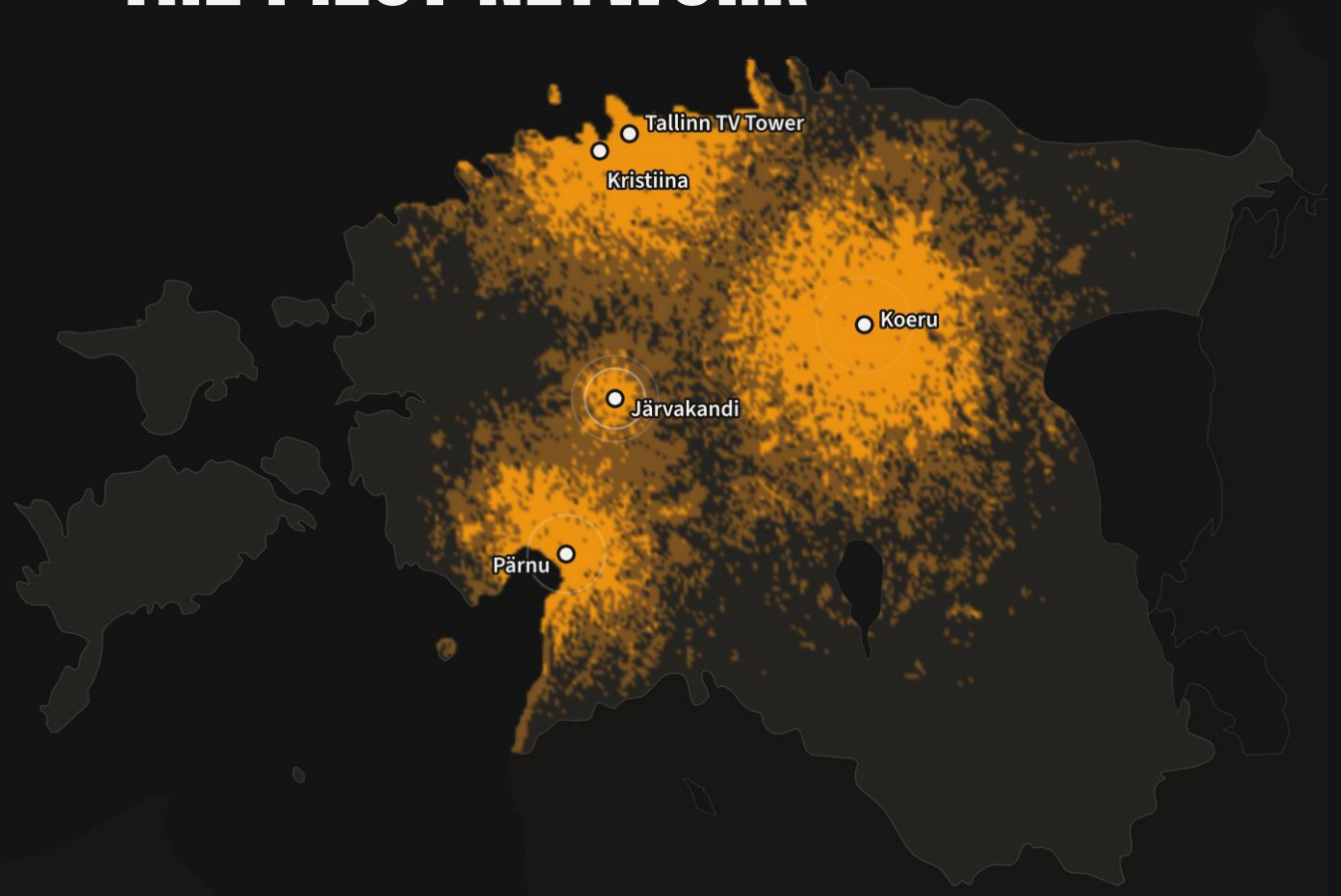
THE BUILD

Five transmitters on existing Levira broadcast towers, a central core central core and test phones, on air in July 2025.



02 · BUILD

THE PILOT NETWORK



Site	Type	Mast	Ch.	TX	ERP
Tallinn TV Tower	HPHT	270 m	E40	3 kW	40.0 dBW
Koeru	HPHT	337 m	E41	3 kW	39.3 dBW
Pärnu	HPHT	187 m	E41	3 kW	42.6 dBW
Kristiina	LPLT	97 m	E40	600 W	29.0 dBW
Järvakandi	LPLT	78 m	E41	600 W	30.0 dBW

SFN Koeru, Pärnu and Järvakandi share E41 (634 MHz). MFN Tallinn Tallinn runs on E40 (626 MHz). 5 MHz carriers in band 71.

High-power sites 86–123 km apart: Tallinn–Koeru 86 km, Koeru–Koeru–Pärnu 108 km, Tallinn–Pärnu 123 km.

Video, SINR ≥ 10 dB Alert, SINR ≥ 0 dB

02 · BUILD

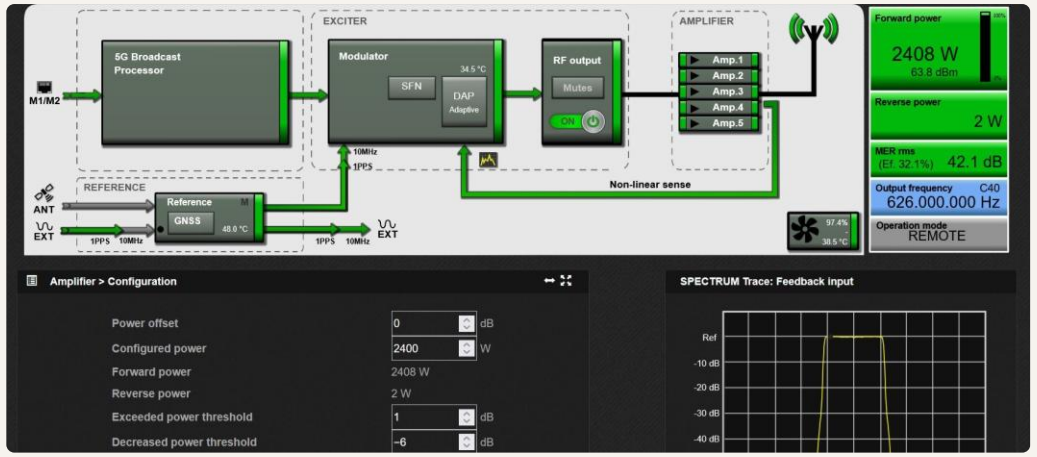
TRANSMITTERS ON SITE



3 kW high-power: Tallinn TV Tower, Koeru, Pärnu



600 W fillers: Kristiina, Järvakandi



Tallinn TV Tower, channel C40 / 626 MHz: 2 408 W forward power, MER 42.1 dB, SFN mode with GNSS, 10 MHz and 1 PPS reference

---

JAN 2025

Contract and platform build start

16 JUL 2025

Network on air, first test day

MER > 40 DB

at transmitter output (Järvakandi 40.8 dB)

JAN 2027

End of the 18-month warning service

03

TESTING

Scenario tests with authorities and the public, device behaviour from logs, geofencing and indoor reception. reception.



03 · TESTING

FIVE TEST DAYS

16 Jul 2025

Tallinn, at sea, Pärnu, Rakvere

Regional scenarios incl. a police police boat test off Naissaar; 22 22 test phones, 72 respondents respondents

10 Dec 2025

Tallinn: Pirita, Kristiine, centre

9 messages to warning areas areas in three districts; 52 respondents

31 Mar 2026

Pärnu

Missing child, flood and forest fire scenarios with device geofencing; about 130 130 respondents

12 May 2026

13 shopping centres

Indoor reception walk-tests tests in and around Tallinn; Tallinn; 869 log records

22 Oct 2026

Pocket Siren Forum

Closing event and a new app app for sending event updates



Organised with the Ministry of the Interior, Rescue Board, TTJA and RIKS. Pictured: the monthly-test alert in Tallinn centre, 10 December 2025. User-feedback results are presented by TalTech.

