

Narrowband IoT

May 2019



Vodafone: powering the Internet of Things

80 million
mobile IoT
connections
global

17%
revenue
growth
YoY

1,400 IoT
professionals

130 million
Mb of data
supplied
each month



Fixed



Wireless



Satellite




2G-5G



LPWA

The IoT demands a whole range of connectivity solutions





What is LPWA and
why do we need it?



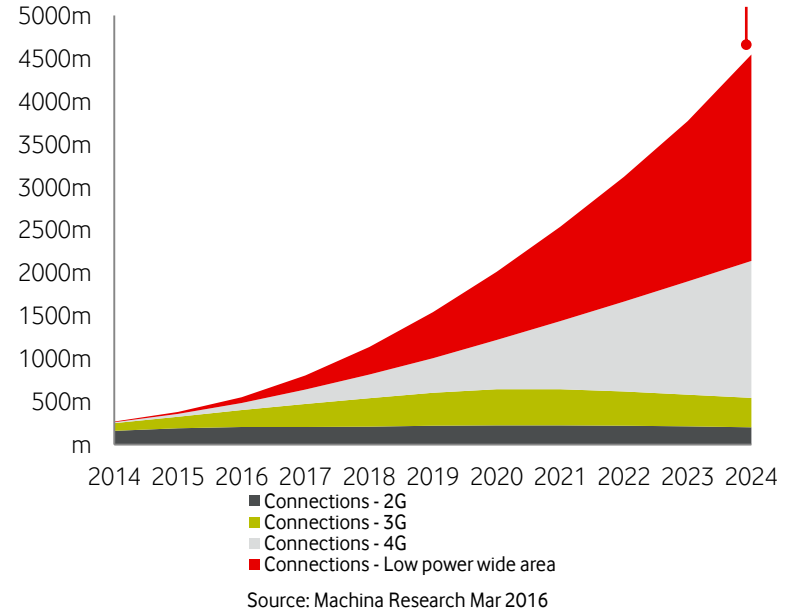
What is LPWA and Why do we need it?

LPWA is a Low Power Wide Area wireless network technology specifically for connecting devices with low bandwidth, using low power whilst providing increased penetration.

Many millions of devices will be connected via LPWA.

- 10+ years battery life
- Deep penetration
- Mass deployment
- Low bandwidth
- Lower device cost

Addressable IoT Opportunity



Which applications are suited to LPWA?



Gas metering

Large homogenous market measured in millions
Battery life and propagation is critical
Large number of potential meter manufacturers



Water metering

Large homogenous market measured in millions
Battery life and propagation is critical
Large number of potential meter manufacturers



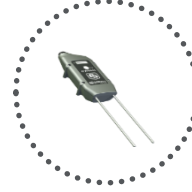
Liquid and pressurised fuels

Large homogenous market measured in millions
Asset is currently un-monitored & losses are high
Battery life is critical



Smart Bins

Growing market with good business case
Battery life and network coverage is critical
Complements our high end connected bins



Environmental Monitoring

Latent market waiting for a low power solution
Battery life and network coverage is critical
Fragmented channel to market in low volumes



Smoke and fire alarms

Massive market measured in hundreds of millions
Battery life and ability to test device is critical
High volume B2C play



Parking monitoring

Market measured in hundreds of thousands
Battery life and low install cost are critical
Low data throughput



Alarms and event detectors

Market measured in hundreds of thousands
Battery life is ultra critical
Very low data throughput on check and trigger























Why Narrowband-IoT?



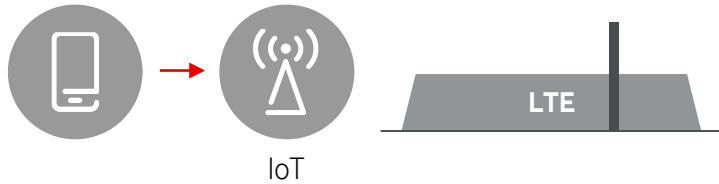
Why use NB-IoT for a LPWA service ?

