TRANSFORMA INSIGHTS

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Using eSIM and iSIM will save money for IoT deployments

June 2022

Executive Summary

Transforma Insights analysis points to an 8-13% saving to be made on lifetime connectivity spend by enterprises if they choose eSIM and iSIM options rather than removable plastic SIM cards for their IoT deployments.

Embedded SIM (eSIM), and to a lesser extent its coming successor integrated SIM (iSIM), have established themselves as part of the range of capabilities that need to be carefully considered by an organisation when planning a cellular-based IoT solution. Alongside the physical components of eSIM and iSIM, the move away from the plastic removable SIM has also created a requirement for remote SIM provisioning (RSP) to manage the profiles on the device. While the technologies are not yet mature, they are now standardised (with a few exceptions) and are being actively promoted by some connectivity providers, particularly the IoT mobile virtual network operators (MVNOs).

Transforma Insights has undertaken an extensive study of the eSIM/iSIM/RSP ecosystem with the aim of understanding the cost implications of the various decisions around components and mechanisms for subscription management. This assessment of cost included both direct costs, such as components and subscription management, and indirect costs including security, compliance and logistics. We also examined the impact that the choice of component and SIM provisioning mechanism would have on the lifetime cost of connectivity for the device. The assessment

Figure 1: Average cellular IoT connectivity and SIM lifetime spend
[Source: Transforma Insights, 2022]

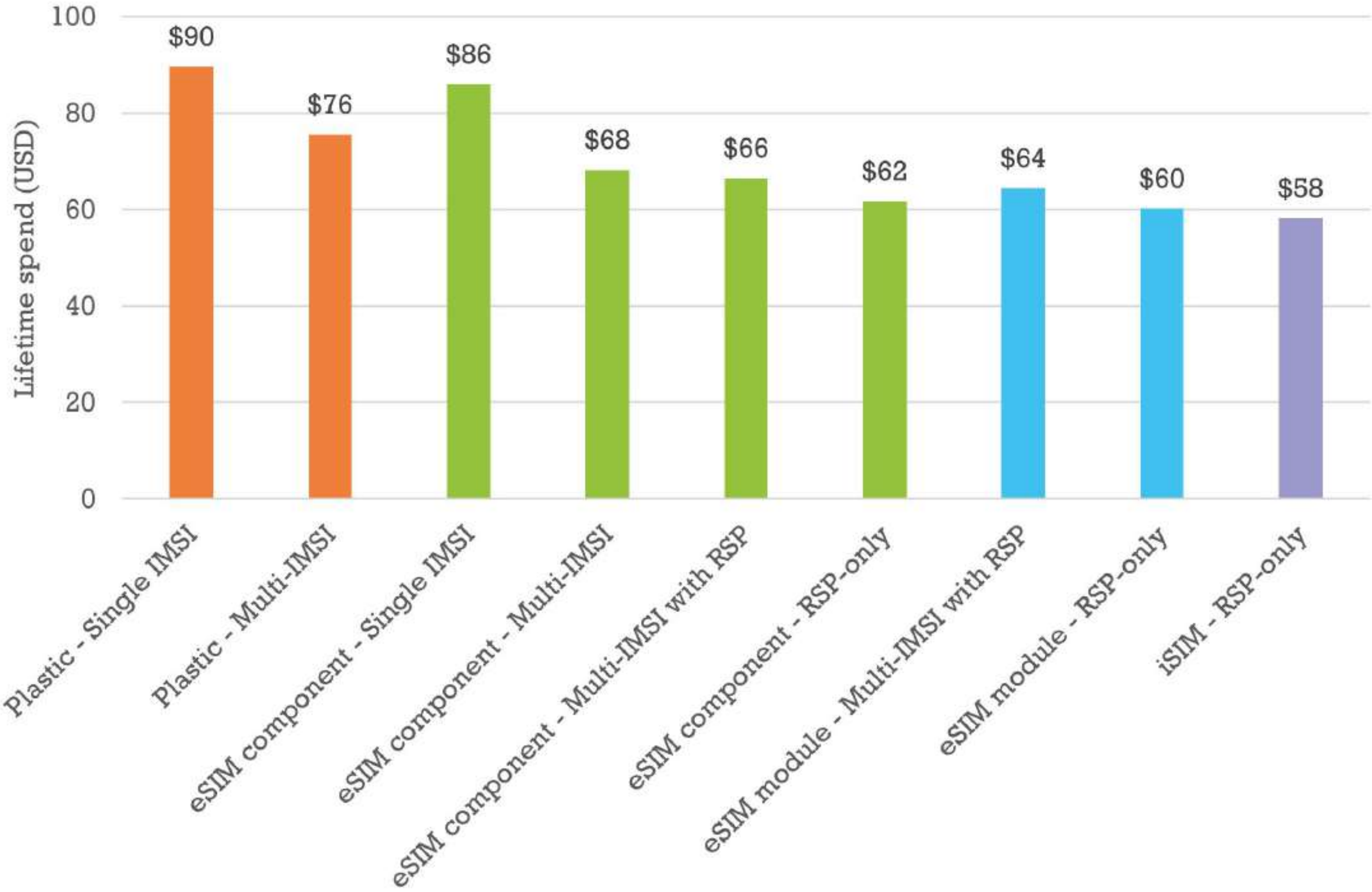
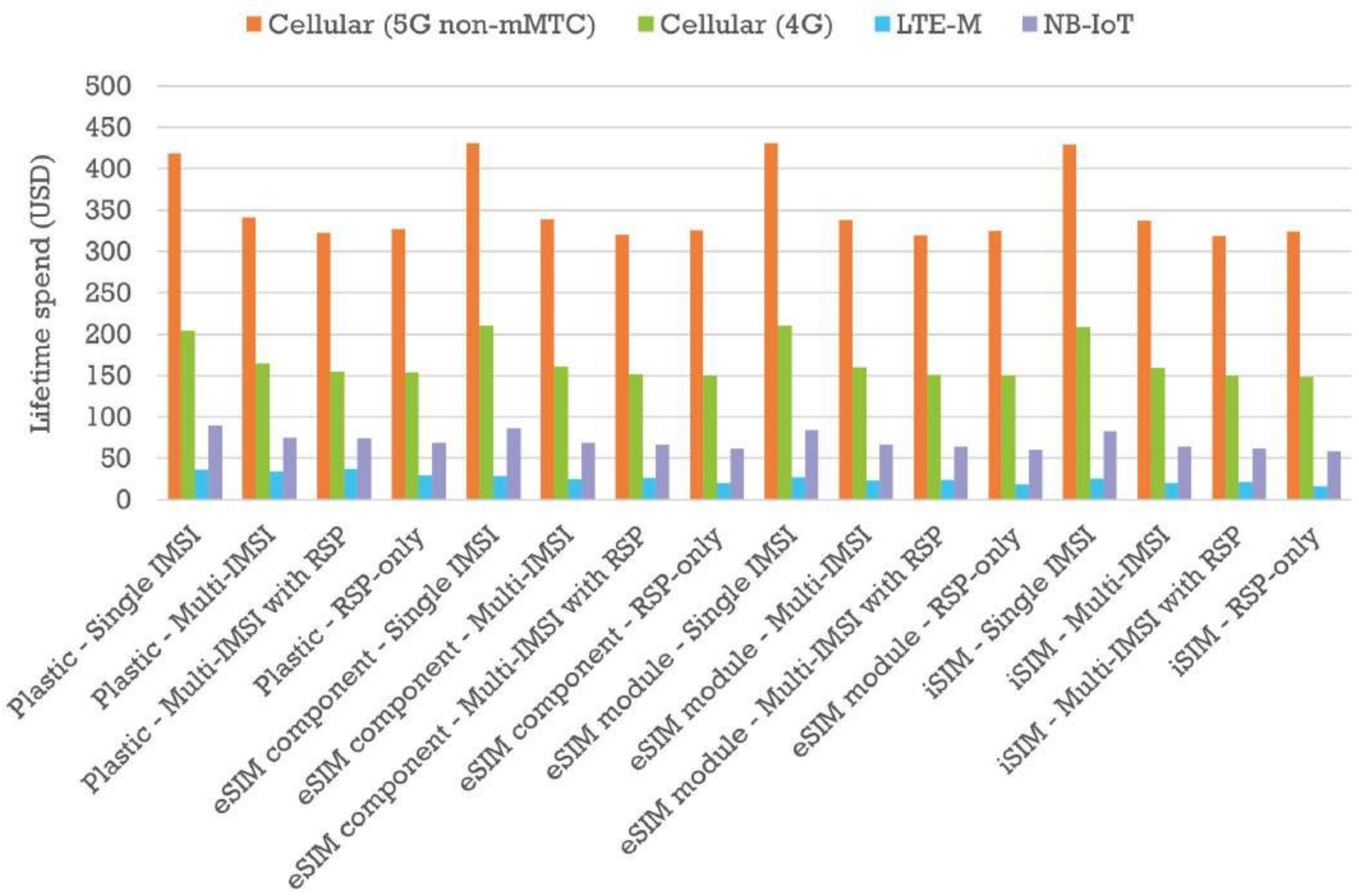