03 · TESTING

FROM BROADCAST TO ALARM ON THE PHONE

0.000 s

Received

Cell broadcast message decoded from the 5G Broadcast carrier

+0.018 s

Duplicate check

Serial number and category category compared with earlier messages

+5.0 s

Location window

Phone waits up to 5 s for a position to apply the geofence geofence

+5.0 s

Alarm

Full-screen alert, sound and and vibration, screen kept on on

+17.0 s

Read aloud

Text-to-speech in Estonian, Estonian, English and Russian Russian

1 350 / 600

characters per message, GSM 7-bit / UCS-2 (needed for Cyrillic)

720 repeats

per hour at a ~5 s interval, so late arrivals still get the alert

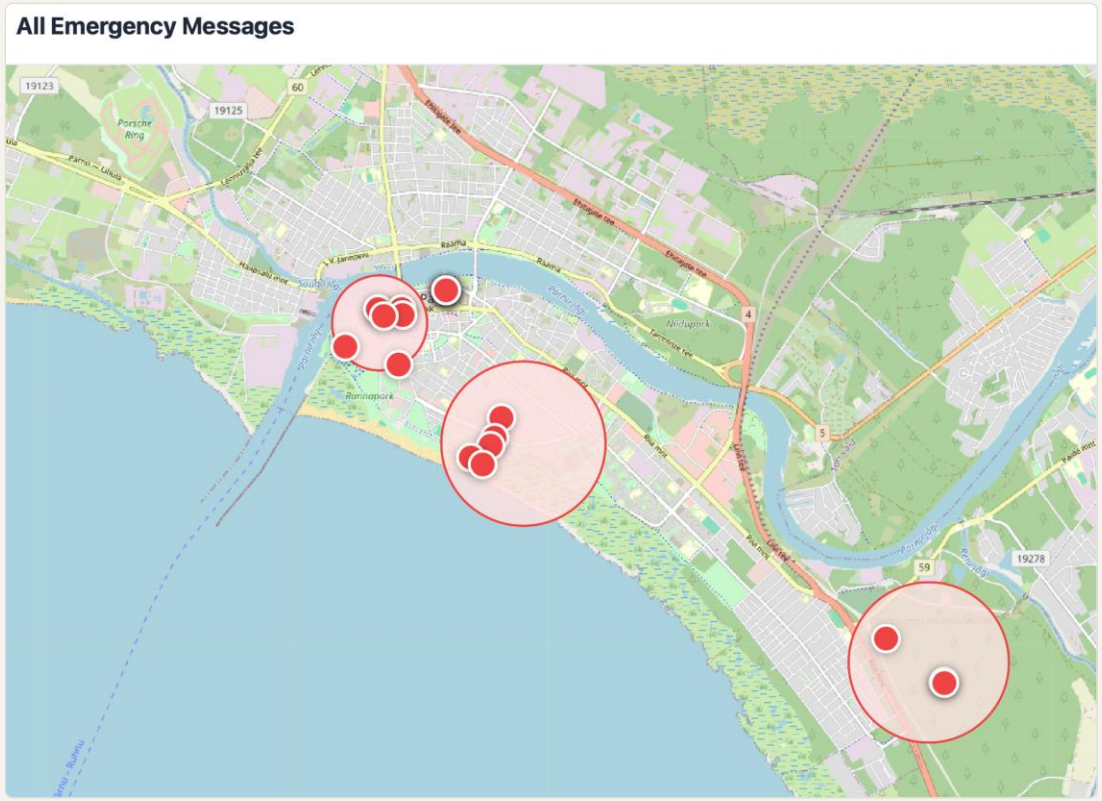
1 024

simultaneous alerts addressable with the the 10-bit serial number

DEVICE LOG, TEST DAY 16 JULY 2025, TIMESTAMPS RELATIVE TO RECEPTION

03 · TESTING · PÄRNU, 31 MARCH 2026

GEOFENCING ON THE DEVICE



Scenario	Cat.	Radius	To centre	Margin
Missing child	4374	484 m	251 m	234 m
Flood	4372	828 m	471 m	357 m
Forest fire	4371	813 m	260 m	552 m

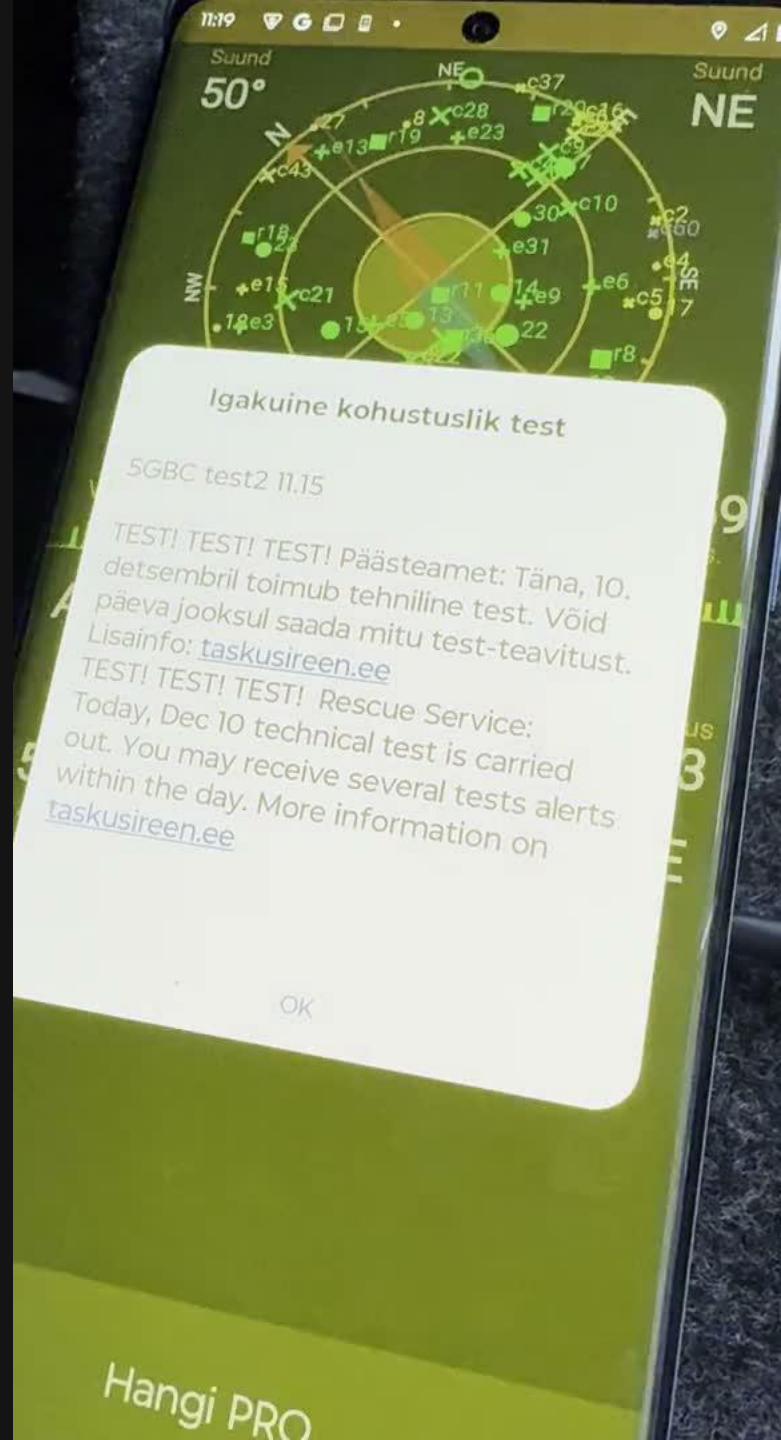
3 of 3 inside the area: each alert decoded, shown as as priority HIGH and tied to the right zone

Distances computed with the haversine formula from the phone's GPS position in the log. Next step: test behaviour when entering and leaving an area.

03 · TESTING

WHAT THE DEVICES SHOWED

WORKS	Presidential alert (4370) sounds even in silent mode (except the OnePlus 10T OnePlus 10T hardware mute switch)
WORKS	TV and radio on Snapdragon 8 Gen 1 or newer, where the maker enables FeMBMS
LIMITED	Categories 4371–4380 follow the phone's sound profile: no siren in silent silent mode
MISSING	Device-based geo-fencing (4400, WEA 3.0) is not active on commercial commercial Android phones in Europe
BLOCKED	iPhone detects the carrier but alerts need Apple's emergency entitlement, not granted for the pilot



03 · TESTING

DUPLICATE ALERTS AT TRANSMITTER HANDOVER

13:31:34 · FIRST ALERT

Serial **5504**, category **4371**, location code **768**

Pärnu transmitter; alert shown and dismissed

28 min drive

13:59:42 · SHOWN AGAIN

Same serial and category, location code **1024**

Koeru transmitter; full-screen alarm and sound repeated repeated

Why it happens

All 5G Broadcast transmitters share PLMN 901-56, so the standard standard would suppress the repeat. Android also resets duplicate duplicate detection on a cell change, so the phone treats the message message as new.

What to do

Coordinate cell and location identities across the network, agree duplicate-detection settings with device makers, and send updates without re-triggering the siren.