	Unlicensed Services (e.g. Sigfox, LoRaWAN)	Licensed Service (e.g. NB-IoT)
Leverages existing network		
Extended Battery Life		
Deep Indoor Coverage		
Security for the IoT		
Experienced Network Support		
Standards Based (non-proprietary)		
Bandwidth Available		
2 Way Communication		
Low Device Cost		

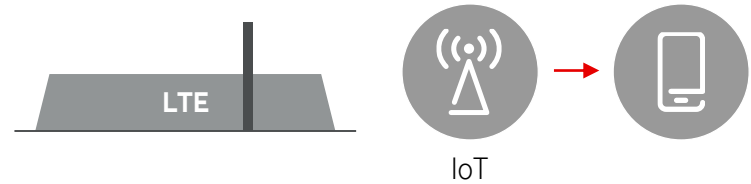


How does Narrowband-IoT work?

Narrowband-IoT is essentially a LTE Frequency Division Duplex (FDD) system.



NB-IoT Uplink



NB-IoT Downlink

At good coverage, multi-tone to get high data rate

At extreme coverage, single-tone for high battery efficiency

FDMA with $\pi/2$ BPSK for high battery efficiency

Two sub-carrier spacing:

- 3.75kHz – to achieve large capacity, good coverage
- 15kHz – for high data rate

OFDMA 15kHz sub-carrier spacing (friendly to adjacent LTE)

6dB power boosting possible (enables DL signals gain coverage)

Efficiently designed synchronization, broadcast and control channels – specifically suited for LPWA

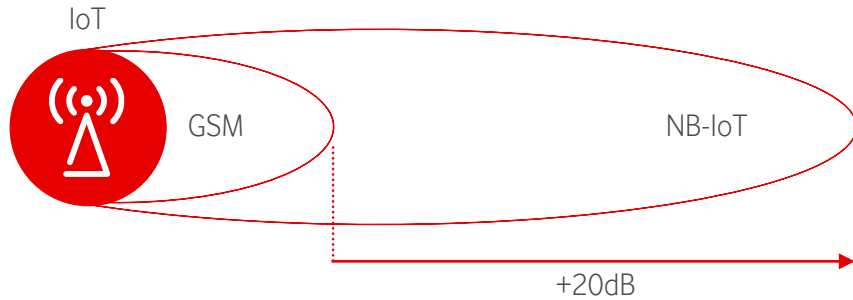


Narrowband-IoT: Extended Coverage

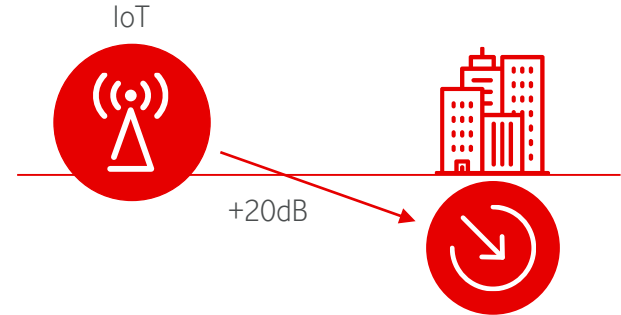
Extended coverage mode extends coverage by +20 dB compared to GSM and is achieved by:

- Narrowband transmission (e.g. 15 kHz sub-carriers)
- Negotiated Symbol Repetition
- New control channels

Based on our testing, NB-IoT will be able to penetrate two to three double-brick walls, enabling connectivity of objects in underground car parks and basements.