Figure 2: Average cellular IoT connectivity and SIM lifetime spend, by technology family and deployment type
[Source: Transforma Insights, 2022]



considered and separately modelled the biggest 30 use cases for cellular IoT, with separate consideration given to different dynamics for each cellular technology, for example, NB-IoT is not, today, able to support RSP and that is an important, different dynamic.

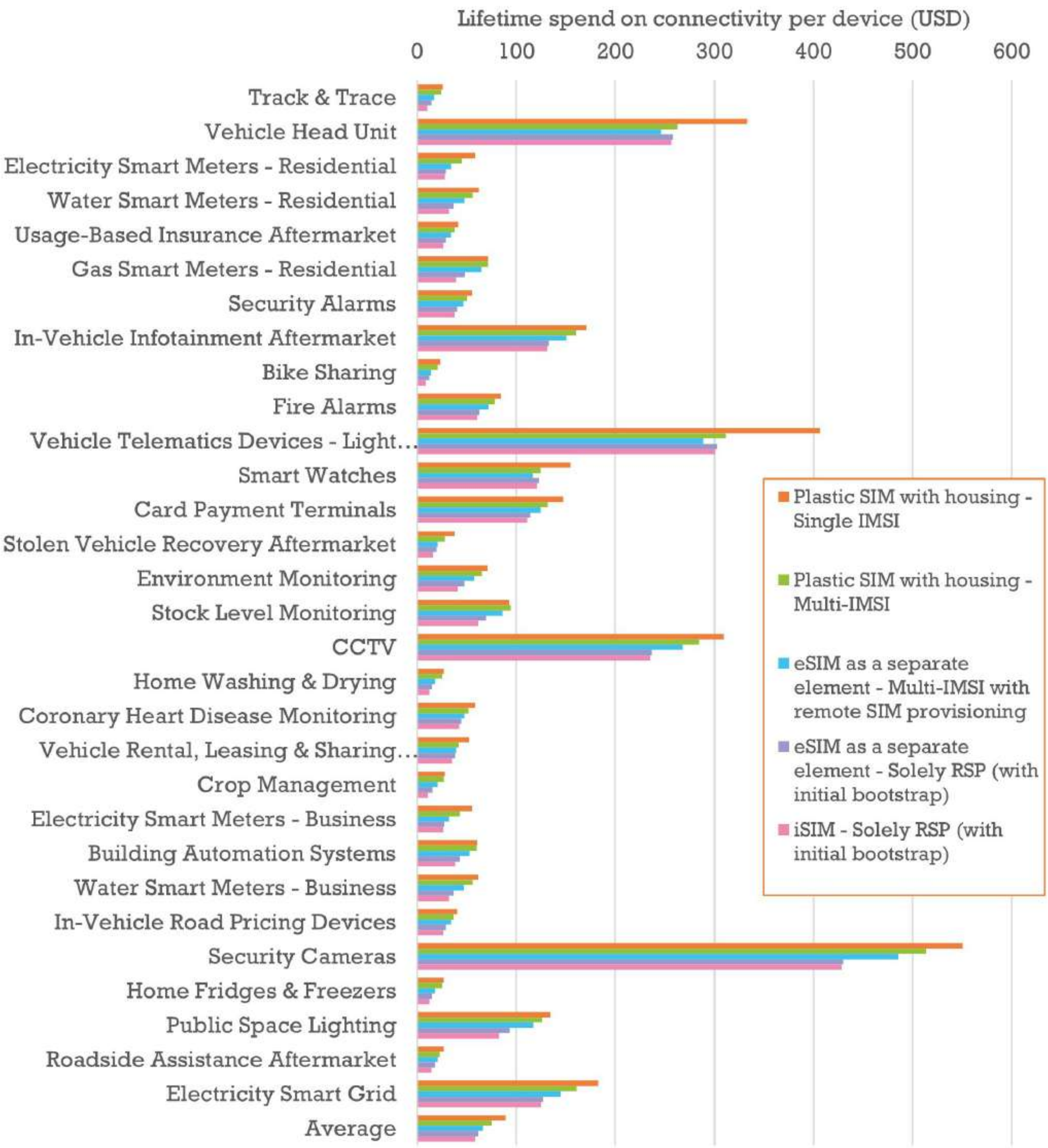
The key finding of the research was that on average eSIM devices cost 8% less over the lifetime of the device on a like-for-like basis than those using plastic removable SIM. If that eSIM is part of an integrated module that moves to 11%. Even greater benefits come from iSIM, which is on average 13% cheaper than plastic removable SIM. The chart below represents most of the possible permutations.

