WIK-Consult • Report

Study for ComReg

Strategies to promote Over-the-air provisioning

Authors:
Dajan Baischew
Julian Knips
Ilsa Godlovitch
Christin-Isabel Gries
Ahmed Elbanna
Bernd Sörries

WIK-Consult GmbH
Rhöndorfer Str. 68
53604 Bad Honnef
Germany

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WIK-Consult GmbH
Rhöndorfer Str. 68
53604 Bad Honnef
Germany
Phone: +49 2224 9225-0
Fax: +49 2224 9225-63
eMail: info@wik-consult.com
www.wik-consult.com

Person authorised to sign on behalf of the organisation

General Manager	Dr Cara Schwarz-Schilling
Director	Alex Kalevi Dieke
Director Head of Department Networks and Costs	Dr Thomas Plückebaum
Director Head of Department Regulation and Competition	Dr Bernd Sörries
Head of Administration	Karl-Hubert Strüver
Chairperson of the Supervisory Board	Dr Daniela Brönstrup
Registered at	Amtsgericht Siegburg, HRB 7043
Tax No.	222/5751/0926
VAT-ID	DE 329 763 261

I. Executive summary

I.I Legal and strategic context

Switching is an important measure to support choice for consumers and facilitate market entry. The importance of switching was reflected in long-standing provisions in EU electronic communications legislation regarding number portability.

The recently introduced EU Electronic Communications Code (EECC) further strengthens provisions on switching by requiring NRAs to promote "over-the-air" provisioning – i.e. fully digitised processes (Article 93(6)). The EECC also enables **NRAs to establish the details of the switching and porting processes** and requires (Article 106(6)) That these processes should **include, where technically feasible, a requirement for the porting to be completed through over-the-air provisioning, unless an end-user requests otherwise.**

ComReg has a duty in line with the EECC to promote competition, protect consumer interests and contribute to the development of the internal market. ComReg has further elaborated commitments in this regard in its national strategy.

Over-the-air (OTA) provisioning and switching could make significant contributions to easing the consumer sign-up and switching process, as well as supporting competition amongst existing players and new entrants, and facilitating connectivity for new devices and facilitating the development of new innovative services.

In this study, we aim to support ComReg to develop a strategy for OTA provisioning by identifying key actions that could be taken to promote and support a fully digitised customer journey for mobile sign-up and switching as well as facilitating switching in the context of industrial Machine to Machine (M2M) applications.

I.II What is an eSIM and how does it support OTA provisioning?

An eSIM is a form of programmable SIM that is typically embedded directly into a device. It contains the same information as a traditional SIM card about a customer's identity and connection to a mobile network.

Whereas provisioning traditional SIMs involves the physical insertion or swap-out of the SIM card, eSIM together with OTA technology make it possible for the mobile subscriber to provision and change their subscription and operator remotely, potentially with a fully digitalized customer journey.

Other benefits of the eSIM include its small form factor and fully embedded nature (which provides greater protection from the elements) as well as the potential for a single eSIM to contain multiple different user profiles.

Further information about the eSIM can be found in chapter 2.

I.III How does OTA provisioning and switching work from a technical perspective?

The technical specifications for eSIM and associated OTA provisioning capabilities have been developed by the GSMA within the last decade.

There are two different GSMA Remote SIM Provisioning solutions designed respectively for M2M use cases (the first to be developed) and consumer use cases such as provisioning for smartphones and companion devices. The main difference between these two specifications is the direction of control for selecting a connectivity provider. Under the consumer specification, end-users actively choose their connectivity provider (the pull model), while the M2M specification involves profiles being pushed to the device by the operator's server (push model).

There are also differences in the supporting hardware and software. While the M2M specification has separate servers for management of the profiles (SM-DP) and the routing, loading, activation and deactivation of profiles (SM-SR),[1] the consumer specification combines the roles played by the SM-SR and SM-DP servers into a single server known as an SM DP+.[2] The consumer specification also involves a "local profile assistant" (LPA) which allows the end-user to make their own choices about the operator from which they wish to "pull" a profile.

Number portability, which is typically requested when consumers switch connectivity providers for a device which makes or receives calls, operates today as a separate process from the process involved in switching the connectivity provider, and can be triggered after the activation of a new profile and deactivation of the profile from the donor operator. Number portability processes in Ireland are "OTA-ready" as they already operate without manual intervention and could work with an eSIM just like they do with regular SIM cards. In the future, MNP processes could in theory be combined with profile switching, but there does not seem to be any significant demand for this solution at this time.

More information about the technical processes involved in OTA provisioning and switching as well as number portability can be found in chapter 3.

1 The SM-SR can be managed by the OEM, an operator or an alliance of multiple operators.
2 The SM-DP+ can be operated separately by each operator / operating company, or multiple operators (or subsidiaries) could share a single SM-DP+.

I.IV What are the use cases for eSIM and OTA provisioning and associated customer journeys?

The main consumer use case for eSIM is likely to be for connectivity in smartphones and secondary devices such as wearables and tablets. The fact that eSIM can accommodate multiple profiles also means that consumers can take out subscriptions from different providers on their smartphone or tablet, for example to ensure good coverage or lower prices for data when they travel.

Although today, paper QR codes are still used to create new profiles on an eSIM, as shown below, the most user-friendly process for sign-up on consumer eSIM devices involves an application, which takes care of customer identification, choice of service or bundle and payment, and can also be used for the ongoing management of the subscription.

Figure I-1: Consumer OTA customer journeys: Application based

This process can be fully digital and switching can be just as straightforward.[3] The same fully digital app-based process can also be used to sign-up to a second contract on the eSIM such as services for travel or business, or to sign-up to a contract on a secondary device.[4] If fully digital, QR codes could provide another sign-up option. Alternatively consumer devices (and especially wearables and companion devices) may come with connectivity pre-installed,[5] but this may create challenges with lock-in in some circumstances (as discussed below). [6]

3 Switching can be performed in the same way and involves activating a new profile and deactivating the old one. Post-paid contracts are, as with any SIM, not automatically terminated and customers are charged even if the respective eSIM profile is deactivated. Accidentally "using" the deactivated profile, for however, is not possible. Profiles have to be actively switched by the customer in the phone settings. Switching that involves number portability would, as today typically be led by the new provider which would engage with the former provider to trigger the termination of the contract associated with the number concerned.

4 Depending on the device, it may require a separation subscription or be paired with a smartphone and use the same subscription.

5 The device is active "out of the box" with the address of the SM-DP+ already installed.

6 This risk is not limited to devices with eSIM installed, and may equally apply to wearables with traditional SIMs pre-installed. However, this potential lock-in problem may be exacerbated with the growth in wearables and other connected consumer devices which has been stimulated by eSIM.

eSIM M2M use cases include “mobile / international” use cases such as the provision of connectivity in vehicles or for logistics and use cases which may be more fixed and/or domestic in nature such as the use of eSIM in smart meters and sensors.

There are two main options for the provisioning of eSIM-enabled M2M devices. One is for the industrial customer to purchase the device with a “bootstrap” profile (to provide temporary connectivity out of the box) and negotiate deals with a connectivity provider which then pushes its profiles to the devices. Alternatively, an industrial M2M customer could directly negotiate a deal with a connectivity provider and include this profile in its devices during the manufacturing process e.g. for cars.

Switching is more complex for M2M than for consumer applications and is typically project-based rather than relying on standardised procedures. If the industrial customer controls the SM-SR which is responsible for the activation of profiles, it can direct the devices to the SM-DP of a new connectivity provider. However, if the SM-SR is controlled by the previous connectivity provider, switching to a new provider would require either the continued use of the SM-SR of the previous provider or an “SM-SR” swap which would involve exchanging the profile data between the previous and new provider. Both scenarios require the collaboration of the connectivity provider whose contract is due to be terminated.

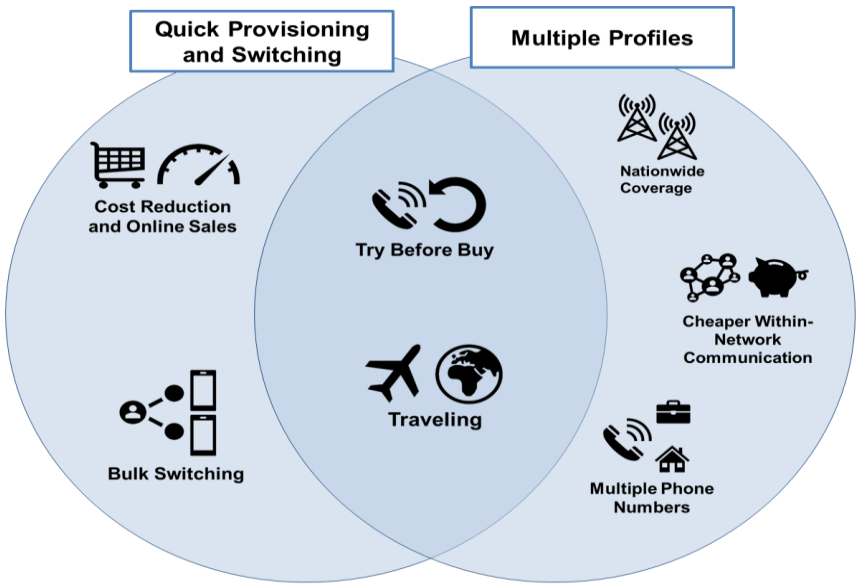
It should be noted that for M2M use cases, connectivity is typically controlled by the industrial customer for its fleet of devices. However, if individual devices are then sold to end-users (such as cars), this can also create lock-in problems (especially for essential features), as the end-user cannot choose his connectivity provider directly.

Further information is available about provisioning and switching processes for consumer and M2M devices in chapter 4, and additional details are provided in the Annex (chapter 9).

I.V Benefits and challenges from eSIM for consumers and the industry?

Benefits and challenges for consumers

The benefits of eSIM and OTA from a consumer perspective include improved provisioning and switching processes, which should in turn boost competition and reduce retail prices. eSIM and OTA also supports connectivity in consumer devices such as smartwatches and health monitoring devices, providing scope for innovative new products and associated services. Consumers also benefit from new services such as the ability to take out secondary contracts to avoid roaming, business vs personal use, or to ensure good coverage. These new use cases and others are illustrated in the following figure.



Source: WIK-Consult.

However, there are risks of lock-in in cases where (especially secondary) devices are pre-connected to certain connectivity providers, without the opportunity to switch.[7] If operators do not support eSIM at all or do not support eSIM connectivity for companion devices, consumers may also face more limited choice then in a physical SIM environment. This may become more of a problem when devices are shipped without the option of a physical SIM. The impending delivery of eSIM only devices may also highlight another challenge, which is that the current GSMA eSIM specification does not allow multiple profiles (e.g. for home / work) to be active at the same time. This means that consumers would need to activate and deactivate different profiles in order to make use of them.[8]

Benefits and challenges for M2M

There are also significant benefits to be gained from the deployment of eSIM in the context of M2M, as it provides the opportunity for industrial customers to purchase devices without connectivity pre-installed and provision them in the field, as well as presenting an opportunity for switching, which would not be possible at all without the recall of devices in a physical SIM environment. eSIM also enables devices to be sealed, and thus robust to extreme conditions with reduced risk of tampering.

7 For example if there is no interface readily available which enables switching or switching is otherwise impeded through contractual or technical means.

8 The GSMA has stated that it is working on an update to the specification that would enable multiple profiles to remain activated at the same time. The Apple iPhone 13 supports dual eSIM, but it is possible that this functionality is supported by installing multiple eSIMs.

Key risks in the M2M segment are that the market for eSIM-enabled devices may be slow to emerge, because of long device lifetimes and because existing connectivity providers for M2M have limited interest in enabling switching. Switching M2M devices can also be complex and costly, even in an eSIM context, in cases where the customer does not control the profiles via the SM-SR.[9] Further lock-in challenges may emerge when consumers purchase pre-connected devices such as cars, as connectivity for certain functions such as telemetry may be controlled by and charged for by the manufacturer on an ongoing basis without a straightforward means for the end-user to switch.

Impact on the ICT value chain

In addition to the direct impacts on end-users, eSIM could also have a significant impact on the underlying ICT value chain. A significant effect is that it enables equipment manufacturers and OSS providers such as Apple, Microsoft and Google (as well as car manufacturers) to engage in the process of providing or bundling connectivity. This could give device manufacturers a degree of control over which connectivity options are offered and how they are presented, which may raise potential lock-in concerns. Due to the lack of standardisation in this area, device manufacturers may also be able to control which mobile service providers can support companion devices, which could also impact competitive dynamics in mobile markets.

The shift from manual SIM provisioning to all-digital app-based provisioning of connectivity could also negatively impact mobile service providers which rely on physical outlets for sales and top-ups (including stores, supermarkets, post offices etc)[10] and provide the means for tech companies with established applications (such as Google, Facebook etc) to establish their own MVNOs, which could pose a potential threat to certain established operators.

MNOs will also need to incur certain costs to support eSIM technology[11] and reform their internal processes, while MVNOs may find that eSIM support is another feature that they need to negotiate with their host MNOs in order to be able to support the latest smartphones and companion devices.

On the other hand, the new use cases enabled by eSIM should provide an opportunity for MNOs and specialist MVNOs to engage in the growing markets for M2M connectivity and applications, and secondary services such as travel.

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9 Issues may arise in particular if the transferring or donor operator obstructs or delays the switch or sets excessive charges for switching.

10 There may also be a negative impact on physical outlets themselves with less scope for independent retailers selling mobile packages in physical stores.

11 Solutions are however available from eSIM management providers which could facilitate swifter adoption of eSIM at least in the early phase. MNOs may later decide to invest in the relevant infrastructure themselves at a later stage.

eSIM could also reduce costs for MNOs and deliver environmental benefits due to the reduced plastic waste and associated physical transport.

Further details of how eSIM and associated OTA provisioning and switching processes will affect consumers and the ICT value chain are available in chapter 5 of the report.

I.VI What is the status of eSIM deployment internationally and in Ireland?

In 2020, 25% of operators surveyed by the GSMA had launched eSIM services for smartphones. Much of the growth is occurring in Europe. The key driver of deployment in the consumer segment are the provision of eSIM-enabled premium devices initially by Apple and Google, and more recently by Samsung. The most popular applications for eSIM in the M2M space are connected cars (110 million vehicles globally in 2020).

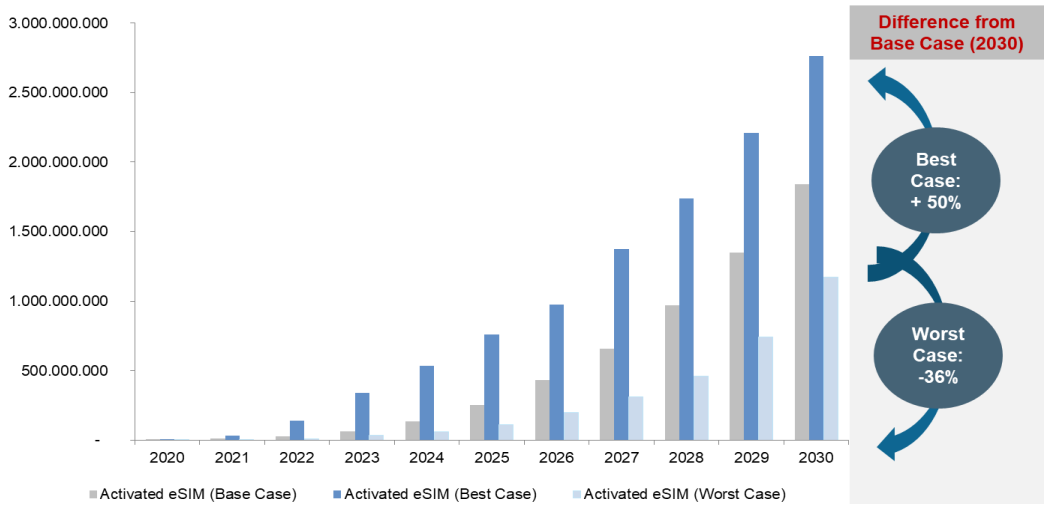
Differences in eSIM take-up in different countries can be driven by the number of operators supporting eSIM, as well as the popularity of smartphone models which support eSIM. On the M2M side, differences in eSIM take-up can also be influenced by the proportion of vehicles sold after 2018 (when eCall was mandated) and the use of eSIM connectivity for smart meters.

eSIM availability in Ireland is likely to be relatively high compared with other countries in Europe. Based on consumer usage patterns, around 15% of smartphones may be eSIM-compatible, and more than 10% of vehicles are likely to support eSIM in Ireland. eSIM is also being used to support smart metering deployment by the ESB.

However, Irish MNOs have been slow to support eSIM, with only Vodafone making it available for a range of smartphones (but not companion devices), while Three has focused on eSIM implementation in the context of smart meters. Three is expected to launch eSIM support for consumers in the near future, but no details have been made available, and Eir has not yet made concrete plans. MNO reluctance and lack of consumer awareness are the main factors holding back eSIM take-up in Ireland.

The future evolution of eSIM in Ireland will depend both on the availability of eSIM and the take-up rate. In a base case scenario we forecast that around 28.3 million devices in Ireland will be equipped with eSIM in 2030, and 27 million will have been activated. Under a worst case scenario, the number of activated eSIMs could be 39 % lower, while under a best case, the number of activated eSIMs could be 32 % higher (with a lower and higher number of eSIM equipped devices, respectively).

Figure I-2: Total number activated eSIM in the EU, different scenarios (2020-2030)



Source: WIK-Consult.

Further details about expected market developments internationally and in Ireland are provided in chapters 6 and 7 and the annex (chapter 10).

I.VII Establishing a strategy for eSIM and OTA in Ireland and Europe

Defining a strategy for the promotion of OTA requires a vision and the identification of associated challenges and actions to address the problems identified.

A starting point is that, in line with the provisions of the EU Electronic Communications Code, consumers' interests should be protected and that they should benefit from widespread connectivity, choice and value for money.

From an eSIM perspective this means that consumers should have access to a range of connected devices (in addition to their smartphone) and should benefit from the wide range of services that could be provided on a single device. Furthermore, consumers should be able to benefit from fully digitised processes for sign-up and switching and be able to select from a range of service providers for their various devices and services.

The switching process should be as straightforward as possible, and consumers should be adequately informed about connectivity options and not face unjustified lock-in.[12]

eSIM and OTA processes are also a vital enabler for industrial M2M. Industrial customers should thus have access to a wide range of M2M devices and solutions, and benefit from swift and effective OTA provisioning and switching procedures.

Key barriers that we have identified include lack of awareness, slow uptake and support for eSIM as well as a lack of user-friendly OTA options for provisioning and switching and potential lock-in in certain situations for both consumers and industrial customers. In addition, current standards (or lack thereof) hamper support for multiple profiles on a single device, as well as support for certain companion devices. Monitoring and enforcement may also be challenging for M2M provisioning and switching processes, as devices, services and/or number ranges may be operated cross-border.

Solutions include action on data gathering and information campaigns as well as potential requirements concerning OTA processes and guidelines or requirements to address lock-in concerns. Further development on standards should also be encouraged to support simultaneous multiple profiles and standards for entitlement servers to support choice in connectivity for secondary devices as well as improved switching processes for M2M. Lastly, processes should be established to support cross-border collaboration in enforcement in cases where M2M services involve a cross-border component.

The challenges and possible actions to tackle each concern are summarised in the following table.

12 Lock-in beyond a reasonable contractual period that may be associated with a new contract.

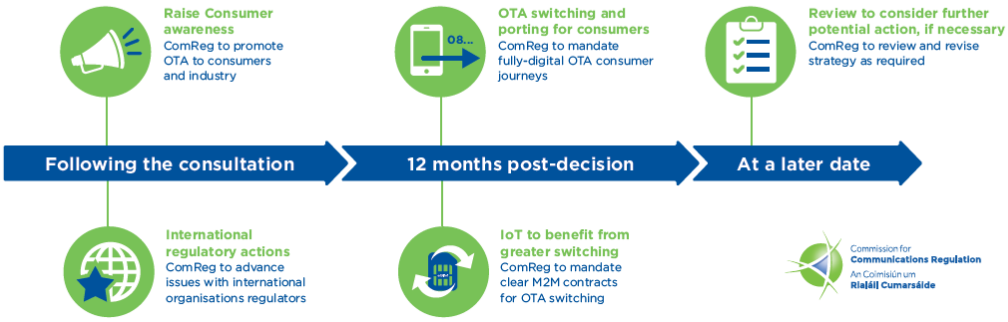
Challenge	For ComReg domestically	Potential EU / international actions
Lack of information	**Monitor availability and take-up** of eSIM across different device types, use cases and mobile service providers, for consumer and M2M applications	Gather **EU-wide data** concerning eSIM deployment and take-up for consumer and M2M use cases
Lack of awareness by consumers	Launch **information campaign** to inform consumers about the benefits of eSIM	
Lack of eSIM support by mobile service providers / insufficient choice of providers	Target and/or mandate fully digital OTA provisioning and switching for eSIM (smartphones only for the moment)	Develop best practice **guidelines for NRAs** which could cover: (i) interpretation of the relevant articles in the EECC; (ii) measures to promote eSIM / OTA; (iii) implementation and enforcement of OTA switching; (iv) eSIM support for MVNOs; (v) best practice actions to prevent lock-in including the role of transparency, best practice contractual provisions and the role of SIM locking rules
Lack of user-friendly OTA provisioning and/or switching options	Mandate MNOs to review /improve existing MNP process	
Insufficient choice of providers / barriers for MVNOs	**Monitor engagement between MVNOs and their hosts** concerning eSIM support	
Lock-in challenges	Recommend or require **clearer information regarding ongoing connectivity usage costs** for consumer devices which are supplied with connectivity by OEMs at the point of sale. Clarify requirements for OTA switching for consumer and M2M use cases. Consider SIM locking rules	SIM locking rules and/or other solutions to address « after-market » issues for devices bundled with connectivity
		Encourage the **adaptation of the consumer specification for M2M, or simplification of M2M specification** to improve switching potential for M2M
Lack of potential to use multiple profiles simultaneously		**Promote the use of the GSMA eSIM** consumer specification, and development of specification for multiple active profiles
High costs / barriers to support multiple companion devices due to lack of standards		Encourage the development and take-up of **industry standards for device entitlement servers**
Challenges with cross-border enforcement		Establish processes to clarify jurisdiction and ensure the effective monitoring and enforcement of any rules regarding provisioning, switching and fair contractual practices when IoT connectivity is provided on a cross-border basis e.g. using international numbers and/or companies registered abroad

Regarding the timing of possible actions, the following milestones could be considered:

- Taking into account the slow eSIM deployment plans of Irish mobile operators, and the need for the Irish market to remain internationally competitive (noting that all MNOs have already launched eSIM support for smartphones in the UK, France, Germany and Spain),[13] ComReg could establish a target of **1 year from the relevant decision** for MNOs to support eSIM and fully digital provisioning and switching processes for consumer devices.[14]This should lead to availability of fully digital processes by **2023.** ComReg could also use its powers under the EECC to mandate OTA provisioning and switching, and issue guidelines on how this should be applied respectively in a consumer and M2M context.
- By the **end of 2026**, ComReg could complete a review to consider whether further actions may be necessary. At this stage of market development, it is too early to say whether any further intervention by the regulatory authority might be necessary. However, examples of potential intervention that could be considered in the medium term, if market solutions are not found, include rules concerning SIM locking and eSIM support for MVNOs.

This potential 5-year roadmap is depicted in the following diagram.

Figure I-3: Roadmap for OTA in Ireland



Source: ComReg.

The recommendations in this study may also be relevant for other NRAs as well as European and international organisations. ComReg could approach these organisations which a view to establishing a timeframe for EU-level guidelines to address key challenges which are common to all Member States or have a cross-border dimension.

Further details concerning the proposed recommendations can be found in Chapter 8.

13 As of May 2021 Presentation by GSMA at World eSIM Virtual Summit.

14 Interviews conducted for this study suggest that a timeframe of between 18 months to 2 years may be needed for MNOs to establish their own eSIM solutions. However, faster solutions are available via the use of eSIM management providers, and the faster adoption rates of eSIM in other EU Member States including by MNOs within the same Group as those operating in Ireland suggests that a 1 year timeframe should be feasible.

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Tables

1 Legal and strategic context

In this chapter, we describe:

- the legal context for the study, with reference to EU provisions concerning OTA provisioning (section 1.1)
- ComReg's statutory duties and objectives in this field (section 1.2); and
- The aims of the study (section 1.3).

Key take-aways are summarised at the end of the chapter.

1.1 Provisions on Over-the-Air switching in the EECC

Ease of switching is an important principle in supporting choice for end-users and businesses, facilitating competition and the potential for new market entrants. The right for consumers to switch provider, including the ability to port telephone numbers when switching fixed and mobile operators, has been included in various iterations of the EU Framework for electronic communications.

Until recently, switching mobile operators has involved the swap-out of a physical SIM card. However, the introduction of eSIM technology has enabled purely digital "over-the-air" (OTA) provisioning and switching processes for both consumers and machine to machine (M2M) devices. In turn, eSIM and the associated potential for fully digital processes for provisioning and switching could open opportunities for easier switching, the development of new types of services (such as specialist "travel" services), and the use of services from different providers simultaneously on the same device, which could improve coverage or enable a single device to be used for home and business use. The remote provisioning and switching capabilities of eSIM also provide an opportunity for customers to switch provider for M2M devices, which has previously been very challenging due to the limitations of previous SIM technologies, especially in cases where there are large numbers of devices in the field. However, it is important to note that various commercial, technical, and operational challenges may prevent customers from realizing the full benefits from eSIM technology.

The potential for new technologies to benefit end-users by enabling OTA provisioning and switching has been recognized in the 2020 EU Electronic Communications Code (EECC),[15] as follows:

15 Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast).

Article 93(6)

> "***Member States shall promote over-the-air provisioning, where technically feasible, to facilitate switching of providers of electronic communications networks or services by end-users, in particular providers and end-users of machine-to-machine services****."*

Article 106(5) and (6)

> *"The porting of numbers and their subsequent activation shall be carried out within the shortest possible time on the date explicitly agreed with the end-user. In any case, end-users who have concluded an agreement to port a number to a new provider shall have that number activated within one working day from the date agreed with the end-user…*
>
> *The receiving provider shall lead the switching and porting processes set out in paragraphs 1 and 5 and both the receiving and transferring providers shall cooperate in good faith. They shall not delay or abuse the switching and porting processes, nor shall they port numbers or switch end-users without the end-users' explicit consent. The end-users' contracts with the transferring provider shall be terminated automatically upon conclusion of the switching process.*
>
> ***National regulatory authorities may establish the details of the switching and porting processes, taking into account national provisions on contracts, technical feasibility and the need to maintain continuity of service to the end-users. This shall include, where technically feasible, a requirement for the porting to be completed through over-the-air provisioning, unless an end-user requests otherwise.*** *National regulatory authorities shall also take appropriate measures ensuring that end-users are adequately informed and protected throughout the switching and porting processes and are not switched to another provider without their consent."*

In a response to a question posed by ComReg concerning the implementation of Article 93(6) and the meaning of "promote" in that context, the European Commission noted that:

"*The obligation in Article 93(6) ("promote") leaves a wide margin of flexibility to Member States when transposing and implementing Art. 93(6). As such, this provision does not require transposition in their national legislation or via secondary technical provisions. However, Member States are required to take measures to promote "over-the-air provisioning". This may imply the adoption of measures encouraging such use, either through binding measure or through soft law (e.g. publishing best practice, policy orientations) with the stated aim to "promote" OTA. At the same time, maintaining or*

introducing national legislation that impedes the deployment of OTA would be contrary to Article 93(6) of the Code."

1.2 ComReg's objectives and strategy in this field

ComReg is the statutory body responsible for the regulation of the electronic communications sector (telecommunications, radiocommunications and broadcasting transmission) and the postal sector. ComReg is the national regulatory authority for these sectors in accordance with EU law, which is subsequently transposed into Irish legislation.

ComReg's primary objectives in carrying out its statutory functions in the context of electronic communications are to:

- promote competition;
- contribute to the development of the internal market;
- promote the interests of users within the Community;
- ensure the efficient management and use of numbers from the national numbering scheme in the State: and
- take the utmost account of the desirability of technological neutrality in complying with the requirements designed to ensure effective competition.

ComReg has further elaborated on these objectives in its draft Five Year Strategy[16] and identified the following target outcomes:

> *SI 1 Competition & Investment: A competitive sector that delivers efficient investment, innovation and choice*
>
> *SI 2 Consumer Protection: Consumers can choose and use electronic communications services with confidence*
>
> *SI 3 Connectivity & Network Resilience: End-Users have widespread access to high-quality and secure communications networks, services and applications*

ComReg notes in this context that: "Our mission remains unchanged from our previous Five-Year Strategy (2017-2021): Through effective and relevant regulation, to facilitate the development of a competitive communications sector in Ireland that attracts investment, encourages innovation and empowers consumers to choose and use communications services with confidence"

16 https://www.comreg.ie/media/2021/03/ComReg-2132.pdf.

Promoting OTA should make a significant contribution to ComReg's wider objectives, as it should serve to:

- Protect end-users' interests for example by facilitating the sign-up and switching process, and ensuring that OTA serves to increase network resilience and widen choice;
- Promote competition amongst existing mobile network and service providers as well as facilitating the entry of new providers;
- Facilitate VHCN connectivity to a wider range of devices, and support the development of new and innovative services

Although it is not an explicit objective for ComReg, supporting fully digital processes for provisioning and switching could also serve to support environmental objectives as outlined under the European Green Deal.[17]

In order to deliver on these objectives, ComReg will need to

- Understand the benefits of OTA provisioning and switching as well as understanding potential costs and implications for different players in the value chain
- Develop a Vision for OTA
- Identify actions necessary to realise the full benefits of OTA and limit potential threats; and
- Develop plans to promote OTA to achieve this vision

1.3 The purpose of this study

In this study, we aim to support ComReg in developing its strategy by describing developments in the eSIM technology as well as developments in its deployment and take-up, discuss the relevance of this technology to achieving fully digitized provisioning and switching, and describe the provisioning and switching process from the perspective of customers and operators for both consumer and M2M use cases. We identify the main benefits of eSIM and associated OTA switching and provisioning capabilities, alongside the barriers to its take-up, including legal, commercial, technical, and operational barriers. We conclude with a discussion of possible actions that could be taken by authorities and industry bodies in Ireland, as well as at European and global level, to ensure that the benefits of eSIM (and specifically those related to OTA provisioning and switching) can be realized.

17 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en.

Our findings are based on an in-depth review of technical and economic literature, alongside 26 structured interviews with market participants. These included SIM management solution providers, major equipment manufacturers, and mobile network operators and service providers. The operators interviewed included those providing mobile services within Ireland as well as those with operations spanning Europe and beyond. The report is structured as follows:

- Chapter 2 describes the main characteristics of eSIM including OTA capabilities, and how it differs from physical SIM cards, and the different players involved in the ecosystem.
- Chapter 3 provides an overview of the OTA provisioning process and its technical implementation
- Chapter 4, describes the different use cases for OTA provisioning and switching for consumer devices and M2M, and describes the associated customer journeys
- Chapter 5 looks into the impact of eSIM and the associated potential for OTA provisioning and switching on consumer welfare and competition as well as its implications for different players in the ICT value chain
- Chapter 6, elaborates on the current status and outlook for eSIM deployment and take-up in the consumer and M2M space, while forecasts concerning eSIM deployment and uptake for the European and Irish markets are presented in Chapter 7.
- Chapter 8, concludes by bringing together the findings from across the report to provide a future vision for OTA provisioning and switching and highlight the potential role that NRAs could play in making this a reality. Our recommendations have been designed to support the move to all-digital processes in the Irish market. However, they may also bring insights for other countries within Europe and beyond.

1.4 Key takeaways

KEY TAKE-AWAYS

- Switching is an important measure to support choice for consumers and facilitate market entry. The importance of switching was reflected in long-standing provisions in EU electronic communications legislation regarding number portability.
- The recently introduced EU Electronic Communications Code (EECC) further strengthens provisions on switching by requiring NRAs to promote “over-the-air” provisioning – i.e. fully digitised processes (Article 93(6)). Article 106(6) also enables NRAs to establish the details of the switching and porting process, which should include a requirement, where technically feasible, for the porting to be completed through OTA provisioning.
- ComReg has a duty in line with the EECC to promote competition, protect consumer interests and contribute to the development of the internal market. ComReg has further elaborated commitments in this regard in its national strategy.
- OTA provisioning and switching could make significant contributions to easing the consumer sign-up and switching process, as well as supporting competition amongst existing players and new entrants, and facilitating connectivity for new devices and facilitating the development of new innovative services.

2 What is eSIM and OTA?

In this chapter, we describe:

- The main characteristics of eSIM including OTA capabilities and differences with traditional SIMs (section 2.1)
- The players involved in the eSIM ecosystem (section 2.2).

Key take-aways are summarized at the end of the chapter.

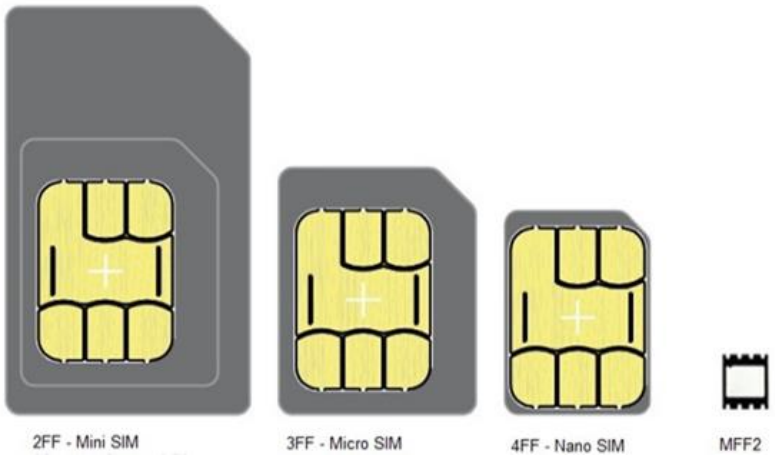
2.1 Key characteristics

A removable smart card – the Subscriber Identity Module (SIM) – was a key component of the first digital cellular mobile Global System for Mobile Communication (GSM) network, also called 2G. Since then, the SIM has been used in every mobile telecommunication network associated with the 3rd Generation Partnership Project (3GPP) (including 3G, 4G and 5G). The module contains the International Mobile Subscriber Identity (IMSI) as well as credentials that are necessary for the identification and authentication of the subscriber to enable connection to the mobile network.

The SIM card itself is a tamper resistant microprocessor card with an operating system, storage and build-in security features that prevent unauthorized individuals from accessing, retrieving, copying, or modifying the subscriber's IMSI and credentials. The different form factors most commonly used today and defined by the standardization bodies ISO/IEC and ETSI, are shown in Figure 2-1.[18]

18 The original SIM card "first" form factor (1FF) with the size of a typical business card (85.6 mm x 53.98 mm x 0.76 mm) as defined in ISO/IEC 7810:2003, ID 1, is omitted in the figure as it is not used in modern devices anymore.

Figure 2-1: Traditional SIM and eSIM form factors and dimensions



Source: ISO/IEC 7810:2003, ID-000 for 2FF; ETSI TS 102 221 for 3FF and 4FF; ETSI TS 102 671 for MFF2. Graphic by EMnify.

Besides the removable SIM cards, which come in the four form factors 1FF, 2FF, 3FF and 4FF, there is also an option to install an embedded SIM called MFF1/MFF2[19]. From a technical perspective, the MFF SIM works in the same way as a regular, removable SIM card but is vacuum-sealed and can be soldered directly onto the circuit board of the device during manufacturing. This makes the chip more shock resident and protects it from corrosion.

The GSMA defined embedded SIM (eSIM) is distinguished only from the MFF by its software and technical capabilities and importantly, the eSIM is not defined by the form factor used. In fact, the GSMA defined eSIM is available in all modern form factors such as the removable 2FF, 3FF and 4FF, and the embedded form factors such as MFF2. Likewise, a SIM which comes in form factor MFF2, i.e., soldered onto the circuit board of the device, does not necessarily have to be an eSIM.[20] Thus, the focus of eSIM relates to its functionality, rather than on its physical form factors. However, the majority of the eSIMs in circulation today are indeed physically soldered and embedded within the device.

Table 2-1 provides an overview of the main differences between traditional, physical SIM cards and eSIMs.

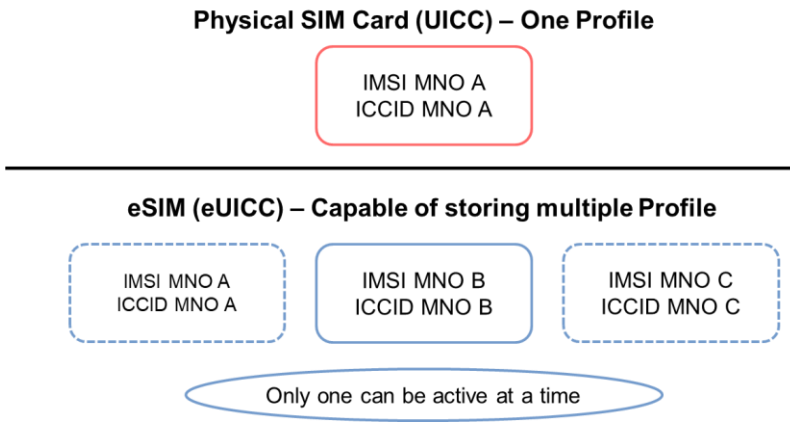
19 Besides these two, there exist also a number of other form factors.
20 See ETSI TS 102 671 V9.0.0 (2010-04) Smart Cards; Machine to Machine UICC; Physical and logical characteristics (Release 9).

