robustel

Managing and Overcoming the Challenges Presented by Global 4G/LTE IoT Deployments

A practical guide from Robustel

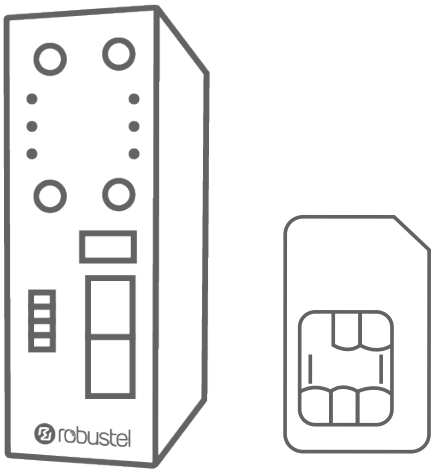
info@robustel.com | www.robustel.com

Contents

Introduction

Most OEMs and Machine Builders who sell products globally quite reasonably believe that adding cellular connectivity to their products should be a relatively trivial undertaking.

“Buy a SIM and a 4G router and plug it in - Simple!”



Unfortunately, there are two issues that act as a major impediment to that goal, and despite lots of discussion around IoT and standardisation, 4G frequency fragmentation and costly certifications remain a barrier for many.

Problem 1:
LTE Fragmentation

"LTE Fragmentation" is a complex way of saying that there are lots of different frequencies used around the world for 4G and many of them are incompatible with each other.

In fact, if we look at how difficult global deployments have become it makes for quite surprising reading:

4

The number of **2G bands required** to achieve Global coverage

5

The number of **3G bands required** to achieve Global coverage

20+

The number of **4G bands required** to achieve Global coverage

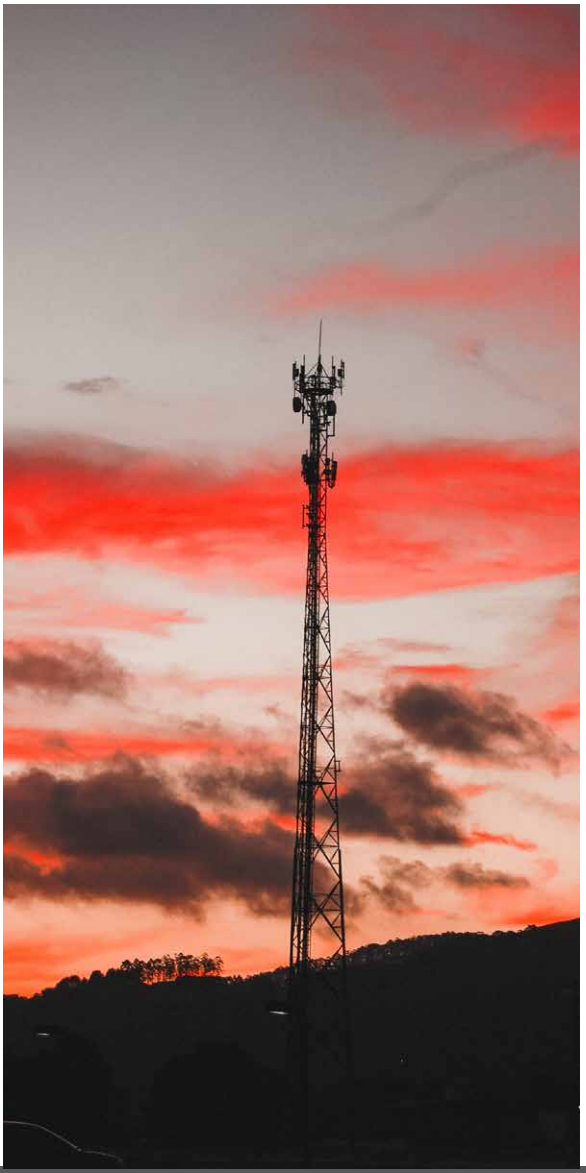
At the time of writing it is very hard to give a definitive figure on the number of 4G bands to provide network coverage on every operator in every region.

The table below (over page) is shared to provide some understanding as to why this is the case.

Figure 1.1 (below) features just 5 rows from the full Wikipedia entry on Global LTE bands out of a total of 72 bands listed.