DEVICE LOG, PÄRNU → RAKVERE DRIVE, 16 JULY 2025 · 3GPP TS 23.041

03 · TESTING · 12 MAY 2026

INDOOR RECEPTION IN 13 SHOPPING CENTRES

79.3%

of 869 log records on the Pocket Siren carrier

-112 dBm

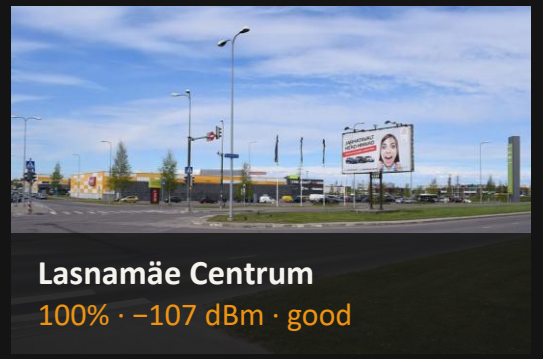
median RSRP indoors

-127 dBm

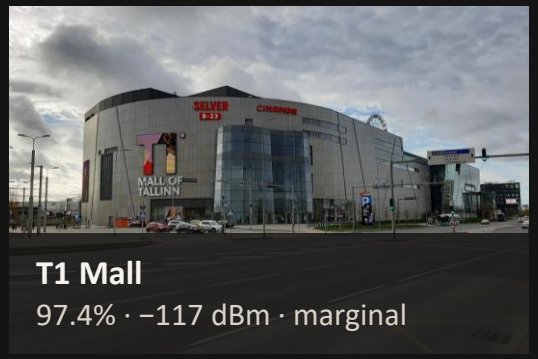
P10, the weakest tenth



Kristiine Centre
100% · −102 dBm · strong



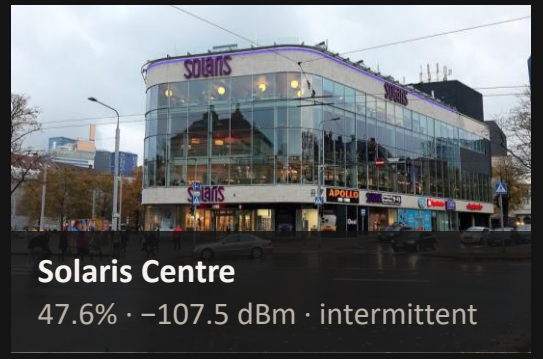
Lasnamäe Centrum
100% · −107 dBm · good



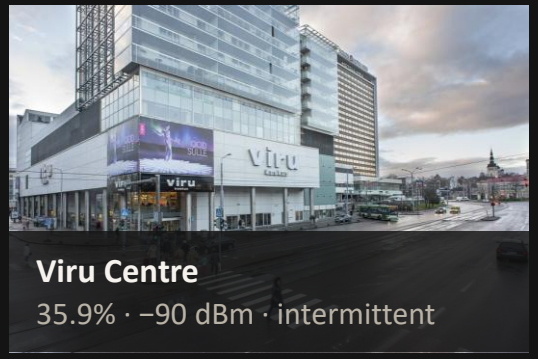
T1 Mall
97.4% · −117 dBm · marginal



Ülemiste Centre
75% · −119 dBm · marginal



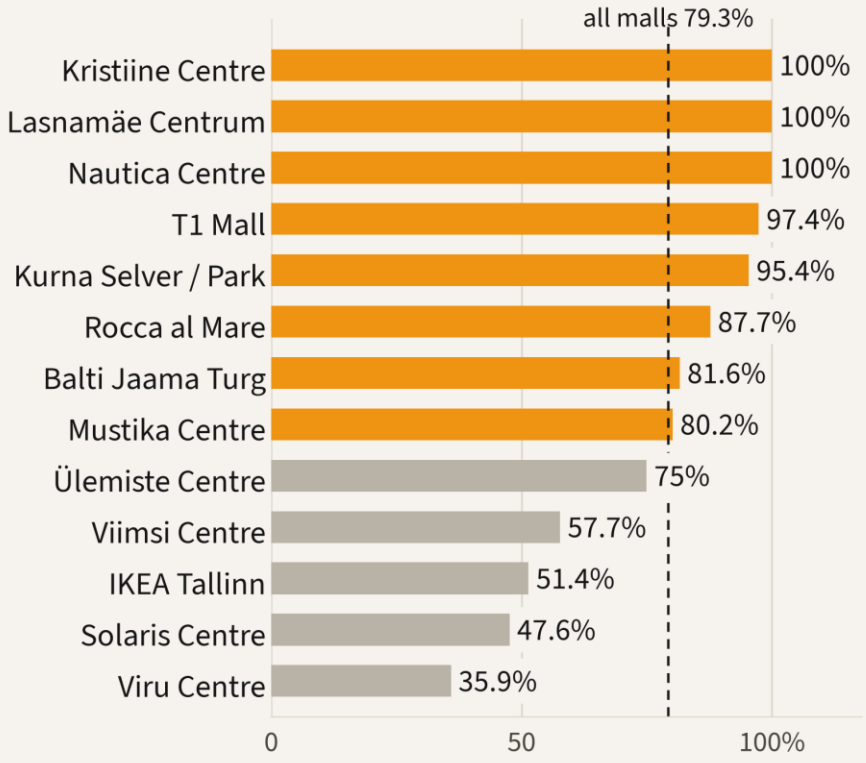
Solaris Centre
47.6% · −107.5 dBm · intermittent

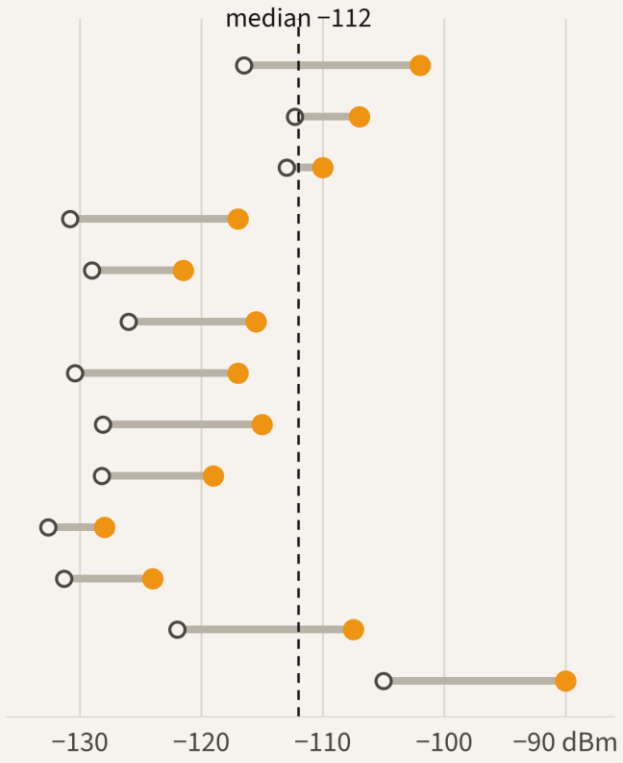


Viru Centre
35.9% · −90 dBm · intermittent

Share of records · median RSRP · class. Photos: Wikimedia Commons, Dmitry G (public domain); Erko, Apiiroja, Aare Piiroja, ViruKeskus (CC BY-SA 4.0) · 15

INDOOR RESULTS BY CENTRE





Bars share of records on the Pocket Siren carrier (901-56, EARFCN 68676)

Dots median RSRP (filled) and P10 (outline)

Viru and Solaris strong where detected; the phone often stayed on commercial networks

One phone, walking a typical visitor route

04

COVERAGE RESULTS

Two seasons of drive tests, an honest look at what changed, and a propagation model calibrated on the measurements.