Source: Ericsson

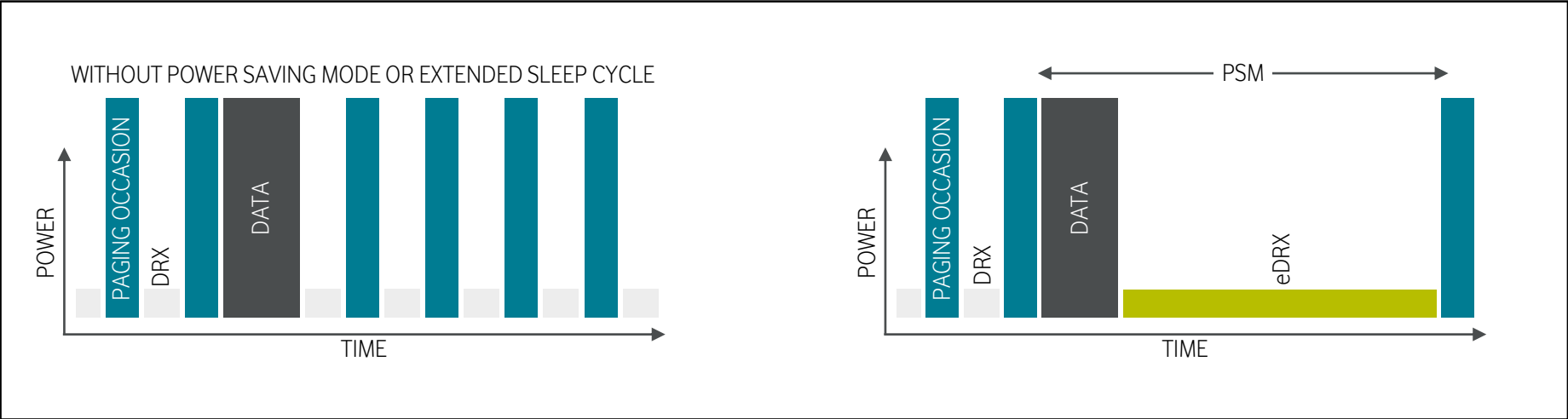


Narrowband-IoT: Low Power Consumption

Combination of Power Saving Mode (PSM) and Extended Sleep Cycle (eDRX)

Extended Sleep Cycle eliminates unnecessary receiver activations

Reachability improved over Power Saving Mode



What is the LTE Evolution to LPWA?

	High Performance 4G	Basic 4G	LPWA	LPWA: Full Capability
	Cat 3/4	Cat 1	Cat M (LTE-M)	NB-IoT
E2E Support	TODAY	TODAY	H1/2017	H1/2017
DL/UL Rates	150Mbps/50Mbps	10Mbps/5Mbps	Up to 1000kbps	Up to 200kbps
Sector Capacity	>200k	>200k	>50k	>200k
Coverage	-4dB GSM	-4dB GSM	+11dB GSM	+20dB GSM
Battery	1 years today	1 years today	> 10 years	> 15 years
Module Cost*	< \$45 (2017)	<\$25 (2017)	\$16 (2017)	<\$8(2017)
Network Upgrade	Supported Today	Supported Today	SW + Some HW Upgrades	SW + Some HW Upgrades

* Based on Module RFI in Feb 2017



What are the different use cases of NB-IoT and LTE-M?



LTE-M (Cat-M1) Target Application

Characteristics:

- Real-time voice requirement
- Instantaneous and frequent messaging requirement
- Throughput in the range of (800kbps in good conditions)
- Does not require +20dB extra coverage
- Does not require 10 year battery life



NB-IoT (Cat –NB1) Application

Characteristics :

- No real-time voice required
- Infrequent periodic messaging (few messages per day)
- Low throughput requirement (<200kbps)
- Requires +20dB extra coverage
- Long battery life (10+years)





How is Vodafone deploying
Narrowband-IoT ?



How is Vodafone Deploying Narrowband-IoT?



From Vodafone 2016 Result Announcement:

‘We will start this year by introducing a new technology called Narrowband-IoT. That basically means that, if you take our existing 4G network, we do a software upgrade in about 85% of our installed base that enables this new technology.’

- Johan Wibergh, CTO

We will begin our roll out in 2017 and our goal is to enable all 4G sites with NB-IoT by 2020