Band	Duplex Mode[B 1]	*f* (MHz)	Common Name	North America[B 2]	Latin America[B 2]	Caribbean[B 2]	Europe[B 3]	Africa[B 3]	Asia[B 4]	Oceania[B 4]
01	**FDD**	**2100**	**IMT**	No	Brazil, Costa Rica	No	Yes	South Africa (Cell C, MTN, Vodacom), Namibia (MTC)	Yes	Australia (Vodafone)
02	FDD	1900	PCS[B 5]	Yes	Yes	Yes	No	No	No	No
03	**FDD**	**1800**	**DCS**	No	Brazil, Costa Rica, French Guiana, Suriname, Venezuela	Partial	Yes	Yes	Yes	Yes
04	FDD	1700	AWS[B 5]	Yes	Yes	Yes	No	No	No	No
05	FDD	850	CLR	Yes	El Salvador, Guatemala	Barbados, Bermuda, Dominican Republic (Altice)	No	Malawi (Access Communications)	Cambodia (SEATEL), India (Jio, Airtel), Indonesia (Smartfren), Malaysia (Telekom Malaysia), Pakistan (Telenor), Philippines (Smart), South Korea (LG U+, SK Telecom), China(China Telecom)	Australia (Vodafone)

Figure 1.1 – Excerpt from Wikipedia "LTE Deployments by Region" table



However, if one consults section 5.5-1 of "E-UTRA Operating Bands" in 3GPP TS 36.101 (Tech Spec from the governing body of 4G), the total count is 88 bands!

Whatever the precise and current number, 70+ bands illustrates a total lack of harmonisation and evidence of bureaucracy working squarely against those that want to do IoT deployments on a global basis.

It's possible to consider 3G, but many operators have been or are switching off their networks. 2G (GPRS) could be an option for low-bandwidth applications but the threat of 2G being discontinued in one or several regions makes the prospect of 2G deployments in 2020 quite risky and unpalatable.

The effect of this patchwork quilt of frequencies on manufacturers is to make global deployment expensive (one-size-fits-all products have traditionally been expensive,) or complicated (it is necessary to use a 4G router or module on a "per-region" basis), leading to multiple products being required and no way to work from a single fixed Bill of Materials (BOM) – every device deployed has to have a specific module/router to ensure coverage.

Problem 2: Certifications – Mandatory & Operator

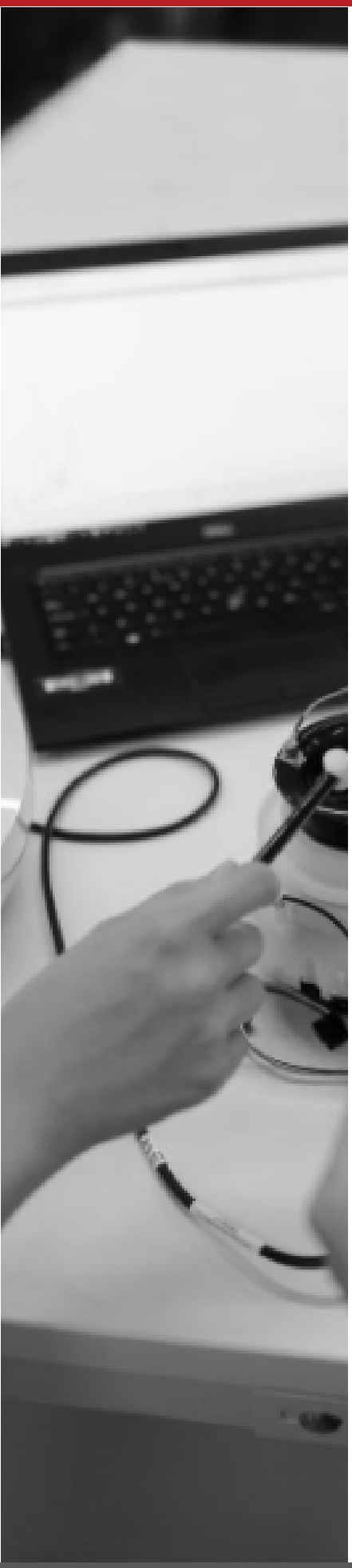
"Europe is easy"

This is a phrase we often use when discussing cellular deployments within the European Union. Good harmonisation for both frequencies and certification means that so long as a cellular product has CE certification and conforms to "GCF" requirements (see: https://www.globalcertificationforum.org/) then the product is deemed legally acceptable to be put on the market AND fit for purpose by the network operators in the EU.