Table 2-1: Differences between physical SIM card and eSIM

Traditional SIMs (UICCI)	eSIMs (eUICC)
Carrier specific & contains only one carrier profile	Operator or OEM specific but can support multiple carrier profiles
Carrier profile cannot be replaced remotely	Remote download & management of additional carrier profiles possible
Physical SIM swap is required to change carriers	Eliminates physical SIM swaps. Over-the-air profile management
Different SIM for each carrier	One SIM for multiple carrier

The eSIM contains the same information as the SIM card for identification and authentication between subscriber and mobile network (see Figure 2-2). However, the eSIM additionally enables Remote SIM Management (RSM) and Remote SIM Provisioning (RSP) capabilities, i.e. **Over-the-Air (OTA) provisioning**. This means that a customer can switch operator without physically changing the SIM card but rather by managing existing and downloading new operator credentials, so called SIM profiles, onto the eSIM.

Figure 2-2: SIM profiles on UICC and eUICC (model)



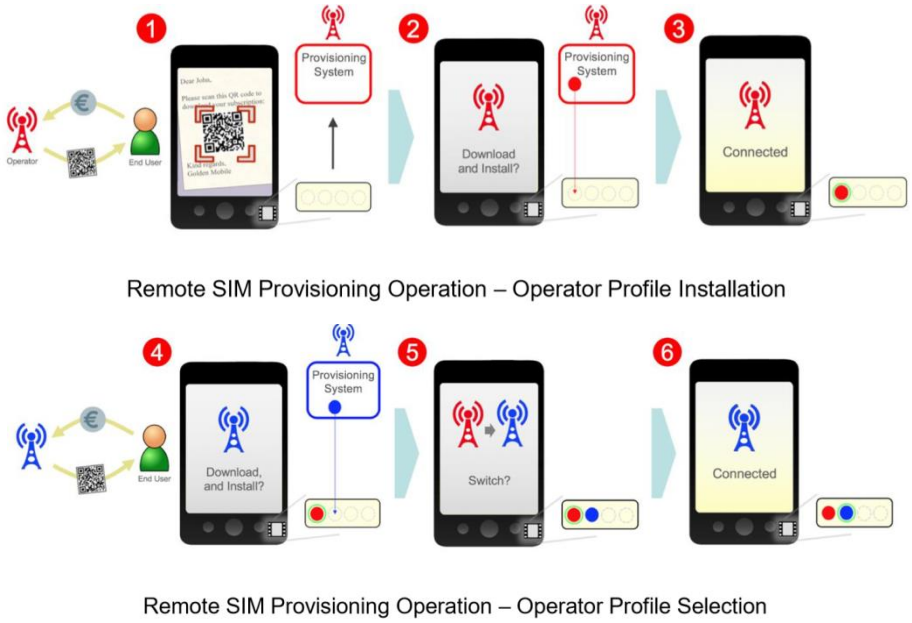
Note: There exist also physical SIM cards that can store multiple IMSIs, however, this is not the case with most SIM cards for the consumer market. Management of profiles, i.e. installation and deletion are not supported on the UICC. SIM profiles may also include security algorithms, OTA and authentication keys and other information used by the MNO. Source: GSMA (2018), eSIM Whitepaper – The what and how of Remote SIM Provisioning. WIK-Consult.

Source: WIK-Consult based on GSMA eSIM white paper (2018) – The what and how of Remote SIM Provisioning.

Figure 2-3 illustrates a high-level consumer remote provisioning process. A customer subscribes to MNO “Red”. The terminal equipment connects to the operator’s provisioning system; (2) downloads the eSIM profile and stores it on the eSIM; and

(3) is then ready for service. Switching between operators works in a similar manner. Following subscription to MNO "Blue", the terminal equipment connects to the new operator's provisioning system; (4) downloads the new eSIM profile; (5) and is ready for service on the new operator's network (6).

Figure 2-3: Remote SIM provisioning operation process (for consumer solutions)



Source: GSMA (2018).[21]

Opportunities for eSIM

OTA or eSIM allows for several new applications. For **machine-to-machine (M2M)** type devices, the original equipment manufacturer (OEM) can insert the SIM into the device circuit board during manufacturing, like any other component, and without the need to determine the MNO at that point. This is because the SIM does not need to be easily and physically accessible in order to connect the device to a mobile network or to switch MNOs. In addition, the equipment containing the eSIM does not need to be easily and physically accessible to provide it with an MNO's profile or to switch between different MNOs. This is especially useful when switching MNOs for devices which are remote and may require regular software updates. Remote provisioning may also simplify provision of profiles and operator switching in use cases involving multiple devices.

Consumer devices can also benefit from eSIM because the device manufacturer can make use of smaller form factors, e.g. MFF2, and still allow end-users to switch MNOs. Embedded form factors may in turn improve device shock and water resistance

21 See GSMA (2018): eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf, page 5-6.

performance and take up less space within the device. The switching process between MNOs for consumers could also potentially be accelerated. With a SIM card, customers must go to a store or order a SIM card online, which takes time to ship. It may also be time consuming for business customers to swap out the physical SIM card in potentially multiple devices that are associated with one contract. With an eSIM, switching MNOs can be reduced to a process of only a few minutes and the customer journey can be fully digitalized (more details on this can be found in the next chapter).

This ease of switching increases use cases for customers nd in addition, presents revenue opportunities for MNOs. Ease of switching facilities opportunities for customers to scale up their mobile service plans by adding new devices like wearables, as well as supporting specific travel services and other applications. It is also important to note that logistics costs associated with distribution of physical SIM cards are not negligible for operators, and thus the rollout of eSIM may be cost-effective, at least in the medium to long term.

2.2 Players involved in the eSIM ecosystem

Delivering OTA via eSIM involves the same players as in the traditional SIM world, however roles and opportunities for some players vary due to changes in the processes and procedures associated with eSIM[22]:

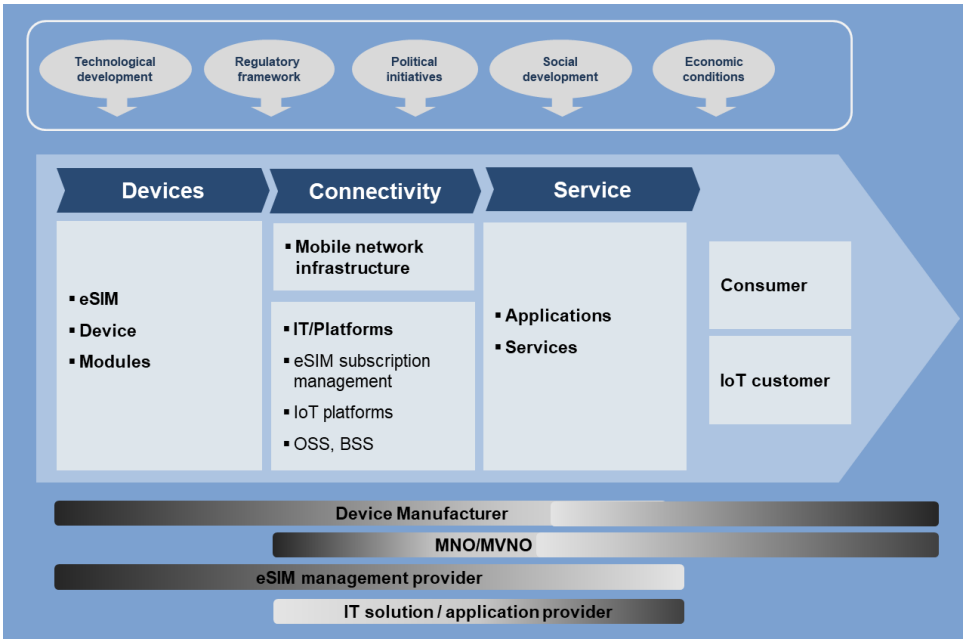
- **Device manufacturers** produce and sell devices to customers, ranging from consumer devices (mainly smartphones, smartwatches, tablets, and new consumer IoT products) to eSIM in machines (mainly cars and many other – typically moving – objects, e.g. containers, bicycles). The main difference compared with a traditional SIM is that they also integrate the eSIM chip into the device. This opens new opportunities for product design and device manufacturers with connectivity and services being bundled with devices. (e.g. by preselecting connectivity providers).
- **MNOs** have a direct link to the customer via the traditional SIM card. To provide services via eSIM they need to set up the required systems to support eSIM profile downloads and updates, integrate the new elements into their existing IT systems (BSS, OSS) and this may require reconsideration of the customer journey. For consumer services, the currently close relationship with the customer supported by the physical SIM may be weakened. However, for IoT services, new opportunities arise.

22 See also See e.g. GSMA (2017): The future of the SIM: potential market and technology implications for the mobile ecosystem, February 2017, https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=28999708&file=The%20future%20of%20the%20SIM%20potential%20market%20and%20technology%20implications%20for%20the%20mobile%20ecosystem.pdf , page 6-7.

- **MVNOs**, especially those with a special focus e.g. on travel, IoT or pure online distribution, may potentially be able to streamline their processes and develop fully digital offers for their customers.
- **SIM manufacturers** traditionally produce SIM cards and offer some additional SIM management functions. While they no longer produce physical SIM cards in the eSIM world, they may have new opportunities as **eSIM subscription management providers** and might also expand to offer other services and applications.
- eSIM opens various opportunities for a wide range of providers in the field of **IT solutions and applications,** e.g. for BSS orchestration.

On the consumer side, eSIM is likely to make a substantial contribution to increasing switching options, as well as facilitating the use of multiple providers. These use cases and the underlying processes are further described in chapter 4.

Figure 2-4: eSIM ecosystem



Source: WIK-Consult.

The success of eSIM depends on the interaction of all players involved. However, realizing the benefits of this technology is likely to be affected by various factors including technical, regulatory, political, social, and economic conditions.

To some extent, these factors are interdependent, e.g. technological development could be promoted by market players and/or in connection with regulatory strategies and initiatives.

2.3 Key take-aways

KEY TAKE-AWAYS

- The eSIM is typically pre-installed within the device. It contains the same information as a traditional SIM card but differs in that it can contain multiple user profiles on the same device, which can be activated and switched remotely.
- Key benefits of the eSIM include its small form factor, its fully embedded (protected) nature and OTA capabilities. These features enable consumers to benefit from fully digitised processes for sign-up and switching as well as enabling a wider range of devices in the field to be connected.
- Alongside the traditional players in the mobile value chain (MNOs, MVNOs, device manufacturers and SIM manufacturers), eSIM and its associated applications has also opened up new opportunities for eSIM subscription management providers and providers of IT solutions and applications.

3 How does OTA provisioning and switching work from a technical perspective?

In this chapter, we provide an overview of:

- the OTA provisioning and switching process and its technical implementation (section 3.1);
- eSIM specifications developed by the GSMA (section 3.2)and the difference between processes for M2M (section 3.3) and consumer devices (section 3.4);
- GSMA compliance and security requirements (section 3.5); and
- mobile number portability processes (section 3.6).

Key take-aways are summarized at the end of the chapter.

3.1 Overview of OTA provisioning and switching processes

Depending on the context, OTA can refer to different applications and services. In its broadest sense, OTA means wireless. Different OTA applications have existed for a long time in the context of wireless technologies and date from before the introduction of eSIM technology.

With respect to physical SIM cards, OTA can be defined as a wireless technology used to communicate with a SIM card, download applications to a SIM card, and update and modify data stored on the SIM card without being physically connected to the card and without having to re-issue it. OTA allows an MNO to introduce new SIM services or to remotely change the content of SIM cards which are already in the field (e.g. changing the preferred roaming partner) quickly and inexpensively. OTA is based on a client/server architecture, where on one side there is a set of operator back-end systems (customer care, billing system, application server, etc.) and on the other side, there is a SIM card in each device. The operator's back-end systems send service requests to an OTA gateway (or platform), which converts the requests into Short Messages and forwards them to a Short Message Service Centre (SMSC), which transmits them to one or more SIM cards in the field[23].

In terms of eSIM technology as specified by GSMA, SIM provisioning over the air is referred to as a wireless technology used for the provisioning of SIM profiles. In this context, OTA activation, provisioning and switching describes the management of SIM profiles, which are stored on the embedded universal integrated circuit chip (eUICC) as described in section 2.1. OTA plays an integral role in the switching process for eSIM (e.g. a customer switching between two operators), since the customer does not have to exchange the physical SIM and can switch between different operators while using

23 https://www.thalesgroup.com/en/markets/digital-identity-and-security/technology/ota.

the same eSIM. In this sense, eSIM together with OTA technology make it possible for the mobile subscriber to change subscription and operator remotely, potentially with a fully digitalized customer journey, which is one of the evolutionary benefits that eSIM brings to the customer.

3.2 Evolution of eSIM standards

Currently, the contents of a SIM can be securely downloaded into a 'Secure Element' that can be permanently embedded inside any type of device. However, distributing digital eSIM profiles requires a specific IT architecture on the operator's side and an eSIM equipped device on the customer's side.

An ecosystem of trusted platforms and players has been defined by the GSMA,[24] creating the eSIM solution as de facto standard for eSIM. Based on this, various organizations such as European Telecommunications Standards Institute ETSI (SIM functionality), Global Platform (Smartcard security domain concepts) and Trusted Connectivity Alliance support the interoperability of solutions.

This results in an extension of the existing technology, while keeping most processes associated with mobile network operations the same as for the regular SIM card[25]. The GSMA also provides operational services to enable eSIM services to be securely brought to market. Finally, GSMA provides an operational (non-unique) capability that provides a mechanism for eSIM devices and networks to establish communication links, if needed.[26]

In December 2013, the GSMA released version 1.1 of the "Remote Provisioning Architecture for eUICC" and the associated Technical Specification, creating the de-facto standard for Subscription Management systems for machine-to-machine (M2M) and IoT devices[27], thereby allowing eSIMs to be managed over the air. A strategic weakness of this specification was the absence of an interoperable profile download mechanism. This gap was closed with the release of the Interoperable Profile Description specification by SIMalliance in May 2015 and the GSMA SGP.02 v3.0 specification in June 2015[28]. In 2015, GSMA began work on the Subscription Management (SM) specifications for consumer devices, resulting in the release of the

24 The GSMA is an association that also represents the interests of mobile operators worldwide, uniting more than 750 operators with almost 400 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors.

25 Achelos (2020): eSIM handbook , https://iot.achelos.com/en/esim-management.html#:~:text=When%20in%201991%20the%20first,module%20storing%20subscriber%20specific%20information.

26 GSMA Discovery Services.

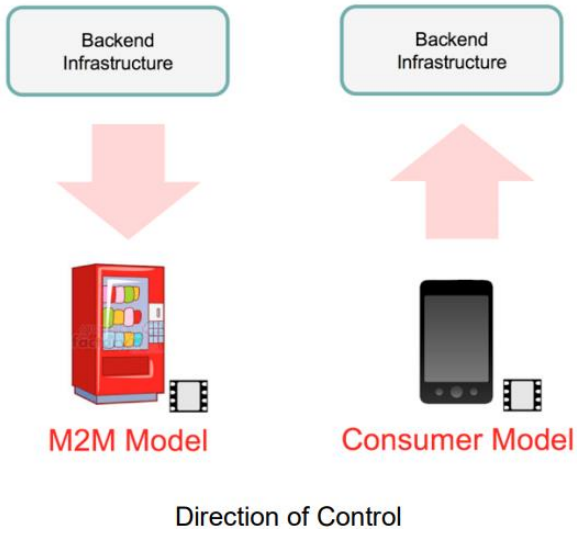
27 https://www.gsma.com/iot/wp-content/uploads/2014/01/1.-GSMA-Embedded-SIM-Remote-Provisioning-Architecture-Version-1.1.pdf.

28 https://www.gsma.com/iot/wp-content/uploads/2012/03/SGP-02-v3-0.pdf.

first version in January 2016[29] V 1.0, updated to v2.2 in 2017[30]. Hence, to understand the technical challenges associated with the eSIM, one must consider several specifications and a need to ensure interoperability with existing standards, defined by different industry groups.

At a high level there are two different GSMA Remote SIM Provisioning solutions for which the fundamental difference is the direction of control as illustrated in Figure 3-1.

Figure 3-1: Two different GSMA Remote SIM Provisioning solutions



Source: GSMA (2018). eSIM Whitepaper – The what and how of Remote SIM Provisioning.

As the combination of the two different solutions with their different requirements into a single technical solution and architecture is not currently practical, the GSMA has specified two solutions, one for M2M and one for consumer applications:

- Machine-to-Machine (M2M) solution: Here, the M2M or IoT device normally operates without any local human control over connectivity. This means that connectivity is managed by the operator's backend infrastructure which will select the Profiles to be downloaded and to be enabled/disabled depending on the selected operator.
- Consumer solution: This solution is required where there is a human-interface. Consumer solutions require a high level of interaction with the end user, the principle being that the end user is familiar with the operation of the end user interface and actively chooses their network connectivity provider. The consumer solution is also often used for devices targeted at the consumer market.

29 https://www.gsma.com/newsroom/wp-content/uploads/SGP.22-v1.0.pdf.
30 https://www.gsma.com/newsroom/wp-content/uploads//SGP.22_v2.2.pdf.

3.3 M2M architecture and ecosystem

The GSMA initially developed the M2M solution[31] as the first Remote SIM Provisioning solution, due to the immediate commercial need for technical solutions that support B2B deployments, alongside regulatory requirements for the launch of services such as eCall[32].

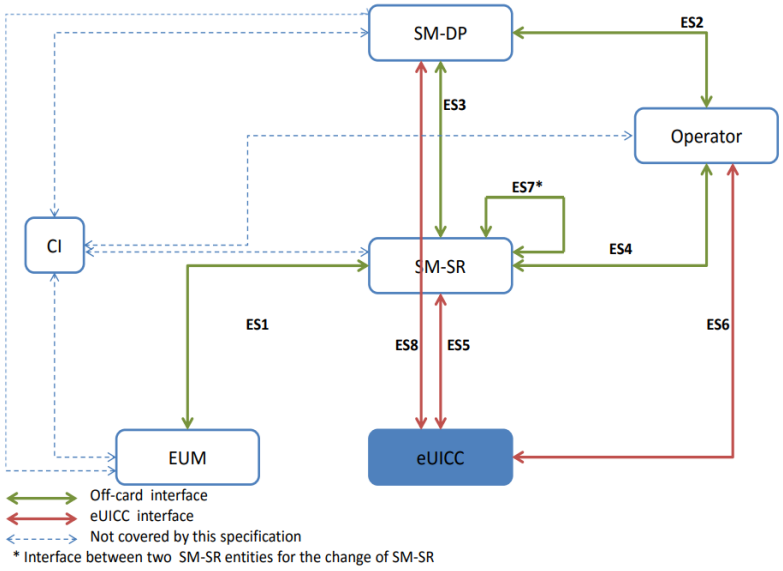
3.3.1 Technical specifications and architecture

With the M2M specification, Remote SIM Provisioning typically requires no or very limited interaction with an end-user and therefore is a server driven model (push model) for provisioning and remote management of operator Profiles. The reason for this is that many devices will be located where physical human access may be difficult or even impossible, or the device has no User Interface (UI) capability, such as a smartphone. The solution is organized around the following elements: the SM-DP (Subscription Management - Data Preparation), the SM-SR (Subscription Management - Secure Routing), and the eUICC as depicted in Figure 3-2.

The subscribers typically come from the automotive sector or other vertical industries (utility, healthcare, security, etc.)[33] and end users are served through corporate subscriptions with a connectivity provider or mobile operators.

31 https://www.gsma.com/iot//wp-content/uploads/2015/02/CLP.05-v1.0-BPD.pdf, page 6.
32 https://ec.europa.eu/transport/themes/its/road/action_plan/ecall_en.
33 Industrial M2M and IoT service providers, including cellular modules, sensors, trackers, meters, and many other components, all applied in an industrial and non-end-user interactive environment.

Figure 3-2: M2M eSIM Ecosystem and Architecture



Source: GSMA (2015): https://www.gsma.com/iot/wp-content/uploads/2015/02/CLP.05-v1.0-BPD.pdf.

All the ES interfaces shown in Figure 3-2 are detailed throughout SGP.02[34].

The operator is the owner of the user/device profile and can be either of the following:

- Operator which provides the bootstrap profile: An operator owns the profile and has contracted to provide the bootstrap profile[35], which allows the device to access a mobile network for provisioning purposes
- Operator providing the operational profile: An operator owns the profile and has contracted to provide the operational profile that enables the device to access a mobile network for provisioning purposes.

There are the following main function blocks:

The SM-DP (Subscription Manager-Data Preparation) represents the profile owner and manages the profiles of the mobile network operator. It prepares operational and bootstrap profiles to be securely provisioned on the eUICC and manages the installation of these profiles on an eUICC. It also securely encrypts the network access data (i.e. the profile) and enables secure remote provisioning on the eSIM.

The SM-SR (Subscription Manager-Secure Routing) is responsible for eSIM management and securely delivers the encrypted operator profile to the eSIM. It acts as

34 https://www.gsma.com/iot/wp-content/uploads/2014/10/SGP02-Remote-Provisioning-Architecture-for-Embedded-UICC-Technical-Specification-v2.0.pdf.

35 A bootstrap profile enables the chip to connect to a mobile network when an IoT devices is turned on. An operator can then provide the chip with its preferred SIM vendor's profile, which overrides the bootstrap profile.

the gateway between the SM-DP and the eUICC. The SM-SR remotely manages the eUICC during its lifetime using a specific set of operations, such as loading, activating, deactivating, and deleting profiles on it. The SM-SR selects the most relevant transport protocol based on the operation being executed and according to the capabilities of the targeted eUICC and device. The SM-SR can be linked to multiple SM-DPs.

The eUICC (embedded Universal Integrated Circuit Card) is a secure element that contains one or more subscription profiles. Each profile allows the eUICC to function like a removable SIM card issued by the operator which created it. An eUICC can be built with any form factor, from the traditional removable card to embedded formats that are soldered into devices. In the M2M case, one eUICC is always linked only to one SM-SR. Also uniquely to the M2M case, the eUICC always needs to have either a bootstrap profile or a full profile from the operator installed to ensure communications between the eUICC and the SM-SR.

EUM (eUICC manufacturer) is the supplier or manufacturer of the physical eUICC modules, including their operating systems and applications. EUMs receive data from the network operator, generate personalization data and personalize the eUICC. The following activities are involved (these may be performed by a single organization or split between multiple vendors): Preparation of card personalization, processing of input data, generation of personalization data, card personalization and output file issuance. EUMs must hold the appropriate GSMA security accreditation and possess the associated certificate[36] before they can deliver personalized eUICCs for use. In addition, the EUM issuing the eUICC Remote Service Provisioning (RSP) Public Key Infrastructure (PKI) certificate must ensure that the eUICC product has achieved GSMA compliance from both a security and functional perspective.

CI (Certificate Issuer) Issues certificates for Embedded UICC remote provisioning system entities and acts as a trusted third party for the purpose of mutual authentication of the entities of the system according to the policies specified in SGP.14[37]

In cases where the eSIM is supplied with connectivity in place (which is common for M2M applications), a bootstrap profile is loaded onto the eUICC by the device manufacturer. The process of delivering the bootstrap profile to the eUICC is based on commercial agreements and is not part of the GSMA specifications, and thus a number of proprietary solutions have been developed for various manufacturers. This may cause dependencies (lock-in) from suppliers and operators (see chapter 5 for a detailed elaboration).

36 A certificate issued to a GSMA accredited EUM which can be used to verify eUICC certificates.
37 https://www.gsma.com/iot/wp-content/uploads/2017/04/SGP.14_v1.1.pdf.

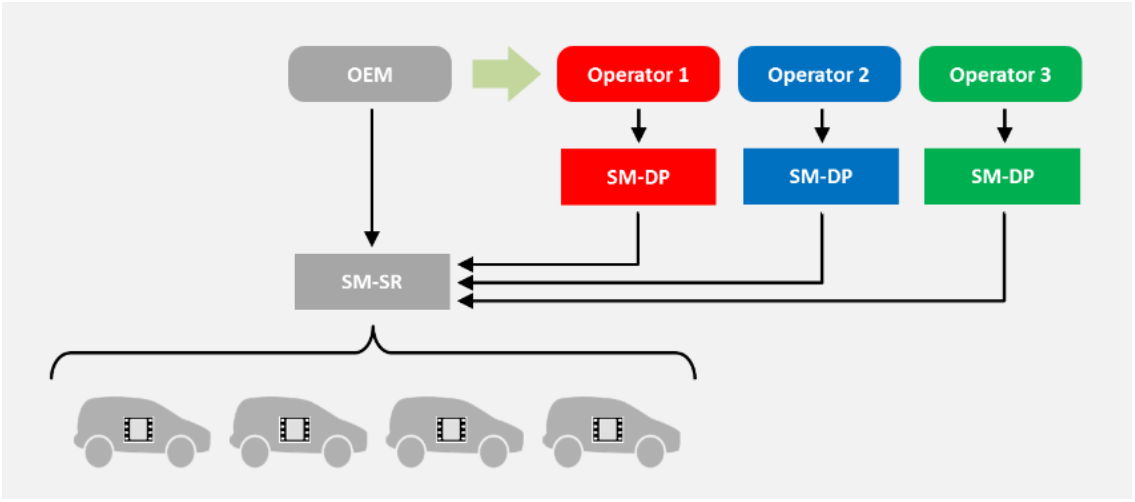
3.3.2 Management Business Models for M2M

The GSMA specification for M2M permits a wide range of implementation scenarios. These scenarios help in understanding how customers can switch between different operators from a technical perspective. Specifically, the GSMA has identified three main eSIM management models:

- **Model 1: Original Equipment Manufacturer (OEM) manages SM-SR**

In this model, each operator has his own SM-DP. All SM-DPs are connected to one SM-SR which is managed by the OEM as depicted in Figure 3-3.

Figure 3-3: GSMA eSIM Management Business Models for M2M, OEM managed SM-SR



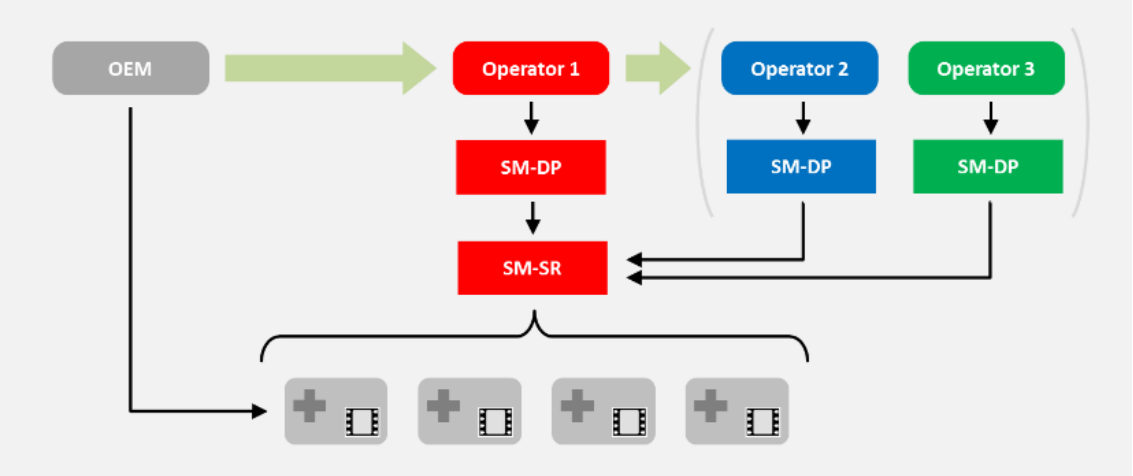
Source: GSMA Interview.

This scenario could involve a global manufacturer of connected electric cars (OEM), wishing to manage its own SM-SR, to have a tight control over connectivity. This SM-SR manages the entire fleet of vehicles. The OEM sets up several contracts with different mobile network operators, so that they can achieve global coverage. Each of these operators manage their own SM-DP, but they are all linked to OEM's SM-SR. The OEM also sets up a contract with one of the operators to provide a pre-installed bootstrap profile, allowing an initial mobile connection.

- **Model 2: Single operator managed SM-SR**

In this model, each operator has its own SM-DP. All SM-DPs are connected to one SM-SR which is managed only by operator 1 as depicted in Figure 3-4.

Figure 3-4: GSMA eSIM Management Business Models for M2M, Single operator managed SM-SR



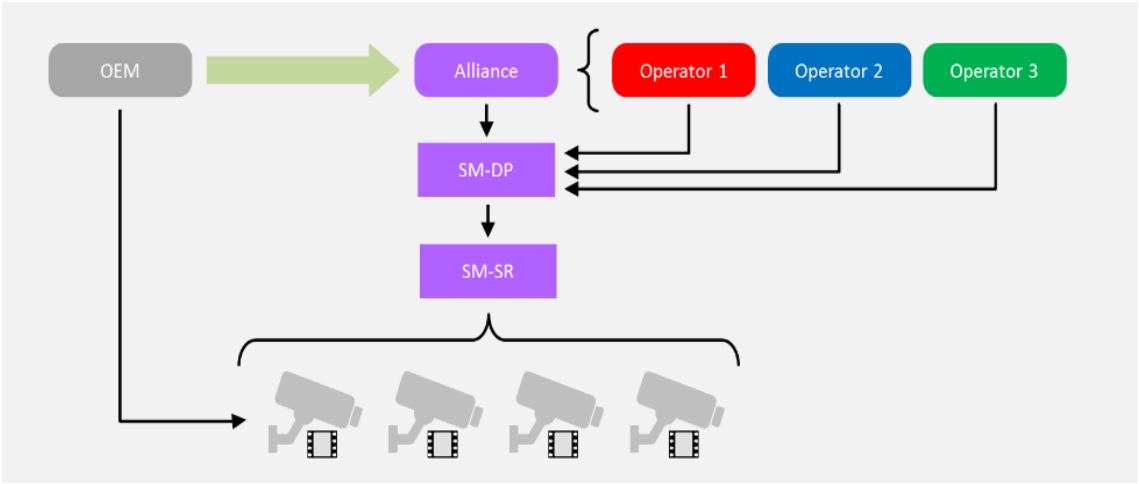
Source: GSMA Interview.

This scenario might involve an OEM providing 'in the field' medical equipment for worldwide use. As it is not their core expertise, this OEM sets up a contract with Operator 1 to provide device connectivity on a global basis. In turn, Operator 1, sets up a contract with Operator 2 and Operator 3, to provide global coverage. Operator 1 also provides a pre-installed bootstrap profile, to allow initial mobile connection for new devices. Each operator manages their own SM-DP, but these are all linked to an SM-SR operated by Operator 1. This SM-SR manages the entire estate of the OEM's products.

- **Model 3: Alliance managed SM-DP and SM-SR**

In this model, the three operators do not host or manage the SM-DP and SM-SR on their own. Instead, an M2M alliance manages both as depicted in Figure 3-5.

Figure 3-5: GSMA eSIM Management Business Models for M2M, Alliance managed SM-DP and SM-SR



Source: GSMA Interview.

This scenario might be relevant for an OEM providing artificial intelligence enabled security cameras as part of a global service offering. For world-wide connectivity, this OEM sets up a contract with one of the M2M alliances. This alliance manages their own SM-DP and SM-SR and sets up a contract with all the operators within the alliance to provide subscription credentials directly to the Alliance SM-DP, which in turn, creates suitable profiles on demand. The Alliance also provides a pre-installed bootstrap profile, to allow initial mobile connection for new devices. The Alliance SM-SR manages the global estate of the OEM's security cameras.

3.4 Consumer eSIM Ecosystem and Architecture

In contrast to the M2M specifications, the consumer solution requires that all operations with subscription profiles are under the control of the end user, or at least subject to end user approval. This is done through an end-user interface on the device. For companion devices (e.g., wearables), the end-user interface can be provided on a primary device such as a phone or tablet, which can offer a more user-friendly interface for the required interactions.

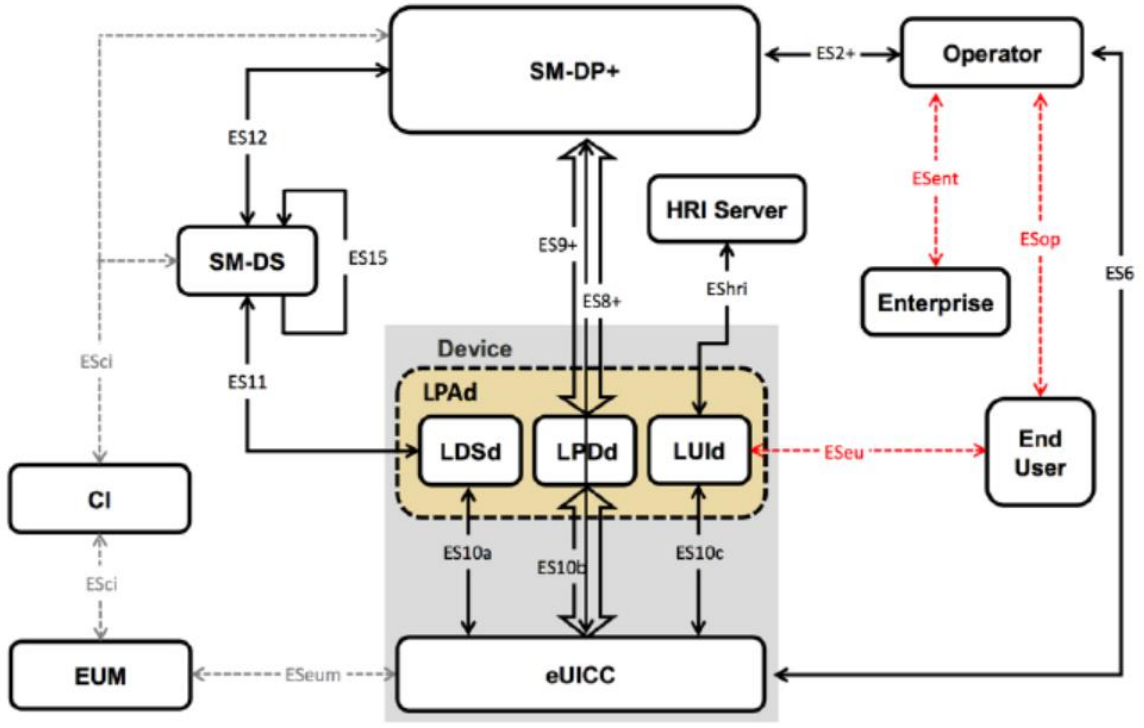
The consumer solution differs from M2M in that the request and change of profiles must be initiated by the consumer, who is typically the owner of the device and has a contract with a connectivity provider (MNO/MVNO).

3.4.1 Technical specifications and architecture

The GSMA released the first iteration of the Consumer RSP solution in 2016[38], which was developed to handle consumer device provisioning scenarios. The primary target was network operators providing connectivity for companion devices such as wearables, while smartphone support was addressed in the next iteration. Its basis is an eUICC element with many security and communication concepts like those of M2M. Similar to the M2M solution, there are multiple stakeholders involved in the remote provisioning process. Some of the stakeholders have a similar role to the entities involved in the M2M solution, such as the CI, the EUM, and the service provider.

The consumer eSIM architecture consists of four main elements: the SM-DP+ (Subscription Management - Data Preparation +), the SM-DS (Subscription Management - Discovery Server), the LPA (Local Profile Assistant) and the eUICC, as depicted in Figure 3-6.

Figure 3-6: Consumer eSIM Ecosystem and Architecture



Source: GSMA white paper 2018 (https://www.gsma.com/esim/wp-content/uploads/2018/12/esim-whitepaper.pdf)

38 https://www.gsma.com/newsroom/wp-content/uploads/SGP.22-v1.0.pdf.

The operator plays a similar role as in M2M solution, but different deployment scenarios might apply e.g. hosting the SM-DP+ platform on its premises (backend systems), making the data/profiles available for a third party e.g. a solution provider that provides an end-to-end service to the subscribers.

The SM-DP+: SM-DP+ is an extension of the SM-DP discussed in relation to the M2M solution. It is a platform responsible for creating, allocating and downloading a dedicated and functional eSIM profile as well as all eSIM profile management operations on the eUICC (enable, disable, update, delete). From a security perspective, the SM-DP+ also protects the operator's credentials (profile credentials) on the server. It is given the "+" designation because it effectively combines the SM-DP and SM-SR functions in the M2M solution.

The SM-DS (Subscription Management-Discovery Server) is a server that allows an eUICC to determine if a profile has been made available for download as well as the location of the SM-DP+ from where to download it. It makes it possible for an SM-DP+ to connect to the eUICC without having to know which network the device is connected to. The publisher of the profile can notify the availability of the profile by using the SM-DS. Importantly, this service remains optional and is a product provided by the GSMA to facilitate the provisioning process between the SM-DP+ and the eUICC.

eUICC: In the consumer solution, the eUICC serves the same high-level purpose as in the M2M solution. However, the implementation is different to support end-user interaction within the consumer solution. The eUICC has modifications to support the Local Profile Assistant (LPA) for end-user interaction, as shown in Figure 2-3. As there is no SM-SR necessary in the consumer specification, the eUICC can directly connect to any and multiple SM-DP+ entities.

The Local Profile Assistant (LPA) is another new function in the remote provisioning ecosystem of the consumer solution. It provides local eUICC profile management and user interface integration capabilities for end-user profile downloads and management tasks that may be subject to operator business rules. LPA is an application interface that may be part of the device software or a proprietary application that does not belong to the device/eUICC manufacturer. The main functions of the LPA may also be built into the eUICC. The LPA module included in the device provides the following three main functions,[39] as shown in the brown box in Figure 2-3 (functions implemented in the device):

- **Local Profile Download (LPD)** This plays a proxy role for the efficient download of a profile package. This function depends on network, device and eUICC capabilities;

39 A detailed description of LPA eUICC interoperability and functionalities can be found under: https://www.gsma.com/newsroom/wp-content/uploads/SGP.21_v2.1.pdf.