04 · COVERAGE

TWO DRIVE-TEST CAMPAIGNS

	2025	2026
Routes	39	18
Days	9	13
Records	39 588	62 206
Decoded	31.5%	22.9%

Gsertel Hexylon scanner on both carriers (626 (626 and 634 MHz), July to October each year. year

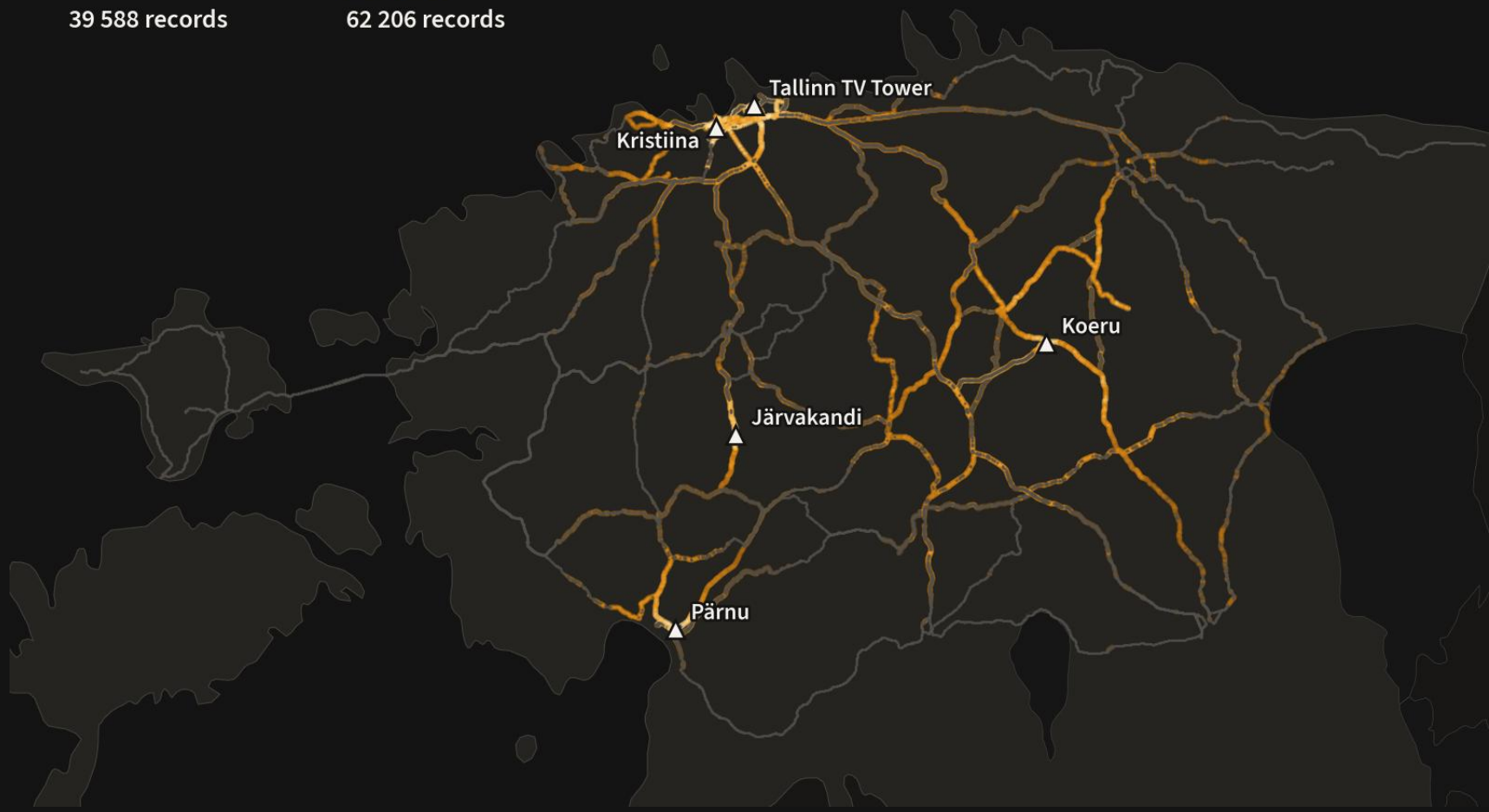
–125 to –70 dBm

dBm

not decoded

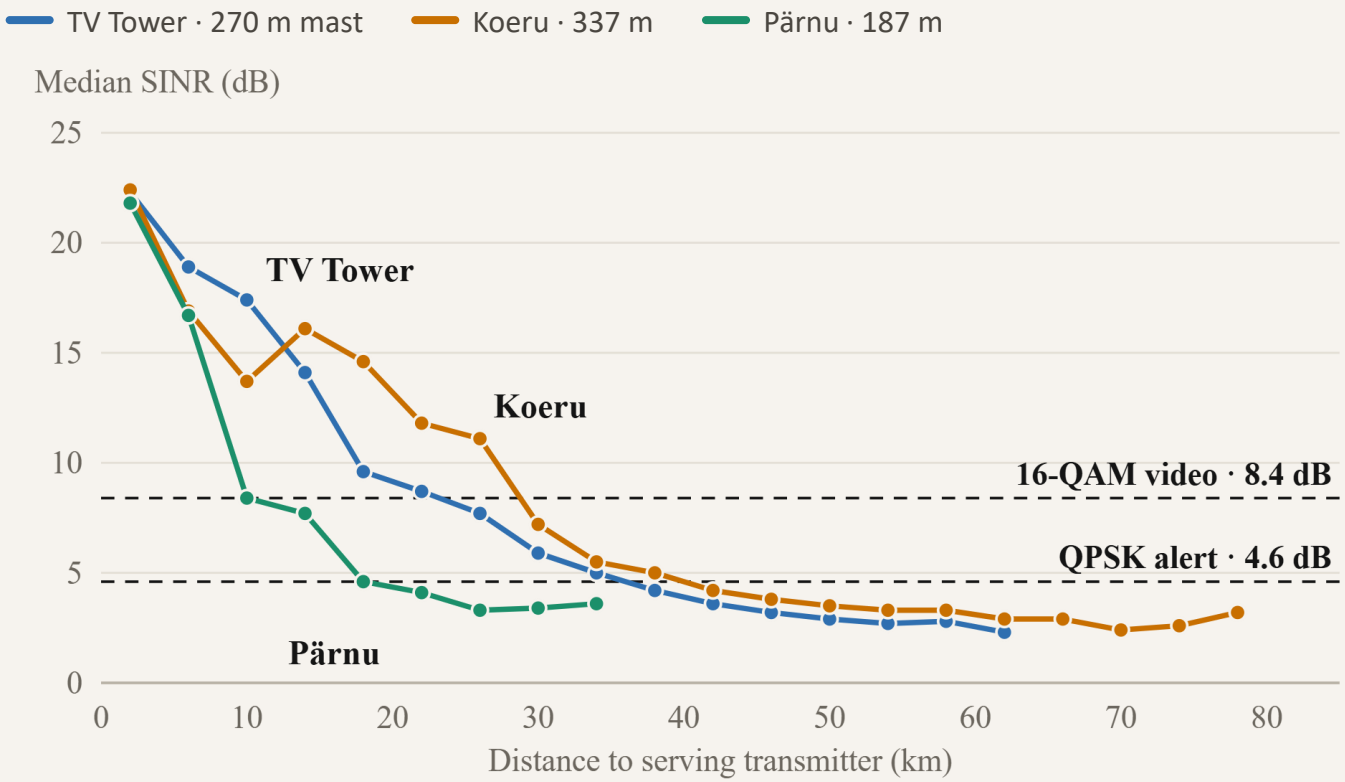
2025
39 588 records

2026
62 206 records



04 · COVERAGE

HOW FAR THE SIGNAL CARRIES



23-29 km

video (16-QAM) from the TV Tower and Koeru

36-40 km

alerts (QPSK) from the same towers

10 / 18 km

video / alerts from Pärnu, the lowest tower

Single towers, measured on the reference signal: SFN gain on the service channel comes on top.