The fact it is relatively "easy" gives many EU based manufacturers a 'false sense of security' and so make assumptions that deploying products outside the EU is just as easy and subject to the same criteria as those deployed in the EU. Fully accepting what global certification really entails is often a bitter pill to swallow for those keen to provide a connected service and regularly results in a disappointing about-turn on a business venture due to the costs involved.

The table below gives a succinct overview of the relevant types of certification:

Figure 1.2 – Table of Certification types relevant to 4G devices with examples



Regulatory certification / compliance

Some of the most famous examples of regulatory certification are:
CE – European standard
FCC – USA standard

These are broadly mandatory for all types of electronic RF product sold in the relevant continent. The standards reference several tests that must be completed and only if the tests are successful then the products can be legally made available for sale.

Some countries allow FCC or CE to be refenced within their jurisdiction but there are also many that insist on their own specifics standards being met.

Failure to conform is a legal issue and in the worst cases, non-compliance can result in imprisonment for company Directors, especially when products pose a threat to health and safety.

Telecom Industry Certification

GCF (www.globalcertificationforum.org/) and PTCRB (www.ptcrb.com/) are organisations responsible for certifying that a cellular product will fundamentally not “break” a mobile operator’s network and is fit for purpose.

Exactly where they sit in the hierarchy of manufacturer obligations is beyond the scope of this document but suffice it to say that they ultimately equate to expenditure of time and money for anyone developing cellular products.

Operator Certification

Many people are surprised to discover that despite gaining regulatory and telecom industry certification there can be yet more hurdles to get over before a product can be sold.

Operator certification is yet another process that must be completed – fundamentally to assure the network operator that your device is fit to operate on their network. Common examples of this requirement come from AT+T and Verizon in the USA.

Only a minority of operators make an absolute mandate that this must be done but it is generally the more influential ones and so it has to be considered as part of overall deployment considerations.

Operator certification equates to yet more time and money.

Robustel's solution to global deployment challenges

The new "GLOBAL" router series from Robustel will be one of the world's first globally applicable LTE routers offered at a highly competitive price – something that has been unachievable until very recently (as of 2020).

This opportunity has come about due to more competitive "global" 4G (LTE) chipsets/modules becoming available and Robustel's drive to gain fast time to market on such a desirable product.

A global router requires two things; global frequencies and global certifications. Both have traditionally been expensive to achieve, putting an entry barrier on bringing such a product to market and any that have must have an associated premium price tag, putting them out of the reach of many IoT applications – especially at scale.

Maintaining several versions of a router can mean greater stock-holding, multiple config files and a more complex process for associating Things/Devices with routers giving rise to more possibility of human error. Quite reasonably, clients often ask at the outset:

"Can't I just have a 4G router that works everywhere?"

For these reasons, a one-size-fits-all 4G solution at an affordable price is a desirable product for global manufacturers/OEMs wanting to offer a "connected product" service, and it is this market that Robustel's "GLOBAL" series aims to address.

The current mainstays of Robustel's GLOBAL router offering are as follows:

R3000-GLOBAL
Industrial-Grade 4G Router
· 2 x Ethernet,
· RS232
· R485
· Optional GPS & Digital IO

R1520-GLOBAL
Light Industrial 4G Router
· 5 x Ethernet
· RS232
· R485
· GPS & Digital + Analogue IO

Apart from a large number of LTE frequencies providing coverage on all continents, the GLOBAL series has benefitted from very significant investment in costly certifications by Robustel making them the best certified products in their price bracket available today.

A full list of current, pending and road-mapped certifications for R1520 and R3000 are available from your Robustel representative. If a router does not have a specific certification for a customer project, Robustel will entertain getting that certification to allow the project to be fulfilled. Such an exercise would form part of an overall negotiation in the procurement of Robustel hardware. Robustel's R+D team have extensive experience in gaining global certifications and are happy to provide consultancy on the subject matter to find the most cost-effective solution to a specific set of project requirements.

Global testing – Robustel has done it so you don't have to

4G/LTE is a vastly complex system with many technologies working together to deliver an excellent experience for most consumers. However, the needs of industrial users are a little different with connections to mainly static assets (ones that can never move to a better signal area!) requiring as close to 100% uptime as possible.