- **Local User Interface (LUI)** This function allows local profile management on the device by the end-user, enabling the end-user to exercise his or her own preference.
- **Local Discovery Service (LDS)** Retrieves the SM-DP+ address from the SM-DS (supporting the “pull” model) which is then utilized by the LPA to locate the SM-DP+ for profile downloading.

Unlike the M2M solution that only allows connection to one server, the consumer solution allows connection of any eUICC and SM -DP+ if they use the same root PKI certificate, which significantly increases the flexibility of the consumer eUICC. A consumer solution is technically different from an M2M solution and there are clear technical barriers that prevent one from acting as the other and vice versa. However, introducing customizations that result in the same overall architecture being able to serve both scenarios is possible in theory. In this case, the connectivity provider would make an eSIM profile available on the SM -DP+ server for download and provision the profile through the companies’ IT system (e.g. dedicated device entitlement servers) from which their devices can be remotely controlled.

3.4.2 eSIM Management Business Models for Consumer

Under the current GSMA consumer specification, a wide range of implementation scenarios can be realised. These scenarios help in understanding how the SM-DP+/s of different operator/s can be managed from a technical point of view. The GSMA has identified three main deployment models:

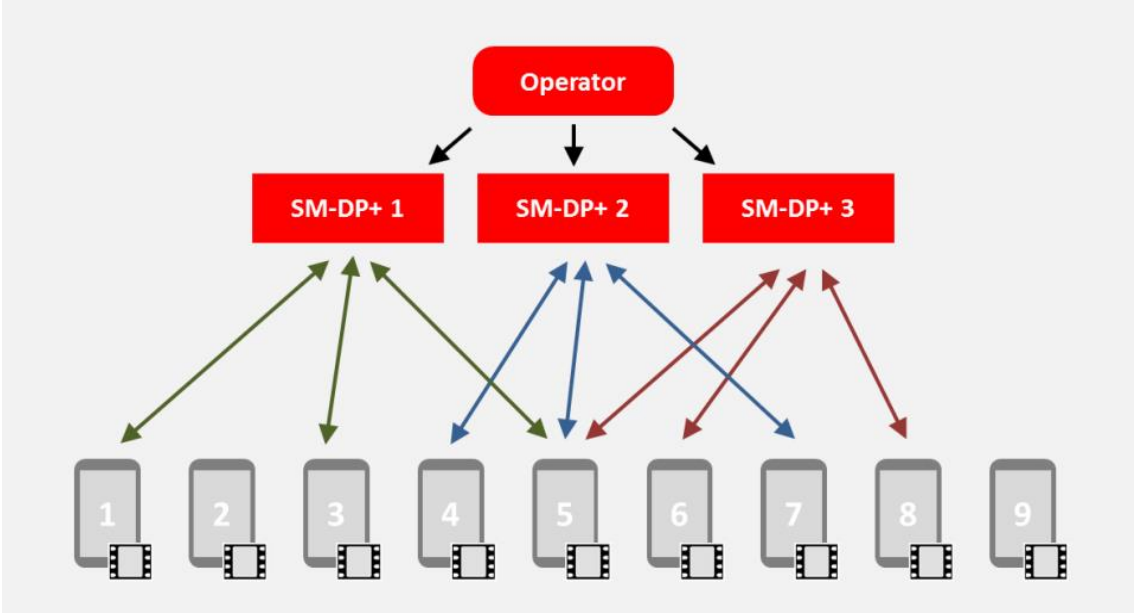
- **Model 1: Each operator manages their own SM-DP+**

In this model, each operator manages their own SM-DP+ entity, which can create and distribute profiles on behalf of that operator. This SM-DP+ physical infrastructure may be located within the data centre in the operator’s country of operation. Alternatively, the SM-DP+ may be a “managed service” provided by a third-party hosting infrastructure in the same country as the operator, or a different country.

- **Model 2: A single operator manages multiple SM-DP+**

In this model, an operator manages multiple SM-DP+ as depicted in Figure 3-7.

Figure 3-7: GSMA eSIM Management Business Models for Consumer; A single operator manages multiple SM-DP+



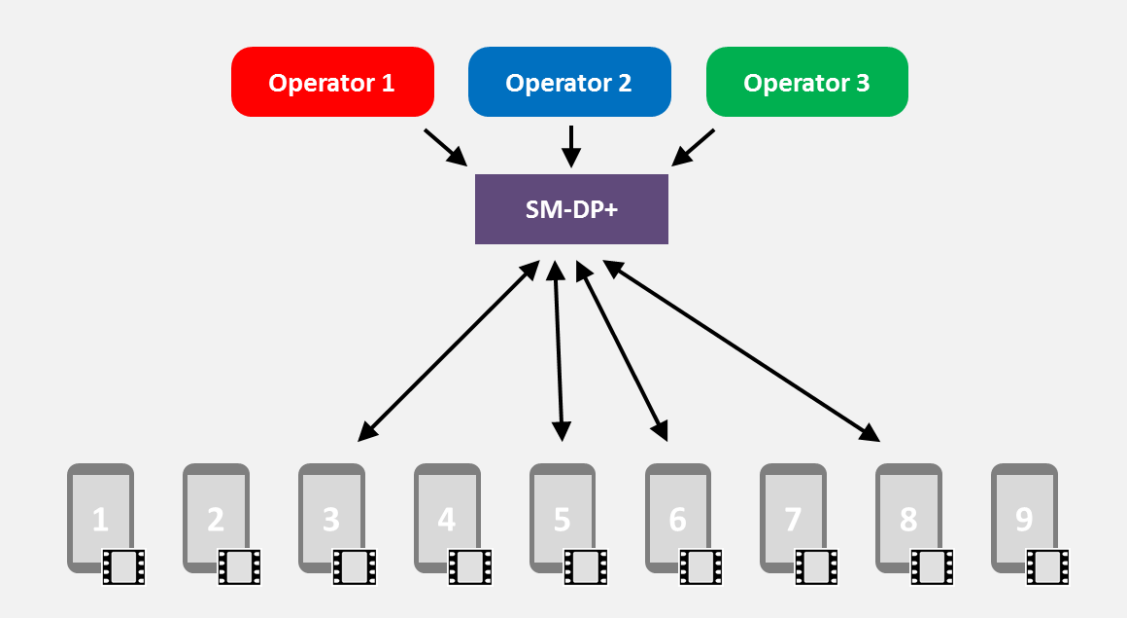
Source: GSMA Interview.

This scenario considers an MNO who manages three separate SM-DP+ entities. The first entity is used exclusively for the download of profiles to any device, while the second one is used exclusively for the processing of Remote Profile Management (RPM) commands. The third one is used exclusively for enterprises (both profile download and RPM).

- **Model 3: Shared SM-DP+ between Operators**

In this model, multiple operators share one SM-DP+ entity as depicted in Figure 3-8.

Figure 3-8: GSMA eSIM Management Business Models for Consumer; Shared SM-DP+ between Operators



Source: GSMA Interview.

This deployment scenario can be a very efficient solution for a large global mobile operator with operations in several countries. Rather than each operator within the group managing their own SM-DP+, in this scenario a global MNO would rely on a managed service provided by a third party, delivered to all the operators in the group. This scenario could also be relevant for three relatively small operators which share between them a single SM-DP+ to reduce operating costs.

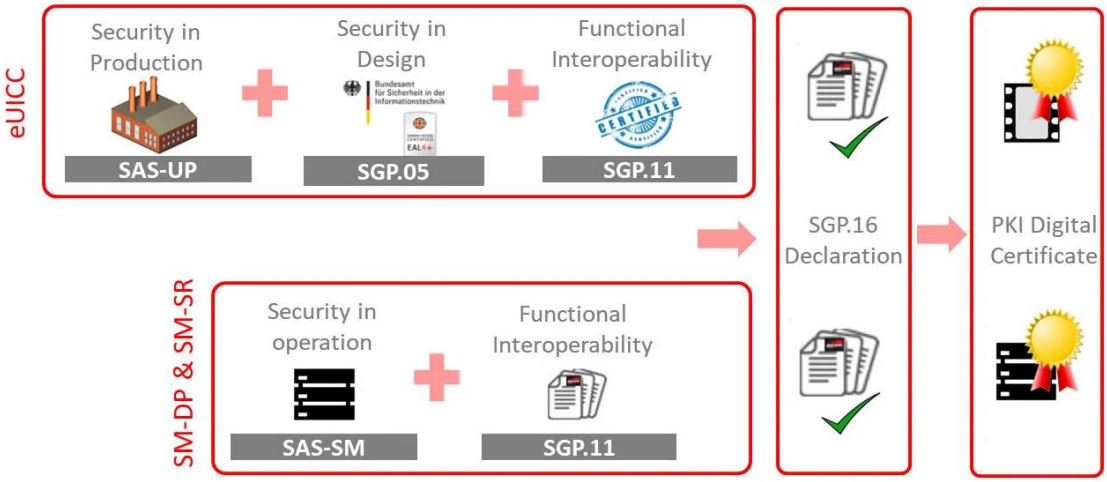
3.5 GSMA Compliance and security requirements

Since the eSIM ecosystem involves a number of players, it is important to ensure that this ecosystem is secure and interoperable. In this context, the GSMA has worked on compliance frameworks for both M2M and consumer remote provisioning.

The interaction between the subscription management servers - SM-DP, SM-SR for M2M and SM-DP+, SM-DS for consumer - and eUICC requires an end-to-end security (authentication), as it relies on digital certificates (PKIs) or pre-shared keys (PSKs) that are revoked in the event that there are security issues. GSMA PKIs play an essential

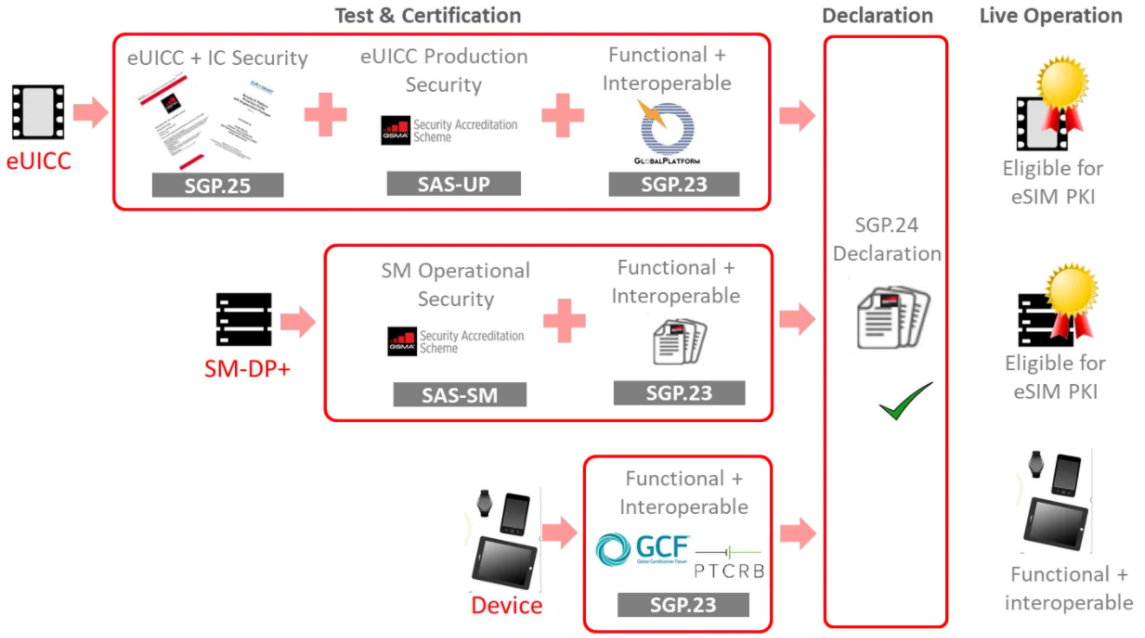
role within the GSMA eSIM remote provisioning solutions. They enable eUICC and the subscription management entities to identify and provide authentication within the GSMA remote provisioning ecosystems. The compliance requirements focus on security assurance and interoperability. Figure 3-9 illustrates the compliance framework for M2M eSIM, whereas Figure 3-10 depicts the framework for the consumer eSIM ecosystem.

Figure 3-9: GSMA compliance framework for the eSIM M2M solution



Source: GSMA Compliance https://www.gsma.com/esim/what-is-m2m-compliance/.

Figure 3-10: GSMA compliance framework for the eSIM consumer solution



Source: GSMA Compliance, https://www.gsma.com/esim/compliance/.

The GSMA plays the role of the Policy Authority for the nomination of PKI Certificate Authorities able to issue PKI certificates for SM servers (SM-DP&SM-SR, or SM-DP+) and eUICCs that are compliant with the GSMA specifications. GSMA PKIs are managed by GSMA Certificate Issuers (CIs); organisations recognised by GSMA as Certificate Authorities. There are currently two security certification partners that are listed as GSMA Certificate Issuers; Cybertrust[40], digicert[41].

GSMA provides two security certifications[42] required for each eSIM product:

- Security Accreditation Scheme (SAS) for UICC Production (SAS-UP): This is a well-established scheme through which UICC and eUICC manufacturers subject their production sites and processes to a comprehensive security audit.
- Security Accreditation Scheme for Subscription Management (SAS-SM): a related security auditing and accreditation scheme is available for providers of eUICC subscription management services to ensure industry confidence in the security of remote provisioning for eUICCs,

40 https://www.cybertrust.co.jp/english/.
41 https://www.digicert.com/.
42 http://www.GSMA.com/sas.

GSMA has also developed a eUICC Security Assurance Scheme (eSA) to provide assurance and trust to all stakeholders on the robustness of the implementation of security features on eUICCs. The eUICC security assurance step-by-step guide provides an overview of the steps to be followed to apply for the GSMA eSA scheme as well as the list of GSMA eSA licensed laboratories and GSMA certification bodies[43].

The GSMA's test specifications[44] require not only security, but also functional compliance. Global Platform[45] has created and run a functional test and qualification program for eUICCs based on the GSMA defined test cases. Only eUICC manufacturers, and SM hosting organisations (SM-DP, SM-SR, or SM-DP+) that have successfully been accredited by the GSMA SAS can apply for the necessary certificates from the GSMA Certificate Issuer to participate in the GSMA approved ecosystem.

3.6 Mobile Number Portability (MNP) processes

3.6.1 EU requirements for MNP

Article 30 paragraph 1 of the 2002 Universal Service Directive[46] states that "Member States shall ensure that all subscribers of publicly available telephone services, including mobile services, who so request can retain their number(s) independently of the undertaking providing the service".

Furthermore Article 106 of the 2018 EECC[47] requires Member States to implement a recipient-led MNP process (Article 106, paragraph 6). Furthermore, operators are required to complete the MNP process within a maximum time limit of one working day from the moment of concluding an operator change agreement to the moment when the number is activated with another operator; not exceed one working day's loss of service during the process of changing operator and carry out the overall process within the shortest time possible (Article 106, paragraph 5).

In many European countries, including Ireland, the number porting process (as distinct from the process of switching operator profiles) is already implemented OTA, in a broad sense[48], as consumers do not have to physically send in a physical porting request to the receiving or donating operator and do not have to physically connect their SIM cards to the operators' databases to change phone numbers. This means that regardless of

43 https://www.gsma.com/esim/wp-content/uploads/2021/02/eSA-Scheme-Step-by-Step-Guide_.pdf.
44 https://www.gsma.com/iot/wp-content/uploads/2014/10/SGP-11-Remote-Provisioning-Architecture-for-Embedded-UICC-Test-Specification.pdf.
45 https://globalplatform.org/.
46 DIRECTIVE 2002/22/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCILof 7 March 2002 on universal service and users' rights relating to electronic communications networks and services (Universal Service Directive).
47 Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast).
48 In this context, OTA should not be confused with RSM or RSP as defined by the GSMA.

whether a physical SIM or an eSIM is used, the number porting process is OTA-ready and is separate from the remote provisioning of the operator's profile onto the eSIM or physical SIM.Benefits of fast MNP and switching.

Although EU legislation sets a maximum time limit for number portability, various benchmarking reports suggest that that there are (or have historically been) significant differences in the regulated timeframes for the mobile number portability process as well as in the actual experience of portability between different Member States.

For example, a 2011 report by the OECD[49] shows that in Belgium the time taken was between 1-2 working days for MNP, but 3 workshop days was cited for France and delays as long as 14 working days were cited in the Czech Republic.

Meanwhile, in its 2016 Evaluation report concerning the EU Framework for Electronic Communications, the European Commission reports that as of 2015, the average time mandated in national regulations to port mobile numbers was 1.4 days, while the actual time taken was 4.6 days, with significant variations between Member States.[50] In the 2016 Consumer Markets Scoreboard, consumers across the EU28 reported more problems with switching telecoms services than in a range of other services including banking, insurance, and other utility services.[51]

Challenges in switching, as may be experienced as a result of lengthy MNP procedures can in turn reduce competitive pressure, with impacts on the choices and price available to consumers. For example in research published in 2006,[52] Lyons found that prices were lower and churn was increased in countries which had a shorter (and free) MNP process. A particularly strong lowering effect on retail prices was found in countries which had an MNP standard of 2 hours or less.

3.6.2 MNP in Ireland

Ireland follows a recipient-led MNP process, which enables the porting of personal phone numbers (MSISDNs) from one operator, the donor operator (DO) to another operator, the recipient operator (RO).

The customer initiates the process through the RO. Depending on the customer type, the RO must capture information on the MSISDN(s), subscriber type, DO account number, date/time of the request and date/time of the port (if different). After the customer accepts the port, the RO must validate the customer's mobile number by text, call or by viewing the customer's bill. The customer must then authorise the port by signature, which can be in digital form, or through an audio recording.

49 https://www.oecd.org/sti/broadband/2-4_v2.pdf.
50 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2016:0313:FIN:EN:PDF.
51 Page 83 https://ec.europa.eu/info/sites/default/files/consumer_markets_scoreboard_2016_-_final_lr_en_0.pdf.
52 https://www.tcd.ie/Economics/TEP/2006_papers/TEP9.pdf.

The DO receives the customer request to port from the RO and validates this against the information held on the MSISDN(s) on the DO internal systems. When the port is accepted, the RO adds the MSISDN to the HLR and updates the SRF system so that any calls from the RO network will be routed on-net to the MSISDN.

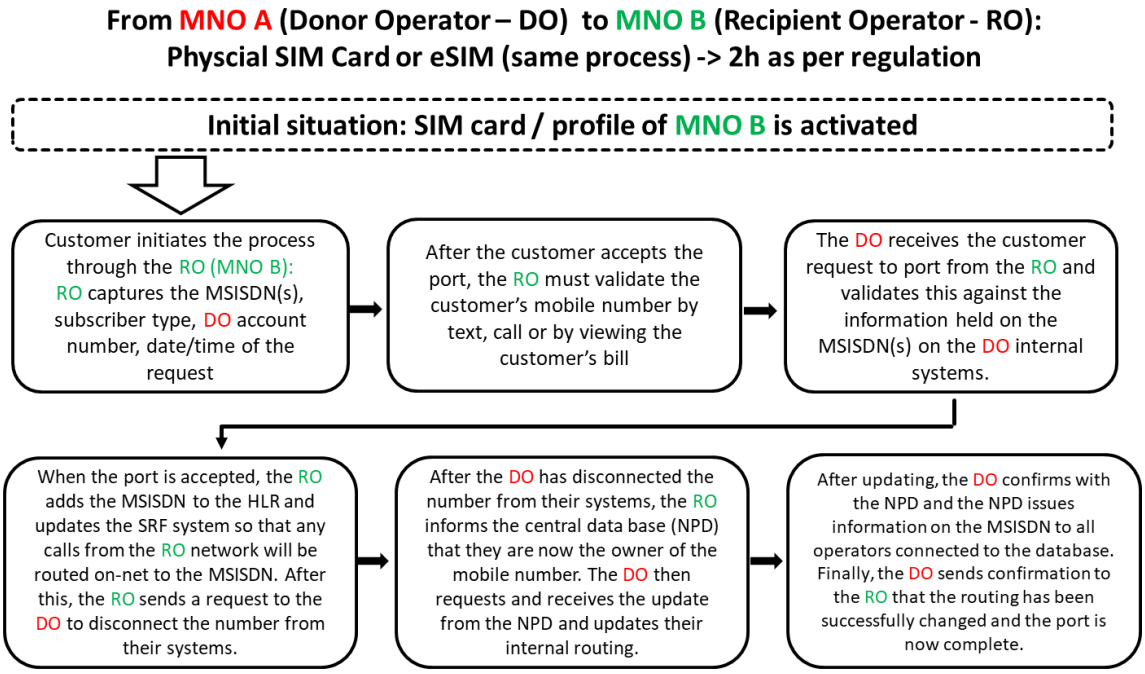
After this, the RO sends a request to the DO to disconnect the number from their systems. After the DO has disconnected the number from their systems, the RO informs the central database (NPD) that they are now the owner of the mobile number. The DO then requests and receives the update from the NPD and updates their internal routing. After updating, the DO confirms with the NPD and the NPD issues information on the MSISDN to all operators connected to the database. Finally, the DO sends confirmation to the RO that the routing has been successfully changed and the port is now complete (see Figure 3-11).

Importantly, the entire process is fully automated and can be, and frequently is, completed within seconds. Specifically, (with the exception of intervention in the event of errors) there are no manual interventions, each request is individually and immediately and swiftly processed, all operators are fully integrated into the processes and the communication between them is fully automated. After each port, the operators' databases that mirror the NPD are updated immediately, so each operator is aware of the port and can route the call to the correct IMSI.

If a customer requests the porting of a large number of phone numbers, for example from a company that is switching providers for their entire fleet of mobile phones, operators build in safety procedures so that a company does not port hundreds of numbers accidentally.[53] There are no other distinctions between customer groups however and post-paid and pre-paid customers are treated in the same way.

53 According to Irish MNOs, the intentional delay in the porting window is about 8 hours for multiline ports for businesses.

Figure 3-11: MNP Process in Ireland



Source: WIK-Consult based on Mobile Number Portability Process Manual Issue 6.01, p.19f.

According to information provided by ComReg, consumer complaints and queries regarding mobile operators regarding MNP account for only 2-3 % of consumer complaints regarding mobile services. This is a very small share of complaints and is low relative to the total number of ports, with only 3 to 7 out of 10,000 ports resulting in a complaint to ComReg.

Regarding the actual speed of the MNP process in Ireland, operators claim in expert interviews that the porting process often only takes minutes, and thus in a significantly shorter time than the 2 hours set by the regulator, as in most cases, there is no human intervention needed and the process is fully automatic. The Irish processes are regarded in this context as efficient by international standards.

3.6.3 Potential, future MNP processes

Furthermore, as seen in the Irish case, remote SIM provisioning as specified by the GSMA does not interfere with existing MNP processes because they are completely separated and consecutive process. With eSIM, the user profile first needs to be downloaded and activated. Only after that, is the personal phone number ported from the previous IMSI of the DO to the new IMSI in the profile of the RO. Furthermore, the process remains the same compared to traditional, physical SIM cards. Hence, there is no action needed for ComReg in the context of OTA RSP.

Also, as shown in the Irish case, there are few complaints about the current implementation of the process and in expert interviews, Irish operators stated that they are satisfied with the current functioning and most importantly, that it will work with GSMA's defined RSP.

However, in the future, MNP processes may be combined with RSP processes not just from a customer journey perspective (see chapter 4) but also on the process level. A patent application by Samsung describes a method of performing integrated mobile number portability and remote SIM provisioning The patent describes an architecture where an MNP Handler (NPD) and SM-DS are combined into one entity.[54] It is possible that in the future this could enable an even faster or easier switching and porting process, though this is not possible to confirm at present.

Despite the patent, from expert interviews, this solution may only come in the distant future and there are no indications that operators or the GSMA are actively working on such a solution. Factors that may currently limit interest in this solution include the low adoption rates of eSIM and the limited reliance on an SM-DS in the download of eSIM profiles. If these dynamics change and interest emerges, this solution could be further investigated.

54 Samsung Electronics CO., LTD.: WO2019054753 - SYSTEM AND METHOD OF PERFORMING INTEGRATED MOBILE NUMBER PORTABILITY AND REMOTE SIM PROVISIONING, Publication Date 21.03.2019, https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2019054753.

3.7 Key take-aways

KEY TAKE-AWAYS

- In its broadest sense, OTA means “wireless”. eSIM together with OTA technology make it possible for the mobile subscriber to change their subscription and operator remotely, potentially with a fully digitalized customer journey.
- The technical specifications for eSIM and associated OTA provisioning capabilities have been established through a number of standards developed by the GSMA within the last decade.
- There are two different GSMA Remote SIM Provisioning solutions for which the fundamental difference is the direction of control. The consumer specification involves the end-users actively choosing their connectivity provider (the pull model), while the M2M specification involves profiles being pushed to the device by the operator’s server (push model).
- The M2M specification involves separate servers for management of the profiles (SM-DP) and the routing, loading, activation and deactivation of profiles (SM-SR). The SM-SR can be managed by the OEM, an operator or an alliance of multiple operators. In contrast, for the consumer specification there is no SM-SR and instead the SM-DP+ combines the roles played by the SM-SR and SM-DP servers in the M2M specification. The consumer specification also involves a “local profile assistant” (LPA) that allows the end-user to make their own choices by supporting the retrieval of the address for the SM-DP+ from a discovery server (SM-DS). The SMDP+ can be operated separately by each operator / operating company, or multiple operators (or subsidiaries) could share a single SM-DP+.
- The number portability process is already operated OTA in Ireland (i.e. without manual intervention). This process is for the moment entirely separate from the profile provisioning process associated with eSIM, and MNP can be triggered by the new operator after the activation of a new profile and deactivation of the profile from the donor operator. In the future, from a technical perspective MNP processes could be combined with profile switching, using a mechanism whereby the MNP handler and SM-DS are combined, but operators have not as yet expressed a need for such as solution.

4 Use cases for eSIM and OTA provisioning and switching and associated customer journeys

In this chapter, we describe:

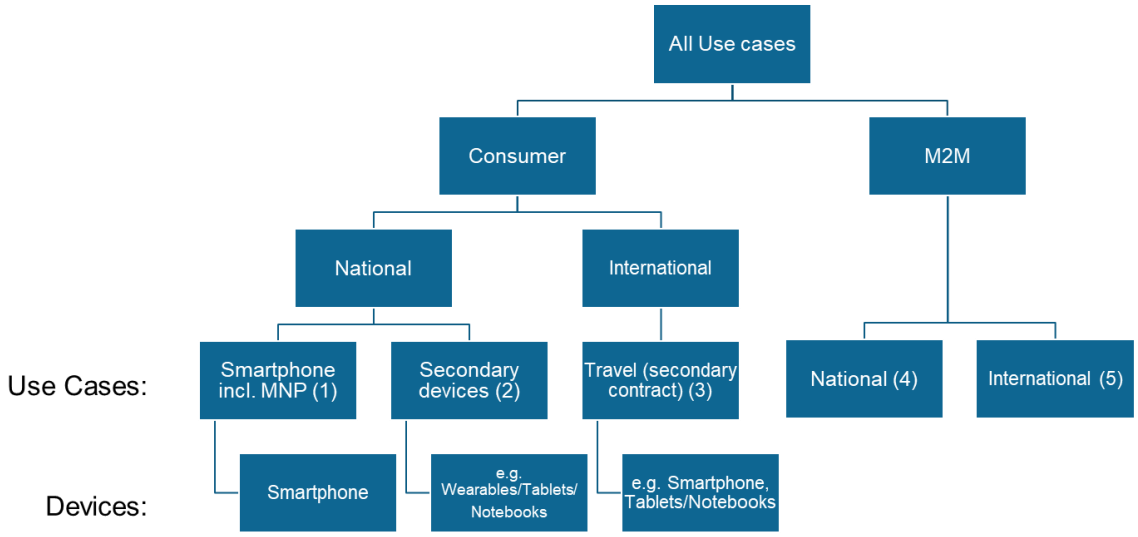
- the different use cases for eSIM and associated OTA provisioning (section 4.1)
- provisioning and switching processes for the consumer use case (section 4.2)
- provisioning and switching processes for the M2M use case (section 4.3).

Key take-aways are summarized at the end of the chapter.

4.1 Use cases for eSIM and OTA

As discussed in the technical overview (chapter 3), as a result of the different GSMA specifications (and associated push vs pull provisioning models), there are procedural differences between the consumer and M2M use case(s) for eSIM. Further use cases with distinct provisioning and switching journeys and/or associated contractual or regulatory challenges can also be identified within the consumer and M2M families, as shown in the following figure.

Figure 4-1: Use cases



Source: WIK-Consult.

Within the consumer area, Smartphones are the most significant use case , as these devices are increasingly being distributed with an eSIM in addition to, or in time as an alternative to the physical SIM. MNP is also relevant within the smartphone use case

and there are requirements to facilitate this process over-the-air in line with the requirements of the EECC (see section 1.1).

The second consumer use case concerns secondary devices. In practice, this currently includes mainly wearables, and more specifically smartwatches, as well as cellular connectivity in computers (tablets/notebooks). This use case can be distinguished from the smartphones case as these devices do not require mobile number portability (with some exceptions) Secondary devices often involve a more complicated technical process for deploying profiles, as additional servers (entitlement servers) are necessary on the operator's end.

The third use case concerns secondary contracts, which may be used by consumers for travel purposes as well as ensuring good coverage and/or mixing and matching different aspects of offers from mobile service providers. In the travel use case, additional SIM profiles can be used to provide local connectivity on an eSIM-enabled device when abroad. The service may be provided by a specialized international operator, by a local operator in the destination country or by the customer's primary operator itself. This presents the possibility for local companies to offer contracts to customers in other countries and vice versa. Such contracts can also be used for laptops and tablets, especially for business customers.

With M2M use cases, a distinction can be made between national and international implementation. The national use case covers devices that are mainly used at a fixed location within one country. Connectivity in this case is more likely to be provided directly by a domestic operator. In the international use case, devices may be shipped globally and there may also be mobile and potential cross-border use involved. From a technical perspective, the use cases do not differ significantly. However, there are certain regulatory issues that are more likely to occur with international use. These use cases also differ in their applications and their specific challenges.

The use cases can be linked to different possible customer journeys as follows:

Use case		Customer journey
Consumer smartphone	Activation	Smartphone activation via QR Code
		Smartphone activation via App
		Smartphone activation via “Out-of-the-box”
	Switching	Smartphone switching via OTA via QR code
		Smartphone switching via OTA via App
Consumer companion devices	Activation	Subscription management of bundled devices
	Switching	Switching bundled devices
M2M	Activation	Activation and connectivity management domestic
		Activation and connectivity management international
	Switching	Switching domestic
		Switching international

Source: WIK-Consult.

These are described in more detail in the following sections.

4.2 The consumer use case

The consumer use case includes the use of smartphones by individuals or businesses, alongside potential companion devices such as smart watches and tablets. Consumers may subscribe to a primary service provider (which typically provides the number associated with their smartphone) alongside secondary service providers which may for example, be used to achieve more cost -effective solutions e.g. in the context of travel or specific services.

eSIM can be used for both smartphones and companion devices, and for primary as well as secondary services. OTA provisioning and switching with a fully digital customer journey is technically feasible for all these use cases, as described below.

4.2.1 Smartphones

For the last three decades, identification for consumer devices has been provided via physical, plastic SIM cards. Although the size of SIM cards has reduced, few specifics besides the form factor have changed. To connect to a mobile network, the consumer needs to either go to a physical retail store to buy a plastic SIM card or needs to order a SIM card online or on the phone. The latter process might take one to two days, depending on the shipping time of the SIM card to the consumer’s premise.

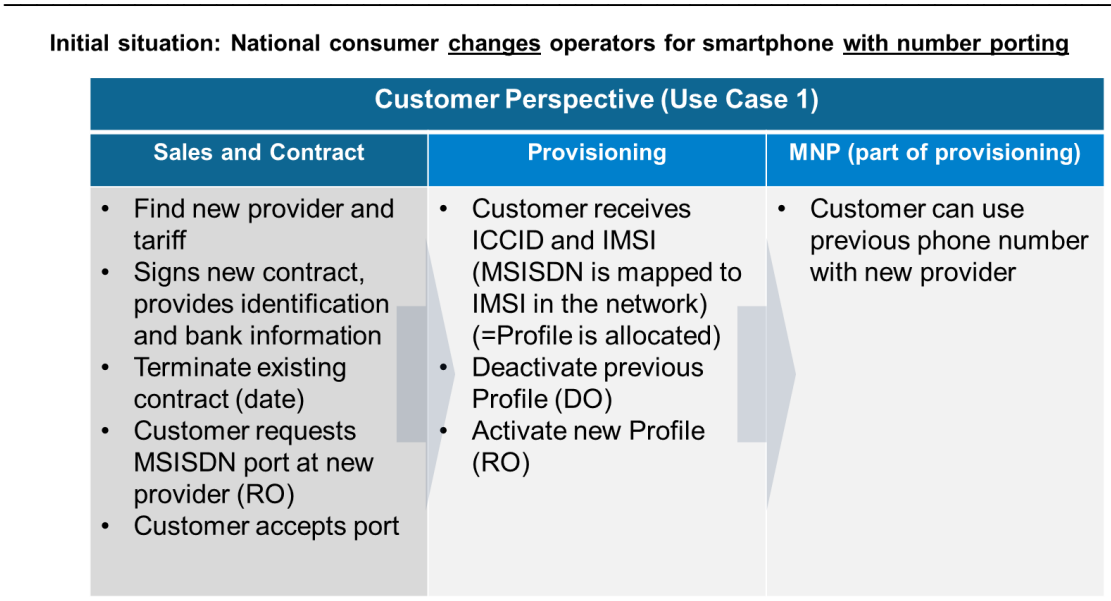
After receiving the SIM card, the consumer must plug it into their device. In the past, most phones had to be turned off, the battery removed and the SIM card put into the SIM card slot. Modern phones that come with non-removable batteries and are

generally harder to open often allow the end user to plug in the SIM card using a SIM card tray on the side of the phone without having to turn off the device first. After the initial activation period, the consumer connects to the mobile network of their choice.

With OTA provisioning, the customer journey can be fully digitised and the process of connecting the device to a mobile network can potentially be reduced to a few minutes and be carried out from any place in the world.

The following diagram displays the steps involved in the switching process from a consumer perspective.

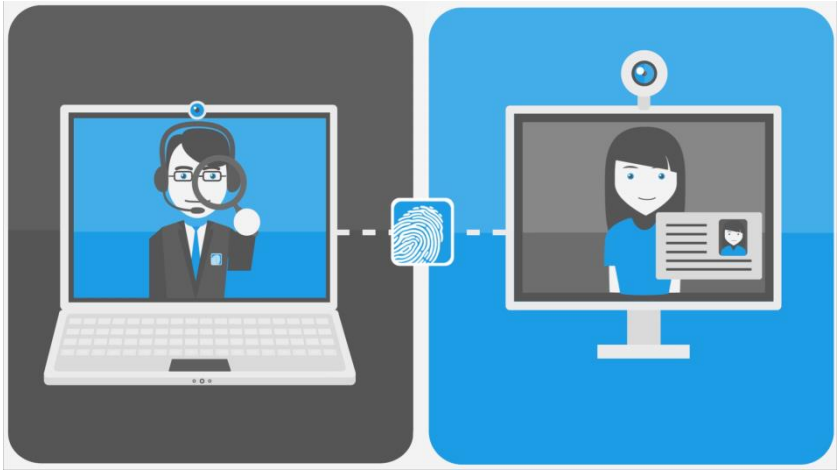
Figure 4-2: Customer Perspective – Customer journey



Source: WIK-Consult.

For a fully digitised contractual process, the consumer needs to engage in a digital identification process, which might be done for example via a webcam.

Figure 4-3: Digital identification via video call



Note: Instead of the webcam of the computer, a smartphone camera can also be utilized.

Source: WebID https://webid-solutions.de/solutions/?lang=en.

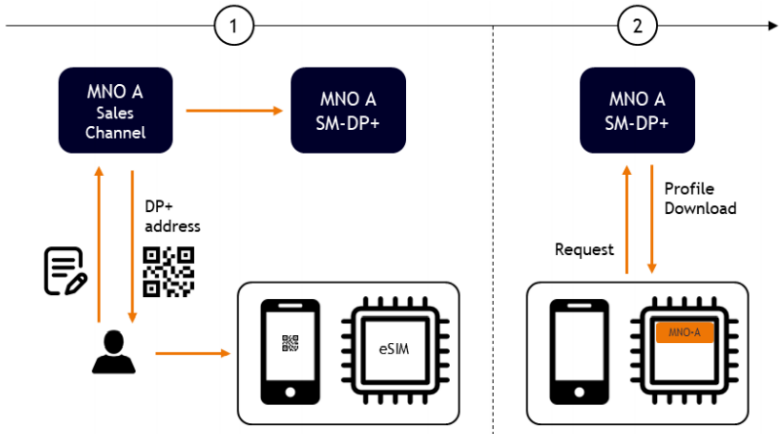
Regarding provisioning, there are a number of options possible, to enable the activation of the new profile.

Activation code

The first method is via an activation code which contains the address of the SM-DP+ from which the operator's profile can be downloaded onto the device's eSIM. This code may come in the form of a QR code, which can be scanned by the camera of the customer's device, which needs to be connected to the Internet. The interface in which the user scans the QR code and manages the profiles on the device is done through the Local Profile Assistant (LPA). This software can be either installed on the eUICC or integrated in the device's software. With the LPA, the customer is also able to give the required permission for the profile to be installed on the device.

