

TECHNICAL NOTE

Range test of 7 WiFi routers

Telenor A/S

Report no.: 120-36553-2 Rev. 1

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Report responsible

GTS

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OVERVIEW

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Revisions	This test report replaces previously issued test report 120-36553-2 dated 2021-03-10. The changes in this revision are: Test results for Icotera i4850 is updated with test results on new device due to errors in initial tested device. Serial number for Zyxel VMG3925-10A is corrected.
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1 Introduction

On request from Telenor A/S, measurement of 7 different WiFi routers has been performed. The test was performed in a reverberation chamber with its fading profile adjusted for emulation of real case scenario. The maximum throughput was limited to approximately 1000 Mbit/sec by hardware, not relevant for the WiFi performance.

2 Test results

Below, the test results can be found. The test results are stated as an average measured throughput with associated standard deviation of measurements. Average is a well-known concept to most people. However, standard deviation might not be a commonly known term. Standard deviation is a statistical term that describes the spreading of a series of data. In a series of data 68 % of data has value within a range of (\pm) one standard deviation from the average, and 95.5 % of the data has a value within two standard deviations from the average. As an example, a measurement series with an average throughput of 851 Mbit/sec and a standard deviation of 93 Mbit/sec, there is a probability of 68 % that a single measurement of throughput is in the range from 758 Mbit/sec to 944 Mbit/sec. This means that the probability of the measurement being greater than 758 Mbit/sec is 84 %. The corresponding figures for two standard deviations become 95.5 % probability for a measured throughput between 665 Mbit/sec and 1037 Mbit/sec, and 97.7 % probability that throughput is greater than 665 Mbit/sec.

Estimated indoor range is taken, as the ideal range divided by 3.3. However, this shall be expected to subject to great variance due to building properties and background noise.

For description of test set-up, case and method please refer to Section 3.



Estimated indoor range [m]	0.1	0.4	1.3	4.2	13.1	41.6	58.7	82.9	117.1	165.5	233.7
	Throughput average / standard deviation [Mbit/s]										
Icoteria i4882	851 / 93.3	860 / 127	877 / 92.7	973 / 63.3	598 / 181	315 / 52.1	294 / 93.1	158 / 33.4	82.9 / 19.3	39.2 / 12.7	7.42 / 7.63
Kaon DG2200	535 / 13.2	535 / 13.9	540 / 14.3	540 / 15.4	400 / 91.2	183 / 39.3	146 / 37.4	55.4 / 29.7	12.0 / 17.5	- ¹	- ¹
SagemCom F@st 3890	628 / 17.8	628 / 16.0	628 / 16.1	623 / 31.6	490 / 37.9	240 / 50.1	155 / 28.4	87.5 / 21.8	64.4 / 22.6	46.9 / 20.1	13.8 / 17.4
Technicolor DGA4330	651 / 17.1	650 / 39.9	655 / 16.3	577 / 142	482 / 147	214 / 94.3	205 / 39.6	163 / 31.0	93.3 / 32.1	43.6 / 14.4	6.99 / 9.18
Kaon DG3420TD	529 / 47.9	534 / 14.4	539 / 15.5	539 / 14.6	487 / 52.8	290 / 62.5	227 / 39.1	120 / 29.2	44.9 / 26.8	13.6 / 19.4	1.22 / 8.77
Icoteria i4850	614 / 85.5	605 / 74.1	579 / 74.6	533 / 120	424 / 70.9	204 / 48.5	129 / 27.1	77.2 / 26.3	43.6 / 27.5	0.00418 / 0.00983	- ¹
Zyxel VMG3925-10A	596 / 18.9	615 / 23.4	595 / 16.5	579 / 20.2	355 / 77.4	170 / 38.8	73.9 / 24.9	33.0 / 17.9	22.1 / 12.8	9.7 / 11.5	2.1 / 4.21

¹The router and client was not able to maintain WiFi connection over a full stirrer rotation.

3 Test set-up

Modern wireless MIMO technology depends heavily on multipath propagation of the wireless signal. Hence, performing test in an anechoic chamber might not represent the actual performance of the system.