In any new technology there can be teething problems throughout the supply chain (SIMs/components/firmware) and on this premise, Robustel committed to shipping an "R3000-GLOBAL" around the world to measure real world performance and to check for anomalies or unexpected behaviour.

Figure 1.3 – Test Locations of Robustel's "GLOBAL" Router

Test Regime

The primary goal was to check the network attachment/registration process and the subsequent building of a data connection in a variety of locations.

It also served as an opportunity to test Robustel's unique "Smart Reboot" capability, which is described later in this document.

In each location the router was powered on and standard boot routine took place. Close scrutiny was given to the network selection process which, in the absence of a "last known good network" depends on the router performing a dynamic scan for available networks then choosing from those with a "good quality signal" as defined by signal strength being above an acceptable threshold. If multiple networks meet the criteria then the router chooses from available networks at random to share/distribute the connection load on surrounding cellular networks/cells.

For a more detailed description of the network selection process, please ask your Robustel representative for a copy of the "Smart Roaming" white paper or download from the whitepapers section at:
www.robustel.com/white-paper/smart-roaming-next-generation-3g-4g-reliability/

In all locations the router performed as expected building connections automatically within an acceptable period to networks as follows:

Location	Network
Guangzhou, China	China Unicom
Melbourne, Australia	Telstra
Brighton, UK	Three UK
Munich, Germany	Vodafone Germany
Florida, USA	AT&T
Toronto, Canada	Bell
Sao Paulo, Brazil	TBC

Figure 1.4 – Test Locations of Robustel's "GLOBAL" Router with GSM Networks to which router first attached

USA – a special case

Of particular importance is the testing performed in North America where traditionally the two major networks have required different router models for technological and political reasons.

Typically, the choice has been for a Verizon approved router or an AT+T approved router, which is not ideal for those just wanting the best possible coverage, logistical simplicity & reliability. The R3000-GLOBAL, when used with an appropriate SIM can achieve a 4G Connection on all major US networks as follows:

· AT+T
· Verizon
· T-Mobile
· Sprint

Traditionally, Verizon and Sprint used CDMA technology which was incompatible with the GSM cellular technology used by AT+T and T-Mobile.

With the advent of 4G this incompatibility has been removed as all operators have converged on LTE (4G) meaning that a single roaming SIM plus a "GLOBAL" router could now provide internet access on all major operators in the US.

A cost-effective 4G router that can connect to both AT+T and Verizon is a desirable solution as many US organisations choose one or other and stick with that operator for political or financial reasons.

OEMs need to be able to cater for these "customer choices" without imposing a significant financial constraint on the overall solution and it is precisely this that the GLOBAL series can help with in the USA.

Smart Reboot – Robustel's unique solution to a Global problem

Roaming SIM cards are often sold as a way to improve reliability in IoT applications but there are many examples of unsuccessful outcomes by virtue of the 4G router not roaming to a different network when Data Comms has failed on the current network.

A detailed explanation of this issue is available in the Smart Roaming product brief available from your Robustel Sales representative or can be downloaded from:
www.robustel.com/white-paper/smart-roaming-next-generation-3g-4g-reliability/

In short, the process that routers use to determine which network to use (Automatic Network Selection) only uses signal strength to determine a usable network and this doesn't necessarily correlate with a network that can actually transmit data.

By sending an SMS message to a Robustel router with the body – "SIM1 SMARTREBOOT", the router will delete the 'last known good network' from the SIM then reboot the router. This means the router will perform a scan and choose a network at random from a list of networks with adequate signal strength per the 3GPP definition of Automatic Network selection.

The Global test project was an excellent opportunity to stress test Smart Reboot in different environments.

In the context of globally deployed routers, a simple SMS Smart Reboot message could be the difference between having to visit site or not. A 10c SMS message could save a $1000 site visit by airplane.