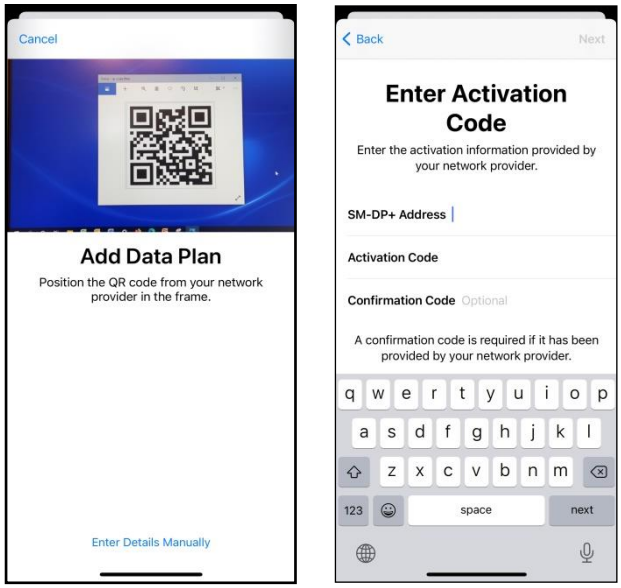
Figure 4-4 shows schematically the remote provisioning process using a QR code to transmit SM-DP+ address while Figure 4-6 shows the concrete interface of the LPA on an iPhone. The interface in which the user scans the QR code and manages the profiles on the device is done through the LPA. This software can either be installed on the eUICC or integrated in the device's software. With the LPA, the customer is also able to give the required permission for the profile to be installed on the device.

Figure 4-4: Customer journey of OTA provisioning using QR code



Source: Achelos (2020).

Figure 4-5: Activation with an QR code through iOS' local profile assistant



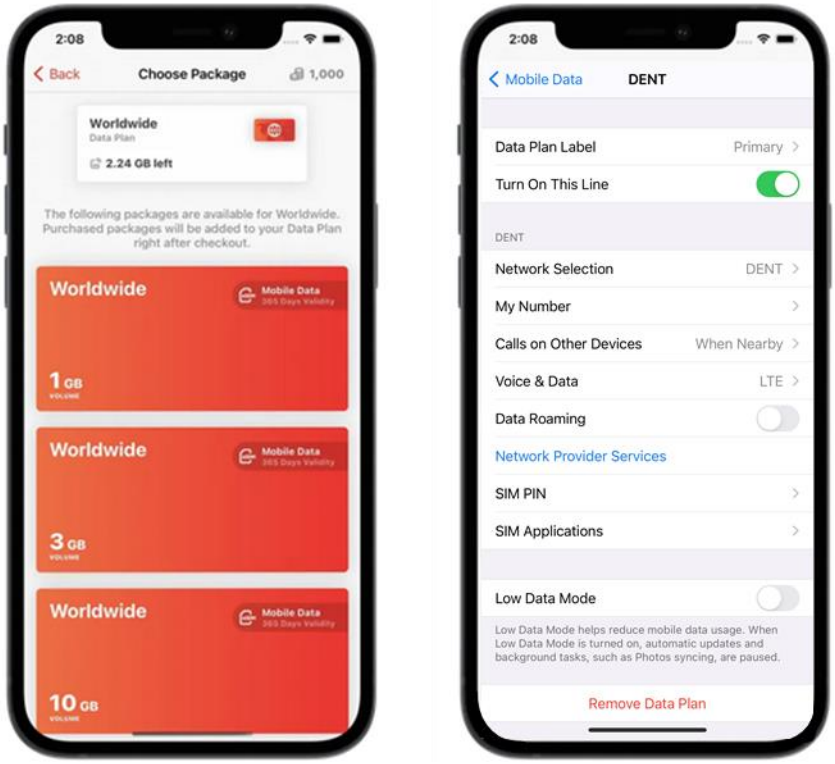
Note: Activation through Apple's own LPA on an iPhone 12. Subscription can be added in "Settings – Mobile Data" by scanning a QR code with the SM-DP+ address or by manually typing in the needed credentials.

Source: Apple iOS 14.4, Screenshot.

Similarly to the QR code activation, the SM-DP+ server address can also be provided via a smartphone app from the operator. In this case, the customer does not need to use the device's camera to scan a QR code. This solution does not require a secondary

screen or print-out of the QR code.[55] The profile is downloaded through the app onto the eUICC but managed, in the device's LPA. In theory, such an app could also be used as the contract and sales point and ID checks could also be integrated into such an app.[56]

Figure 4-6: Activation through an operator's app



Source: Dent Wireless https://www.dentwireless.com/dent-app.

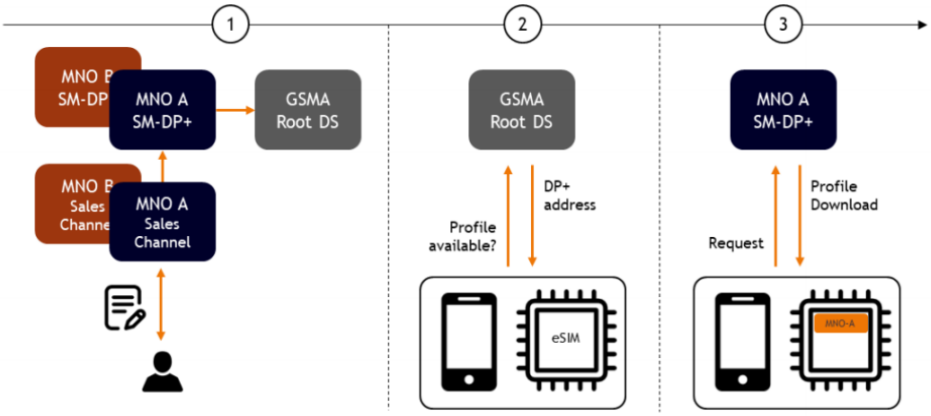
GSMA Discovery Service.

It is also possible for a user to download an operator's profile after subscribing via the GSMA Discovery Service. The Discovery Service is a globally available Internet service and acts as a central communication point between consumer devices and operators' SM-DP+ entities. After the contract between customer and operator is signed, using the LPA, the customer can request a check for a new profile and receive the SM-DP+ address from the discovery server. The device then contacts the operator's SM-DP+ and can start the download and installation of the profile onto the eUICC.

55 In case the SM-DP+ address is provided via an QR code, operators often also give the SM-DP+ address in text form in case the consumer does not have a second screen to scan the code or the smartphones camera is not working. If so, the customer needs to type in the SM-DP+ address manually.

56 For example, the IT company WebID provides such solutions that can be directly integrated into the operators app. Source: https://webid-solutions.de/solutions/?lang=en.

Figure 4-7: Customer journey of OTA provisioning using GSMA discovery service



Source: Achelos (2020).

Device entitlement server.

A third way is through an entitlement server. The entitlement sever is a remote manager for a particular device, for example a smartphone or a smartwatch. This entity is within the operator's domain[57] and is configured to the device specification from the OEM. Through a separate authentication, an entitlement server links a subscription account to a device and instructs the device to contact an SM-DP+.

SM-DP+ address stored on shipped eUICC.

There is a further, less popular method for activating mobile network connectivity on the consumer's device by shipping the eUICC (embedded in the device) with a SM-DP+ address assigned to an operator's eSIM profile. On receiving the device, the consumer already has the address of the SM-DP+ contained on the eUICC and can download and install the associated profile from the server. As the eUICC can only contain one SM-DP+ address, this method may limit the end-user in choosing his or her preferred operator or establish lock-in effects.

All the methods described result in the customer downloading the operator's profile and installing it on the eUICC. In each case, the customer's permission must be given before installation, which is also done through the LPA. Once the profile is correctly installed on the eUICC, the customer will start enabling the profile.

If there are already profiles installed and one of them is active, the end-user would need to disable the profile before activating the newly downloaded one. If there is no other

57 In the operator's domain does not necessarily require the operator to run the server. As with the SM-DP+, the entitlement server can also be run by a third party.

profile installed, the customer can activate the downloaded profile and will be connected to the mobile network, as with current SIM cards.

Besides the advantage of the faster and potentially fully digitalized eSIM activation process, the eSIM provides further benefits. The eUICC can hold multiple profiles at once – the number is limited only by eUICC storage and operator's profile size. Although in the current GSMA specification only one profile can be active at the same time, many other profiles can be installed and switching between them can be done instantly through the LPA.[58]

Mobile number portability process

For physical SIM cards, when the MNP request is timed with the arrival of the new SIM card, the new SIM card can be used right away with the previous phone number[59]. The MNP process can also be timed such that the number is only ported after the previous contract is terminated and shortly before using the new SIM card. The old SIM card will be then deactivated from the donating operator (previous operator).

In Ireland, number porting is processed fully automatically and can be completed within seconds. This means that downtime should not be an issue for an average customer[60]. The new SIM card can also be used before the MNP process is completed or even requested, as each IMSI has a mapped MSISDN, even when the customer does not plan on using it.

Regarding MNP, in case of eSIM and remote SIM provisioning, the process is similar for the customer. After the customer has downloaded the new operator profile, the existing phone number can be ported to the new operator. The eSIM profile also contains an IMSI to which the previous MSISDN is mapped. As with the physical SIM card, the previous profile can no longer be used.

As noted, since the role of the IMSI does not change with eSIM, customers can also port their numbers to an eSIM when they used a physical SIM card from a different operator previously, and vice versa.

The switching process for the operator also involves a two-step process involving a contractual arrangement followed by a provisioning process. The processes involved are shown in the following diagram. As described above, for a seamless digital experience, the operator could include the ID and contractual process alongside

58 To illustrate this point further, inactive profiles can be seen as SIM cards that are activated but currently not plugged into any device. The number of eSIM profiles is only limited by the size of the profile and the storage of the eUICC. Current consumer eSIMs in the market can usually hold five to ten profiles.

59 In this case, the MNP process is already completed and the MSISDN of the donating operator (i.e. the previous operator) is already mapped to the new IMSI of the recipient operator (i.e. the new operator).

60 The downtime is two hours maximum in Ireland if the request can be processed correctly, and one working day in EU, see section 3.6.

provisioning (and after-sales support) within a specially designed application. The operator could trigger the (currently separately managed) MNP process after the provisioning process (and deactivation of the former profile) is complete.

Figure 4-8: Operator's perspective – Customer journey

Initial situation: National consumer changes operators for smartphone with number porting

MNO Perspective (Use Case 1)		
Sales and Contract	**Provisioning**	**MNP (part of provisioning)**
• Get in contact with customer (Point of sale) • Let customer decide on tarif • Get customer identification and billing information • Get order signed • (Terminate customer's previous contract with DO, in case of one-stop shopping, with date) • For MNP, capture the previous MSISDN(s), subscriber type, DO account number, date/time of the MNP request	• Create new customer and implement his/her product characteristics, access/connection; register customer in HSS/HLR • Allocation and control of rights per customer contract and customer terminal(s) • Enabling billing (collection/control of charge relevant data/ traffic flows) • Allocate ICCID and IMSI with mapped *unused* MSISDN (profile) • Send Profile to customer	• Validate the customer's mobile number by text, call or by viewing the customer's bill • Send request to DO (DO validates this against the information held on the MSISDN(s) on the its internal systems, accepts port) • RO adds MSISDN to HLR and updates SRF; sends DO request to disconnect the number from their systems • After DO has disconnected the number from its system, RO informs NPD that they are now the owner of the mobile number • After DO confirms with NPD and NPD issues information on the MSISDN to all operators, RO receives confirmation that the port is complete

Source: WIK-Consult.

4.2.2 Secondary devices

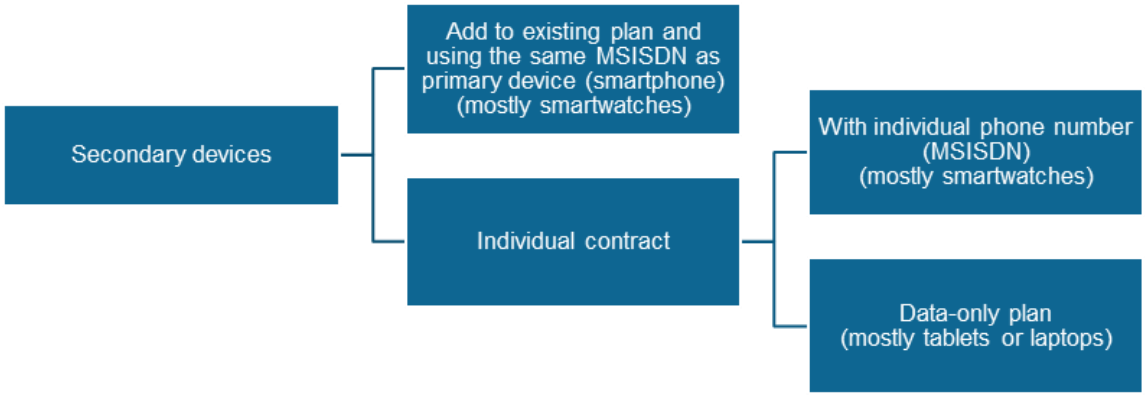
eSIM technology not only allows for a fully digital and fast provisioning process, but also for more compact device designs, since eSIMs come in a smaller size and are directly soldered into the device[61]. This also makes it easier for manufacturers to make their devices more shock and water resistant.

As a result, eSIMs make it possible to connect more devices to the mobile network that were not connected before. The most prominent use case is smartwatches, but other "secondary" devices such as tablets and laptops can benefit from eSIM as well.

For secondary devices, different provisioning scenarios are possible, depending on the type of device, manufacturer and model as depicted in Figure 4-9.

61 As mentioned before, eSIM is not defines by the form factor but by the functionality. However, for consumer devices, the eSIM almost always comes in the MFF2 form factor (chip soldered onto the device). Conversely, there are almost no phones for the consumer market that come with a soldered, non-reprogrammable SIM.

Figure 4-9: Differentiation in contracts and capability for the connectivity of secondary devices



Source: WIK-Consult.

There are three different scenarios for smartwatches: They can be added to an existing smartphone plan where the smartwatch can also use the same MSISDN as the phone to make and receive calls (thereby sharing the same phone number) or they can be assigned an individual contract. The individual contract can also come with an individual phone number, i.e. the smartwatch can have the full functionality of a smartphone where it can receive and make calls from an individual number. This differentiation is based on the functionality of different smartwatches and some models are only capable of a subset of these three connectivity scenarios. Additionally, some operators are also only capable of providing services for a subset of these three connectivity scenarios.

Tablets and laptops usually use data-only plans.[62]

As with smartphones, the customer provisioning journey for secondary devices can be divided between the sales and contractual process and the provisioning process (see below). Different steps are involved depending on whether the device is added to an existing plan or requires an individual plan. The download and the activation for consumer secondary devices may use any of the activation procedures listed in the smartphone (primary contract) case. However, as the form factors may not always allow an LPA with a user-friendly user interface, primary devices such as smartphones may be used to provision the operator's profile onto the smartwatch's eUICC.

It is also possible that secondary devices such as smartwatches may come preloaded with a plan from a specific provider, which may create lock-in challenges for the end-

62 On one hand, the Apple Watch, for example, can essentially be used as a phone where calls are made and received directly to it (without routing through the paired smart phone). An iPad cellular on the other hand, for example, cannot be used as a phone (see https://support.apple.com/guide/watch/make-phone-calls-apdc38d7a95e/7.0/watchos/7.0 and https://support.apple.com/guide/ipad/make-and-receive-phone-calls-ipadf97892b2/ipados).

user, if the connectivity provider implements SIM locking and/or if there is no user interface which enables switching.

Figure 4-10: Customer journey OTA provisioning - Customer perspective

Initial situation: National consumer connects to operator for secondary contract (without number porting)

Customer Perspective (Use Case 2)	
Sales and Contract	**Provisioning**
Three alternative scenarios: **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Contact existing operator and add secondary device to plan **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Sign new contract, provide identification and bank information	• In case of smartwatch: Pair smartwatch to primary device (smartphone) **Three alternative scenarios:** **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Customer downloads and installs *clone* Profile of existing plan (same ICCID and IMSI as smartphone) through paired smartphone **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Download and install Profile (through smartphone in case of smartwatch)

Source: WIK-Consult.

For secondary devices which do enable switching by the end-user, the process for switching provider is similar to the provisioning process, except that it involves the deactivation of the previously used profile, and MNP in cases where the device is used to make and/or receive calls via a separate contract or as part of a bundle with a smartphone. A further challenge for end-users when it comes to switching contracts involving secondary devices is that there may be a limited number of providers which offer support for secondary devices (on a standalone basis or paired with a smartphone contract).

The steps taken by a mobile network operator or service provider in provisioning a secondary device are shown in the following chart.

Figure 4-11: Customer journey OTA provisioning - MNO perspective

Initial situation: National consumer connects to operator for secondary contract (without number porting)

MNO Perspective (Use Case 2)	
Sales and Contract	**Provisioning**
Three alternative scenarios: **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Let customer add secondary device to existing plan • Get order signed **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Get in contact with customer (Point of sale) • Let customer decide on tarif • Get customer identification and billing information • Get order signed	**Three alternative scenarios:** **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Allocate MultiSIM Profile to customer through Entiltment Server **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Create new customer and implement his/her product characteristics, access/connection; register customer in HSS/HLR • Allocation and control of rights per customer contract and customer terminal(s) • Enabling billing (collection/control of charge relevant data/ traffic flows) • Allocate ICCID and IMSI with mapped MSISDN (profile) (unused in the data only case) • Send Profile to customer

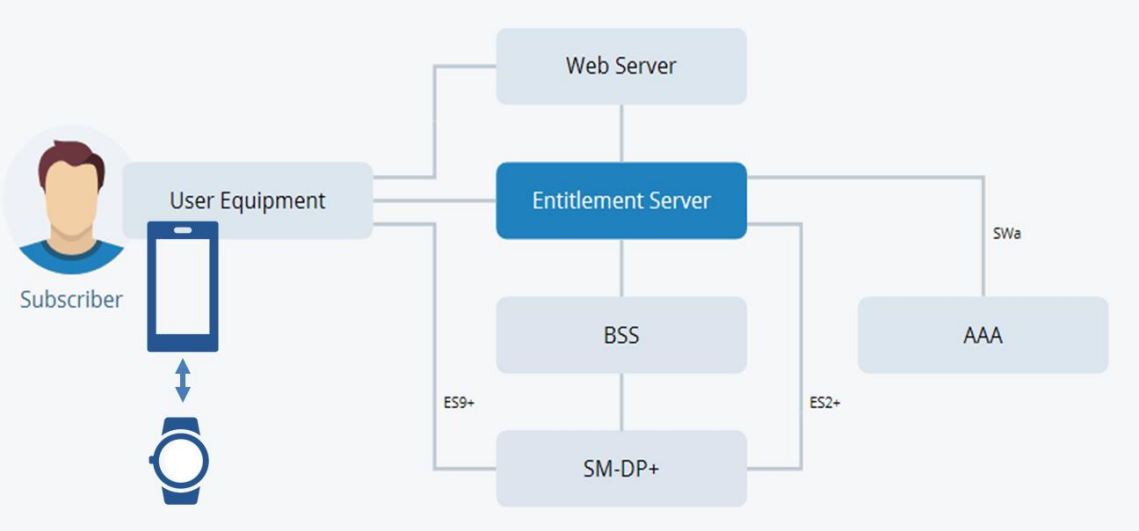
Source: WIK-Consult.

An important difference for an operator between provisioning a smartphone and a secondary device is that there may be a role for an “entitlement server”, in particular where devices such as smartwatches are added to an existing plan.

The entitlement server has a direct connection with the customers equipment (smartwatch paired with smartphone). Other network components of the operator are connected with the entitlement server. The entitlement server authenticates the device, checks whether they are allowed to use the service, and facilitates the download of eSIMs to the secondary devices.[63]

63 https://elitnet.eu/wp-content/uploads/2021/04/ELITNET-Entitlement-Server.pdf.

Figure 4-12: Remote Provisioning Smartwatch



Source: https://elitnet.eu/wp-content/uploads/2021/04/ELITNET-Entitlement-Server.pdf; BSS – Business support system, AAA – Authentication, Authorisation and Accounting servers.

Apple, for example, requires operators supporting the Apple Watch to buy or develop such an entitlement server with certain specifications that acts as a gateway between the eUICC on the Apple Watch and the SM-DP+ server of the operator. Although a companion device is still needed for the communication between the entitlement server and the Apple Watch, the operator's profile is delivered from the SM-DP+ to the Apple Watch.

The need to invest in potentially different entitlement servers for different devices may serve to raise costs for MNOs and deter them from supporting a large range of different devices.

4.2.3 Secondary services (national and international)

Most eSIM-enabled smartphones shipped today still have a physical SIM card tray, the eSIM acts as an additional SIM, making the smartphone essentially a dual SIM phone. The traditional, physical SIM card may be used as the home-country SIM and the eSIM can download a subscription profile from a local operator when travelling. This allows the traveler to avoid international roaming charges and benefit from local data rates while still being contactable on their primary home-country subscription.

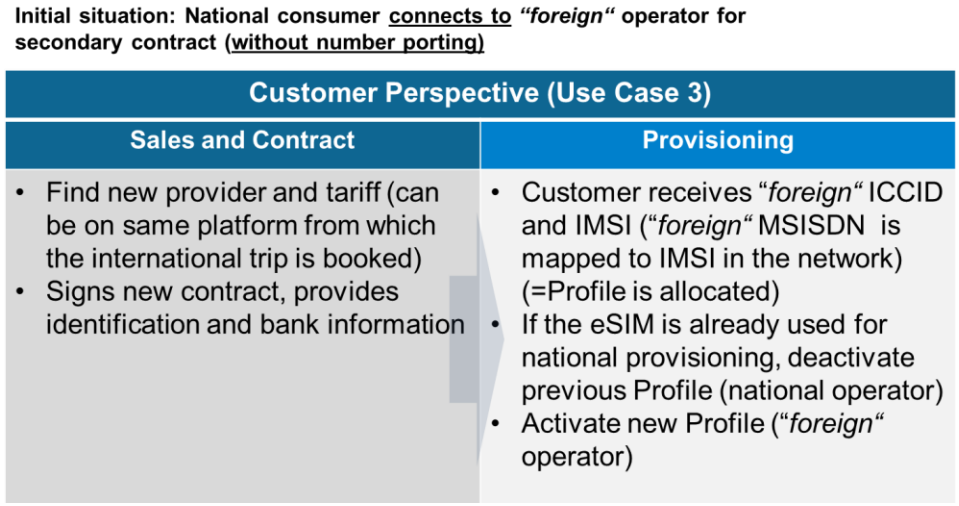
Laptops and tablets can also be provisioned with local mobile connectivity, which is especially relevant for business trips. The potentially fully digitised journey allows companies to remotely download a new profile onto employees' devices before an

international trip. For this, the device only needs to be turned on and connected to the Internet and the devices are controlled by the company's IT infrastructure.

In addition to offering advantages for travellers, the dual SIM functionality enabled by eSIM (with physical SIM) or the potential to switch between different eSIM profiles could also facilitate other use cases such as the use of different telephone numbers on the same handset, or the provision of a back-up service to guarantee coverage.

The process of signing up to a secondary service (such as a local provider when travelling or a specialist "travel" data plan) is similar to the provisioning process described in relation to smartphones.

Figure 4-13: Customer journey OTA provisioning secondary device - Customer perspective



Source: WIK-Consult.

Challenges specific to this use case when consumers are subscribing to a "foreign" service provider may include difficulties with the identification process and a lack of user-friendly options for redress if contracts and support are provided in a different jurisdiction.

Another challenge linked to the lack of support for simultaneous use of multiple eSIM profiles under the current GSMA consumer specification, is that, if consumers do not have a physical SIM card alongside the eSIM, they may need to manually deactivate and activate the different profiles in order to benefit from the different services.

4.3 The M2M Use case

"Machine-to-Machine Communication" (M2M) can be defined as data communication between devices or systems in which human intervention plays at most a limited role. The term "Internet of Things" (IoT) is often used interchangeably.[64] In the context of this study, we refer as M2M to everything which is covered within the GSMA M2M eSIM specification. The few exceptions are applications where the consumer specification is used, but clearly as a workaround to connect devices that are limited by the M2M specification.

Generally, two kinds of companies can be the customer in M2M:

a) M2M users: The customer can be a company buying devices and entering connectivity contracts separately with an operator of their choice. This would typically be the case for a utility company implementing smart meters but also for logistics companies that use devices to track goods.

b) Device manufacturers: It can also be possible for device manufacturers to make contracts with connectivity providers themselves and then sell the devices including connectivity to third parties or end users. This happens in the automotive space with connected cars, where the manufacturer of the car chooses a connectivity provider and has the connectivity included when selling the product to end users.

Because many industrial M2M devices are deployed in the field and cannot easily be accessed by the M2M customer after their deployment, they are typically deployed with connectivity already pre-installed. Especially in cases where the device manufacturer is the customer, they may choose to conduct the installation during manufacturing. Otherwise (and in particular in cases where the customer is an M2M user), a bootstrap profile may be installed, enabling the selection of a connectivity provider at a later date.

Unlike the consumer eSIM specification, which relies on a "pull" approach driven by the end-user to select a new profile, the M2M specification involves the profile being "pushed" to the devices by the SM-SR (the system that delivers the operator credentials to the eSIM). In this context, the customer's decision over whether they directly take responsibility for the SM-SR or leave this function to the connectivity provider has important implications for the ease of switching electronic communication provider at a later stage.

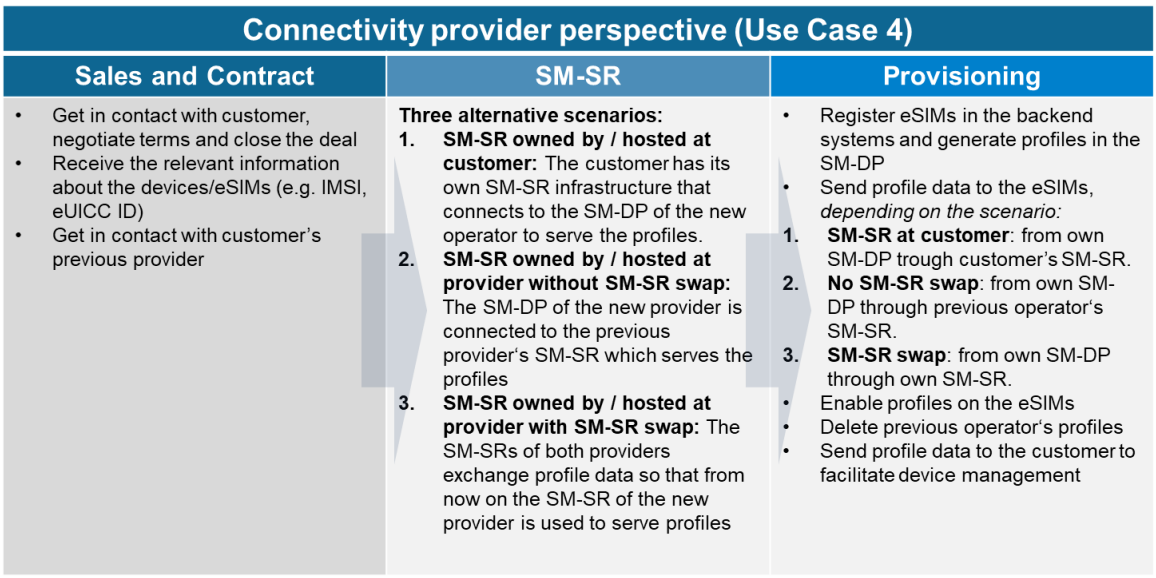
In general, eSIM can be used in M2M devices (whether deployed in a national or cross-border context) and provisioning can be completed OTA. However, the provisioning and

64 A more detailed discussion on the definition of M2M and IoT can be found in BEREC (2016): BEREC Report on Enabling the Internet of Things, BoR (16) 39, available at: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5755-berec-report-on-enabling-the-internet-of-things.

switching process will not necessarily be through a fully digitised customer journey, as for switching in particular, manual intervention may be required.

The following diagram shows the different processes for switching M2M connectivity from the perspective of the communications provider.

Figure 4-14: Connectivity provider perspective on profile switching



Source: WIK-Consult.

If the customer is in control of the SM-SR (either directly or through a subcontractor), the customer can itself connect to the SM-DP of the new operator to serve the profiles. Otherwise, if the SM-SR was controlled by the connectivity provider, the previous connectivity provider will need either to continue with the operation of the SM-SR and connect to the SM-DP of the new provider, or perform an SM-SR swap, which involves an exchange of profile data between the former and new connectivity providers.

These interactions and/or need for ongoing relationships (if there is no SM-SR swap) provide scope for the previous provider to impede the switching process through delays, failure to co-operate and/or through excessive charging, for operation of the SM-SR or for the data swap. Thus, it is important for this process to be tightly controlled via the commercial contract as well as being supported by suitable regulatory requirements.

When M2M services are provided on a national basis (i.e. involving devices that are used at a fixed location within one country with connectivity from a nationally authorized provider e.g. as may arise in the case of smart meters or smart factories), regulatory issues can be addressed solely by the NRA in the country concerned. More

complexities may arise when M2M services are international in nature, because the devices are mobile and/or because the connectivity provider is foreign or makes use of international number ranges.

Connected cars and logistics / tracking provide important examples of an international use case. In this setting, roaming (including potentially permanent roaming) and/or MVNO arrangements may be needed to provide connectivity, and the connectivity provider may be established and subject to regulatory requirements in a different country or range of countries.

These situations highlight the need for roaming regulations to be appropriately adapted to the M2M use case (as well as monitoring the provision of MVNO access for M2M), and may require cross-border collaboration to ensure the appropriate implementation and enforcement of regulation concerning numbering and switching.

4.4 Key take-aways

KEY TAKE-AWAYS

- The main use cases of eSIM for consumers are likely to be smartphones and secondary devices such as wearables and tablets. Most consumers would use communications in-country and benefit from the potentially fully digitalized and faster set up, but they could also take advantage of eSIM to take out secondary contracts to provide connectivity while travelling. M2M use cases include “mobile / international” use cases such as eSIM in vehicles and use cases which may be more fixed / domestic in nature such as the use of eSIM in smart meters.
- Activation of smartphones can be completed by the consumer using a QR code or application. Switching can be performed in the same way and involves activating a new profile and deactivating the old one. Smartphones and secondary devices could also in principle be active “out of the box”. However, in certain set-ups this may mean that it is not possible for the consumer to switch their connectivity provider. The addition of new devices or switching of bundled contracts is best conducted through an application. In cases where smartphones have an eSIM in parallel with a physical SIM, the eSIM can be used to host a secondary contract which can be used for applications such as travel, or a second number e.g. for business or to provide back-up coverage. The eSIM could also be used to hold multiple profiles, but as these cannot be active at the same time under current specifications, the end-user would need to deactivate and activate different profiles in order to make use of the different services.
- Industrial M2M customers such as energy companies seeking connectivity for devices under their continued control (e.g. smart meters) may purchase devices with a bootstrap profile and negotiate deals with a connectivity provider which then pushes its profiles to the devices. Switching is more complex for M2M than for consumer applications, and there may be challenges in particular in cases where the SM-SR (responsible for managing the profiles) is not owned or controlled by the customer. In such cases, the new provider would need remain connected to previous provider’s SM-SR, or an SM-SR swap would need to be performed involving the exchange of profile data between the previous and new provider. Issues may arise in particular if the previous provider obstructs the switch or sets excessive charges. It is important for such arrangements to be properly addressed in the contract between the (industrial) customer and provider. Further lock-in challenges apply to consumers purchasing pre-connected devices such as cars, as connectivity for certain functions such as telemetry may be controlled by and charged for by the manufacturer on an ongoing basis without a straightforward means to switch.
- OTA provisioning and switching is technically teasible for both the consumer and M2M use cases. Fully digital customer journeys are possible for consumer use cases (including business use of personal devices such as smartphones, tablets, laptops etc). Fully digital customer journeys are not always possible for M2M, as manual intervention may be required, in particular in the case of switching.

5 Impact of eSIM and associated OTA provisioning and switching on consumer welfare and competition

In this chapter, we consider the opportunities and challenges that may be associated with eSIM and OTA provisioning and switching processes. Our analysis covers the:

- Impact on customers including consumers and industrial users of eSIM (section 0)
- Impact on market players (section 5.2)
- Environmental benefits and challenges (section 0); and
- Implications for security (section 5.4).

Key take-aways are summarized at the end of the chapter.

5.1 Impact on customers

The benefits of eSIM from a customer perspective include improved provisioning and switching processes, which should in turn facilitate switching and competition. eSIM and OTA also offer the prospect for consumers to benefit from new services and connected devices and enable them to improve coverage and access competitive offers while abroad. These benefits are further elaborated below.

5.1.1 Benefits and challenges for consumers

Instant connectivity

A key benefit of eSIM and OTA provisioning for consumers is that the need to obtain a physical SIM card, an element which has contributed to complexity and delays in the process, will be removed. All of the available customer journeys (including the use of an application, QR code or “out-of-the-box” solution), can result in instant connectivity. Together with Ireland’s effective MNP process which already operates OTA, the provisioning process for consumers could be significantly accelerated and simplified.

Easier switching for existing services

Another important benefit for consumers, is that the removal of the need for a physical SIM swap will make switching between service providers faster and more straightforward. In turn, reduced hassle may encourage more consumers to switch and take advantage of better deals.

The potentially fully digitized customer journey for activation of eSIMs and switching between operators also makes it substantially easier for customers with a fleet of devices such as enterprises. Instead of having to order, unpack and plug-in hundreds of

physical SIM cards into smartphones, laptops, or tablets when the enterprise decides to switch operators, the activation and switching process can be done remotely and automatically[65]. For this remote provisioning and switching process, the devices can still be in the hands of the employees and only need to be turned on and connected to the Internet. The ability to switch the entire fleet of personal devices from enterprises substantially reduces the barriers to switching operators. This is especially important considering that the devices' lifetime outlasts the average contractual period of two to four years and companies will no longer need to renew contracts to avoid the extra time and effort involved in replacing SIM cards in all devices. This is likely to make the decision to switch operators considerably easier for enterprises with a large fleet of devices. One important consequence of reducing barriers to switching is that it is likely to increase competition between mobile service providers, leading to price reductions for end-users. The scale of the impact of eSIM on reducing switching barriers is difficult to determine ex ante, but it should be recalled that the increased competition that resulted from MNP is estimated to have reduced prices for mobile services in Europe by 7.9%, and increased consumer welfare by €2.86 per person.[66] If eSIM triggers price reductions of even a fraction of this amount, the benefits would be very significant.

New connected devices

Besides the benefits from faster connectivity, eSIM and associated OTA provisioning processes also facilitate connectivity to a new range of devices, as well as the capability of switching operator for consumer IoT. Because it can be reprogrammed and possibly smaller form factor[67], the eSIM enables more devices to connect to mobile networks. Being able to remove the physical SIM card slot and use an eSIM (i.e. embedded into the device) instead, enables OEMs to make new design choices, frees up space in the device and makes it easier for them to make their devices waterproof and dust resistant. According to a survey conducted among 371 global eSIM stakeholders[68], smartwatches are best suited to adopting eSIM, closely followed by smartphones. Laptop adoption is slow as they mostly rely on Wi-Fi or fixed connectivity. However, for business travel, laptops with eSIM may be particularly useful.

Multiple subscriptions and services, for home and abroad

Alongside enabling connectivity for more devices, eSIM coupled with swift provisioning and switching arrangements enables consumers to make use of multiple service providers from the same device. This can be used in several ways.

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65 For example with a dedicated app controlled by the IT department of said enterprise.

66 Cho, Ferreira et al (2013) The Impact of Mobile Number Portability on Price, Competition and Consumer Welfare https://www.researchgate.net/publication/256063201_The_Impact_of_Mobile_Number_Portability_on_Price_Competition_and_Consumer_Welfare

67 As explained, the eSIM is not defined by its form factor but by its software. However, most eSIMs (eUICCs) shipped come in the embedded MFF2 form factor.

68 Truphone and Mobile World Live (2021): How eSIM is transforming connectivity for consumers and enterprises. Survey Report.

Network resilience There are several large countries for which one single operator is not capable of providing coverage for the entire country, or at least unable to do so with consistently good quality of service. In India for example, a single operator that may provide good coverage at the home address of a consumer may not provide good coverage at the consumer's workplace. In these countries, consumers may want to subscribe to two different operators which differ in the coverage and quality across the country. Instead of using two phones or switching SIM cards multiple times per day, the customer of a dual SIM card phone can benefit from the coverage of two mobile networks. In the United States where high quality coverage via a single network is not necessarily available nationwide due to the country's size, Google has started a mobile phone plan, Google Fi, that shifts between multiple mobile networks and millions of Wi-Fi connections to deliver the strongest signal available to the customer. It therefore acts as an MVNO with multiple partnering parent networks, namely T-Mobile, Sprint and U.S. Cellular.[69] The subscription plan is primarily for phones[70] that are specifically designed for the service and have the necessary hardware components of intelligently shifting between multiple mobile networks. It should be noted that although Google Fi also supports the eSIM, its shifting technology does not rely on OTA. However this use case highlights the necessity for some countries to be able to switch between mobile networks to achieve full coverage. This need to rely on multiple mobile networks to obtain full coverage is also reflected to some extent in differences in dual SIM phone penetration across countries. The ease of the OTA switching process may also facilitate the process of signing up to a different operator if the network of the primary operator goes down.

Cheap or free communication to other networks. Dual SIM phones and the ability to have two subscriptions to two different operators enables customer to benefit from low fees for calling and texting between customers on the same mobile network. This is also reflected in the adoption of dual SIM phones across countries as it is mainly applicable in countries where flat rates for calling between mobile networks are uncommon and/or expensive.

Multiple phone numbers. Another use case for dual SIM phones is enabled by the usage of two different phone numbers. For example, a single phone can make and receive phone calls and messages using a private and a business phone number. With this, there is no need to carry separate business and private mobile phones and users can e.g. disable their business phone after hours.

69 https://fi.google.com/about/faq/.