This average view is useful to understand, but it masks a lot of variation in both market dynamics and resulting differences in costs. For instance, certain use cases will tend to avoid multiple international mobile subscriber identity (multi-IMSI) SIM. In other cases, NB-IoT is the favoured option of a particular application which will therefore see no adoption of RSP-based solutions. Furthermore, some use cases, such as automotive, demand ruggedised SIM cards, with associated additional cost. Therefore, it is necessary for us to look at each of the use cases to understand the real dynamics. And, no company deploys an average IoT device. The characteristics of each vertical will dictate the extent to which eSIM and iSIM might be the favoured solution.

Figure 2, above, illustrates the variation between devices, with 5G having the highest lifetime spend followed by 4G. Perhaps surprisingly NB-IoT has a higher spend than LTE-M. This is due to the use of NB-IoT for smart metering, where each individually deployed device has a long lifespan.

The most valuable comparison is between the various options for any given single application. In Figure 3 are those figures for five permutations of SIM and subscription management. The cost analysis section below presents seven example of key use cases and the dynamics of each of those.

Figure 3: Lifetime spend per device on connectivity (including SIM, subscription and associated costs)
[Source: Transforma Insights, 2022]



Modelling the cost of eSIM, iSIM and RSP

This section discusses the various elements that comprise the total cost of connecting a cellular-enabled device and how those vary depending on the choice of SIM/eSIM/iSIM that might be selected. Transforma Insights has identified nine separate dimensions of cost related to choice of SIM type and IMSI management. These incorporate both direct (i.e. related to the SIM and its operation) and indirect (i.e. related to other cost implications of the choice) costs. The nine areas are outlined in the sub-sections below, alongside explanation of how the cost calculation is undertaken. The overall approach was to look at the lifetime cost of the SIM, including initial purchase, operation, connectivity spend, duration, requirement for replacement during the lifetime, and events within that lifetime, such as RSP events.

Component cost

This is defined as the costs of the physical SIM item. In the case of the plastic SIM, it comprises the cost of the SIM card itself as well as the housing. For the eSIM it is the cost of the MFF chip. For iSIM we take a notional cost for the additional secure element, which is typically located within the baseband chipset. The cost of the physical item is a single up-front cost. Input for this element comes from SIM vendors and other participants in the value chain.

In the case of the removable SIM the cost comprises the cost of the SIM card itself as well as the housing. There are very low-cost plastic SIMs available, from as little as USD0.10. However, they won't be durable and therefore particularly suitable for IoT. Any cost saving is likely to be wiped out by the cost associated with replacing sub-standard products. For a more durable product we could expect a typical price of USD1 to USD1.5, including perhaps USD0.5 for the SIM tray.

It should be noted that there is currently pressure on supply because foundries are ramping down manufacture in anticipation of reducing demand and in the face of unprecedented demand for other products.

In comparison, the eSIM component costs around USD2. For iSIM there is no dedicated component cost, but there is a notional cost for the additional secure element, which is typically located within the baseband chipset. This includes the royalties for the SIM OS functionality and a slightly more expensive component. We estimate that this adds approximately USD0.5 to the bill of materials.

For all of the calculations we also allow for some variation depending on the requirement for more expensive ruggedised devices and the volumes required by the buyer. Small volumes of ruggedised devices will command a premium, whereas large volumes of non-ruggedised will be cheaper. This inevitably means that different use cases will see different average costs.

Included within this cost is the charge for an initial bootstrap and/or initial live eSIM profile. During our research we have been quoted prices from USD0.10 to USD1.00 per unit for these.

Those devices with shorter lifespans, such as smart watches or other consumer electronics, will have a higher proportion of their cost associated with the hardware, compared to devices with long lifespans, such as smart meters.

Subscription management costs

The shift to eSIM introduced an additional set of costs associated with managing the IMSI and eSIM profile. Because the eSIM is embedded, the industry required a capability to change the SIM profile through a mechanism other than physically swapping out SIM cards. That mechanism is remote SIM provisioning (RSP), which was specified by the GSM Association in 2014, initially for machine-to-machine ('M2M') devices, and then in 2016 for 'Consumer' devices. During 2021 there were further moves within the GSMA working group on eSIM to standardise a new approach, which has been dubbed 'IoT', to allow devices to make use of a variant of the Consumer style.

The management of eSIM profiles and IMSIs has a cost associated with it. In some cases, enterprises may choose to operate their own subscription management infrastructure, but in most cases, it will be handled on a managed basis by a third-party vendor. Currently the prevailing trend is for a per-event charge, of typically USD1 per switch. To calculate the lifetime cost per device, we estimate the number of likely switches during that period (which varies by use case) and multiply it by the expected cost. In this category we also consider the equivalent cost associated with switching out a SIM card, should that need to be the case.

We should note that the pricing dynamics are likely to change significantly in the coming years. We expect service providers in the space would want to price it on a recurring basis rather than per event, and as part of a wider portfolio of capabilities, such as for a connectivity management platform.

Cost of IMSI switching failures

There is a small, but not insignificant, risk that failure of IMSI switching leaves the end device without any connectivity. This may require a truck-roll to reset the SIM, depending on the use case. Consumer use cases, for instance, are likely to be fixable by the user themselves, whereas remote environmental monitoring devices will be more costly to fix. This was a big challenge ten years ago when our analysts were first talking about it but the technology has matured to the point where it is only a very marginal risk and will happen only very rarely.

This potential cost should be balanced against the 'future-proofing' cost (see below) that exposes the risk of not having IMSI switching capability.

Connectivity cost

The main cost associated with the SIM card will be the connectivity spend associated with the recurring fees paid to the mobile network operator or MVNO. This fee is not explicitly one related to the SIM but choice of SIM might cause some variation in pricing. For instance, an eSIM or iSIM capable of RSP will be able to localise to a domestic network, with typically lower per-month fees than the equivalent for a roaming SIM. Similarly, a multi-IMSI SIM will often be able to choose between networks to find the cheapest option.

Prices for cellular connectivity are falling all the time, but it is still not unusual to pay upwards of USD1 per month depending on the use case. As noted above, in this modelling exercise we look at the lifetime value of the customer. Therefore devices which are expected to be in the field for over ten years, such as smart meters or connected cars, will have a higher lifetime value.

In this category there are a lot of considerations related to the charges that might accrue to the end customer depending on whether the device is using multi-IMSI or RSP or any other combination. This will largely depend on whether the device is expected to be located exclusively in a single country, or will roam between countries. Each of the permutations of single IMSI/multi IMSI/RSP will have implications for connectivity costs.