Major Vodafone milestones in NB-IoT

Switch on

First global
NB-IoT connection
September 2016

First NB-IoT
network

Launched
January 2017
in Spain

Ireland

First national
NB-IoT
enablement 2017

800+

Companies
building on
NB-IoT

South Africa

Commercial
launch November
2017

450+

Visits to
Open Labs
in a year

Live in
15 markets

More to follow
over the next
two years

5G

NB-IoT and
LTE-M become
5G standard



Narrowband-IoT: a global network

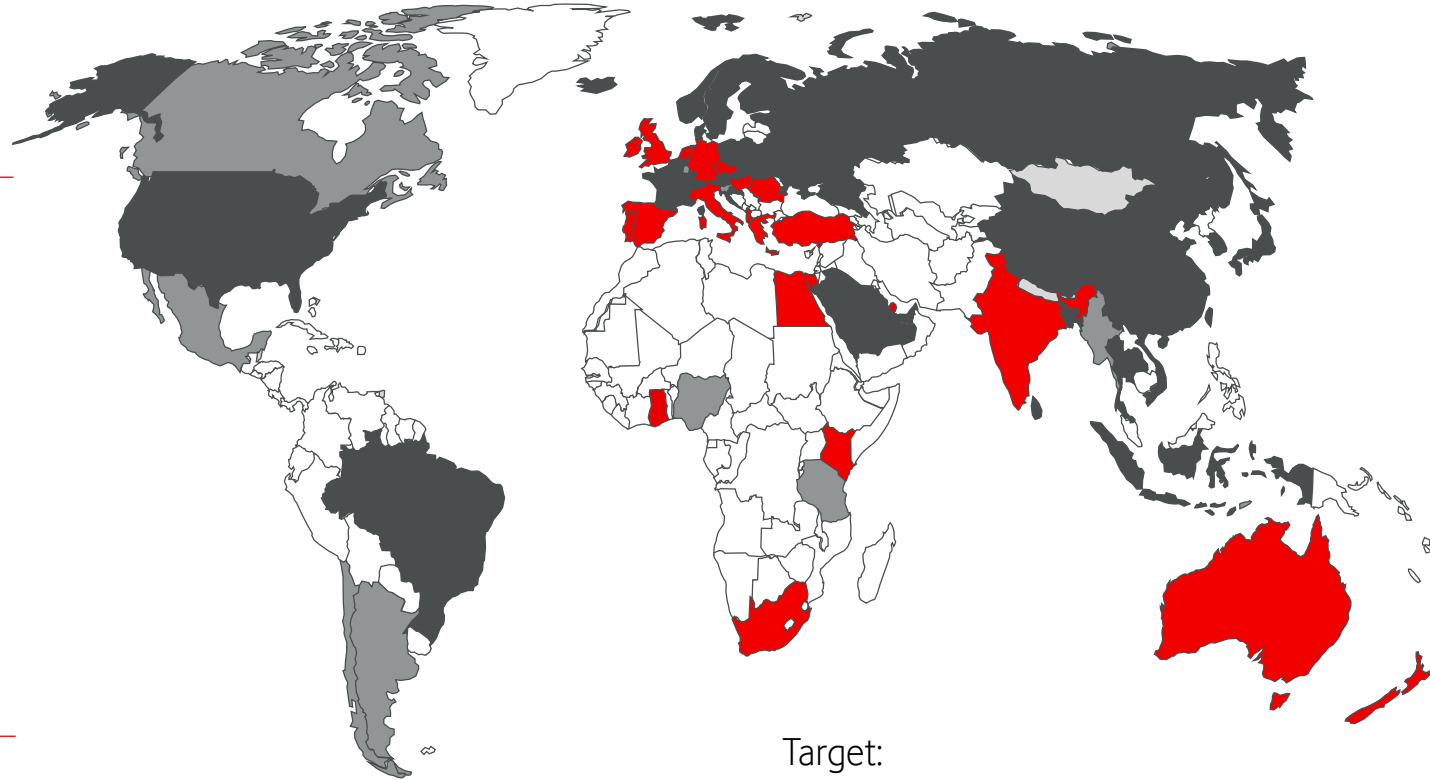
- Vodafone
- Other network providers – NB-IoT launched
- Other network providers – NB-IoT on the roadmap

Launched

- | | |
|----------------|----------------|
| Spain | Turkey |
| Ireland | Czech Republic |
| Italy | South Africa |
| Australia | Germany |
| Netherlands | Greece |
| Malta | New Zealand |
| United Kingdom | Portugal |
| Hungary | |

2019

- Romania

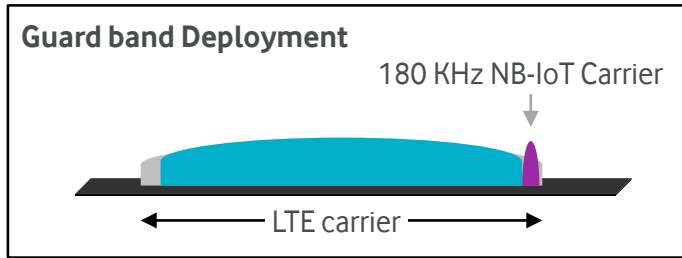


Target:
All Vodafone 4G masts by 2020



Narrowband-IoT : Vodafone's UK Rollout

Vodafone is currently rolling out NB-IoT in the UK, starting in the West. Deployment is ongoing in the LTE 800 MHz (Band 20) Guard Band



Vodafone trialled NB-IoT in areas of Liverpool & Manchester during 2018.

As of March 2019, Glasgow, Liverpool, Manchester, Birmingham, Cardiff & Bristol all have good NB-IoT coverage. And of course the rollout continues.