04 · COVERAGE

MEASURED FROM THE AIR

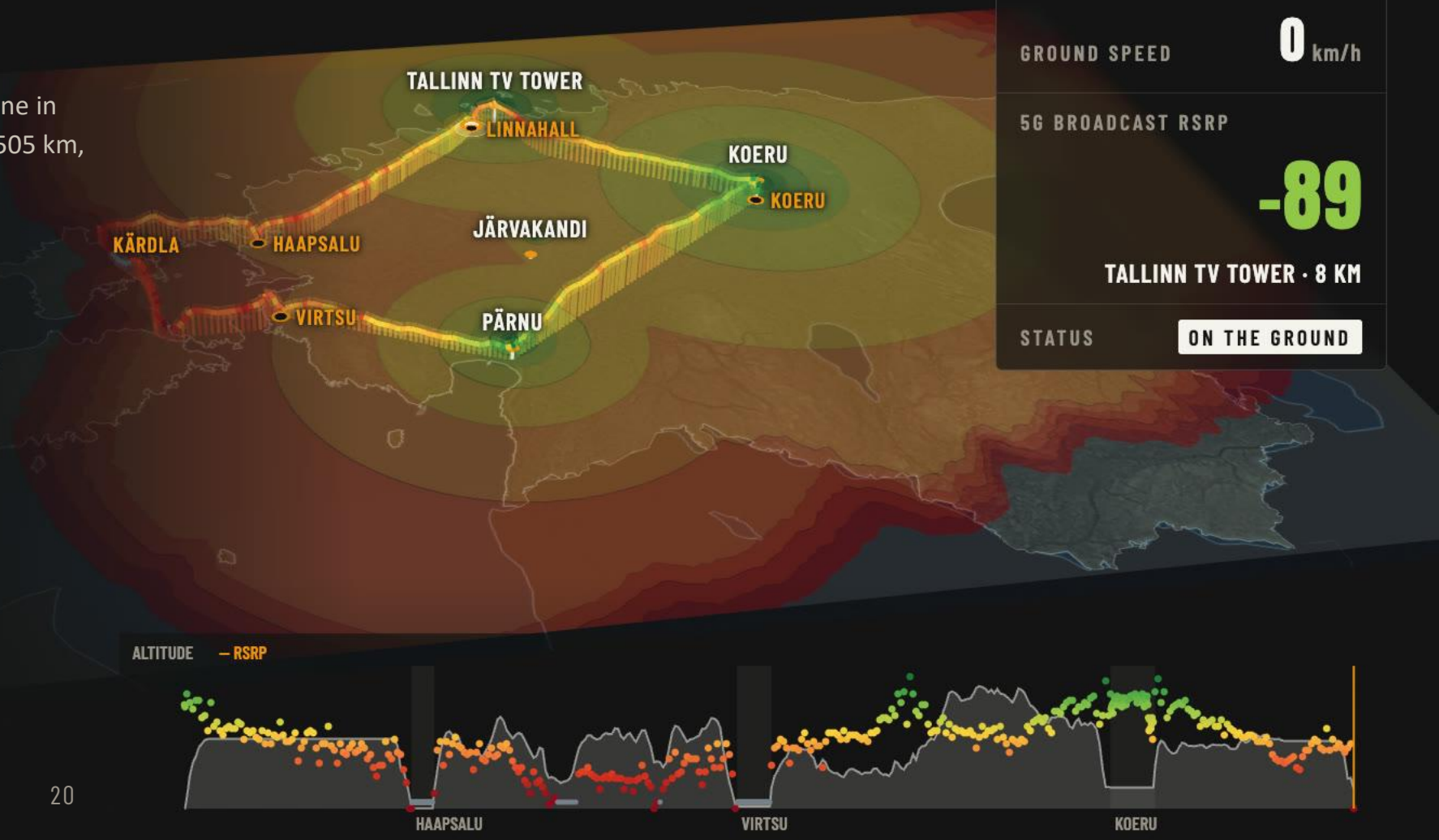
Helicopter flight on 15 October 2026. A phone in the cabin logged the signal every 30 s over 505 km, cruising at about 345 m.

98%

of samples decoded in flight (349 of 357)

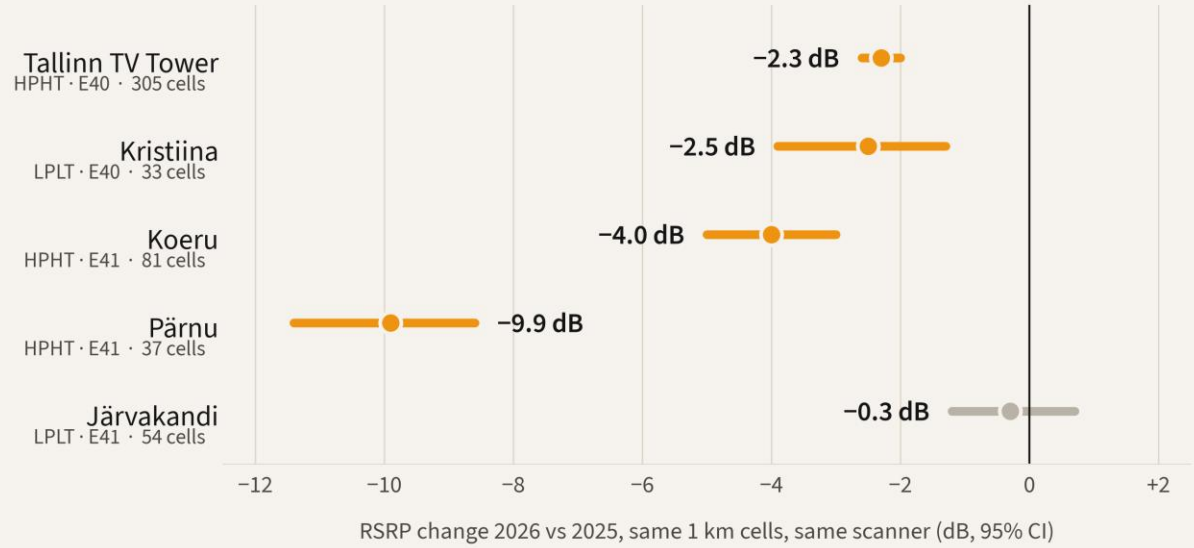
146 km

farthest decode from the TV Tower



04 · COVERAGE

SIGNAL LEVEL 2025 → 2026



RESULT In 2026 the signal was 2–4 dB lower at four of five transmitters and 9.9 dB lower at Pärnu. The model is calibrated on the weaker 2026 data, so the coverage figures are conservative.

Not transmitter power

ERP was the same in both years

Not weather or season

Both campaigns July to October; refractivity near refractivity near standard, no ducting (ERA5); no (ERA5); no trend with distance

Not foliage

Same drop in open terrain and in forest (TV (TV Tower −2.7 vs −2.0 dB)

SAME SCANNER, SAME 1 KM CELLS, 95% CI · GREY = NOT SIGNIFICANT

04 · COVERAGE

A MODEL CALIBRATED ON MEASUREMENTS

1

Terrain and trees

Copernicus GLO-90 elevation, ESA WorldCover 10 m tree cover

2

Path loss

Free space plus ITU-R P.452-18 18 Bullington diffraction, k = 4/3 4/3

3

Calibration

Censored regression on 62 206 206 records of 2026, incl. 47 936 936 non-detections below −114.5 −114.5 dBm

4

Service layers

SINR per 1 km pixel with SFN at at 200 µs cyclic prefix; phone noise noise figure 9 dB (3GPP TR 36.942) 36.942)

0.95

diffraction-loss factor

-3.8 dB

forest-cover correction

8.9 dB

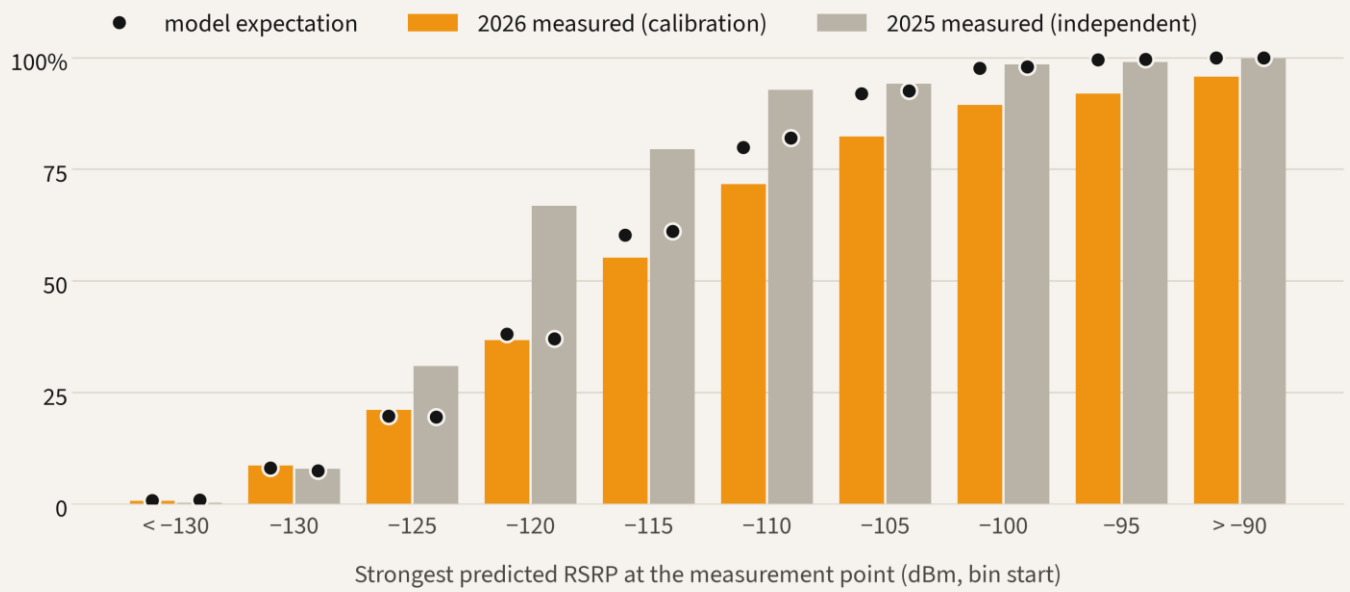
location variability (σ)