Battery replacement

for NB-IoT and LTE-M having a local profile may mean access to PSM/eDRX features extending battery life and meaning fewer battery switches. Roaming profiles will give access to these features, as we are seeing them come online (but slowly). However, organisations have to trade that off against the battery life you get with the device and using eSIM.

Logistics cost

Two types of costs could be considered under 'logistics'. Firstly, the supply chain costs associated with building the device. We consider this under the component cost, above. The other relates to the cost to the end customer of shipping plastic SIM cards to be used with the IoT device, the nominal cost of manual insertion, the potential debugging costs for those manually inserted SIMs, and the localisation of the deployment with the provisioning of access point names (APNs) and similar.

These costs apply on first initial set-up and at any time a network switch might be required, although this is likely to be mercifully rarely given the significant pain this would cause for replacing the plastic SIM cards in a fleet of devices already deployed in the field.

There is no simple calculation for this element but Transforma Insights estimates it to be an average of USD5-USD10 per device over its lifetime.

Compliance costs

In some cases the use of roaming SIMs or multi-IMSI might make an IoT solution non-compliant. This would apply only in very limited circumstances but may be quite a painful cost if it should occur. The most prominent examples are where there is regulatory prohibition on permanent roaming or where host operators (usually in US and Canada) disconnect the devices due to infringement of their commercial permanent roaming restrictions. This results in both tangible and intangible costs. The managing operator would have to reconnect the device, or in some cases agree to more punitive contract terms. In both cases they may also suffer reputational damage and end-users may suffer disruptions to service.

Future-proofing

Another similar dynamic might involve the host network being switched off, leaving the device stranded. The most common example of this is the 2G/3G refarming that is quite common around the world today, but it is not alone. Network switch offs of other technologies do happen. NTT Docomo recently elected to switch off its NB-IoT network, for instance. While it did not have significant numbers of contracted customers, it nevertheless shows that mobile network operators are not always going to support every technology in perpetuity. Again, there is only a very small likelihood of this happening, but should it occur it would be very costly.

Security costs

Similar to the last few items, a security breach is unlikely, but it may happen causing financial and reputational damage. The SIM is a highly secure system, but fraud risks are exacerbated by having a removable SIM card, albeit that any risk should be easy enough to mitigate with robust policy management. Concerns also persist about iSIM having inherently less security than the dedicated component that is the eSIM.

Cost analysis

The average lifetime spend on each of the various SIM and RSP options is shown in the chart below. There are two things to note. First that the low cost of removable plastic SIMs and the premium for RSP, is more than cancelled out by the cost savings associated with the logistics simplification, lower tariffs and avoidance of compliance, security and other issues.

There are quite significant savings to be made through the use of RSP, with the RSP-only option registering on average as 15% cheaper than the plastic removable SIM variant, as illustrated in Figure 4, below.

Typically, the cost savings are due to cheaper data tariffs. As shown in the figure below, over 80% of the connectivity spend is accounted for by the subscription itself. Therefore, if savings can be made there, for example through using multi-IMSI or eSIM localisation, that has more significant implications for the lifetime cost of the connectivity.

It must be noted that taking an average across all of the various use cases is not as useful as digging into the savings that are possible for each individual use case. The average reflects the mix of different use cases rather than the real delta between removable SIM, eSIM and iSIM. For instance, some use cases will favour certain technologies for which RSP, for instance, might not be viable. The most appropriate way to compare the relative costs of each of the options is to look at specific scenarios.

In the overall modelling exercise we looked at 30 different use cases connected using four technologies (4G/LTE, 5G, NB-IoT and LTE-M) - see the Methodology section for more details. Clearly some combinations of use case and technology will not be viable. For instance, few cameras, cars or other high bandwidth devices will be connected using NB-IoT. Similarly, environmental monitoring devices will tend not to use expensive and power-hungry 5G.

In this section we have selected eight combinations of use case and technology that we consider to be significant, including the biggest use cases overall with their dominant associated technologies, as well as the top use cases for each of the technologies.

We include consideration of all the relevant SIM/RSP options for this use case/technology combination (for example, no RSP-based options for NB-IoT). We always include single-IMSI removable as an option for comparison's sake.

Figure 4: Lifetime SIM and connectivity costs, blended, all technologies
[Source: Transforma Insights, 2022]

