BoR PC14 (22) 03

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Pirlys dimensioning tool presentation

Quality by data

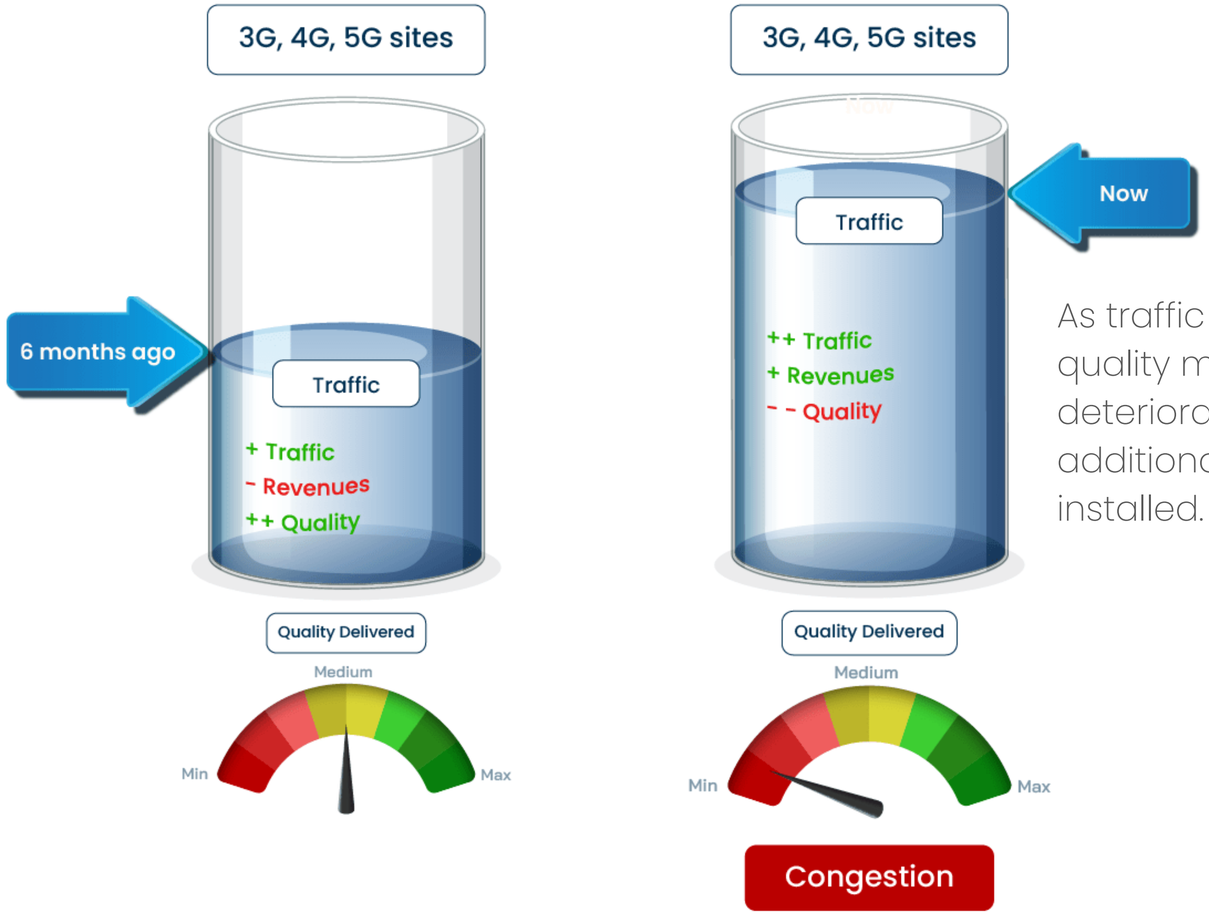
Olivier & Thibault, August 9th 2022

Pirlys is a partner of GSA 4G-5G FWA Forum

GSA 4G 5G Fixed Wireless Access Forum

What are the problems Pirlys is solving?

What is the root cause of the problem?

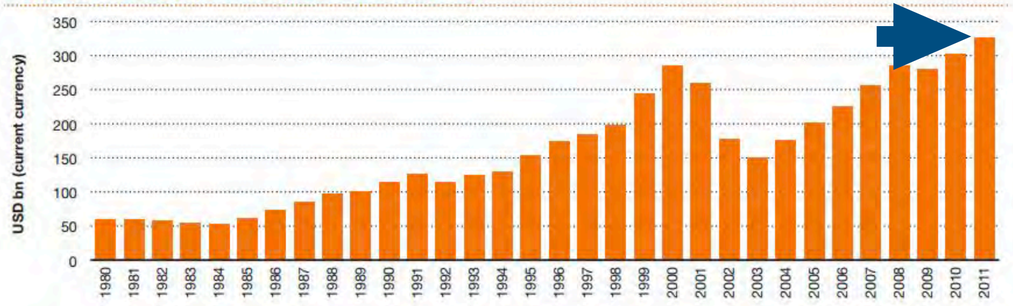


As traffic increases, the quality mechanically deteriorates if no additional capacity is installed.

Mobile telecom industry's critical challenge

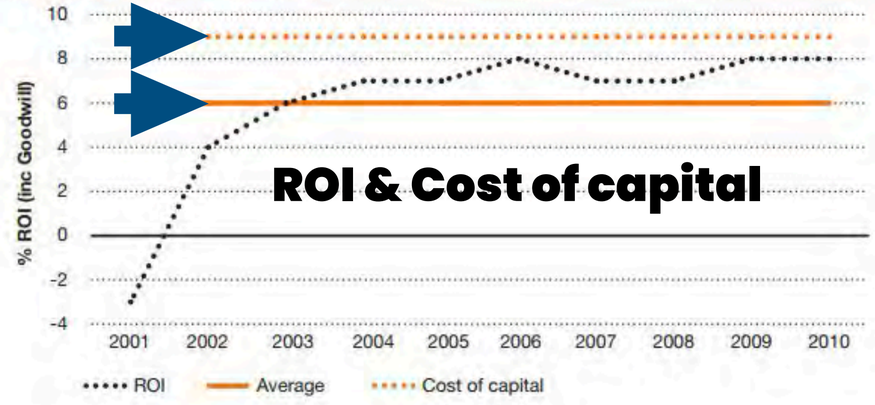
Billions of dollars misallocated

Figure 1: Global capex levels in the telecoms industry



Excludes Licences, Spectrum and R&D
Source: OECD, PwC analysis

Figure 2: Average returns on investment



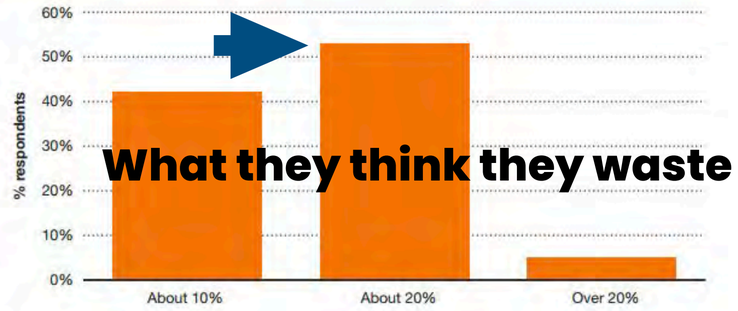
ROI & Cost of capital

Source: Capital IQ, PwC analysis

$65billion/year wasted

20% wasted per year

Figure 6: The proportion of annual capex spent on assets that fail to return their cost of capital



What they think they waste

Source: PwC

Poor decision making can cost–and, in an industry that invests as much as telecoms, the total cost can be very large indeed. More than half the respondents in our survey estimate that about 20% of their company's capex is spent on assets which don't recover their cost of capital (see Figure 6).

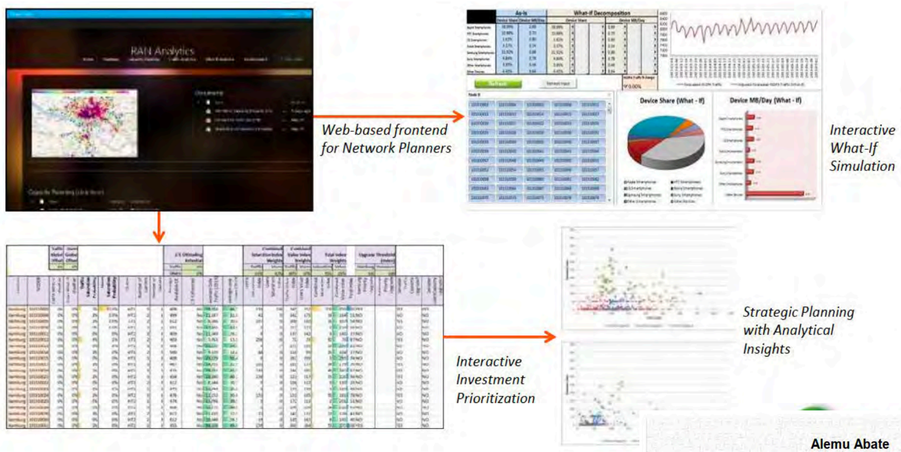
This is consistent with the fact that the industry generates average returns of 6% on capital that costs 9%, although it implies that the misallocated capital generates absolutely no return. What's more likely, as one respondent noted, is that about 70% of investments cover their cost of capital and about 30% generate very poor returns indeed. The difference is easy to explain. We calculate that most telecoms operators misallocate about 20-22% of their discretionary capex, but when you include the non-discretionary capex they're required to make for regulatory reasons the percentage rises to about 30%.