Why censored

fitting only detections would overstate coverage

04 · COVERAGE

THE MODEL MATCHES THE MEASUREMENTS



22.9% vs 24.2%

detected, measured vs model, 2026

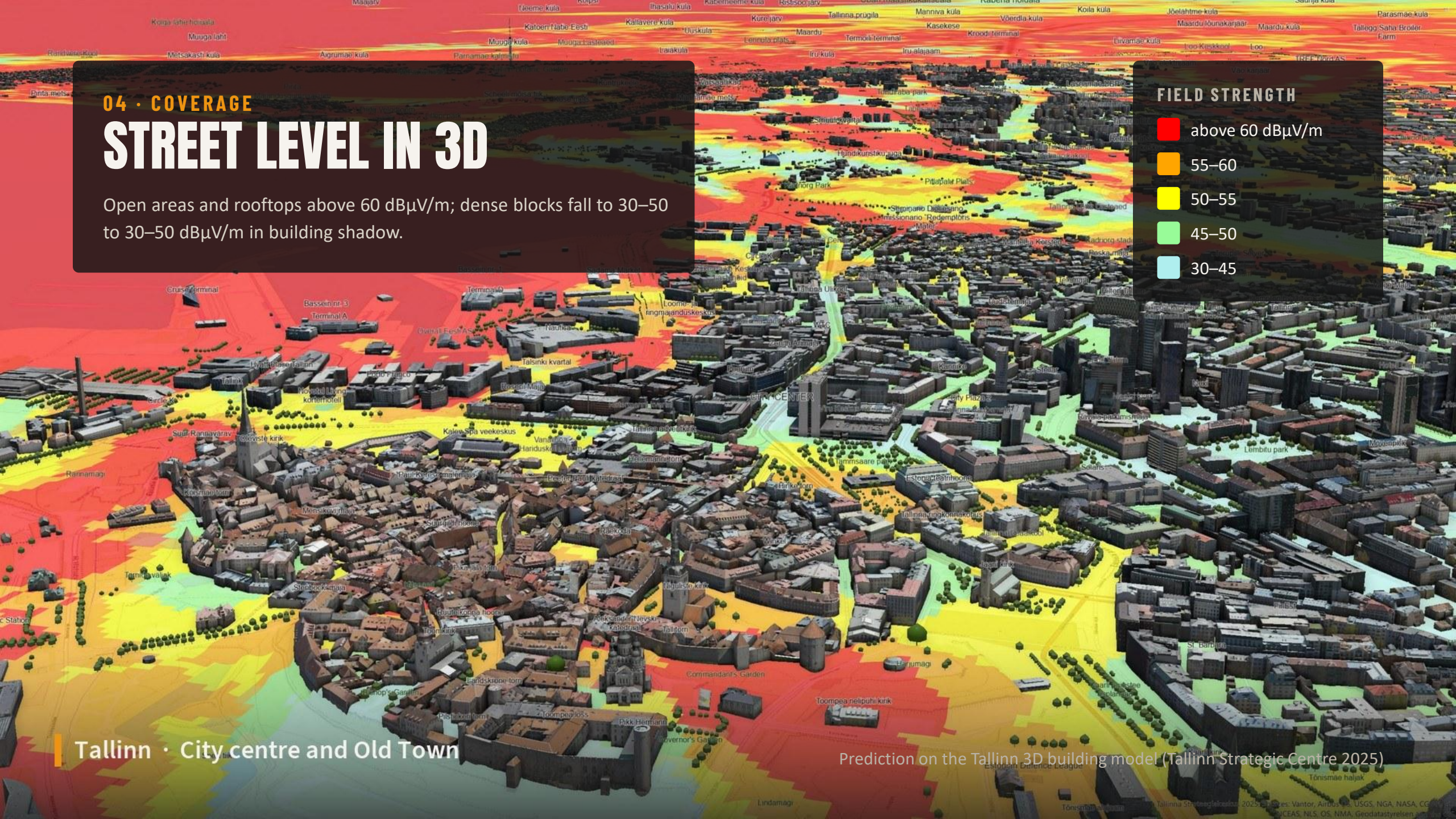
44.0% vs 39.2%

same check on independent 2025 data

±3-5 dB

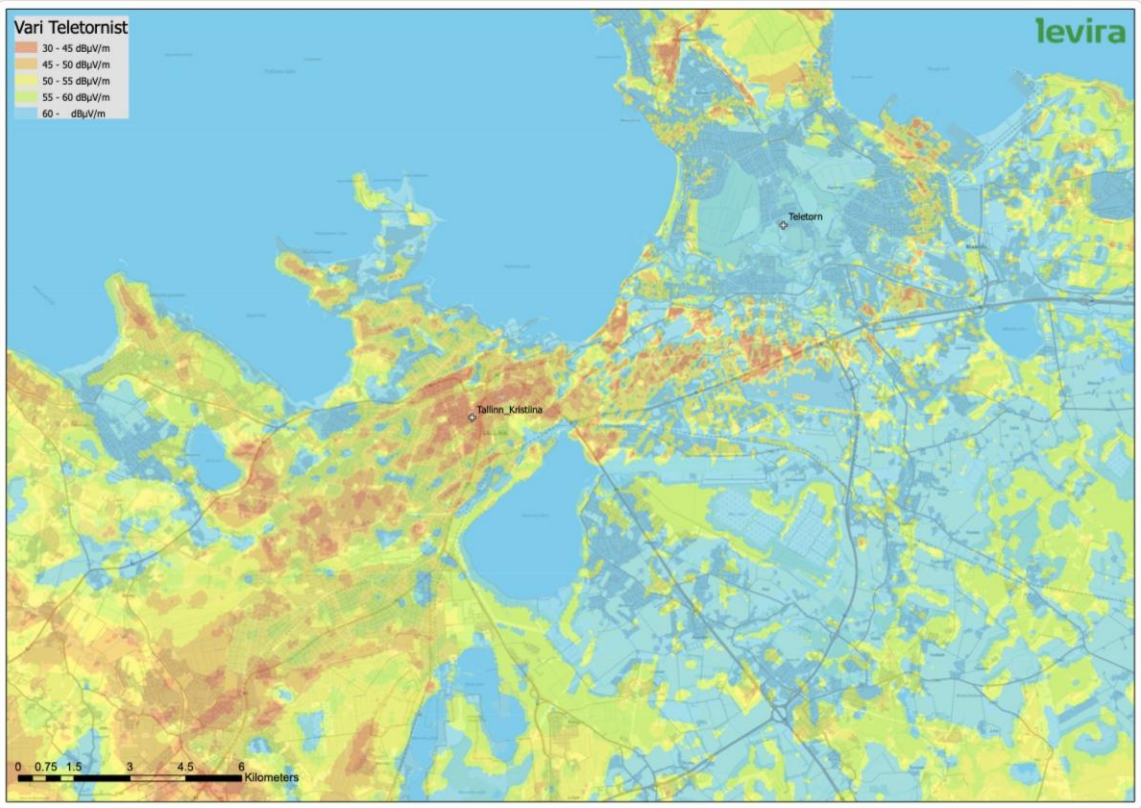
error for a transmitter left out of calibration

FIELD CHECK Live video worked on a phone in Kose, 35 km from the TV Tower. The model predicts 13 dB SINR there, above the 10 dB video threshold. video threshold.


04 · COVERAGE
STREET LEVEL IN 3D
Open areas and rooftops above 60 dBµV/m; dense blocks fall to 30–50 to 30–50 dBµV/m in building shadow.
FIELD STRENGTH
above 60 dBµV/m
55–60
50–55
45–50
30–45
Tallinn · City centre and Old Town
Prediction on the Tallinn 3D building model (Tallinn Strategic Centre 2025)

04 · COVERAGE

WHERE THE TV TOWER CASTS SHADOWS



TV Tower alone

Weakest field (red, 30–45 dBµV/m) in Kristiine, the city centre and Mustamäe–Nõmme

The filler is in the right place

The Kristiina transmitter sits in the TV Tower's weakest zone and fills it

Smaller towns

Pärnu is above 60 dBµV/m almost everywhere. Põltsamaa, 30 km from Koeru, is mostly 50–55 dBµV/m, 45–50 in the centre: indoor use may need more margin or a filler

SHADOW MAP COLOUR SCALE: RED WEAKEST, BLUE STRONGEST (ABOVE 60 DBMV/M)

05

NETWORK PLAN

From five pilot sites to twenty, all on existing broadcast masts, with regional single-frequency clusters.