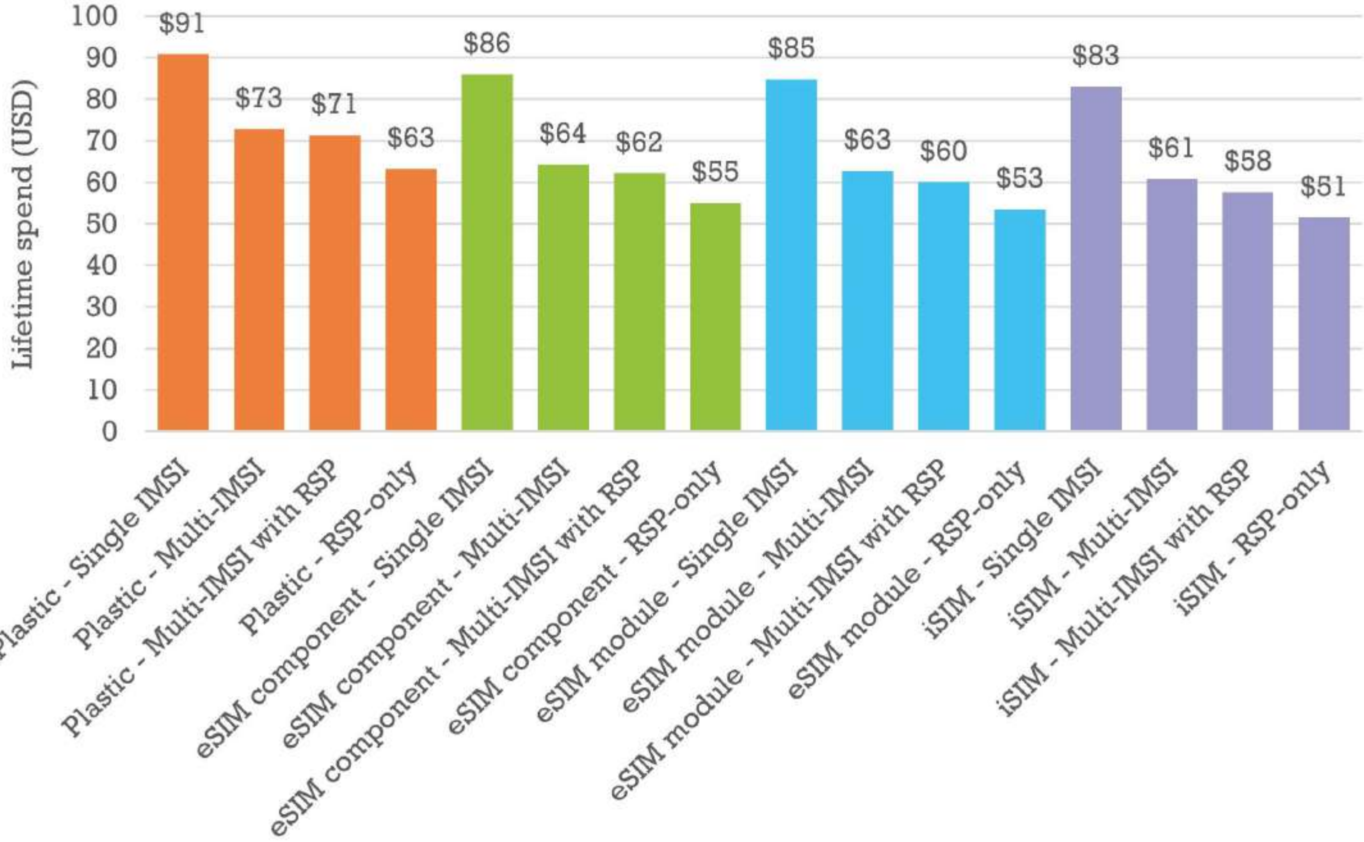
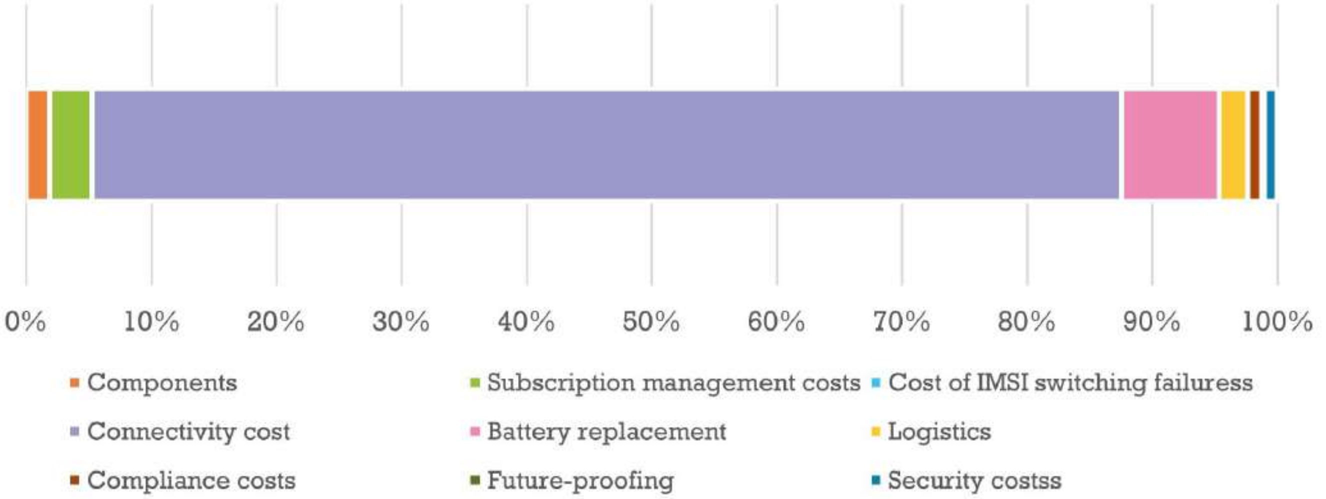


Figure 5: Average cost of connectivity elements of a cellular-based IoT applications, blended, all technologies
[Source: Transforma Insights, 2022]

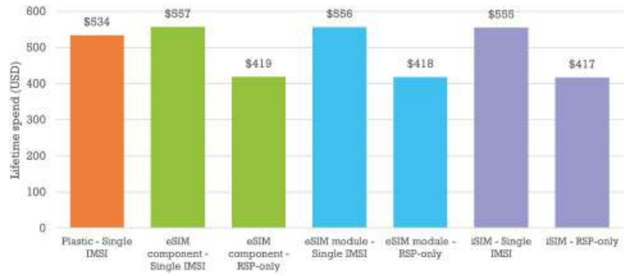


5G vehicle head unit

5G is today used in only a few very specific circumstances. Typically, this revolves around high bandwidth applications such as cars and video streaming. Eventually we expect the lower latency capabilities to encourage other diverse use cases, but for now the most important are connected cars and CCTV.

A factory-fit vehicle will not use a plastic SIM (although we include that within the range of options in the chart below for comparison), it will universally use eSIM or iSIM for reasons of robustness, such as sensitivity to vibration. Also, very few auto makers will entertain using non-standardised multi-IMSI. They tend to procure connectivity direct from MNOs. Realistically, therefore, the difference is between single IMSI or RSP-based systems, using either eSIM or iSIM. In reality almost all auto makers will opt for using RSP, at the least to provide an insurance policy given that devices will be active for over ten years in many cases.

Figure 6: Lifetime SIM and connectivity costs, 5G Vehicle Head Unit
[Source: Transforma Insights, 2022]



5G CCTV

The options for connectivity for a public CCTV camera are much more diverse. As with other high bandwidth use cases, the connectivity cost dominates the spend by the end user. As a result, the savings are to be made due to use of RSP and/or multi-IMSI, rather than the choice of hardware itself being particularly relevant. Like-for-like, eSIM is only about 2% cheaper than removable.

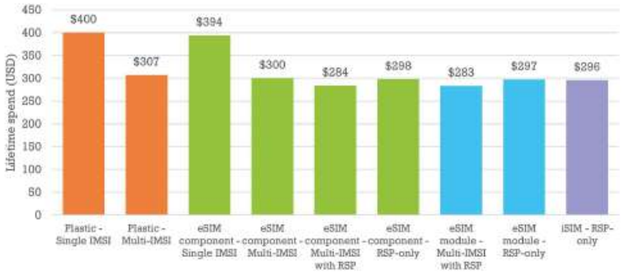
Figure 7: Lifetime SIM and connectivity costs, 5G CCTV
[Source: Transforma Insights, 2022]

LTE vehicle telematics - light vehicles

LTE is the dominant technology for connecting wide area devices today. Across most of the use cases it accounts for the majority of cellular connections. This will change over time, with 5G, and the LPWA technologies (today represented by NB-IoT and LTE-M) eventually overtaking it. For this reason, we include four comparisons in this section, whereas we include only two for the other technologies.

As with connected cars, this use case has a very long assumed lifespan (ten years). As a result the greatest impact will come from the savings that might accrue to the connectivity cost. This is particularly exacerbated by the cross-border nature of the use case, with potentially strong savings associated with localisation or multi-IMSI versus pure roaming. The variation between form factors is much less relevant, to the point of being almost non-existent.