So, what are the implications? If the industry invests about $325 billion a year on capital projects and generates returns that are equivalent to nil on 20% of its investment, it's effectively wasting about $65 billion a year. That's more than the entire revenue generated by the global video games market in 2011 ($59.3 billion).[2] In fact, it's enough to run point-to-point fibre to every home and business in Britain (at a one-off cost of about $50 billion) and still have some spare change.

Measured inefficiency, what they really waste

In reality 2 issues & higher degradation levels

- Lack of granular data-driven predictive insights prohibits legacy approaches to utilise network capacity upgrade budget at maximum efficiency
- Over-investment: **66% of total upgrades** were planned on nodes with **low saturation risk** and low value
- Under-investment: **80% of nodes with high saturation risk were not the planned for upgrades**
- In the case study example roughly 41% of the planned CAPEX would have to be reallocated to tackle the under-investment problem and an additional 25% could be to deferred to limit over-investment
- … all this work was done after the upgrades were completed



Telefonica Germany audit

Alemu Abate
Engineering Access & Transport Mobile Access

Telefónica Germany GmbH & Co. OHG
Georg-Brauchle-Ring 23-25
80992 München
Tel: +49 176 2442 4816
alemu.abate@telefonica.com

Markus Beckmann
Network Analytics Offering Lead

Accenture
Anni-Albers Str.11
D-80807 München

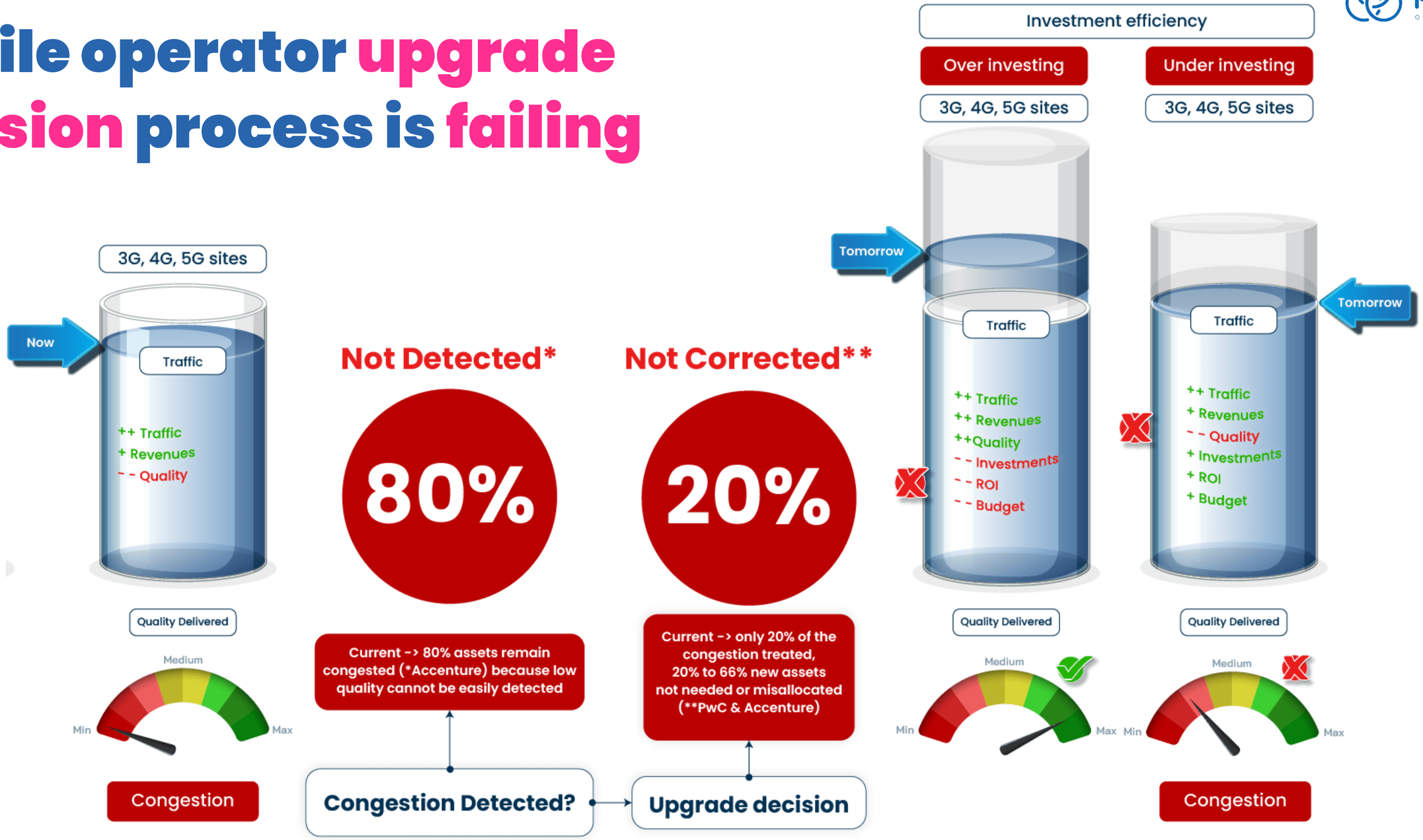
Tel: +49 175 57 68467
markus.beckmann@accenture.com

Rank	Company
1	China Mobile Communications Corporation
2	Bharti Airtel Limited
3	Reliance Jio Infocomm Limited
4	China Telecom Corp., Ltd
5	Vodafone Group plc
6	China Unicom Limited
7	América Móvil, S.A.B. de C.V
8	Telefónica S.A.
9	MTN Group Limited
10	Orange S.A.
11	Vodafone Idea
12	Deutsche Telekom AG

66% wasted per year
660M€ wasted

80% not done per year
80% of the network coverage suffers from congestion

Mobile operator upgrade decision process is failing



*** Source PwC 20%, * Source Accenture*

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Why is the existing so inefficient?

Revenues versus Expenses

For GSM 2G … MNO were highly profitable

- Revenues are generated by traffic loads
- Expenses are the capacity deployed to handle the load growth
- Revenues shall be directly linked to expenses = $1 invested shall generate $2 or $3, … in new revenues from traffic
- Before Erlang B table, decide the QoX, reads the traffic OSS data, infer configuration and upgrades

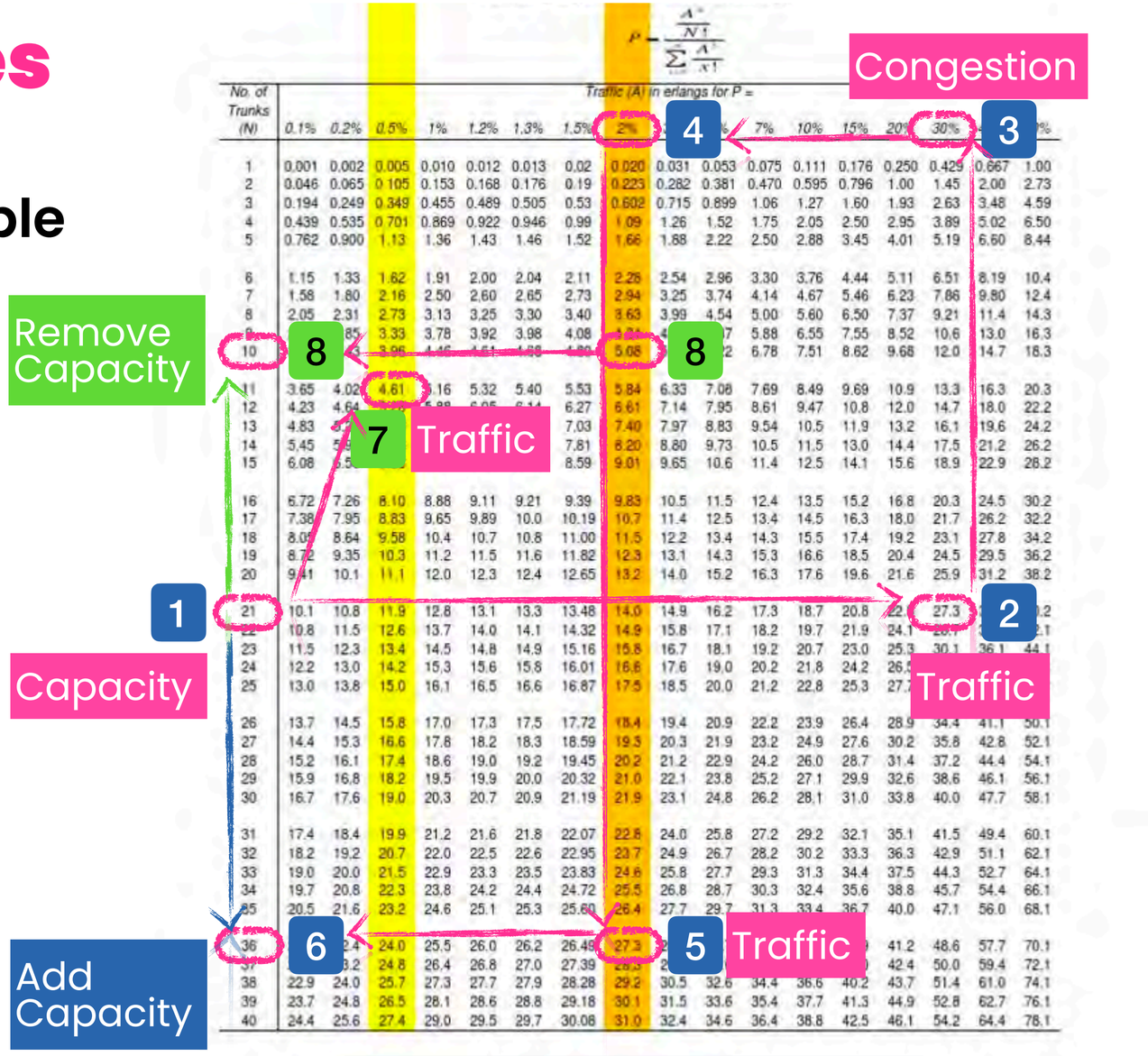
Erlang B is for one dimension traffic 2G only