For measurement of WiFi range performance the set-up shown in Figure 3-1 was used. The testing was performed in an electromagnetic reverberation chamber. The reverberation offers a multitude of propagation paths. However, fading of signals takes much longer time than real case scenario. The fading profile was adjusted by adding 6 RF absorbers. The reverberation offers many different propagation paths, but not all equally good. The available propagation paths are most sensitive, even small displacement of antennas causes changes in propagation paths.

A reverberation chamber has an electromagnetic stirrer, which can alter all propagation paths inside the chamber except for the direct path between two antennas. To test a multitude of different propagation scenarios, a test of throughput was performed over one full stirrer rotation. An RF absorber was placed between the WiFi client and the router under test since this path can not be altered by the electromagnetic stirrer and otherwise is dominating.

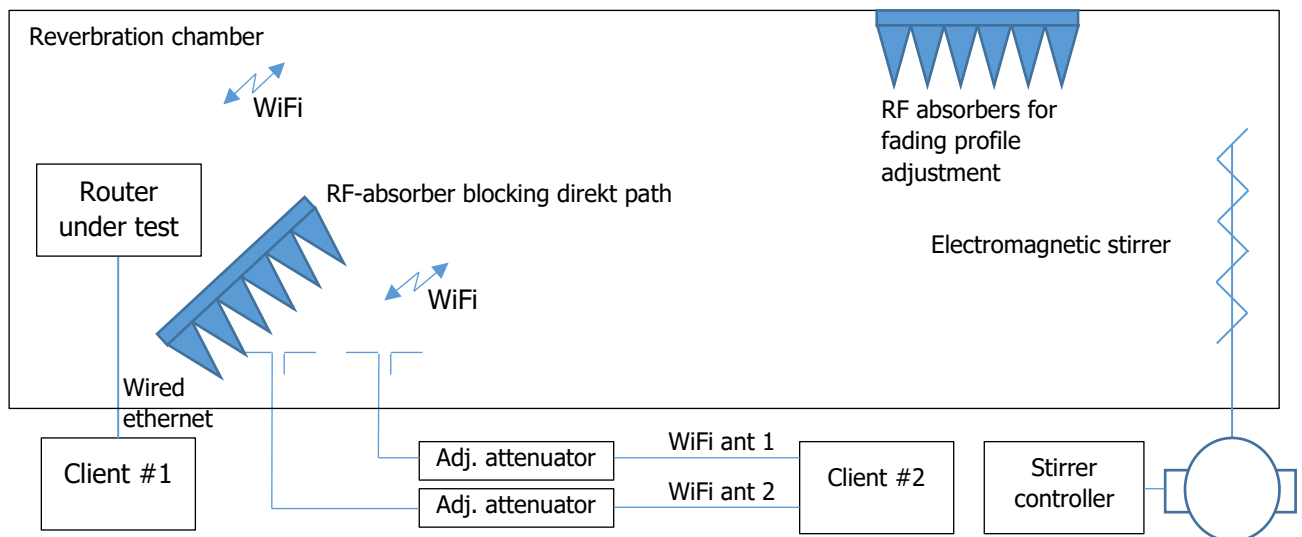


Figure 3-1 Schematic of test set-up. Range increments are simulated by increasing the adjustable attenuators. All measurement is performed over one full stirrer rotation with 193 measurements.

Before test start, the router under test was replaced with an antenna, and path loss between this antenna and the antennas connected to client#2, was measured over one full stirrer rotation and minimum loss was recorded.

Throughput data was collected with iPerf3¹ as on rotation of the stirrer takes 193 seconds this resulted in 193 throughput measurements over one stirrer rotation each covering 1 second of stirrer rotation. Below the exact iPerf3 command can be seen.

```
iperf3 -c <ip of client> -P10 -O 10 -t 193
```

This starts a test with 10 parallel streams. A test duration of 193 seconds with the first 10 seconds omitted giving time to synchronize start of stirrer rotation.

The above described test was repeated with increasing attenuation setting of the adjustable attenuators, simulating increased distance between the router under test and client#2. Test was repeated until that connection between the router under test and client#2 could not be maintained during a full stirrer rotation.