70 The current phones designed for Fi are North American models of Google Pixels, Moto G7, Moto G6, LG G7 ThinQ, LG V35 ThinQ, and Android One Moto X4. Other Android phones and iPhones currently do not have the switching technology and cannot benefit from the coverage of multiple MNOs. For these phones, the Google Fi connects them only to T-Mobile US (https://fi.google.com/about/faq/).

Traveling. Travelers might also benefit from eSIM as an alternative to roaming with their primary provider by purchasing a subscription from a specialized travel provider or taking out a short-term contract with operators in the visited country (local break-out). This may be particularly relevant outside the EU, where high roaming charges may still apply. Within the EU, the "Roam like at Home" obligations[71] may render this capability less attractive. The traveling use case is discussed in detail in section 4.2.3.

It should be noted that these benefits arise today because most eSIM enabled smartphones come with an eSIM alongside a physical SIM slot and are therefore in fact dual SIM capable phones. They can thus be used to accommodate multiple services simultaneously. In the context of roaming for example, this allows a customer to retain their home voice subscription and number via the physical SIM while simultaneously relying on an eSIM profile to provide data at rates which are more favourable than those provided by the primary operator.[72] Current eSIM specifications do not allow for multiple profiles to be active simultaneously via the eSIM. However, as the OTA switching process enabled by eSIM is an instantaneous process, some dual SIM use cases can be, at least to some extent, realized just with the eSIM itself. In addition, as the GSMA specifications are still evolving, future eSIMs may be capable of fully acting as dual SIM in the traditional sense with multiple active profiles.[73]

Try before you buy

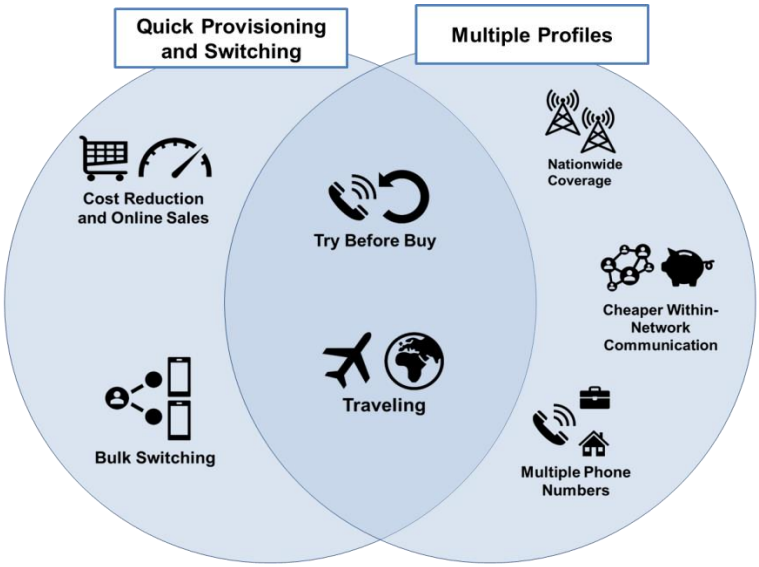
The potentially fully digitised and quick customer journey for subscription and activation as well as the reduced logistical costs to provide physical SIM cards also allow for new business opportunities from the operator's perspective. Similar to music and movie streaming services, operators could give consumers the opportunity to sign on to their mobile network service for a free trial period.[74] Especially in the case of MVNOs or non-incumbent operators, customers may be unsure about the network coverage and quality of service. Although coverage maps are provided by NRAs, operators or third parties, these often do not state the specific service quality. However, with the accessibility of a free trial period, the connectivity and quality of service for locations that are essential to the customer, such as his or her home, daily commute, or the office room the customer is working in can be individually determined. This may make the customer's decision process easier and lowers barriers for switching operators. The try before buy use case may also be even more appealing in the case of major rollouts of new technologies such as 5G. The customer is often not able to immediately appreciate the benefits of a new technology, until they can personally try it out. Upselling and retention of existing customers who already have 5G-ready smartphones and are currently on 4G plans

71 https://digital-strategy.ec.europa.eu/en/policies/roaming.
72 See WIK (2018) Technological developments and roaming https://ec.europa.eu/digital-single-market/en/news/technological-developments-and-roaming-smart-20180012-0.
73 See section on the evolution of the eSIM specifications and visions for future adjustments.
74 This is already done by MVNO Truphone that offers consumers 100MB for 30 days as a free trial for smartphones and tablets (see, for example, https://www.truphone.com/consumer/esim-for-smartphone/).

could become easier for operators. Furthermore operators offering 5G services can potentially acquire customers with 5G-ready smartphones that are currently using operators without a 5G network. This increases the incentive for operators to roll-out their 5G networks faster.

A summary of the applications enabled by quick provisioning and switching (including the potentially fully digitised customer journey), applications enabled by storing multiple operator's profiles on a single device and intersections of the two are shown in the Figure 5-1.

Figure 5-1: Applications enabled by eSIM



Source: WIK-Consult.

At the same time, while eSIM and the associated OTA provisioning and switching processes brings many benefits to consumers, it could also give rise to some concerns. As the eSIM is soldered into the device and cannot be physically removed and replaced with another SIM card, the consumer is more reliant on the operators concerned to effect switching processes efficiently.

For some consumer IoT devices, where connectivity is bundled together with the device by the equipment manufacturer, there may also be problems regarding lock-in, and resulting concerns around excessive prices for the services rendered over time. Examples of such products include certain smart watches.[75] Connectivity for eSIM enabled laptops and tablets can also be pre-installed and/or controlled by device

75 For example, the Spotter GPS, which provides tracking services for children and the elderly is bundled with subscription and phone number which cannot be altered by the consumer purchasing the device https://www.spottergps.com/?gclid=Cj0KCQjwxdSHBhCdARIsAG6zhlW8Ybhoi3FTofMZTc0FAnvdn2Am_a39g3bItsZ2k1QXV_Zsjq9L_VwaAtX4EALw_wcB.

manufacturers in a manner which may steer customers and/or limit choice. For example, the Microsoft Surface Pro laptop comes with connectivity from Transatel pre-installed.[76]

Even where devices do not come with a pre-installed connectivity provider, consumers typically have a limited choice of provider due the lack of operators supporting eSIM-enabled companion devices, which may limit competition in the rates provided. In addition, consumers purchasing bundles which include connectivity for companion devices and/or home IoT alongside their smartphone, may be less inclined to switch, and may find the choices available more limited than for contracts covering the smartphone alone.

5.1.2 Benefits and challenges for industrial users

eSIM has the potential to be transformational for industrial IoT.

Switching connectivity providers is in practice nearly never feasible in M2M when physical SIM cards need to be replaced. It is unlikely to be cost-efficient to send technicians to change hundreds or thousands of physical SIMs to save a few cents per month, when the cost of switching could be as much as $250 to swap out a single SIM card in a car.[77] Consequently, the OTA and **switching potential of eSIM essential to support competition** in the growing industrial M2M market.

Ease of switching may also make it easier to resolve challenges associated with regulatory limitations. For example, if a regulator does not allow extraterritorial use of numbers in a certain context (or changes its policy in this respect) and there is no grandfathering of existing customers, switching the profile to another is possible over-the-air with eSIM. While this process is costly and inconvenient for the connectivity provider and customer and should therefore not be the norm, in the world of physical SIM cards it would likely lead to the need to shut the devices off completely, perform a costly swapping process or trigger an expensive lawsuit.

There are also other significant further benefits to be gained for the industrial customer from the implementation of eSIM in M2M:

- Devices can be **manufactured in one country and shipped with the same SIM profile/SIM module to the whole world**, from where a local profile will be downloaded.
- The fact that the eSIM is soldered into the device and sealed increases the **robustness** of this solution and enables it to be used in devices that may be

76 https://www.transatel.com/news-and-insights/press-releases/iot-solutions/transatel-enables-box-global-cellular-connectivity-microsoft-surface-pro-lte-advanced/.

77 Study from the automobile industry references in presentation by John Nix, Vobal Technologies 2015: Benefits and Costs of Embedded SIMs in M2M applications.

subject to extreme conditions and ensures that the device is more resistant to tampering.

- **Smaller connectivity providers (e.g. MVNOs specialized in M2M) can become players in the market.** Previously, they were often disregarded by customers as in the case of bankruptcy, the devices would be without connectivity and potentially worthless. Now, a switch could be performed in such a case, so the **eSIM provides a gateway for new entrants in the market** and acts as an insurance policy. It is even possible to implement physical SIM cards and have the eSIM only as a backup solution for such use cases.[78]
- Switching capability also helps to **avoid lock-in effects** and thereby gives the customer more market power.
- The potential to switch also acts as a **safeguard in case of bad or worsening network coverage** (e.g. because of the switch-off of 2G/3G in some countries).

However, notwithstanding the many benefits of eSIM for industrial IoT, there are a large number of challenges which are likely to impede its introduction and/or the effective completion of switching.

The advantages for customers in terms of easier switching in turn mean that the **current providers of physical SIM cards for M2M do not have a significant interest to promote eSIM** because they profit from these lock-in effects.

Therefore, waiting for operators – and especially MNOs, to implement the required processes, is unlikely to achieve the goal of increasing adoption of eSIM and switching capabilities in M2M. Operators will implement these processes only when customers and/or device manufacturers request such capabilities, i.e. the process will need to be driven from the lower stages of the value chain. In the consumer use case (see section 4.2) this process is mainly driven by manufacturers of smartphones and wearables, especially Apple. This means that eSIM support is likely to be provided in time, even if existing MNOs are resistant. However, in the M2M space there is no obvious player to push the eSIM because of the wide range of devices and applications. Car manufacturers do drive the migration for current car models, but this does not necessarily spill over to other uses of M2M.[79]

Another challenge is that while switching operators is possible in theory, it has still not been tested on a large scale in the field. Connections and/or information exchange between the backend systems of the previous operator and the new operator need to be established (and/or to the customer's own systems). As such, currently there has to

78 Because of higher cost, this is only feasible in settings with relatively high-priced devices, such as cars.

79 One exception would be that operators may build infrastructure and expertise that could potentially also be used for offering eSIM to other M2M customers. Car manufacturers are however more likely to build/buy certain infrastructure elements themselves (especially the SM-SR), which is not feasible for smaller M2M customers, therefore their comparability to others is limited.

be some manual effort for every single switching project. In addition, it is not yet that the case that every backend device/eSIM management system will be able to handle the fast and accurate switching of several thousand SIM profiles. Therefore, **switching will be an extensive and expensive IT project for M2M the foreseeable future**.

Switching could be hampered by fees that are implemented to accommodate the switch. These could be ongoing fees for the use of the SM-SR of the previous provider or one-time fees to help with the technical interconnection necessary for the switch. If a third party is involved to help with the technical aspects of switching, fees will also be charged. As the M2M business often operates on small costs per device, any additional fee could result in making switching too expensive and implement a de facto lock-in.

Overall, because of the high complexity of the technical implementation of eSIM, it tends to be implemented only in large-scale projects (e.g. fleets of connected cars, nationwide smart metering projects), where the customer benefits of switching are large. In addition, the market power of the customer must be significant enough to incentivise connectivity providers to deliver connectivity even if they have to build capabilities specifically for it. Last but not least, there have to be devices that support eSIM.

The **slow uptake and low penetration of eSIM in the industrial field also means that it will take several years until "best practices" are established regarding contracts, fees, the handling of provisioning and switching and of potential legal and regulatory problems**.

Not only because of these facts but also because of **long device lifetimes in the IoT/M2M in general**[80], this is likely to lead to physical SIM processes still being in place for years to come.

5.2 Impact on market players

The "digital only" processes enabled by eSIM, alongside the increasing role for device manufacturers, and ease of switching and multi-homing may in time have a significant impact on the mobile value chain.

5.2.1 Benefits and challenges for mobile network operators

MNOs stand to gain from eSIM and the associated OTA switching processes in a number of ways.

80 While the typical device lifetime for consumer smartphones lies at 2-4 years (see e.g. https://www.statista.com/statistics/619788/average-smartphone-life/), this is less common in M2M. Especially in the connected car (lifetime of 10-15 years) and smart metering (lifetime of up to 40 years) where battery lifespan does not play a role, the replacement rate is far lower.

Firstly, **eSIM can contribute to lower costs**. Important savings can be made as a result of the fact that a fully digitized process can reduce the need for physical stores, as well as eliminating the need for physical mail-outs of SIM cards when ordered online. Industry experts estimate that for operators, the cost of a physical SIM card is 7 to 10 times higher than an eSIM due to logistics and the need to keep stock. Inventory costs may also be inflated because many SIM cards are destroyed without ever being used. The associated move to automated processes for customer sign-up could also enable mobile operators to reduce headcount. Estimates put the cost of manufacturing an eSIM at $0.50.[81]

MNOs could also benefit from **new revenue streams** associated with eSIM-based services. These include:

- Potential revenues from secondary consumer devices such as wearables, tablets, and laptops – alongside the opportunity to sell multi-device bundles, which could reduce churn. Increased information about the interests of consumers e.g. whether they own a smartwatch, could also enable more tailored marketing campaigns
- Potential retail revenues from industrial IoT including related consulting and software. There could also be opportunities from providing connectivity to support IoT at the wholesale level e.g. to specialist IoT providers
- The ability to target new customers including visitors requiring an alternative to roaming services – especially in cases where these visitors do not benefit from the Roam Like at Home regime present in the EU
- Improved opportunities to acquire customers by providing “Try-Before-you-Buy” offers. Customers may want to try out coverage for locations they frequent or experience new technologies such as 5G.

Turning to the costs, it is true that introducing eSIM will entail up-front costs in the form of investment in the required infrastructure or outsourcing to other players as well as investing in applications for the digital journey. Mobile service providers which previously relied on business models connected with the sale of physical SIM cards through physical outlets, will also need to invest in re-engineering those business models and retraining staff. The precise set-up costs will vary from one operator to another and depend not only on the eSIM solution chosen by the MNO (i.e. outsourcing vs own provision), but also on its previous business model, and the degree to which changes are needed to its business processes and human resources to adapt to digital provisioning. However, it should be emphasized that these investments are unavoidable, due to the increasing prevalence of eSIM-enabled devices and need to

81 Interviews, https://internetpkg.com/average-cost-of-manufacturing-a-sim-card/. https://hybridsim.com/sim-card-cost/. Consumer-eSIM-A-game-changer-or-a-gimmick.pdf (mobiliseglobal.com) https://www.mobiliseglobal.com/wp-content/uploads/2021/04/Consumer-eSIM-A-game-changer-or-a-gimmick.pdf

support eSIM-only devices once these become mainstream. Thus, these costs would be incurred at some time, regardless of whether the MNOs concerned will ultimately benefit from this technological development.[82]

The fact that eSIM facilitates switching (especially in the consumer segment), and "multi-homing" (including the potential "cherry-picking" of certain services which may be more expensive from the primary provider such as non-EU roaming), as well as digital sign-up, which reduces barriers to entry for those without physical presence could increase the prospects for competition from specialist providers as well as other MNOs. eSIM and OTA switching may thus present a threat to more established operators.

The installation of the eSIM by hardware and device manufacturers may also introduce competition from another element of the value chain. Whereas mobile operators were previously in control of the provisioning and switching process including the provision of the SIM, OEMs may now play a role in steering customers or pre-installing connectivity, bypassing MNOs in this process. In order to benefit from the revenue opportunities from newly connected devices, MNOs may thus have to invest in building new kinds of relationships with OEMs and specialist IoT connectivity providers.

Thus far, device manufacturers have not sought to disrupt the core business of providing connectivity for smartphones. However, there is a risk for MNOs that device manufacturers and/or operating system providers could enter the market as MVNOs and steer customers towards their own consumer-oriented mobile service. For example, although it is not pre-installed on Android devices, Google, which controls the Android operating system operates the Google Fi service in the US, an MVNO which relies on connectivity from T-Mobile and US cellular.[83] MNOs still maintain control of the connectivity itself, by virtue of their ownership of licensed spectrum. However, markets in which at least one of the MNOs are open to making wholesale arrangements with a leading application provider or device manufacturer, could pose a threat to MNOs which are seeking to focus on growing their own retail subscriber-base.

These potential threats could serve to further limit and focus the scope of MNOs' remit, which has already been reduced by the voluntary actions of some MNOs to divest towers and reduce their retail presence.[84]

82 Although MNOs could reap benefits from eSIM, the primary beneficiaries are likely to be end-users (both consumers and industrial customers) as well as equipment manufacturers and providers of secondary services and M2M applications

83 https://fi.google.com/about/.

84 These developments are discussed in more detail in a separate report by WIK-Consult for ComReg on the Irish mobile market due for publication in 2021.

5.2.2 Benefits and challenges for MVNOs

eSIM with its associated OTA provisioning and switching capabilities presents many opportunities for certain types of MVNOs, while presenting significant risks for others.

The main beneficiaries are likely to be MVNOs specializing in services which are supported by the eSIM / OTA model including providers of mobile connectivity to travelers such as Dent,[85] Truphone[86] or SIM Local,[87] as well as MVNOs specializing in IoT applications such as Transatel.[88] These MVNOs have an opportunity to take a share in the expanding IoT market including associated software and consulting services, or in the case of travel providers, attract roaming revenues away from MNOs.

When it comes to mass-market MVNOs, smaller players and entrants could in theory benefit from the increased ease of switching and the trend towards online sign-up, as this would obviate the need for a costly physical presence. Another benefit is that MVNOs could switch more easily between different host MNOs, because the switching could be completed for the whole customer-base remotely rather than requiring all customers to swap out their SIM card. In turn, greater ease in switching the host provider should give MVNOs more bargaining power when agreeing wholesale access conditions with MNOs.

However, the eSIM / OTA model might pose challenges for larger MVNOs without unique or attractive offers, which could see their customers migrate elsewhere (a threat similar to those experienced by MNOs). A new threat in this regard may arise if large platforms such as Facebook or Amazon with an already existing customer base and widespread customer recognition decide to become an MVNOs and can reach a suitable wholesale agreement.

There are also risks for MVNOs which have built their business model around physical outlets, such as Post Offices and supermarkets, although MVNOs with retail outlets may be able to attract customers which are less comfortable in engaging with their telecom service provider via an application such as potentially older age groups, by catering to this niche at a time when other providers are scaling back their physical presence.

Another important challenge for MVNOs is the cost of investing in eSIM solutions. Interviews suggest that established consumer MVNOs may make the transition later than MNOs and are likely to do this only as a defensive mechanism, once the transition towards digital subscriptions via eSIM is complete. This problem was also observed in a

85 http://www.dentwireless.com/dentesim.
86 https://www.truphone.com/consumer/.
87 https://www.simlocal.com/.
88 https://www.transatel.com/solutions/m2m-and-iot/iot-connect/?utm_source=google&utm_medium=cpc&utm_campaign=IoTEN&utm_term=IoT&utm_content=dynamic&gclid=Cj0KCQjw6NmHBhD2ARIsAI3hrM0I5xpdtlPwKiZMLyA4xDAMC11mXIiMw-87z_U0vG4qh3eFz2MBTDcaAm4UEALw_wcB.

2018 market study by the Australian regulatory authority ACCC[89] which identified that the delay in MVNO support for eSIM was caused by the need for investments in IT platforms for MVNO use, which need to be developed together with the hosting MNO. This issue is also likely to be relevant for European MVNOs.

5.2.3 Opportunities and challenges for eSIM management providers / manufacturers

Traditional SIM card vendors such as Gemalto and Giesecke+Devrient have been heavily involved in the development of the eSIM specification and have also, naturally, invested into the new technology, namely the SM-DP and SM-SR for the M2M segment and SM-DP+ for the consumer segment. They also already bring know-how from their previous role as the two technologies (regular SIM and eSIM) are similar from their perspective: Instead of uploading the profile in the factory they upload the profile OTA on the eSIM of their customer. These SIM card vendors now provide the majority of eSIM profile downloads for the consumer market as operators in Europe most often opt to outsource eSIM management to them.

Besides providing the full eSIM management service, these companies also sell the technologies without the service (i.e. only the servers) to MNOs that want to have eSIM management in-house, or to connectivity providers that in turn sell the eSIM management service to MNOs, MVNOs, and/or IoT manufacturers.

Connectivity providers can also reap significant profits from eSIM rollout in the M2M market. This market opportunity comes from the fact that more devices can be connected, as well as the fact that container or smart metre manufacturers and logistic or utility companies will often need to outsource eSIM management, because they lack know-how, and this function is unrelated to their core business. Expanding competition amongst eSIM management providers, should in turn drive lower prices and further accelerate eSIM adoption for the M2M market.

Because the eSIM specifications set by the GSMA are still changing, eSIM management servers need to be updated regularly, which makes outsourcing the eSIM management service the preferred option for many operators. In the future, some eSIM management providers may face the threat that operators want to manage their eSIMs in-house once the specifications are changing less frequently and eSIM adoption is much higher. As most operators are charged per eSIM profile download, investing in the capability to provide this service in-house might also become more financially attractive once increased CAPEX requirements can be balanced by the reduced OPEX involved with managing the process in-house. However, the general trend to outsourcing business segments to specialist companies may limit operators' capabilities to build

89 ACCC (2018). Communications sector market study final report. https://www.accc.gov.au/publications/communications-sector-market-study-final-report.

their own solution. Thus, whether operators will manage their eSIM in the future or continue to outsource is difficult to predict.

5.2.4 A new role for equipment manufacturers and OSS providers

The transfer of control over the provision of the SIM from mobile service providers to device manufacturers provides an opportunity for device and equipment manufacturers to bundle connectivity with their service either directly or via partnerships with specialized MVNOs. Examples include the partnership between Microsoft and Transatel[90] for connectivity in laptops, or Audi and Cubic telecom[91] for connectivity in cars. The transition to purchasing connectivity via applications could also provide an opportunity for OSS providers to steer consumers towards purchasing certain connectivity solutions e.g. by pre-loading applications to purchase connectivity.

On the one hand, this clearly provides a revenue-making opportunity for these players and enables them to reduce their reliance in the consumer space on marketing by MNOs which may previously have influenced device purchases by their practice of bundling and cross-subsidising devices with connectivity.

On the other hand, switching challenges prevalent in the IoT space in particular (see section 5.1.2) present the risk of lock-in for device manufacturers, which have contracted with third parties to provide connectivity.

5.2.5 The evolution of distribution channels

The move towards all-digital customer journeys that will be facilitated by eSIM and OTA provisioning and switching processes is also likely to accelerate trends away from physical distribution channels for mobile services, towards online sales and support channels, and ultimately mobile-centred sales and support channels.

A major casualty of this trend has been independent mobile retailers. For example, although it predated eSIM, the closure of Carphone warehouse in Ireland, as well as standalone Carphone Warehouse stores in the UK may have been triggered by the increasing trend towards digital sales.

Carphone Warehouse reports that its Irish business had seen a drop in footfall of more than 40% and a 25% increase in customers buying SIM-free handsets.[92] The company also noted that customers were increasingly choosing to shop with its online business. The withdrawal of Vodafone as a supplier in March 2021 – as Vodafone shifted to an "omni-channel approach to sales and service" including through its online sales

90 https://www.transatel.com/news-and-insights/press-releases/iot-solutions/transatel-enables-box-global-cellular-connectivity-microsoft-surface-pro-lte-advanced/.
91 https://audi.cubictelecom.com/en/.
92 https://www.rte.ie/news/business/2021/0421/1211181-carphone-warehouse-to-exit-ireland/.

channels, may also have precipitated the closure.[93] The closure of Carphone Warehouse's retail stores follows the closure of its MVNO business ID Mobile in 2018,[94] which had sought to use the firm's physical presence as one of its channels to grow its customer base. As discussed above (in section 5.2.2), MVNOs which rely heavily on a physical presence to market and distribute their mobile services may also be negatively impacted by the virtualization of mobile service provision.

On the other hand, the development of a wider range of smart devices may support the emergence of new physical sales channels with a focus on consumer IoT and "lifestyle" For example, Three has announced that it will be bringing a new "connected lifestyle experience" to 60 of their stores within Ireland.[95] By focusing on the sale of connected devices (which may lend themselves to a physical showroom experience), MNOs could seek to increase revenues through connectivity as an "after-market", knowing that switching connectivity providers for IoT devices might be more complex and burdensome than switching smartphone providers.

5.3 Environmental Benefits and challenges

One of the benefits that operators have cited[96] in relation to eSIM is the potential to reduce plastic waste and thus contribute to environmental sustainability. The carbon footprint of plastic from SIM cards and the associated housing has been estimated at 35g of CO2e per card [97] Thales estimates that 4.5 billion SMP cards are produced globally, involving 20,000 tons of polymers.[98] .

The complete elimination of physical SIM cards may take some time, as physical SIMs are expected to co-exist with eSIMs in the short term.[99] In the meantime, the impact of traditional SIMs could be reduced by the use of smaller SIM cards. For example Telefonica Germany[100] introduced a so called half-SIM carrier format, which, compared to the previous credit card format, is only half the size and weight, leading to a saving of more than 30 tons of plastic per year. Similar numbers are published by Vodafone (reduction of 20 tons of plastic and 300 tons of CO^2 emissions)[101]. Thales has also introduced SIM cards which are made from recycled plastic.[102] However, neither smaller SIM cards nor EcoSIMs are likely to achieve the savings in GHG emissions that

93 https://www.independent.ie/business/technology/vodafone-walks-away-from-carphone-warehouse-in-ireland-40184286.html.
94 https://www.rte.ie/news/business/2018/0306/945444-id-mobile/.
95 https://www.rte.ie/news/business/2021/0805/1239129-three-ireland-to-invest-27m-in-retail-stores/.
96 See for example claims by Proximus https://www.proximus.be/en/id_b_cr_esim/personal/blog/news/be-the-first-to-know/the-esim-is-here.html.
97 http://www.icma.com/ArticleArchives/CarbonFootprint_SE2-12.pdf.
98 How eco-friendly SIM card offer can help mobile operators address their sustainable goals.
99 https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications.
100 https://www.teltarif.de/o2-sim-karten-halter-umwelt-telefonica-plastik-co2/news/76287.html.
101 https://www.logitel.de/blog/vertraege/fuer-die-umwelt-vodafone-halbiert-sim-karten/.
102 https://www.thalesgroup.com/en/markets/digital-identity-and-security/mobile/packaging.

should be linked to eSIM, because they still entail manufacturing for a product that is ultimately disposable and will not necessarily be recycled.

One potential negative effect from eSIM may be that the development of a new range of eSIM-enabled consumer devices alongside the launch of additional consumer and industrial IoT devices could lead to accelerated smartphone renewal and increase the overall number of devices, leading to greater environmental impacts associated with the production of devices and their operation. However, negative impacts from the production and use of new devices may be offset by the enabling effects that connected devices may have on improving energy efficiency and limiting waste in other sectors such as energy, water and transport.[103] Manufacturers are also continually striving to increase energy efficiency, which may mean that newer devices consume less energy for a given usage pattern than older devices.

5.4 Impacts on Security

Traditional, physical SIM cards contain a separate chip, the UICC, which contains the SIM functionality. The eSIM is still a physical, separate chip, the eUICC, and can therefore generally provide higher security levels, than purely virtual SIMs such as SoftSIM with SIM functionalities as software. Certain risks may remain, but others may be mitigated compared with physical SIMs. A comparative analysis of risks for eSIM compared with traditional SIM alongside solutions is presented in the following table.

103 See WIK-Consult 2020 Neutral fibre and the European Green Deal https://www.wik.org/fileadmin/Konferenzbeitraege/2021/Stokab_greendeal_29042021.pdf.

Table 5-1: Security risks analysis

Risk	Description
Hacking of IP networks	RSP is done through IP networks, which may make telecom providers more vulnerable compared to provisioning with traditional SIM card and Network Security vulnerabilities may be used to commit telecom fraud. **However**, The GSMA's Security Accreditation Scheme (SAS) enables mobile operators, regardless of their resources or experience, to assess the security of their UICC and Embedded SIM suppliers. This means there is **no way to download applications to the UICC without the consent of the operator**.
Subscription fraud	According to the Communications Fraud Control Association,[104] identity fraud in telecommunication during the subscription process remains one of the most common methods of telecommunication fraud. It typically involves identity theft or the use of false identification at the point of sale, enabling either the fraudulent use of telecom services, or the use of such services for other fraudulent activities.[105] As long as identification measures imposed by the operator remain the same, the **risk level compared to regular SIM cards also remains the same**. The use of more secure identification (e.g. two factor authentication, eID, etc.) may be applied to both technologies to prevent subscription fraud.
SIM cloning	SIM cloning is where traditional SIM access is obtained using non-legitimate ways, typically from using hacking software. This access can then be used as an enabler to commit International Revenue Share Fraud,[106] Roaming, or Traffic Pumping fraud.[107] Since the eSIM is now stored digitally in a secure manner on the device, removing it to read its contents should be more difficult compared to physically taking it out of a SIM card slot and plugging it into a SIM card reader.

Source: WIK-Consult based on CFCA and Europol.

As noted in section 3.5, GSMA has been working on security in eSIM operation, and has established, industry respected, Security Accreditation Scheme (SAS), an audit-based scheme that should be considered when planning a compliance campaign for eUICC, SM-SR and SM-DP. The GSMA eSIM standard continues to be developed to meet industry requirements.

104 https://cfca.org/.

105 Source: CFCA Global Telecom Fraud Survey via FICO, see https://www.fico.com/blogs/top-fraud-issues-telecommunications-survey-results.

106 A type of telephone fraud that utilizes technical means to make unauthorized calls to premium numbers. Cybercriminals may use stolen SIM cards to direct calls to their own or leased lines with billing of incoming connections. For more information, see https://www.europol.europa.eu/publications-documents/toll-fraud-international-revenue-share-fraud-and-more-how-criminals-monetise-hacked-cell-phones-and-iot-devices-for-telecom.

107 Also known as access stimulation, where local carriers inflate the volume of incoming calls to their networks to profit from intercarrier compensation fees (for example in the United States, where they are entitled to compensation by the Telecommunications Act of 1996. See, for example, https://broadband.wordpress.com/2007/05/09/sprint-nextel-fights-traffic-pumping-schemes/.

5.5 Key take-aways

KEY TAKE-AWAYS

- The benefits of eSIM and OTA from a consumer perspective include improved provisioning and switching processes, which should in turn boost competition and reduce retail prices. eSIM and OTA also supports connectivity in consumer devices such as smartwatches and health monitoring devices, providing scope for innovative new products and associated services. Consumers also benefit from new services such as the ability to take out secondary contracts for roaming, business vs personal use, or to ensure good coverage. However, there are risks of lock-in in cases where (especially secondary) devices are pre-connected to certain connectivity providers, without the opportunity to switch. If operators do not support eSIM at all or do not support eSIM connectivity for companion devices, consumers may also face more limited choice then in a physical SIM environment. This may become more of a problem when devices are shipped without the option of a physical SIM, if mobile service providers do not provide eSIM support for these devices beforehand.
- eSIM and OTA provides the opportunity for industrial customers to purchase devices without connectivity pre-installed and provision them in the field, as well as presenting an opportunity for switching, which would not be possible without the recall of devices in a physical SIM environment. eSIM also enables devices to be sealed, and thus robust to extreme conditions with reduced risk of tampering. However, there is the risk that the market may be slow to emerge, because of long device lifetimes and because existing providers have limited interest in enabling switching. Switching may also be complex and costly, especially where the customer does not control the profiles via the SM-SR.
- eSIM may have a significant impact on market structures going forwards, in particular because it enables equipment manufacturers and OSS providers such as Apple, Microsoft and Google (as well as car manufacturers) to engage in the process of providing or bundling connectivity. In addition to potentially benefiting these actors, other beneficiaries may be MVNOs which are specialised in international connectivity and applications for IoT and consumer / business travel. MNOs could benefit from reduced costs resulting from the shift from physical to digital processes and outlets, and potential new revenue streams. However, achieving these benefits will require up-front investment and they also risk losing revenues as a result of the increased potential for competition (including competition from new entrants) that may be supported by eSIM. Traditional consumer MVNOs relying on physical sales outlets such as post offices and supermarkets (as well as independent retailers selling mobile packages in physical stores) may also lose out from the shift to all digital transactions. Notwithstanding these potential costs and risks, MNOs and MVNOs will have to invest in eSIM once eSIM-only devices become more prevalent.
- eSIM could have environmental benefits due to the reduced plastic waste and associated physical transport. In addition, M2M applications supported by OTA could support energy efficiency in other sectors, such as transport, energy etc

6 What is the status of eSIM deployment internationally?

In this chapter, we look into trends in eSIM deployment internationally with a focus on:

- The main drivers of eSIM growth (section 6.1)
- The status of eSIM in the consumer segment (section 6.2); and
- The status of eSIM in the M2M segment (section 6.3).

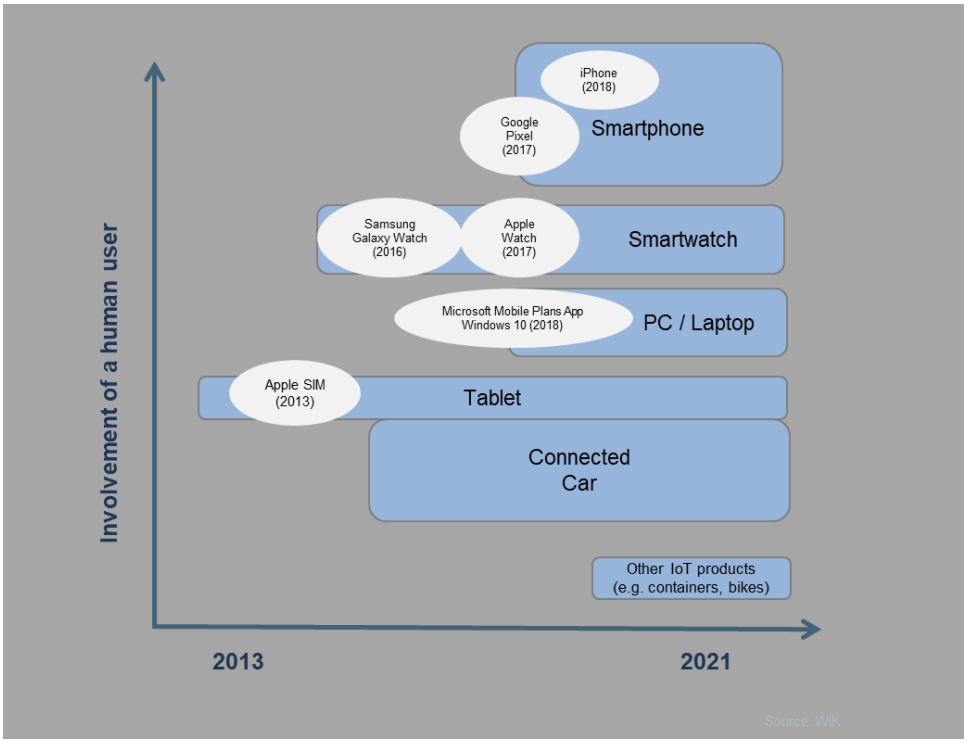
Key take-aways are summarized at the end of the chapter.

6.1 Drivers of eSIM growth

eSIM technology and associated standards have been available for around 10 years. Initially, there was a focus on M2M. However, within the last 5 years, there has been a growing number of product launches for consumers, accompanied by an ongoing specification development process at the GSMA.

eSIM has now been implemented across various product categories, with the most recent being the Smartphone, PCs, and laptops (see Figure 6-1).

Figure 6-1: Major steps in eSIM development



Size of box should roughly indicate size of segment today

Source: WIK-Consult.

In the context of the total mobile market, eSIM is still at an early stage. However, in 2020 significant progress was reported by both the GSMA[108] and the Trusted Connectivity Alliance (TCA)[109].

While eSIM technology was initially developed for the M2M market (see section 3.2), it is now far more advanced in the consumer market. Current growth is mainly driven by the launch of new eSIM-enabled smartphone models and smartwatches and was also promoted by regulation such as the European eCall initiative.[110] According to a global survey by Truphone (2021), smartphones are regarded as the most well-suited for eSIM by MNOs and device manufacturers (followed by smartwatches and cars, see Figure 6-7).[111]

Overall, eSIMs are being integrated into an increasing number of devices for a wide range of applications. In 2020, a total of 309 million eSIM units were shipped. While the traditional SIM (including removable and soldered M2M SIM) was estimated at 4.8 billion units, the share of eSIM reached around 6% of all M2M SIMs shipped in 2020. eSIM shipments increased by 83% between 2019 and 2020. [112]

6.2 Status of eSIM in the consumer segment

The first eSIM products for consumers were launched around 8 years ago (as proprietary solutions). Since then, the market for consumer devices incorporating eSIMs has evolved rapidly, and the GSMA reports that up to 2 billion mobile users worldwide could adopt eSIM.[113]

The eSIM has been promoted in the consumer segment mainly by Apple. Its first engagement with eSIM dates from the launch of a proprietary solution called “Apple SIM” that was integrated into the iPad Air 2 in 2013. Since then, it has pursued various approaches (preinstalled, removable SIM, eSIM) to provide cellular connectivity for

108 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 4.

109 See Trusted Connectivity Alliance (TCA) (2021): 3 factors driving eSIM adoption, 19 April 2021, https://trustedconnectivityalliance.org/3-key-factors-driving-esim-adoption/ and TCA (2021): TRE Industry Insights, https://trustedconnectivityalliance.org/wp-content/uploads/2021/03/TCA_INDUSTRY-INSIGHTS_FINAL.pdf.

110 See Trusted Connectivity Alliance (TCA) (2021): 3 factors driving eSIM adoption, 19 April 2021, https://trustedconnectivityalliance.org/3-key-factors-driving-esim-adoption/ and TCA (2021): TRE Industry Insights, https://trustedconnectivityalliance.org/wp-content/uploads/2021/03/TCA_INDUSTRY-INSIGHTS_FINAL.pdf.