Smart Reboot performed as expected in all countries – an example use of Smart Reboot features below whilst the router was in China. Note that the SMS message sequence is chronologically from the bottom up with a description of each 'action' in the "Note" column alongside:

Timestamp	Direction	SMS message content	Note
27/11/2019 11:00	MO	"modem_status=Ready reg=Registered, roaming cell_id=524C706 plmn_id=46000 csq_value=28 network=LTE"	This SMS response summarises current connection status. SMARTREBOOT has achieved a change from network 46001 (China Unicom) to 46000 (China Mobile)
27/11/2019 10:59	MT	"SIM CELLSTAT"	This SMS Command interrogates current connection status.
27/11/2019 10:58	MO	"SMARTREBOOT&D complete"	This response is sent from the current network to indicate Smart Reboot is complete.
27/11/2019 10:57	MO	"SMARTREBOOT&D commencing ..."	This response is sent from the current network to indicate Smart Reboot is commencing.
27/11/2019 10:57	MT	"SIM 1 SMARTREBOOT&D"	This command, is used if there is a problem with Data Comms on the current network and attempts to force a network change.
27/11/2019 10:55	MO	"modem_status=Ready reg=Registered, roaming cell_id=6074716 plmn_id=46001 csq_value=27 network=LTE"	This SMS response summarises current connection status.
27/11/2019 10:55	MT	"SIM CELLSTAT"	This SMS Command interrogates current connection status.

Figure 1.5 – SMS conversation between mobile handset in UK and Robustel's 4G router in China

Communications problems are always a threat when dealing with 3rd party RF systems but the stakes are much higher when deploying globally and the cost of a site visit can escalate to thousands of dollars. This is why Robustel's Smart Reboot capability can be an invaluable aid when trying to manage an estate of widely dispersed 4G routers.
More information at: https://www.robustel.com/app/smart-reboot/

RobustVPN – Another piece of the jigsaw

Another challenge for OEMs deploying globally is the issue of remote access.
If part of the installed equipment includes a PC running applications such as Teamviewer or Logmein then an instantaneous outbound connection to devices connected to a 4G router can be relatively easy to achieve.

However, many IoT devices don't have the luxury of such consumer-friendly software packages (and associated hardware to run Operating Systems) and the ability to connect directly to a device by IP address and TCP port number is essential – and this, very often, is where the problems start!

By their nature, 4G networks do not make easy provision for such "inbound" connections, so a solution to this issue – often known as the 'one way problem' – must be found.

The simplest option is to go to a SIM provider that offers a fixed IP SIM and associated VPN service but it is not always possible or desirable (SIM contracts can be risky and onerous) for the OEM to dictate which SIM cards are used by the end customer in every location.

There is also the issue that in some regions a roaming SIM can be prohibitively expensive so a different 'local' SIM needs to be used and this is where Robustel's RobustVPN service can be an invaluable solution.

RobustVPN is an innovative application of Cloud Based VPN tunnelling technology to provide Robustel routers with fixed private IP addresses that allow easy remote access from anywhere in the world.

Robustel's Microsoft Azure hosted server takes care of the complicated setup issues typically associated with OpenVPN, including certificate exchange and passwords.

RobustVPN is entirely SIM independent – this means ANY SIM card from any provider can be used and a fixed IP service is effectively overlaid on top of that 4G SIM.