$$\Pr\{blocking\} = GOS = \frac{\frac{A^n}{n!}}{\sum_{k=0}^{n} \frac{A^k}{k!}}$$

n=number of trunked channels

A=total offered traffic

Traffic load A and configuration N, P blocking probability



No. of Trunks (N)	Traffic (A) in erlangs for P = 0.1%	0.2%	0.5%	1%	1.2%	1.3%	1.5%	2%	3%	4%	5%	7%	10%	15%	20%	30%	40%	50%
1	0.001	0.002	0.005	0.010	0.012	0.013	0.02	0.020	0.031	0.053	0.075	0.111	0.176	0.250	0.429	0.667	1.00	
2	0.046	0.065	0.105	0.153	0.168	0.176	0.19	0.223	0.282	0.381	0.470	0.595	0.796	1.00	1.45	2.00	2.73	
3	0.194	0.249	0.349	0.455	0.489	0.505	0.53	0.602	0.715	0.899	1.06	1.27	1.60	1.93	2.63	3.48	4.59	
4	0.439	0.535	0.701	0.869	0.922	0.946	0.99	1.09	1.26	1.52	1.75	2.05	2.50	2.95	3.89	5.02	6.50	
5	0.762	0.900	1.13	1.36	1.43	1.46	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44	
6	1.15	1.33	1.62	1.91	2.00	2.04	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4	
7	1.58	1.80	2.16	2.50	2.60	2.65	2.73	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4	
8	2.05	2.31	2.73	3.13	3.25	3.30	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3	
9			3.33	3.78	3.92	3.98	4.08				5.88	6.55	7.55	8.52	10.6	13.0	16.3	
10								5.08			6.78	7.51	8.62	9.68	12.0	14.7	18.3	
11	3.65	4.02	4.61	5.16	5.32	5.40	5.53	5.84	6.33	7.08	7.69	8.49	9.69	10.9	13.3	16.3	20.3	
12	4.23	4.64					6.27	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2	
13	4.83						7.03	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2	
14	5.45						7.81	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2	
15	6.08						8.59	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2	
16	6.72	7.26	8.10	8.88	9.11	9.21	9.39	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.2	
17	7.38	7.95	8.83	9.65	9.89	10.0	10.19	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.2	
18	8.05	8.64	9.58	10.4	10.7	10.8	11.00	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2	
19	8.72	9.35	10.3	11.2	11.5	11.6	11.82	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2	
20	9.41	10.1	11.1	12.0	12.3	12.4	12.65	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9	31.2	38.2	
21	10.1	10.8	11.9	12.8	13.1	13.3	13.48	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3			
22	10.8	11.5	12.6	13.7	14.0	14.1	14.32	14.9	15.8	17.1	18.2	19.7	21.9	24.1				
23	11.5	12.3	13.4	14.5	14.8	14.9	15.16	15.8	16.7	18.1	19.2	20.7	23.0	25.3				
24	12.2	13.0	14.2	15.3	15.6	15.8	16.01	16.6	17.6	19.0	20.2	21.8	24.2					
25	13.0	13.8	15.0	16.1	16.5	16.6	16.87	17.5	18.5	20.0	21.2	22.8	25.3					
26	13.7	14.5	15.8	17.0	17.3	17.5	17.72	18.4	19.4	20.9	22.2	23.9	26.4	28.9				
27	14.4	15.3	16.6	17.8	18.2	18.3	18.59	19.3	20.3	21.9	23.2	24.9	27.6	30.2				
28	15.2	16.1	17.4	18.6	19.0	19.2	19.45	20.2	21.2	22.9	24.2	26.0	28.7	31.4				
29	15.9	16.8	18.2	19.5	19.9	20.0	20.32	21.0	22.1	23.8	25.2	27.1	29.9	32.6				
30	16.7	17.6	19.0	20.3	20.7	20.9	21.19	21.9	23.1	24.8	26.2	28.1	31.0	33.8				
31	17.4	18.4	19.9	21.2	21.6	21.8	22.07	22.8	24.0	25.8	27.2	29.2	32.1	35.1				
32	18.2	19.2	20.7	22.0	22.5	22.6	22.95	23.7	24.9	26.7	28.2	30.2	33.3	36.3				
33	19.0	20.0	21.5	22.9	23.3	23.5	23.83	24.6	25.8	27.7	29.3	31.3	34.4	37.5				
34	19.7	20.8	22.3	23.8	24.2	24.4	24.72	25.5	26.8	28.7	30.3	32.4	35.6	38.8				
35	20.5	21.6	23.2	24.6	25.1	25.3	25.60	26.4	27.7	29.7	31.3	33.4	36.7	40.0				
36			24.0	25.5	26.0	26.2	26.49	27.3						41.2				
37			24.8	26.4	26.8	27.0	27.39							42.4				
38	22.9	24.0	25.7	27.3	27.7	27.9	28.28	29.2	30.5	32.6	34.4	36.6	40.2	43.7				
39	23.7	24.8	26.5	28.1	28.6	28.8	29.18	30.1	31.5	33.6	35.4	37.7	41.3	44.9				
40	24.4	25.6	27.4	29.0	29.5	29.7	30.08	31.0	32.4	34.6	36.4	38.8	42.5	46.1				

Maximum wasted assets: 8%
Maximum congestion levels: 2%

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ErlangB only valid when 1 unit of capacity = 1 service, so ok for 2G GSM FR

(1 voice call session = 1 time slot)

For 2G GSM HR/FR, 3G, 4G and 5G, 1 service can take any units of capacity, ErlangB is useless

(example Youtube session on 3G can take up to 96 Channel Elements)