111 Survey among 371 MNO and device manufacturers (consumer and M2M), see Truphone (2021): How eSIM is transforming connectivity for consumers and enterprises, survey report, https://d110erj175o600.cloudfront.net/wp-content/uploads/2021/02/19103110/24602-Truphone-survey-report-003.pdf ,page 7.

112 See Trusted Connectivity Alliance (TCA) (2021): 3 factors driving eSIM adoption, 19 April 2021, https://trustedconnectivityalliance.org/3-key-factors-driving-esim-adoption/ and TCA (2021): TRE Industry Insights, https://trustedconnectivityalliance.org/wp-content/uploads/2021/03/TCA_INDUSTRY-INSIGHTS_FINAL.pdf.

113 GSMA (2021): eSIM for Consumers: state of the market and future outlook.

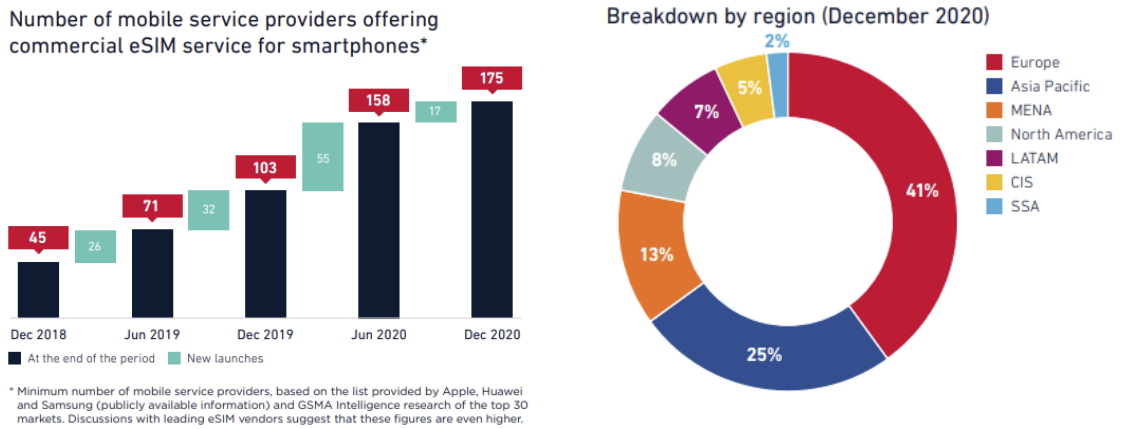
tablets. In 2016/2017, the first smartwatches with eSIM (Samsung Galaxy 2017, Apple Watch 2017) were launched, followed by eSIM enabled smartphones in 2018.

However, consumer's awareness of eSIM is still relatively low. A survey by GSMA found that only 20% of consumers are aware of eSIM, with awareness higher amongst 25–34-year-old consumers.[114] Feedback from interviews conducted by the GSMA suggests that low awareness and take-up could be addressed if MNOs increased promotional activities related to eSIM.[115]

6.2.1 eSIM implementation by MNOs

MNOs have started to support eSIM in a growing number of countries. Overall, 25% of operators surveyed by the GSMA in 2020 had launched eSIM services for smartphones (see Figure 6-2).[116] By the end of 2020, eSIM services were commercially available from 175 mobile service providers (MNO, MVNO and global connectivity providers such as Truphone or SIM Local) in at least 69 countries, with a strong focus on Europe (see Figure 6-2).[117] The GSMA reports that 70% of MNOs have launched in larger markets, and all MNOs are providing eSIM support in countries such as Spain, France, Germany and the UK.[118]

Figure 6-2: Overview on MNO services (for smartphones) (2020)



Source: GSMA.[119]

114 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 8.
115 GSMA (2021): eSIM for Consumers: state of the market and future outlook.
116 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption page 18.
117 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021 , page 19.
118 See GSMA (2021): eSIM for Consumers: State of the Market and Future Outlook.
119 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 19.

eSIM subscription management platforms have been implemented by a growing number of players, including all the major SIM card producers (such as G&D, Thales, Valid, Idemia). In total, 687 eSIM subscription manager (SM) platforms were deployed by the end of 2020 (+ 154% compared to 2019) globally.[120] The number of eSIM profile transactions (i.e. number of downloads of an MNO profile to a device) via these platforms is not publicly available. However, the TCA reported a 300% increase in eSIM profile transactions in 2020.[121]

6.2.2 Smartphones

Apple's launch of eSIM in its iPhone models XR and S in September 2018 proved to be a key milestone. By this time, Google had already integrated eSIM in its Pixel smartphone (October 2017), but this had less impact on the eSIM market because of its minor market share. After these initial launches, it took some time before other major manufacturers followed with the deployment of integrated eSIM in smartphones Samsung and Huawei launched their solutions in 2020.

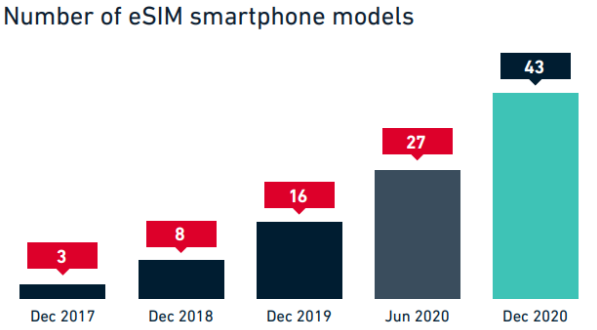
It should be noted that not all smartphones from these leading manufacturers have eSIM capability, but the number of available eSIM equipped smartphone models has been growing continuously: In total, GSMA identified 43 eSIM smartphone models in December 2020 compared with only 3 in December 2017.[122]

120 See Trusted Connectivity Alliance (TCA) (2021): 3 factors driving eSIM adoption, 19 April 2021, https://trustedconnectivityalliance.org/3-key-factors-driving-esim-adoption/ and TCA (2021): TRE Industry Insights, https://trustedconnectivityalliance.org/wp-content/uploads/2021/03/TCA_INDUSTRY-INSIGHTS_FINAL.pdf.

121 See Trusted Connectivity Alliance (TCA) (2021): 3 factors driving eSIM adoption, 19 April 2021, https://trustedconnectivityalliance.org/3-key-factors-driving-esim-adoption/ and TCA (2021): TRE Industry Insights, https://trustedconnectivityalliance.org/wp-content/uploads/2021/03/TCA_INDUSTRY-INSIGHTS_FINAL.pdf.

122 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 13.

Figure 6-3: eSIM smartphone models (Dec 2020)



By OEM	Number of eSIM smartphone models
Total	**43**
Samsung	14
Apple	11
Google	11
Huawei	3
Motorola	2
Microsoft	1
NUU Mobile	1

Source: GSMA (2021).[123]

Thus far, eSIM has mainly been implemented in premium handsets (average price for eSIM enabled smartphones about twice of the average smartphone price, i.e. 800 Euro compared with 350 Euro).[124] However, GSMA observes a trend towards declining prices, as cheaper eSIM smartphones have started to gain traction.[125]

Moreover, current eSIM equipped smartphones are not eSIM-only (with the exception of the Motorola Razr), but typically Dual SIM Dual Standby.[126]

While dual SIM smartphones have been available for many years, they are not widespread in Europe (in contrast to some Asian markets). One reason is sufficient coverage and frictionless roaming. Moreover, Apple has a strong market position in Europe and had never produced Dual SIM-phones before it launched eSIM.[127]

Dual SIM is typically used where a customer requires separate lines for different purposes – typically for a permanent primary subscription and for an additional secondary subscription (that is subject to change according to the customer needs in

123 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 13.
124 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 15.
125 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 15.
126 See e.g. SIM Local (2020): Dual SIM – the route to new eSIM revenues for operators, Whitepaper, page 7.
127 See SIM Local (2020): Dual SIM – the route to new eSIM revenues for operators, Whitepaper, page 6.

specific locations or situations, e.g. travelling, constant coverage or personal and business use of the same device).[128]

Dual SIM is an important feature for eSIM-equipped smartphones at this time, because the current GSMA specification allows only one eSIM profile to be active at any time. Customers with eSIM enabled phones today typically rely on the physical SIM for their primary connection.

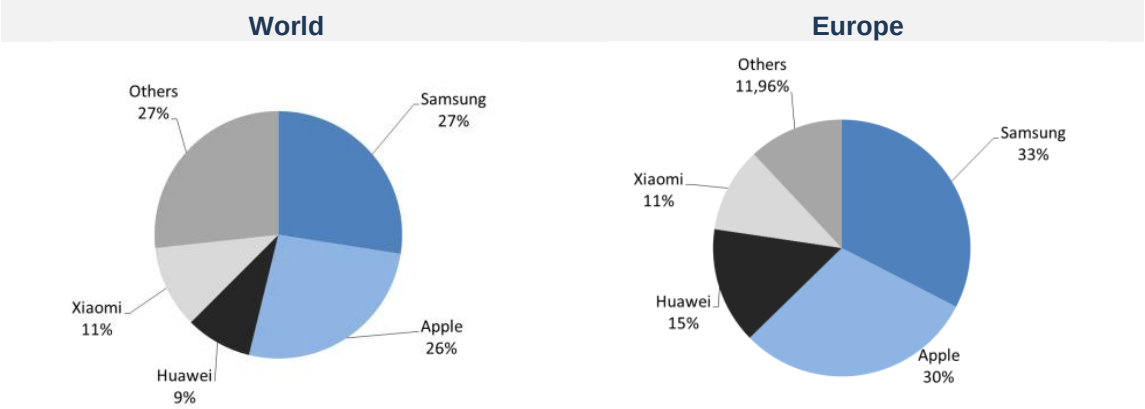
According to experts interviewed for this study, most owners of eSIM equipped smartphones do not activate the eSIM but instead use the physical SIM card. Where eSIM is used, this is typically to add one or multiple eSIM profiles as secondary subscriptions.

The market share of leading smartphone vendors differs markedly between countries. Publicly available information varies, but provides some indication:

- According to a consumer survey conducted by GSMA some countries are led by Apple (e.g. US, Canada, and Japan with more than 40% market share in the smartphone user base), while Samsung is strongest in South Korea (68%) and Huawei in China (34%).[129]
- According to Statcounter (April 2021), Samsung is in a leading position across Europe as a whole (33%), followed by Apple (30%) and Huawei (15%) (see Figure 6-4).

128 See SIM Local (2020): Dual SIM – the route to new eSIM revenues for operators, Whitepaper, page 6.
129 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 13.

Figure 6-4: Market shares of device manufacturers, worldwide and in Europe* (June 2021)



*referring to usage based on web analytics

Source: WIK-Consult based on Statcounter (2021).[130]

Services for travelers are among the most attractive connectivity use cases for eSIM-enabled smartphones (see also section 4.2.3). Connectivity solutions for travelers are currently mainly offered by global connectivity providers. Some of the companies active in this space previously offered connectivity to travelers via traditional SIM solutions and sold global roaming services or local SIM cards (e.g. SIM Local) before. However, the ease of subscribing to a new profile via eSIM has provided an opportunity for these players to expand, and for new players to emerge.

For example, in 2020, eSIM.net[131] – a start-up with focus on eSIM services founded in the UK in 2019 - launched a global Pay As You Go eSIM service that was said to be Europe's first offering of this kind.[132]

An attractive aspect of eSIM is that it allows travelers to subscribe through a fully digital process.

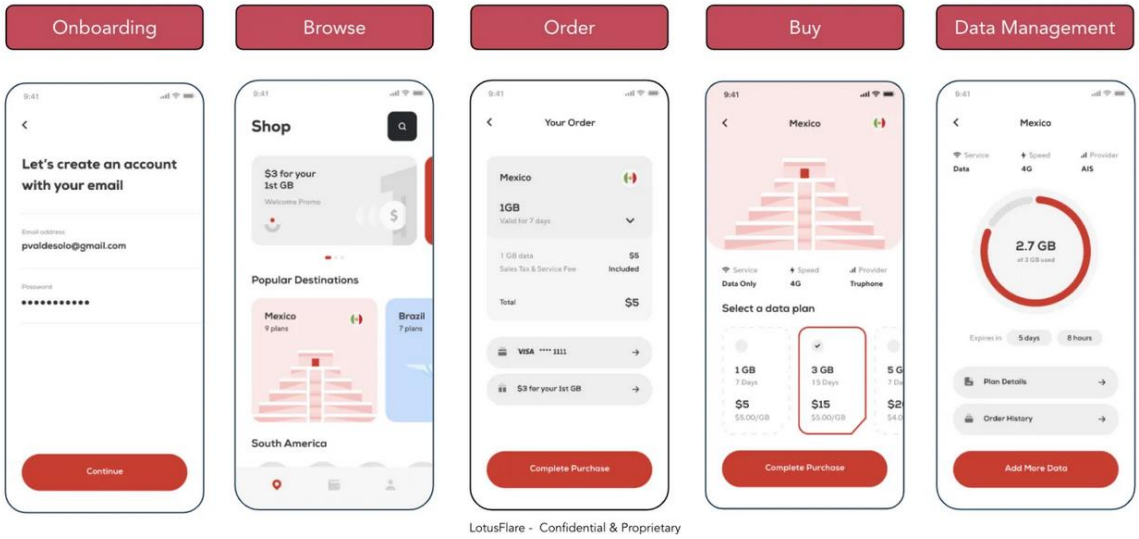
An example of the eSIM-based sign-up process for travel services from Lotusflare is shown in Figure 6-5.

130 See Statcounter (2021): Mobile Vendor market share worldwide, https://gs.statcounter.com/vendor-market-share/mobile/worldwide and Statcounter (2021): Mobile Vendor market share in Europe – June 2021, https://gs.statcounter.com/vendor-market-share/mobile/europe.

131 https://www.esim.net/aboutus.

132 https://www.esim.net/pay-as-you-go-esim. See also https://www.computerweekly.com/news/252485857/Worlds-first-5G-eSIM-service-goes-live.

Figure 6-5: Example: eSIM traveler App by Lotusflare



Source: GSMA (2021).[133]

Although eSIM provides an opportunity for MNOs to offer connectivity services for travelers into their home countries (a kind of "local break-out"), most have not yet pursued this opportunity. However, some MNOs have collaborated with MVNOs to support the launch of eSIM services for travelers. Some examples are:

- In July 2020, Orange Wholesale France (OWF) launched eSIM services for MVNOs in cooperation with the European MVNO Prixtel, based in France.[134]
- In April 2021, Vodafone announced a partnership with Sim Local to provide seamless connectivity to international travelers.[135]

6.2.3 Smartwatches

Smartwatches were among the first consumer products equipped with eSIM and are amongst the most significant devices supporting eSIM today.

eSIM in smartwatches was available before it was integrated into smartphones:

- In November 2016, Samsung started to offer its smartwatch, Samsung Gear S2 classic with eSIM capability.

133 See GSMA (2021): Could eSIM revive roaming revenues?, GSMA blog, 23 March 2021, https://www.gsma.com/esim/blog-from-lotusflare-could-esim-revive-roaming-revenues/.

134 See e.g. https://www.mobileeurope.co.uk/press-wire/14932-orange-wholesale-france-to-offer-esims-to-customers.

135 See Vodafone (2021): Sim Local to accelerate eSIM travel growth, press release, 21 April 2021, https://newscentre.vodafone.co.uk/press-release/sim-local-to-accelerate-esim-travel-growth/.

- In September 2017, Apple launched its Apple Watch 3 with eSIM.
- Other smartwatch producers followed: market leaders like Huawei as well as other big Asian manufacturers (e.g. Oppo, Xiaomi, STE) and some smaller manufacturers.
- By the end 2020, GSMA counted 27 smart watch models with eSIM[136]

Apple is currently leading in this market segment with around 40% share in global smartwatch shipments – however, not all Apple Watch models contain eSIM.[137] Smartwatches represent an attractive growing business segment for Apple: It reported a 25% growth for the broader service category "Wearables, home and accessories" between 2019 and 2020, while growth in iPhone sales was only 3%.[138]

It should be noted that among the large number of available wearables and smartwatches,[139] most models do not provide any connectivity themselves. However, for smart watches which have their own connectivity, eSIM is the dominant technology, and traditional SIMs play only a very limited role. eSIM enables an autonomous connection to a mobile network for the smartwatch: without eSIM, any call functions via the smartwatch can be used only in combination with a connected smartphone.

It should be noted that, even when smart watches are eSIM enabled, not all owners of eSIM-enabled smartwatches use it. There are still some preconditions for using the eSIM in smartwatches that might prevent usage to some extent. For example, activating the eSIM in the smartwatch is typically associated with additional costs (depending on the subscription plan, often around 5% per month).[140]

The choice of connectivity provider for the smartwatch is also limited (and conversely, the choice of primary connectivity provider can influence the choice of the eSIM-enabled smartwatch). Specifically:

- Only providers that offer support for the eSIM in the specific smartwatch can be chosen, but the number of providers is still limited. With 100 supporting operators[141] around 50% fewer companies provide connectivity for

136 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 12.
137 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption page 31.
138 Apple (2020): Annual Report 2020, https://s2.q4cdn.com/470004039/files/doc_financials/2020/ar/_10-K-2020-(As-Filed).pdf , page 9.
139 The overall smartwatch adoption has continuously increased during the last years and doubled between 2017 and 2020 with an installed base of 200 million globally, see GSMA (2021): eSIM State of the consumer market and the road ahead, page 22.
140 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption page 31.
141 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption page 31.

smartwatches than for smartphones (although in some Asian countries eSIM connectivity for smartwatches is available, but not for smartphones).

- For the use of a single number for both smartphone and smartwatch a contract with the same carrier is required (see e.g. Samsung Galaxy).
- Apple generally requires the use of the same provider for both smartphone and smartwatch. Moreover, it does not support roaming. In combination with the required use of the same carrier for both smartphone and smartwatch this results in the Apple Watch being usable only in the home country of the user.

These challenges multiply if the customer wants to switch their provider, as they need to make sure that the new provider can support both products in the case of Apple Watch or single number use for other smartwatches.

6.2.4 Other devices: PCs, Laptops, Tablets

Microsoft started to support eSIM around 5 years ago and their entry into this space was perceived as a potentially significant driver of the technology:[142]

- At the end of 2016, Microsoft announced that eSIM, in cooperation with Qualcomm, would soon be introduced for Windows 10.
- In early 2017, Microsoft signed a partnership with Gemalto for Subscription Management.
- In mid-2017, more details about the plans were published referring to the next generation of Windows 10 hardware and the introduction of the “Always Connected PC”.
- Currently, discussions with the network operators are still ongoing.
- In 2018, the “Mobile Plans app” in Windows 10 was presented. It was designed to set up and manage a cellular data plan with a supported mobile operator.

A precondition for the use of Mobile Plan app in Windows 10 are eSIM-equipped PCs, which are mainly mobile devices (i.e. laptops). These were launched in 2017 and Microsoft claims that almost 70% of PCs for commercial use could be connected today (see Figure 6-6).

142 See also Godlovitch et al (2019): Technological developments and roaming - Final Report. Study by WIK prepared for the European Commission, page 34 ff.

Figure 6-6: Availability of PCs with cellular connectivity

Source: Mobile World Live (2021).[143]

By the end of 2020, GSMA counted 23 laptops and 17 tablet models equipped with eSIM.[144] These are provided mainly by the largest laptop vendors Lenovo, HP, and Dell as well as by Apple (tablets).

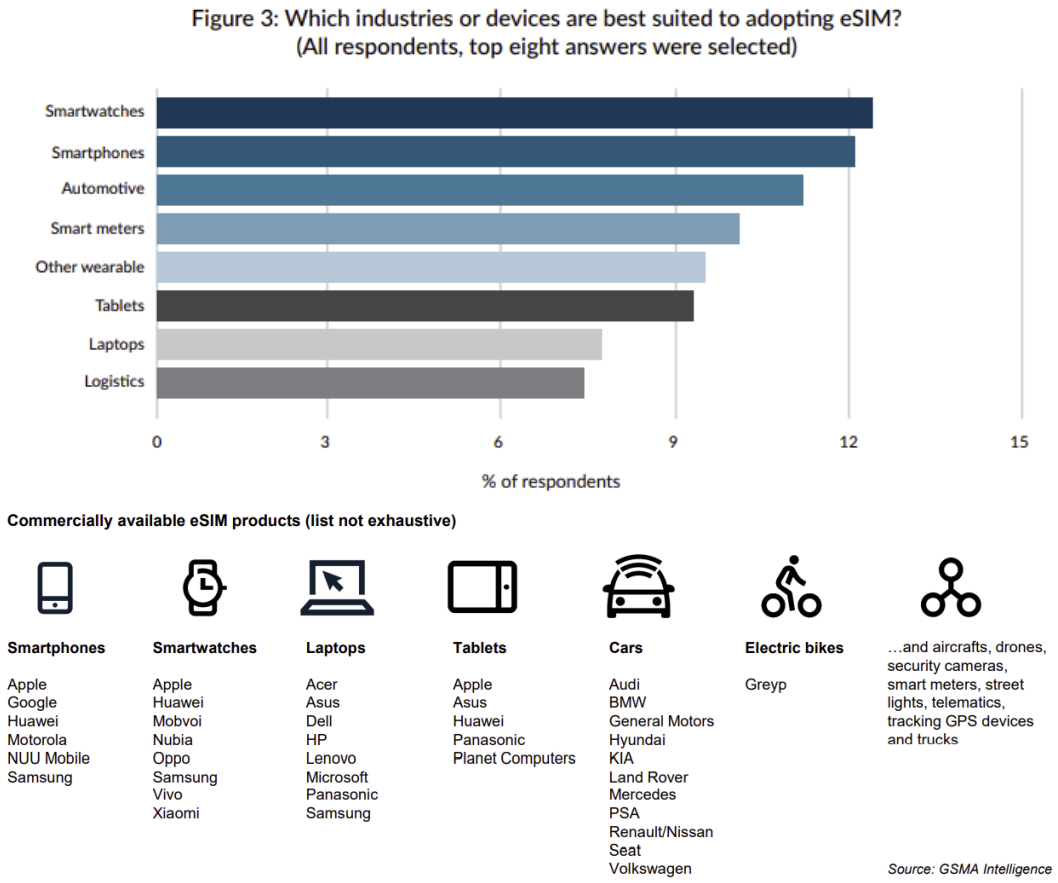
However, the actual use of the eSIM capability within those devices is still very low and is likely to be mainly limited to the enterprise customer segment.

One reason may be the relatively limited number of providers offering mobile plans for the Mobile Plans App in Windows 10 – especially compared with those supporting eSIM in smartwatches and smartphones.[145]

Another reason highlighted by our interview partners is the relatively limited promotion of the connectivity option by Microsoft itself.

143 See Mobile World Live (2021): Enterprise eSIM device management, report sponsored by HP, ivanti, Microsoft, https://www.mobileworldlive.com/wp-content/uploads/2021/05/MWL-HP-Enterprise-whitepaper-Enterprise-eSIM-Device-Management.pdf , page 8.
144 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 12.
145 See https://www.microsoft.com/en-us/windows/lte-connectivity-mobile-plans-app.

Figure 6-7: Overview of eSIM relevance by device type



Source: Survey results: Truphone (2021)[146], List of products: GSMA (2020)[147], page 10.

6.3 Status of eSIM in the M2M segment

Despite the strong growth of the IoT market, the focus of eSIM deployment has shifted towards the consumer segment (see chapter 6.1).

6.3.1 Challenges of IoT projects from the customers perspective

Implementing IoT use cases is a challenging task for the IoT customer: The IoT ecosystem is complex and highly fragmented with a large variety of players offering IoT related products and services to enterprises; collaboration among several players in the

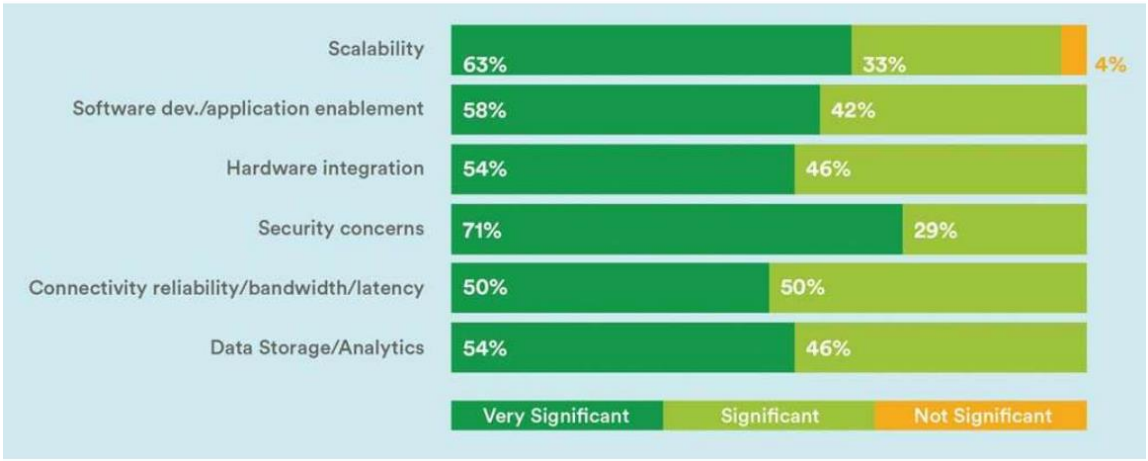
146 See Truphone (2021): How eSIM is transforming connectivity for consumers and enterprises, survey report, https://d110erj175o600.cloudfront.net/wp-content/uploads/2021/02/19103110/24602-Truphone-survey-report-003.pdf, page 7.

147 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 10.

IoT ecosystem is needed.[148] Besides technical requirements, commercial and ecosystem-related criteria play a significant role. Enterprises deploying IoT have to take strategic decisions with long-term implications related to their processes. Typical characteristics of IoT projects include:

- Many connected devices in IoT use cases have a very long lifetime (e.g. 30-40 years for meters) - that significantly exceeds the lifetime of the eSIM itself.
- Contracts typically extend for at least 3 years (some 5-7 years).
- Scalability and switching are key requirements and present major challenges.
- IoT solutions involve various technical challenges (see Figure 6-8)[149]

Figure 6-8: Challenges in IoT solutions



Source: Beecham (2020).[150]

148 E, g, for a smart metering solution Iskaemeco, a OEM based in Slovenia provided the smart meters, cooperated with Sierra Wireless, Workz, Telemach Slovenia and Kigen, see Kigen Case Study : eSIM in Smart Meters, https://kigen.com/wp-content/uploads/2020/10/Kigen-eSIM-Iskra-Smart-Meter-Case-Study.pdf.

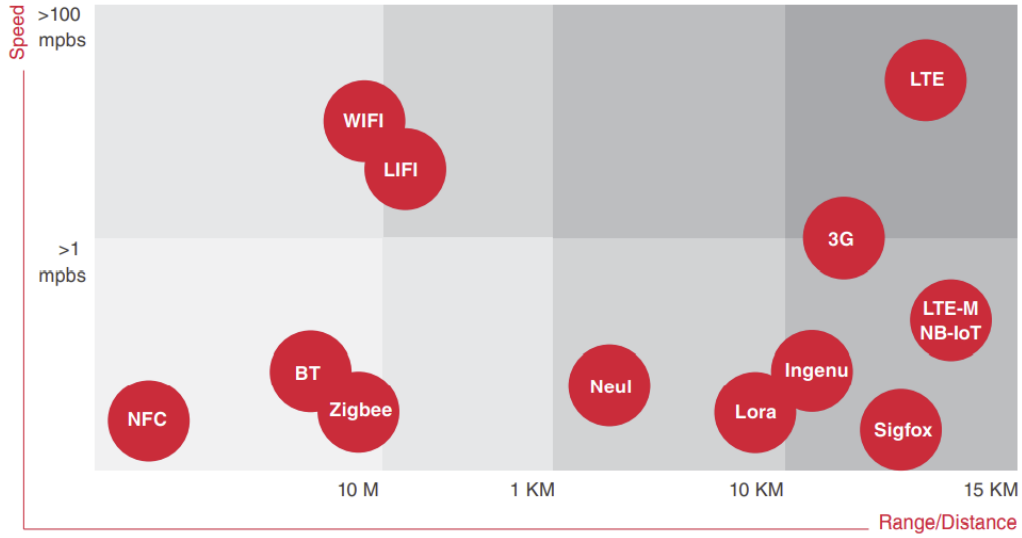
149 See Beecham (2020): Why IoT projects fail: towards new business value, https://iot-now.com/wp-content/uploads/IoT-Now-Magazines/2020-Q1/Why-IoT-projects-fail.pdf, page 22.

150 See Beecham (2020): Why IoT projects fail: towards new business value, https://iot-now.com/wp-content/uploads/IoT-Now-Magazines/2020-Q1/Why-IoT-projects-fail.pdf, page 22.

6.3.2 The role of cellular connectivity for IoT use cases

Connectivity is a key component for each IoT use case. However, it should be noted that each use case has specific connectivity requirements and there are no one-size-fits all solutions.[151] For wireless connectivity, there are a wide range of technologies available – they differ e.g. with regard to speed and range (see Figure 6-9). According to an OVUM survey (2017-2018), enterprises deploying IoT solutions tend to use a variety of connectivity technologies at the same time, for different applications and different locations.[152]

Figure 6-9: Capability of wireless connectivity solutions



Source: Frost and Sullivan (2016).[153]

The data transferred in massive IoT applications tend to be small and a low power consumption is required. **LPWAN** (Low Power Wide Area Networks) technologies have been developed to meet those particular needs. Various LPWAN technologies rely on licence free spectrum (SigFox and LoRaWan are the leading technologies). Each of the currently available LPWAN technologies has specific characteristics with regard to coverage, data throughput, costs for modules and connectivity.[154] For cellular networks,

151 See for a detailed overview on different connectivity technologies for IoT, requirements of different use cases and most suited solutions e.g. Northstream (2020): Connectivity technologies for IoT, report commissioned by Telenor.

152 While 45% of IoT customers deploy short-range technologies (e.g. Wi-Fi, Bluetooth, Zigbee), 31% use cellular M2M and 21% LPWAN (e.g. NB-IoT, LTE-M, Sigfox). See Ovum (2019): eSIM Solutions Drive New Opportunities for Global IoT Services, February 2019, page 6.

153 See Frost & Sullivan (2016): Growing Industry Applications of LPWAN Technologies, https://rfdesignuk.com/uploads/9/4/6/0/94609530/murata, page 6.

154 E.g. “SigFox suits small data sensors due to the small size of data as well as long range and power efficiency while LoRa provides a higher throughput or big data size with lower range offering private networks to cover oil refineries or agricultural farms.”, see Frost & Sullivan (2016): Growing Industry

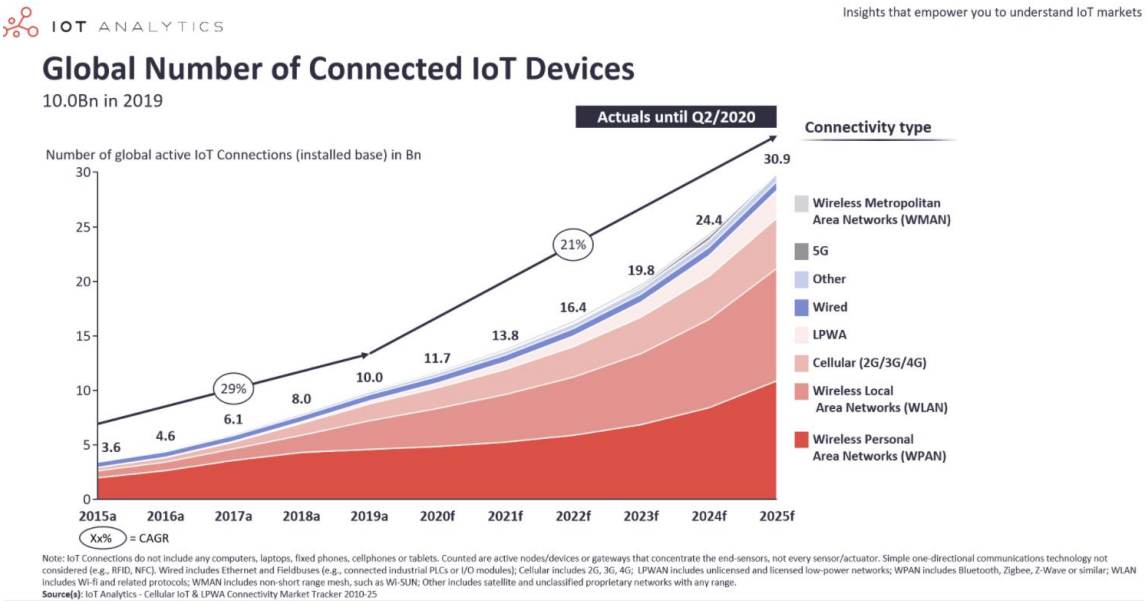
MNOs have developed **LTE-M and NB-IoT** as new LPWAN standards and are in the process of deploying networks. At the time of writing, mobile IoT solutions, using LTE-M and NB-IoT technologies, have been launched on 159 commercial networks.[155]

IoT solutions that are based on **cellular technology** are typically related to widespread devices (otherwise alternative wireless technologies like Wi-Fi or Bluetooth tend to be more attractive). Some of these IoT devices are fixed (e.g. smart meters), while others could be moved (e.g. connected machines). Depending on the use case, devices can be distributed within a country or cross-border.

According to the GSMA, there were 1.9 billion IoT licensed cellular connections in 2020.[156]

Compared with other IoT technologies cellular networks play a minor role for current IoT deployments today (see Figure 6-10).

Figure 6-10: IoT devices by connectivity (2015-2025)



Source: IoT Analytics (2020).[157]

Applications of LPWAN Technologies, https://rfdesignuk.com/uploads/9/4/6/0/94609530/murata_ page 8-9.

155 GSMA | Mobile IoT LPWA - LTE-M & NB-IoT Commercial Launches | GSMA.

156 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 37.

157 See IoT Analytics (2020): State of the IoT 2020: 12 billion IoT connections, surpassing non-IoT for the first time, 19 November 2020, https://iot-analytics.com/state-of-the-iot-2020-12-billion-iot-connections-surpassing-non-iot-for-the-first-time/.

6.3.3 The relevance of eSIM in IoT

Experts agree that eSIM technology will play a significant role for cellular IoT. It might be regarded as the "missing link to the IoT" [158], as it helps to overcome problems associated with traditional SIM. The technology opens new opportunities to develop massive IoT use cases that require high scalability and coverage and face severe constraints when implemented with traditional SIM.

Overall, eSIM has the potential to be deployed in a variety of IoT use cases with a focus on "moving objects" (e.g. drones, smart glasses, VR headsets, containers) as well as fixed objects (e.g. smart meters). Some of them are designed to be used by consumers (e.g. tracking of bikes or boats, health monitoring devices), some by business users (e.g. remote monitoring). Some of them have a national scope while others could be international. The range of potential use cases is very wide and still under development.

However, the successful development of eSIM technology in IoT use cases depends on how it is implemented. In this respect, standardization and interoperability are crucial for IoT to fully benefit from the OTA provisioning and switching capabilities of eSIM. The early implementations of eSIM-based IoT solutions often rely on proprietary solutions[159] which be a major challenge to switching at a later stage and is a long-standing issue due to the considerable lifetime of IoT devices.

While the potential advantages of eSIM for deployment in IoT use cases is obvious[160] (see section 5.1.2) and standardization efforts at the GSMA were initially focusing on M2M (see section 3.2), the current usage of eSIM in IoT is still very limited (with the exception of connected car).[161]

There are no reliable statistics available about the current use of eSIM in IoT use cases. Operators report the number of SIM cards in use for M2M purposes, but no share of eSIM is provided. Counterpoint (2020) claims that the share of eSIM in all cellular IoT subscriptions activated was close to three quarters in 2017.[162] However, the market

158 See https://m2mdataconnect.com/esims-the-missing-link-in-the-internet-of-things/.

159 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 9.

160 See e.g. GSMA (2017): The future of the SIM: potential market and technology implications for the mobile ecosystem, February 2017, https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=28999708&file=The%20future%20of%20the%20SIM%20potential%20market%20and%20technology%20implications%20for%20the%20mobile%20ecosystem.pdf.

161 See GSMA (2020): eSIM moving up the agenda: from industry work to customer adoption, June 2020, available for download under https://data.gsmaintelligence.com/research/research/research-2020/esim-moving-up-the-agenda-from-industry-work-to-customer-adoption, page 34.

162 See Counterpoint (2020): eSIM: Opportunities, Trends & Outlook, https://redteasim.com/wp-content/uploads/2020/09/Counterpoint-Research-eSIM-Opportunities-Trends-and-Outlook_Redtea_Mobile.pdf, page 20.

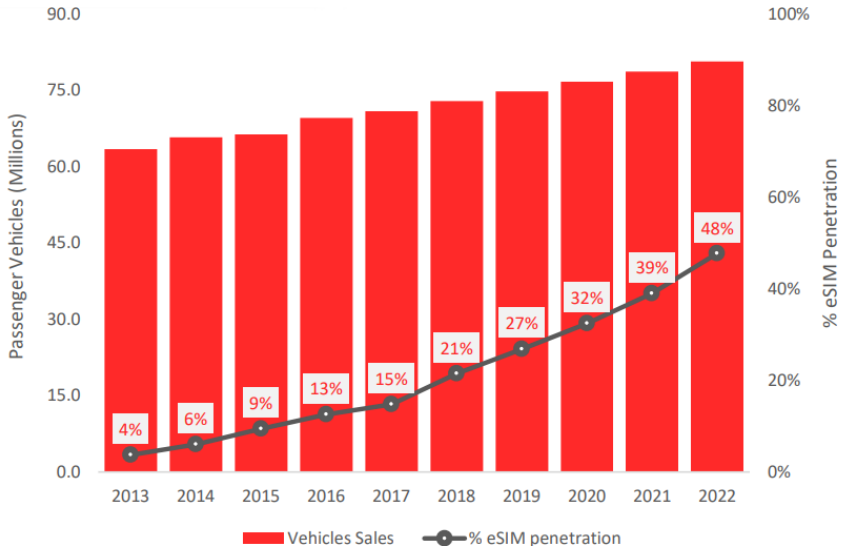
experts interviewed for this study[163] estimate that less than 1% of all IoT use cases are currently based on eSIM.