¹ Iperf3 is a widely used software that measures throughput between two endpoints

Data was subsequently processed statistically. It has been assumed that the data is distributed in a Gaussian shape around an average. However, this might not be completely correct for all cases, especially when throughput is limited either upwards or downwards (e.g. HW limited or throughput approaches zero).

The ideal range was calculated from attenuation setting combined with the minimum value of the loss recorded initially. The ideal range is in real case scenarios reduced by buildings and other obstructions in the propagation path along with higher level of background noise (e.g. adjacent routers operating on the same frequency). The reduction is set to 3.3 in this work but could be anywhere between 1 and 10 depending on the exact location.

Table 3-1 Hardware used

Manufacturer	Model
Lenovo / Intel	M920 Tiny ¹ / Wi-Fi 6 AX200
Lenovo / QNAP systems	T480 / QNA-UC5G1T

¹After performing the test, it was discovered that the m2 slot for the WiFi adapter was of a 'x1' type limited to approx. 1000 Mbit / sec. This has therefore limited the measured maximum capacity.

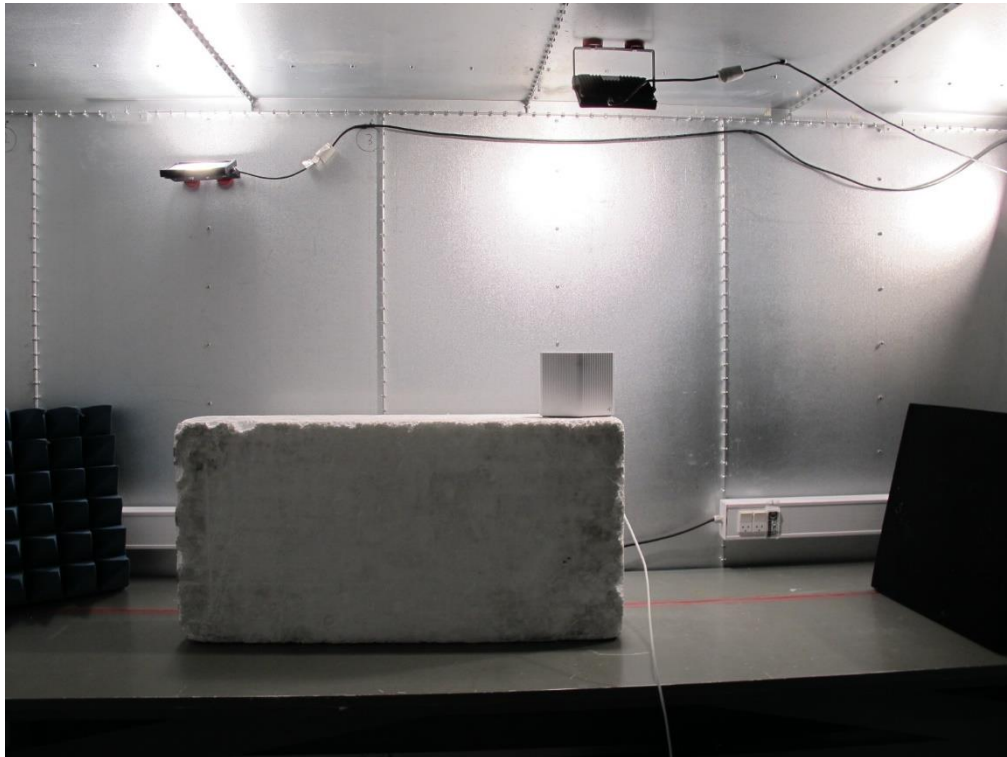
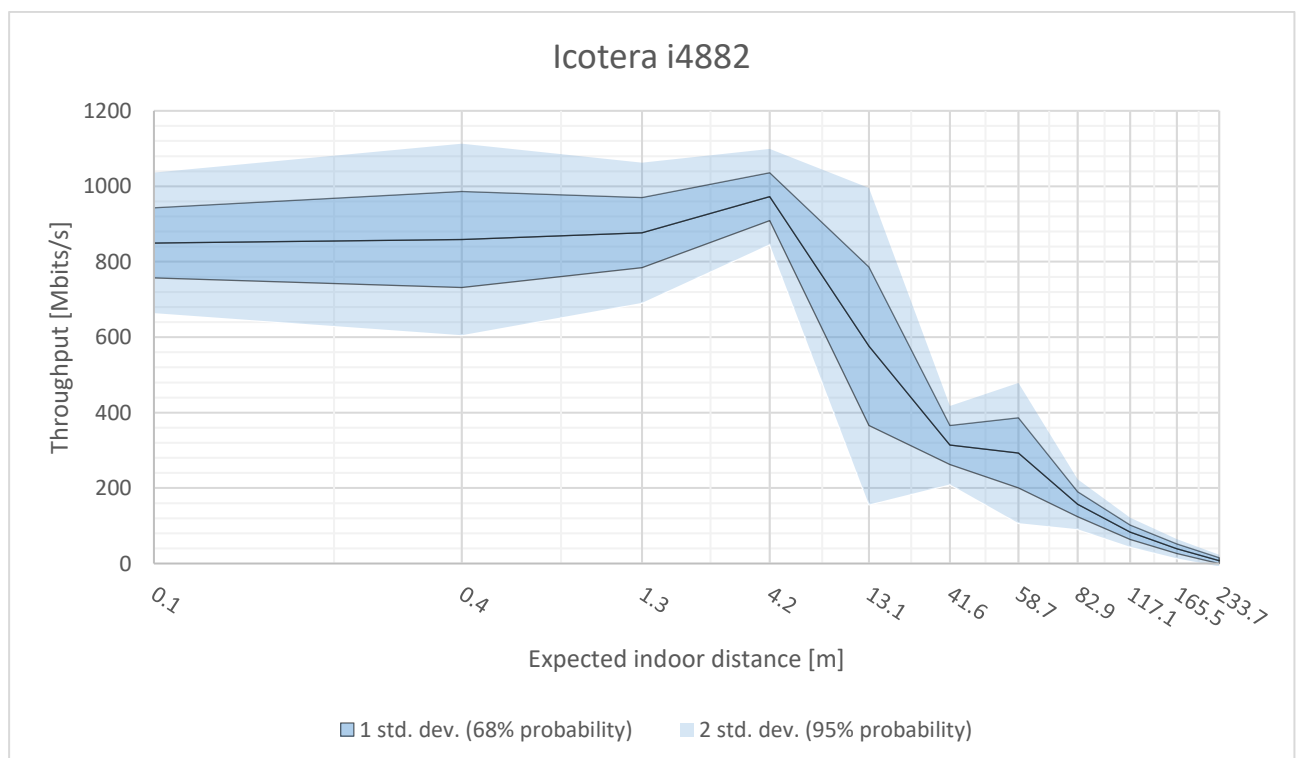