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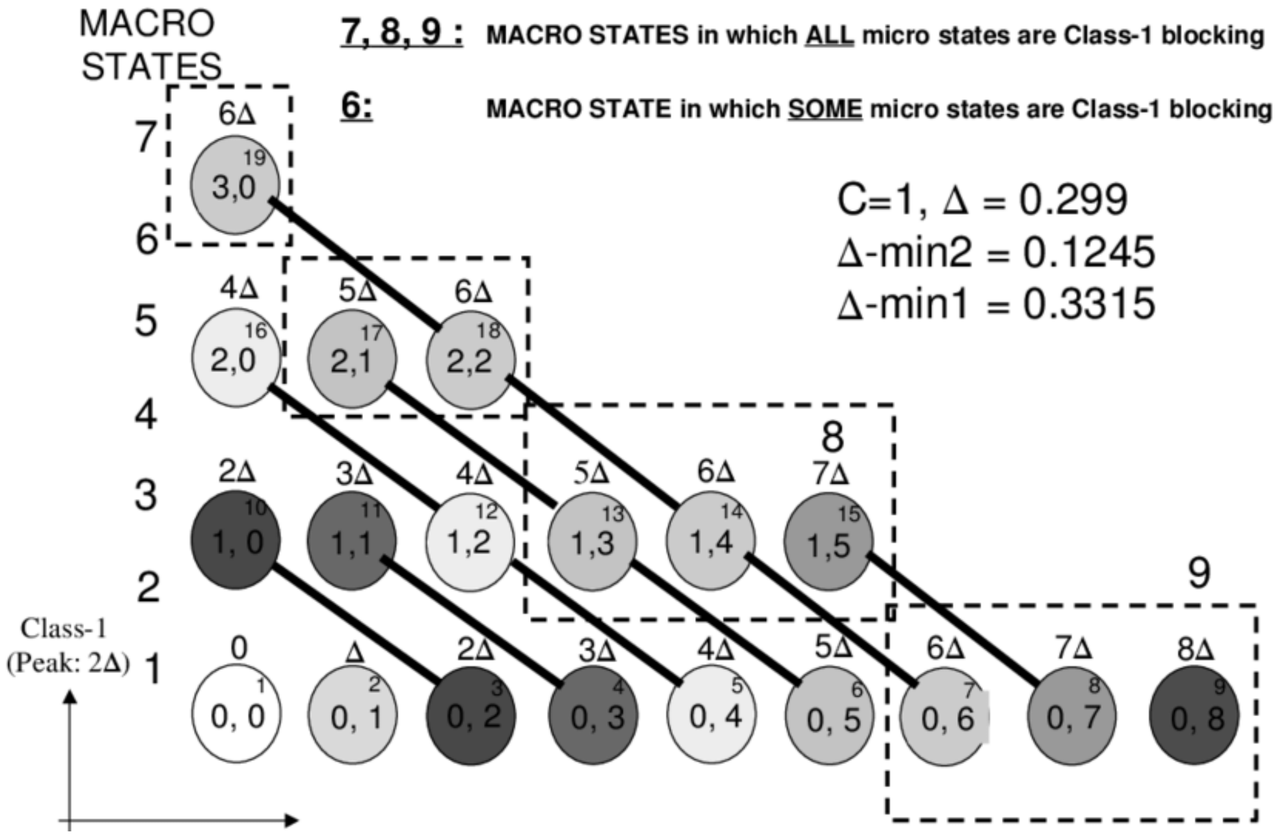
When we adapted the Kaufman-Roberts stochastic birth and death model to run on servers, we cracked the Capex code

Unique model for multidimensional traffic

Connection between traffic, QoE and dimensioning is broken for 2.5G, 3G, 4G …

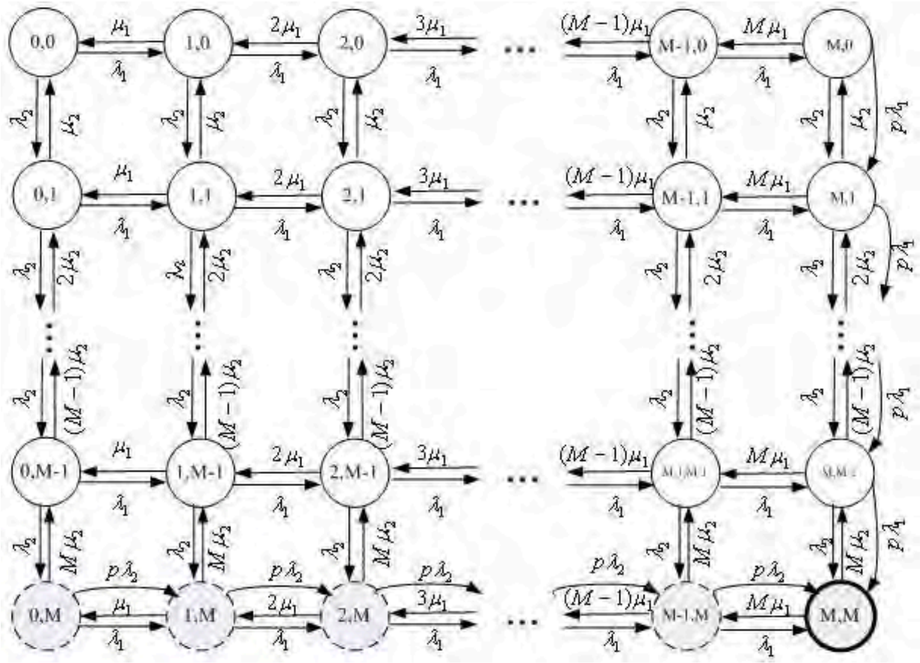
Unique applicable model for multidimensional traffic is Kaufman-Roberts … but exponential computation time, therefore model was not used

For 2 or more dimensions: Kaufman-Roberts



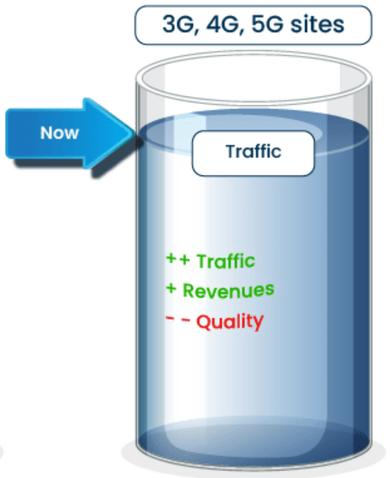
Theorem 1: The $q(j)$ unnormalized macro state probabilities satisfy the following set of recursive equations:

$$\mathrm{Min}[\nu_j, \hat{\Psi}] \cdot q(j) = \sum_{i=1}^{I} \rho_i \cdot \Delta_i \cdot \sigma_i\big(\mathcal{J}(\nu_j - \Delta_i)\big) \cdot \Big(q\big(\mathcal{J}(\nu_j - \Delta_i)\big) - \beta_i\big(\mathcal{J}(\nu_j - \Delta_i)\big)\Big). \quad (12)$$



Only Pirlys cracked the code and overcame the technical barrier

Pirlys brings the solution



Detected

100%

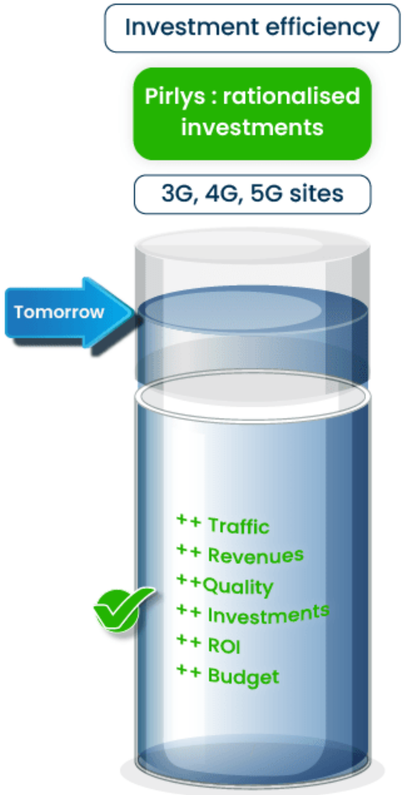
Pirlys-> 100% of congestion is detected by an automated and efficient process