Figure 8: Lifetime SIM and connectivity costs, 4G/LTE vehicle telematics
[Source: Transforma Insights, 2022]



LTE smart watches

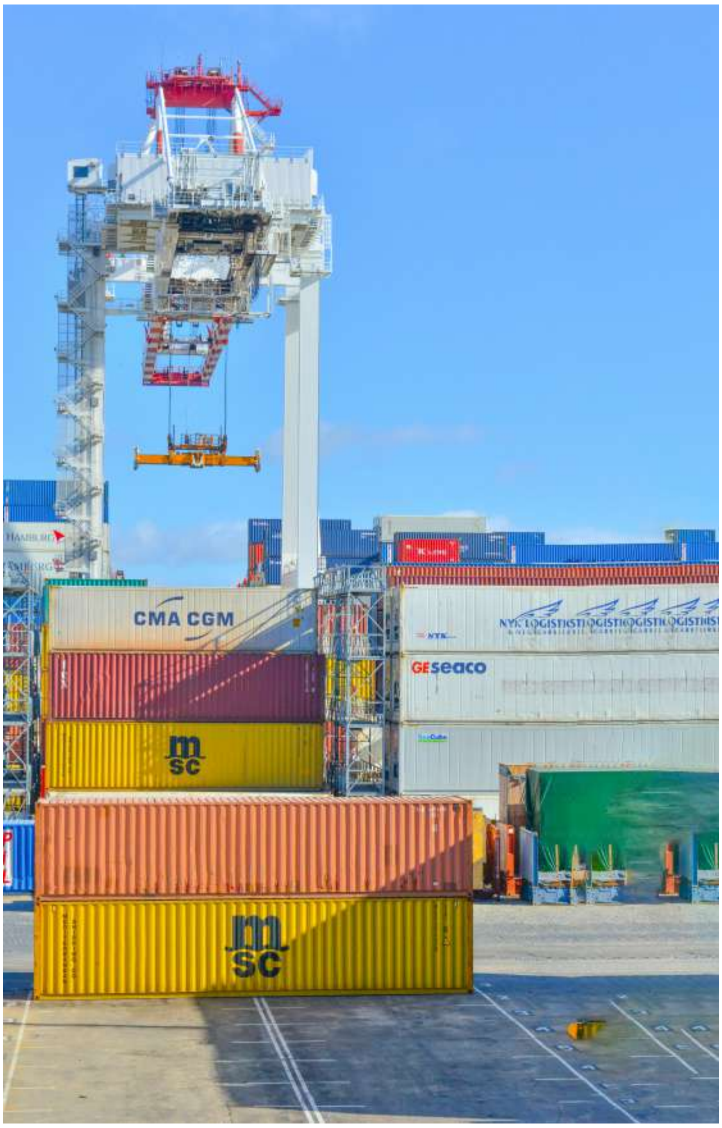
Smart watch manufacturers will have a stronger motivation than most to embrace eSIM and iSIM. Space is at a premium and they will want to use any mechanism for reducing the componentry. It is a moot point whether such OEMs will be comfortable using multi-IMSI. More likely this segment will be dominated substantially by eSIM and then iSIM. The combination of physical component and subscription management approach will make very little difference to the lifetime cost, as illustrated below.

Figure 9: Lifetime SIM and connectivity costs, LTE smart watches
[Source: Transforma Insights, 2022]

LTE security cameras

This category of device is differentiated from 'CCTV' because it focuses on consumer devices typically deployed in and around the home. Here again, there is a modest saving associated with moving from plastic SIM to eSIM and iSIM, but a much more significant saving from using remote SIM provisioning, versus using single IMSI or multi-IMSI.

Figure 10: Lifetime SIM and connectivity costs, 4G security cameras
[Source: Transforma Insights, 2022]



LTE-M usage-based insurance aftermarket

LTE-M and NB-IoT have rather different dynamics from 4G/LTE and 5G. Firstly they are often deployed in power-constrained environments, particularly NB-IoT. They also typically have low revenue per connection.

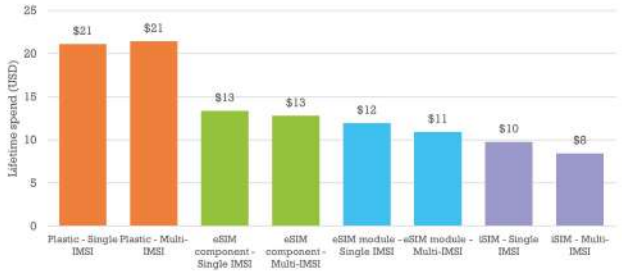
In usage-based insurance, aftermarket devices are used for monitoring driver behaviour. They typically have short lifespans and low revenue per connection. This means that the componentry cost is a larger proportion of the overall cost, making both removable SIM and eSIM proportionally more expensive.

Figure 11: Lifetime SIM and connectivity costs, LTE-M Usage Based Insurance
[Source: Transforma Insights, 2022]

NB-IoT track & trace

Track & trace covers a wide range of use cases and is the key use case for a low power low bandwidth technology such as NB-IoT. The greatest risk/cost when considering NB-IoT is the battery drain of multi-IMSI and RSP. Indeed, RSP is not today possible with NB-IoT because of the lack of support for SMS within NB-IoT. Any savings coming from using multi-IMSI are all but wiped out by the additional cost that might come from battery replacement. Similarly, this partially accounts for why removable SIM is significantly more expensive than the other form factors, due to superior power consumption on eSIM and iSIM.

Figure 12: Lifetime SIM and connectivity costs, NB-IoT track & trace
[Source: Transforma Insights, 2022]



Non-cost considerations

There are a number of considerations beyond just the relative cost of plastic SIM vs eSIM vs iSIM. In this report we have sought to quantify the financial impact of these decisions, but enterprise IoT adopters may also want to consider the following:

Size and weight

Using removable plastic cards (including the SIM housing) takes up space within a device. In most cases this is not a particularly significant consideration. A smart meter, for instance, has no great requirement to shave off small amounts of space. However, for a smart watch, the ability to reduce size and weight might be considerable. Use of eSIM, and subsequently iSIM would therefore give a competitive advantage not considered here.

In some cases, the reduction in weight of using successively eSIM and iSIM may also be relevant, although the variation is very small and there are few circumstances where the price sensitivity, such as in cost of shipping goods, would notice such a difference.

Environmental impact

Almost every large organisation today has set itself sustainability-related goals. Therefore, it is worth considering also the environmental impact of the various options of SIMs and SIM management. The removable SIM and its housing is bulker than the eSIM and with the iSIM it disappears altogether. The key issue is with switching. As a profile changes a removable SIM will likely simply be discarded, whereas there is no such wastage with eSIM and iSIM.