Figure 3-2 Picture of router in test set-up.

4 Test specimens

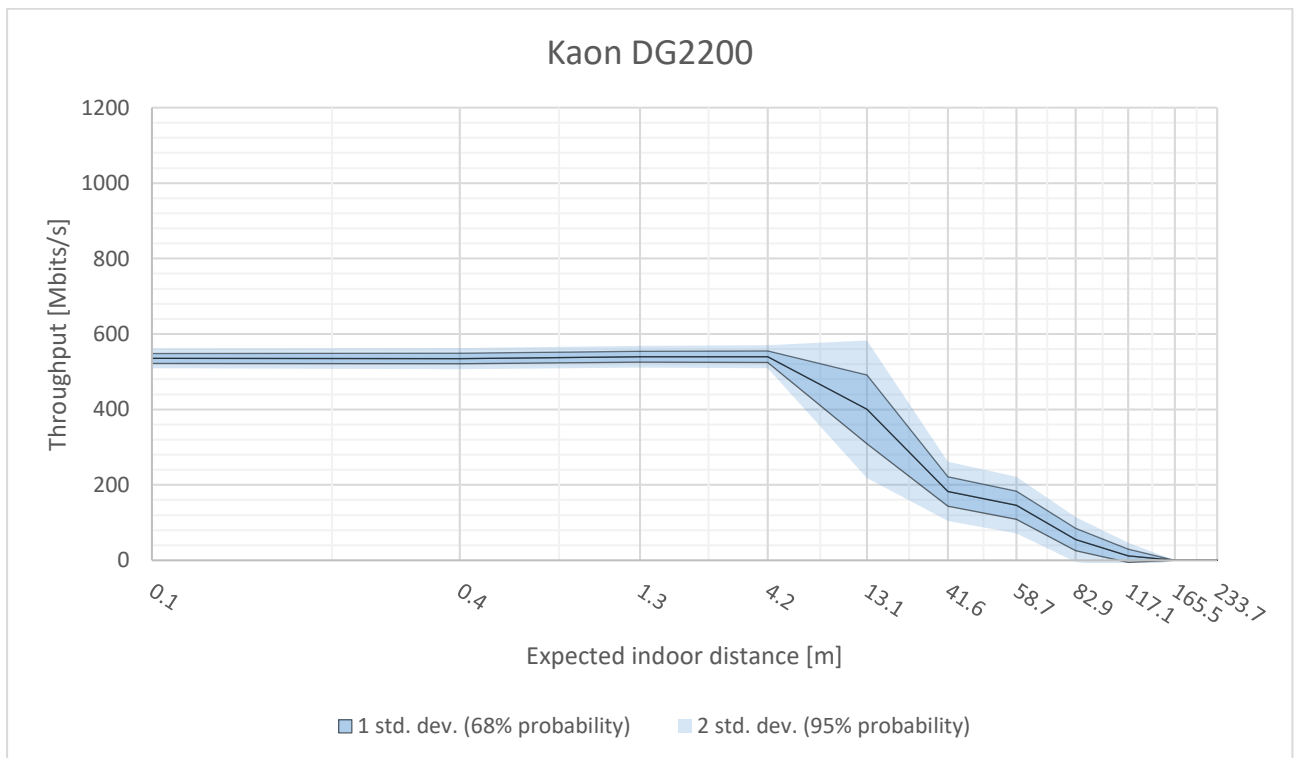
4.1 Icotera I4882

Model / type	I4882
Serial no.	4882700000413
Producent	Icotera



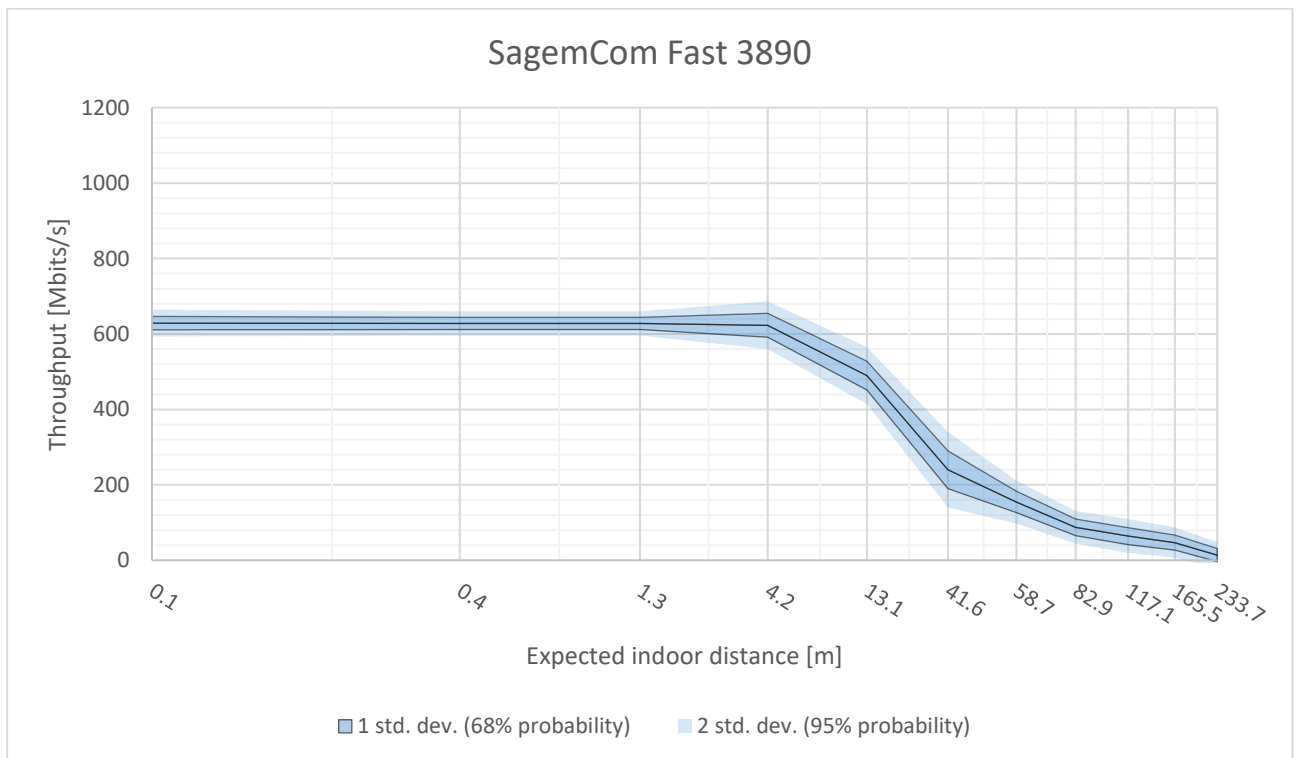