Corrected

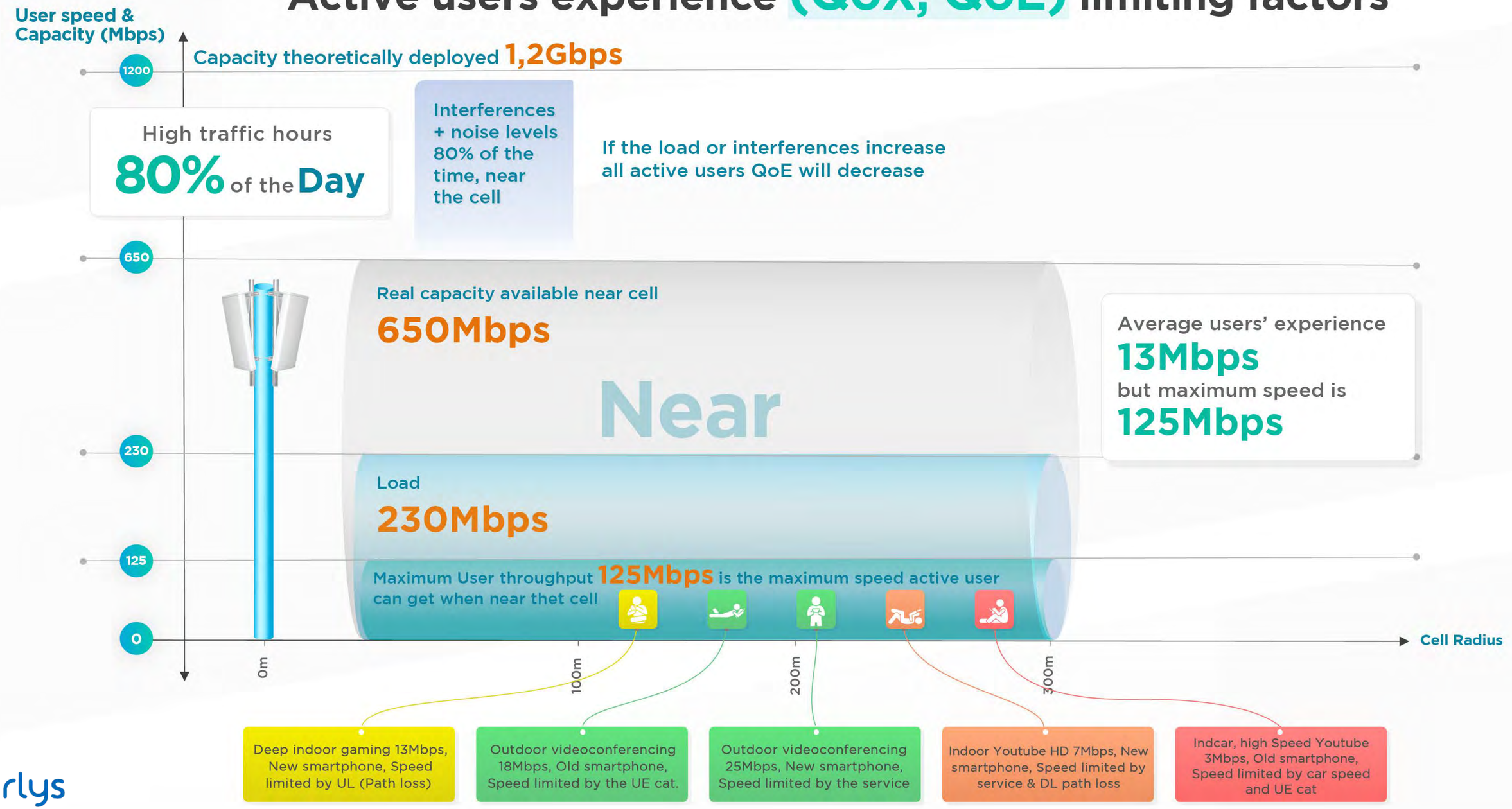
100%

Pirlys -> Congestion is accurately corrected according to the desired target quality and the available budget

Congestion Detected? → **Upgrade decision**



Active users experience (QoX, QoE) limiting factors



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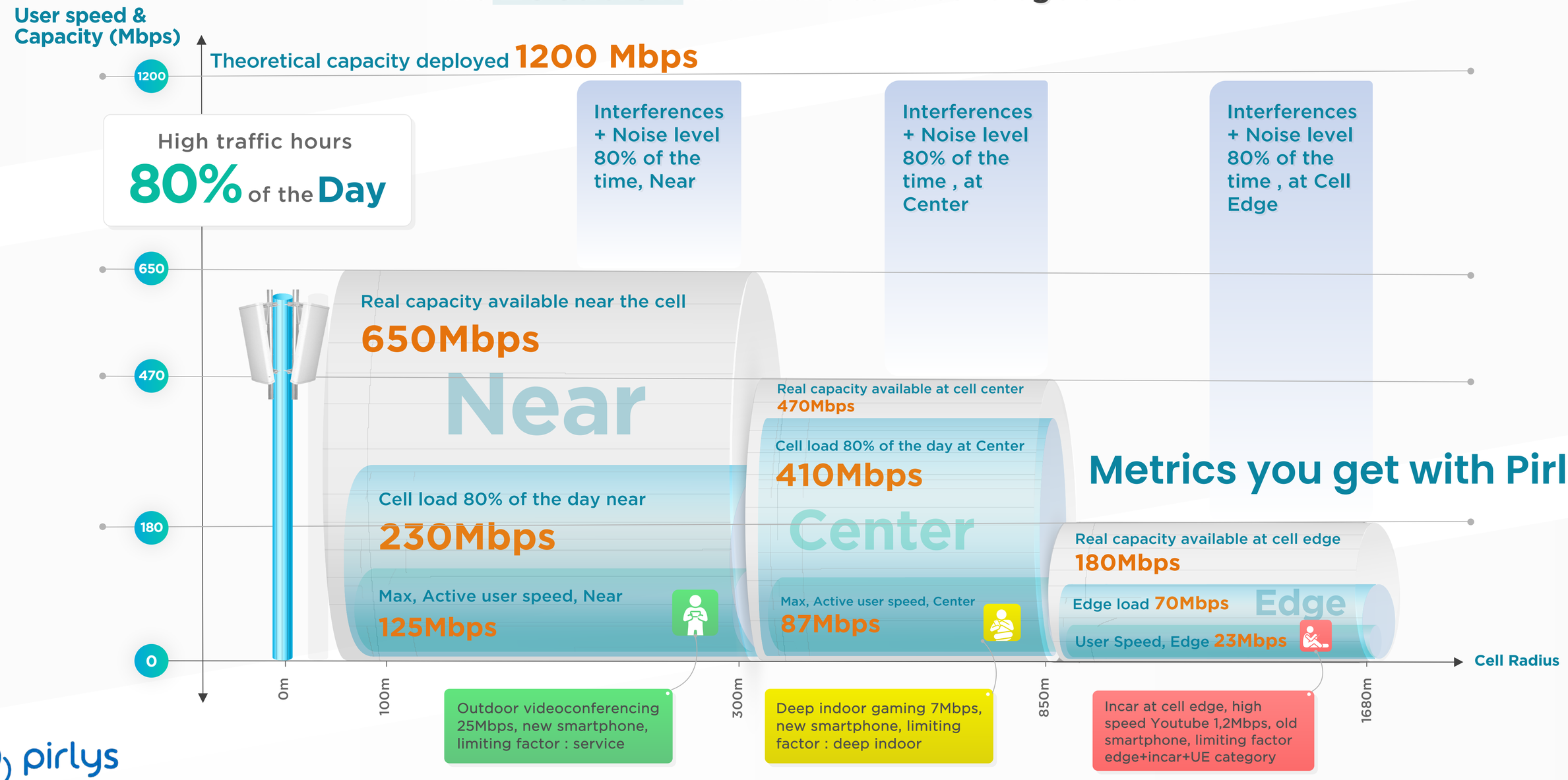
The **Quality of Experience** of active users depends on the **Distribution of Traffic** and the **Location** within the cell's coverage area



Metrics you get with Pirlys

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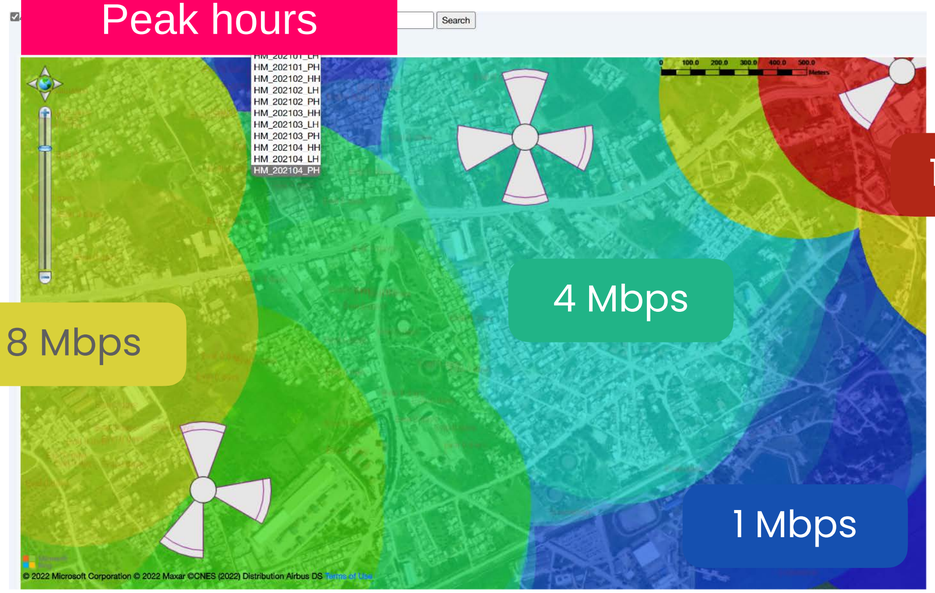
When sites are turned off at night, we can simulate the resulting quality before actually implementing it. It is also possible to switch off a great deal of sites at night while maintaining the same quality as during the day.