Multi-IMSI challenges

As noted in some of the analyses above, multi-IMSI is often a preferred choice for many IoT deployments, predominantly when sold by IoT mobile virtual network operators (MVNOs). However, it is not without its challenges. Firstly, it's based on proprietary technology, so there's the potential for push-back from MNOs over time. Many are already fairly unhappy about its use, not least because there may be regulatory issues with using the wrong core network to support a connection, and associated data break-out, security issues with sharing network keys, and logistical issues such as the time it takes to register to the network, long scanning periods and application time-outs. Multi-IMSI is a quick fix solution for multi-network connectivity but it has problems that will persist, and could be exacerbated by MNO push-back. In contrast, RSP is standards-based and neater in completely changing the number and core network.

Reputation

It has been noted a few times in the earlier sections that enterprises risk reputational damage if IoT devices cease to function either due to lack of future-proofing, security breaches, IMSI switching failures or the other areas outlined in the cost analysis section, above. It is impossible to quantify the associated cost.

Roadmap

The eSIM environment is changing rapidly. As noted above, we will soon see the new IoT variant of RSP. There are also initiatives such as nuSIM from Deutsche Telekom which may prove popular. In such a rapidly evolving market it is unsurprising that some buyers will be hesitant about their technology choices. The key is to make selections that are as standards-based and future-proof as possible.

Report methodology

To build its model of the cost of using the various types of SIM, Transforma Insights identified first the nine key cost elements that might be most prominently influenced by choice of SIM. These range from the component cost itself, to the future-proofing risk of the various options. Then, for each of the top 30 use cases (as taken from the Transforma Insights IoT Forecast Database) we analysed the cost elements for each of four different types of SIMs (eSIM, iSIM etc.) used in four different ways (single IMSI, multi-IMSI, RSP etc.) for the four main cellular technologies (5G, 4G/LTE, NB-IoT and LTE-M).

For each of those permutations of use case, technology, SIM type and deployment type we calculated the lifetime cost of supporting a connection of that type. This allows us to look at the variation is cost for each use cases as well as blended averages. Clearly some combinations will not be viable. Cars are not connected using NB-IoT, for instance, and some verticals will be predisposed against multi-IMSI products because they are proprietary. For this reason, in many of the analyses we will exclude unlikely combinations.

Further explanation of the different dimensions are presented below:

Cost elements (9)

Transforma Insights models nine different costs that will be influenced directly or indirectly by the use of different forms of eSIM, iSIM, remote SIM provisioning and subscription management. All of these are examined in detail in the Modelling section, above.

- Component
- Subscription management costs
- Cost of IMSI switching failures
- Connectivity cost savings
- Battery replacement
- Logistics cost of shipping and installing plastic SIM cards
- Compliance costs
- Future-proofing
- Security costs

Use cases (30)

Transforma Insights has modelled the following 30 application groups, which, according to the Transforma Insights IoT Forecast Database account for over 80% of all cellular connections.

Track & Trace: The use of trackers to monitor the location (and potentially condition) of a particular item, which could include tools, manhole covers, goods in transit or almost anything else. Can be used for supply chain efficiency, theft detection and asset location monitoring. It includes all other location tracking not elsewhere covered. Excludes shipping containers.

Vehicle Head Unit: Embedded connection that provides the vehicle's wide area connection. May be included as part of the vehicle's infotainment unit, or a telematics control unit. This connection will typically support multiple other connected vehicle applications.

Electricity Smart Meters: Residential: Device that records the consumption and, where relevant, generation of electricity at a location and transmits this usage data to providers. In some instances these devices will transmit usage data to users in order to encourage more energy efficient behaviour. This application includes smart meters in a residential setting.

Water Smart Meters, Residential: Device that records the consumption of water at a location and transmits this usage data to providers. In some instances these devices will transmit usage data to users in order to encourage more water efficient behaviour. This application includes smart meters in a residential setting.

Usage-Based Insurance Aftermarket: This application covers onboard devices used to monitor vehicle usage and driver behaviour to provide a more accurate or reduced insurance premium. In some cases, drivers are provided with instruction through smartphone-based apps to improve their driving.

Gas Smart Meters, Residential: Device that records the consumption of natural gas at a location and transmits this usage data to providers. In some instances these devices will transmit usage data to users in order to encourage more energy efficient behaviour. This application includes smart meters in a residential setting.

Security Alarms: Smart connected security alarms in either consumer or enterprise (cross vertical) contexts.

In-Vehicle Infotainment, Aftermarket: In-vehicle infotainment applications including music, video and device tethering via aftermarket devices. Vehicle connections and OEM mirroring systems such as Android Auto and Apple Carplay are counted as part of the Vehicle Head Unit Application Group.

Bike Sharing: Tracking and monitoring devices embedded in locks, bicycles, scooters and docking stations. These devices may allow customers to access the nearest available vehicle, prevent theft, or enable the collection, redistribution and recharging of vehicles.

Fire Alarms: Smart connected fire alarms in either consumer or enterprise (cross vertical) contexts.

Vehicle Telematics Devices - Light Duty Vehicles: In-vehicle aftermarket devices used for fleet management and other telematics applications.

Smart Watches: A wearable computing device that resembles a wristwatch and is equipped with a combination of Bluetooth, Wi-Fi, or cellular capabilities. These devices can operate independently, which is particularly the case for cellular devices, however they are often paired with a smartphone. These watches are often equipped with GPS and have their own applications capable of gathering and tracking data about the wearer's pulse rate, oxygen level and stress level or providing the wearer with walking or driving directions.

Card Payment Terminals: These machines often supplement checkout systems but can operate independently. These terminals are available as fixed devices at checkout points or wireless for mobile use. Card Payment Terminals accept input from an NFC, swipe, or chip-based payment card.

Stolen Vehicle Recovery, Aftermarket: Vehicle tracking to warn of break-ins, prevent theft or facilitate vehicle recovery in the event of theft. In more sophisticated systems it may be possible to sound alarms or shut down vehicle functions. This application includes aftermarket devices placed in the vehicle.

Environment Monitoring: The use of sensors to monitor for a diverse range of pollutants or other environmental factors. This might include CO2, flood water, radioactivity, seismic shock, or pollutants from industrial processes.

Stock Level Monitoring: Includes specialist inventory systems, baggage handling systems, soap dispensers, toilet doors, pest control, and many other diverse use cases.

CCTV: Connected video cameras used by governments for monitoring of streets and public places.

Home Washing & Drying: Connected washing machines, drying machines, and washer-dryers.

Coronary Heart Disease Monitoring: Remote monitoring of patients for heart disease and associated conditions.