4.2 Kaon DG2200

Model / type	DG2200
Serial no.	071201600057588
Producent	Kaon



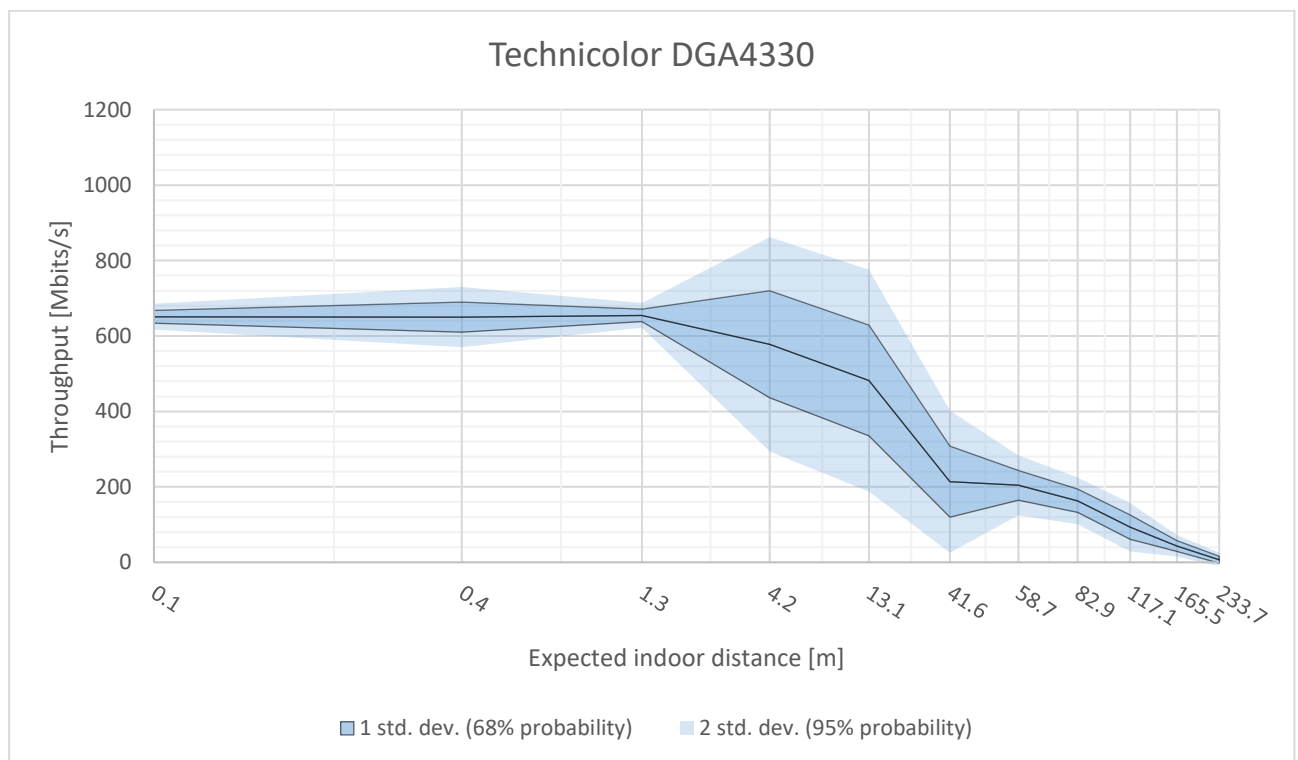
4.3 SagemCom F@st 3890

Model / type	F@st 3890
Serial no.	DM1815618005326
Producent	SagemCom