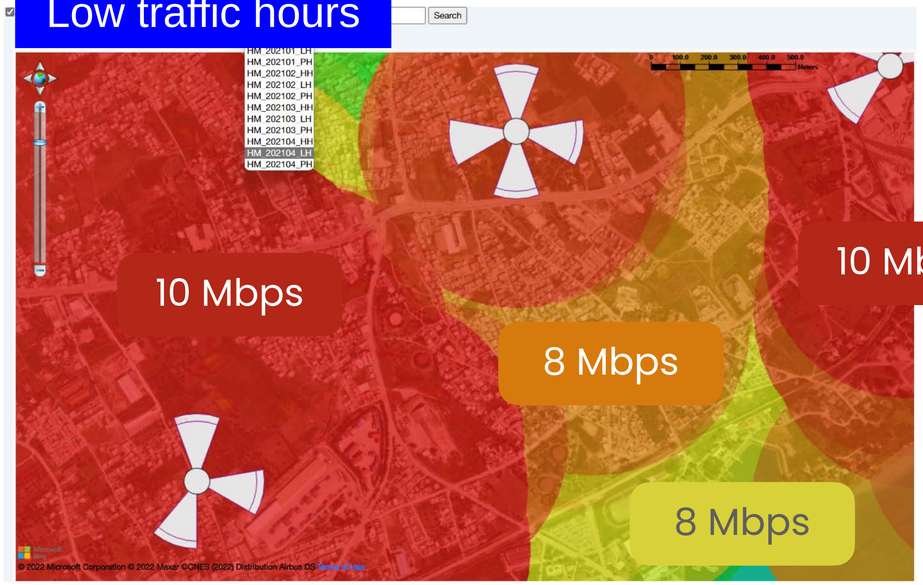
The quality of service will not change for subscribers and operators will see a 10-20% reduction in operating costs

Pirlys is a Drive Test 24/7 on 100% of the network

Peak hours

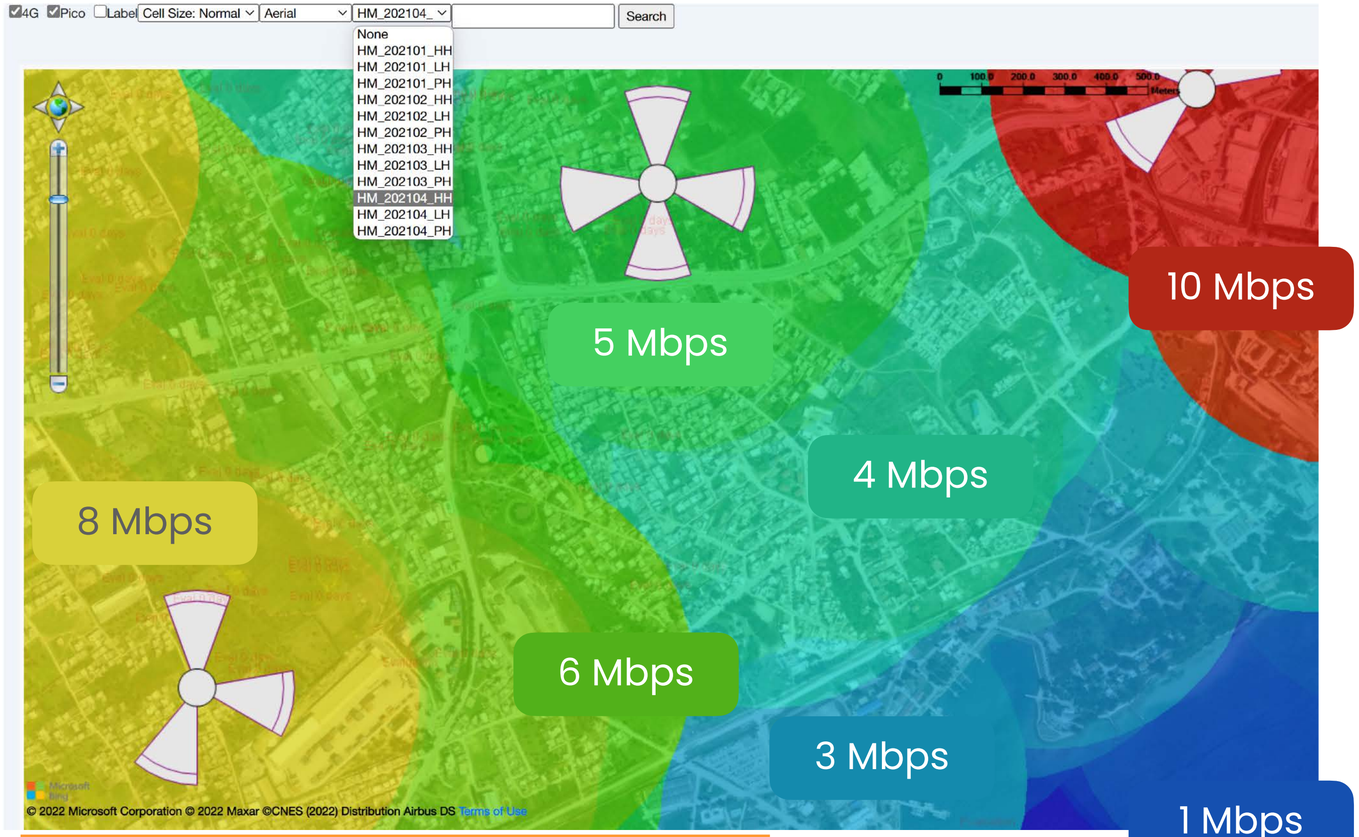


Low traffic hours



- 0 Mbps
- 1 Mbps
- 3 Mbps
- 4 Mbps
- 5 Mbps
- 6 Mbps
- 8 Mbps
- 9 Mbps
- 10 Mbps

Difference in QoX between peak hour 17:00 to 22:00 and high traffic hours or off-peak hours 23:00 to 16:00



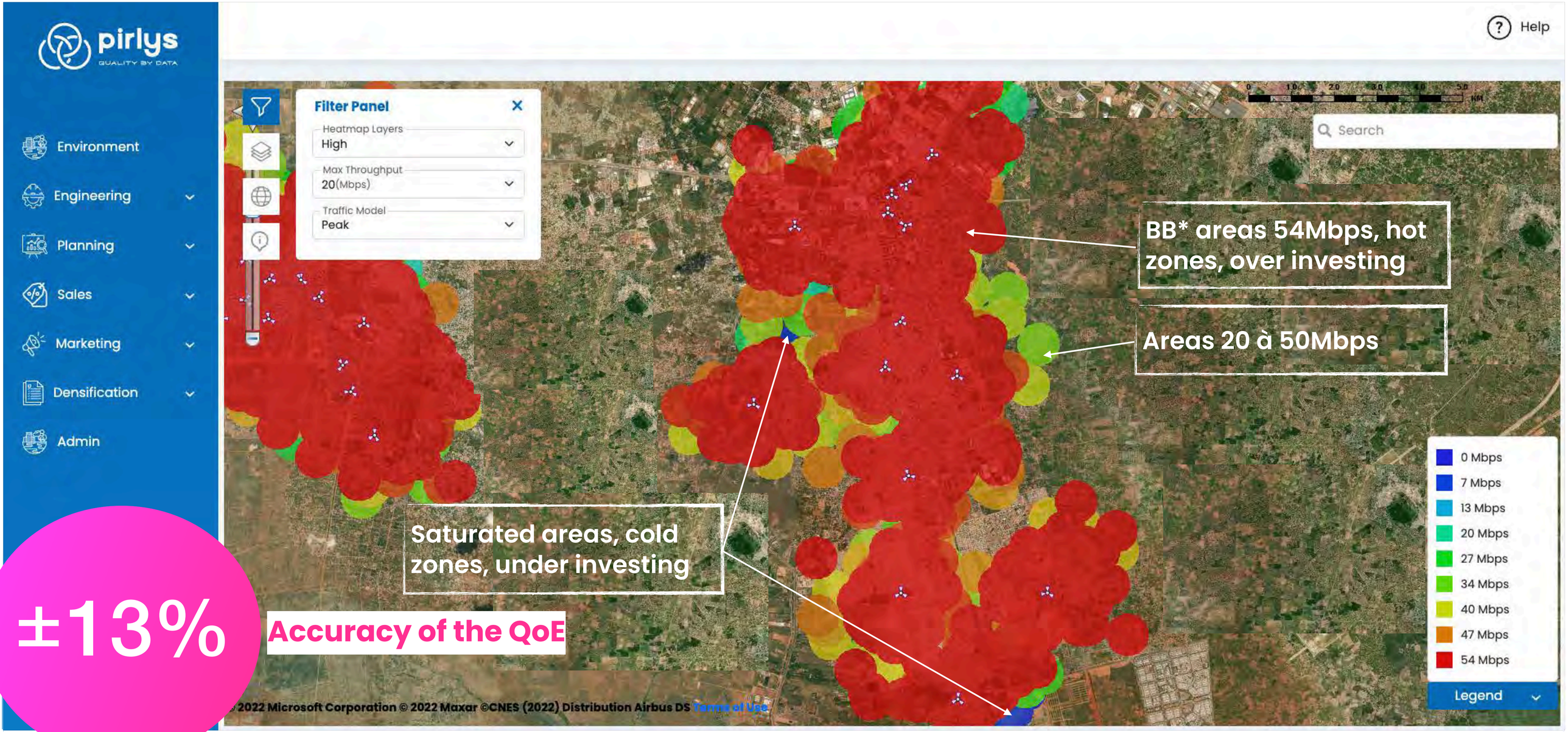
High traffic hours – 83% du temps

MNO can switch off 30% to 50% of its network at night without degrading quality perception

When one operator's traffic will soon roam onto another operator's network with already existing traffic, major unpredictably degradation can occur.

In addition to simulating the impact of this new traffic on QoE, we compute the expansion needed to maintain the QoE of the recipient network before the roaming happens.