05 · NETWORK PLAN

FROM 5 TO 20 TRANSMITTERS

80.6% → 96.4%

of the population with alert service (robust QPSK, SINR ≥ 0 dB)
0 dB)

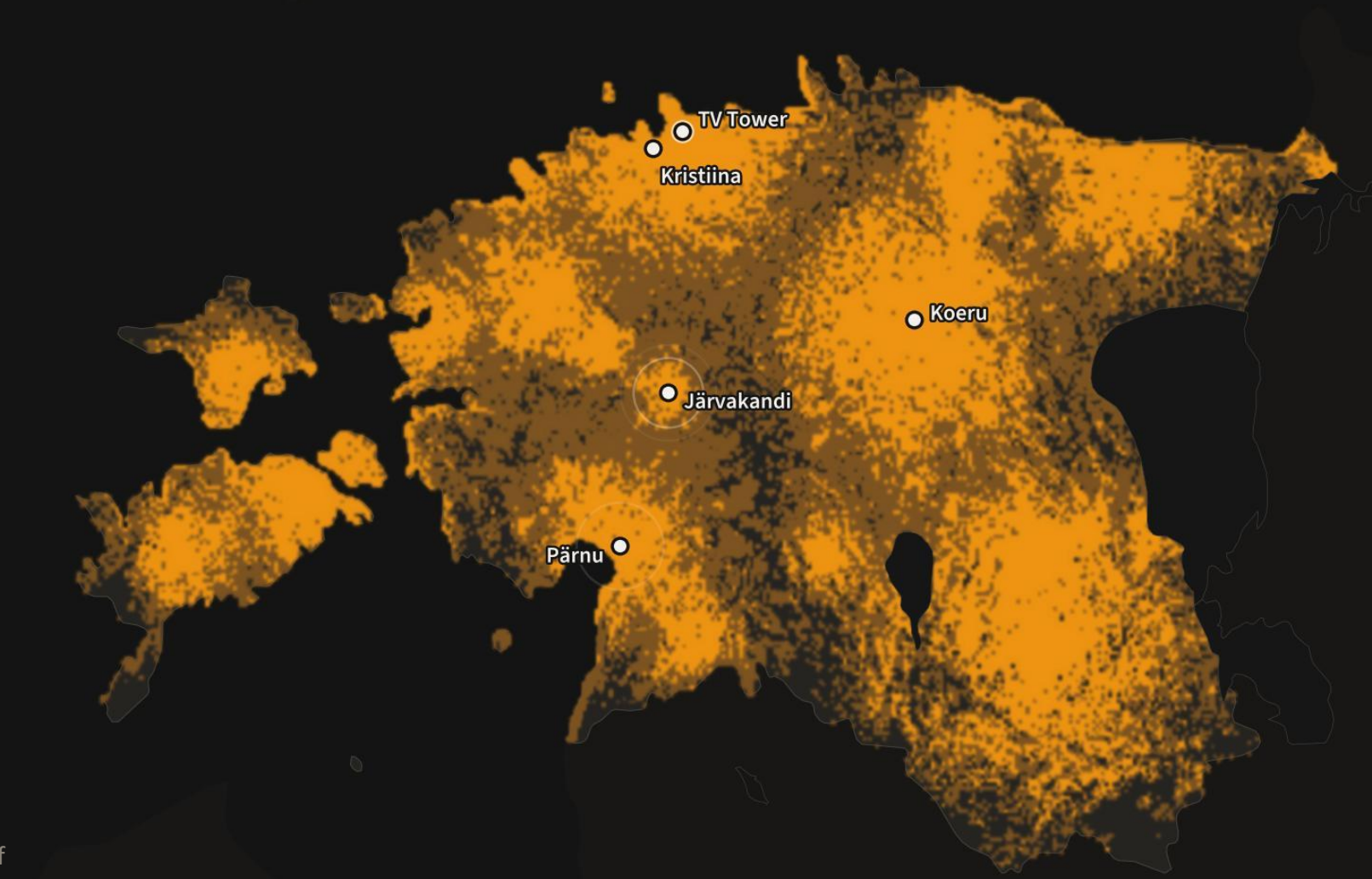
38.7% → 83.6%

of the land area with alert service

73.7% → 86.0%

of the population with video (16-QAM, SINR ≥ 10 dB)

20 transmitters on existing Levira masts. Handheld phone at phone at 1.5 m; an area counts as covered when at least half least half of the spots in it receive the service. Population: Population: Kontur 2023.



COVERAGE OF POPULATION AND LAND

LAND AREA | POPULATION

Service	Locations	Pilot	20 sites	20 sites
Alert, robust QPSK	50%	38.7%	83.6%	96.4%
SINR ≥ 0 dB	70%	25.3%	64.3%	92.1%
	90%	13.2%	36.3%	84.6%
Alert, QPSK	50%	29.8%	72.1%	94.2%
SINR ≥ 3 dB	70%	18.9%	50.8%	88.8%
	90%	9.8%	26.8%	79.9%
Video, 16-QAM	50%	15.1%	41.2%	86.0%
SINR ≥ 10 dB	70%	9.5%	26.1%	79.7%
	90%	4.8%	12.9%	69.5%

96%

of the population reached by alerts with with 20 sites (84% of land)

Reliability costs margin

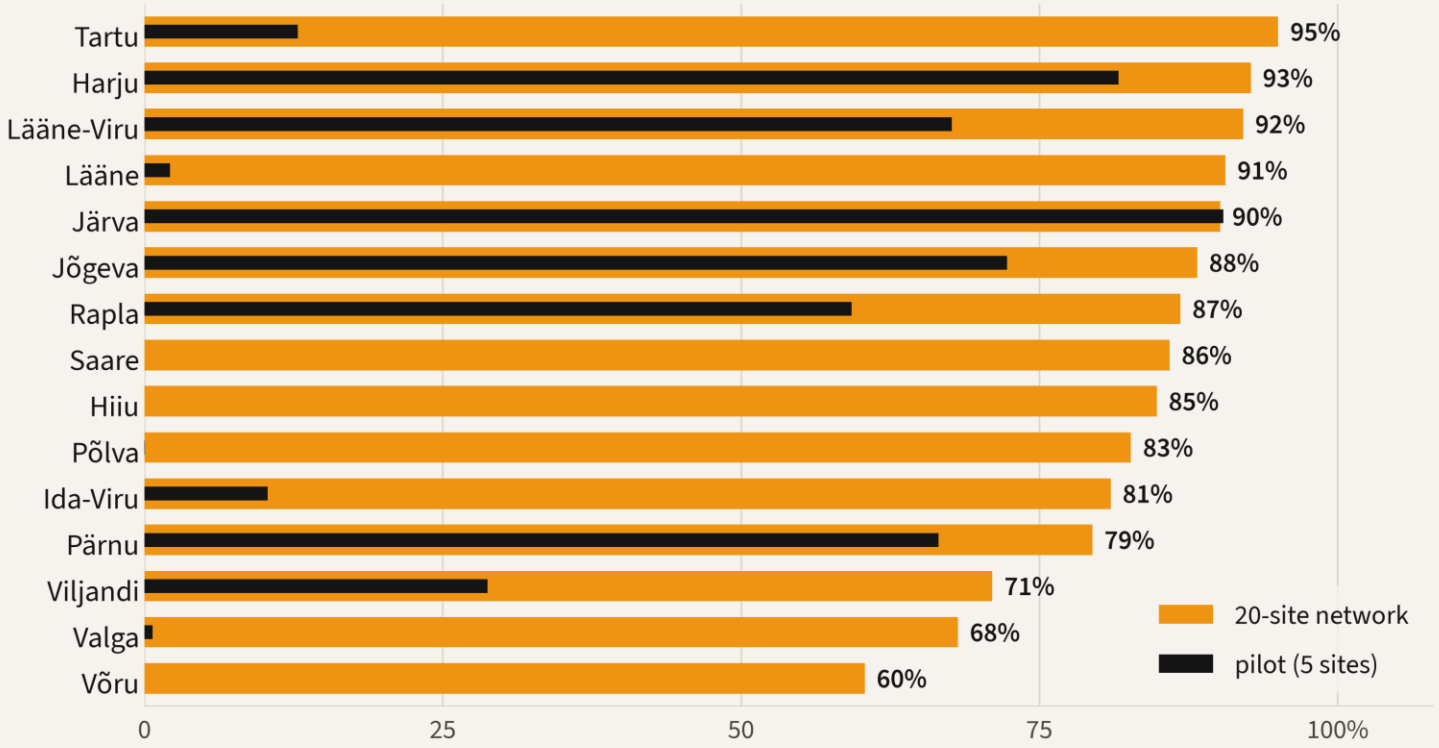
At 90% of locations: 85% of people, 36% of land land

The threshold matters

SINR ≥ 0 dB: 84% of land, 96% of people. At 3 dB: 3 dB: 72% and 94%

LAND 43 455 KM² · POPULATION 1.33 M (KONTUR 2023) · SEA NOT MODELLED

ALERT COVERAGE BY COUNTY



Largest gains

Tartu 13 → 95%, Lääne 2 → 91%, Saare 0 → 86%

Weakest counties

Võru 60%, Valga 68%, Viljandi 71%: first candidates for extra sites

Pärnu trade-off

Moving Pärnu from E41 (634 MHz) to E46 E46 (674 MHz) lowers its gain

ROBUST QPSK, SINR ≥ 0 DB · PHONE AT 1.5 M · 50% OF LOCATIONS

05 · NETWORK PLAN

THREE CHANNELS, REGIONAL SFNS

- **E40 · 622–630 MHz**
  Tallinn and the north-west
- **E41 · 630–638 MHz**
  Central and southern Estonia
- **E46 · 670–678 MHz**
  Islands, Pärnu and the south-west, Ida-Viru

---

200 µs cyclic prefix as baseline; 300 µs checked for long and sea and sea paths. SFN delays to be tuned per cluster.