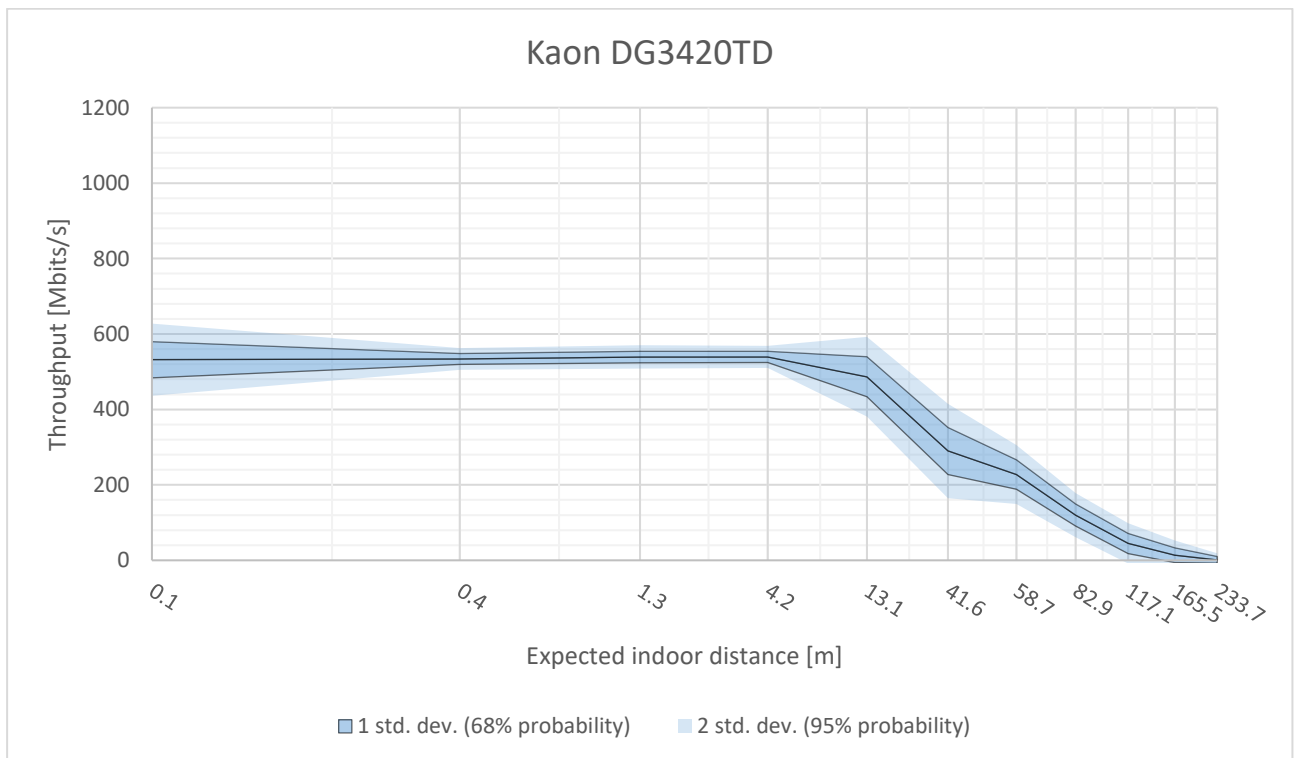
4.4 Technicolor DGA4330

Model / type	DGA4330
Serial no.	CP2007RA6JE
Producent	Technicolor



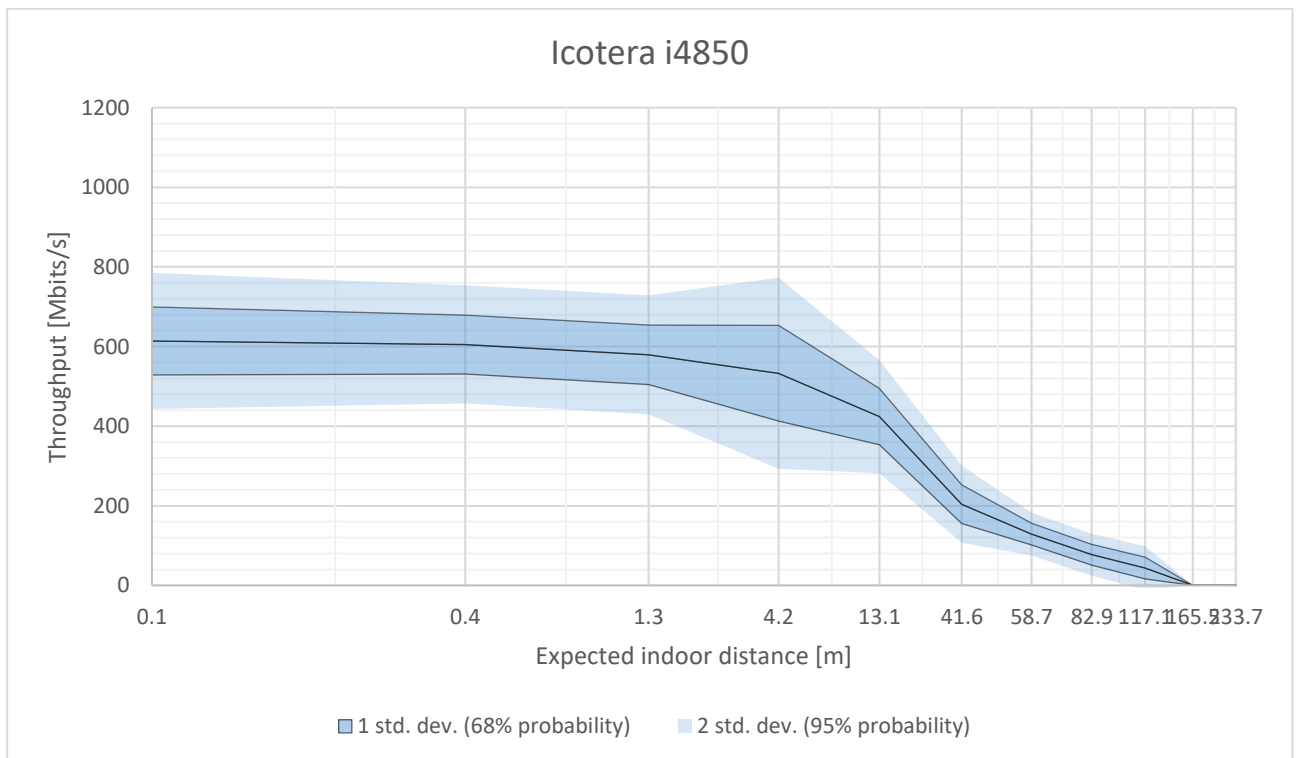
4.5 Kaon DG3420TD

Model / type	DG3420TD
Serial no.	BS10064932001675
Producent	Kaon



4.6 Icotera I4850

Model / type I4850
Serial no. 4850003418021898
Producent Icotera



4.7 Zyxel VMG3925-10A

Model / type	VMG3925-10A
Serial no.	S200Y27012989
Producent	Zyxel