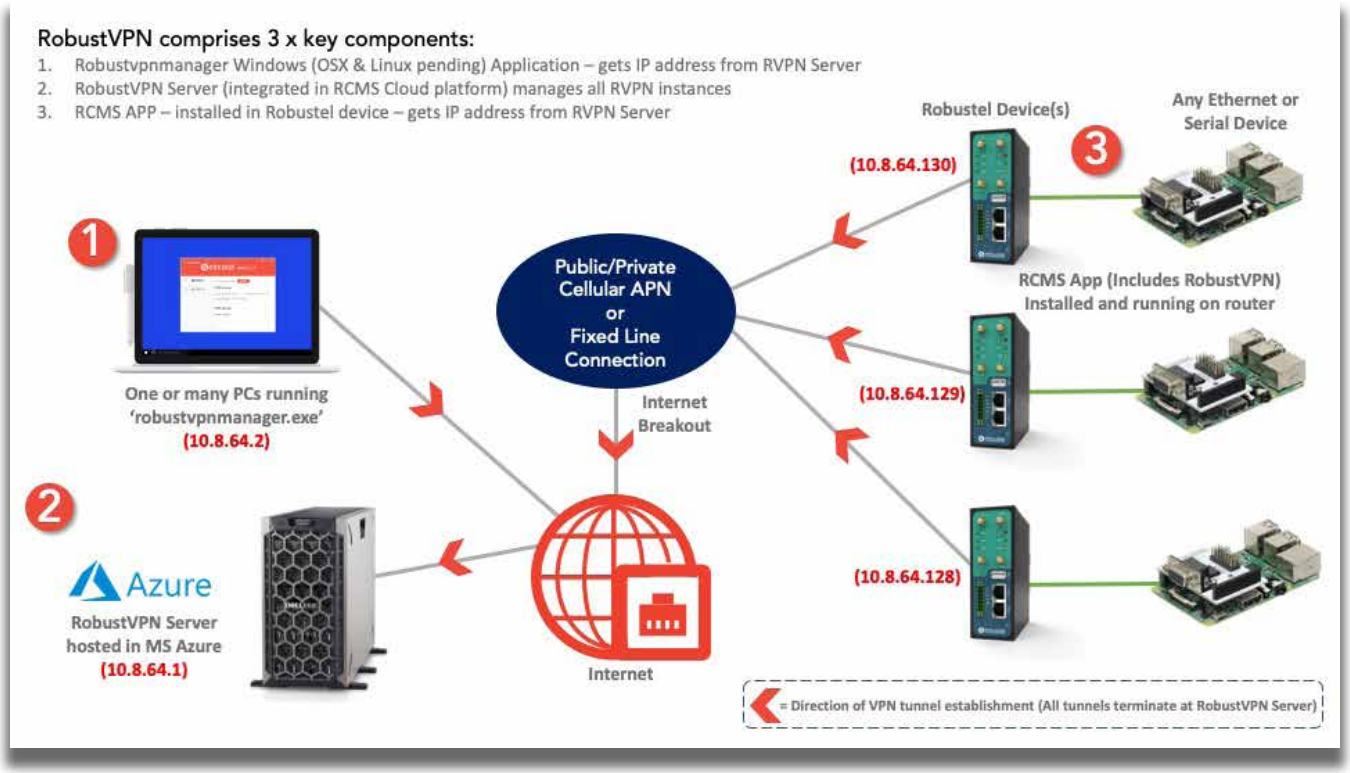


Figure 1.6 – RobustVPN architecture diagram

RobustVPN is also "bearer independent" – this means that not only can it work on any 4G SIM, it can also work across any wired or wireless internet connection, giving complete flexibility when the available internet connection type on each site may vary.
RobustVPN is also used across Satellite modem (VSAT) connections on global shipping routes.

RobustVPN is an integral part of Robustel's Router Cloud Management System – a free trial is available at www.rcms-cloud.robustel.net

Conclusion

Global IoT deployments will always be complex by their nature.

This document demonstrates that leveraging Robustel's toolkit can help OEMs deal with some of the key challenges, specifically:

4G Frequencies

4G LTE is delivered on a wide range of bands – a problem that has traditionally been expensive or difficult to solve.

Leveraging Robustel's latest generation of GLOBAL routers provides a direct answer to that issue.

Costly Certification

Global certification is expensive - pure and simple.
Robustel's investment in costly certification for cost-effective 4G routers means OEMs can disown this challenge without an onerous cost penalty. Put simply – Robustel provide globally certified products at very competitive prices.

Risk Reduction

Robustel committed to sending one of its GLOBAL routers with a well-known brand of roaming SIM around the world and achieved 100% success rate.

This exercise does not mitigate all risks associated with using cellular networks but does serve as an excellent signpost that a successful outcome is likely if OEMs replicate the process followed by Robustel.

Additionally, "Smart Reboot" is an extra layer of protection against the vagaries of global cellular networks.

Remote Access

Getting an inbound connection in the way required by an OEM's electronic equipment (RS232, RS485, Modbus or Ethernet) is often an afterthought, and can be a significant stumbling block.
RobustVPN provides an extremely innovative solution at a very low cost.

If a more complex or customised infrastructure is required than can be afforded by RobustVPN then the native VPN technologies in Robustel routers such as OpenVPN, Wireguard (pending), IPSEC, GRE, L2TP, PPTP and more can be leveraged to achieve fully-integrated solutions.

If you would like to discuss how Robustel's GLOBAL 4G router products can help solve existing problems, reduce costs or accelerate time to market for new IoT ventures, please email **info@robustel.com** or contact your local Robustel representative.