6.3.3.1 Automotive

The connected car is the most well-developed IoT use case in current eSIM deployments (see Figure 6-7).

According to Juniper Research (2020), 110 million vehicles had embedded connectivity in 2020 globally.[164] According to Counterpoint Research, eSIM penetration in vehicle sales has increased significantly, starting from 4% in 2013 and reaching 32% in 2020. Some vehicles even accommodate multiple SIMs.

Figure 6-11: eSIM penetration in vehicle sales (2013-2022)



Source: Counterpoint.[165]

The major automotive producers started to implement eSIM in cars around five years ago. Some developments include:

- In spring 2016, Audi rolled out eSIM ("Audi connect SIM") run over its modular infotainment platform (MIB) for many Audi models, among them A3, A4, A5, Q2

163 Interviews conducted during Q2 2021.

164 See Juniper Research (2020): Cars with embedded connectivity to reach 200 million by 2025, with 5G adoption set to soar, 1 September 2020, https://www.juniperresearch.com/press/cars-with-embedded-connectivity-to-reach-200.

165 See Counterpoint (2020): eSIM: Opportunities, Trends & Outlook, https://redteasim.com/wp-content/uploads/2020/09/Counterpoint-Research-eSIM-Opportunities-Trends-and-Outlook_Redtea_Mobile.pdf, page 16.

and Q7 model series.[166] The connectivity partner of Audi is the Irish service provider Cubic Telecom; Audi subsidiary Audi Electronic Venture GmbH (AEV) became a strategic investor in Cubic Telecom in May 2015.[167]

- BMW provides connected vehicle solutions in cooperation with Deutsche Telekom ("BMW Connected Drive"). The first launch of a Wi-Fi hotspot was included within the new BMW 7 Series in October 2015 and expanded to many other BMW models in July 2016 and to motorcycles in 2017.[168]

Connectivity in the car extends from emergency services, to infotainment and content streaming, as well as remote diagnostics.

Figure 6-12: Ranges of services in the connected car

Source: Counterpoint Research.[169]

The EU regulation to implement eCall[170] played a significant role in pushing eSIM to the automotive sector. Almost ten years after first discussions, all new passenger cars and light commercial vehicles sold in the EU after April 2018 are required to support

166 See Audi (2016): Audi connect production technology, 29 August 2016, https://www.audi-mediacenter.com/en/connectivity-techday-6597/audi-connect-production-technology-6599.

167 See Cubic Telecom (2016): Cubic Telecom powers In-Car connectivity, 2 June 2016, https://www.cubictelecom.com/Media/PressRelease/1.

168 See BMW (2016): Intelligent connectivity for BMW vehicles. BMW expands high-performance connectivity for cars and motorcycles, press release, 21 July 2016, https://www.press.bmwgroup.com/global/article/detail/T0262212EN/intelligent-connectivity-for-bmw-vehicles-bmw-expands-high-performance-connectivity-for-cars-and-motorcycles?language=en .

169 See Counterpoint (2020): eSIM: Opportunities, Trends & Outlook, https://redteasim.com/wp-content/uploads/2020/09/Counterpoint-Research-eSIM-Opportunities-Trends-and-Outlook_Redtea_Mobile.pdf, page 16.

170 An overview about the actors involved in eCall and eCall callback process is given by ECC (2020): eCall – an update, ECC Newsletter, August 2020, http://apps.cept.org/eccnews/aug-2020/ecall_an_update.html.

eCall.[171] The process is still ongoing with a current focus on extending the requirements to all categories of vehicles and developing standardized solutions for after-market eCall.

In the EU, 242.7 million passenger cars and more than 35 million commercial vehicles and buses were in use in 2019 – the total fleet grew by 1.8% between 2018 and 2019.[172]

Cars have a long lifetime compared with other IoT devices. In the EU the average age of a passenger car is 11.5 years, while for light commercial vehicles the figure is 11.6 years.

6.3.3.2 Smart metering

eSIM provides significant potential to be implemented in smart metering, as there are massive numbers of devices, which are widely distributed and have a very long lifetime.

Overall smart metering deployment by utilities is mainly driven by EU regulation: In 2009, the EU required member states to conduct a cost benefit analysis on the deployment of smart metering.[173] By 2018 all member states except two completed cost benefit analysis with positive results for at least 80% of the cases assessed.[174] However, the process of deploying smart meters has been much slower than intended. A benchmarking report found that smart metering in electricity meters would reach a penetration rate of 77% (i.e. 223 million) by 2024 and 92%(i.e. 266 million) in 2030.[175] Various standards have been developed to ensure interoperability, safety, and reliable connectivity.[176]

Cellular connectivity has played a minor role in smart metering thus far. According to ABI Research, the share of cellular connectivity in smart metering use cases was

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171 See for the history of relevant directives and regulation https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/ecall-rp2020, as well as European Commission (2015): Regulation (EU) 2015/758 of the European Parliament and of the Council of 29 April 2015 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.123.01.0077.01.ENG.

172 See ACEO (2021): Size and distribution of the EU vehicle fleet, https://www.acea.be/statistics/tag/category/size-distribution-of-vehicle-fleet.

173 i.e. adoption of the 2009/72/EC Electricity Directive and the 2009/73/EC Gas Directive.

174 See EU: European Commission (2019): Benchmarking smart metering deployment in the EU-28, final report prepared by Tractebel, December 2019, https://www.buildup.eu/sites/default/files/content/mj0220176enn.en_.pdf , page 17.

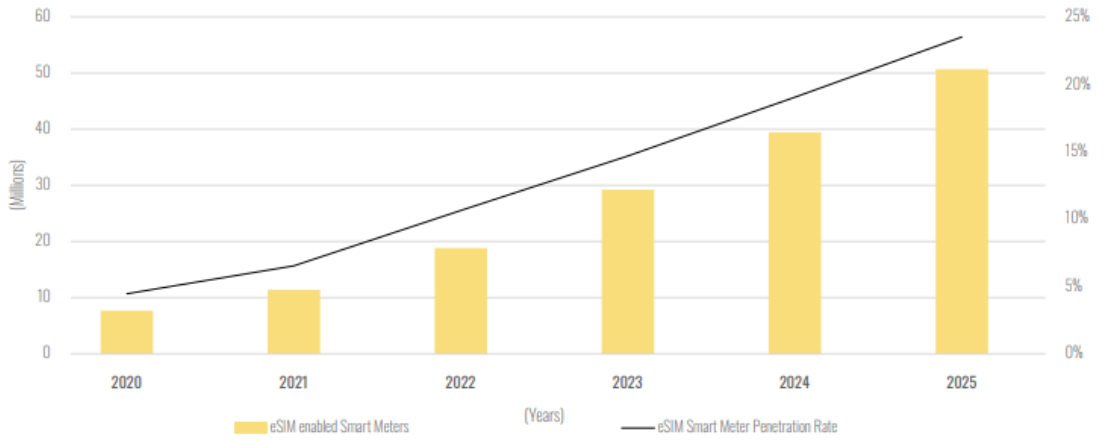
175 See EU: European Commission (2019): Benchmarking smart metering deployment in the EU-28, final report prepared by Tractebel, December 2019, https://www.buildup.eu/sites/default/files/content/mj0220176enn.en_.pdf , page 19-20.

176 The Interoperable Device Interface Specification (IDIS) Companion Specification defines electric smart meter use cases and options for different communication technologies that are required for seamless data flows and smooth upgrades for new applications, see Kigen (2020): eSIM in Smart Meters. Case Study, https://kigen.com/wp-content/uploads/2020/10/Kigen-eSIM-Iskra-Smart-Meter-Case-Study.pdf.

estimated at only 7% in 2019, while the majority of use cases (58%) relied on Powerline (2019).[177]

For smart metering use cases implemented via cellular networks, eSIM is expected to play an increasingly important role. ABI Research estimates that in 2020, 7.7 million eSIM smart meters were shipped worldwide.[178] The share of eSIM in smart meters is about 10% in 2020 (see Figure 6-13).

Figure 6-13: eSIM in smart metering (2020-205)



Source: Abi Research (2020).[179]

177 See Abi Research (2020): eSIM and smart meters: why eSIM and why now? October 2020, page 2. In total, there are more than 700 million smart meter installation for electricity purposes and account for 77% of all smart meters installed worldwide.
178 See Abi Research (2020): eSIM and smart meters: why eSIM and why now? October 2020, page 6.
179 See Abi Research (2020): eSIM and smart meters: why eSIM and why now? October 2020, page 6.

6.4 Key take-aways

KEY TAKE-AWAYS

- Initially standards for eSIM technology were driven by M2M requirements, and eSIM deployment focused on M2M applications such as connected cars. However, more recently, the focus has shifted to consumer applications, and the growth of eSIM enabled devices is being driven by smartphones.
- In 2020, 25% of operators surveyed by the GSMA had launched eSIM services for smartphones. Much of this growth has occurred in Europe.
- Despite the growing availability, consumer awareness of eSIM is low – with only around 20% of consumers being aware of this technology. Nonetheless, take-up is increasing from a low base. The TCA reported a 300% increase in eSIM profile transactions in 2020.
- The key driver of deployment in the consumer segment are the provision of eSIM-enabled premium devices initially by Apple and Google, and more recently by Samsung. Nearly all eSIM enabled devices currently also have a physical SIM-card slot, and the eSIM capability is often not activated.
- The most popular applications for eSIM in the M2M space are connected cars (110 million vehicles globally in 2020) and the provision of travel services and connected devices such as laptops, tablets, and watches for consumers.
- eSIM penetration in M2M has been held back by long device life-times and complexities in switching existing equipment. In addition, it should be noted that most M2M devices rely on non-cellular / unlicensed connectivity.

7 What is the status of eSIM deployment in Ireland?

In this chapter, we look in more detail at the development of eSIM in the Irish market and estimate:

- Country specific factors linked to eSIM adoption (section 7.1)
- Implementation of eSIM by Irish MNOs (section 7.2)
- Availability of eSIM in the Irish market for smartphones (section 7.3) and IoT (section 7.4)
- Forecasts for eSIM deployment and adoption in Europe and Ireland (section 7.5).

A summary of key take-aways is shown at the end of the chapter.

7.1 Country specific factors associated with eSIM take-up

eSIM is mainly driven by global players and the main developments are relevant in mobile markets worldwide. However, there are certain aspects that may lead to country-specific differences:

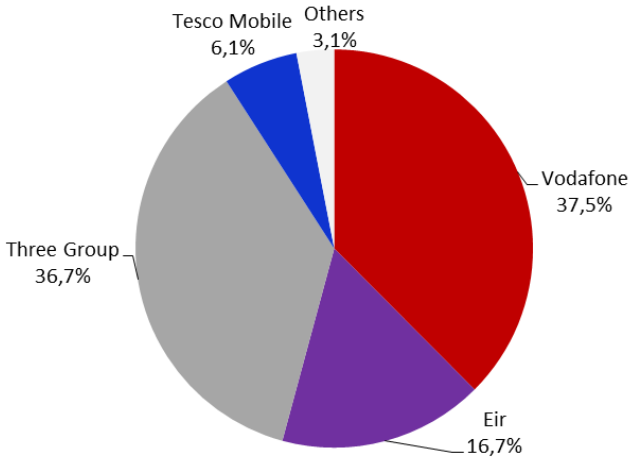
- The most important difference is the support of eSIM by national MNOs as a precondition of eSIM use by customers; and
- Leading smartphone manufacturers act on a global scale, but their market shares differ significantly between the national markets.
- The automotive use case is characterized by country-specific differences regarding the share of connected cars in use. In Europe differences are linked to the age of cars, as eSIM for eCall has been mandatory since 2018.
- eSIM deployment in smart metering is at an early stage, but with some differences between countries.

In the following sections, we outline the status of these factors for Ireland.

7.2 eSIM implementation by MNOs

In Ireland, mobile infrastructure is operated by the three MNOs Vodafone Ireland, Three and Eir Mobile. These three players account for more than 90% market share (see Figure 7-1) when all subscriptions (including M2M) are taken into account. The largest MVNO is Tesco Mobile with around 6% market share.

Figure 7-1: Market shares in Ireland, total mobile subscriptions incl. M2M (Q4 2020)



Source: ComReg.

eSIM is in the process of being introduced by Irish MNOs[180]:

- Vodafone Ireland supports eSIM since the 2nd of July 2021 in 20 smartphone models from Apple, Google, and Samsung[181], but does not support eSIM for other consumer devices such as smartwatches or the Microsoft Windows App.
- Three has implemented eSIM infrastructure for IoT since the introduction of eSIM in smart metering in Ireland. It plans to launch eSIM for consumers in 2021 but has not yet announced any details regarding supported devices and launch dates.
- Eir Mobile is in the process of reviewing the potential of eSIM but has no plans to launch related services yet.

	Smartphones	Smartwatches / IoT
Vodafone Ireland	since 2nd of July 2021	no
Three	announced for 2021	
Eir Mobile	no plans yet	

Moreover, as in other countries, eSIM is available for Irish customers from global connectivity providers such as SIM Local and Truphone with via their own eSIM infrastructure and based on existing roaming agreements with Irish MNOs.

180 See e.g. Weckler, a.d (2021): Mobile 'eSim' cards are coming to Irish phones but not Apple Watches, 24 June 2021, https://www.independent.ie/business/technology/mobileesim-cards-are-coming-to-irish-phones-but-not-apple-watches-40577327.html.

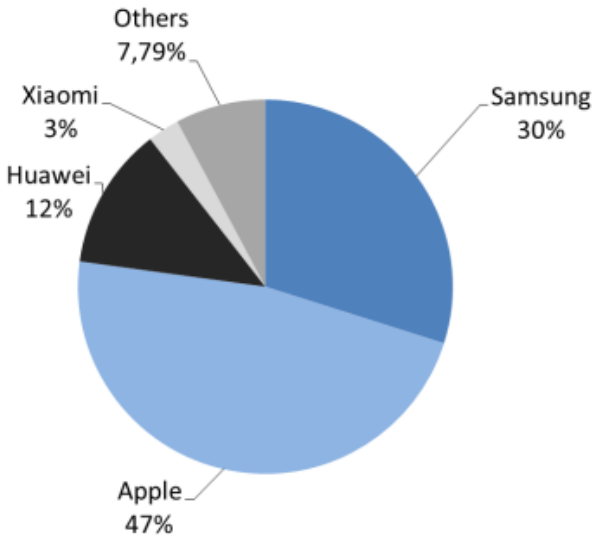
181 See Vodafone Ireland Device Guide: https://deviceguides.vodafone.ie/?genericInstruction=activate-esim.

7.3 Smartphones

Irish mobile subscribers are relatively well equipped with eSIM capable smartphones compared with other countries. The share of premium smartphones is high and smartphone models in use tend to be new. Overall, it can be assumed that at least 6% of the total base of smartphones in use in Ireland can support eSIM today.

In Ireland, the market share of Apple is significantly above the European and worldwide average.[182] According to Statcounter, almost 50% of mobile devices in use are provided by Apple. Samsung Accounts for another 30% market share.

Figure 7-2: Market shares of smartphone manufacturers in Ireland Europe* (June 2021)



*referring to usage based on web analytics

Source: WIK based on Statcounter (2021).

Among iPhones in use in the Irish market, around 15% can assumed to be equipped with eSIM (see Table 7-1).

182 See Statcounter (2021): Mobile Vendor market share in Europe – June 2021, https://gs.statcounter.com/vendor-market-share/mobile/europe, detailed market shares of smartphone vendors per month are available for each country.

Table 7-1: iPhone models in use in Ireland (2020)

iPhone Model	Share	eSIM equipped
iPhone 7	8.85%	
iPhone 11	6.38%	X
iPhone 8	6.01%	
iPhone XR	5.34%	X
iPhone 6S	3.59%	
iPhone 6	2.58%	
iPhone X	1.98%	
iPhone 8 Plus	1.91%	
iPhone 11 Pro Max	1.54%	X
iPhone SE 2nd generation	1.45%	X

Source: WIK-Consult based on Device Atlas, https://deviceatlas.com/blog/most-popular-iphones#ireland.

7.4 IoT

Ireland is relatively advanced compared with other European countries as regards the penetration of IoT devices.

7.4.1 Automotive

As outlined under 6.3.3.1, cars are required to be equipped with eSIM since 2018 and car manufacturers had already started to deploy eSIM in their premium cars before that deadline. The share of cars that have been manufactured since 2018 differs between countries. Ireland tends to have a higher share of connected cars in its total fleet than the EU average.

The average lifespan in Ireland is 8.4 years for passenger cars and 8.8 years for light commercial vehicles. This is the third lowest in the EU after Luxemburg and Austria.

More than 10% of vehicles in Ireland can be assumed to support eCall based on their production date: The share of vehicles built in 2018/2019 is 11% for passenger cars and 13% for light commercial vehicles. In total, Ireland has 238.359 passenger cars and 395.379 light commercial vehicles in use that were built in 2018/2019. [183]

183 See ACEA (European Automobile Manufacturers Association) (2021): Vehicles in use Europe, January 2021, ACEA Report, https://www.acea.be/uploads/publications/report-vehicles-in-use-europe-january-2021.pdf, page 9-10.

7.4.2 Smart metering

Ireland is one of a small number of countries that implement smart metering use cases based on eSIM.[184] The ESB (Electricity Supply Board) decided to mandate eSIM for smart metering implementation as it provides good options for switching at a later stage. Testing of switching played a major role in the implementation process.

Details about smart metering in the Irish market are shown in the following table.

Table 7-2: Example: Smart Metering in Ireland – History and Key Facts

Cost-Benefit-Analysis	▪ A positive result of the economic assessment of long-term costs and benefits for smart metering roll-out in Ireland was published in May 2011.[185]
Delivery Plan	▪ In September 2017 the CRU (Commission for Regulation of Utilities) announced the details of the delivery plan for the introduction of smart meters to Irish homes and businesses.
Electricity Supplier	▪ The CRU has tasked ESB Networks (ESBN) with the roll-out of the National Smart Metering Programme (NSMP), which requires the replacement of all existing electricity meters with Smart Enabled Meters.
Connectivity Provider	▪ Three Ireland was awarded the contract to provide the connectivity for the smart meters deployed b ESBN. ▪ eSIM was mandated. ▪ Options to switch provider at a later stage.
Roll-Out-Plan	▪ 2.3 million smart meters should be deployed in total. ▪ By the end of 2024, the roll-out should be completed. ▪ A phased approach has been taken: initial delivery of 250,000 meters in 2019 – 2020, followed by about 500,000 meters p.a. in the following four years.
Major benefits	▪ Frequent and automatic recording of consumption provides advantages for processes and customers: no estimated bills anymore, faults will be detected faster, more information for customers to better manage electricity consumption, planned services to shift consumption to cheaper off-peak times. ▪ Economic benefits because using smart meters enables to manage energy flow more efficiently during periods of high demand. ▪ Ecological benefits, as smart metering is part of the migration towards a carbon free electricity network.

Sources: Information provided by the regulator and companies.[186]

184 See for the status of smart metering deployment in the EU: European Commission (2019): Benchmarking smart metering deployment in the EU-28, final report prepared by Tractebel, December 2019, https://www.buildup.eu/sites/default/files/content/mj0220176enn.en_.pdf.

185 All relevant documents related to the cost-benefit analysis of smart metering in Ireland are available under https://www.cru.ie/document_group/smart-metering-cost-benefit-analysis-and-trials-findings-reports/ (11 October 2011).

7.5 Forecast of eSIM deployment in Europe and in Ireland

7.5.1 Approach

We have developed a forecast of eSIM deployment and take-up in Europe based on a four-step process.

The analysis is based on the following sources:

- public data sources, e.g. from statistical offices, regulators, OECD
- statistics provided by associations (e.g. GSMA)
- annual reports of companies (e.g. Apple)
- studies of market researchers and analysts about eSIM and IoT
- interviews conducted for this study

It should be noted that available sources typically do not refer to activated eSIM profiles, but to shipment of eSIM equipped devices. In the long run, there will be no (significant) difference between the ownership of an eSIM-equipped device and its activation. In the current situation, however, the difference is significant.[187]

In this study, definition of customer segments is based on the customer journeys identified in this study. In this context, the consumer segment is defined as smartphones and consumer IoT (eSIM-equipped smartwatches, tablets, and laptops). Applications that involve a very limited role of a human are defined as M2M. From this perspective, activation or monitoring of a M2M application or M2M device by a human via a technical device such as a smartphone or tablet is regarded as M2M.

The four steps are described below and shown in the following figure:

Step 1: Analysis **of the current status of eSIM development in Europe and in Ireland.**

Step 2: **Identify the most relevant influencing factors** on eSIM development. As a long period of time is considered (2020-2030), we outline stable trends and uncertainties that would result in alternative paths for future developments.

186 E.g. https://www.energia.ie/smart-meter-upgrade#1, https://www.cru.ie/home/smart-meters/national-smart-metering-programme/.

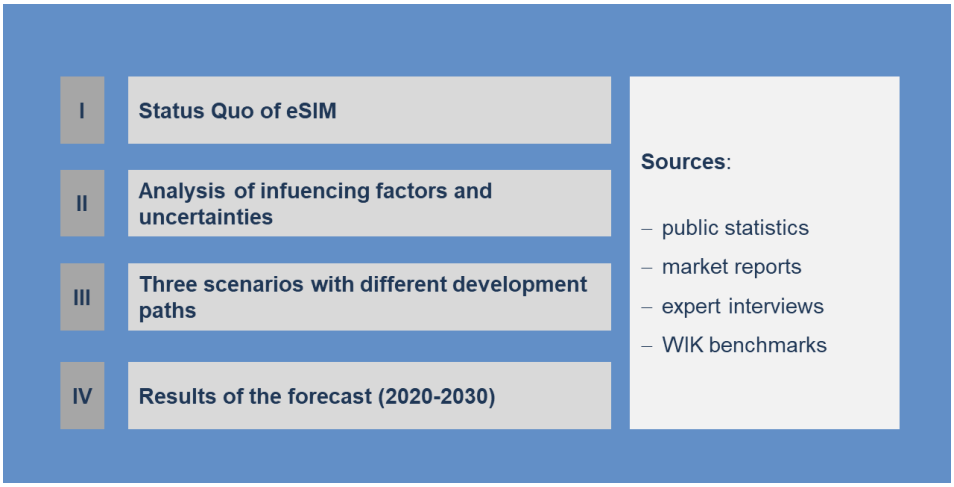
187 In Ireland eSIM smartphones are available due to a strong position of Apple in the handset market, but eSIMs are (mostly) not activated due to missing support by the domestic MNOs (it can be assumed, however, that some eSIM equipped smartphones use eSIM offers of international connectivity providers, but no information about the extent of this usage is available.

Step 3: Define **three scenarios** to reflect potential differences in the future market dynamics.

1. Base case scenario (most likely eSIM market development), best case (stronger growth), worst case (weaker growth).
2. For each scenario, we outline different assumptions for the share of eSIM in total SIM devices and for the share of activated eSIM in eSIM devices on the short term (2022), mid-term (2025) and long term (2030).

Step 4: Calculate and validate the **quantitative forecast** for the EU and for Ireland.

Figure 7-3: Methodology for Forecast



Source: WIK-Consult.

Further details of the methodology on which the forecast is based are shown in the Annex (see chapter 10). The results are summarized below.

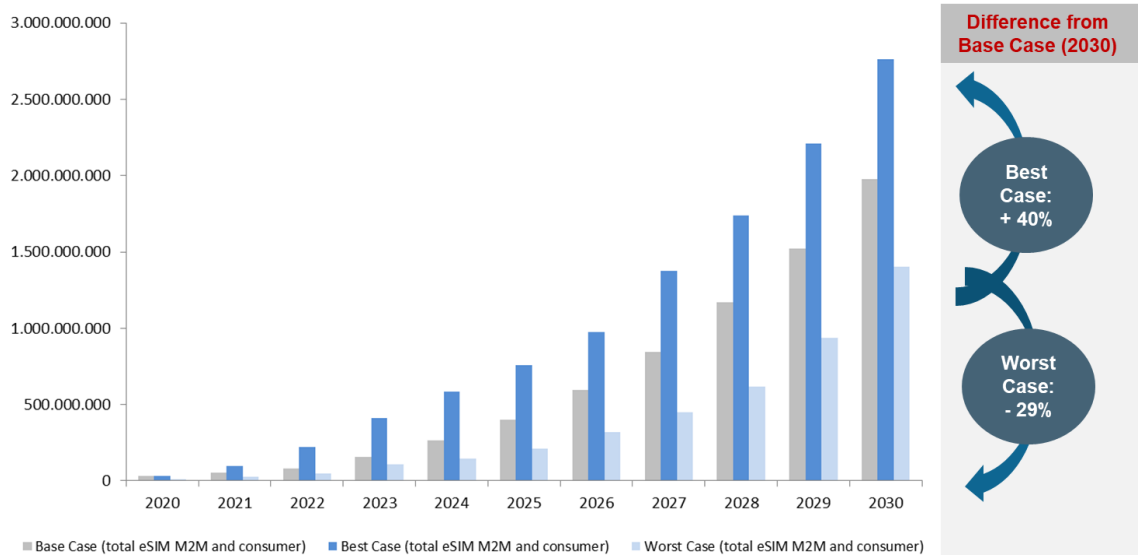
7.5.2 Results of WIK forecast for the EU

In a base case scenario, about 1.9 billion devices in Europe will support eSIM by 2030. A weak growth (worst case) could result in 40% fewer eSIM devices, while a strong growth (best case) could reach 37% more eSIM devices. The relative differences between the three scenarios will decrease in the long term, as they are significantly influenced by short to medium term factors such as MNO support of eSIM.

In all scenarios, the consumer segment will drive eSIM development in the short and medium term. In 2020, more than 90% of eSIM were deployed in the consumer segment. Due to strong overall growth in the M2M segment, all scenarios will result in M2M accounting for 65% of total eSIM deployments by 2030. It should be considered

that in our forecast, the consumer segment includes both smartphones and consumer IoT.

Figure 7-4: Total number eSIM devices in the EU, different scenarios (2020-2030)

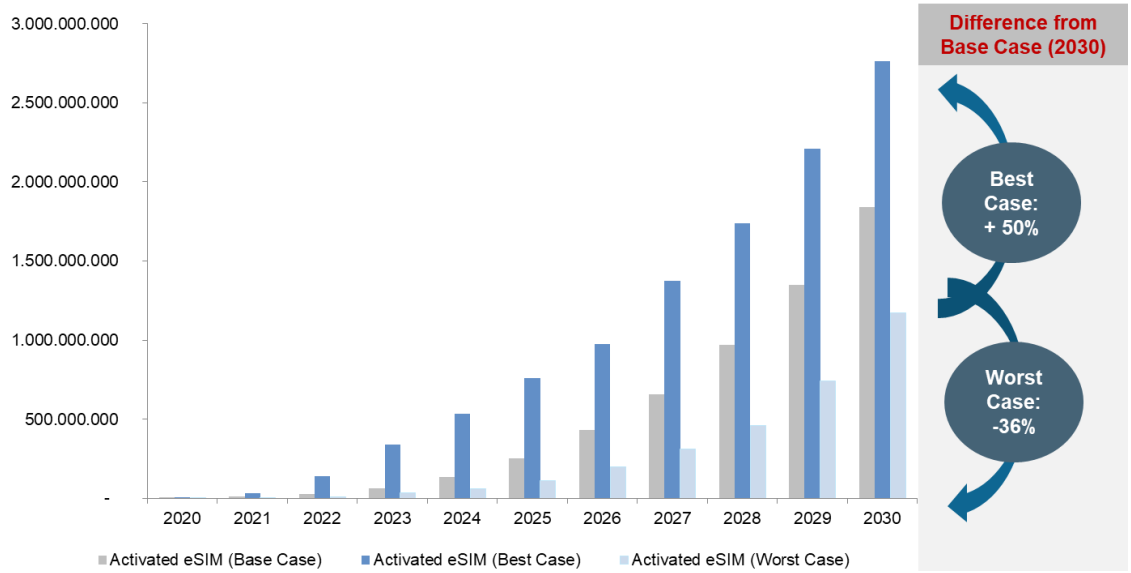


Source: WIK-Consult.

In our forecast, around 90% of eSIM equipped devices will be activated in a base case scenario by 2030. The share of eSIM-enabled devices that are not activated is assumed to be mainly in the laptop and tablet segment (Microsoft Windows 10 App). In the best-case scenario, 100% of eSIM-enabled devices will be activated, while in a worst case the figure would be 80%.

This results in around 1.8 billion activated eSIM in the EU in 2030 in a base case scenario. A worst case could result in 36% lower number of activated eSIM, while a best case could reach 50% more eSIMs activated at the end of the forecasting period.

Figure 7-5: Total number activated eSIM in the EU, different scenarios (2020-2030)



Source: WIK-Consult.

7.5.3 Results of the WIK forecast for Ireland

In a base case scenario, around 28.3 million devices in Ireland will be equipped with eSIM in 2030. This is a 1.4% share of all eSIM devices in the EU.

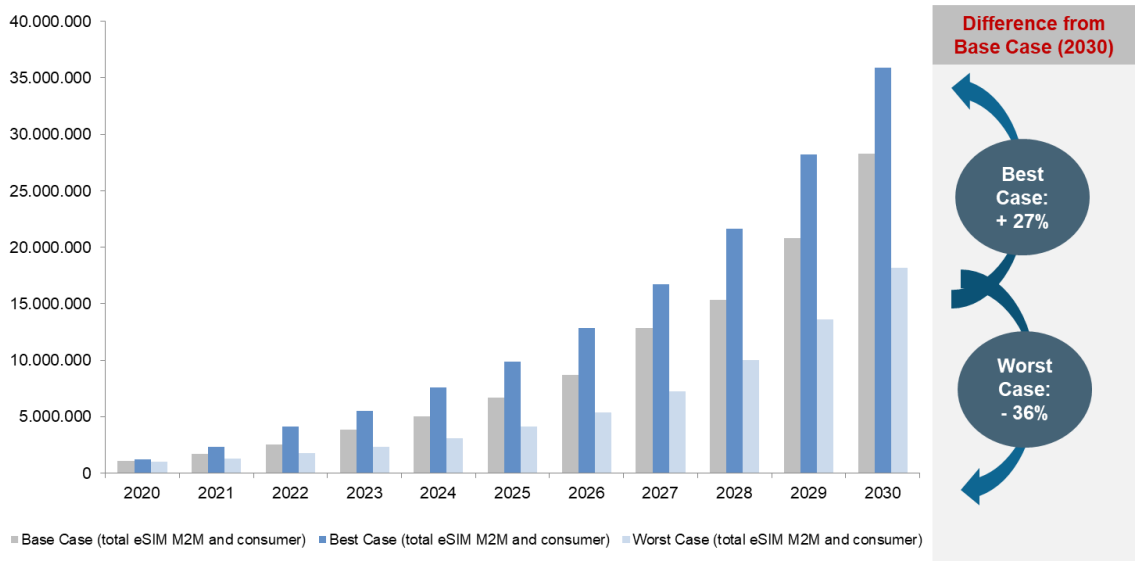
A weak growth (worst case) could result in 36% fewer eSIM devices, while a strong growth (best case) could reach 27% more eSIM devices.

In all scenarios, the consumer segment will drive the eSIM development in the short and medium term. In 2020, more than 90% of eSIM were deployed in the consumer segment. The availability of eSIM equipped devices in Ireland is more than the EU average due to the high market share of Apple and Samsung. A strong overall growth in the M2M segment will result in a 77-79% share of M2M of total eSIM deployments by 2030, noting that in our forecast, consumer IoT is included in the consumer segment. The share of M2M in total eSIM is higher in Ireland than in the EU due to the assumption that there will be a higher growth rate in the Irish IoT segment in the short to medium term due to eSIM deployment in smart metering (and in the long term due to more IoT deployment in a stronger economy[188]).

The relative differences between the three scenarios are likely to decrease in the long term, as they are significantly influenced by short to mid-term factors such as MNO support of eSIM.

188 That can be assumed e.g. based on past GDP growth rates, see e.g. Eurostat (20219: Real GDP growth rate – volume, https://ec.europa.eu/eurostat/databrowser/view/tec00115/default/table?lang=en.

Figure 7-6: Total number of eSIM devices in Ireland, different scenarios (2020-2030)



Source: WIK-Consult.

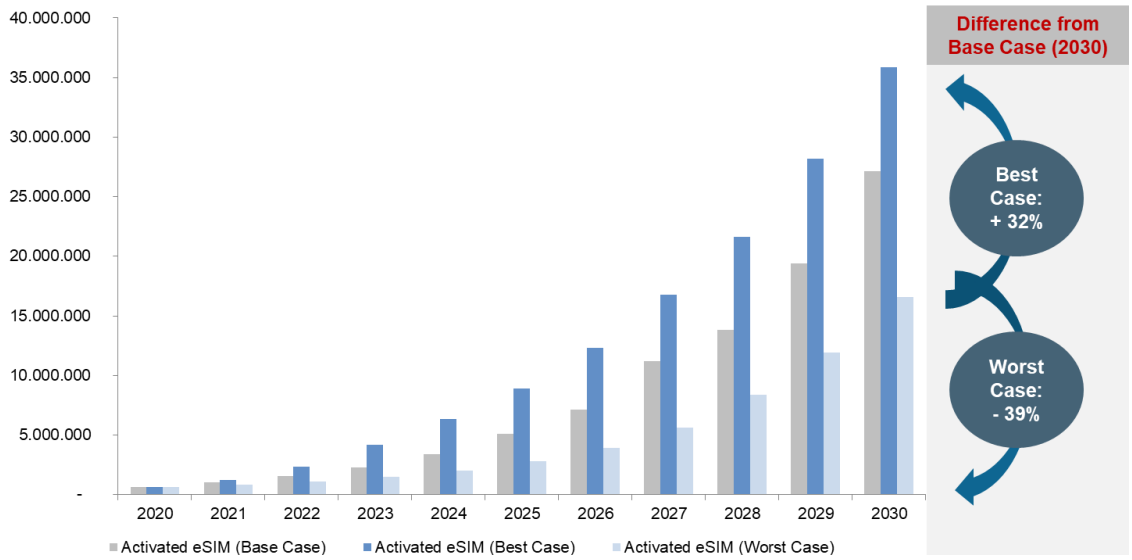
Ireland significantly differs from the EU average regarding short term activation rates. This is mainly because MNOs in Ireland lag behind with regard to eSIM implementation. As explained in our assumptions, the base case scenario reflects the current plans and strategies of the relevant players. Therefore, it assumes that in 2021/2022 all MNOs in Ireland will implement eSIM (based on the current announcement of Vodafone with competitors expected to follow). If this is won't happen, a worst-case scenario would result in significantly lower activation rates.

Mid-term scenarios for eSIM activation in Ireland can vary significantly, as they depend on actions to stimulate activation (e.g. customer education by MNOs and other players such as the regulator).

In our forecast, around 95% of eSIM equipped devices will be activated in a base case scenario by 2030. The share of eSIM-enabled devices that are not activated is assumed to be mainly in the laptop and tablet segment (Microsoft Windows 10 App). In the best-case scenario, 100% of eSIM-enabled devices will be activated, with 90% in a worst case.

This results in around 27 million activated eSIM in Ireland in 2030 under the base case scenario. A worst case could result in 39% lower number of activated eSIM, while a best case could reach 32% more eSIMs activated at the end of the forecasting period.

Figure 7-7: Total number of activated eSIM in Ireland, different scenarios (2020-2030)



Source: WIK-Consult.

7.6 Key take-aways

KEY TAKE-AWAYS

- Differences in eSIM take-up in different countries can be driven by the number of operators supporting eSIM, as well as the popularity of eSIM enabled smartphone models. On the M2M side, differences in eSIM take-up can also be influenced by the proportion of vehicles sold after 2018 (when eCall was mandated) and the use of eSIM connectivity for smart meters.
- eSIM availability in Ireland is likely to be and remain relatively high compared with other European countries. Based on consumer usage patterns, around 15% of smartphones may be eSIM-compatible, and more than 10% of vehicles are likely to support eSIM in Ireland. eSIM is also being used to support smart metering deployment by the ESB (750k in 2020).
- However, MNOs have been slow to support eSIM, with only Vodafone making it available for a range of smartphones (but not companion devices), while Three has focused on eSIM implementation in the context of smart meters. Three is expected to launch eSIM support for consumers in 2021, but no details have been made available, and Eir has not yet made concrete plans. MNO reluctance and lack of consumer awareness are the main factors holding back eSIM take-up in Ireland.
- While eSIM take-up will grow substantially from today's low base, the future evolution of eSIM in Ireland will depend both on the availability of eSIM and the take-up rate. In a base case scenario we forecast that around 28.3 million devices in Ireland will be equipped with eSIM in 2030, and 27 million will have been activated. Under a worst-case scenario, the number of activated eSIMs could be 18.1 million (36% lower), while under a best case, the number of activated eSIMs could be 35.8 million (27% higher).

8 Realising a vision for OTA provisioning and switching

In this chapter, we bring together the findings from across the report to provide a future vision for the implementation of OTA provisioning and switching.

First, we define a Vision for OTA provisioning, and identify the ideal customer journey that would unlock the greatest benefits for consumers and M2M customers. Second, we identify what barriers could potentially inhibit the realisation of this Vision. Thirdly, we identify the actions and options available to NRAs to address the challenges identified. Finally, we recommend actions and an associated roadmap. Our recommendations have been designed to support the move to all-digital processes in the Irish market as well as identifying issues that could be better resolved at the European or international level.

The Chapter is structured as follows:

- Vision for Over-the-Air for Consumer and M2M
- Potential for NRAs to facilitate the realisation of the benefits of the Vision
- Recommendations and proposed strategy to promote Over-the-Air.