Vehicle Rental, Leasing & Sharing Management, Aftermarket: Onboard devices and vehicle head unit hosted applications that are used to provide access, monitor and track the usage of vehicles lent to third parties. This may include traditional hire car companies, shared vehicle programs, and finance companies that lease vehicles to their users.

Crop Management: Crop irrigation, including connections to, and control systems for, systems that are deployed in the open air and also in closed environments such as greenhouses.

Electricity Smart Meters, Business: Device that records the consumption and, where relevant, generation of electricity at a location and transmits this usage data to providers. In some instances these devices will transmit usage data to users in order to encourage more energy efficient behaviour. This application includes smart meters in commercial settings.

Building Automation Systems: Including controllers and peripheral devices (monitoring devices, controlled devices, or actuators) to support smart building functionality in either a consumer or enterprise (cross vertical) context. This Application Group does not include security alarms, fire control systems, or lighting systems.

Water Smart Meters, Business: Device that records the consumption of water at a location and transmits this usage data to providers. In some instances these devices will transmit usage data to users in order to encourage more water efficient behaviour. This application includes smart meters in commercial settings.

In-Vehicle Road Pricing Devices: In-vehicle devices for road tolls and other congestion charging schemes (device installed on the dashboard or windscreen to provide identification and verification for tolling and other similar purposes).

Security Cameras: Private security cameras used in residential and commercial buildings.

Home Fridges & Freezers: Smart connected white goods in consumer contexts, including fridges, freezers, and fridge-freezers.

Public Space Lighting: The monitoring, control and management of smart lighting for streets and other public spaces, typically provided by local government or utilities.

Roadside Assistance, Aftermarket: Application that notifies recovery services in the event of a vehicle breakdown. Diagnostics and location tracking may be included to improve efficiency.

Electricity Smart Grid: The remote monitoring of the electricity grids for maintenance, diagnostics, fault discovery and loss reduction purposes.

For more detail, please contact enquiries@transformainsights.com.

Cellular technologies (4)

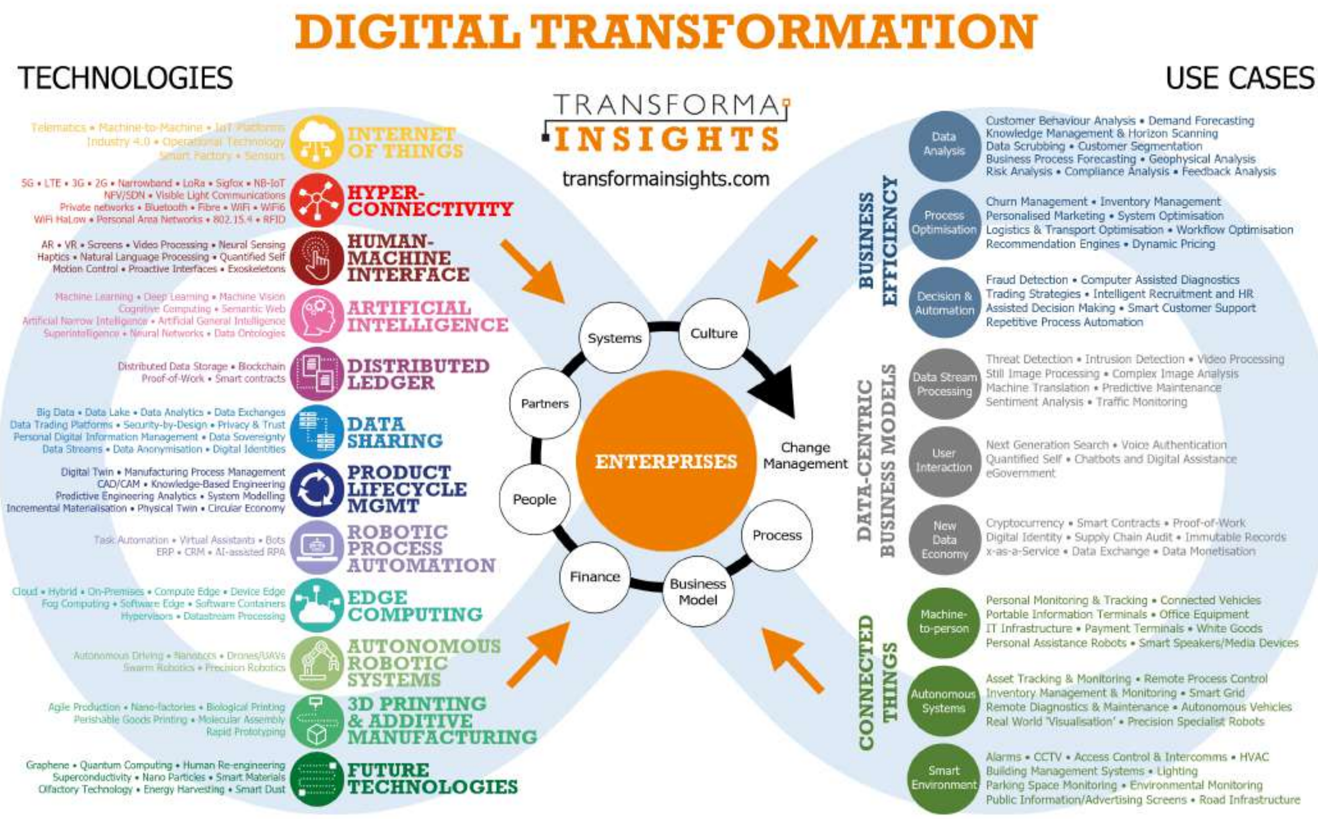
We separately model each of four technologies, which have different dynamics and are variably adopted for the 30 different use cases. Specifically, those are: 5G, 4G/LTE, LTE-M and NB-IoT.

Types of SIM (4)

- Plastic removable SIM - including any of the 2FF/3FF/4FF form factors of regular plastic SIMs which correspond to to, respectively, mini SIMs, micro SIMs and nano SIMs.
- eSIM component - The embedded SIM, a dedicated hardware component. Also referred to as MFF (machine-to-machine form factor), or more specifically currently the second generation, the MFF2.
- eSIM module - A dedicated hardware component, as with eSIM, but installed as an integrated part of a connectivity module.
- iSIM -SIM has no dedicated hardware but is implemented in a system-on-a-chip (SoC) architecture that integrates the SIM function with a processor and modem.

Subscription management and RSP mechanisms (4)

- Single IMSI - A single fixed IMSI for the device.
- Multi-IMSI - The SIM has multiple IMSI profiles loaded initially, with different profile selected according to which is the optimal to use. Proprietary technology.
- Multi-IMSI with RSP - As with multi-IMSI except that the SIM card can also make use of remote SIM provisioning (RSP).
- Solely RSP (with initial bootstrap) - The device has a single active IMSI and changes IMSI only based on remote SIM provisioning using typically a standards-based approach developed by the GSM Association.



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