Needs GE06 coordination with neighbours and re-planning of planning of DVB-T multiplexes.



06

COST

What a nationwide 20-site network would cost the state, based on the pilot's actual cost.



06 · COST · 20-SITE NETWORK, INCL. VAT

COST OF A NATIONWIDE NETWORK

€4.5 M

one-off investment: 20 transmitter sites and and platform

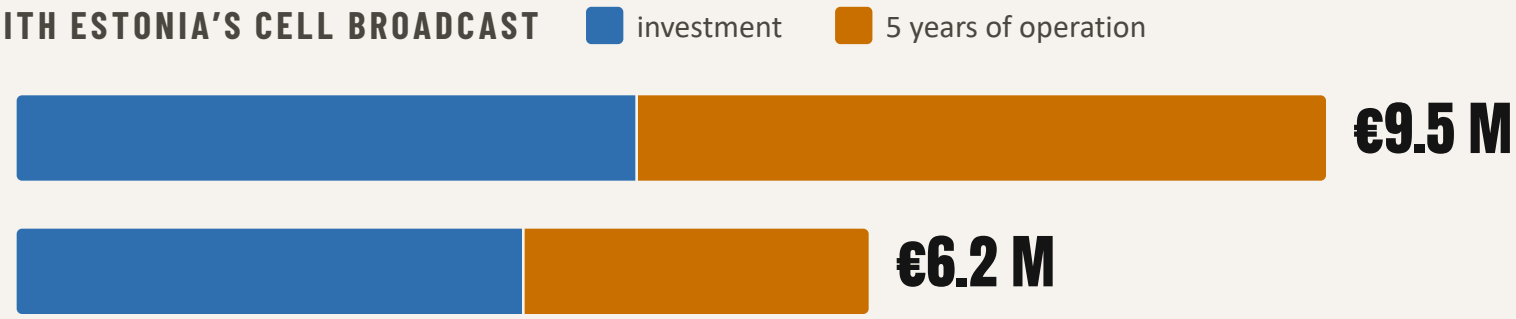
€1 M / yr

to operate: energy, spectrum, monitoring, monitoring, maintenance

€9.5 M

over five years

FIVE YEARS COMPARED WITH ESTONIA'S CELL BROADCAST



A completely new network, built on existing, proven broadcast infrastructure: Levira's masts and sites. Cell broadcast runs on the mobile operators' networks; Pocket Siren is independent of them, also carries TV and radio, and works without a SIM.

CELL BROADCAST: €3.67 M STATE ALLOCATION (2025) + €0.5 M/YR RUNNING COST; VAT NOT STATED

06 · COST · ONE INFRASTRUCTURE, MANY USES

SHARE THE NETWORK, HALVE THE COST

€2.25 M

warning share of the investment, with one more service on the network

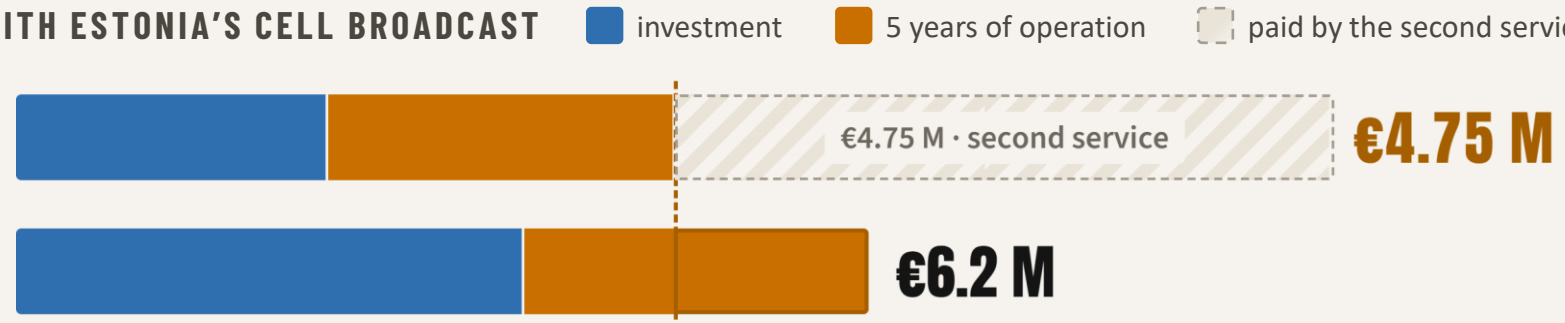
€0.5 M / yr

warning share of operation: the same as cell broadcast

€4.75 M

over five years: less than cell broadcast

FIVE YEARS COMPARED WITH ESTONIA'S CELL BROADCAST



One infrastructure, many uses: a second service could be TV and radio on phones, live video streaming, or data delivery to cars and devices. Every service that shares the transmitters shares the bill; with three, the warning share falls to about €3.2 M.

ILLUSTRATION: NETWORK COST SPLIT EQUALLY BETWEEN SERVICES · CELL BROADCAST AS ON THE PREVIOUS SLIDE

07

CONCLUSIONS

The technology works as a warning channel. What it needs now is devices, spectrum and a decision.



07 · CONCLUSIONS

SUITABILITY ASSESSMENT

WHAT THE PILOT PROVED

The full chain EE-ALARM → NAKOLOS → transmitters → phone works; works; every test-day alert reached the test phones

TV, radio and alerts share one carrier with no load on mobile networks networks

Geofenced display was correct in all three Pärnu scenarios

96% of respondents on the first test day found the alerts necessary

WHAT STILL LIMITS IT

End-user devices: 5G Broadcast reception must be enabled by phone makers makers and few models have it today

Platform gatekeepers: iPhone alerts need Apple's emergency entitlement; entitlement; device-based geofencing (4400) is not active in Europe

No common EU policy: EU warning rules (EECC Art. 110) are built around around mobile operators; nothing requires 5G Broadcast reception in phones in phones

Spectrum: UHF 470–694 MHz is secured for broadcasting only until 2030; new channels need GE06 coordination with neighbours

Suitable as an additional warning channel independent of mobile networks. Recommended for the national warning system.

07 · CONCLUSIONS

ROADMAP TO A NATIONAL SERVICE

2027

Decision

Funding and roles agreed; international frequency coordination coordination starts

2028

Preparation

Licences, channel plan with DVB-T, DVB-T, procurement, site design, EE-EE-ALARM integration, device agreements

2029

Build

New sites, SFN tuning, acceptance acceptance measurements, interface interface tests and exercises

2030

Mature service

Nationwide channel in EE-ALARM with regular tests and monitoring

Spectrum: UHF 470–694 MHz is secured for terrestrial broadcasting until at until at least 2030 (EU 2017/899); GE06 coordination with Latvia, Finland and Russia

Devices: native 5G Broadcast reception in phones by 2030 is the key prerequisite

ASSUMES A DECISION AND FUNDING IN 2027

07 · CONCLUSIONS

RECOMMENDATIONS

1 **Add it to the warning mix**

Use 5G Broadcast in EE-ALARM next to location-based SMS and cell and cell broadcast, for multimedia, many languages and mobile-network mobile-network outages

2 **Make phones receive it**

Seek an EU-level requirement for 5G Broadcast reception and work work with chipset makers, phone makers and Apple

3 **Build where gaps are largest**

Roll out the 20-site plan from the weakest areas first and plan margin margin for high-reliability coverage

4 **Test across borders**

Joint pilots with neighbours, starting with Estonia and Finland: common alert profiles and languages, phones that receive warnings on both sides, coordinated channels at the border

POCKET SIREN · 5G BROADCAST

THANK YOU

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