Pirlys, Active users' QoE coverage map

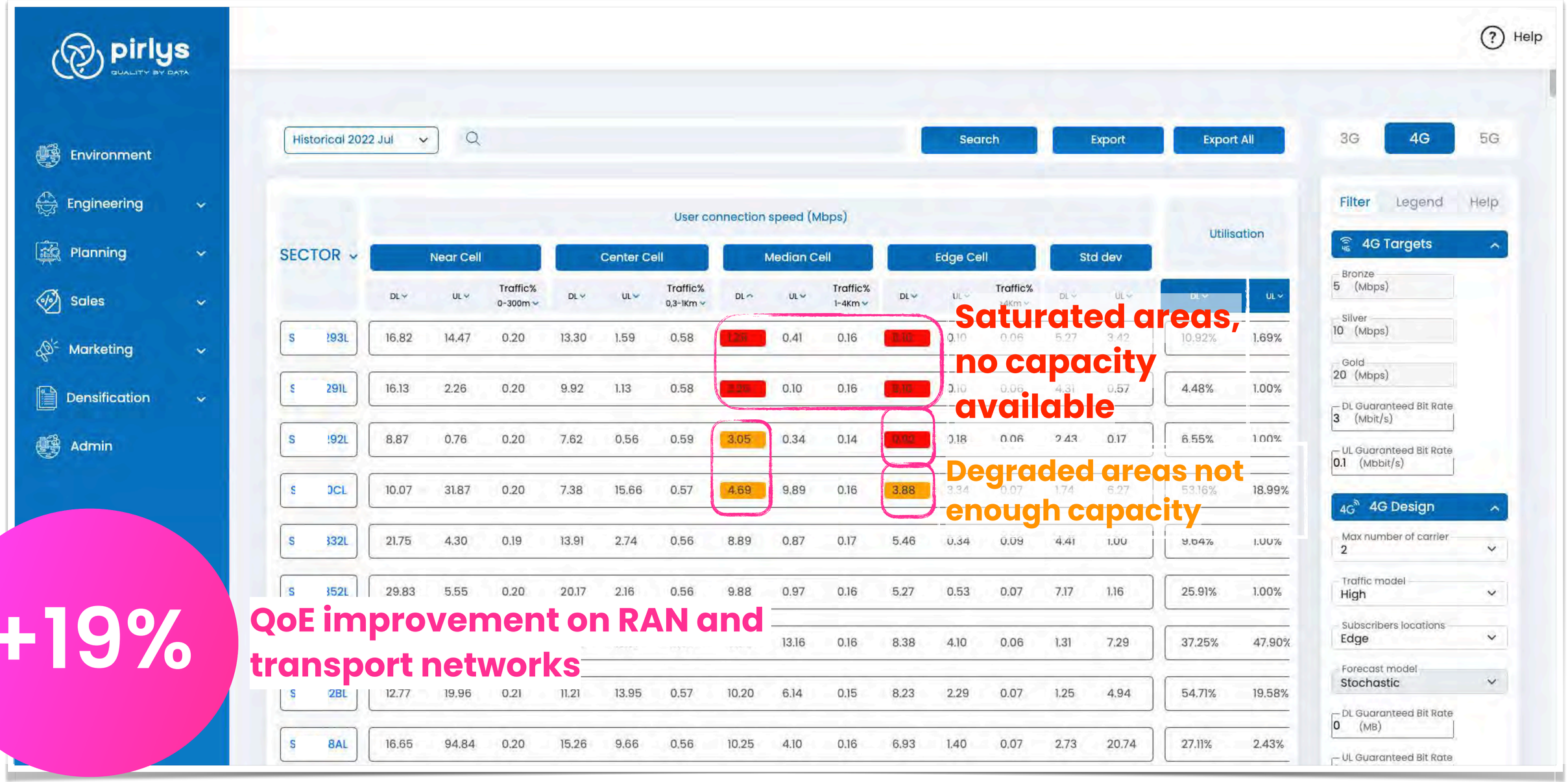


±13%

Accuracy of the QoE

** Broadband areas*

Pirlys, easy detection of congestion

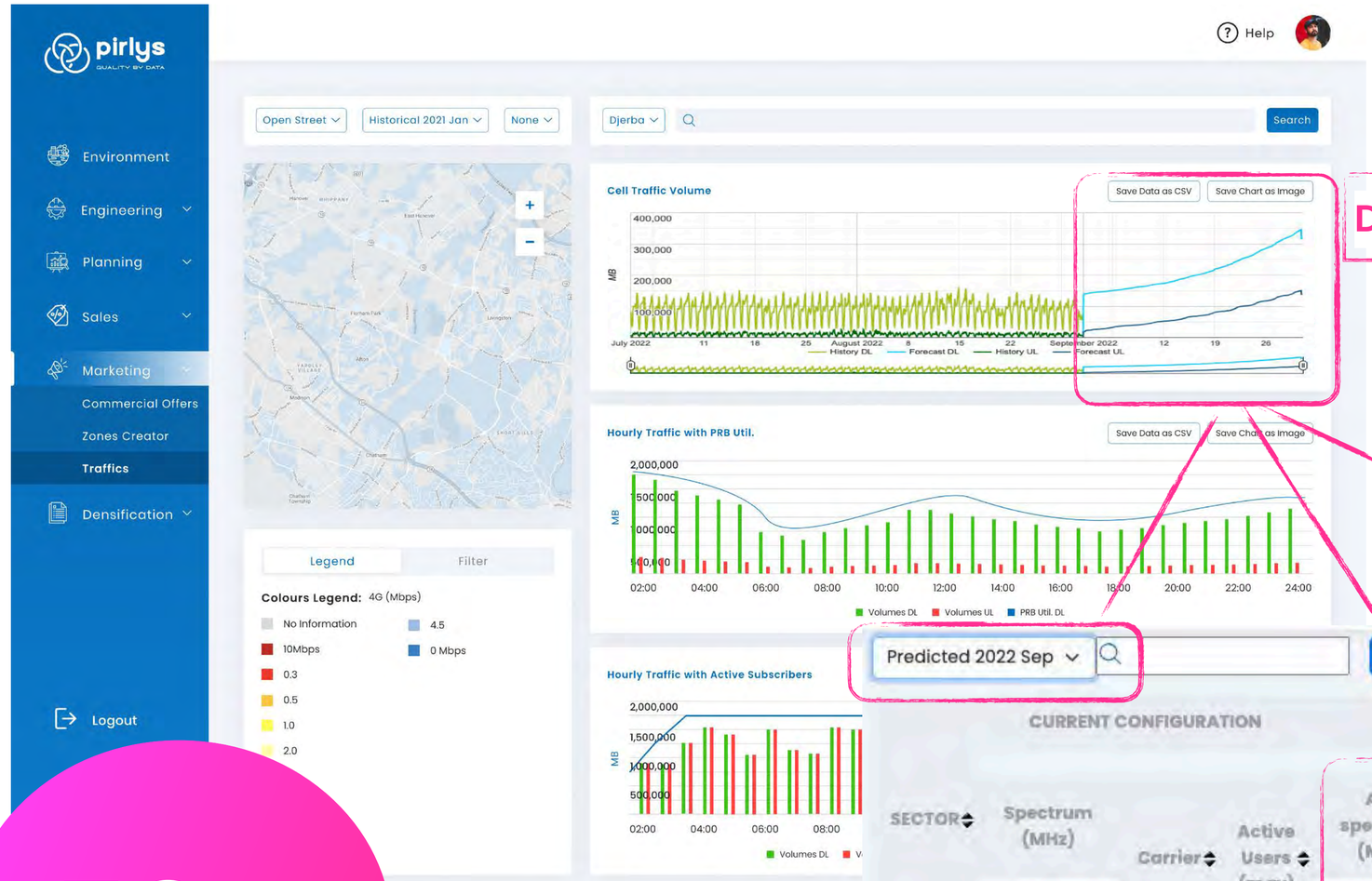


+19%

QoE improvement on RAN and transport networks

With our unique stochastic machine learning tool, we can predict the future based on past traffic patterns.
In general, the more traffic history available, the more accurate the prediction and the further in the future it will be