Vodafone already has > 2500 UK masts enabled for NB-IoT (April 2019)



NB-IoT roaming

Vodafone and other Tier 1 Operators are actively working on this

Deutsche Telekom and Vodafone Group Completed Successful NB-IoT Roaming Trial in Europe in May 2018

NB-IoT is a 4G technology that, with mutual network agreement, can roam just like 4G networks do in the consumer world

Vodafone's Global SIM will allow for national and international roaming





Global Industry Support for
Narrowband-IoT (NB-IoT)



Global GSMA Mobile IoT Forum & Open Labs

Mobile IoT Open Labs

The Open Labs provide an environment where NB-IoT / LTE-M devices and solutions can be tested, in preparation for field deployment.

Vodafone currently has 4 Open Labs

- Newbury, UK (1st to launch)
- Düsseldorf, Germany
- Milan, Italy
- Midrand, Johannesburg, South Africa

- Redwood City, US – soon to be opened

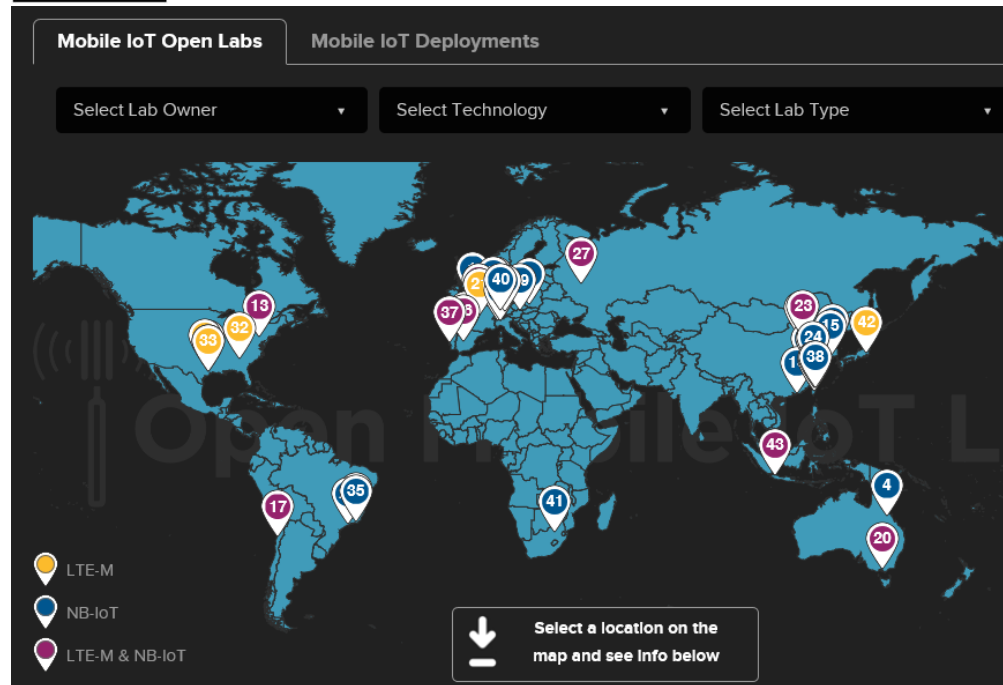
Each Open Lab is part of the GSMA Mobile IoT Open Labs initiative

<https://www.gsma.com/iot/deployment-map/#labs>

43 Open Labs worldwide, as of April 2019



- Mobile-IoT Forum covering NB-IoT & LTE-M organised by GSMA
- Jointly chaired by AT&T and Vodafone.



GSMA NB-IoT Forum Members

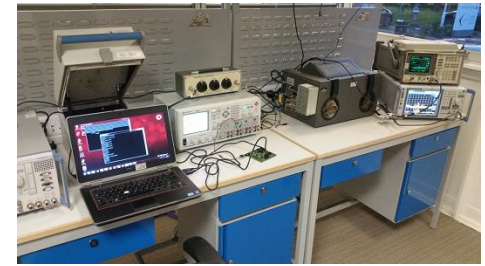
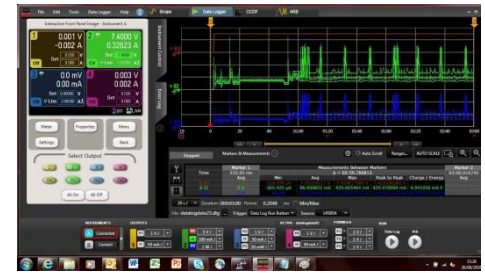