Pirlys, forecasts impacts on QoE



DL/UL traffic forecasts

Upgrades needed to maintain target based on traffic forecasts

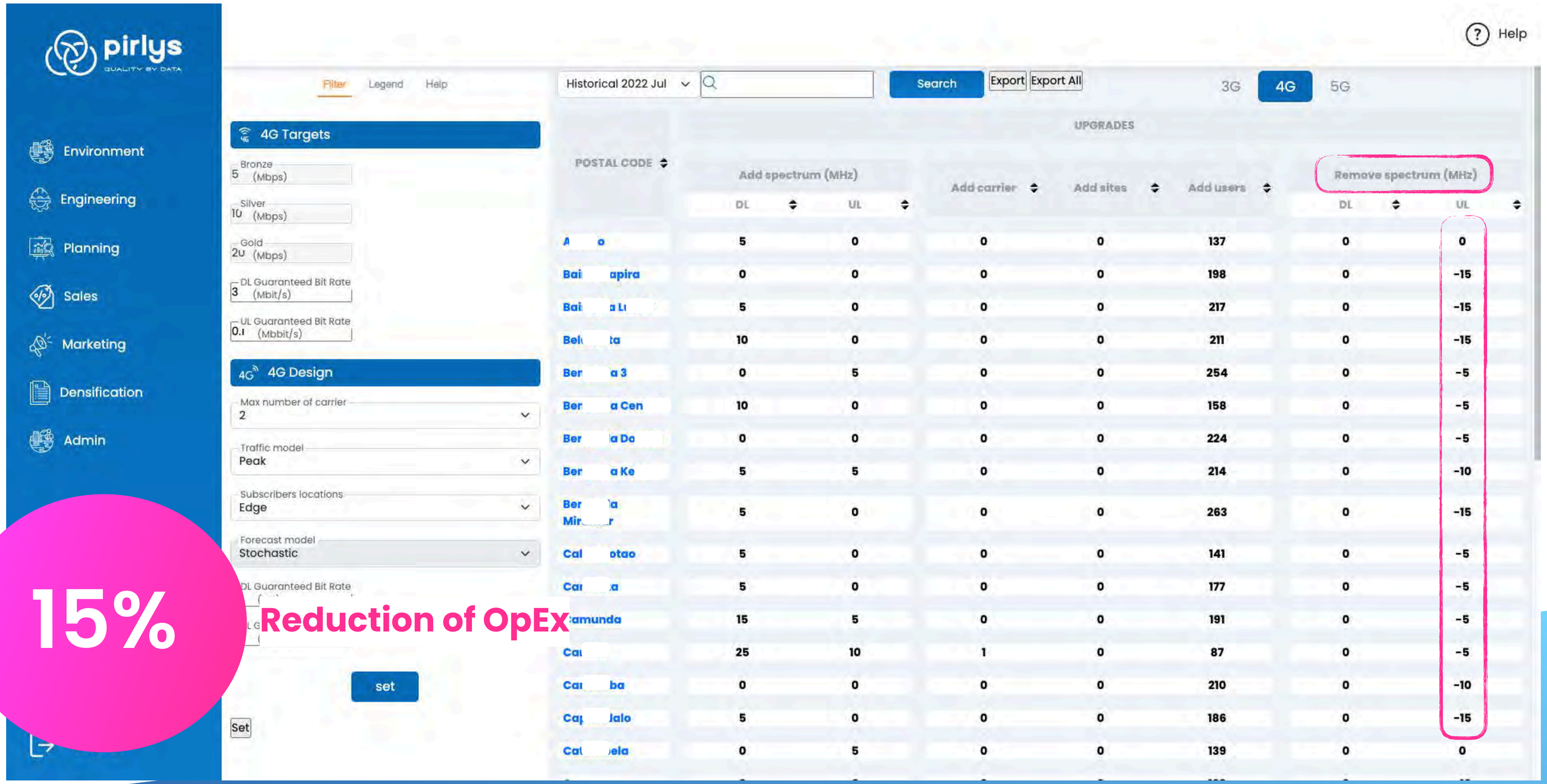
Predicted 2022 Sep | Search | Export | Export All | 3G | 4G | 5G

	CURRENT CONFIGURATION				SITE UPGRADE							SITE DENSIFICATION			DOWNGRADE	
SECTOR	Spectrum (MHz)		Carrier	Active Users (max)	Add spectrum (MHz)		New carrier	NC1 with MHz-DL	NC2 with MHz-DL	NC3 with MHz-DL	NC4 with MHz-DL	Add users (max)	Add spectrum		With carrier	Remove spectrum (MHz)	
	DL	UL			DL	UL							DL	UL		DL	UL
S-LB008AL	10	10	1		10	0	1	20	0	0	0		25	0	2	0	0
S-LB008BL	10	10	1		10	0	1	5	0	0	0		0	0	0	0	0
S-LB008CL	10	10	1		0	0	0	0	0	0	0		0	0	0	0	0

59%

Reduction of CapEx

Pirlys, rationalised investments



15% Reduction of OpEx

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Innovation benefits

Unique benefits

59%

Reduction in oversized CapEx expenditure

38%

Increased FWA revenues for operators

27%

Reductions in CapEx expenditure during QoE corrections

19%

Enhanced subscriber experience

15%

Reduction in energy costs

Success Stories

V1* Audit 2015 – Smart Philippines, via Deutsch Telecom/Detecon

- ✓ Provided network congestion, QoE and correction to achieve quality targets

V2 Audit 2016 – Econet Wireless Zimbabwe, via Astellia/Exfo

- ✓ too much network capacity, recommended buy $1 get $7 air-credit
- ✓ 7% revenue market share increase ~ $57M
- ✓ 60% Capex expenditures reduction ~ $50M

V3 Audit 2018 - Globe Telecom Philippines, Orange Business Service/Sofrecom

- ✓ discovered available 4G broadband fixed lines for sales teams
- ✓ 38% revenue increase ~ $6,9M per month
- ✓ 14% reduction of churn ~ $2,5M per month

V3 Audit 2021 – STA Andorra

- ✓ Provided the network dimensioning for different roaming assumption for the next 5 years

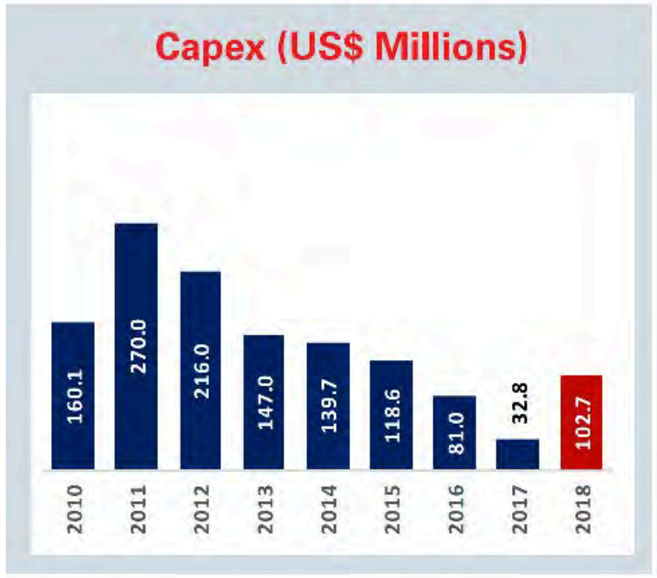
V4 Pirlys 2022

- ✓ Fully automated tool
- ✓ New design
- ✓ New marketing strategy

** Pirlys tool version*

Success Stories, public information*

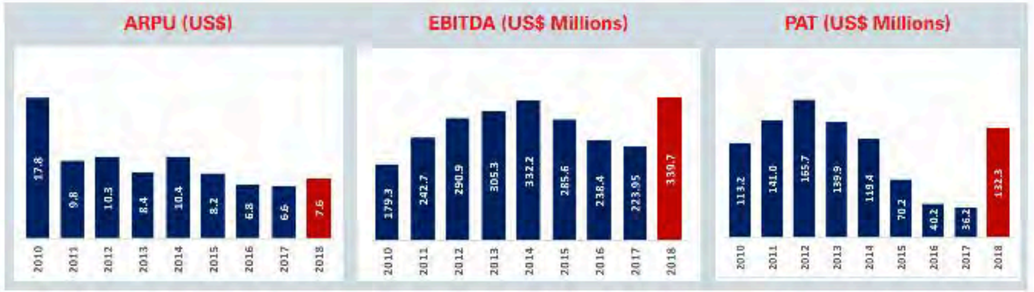
ECONET Wireless



2016 Pirlys initial effect $37,6M savings
2017 Pirlys final effect $48,2M savings

No impacts on ARPU, subscribers base even increased, revenues decreased only 17% when they also had to cut the tariffs by 35%

Performance Highlights



Revenue decline from FY2015 to FY2017 resulted from a 35% tariffs reduction for traditional services streams (Voice and SMS) and the introduction of 10% excise duty on airtime.

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Thibault Korchia

Chief Executive Officer

+33 660 412 332
Av. Dr Mitjavila 33/35 AD500 Andorra La Vella
thibaultkorchia@pirlys.com
https://www.pirlys.com

pirlys
QUALITY BY DATA

Olivier Castel

Chief Sales Officer

+352 691 326 327
Av. Dr Mitjavila 33/35 AD500 Andorra La Vella
oliviercastel@pirlys.com
https://www.pirlys.com

pirlys
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Olivier Rostaing

Chief Technical Officer

+33 761 557 626
Av. Dr Mitjavila 33/35 AD500 Andorra La Vella
olivierrostaing@pirlys.com
https://www.pirlys.com

http://pirlys.com/
Pirlys SL, Avinguda Dr Mitjavila 33/35,
AD500 Andorra La Vella
ANDORRA