The GSMA NB-IoT forum aims to provide all industry and wider ecosystem stakeholders with market representation to accelerate the widespread adoption of 3GPP-based NB-IoT & LTE-M Technologies
(There are currently 78 members - Aug 18)



Vodafone Open Lab Capabilities & Services

- NB-IoT Device – Network Integration
- LTE-M Device – Network Integration (currently Milan only)
- E2E testing : Device – Network – Internet/User Applications
- Power Consumption Testing
- Extended Coverage Testing (ECL0 / ECL1 / ECL2)
- NB-IoT Module Certification



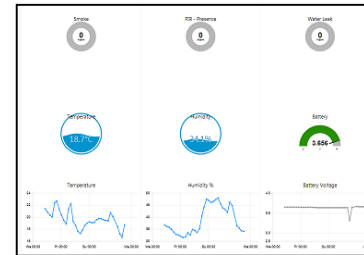
The Open Labs are also used to demonstrate NB-IoT/LTE-M devices and applications



Smart Parking



Smart Meters



Environmental Monitoring



Tracking

Book in a slot with the Open Labs via DL-OpenLabsRequests@vodafone.com



Which chipsets and modules are available for Narrowband-IoT today?





Narrowband-IoT Case Studies



We are running NB-IoT pilots around the world

Open Labs – UK, DE, IT, ES, ZA

- Vodafone's Open Lab created for live network tests, demos and pilots



Romania



- NB-IoT trial with OMV Petrom for oil well automation

Turkey

- NB-IoT smart parking demoed in Istanbul



Ireland



- Dublin City Council is using NB-IoT in the Docklands Smart District to run demos for creating a smarter city
- E.g. Smart gutters/ environmental monitoring

Spain

- Tested in real water meter locations with Aguas de Valencia
- Live pilots in delivery with 6 Utilities companies
- Working with 20+ utility hardware companies



Greece

- Remote tracking of beehives using NB-IoT



Australia

- Testing with South East Water across their sewer pressure monitoring system



Ecosystem devices now available

Asset Tracking



Utilities



Environmental Monitors



Building Security



Parking and Waste



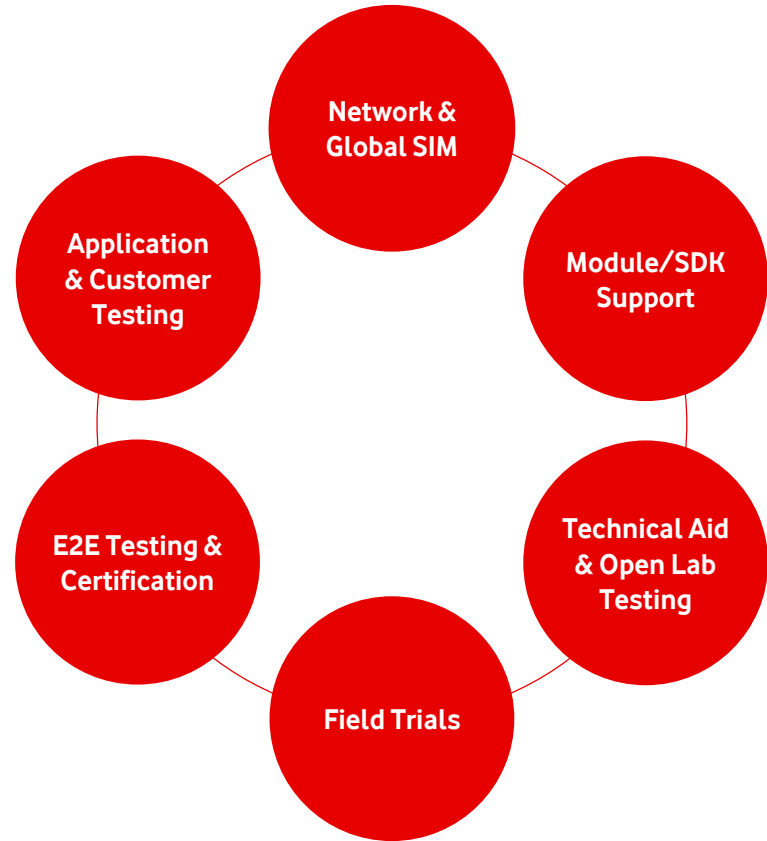
Vodafone can help you integrate NB-IoT

Leader in LPWA standards development

Communications integration expertise

Developing a leading IoT Ecosystem

Customer trial and opportunity primed





Thank you