8.1 The proposed Vision for Over-the-Air for Consumer and M2M

8.1.1 Defining the Vision for Consumer and M2M

There are three statutory objectives that should guide NRAs in terms of their Vision of OTA for Consumer and M2M use cases, as follows:

- Consumers' end-rights and protection
- Connectivity
- Competition.

NRAs play a vital role in ***protecting the interests of consumers*** by monitoring uncompetitive tying and bundling practices, facilitating choice, price and quality, as well as by maintaining the security of networks and services and ensuring a high level of protection for end-users.[189]. For example ComReg has both improving consumer end-rights and consumer protection as a statutory objective and strategic intention.[190]

Under the EU Electronic Communications Code, NRAs have a duty to promote ***connectivity***, access to and take-up of very high capacity networks, including wireless

189 Article 3(2)d EECC.
190 ComReg ECS Strategy Statement 2021-2023 https://www.comreg.ie/?dlm_download=electronic-communications-strategy-statement-2021-2023.

networks by all citizens and businesses.[191] This has also been a longstanding focus of ComReg.[192]

Many NRAs, including ComReg also promote ***competition*** in the provision of electronic communication services[193] alongside facilitating efficient investment and innovation in new and enhanced infrastructure.[194]

OTA provisioning is expected to enable consumers to access a wide range of services more easily and more quickly than by traditional means and thus supports their own ability to combine connectivity from different players and ensure maximum network quality, resilience and security. The customer sign-up journey should not be interrupted or impeded by requirements to wait for or rely on physical documents or processes.

Similarly, OTA provisioning is an important enabler for a range of industrial M2M solutions such as smart meters, connected automotive mobility and tracking, and opens the door to a variety of new business models that can be exploited by specialist players alongside traditional mobile operators. M2M customers should have the ability to make use of OTA processes for the activation of both domestic and international M2M applications and should be able to switch providers efficiently and without hindrance or undue expense.

Likewise, the development of eSIM and OTA processes should foster increased competition amongst connectivity and application providers and device manufacturers and should not hinder the entry or expansion of innovative players.

To achieve these aims:

1. Consumers and M2M customers should have the ability to use OTA, for mobile activation, switching and porting.
2. OTA activation and switching for mobile devices should be as fast and as easy as possible and be possible by means of fully digital journeys at least in the case of smartphones.
3. Consumers should be provided with all information necessary to complete a successful switch, supported by clear contractual terms in the case of M2M customers.

191 Article 3(2)a EECC.
192 ComReg ECS Strategy Statement 2021-2023 https://www.comreg.ie/?dlm_download=electronic-communications-strategy-statement-2021-2023.
193 Article 3(2)b EECC.
194 Article 3(4)d EECC.

4. Switching[195] should continue to be recipient-led for consumer use cases involving MNP (and potentially others if requested), while collaboration will often be needed between the transferring and recipient provider in M2M OTA switching.

5. Consumers should have the ability to use MNP in conjunction with OTA for voice services.
6. OTA provisioning should be safe and secure.
7. OTA provisioning should enable new business models and not foreclose existing business models (e.g., MVNOs).
8. OTA provisioning should enable new forms of eSIM devices and a greater number of devices.

8.1.2 The Idealised fully-digital customer journeys

As discussed in the previous section, ideally provisioning and switching processes for consumer use cases should be fully digitised and not require any manual intervention. We refer to this as an "all-digital" customer journey.

The diagrams below show the different methods by which consumers are expected to be able to connect digitally to a new provider and switch between providers on their smartphone, or companion devices such as smartwatches or tablets.

The most commonly used approach today is a QR code. In order to provide for a fully digital journey, this code should be available on a screen (and not, as is currently often the case printed). Once scanned, using an appropriate QR code application, the new eSIM profile is downloaded and the customer is invited to follow the onscreen instructions to activate the service. A similar process is used for switching, but the process also involves the deactivation of the previous eSIM profile. If requested,[196] the mobile service provider contacts the previous provider to notify them that the customer is requesting termination of their previous contract and takes care of MNP following the activation of the new profile by the customer, making use of existing (or improved) MNP processes (i.e. a recipient-led process).

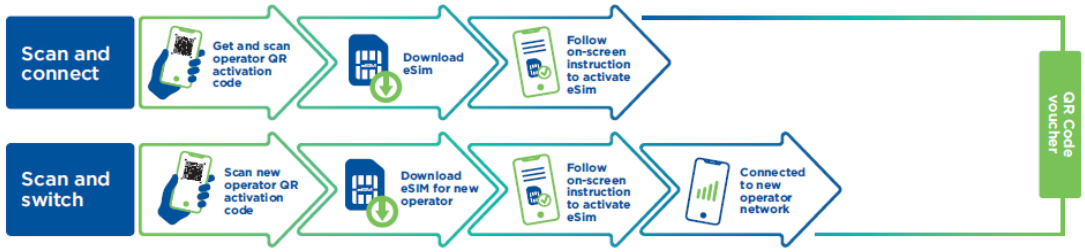
Identification of the customer is normally carried out prior to the distribution of the QR code by the service provider. For an all-digital journey, a digital ID verification process

195 Switching implies the termination of the previously held contract and if desired, the porting of the number. It should be noted that due to the potential for eSIM to hold multiple profiles, consumers may choose to maintain multiple providers rather than switch

196 Because eSIM permits the storage of multiple profiles, the end-user may prefer to maintain the services of different providers. Thus, contact by the new provider with the previous provider to inform them about the termination of the contract and (if relevant) the requirement to port the number requires the consent of the end-user.

should be offered e.g. via the use of an ID card and card reader, or online document and photo verification.[197]

Figure 8-1: Consumer OTA customer journeys – QR code



Source: ComReg.

We expect over time, that the QR code approach will be superseded by the use of an application, which could be downloaded by end-users and serve as the basis not only for subscribing to the service, but also managing the account on an ongoing basis.

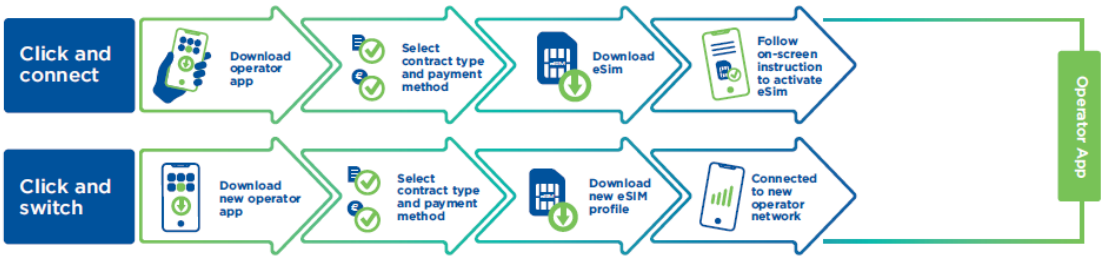
The following diagram shows a typical customer journey in cases where an application is involved (so-called “click and connect”). In this case, the customer first downloads the application from the service provider concerned, and selects the contract type and payment method. The customer is then invited to provide digital ID verification, after which the eSIM profile is downloaded and the customer follows the on-screen instructions for activation of the service. As in the previous example, in the case of switching, the old profile is deactivated and MNP is triggered by the recipient operator following the activation of the new profile.

In essence this application would combine all the necessary steps of customer identification, conclusion of contract, payment, provision of the SM-DP+ address as well as the profile management for installation, deletion, enabling and disabling of multiple profiles (i.e., the functions of the LPA). It could also include a function to request the recipient-operator-led MNP process at the same stage of the conclusion of the contract (the MNP process will still start only after the provisioning of the profile).

The same application could then be used subsequently by the consumer to monitor his usage and change contracts and payment methods. This solution seems to be the one that offers the most user-friendly interface for digital sign-up and management of mobile services.

197 For example through a “Know Your Customer” (KYC) process.

Figure 8-2: Consumer OTA customer journeys: Application based



Source: ComReg.

Another solution that can be considered fully digitised is a solution whereby the device comes pre-installed with connectivity from a certain provider. “Out of the box” connectivity solutions might in particular be offered with certain wearable devices or consumer IoT solutions . However, it should be noted that while connectivity “out of the box” may support ease of use initially, this solution could present lock-in problems for the end-user, if there is no easy way for the consumer to switch his provider. This may be the case particularly if the interface on the device concerned does not allow for switching, or makes it challenging to execute, and if it is also not possible to switch the connectivity provider via another device.

Figure 8-3: Consumer OTA customer journeys: Out of the box solution

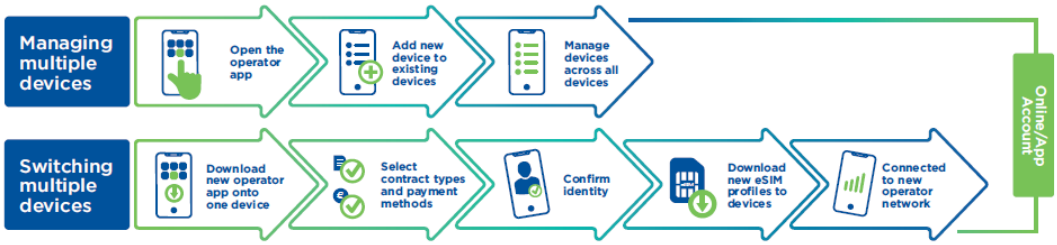
Source: ComReg.

As consumers embrace additional devices, such as wearables and home IoT, we expect that they will increasingly be offered and purchase services which offer connectivity for multiple devices. The most user-friendly mechanism to activate a new device, and to switch between service providers, is likely to be through an application which allows for additional devices to be added or removed from an existing account. Switching could also be facilitated by an application which supports the downloading of new profiles for the devices chosen, and allows for the deactivation of previous profiles.[198] We note however that switching with multiple devices may still be more challenging than for a single device, because there may be fewer offers available which

198 Deactivation (and other mangagment) of companion devices is done through the paired device, e.g. smart phone which is paired with a smart watch. The deactivation of a profile involves a change in the device settings in which profiles are managed, but an application can link to these settings.

cover the full range of devices for which the consumer requires connectivity. This problem can only be solved by increasing the range of providers which support companion devices and consumer IoT.

Figure 8-4: Consumer OTA customer journeys: Managing multiple devices)



Source: ComReg.

8.1.3 The idealized journey for M2M

In an idealized situation for an M2M customer, the customer would establish its own SM-SR server (or subcontract this function to a specialist) and independently select its connectivity provider. Profiles could then be downloaded during the manufacturing stage (in cases where the M2M customer is the manufacturer), or "pushed" to the devices following delivery (in cases where the M2M customer is not the manufacturer of the connected devices).

The contract with the connectivity provider would include clear timeframes and provisions regarding contract termination and migration.

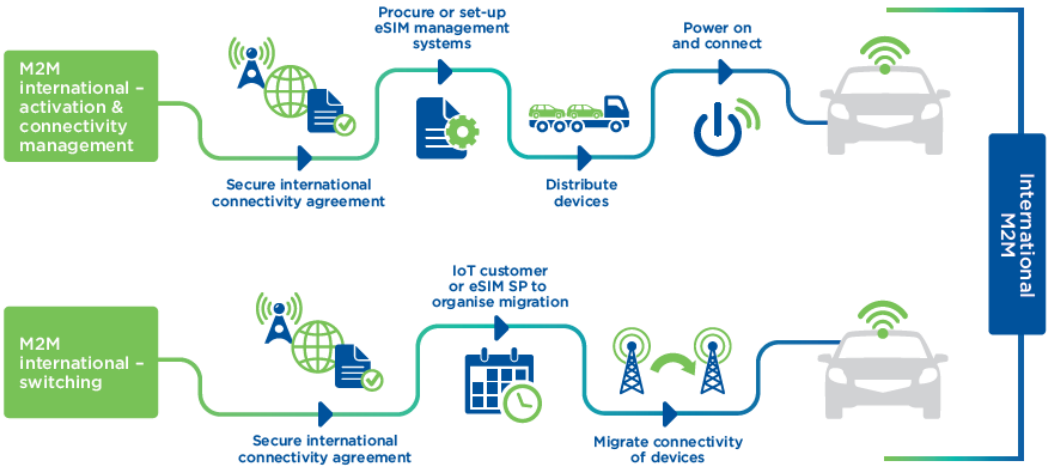
Switching would involve the signature of a new contract and termination of the previous contract, the reconfiguration of the SM-SR by the customer to connect with the new connectivity provider and the download of eSIM profiles thereafter.

If the SM-SR not controlled by the M2M customer, to ensure a smooth customer journey the contract with the connectivity provider would need to include precise details about the collaboration process between the previous and new connectivity providers, the timeframes involved for migration and any cost associated with ongoing maintenance of the SM-SR by the previous connectivity provider or one-off costs associated with the data transfers involved in an SM-SR swap.

The steps in the process for an M2M customer selecting, installing and activating a connectivity solution within its devices is shown in the following diagram, along with the switching process. This specific example relates to an international M2M service, such as a connected car. Due to the international scope of the service, it is likely that the M2M customer in this case would select a specialist provider offering global

connectivity, which might be an MVNO (e.g. Transatel) or MNO with specific expertise in the vertical segment concerned (e.g. Vodafone).

Figure 8-5: M2M OTA customer journeys



Source: ComReg.

The procedural steps for a domestic M2M customer (such as an energy company installing smart meters) are similar, except that only domestic connectivity coverage would be required rather than international connectivity, which could result in choosing a domestic MNO rather than a specialist cross-border connectivity provider. Moreover, if the M2M customer is the corporate user of connectivity rather than being the manufacturer, the customer should be able to opt for the devices to be delivered with a bootstrap profile, enabling the selection of a connectivity provider at a later stage (i.e. not in the context of the manufacturing process).

It should be noted that even if adequate processes are established to enable switching by the M2M customer, this does not mean that the end-user of the product (e.g. the purchaser of a car) will necessarily benefit from the potential to switch. However, in principle, to ensure that the quality and price for connectivity remain competitive, end-users should ideally have the possibility to switch, or if not possible, at least be informed about and if necessary protected from excessive charges that might be associated with ongoing connectivity for connected devices.

8.2 Potential for NRAs to facilitate the realisation of the benefits of the Vision

As noted in chapter 5, OTA provisioning and switching should bring many benefits for both consumers and industry. However, there are also a significant number of areas where there may be challenges around how quickly market participants embrace eSIM technology and adopt appropriately accessible and straight-forward approaches to provisioning and switching that enable end-users to reap the benefits from the digital experience and increased choice and innovation made possible by eSIM. While many of the actions required need to be developed by the industry itself there are also some areas where monitoring or even intervention by NRAs may be needed.

8.2.1 Challenges to the realization the Consumer Vision

The main challenges which may undermine the achievement of the vision for consumers concern a lack of awareness of the benefits of eSIM, a lack of timely support for eSIM from mobile service providers not only for smartphones, but also companion devices, provisioning and switching processes that do not reflect the all-digital potential of the technology, restrictions in using multiple profiles simultaneously and potential concerns over lock-in in circumstances where devices are provisioned “out-of-the-box” with no readily accessible means to switch provider. In certain countries, long delays and/or manual processes required for MNP may also undermine the realization of near-instantaneous switching that should in theory be made possible by eSIM technology and associated OTA processes.

These challenges and the potential harms that may result are summarized in the following table.

Table 8-1: Challenges and associated harm for consumer eSIM and OTA

Source of friction	Challenge	Potential Harm
Consumer	Lack of awareness of eSIM	Failure to embrace new services and devices, undermining the business case for eSIM support and associated technological developments by MNOs and others
Mobile providers	Lagging eSIM support in certain countries	Maintains unnecessary frictions in switching processes, hindering competition and choice, with implications for innovation, price and quality
	Lack of user-friendly all-digital provisioning and switching options	Maintains unnecessary frictions in switching processes, hindering competition and choice, with implications for innovation, price and quality
	Limited eSIM based offers from MVNOs due to initial costs	Limits entry and the deployment of new services, reduces service competition in the high-end segment
	Slow MNP in certain countries (>1 day, >2 hours)	Maintains unnecessary frictions in switching processes, hindering competition and choice, with implications for innovation, price and quality
OEM	Potential lock-in for consumers purchasing devices with “out of the box” solutions where there is a failure to provide a switching option	Potential for OEMs and/or connectivity providers to engage in excessive pricing, inadequate quality and service standards
Standards	Lack of support for Multiple Enabled Profiles	Undermines the potential for consumers to benefit from secondary services for travel, multiple numbers, back-up etc.
	Lack of fit-for-purpose industry standards on device entitlement services	Unnecessarily raises costs for MNOs to support certain devices, and therefore limits consumer choice
	Lack of adherence to a reasonable common standard for eSIM	May impede interoperability

Source: WIK-Consult.

Key challenges specific to M2M include a lack of a champion to support deployment and take-up (and incentives for incumbents to maintain the status quo), the lack of standardization of certain processes, complex switching processes (especially where the SM-SR is not operated by the customer) and the potential for over-charging in this respect, and (for international M2M) potential jurisdictional challenges in enforcement if operators impede the switching process.

8.2.2 Potential remedies to the challenges

Possible solutions to the challenges raised above for consumer devices include:

- **Regulators could promote support for eSIM and the usage of the best practice approach by requiring or encouraging operators to offer a fully digitized OTA process for provisioning and switching and porting**, and not for example to rely on paper-based QR-code vouchers as the primary subscription mechanism.[199] Connecting a smartphone should be possible without using any other devices apart from the smartphone itself. In parallel, **NRAs could encourage MNOs to assess whether improvements are possible to the MNP process and launch an awareness campaign concerning eSIM targeted at consumers.**
- **NRAs could usefully monitor the engagement between MVNOs and their hosts regarding eSIM support** to ensure that choice is maintained as physical SIM cards are phased out, and that MVNOs are not disadvantaged in serving higher-end customer needs.
- Noting that consumers purchasing devices with "out-of-the-box" connectivity may risk lock-in and increasing costs associated with the connectivity provided by the device manufacturer, NRAs could consider **requirements for increased transparency regarding the ongoing price of using such devices at the point of sale**, and consider whether specific requirements may be needed regarding SIM locking.
- Noting that European operators seem to be satisfied with the GSMA eSIM consumer specification, and that proprietary solutions could risk fragmentation and lock-in. **NRAs could consider promoting this de facto industry standard**, providing the GSMA continue to develop and improve it e.g. with reference to multiple active profiles. This should not preclude the development of other technologies and solutions in particular for M2M.
- Noting that the current lack of industry standards on device entitlement servers and the market power of some OEMs to demand proprietary configurations on entitlement servers, increases the cost for M(V)NOs to support certain devices and reduces choice in connectivity for these devices, **bodies such as CEPT and BEREC could usefully encourage the development of and adherence**

199 According to industry experts and operators, the usage of the on-paper QR code for the provisioning of the SM-DP+ server address (QR code voucher), which is sent to the customer's premise, has been used because of the similarity to the provisioning service of the physical SIM card. When the SM-DP+ is hosted by a SIM card vendor, the logistics process between OTA provisioning using an on-paper QR code and a physical SIM card is very similar, allowing simple integration of eSIM for the operator. However, operators and SIM card vendors recognise that the on-paper QR code based provisioning almost defeats the purpose of OTA provisioning, e.g. customers still have to wait for the QR code to arrive in their mail boxes and operators only cut down some of the logistic and packaging costs. That is why industry experts believe that the dominant provisioning scheme, at least for consumer smartphons, will be via smartphone apps provided by the operator or a third party.

to industry standards for device entitlement servers, especially by larger device manufacturers.

- **NRAs could monitor the penetration of eSIM technology and the number of market players supporting eSIM**, especially when more eSIM-only devices enter the smartphone market to assess whether these actions are working.

As regards possible solutions in the M2M space:

- Noting that a key barrier to the increased adoption of eSIM in M2M is a lack of champions in this space, **NRAs could consider awareness campaigns regarding the use-cases for eSIM in M2M, and its benefits could also be supported by Governments in the context of initiatives to promote the "*Digitisation of industry and public services*"**.
- Noting that switching in M2M can be challenging and expensive, and require collaboration between the previous and new provider, especially where the customer does not control the SM-SR, **NRAs could consider Guidelines or rules concerning minimum contractual conditions which are necessary to facilitate the switching process.**
- Noting that the M2M specification could be further improved to facilitate switching, **European, and international regulatory bodies could monitor standardization developments in eSIM and consider supporting** the enhancement of the consumer specification of eSIM to allow for a push model so that it can also be used in the M2M case or a simplification of the M2M infrastructure so that there is no longer a need for two separate infrastructure elements (SM-DP and SM-SR).
- To ensure that concerns around OTA provisioning and switching can be effectively addressed in the case of cross-border M2M,[200] bodies such as BEREC and / CEPT could consider appropriate mechanisms to ensure appropriate **oversight for multi-national M2M providers**, alongside developing guidelines on the extra-territorial use of numbers,[201] and the maintenance of a database for number ranges with a right of extraterritorial use[202]**.**

200 To provide an example, switching from operator A from one country to operator B from another country may lead to operational and practical problems, e.g., if the existing operator has no legal requirement to facilitate switching in its jurisdiction. Such problems cannot be solved by one national regulator alone. BEREC could consider whether a working group might be able to help in addressing such challenges.

201 ECC Recommendation (16)02 https://docdb.cept.org/download/1767.

202 https://berec.europa.eu/eng/news_and_publications/whats_new/8032-the-new-numbering-resources-database-available-on-the-berec-website.

8.3 Proposed Strategy for ComReg to promote consumer welfare

8.3.1 Recommended actions for ComReg to promote Consumer OTA

As Ireland is lagging its European neighbours in embracing eSIM technology, ComReg could usefully take specific action to set targets for fully digital OTA provisioning and switching by MNOs and to monitor the availability and take-up of eSIM as well as the conditions under which MNOs provide eSIM support to MVNOs.

Ireland has also been a leader in adopting fast and efficient MNP processes and could usefully ensure that it maintains this lead in the wake of the introduction of OTA switching processes by reviewing existing MNP processes to check whether further improvements are possible.

Looking further afield, Ireland shares with other countries in Europe and beyond, common challenges relating to the potential for lock-in on secondary devices and consumer IoT and concerns around the limitations of the GSMA consumer specification (lack of support for multiple active profiles) as well as the risk of fragmentation in specifications for device entitlement servers.

ComReg could work with other NRAs in the EU and internationally to monitor developments in standard-setting and encourage the industry to address these shortcomings.

More specifically as regards consumer OTA ComReg could consider the following actions.

Data gathering: ComReg should incorporate into its regular survey and data gathering exercises questions to equipment manufacturers designed to gather data on the availability of eSIM (based on the number of eSIM-enabled consumer devices (including smartphones and secondary devices such as smartwatches) sold), and to MNOs and MVNOs concerning the take-up of eSIM-based subscriptions (distinguishing new subscriptions from subscriptions involving a migration and potentially MNP). ComReg could also report on the devices for which different mobile service providers provide eSIM support. This exercise is necessary to track progress in eSIM availability, support and adoption and monitor the effectiveness of measures to promote OTA processes and facilitate switching.

Promotion of eSIM/OTA: ComReg should launch an information campaign to raise awareness of eSIM and its benefits for consumers including information on the website and potentially wider dissemination e.g. through a press statement. Informational material could for example include a description of eSIM, what is meant by OTA and fully digital sign-up and switching and the typical steps in the process for consumers. ComReg could also issue best practice guidelines to MNOs and other mobile service

providers on support for all-digital sign-up and switching with a focus on solutions such as mobile applications, which incorporate all aspects of the activation process and offer the potential for consumers to monitor their expenditure and mobile usage on an ongoing basis.

In view of the delays by MNOs in providing eSIM support in Ireland, in addition to "soft promotional measures" such as these, ComReg could usefully adopt more concrete measures to "promote" OTA provisioning in accordance with Article 93(6) EECC and to establish details of the switching and porting process including a requirement for porting to be completed through OTA provisioning in accordance with Article 106(6) EECC.[203] Such measures could include:

- A description of what is meant by OTA provisioning and switching along with high level guidelines on how this should be achieved in the context of consumer use cases e.g. in a transparent manner, through a fully digital customer journey,[204] within a short timeframe,[205] following secure processes and with the option of a recipient-led process in cases where the customer wishes to terminate their previous contract and switch to a new provider (as opposed to retaining services from different providers in parallel), while respecting requirements concerning data protection and prohibitions on anti-competitive use of information concerning contract termination.
- The targets of the obligation to provide OTA provisioning and switching for consumer use cases, which should include all MNOs in the first instance (noting that MNOs in a number of neighbouring countries including organisations within the same corporate group as those present in Ireland already support eSIM), but not yet MVNOs in view of MVNOs' dependence on eSIM support from their hosts and the high level of investments required in relation to their customer-base[206]
- The devices to be covered by the obligation, with a focus in the first instance on smartphones. Support for OTA provisioning and switching for other consumer devices cannot be mandated at this stage as such support may require investments in bespoke equipment such as entitlement servers. However, requirements to support OTA provisioning and switching for such devices could be made at a later stage, in particular if concerns around fragmentation in standards for entitlement servers are addressed.
- A date by which OTA provisioning and switching must be provided, noting that the date should ensure that the potentially significant benefits of OTA

203 OTA activation and switching are required to support OTA porting in the context of Article 106 EECC
204 As described in section 4.2, fully digital customer journeys can for example be achieved via QR codes (if digitally provided) or via an application
205 Provisioning and switching should be possible in principle within minutes
206 It is assumed that MVNOs will in any event have an interest in supporting eSIM to be able to support flagship mobile handsets, in particular when eSIM-only models become available

provisioning and switching are made available to consumers in the shortest feasible timeframe, while providing sufficient time for MNOs to implement the relevant solutions. It should be noted that interviews with operators conducted in the context of this study suggest that development or full integration of a system for eSIM management may take around one-and-a-half to two years. However, the timeframe for eSIM implementation can be considerably shortened by using solutions from eSIM management providers, although some time would still be needed to revise processes and train personnel. .

Competition and eSIM: To support OTA provisioning and service innovation by a wider range of mobile service providers, ComReg could usefully request information from MNOs and MVNOs about the conditions and timing under which eSIM support is provided, with the potential to conduct a formal review of access to eSIM support (e.g. in the context of competition law proceedings, a market review, merger review or spectrum assignment proceedings) in the event that MNOs do not provide adequate opportunity for MVNOs to provide eSIM support.

MNP processes: ComReg could issue a mandate for MNOs to review and, if possible, improve existing MNP processes to ensure that Ireland retains its current standard-setting timeframes for number portability and support (to the extent possible) porting timeframes which are consistent with the near instantaneous processes for activating new profiles via eSIM, thereby making the process appear as seamless as possible.

Address potential lock-in: In view of the potential for companion devices and consumer IoT in particular to be subject to lock-in (if no interface is provided to enable switching), ComReg could establish guidelines or rules which require OEMs or connectivity providers which sell devices bundled with pre-installed connectivity to clearly specify the initial and ongoing charges associated with that connectivity and the means by which consumers can switch their connectivity provider. If transparency proves to be insufficient in addressing this potential problem, ComReg could also initiate a review of SIM locking procedures and consider a prohibition on SIM locking.

At a European level, ComReg could complement the activities in its home market by working with other regulatory authorities to:

- Gather EU-wide data on eSIM availability and take-up across different devices and service providers
- Produce EU-wide best practice guidelines on (i) the promotion of OTA processes and switching; and (ii) addressing potential lock-in concerns.

EU-level and international bodies may also be best placed to monitor developments in standard-setting by the GSMA and consider whether standards meet the best interests of consumers and competition e.g. in terms of support for multiple profiles and standardisation of entitlement servers. It should be noted in this context that in 2019 the

US Department of Justice intervened to issue a “business review letter” to the GSMA when it had concerns over anti-competitive developments in the eSIM standard.[207] This resulted in changes to the standard-setting process by GSMA. It could be considered whether the European Commission, in its capacity as competition-law enforcement body, could play a similar role in monitoring standard-setting processes and ensuring compatibility with competition-law principles.

207 https://www.justice.gov/opa/pr/justice-department-issues-business-review-letter-gsma-related-innovative-esims-standard.

8.3.2 Recommendations to promote M2M eSIM and OTA

As regards M2M, eSIM support in Ireland is relatively well advanced due to the decision to install eSIM in smart meters and the high proportion of modern vehicles with eSIM pre-installed. However, in common with other countries, Ireland also suffers from limited eSIM /OTA support in other industrial sectors and potential challenges in switching due to the design of the M2M specification.

Relevant actions for ComReg could include data gathering, awareness campaigns and the development of best practice guidelines for fully digital OTA provisioning and switching for M2M.

At a European or international level, ComReg could also support data gathering on a wider basis, and the development of guidelines to support best practice contractual conditions and switching practices.

In addition, action at least at a European level, and if possible at international level is needed to address jurisdictional issues relating to enforcement of switching obligations and engage in supporting the development of pro-competitive standards for M2M.

More specifically, ComReg could engage in the following activities domestically:

Data gathering: ComReg could in the context of its regular survey market data gathering activities, gather information about the number of eSIM-enabled M2M devices deployed in the Irish market (distinguishing between different types of devices such as cars, smart meters, tracking devices). ComReg could also gather information concerning the connectivity providers and number ranges used for a selection of the M2M devices active in the Irish market (and whether the providers and/or number ranges are domestic or extra-territorial).

Promotion: ComReg could, potentially in conjunction with departments responsible for digitising industry and the digitisation of public services, launch an awareness campaign concerning the benefits of eSIM for industrial and public sector use cases.

As a more concrete measure to implement Article 93(6) EECC, which specifically refers to the promotion of OTA M2M switching, ComReg could establish high level requirements for OTA M2M provisioning and switching, illustrate options which could help to fulfil these requirements (such as an SM-SR swap or management of the SM-SR by the end-user), and provide guidelines on contractual arrangements that should be made to facilitate switching and avoid lock-in.

ComReg could also encourage similar data gathering activities at EU level, and the development of EU-level best practice guidelines concerning OTA M2M provisioning and switching procedures. In this context, ComReg could also propose the

establishment of a work programme to clarify jurisdiction and facilitate cross-border enforcement of any rules regarding OTA provisioning and switching in cases where M2M connectivity is provided using international numbers and/or by companies registered in another jurisdiction e.g. through collaboration between the regulatory authorities responsible for the oversight of the connectivity provider and those involved in the jurisdictions where a potential breach may have taken place.

Lastly, but importantly, ComReg could collaborate with organisations at EU level and elsewhere to monitor and support improvements to the GSMA M2M specification or the adaptation of the GSMA consumer specification to allow it to be used for M2M. The objective of these interventions would be to ensure that the eSIM specification used for M2M supports standardised processes and facilitates switching.

8.3.3 Summary of possible actions

The following table provides a summary of the possible actions that could be taken domestically and at EU level or internationally to support the development and uptake of eSIM alongside effective OTA provisioning and switching processes.

Challenge	For ComReg domestically	Potential EU / international actions
Lack of information	**Monitor availability and take-up** of eSIM across different device types, use cases and mobile service providers, for consumer and M2M applications	Gather **EU-wide data** concerning eSIM deployment and take-up for consumer and M2M use cases
Lack of awareness by consumers	Launch **information campaign** to inform consumers about the benefits of eSIM	
Lack of eSIM support by mobile service providers / insufficient choice of providers	Target and/or mandate fully digital OTA provisioning and switching for eSIM (smartphones only for the moment)	Develop best practice **guidelines for NRAs** which could cover: (i) interpretation of the relevant articles in the EECC; (ii) measures to promote eSIM / OTA; (iii) implementation and enforcement of OTA switching; (iv) eSIM support for MVNOs; (v) best practice actions to prevent lock-in including the role of transparency, best practice contractual provisions and the role of SIM locking rules
Lack of user-friendly OTA provisioning and/or switching options	Mandate MNOs to review /improve existing MNP process	
Insufficient choice of providers / barriers for MVNOs	**Monitor engagement between MVNOs and their hosts** concerning eSIM support	
Lock-in challenges	Recommend or require **clearer information regarding ongoing connectivity usage costs** for consumer devices which are supplied with connectivity by OEMs at the point of sale. Clarify requirements for OTA switching for consumer and M2M use cases. Consider SIM locking rules	SIM locking rules and/or other solutions to address « after-market » issues for devices bundled with connectivity
		Encourage the **adaptation of the consumer specification for M2M, or simplification of M2M specification** to improve switching potential for M2M
Lack of potential to use multiple profiles simultaneously		**Promote the use of the GSMA eSIM** consumer specification, and development of specification for multiple active profiles
High costs / barriers to support multiple companion devices due to lack of standards		Encourage the development and take-up of **industry standards for device entitlement servers**
Challenges with cross-border enforcement		Establish processes to clarify jurisdiction and ensure the effective monitoring and enforcement of any rules regarding provisioning, switching and fair contractual practices when IoT connectivity is provided on a cross-border basis e.g. using international numbers and/or companies registered abroad

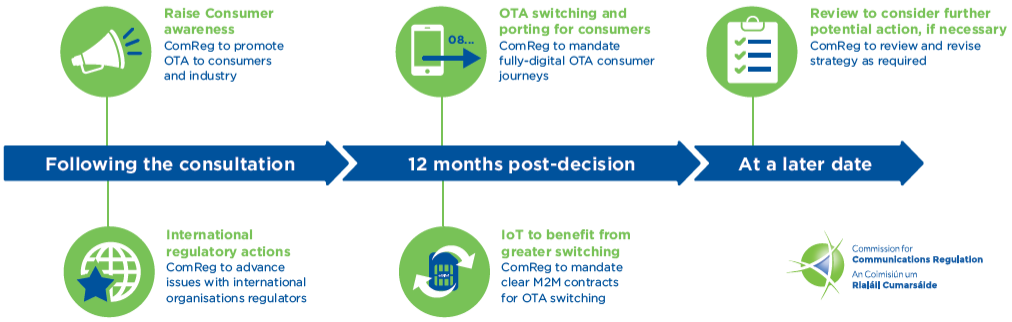
8.3.4 Potential 5-year roadmap

Regarding the timing of possible actions, the following milestones could be considered:

- Taking into account the slow eSIM deployment plans of Irish mobile operators, and the need for the Irish market to remain internationally competitive (noting that all MNOs have already launched eSIM support for smartphones in the UK, France, Germany and Spain),[208] ComReg could establish a target of **1 year from the relevant decision** for MNOs to support eSIM and fully digital provisioning and switching processes for consumer devices.[209]This should lead to availability of fully digital processes by **2023.** ComReg could also use its powers under the EECC to mandate OTA provisioning and switching, and issue guidelines on how this should be applied respectively in a consumer and M2M context.
- By the **end of 2026**, ComReg could complete a review to consider whether further actions may be necessary. At this stage of market development, it is too early to say whether any further intervention by the regulatory authority might be necessary. However, examples of potential intervention that could be considered in the medium term, if market solutions are not found, include rules concerning SIM locking and eSIM support for MVNOs.

This potential 5-year roadmap is depicted in the following diagram.

Figure 8-6: Roadmap for OTA in Ireland



Source: ComReg.

208 As of May 2021 Presentation by GSMA at World eSIM Virtual Summit.

209 Interviews conducted for this study suggest that a timeframe of between 18 months to 2 years may be needed for MNOs to establish their own eSIM solutions. However, faster solutions are available via the use of eSIM management providers, and the faster adoption rates of eSIM in other EU Member States including by MNOs within the same Group as those operating in Ireland suggests that a 1 year timeframe should be feasible.

9 ANNEXES

9.1 Analysis of OTA provisioning and switching processes by use case

9.2 The consumer use case

The consumer use case includes the use of smartphones by individuals or businesses, alongside potential companion devices such as smart watches and tablets. Consumers may subscribe to a primary service provider (which typically provides the number associated with their smartphone) alongside secondary service providers which may for example, be used to achieve more cost -effective solutions e.g. in the context of travel or specific services. In this chapter, we explore the current status of deployment for eSIM in the context of consumer devices, and then consider the processes involved in the provisioning and switching process for consumers and mobile network operators. We conclude by highlighting potential barriers to the smooth provisioning and switching process.

9.2.1 Smartphone (primary subscription)

For the last three decades, identification for consumer devices has been provided via physical, plastic SIM cards. Although the size of SIM cards has reduced, few specifics besides the form factor have changed. To connect to a mobile network, the consumer needs to either go to a physical retail store to buy a plastic SIM card or needs to order a SIM card online or on the phone. The latter process might take one to two days, depending on the shipping time of the SIM card to the consumer's premise.

After receiving the SIM card, the consumer must plug it into their device. In the past, most phones had to be turned off, the battery had be removed and the SIM card had to be put into the SIM card slot. Modern phones that come with non-removable batteries and are generally harder to open often allow the end user to plug in the SIM card using a SIM card tray on the side of the phone without having to turn off the device first. After the initial activation period, the consumer connects to the mobile network of their choice.

With OTA provisioning, the customer journey can be fully digitised and the process of connecting the device to a mobile network can potentially be reduced to a few minutes and be carried out from any place in the world.

9.2.1.1 Requirements for remote provisioning and switching

9.2.1.1.1 The customer perspective

Technical requirements – eSIM enabled smartphone

To be able to change operators remotely, the customer needs to have an eSIM capable smartphone which needs to be connected to the Internet. For this, the customer may utilise Wi-Fi, a second device which is already connected to the Internet or in the case of changing operators, an existing cellular connection to the Internet. For the customer, the process should be as swift and easy as possible and connectivity downtime should be as short as possible.

Figure 9-1: Smartphones models with eSIM, March 2021

Source: WIK-Consult based on https://www.gsmarena.com and manufacturers websites, as of March 2021. For smartphones, all devices except for the Motorola Razr (2019) come with an eSIM additionally to the physical SIM slot. Models may differ across regions.

Legal requirements – Right to switch and port

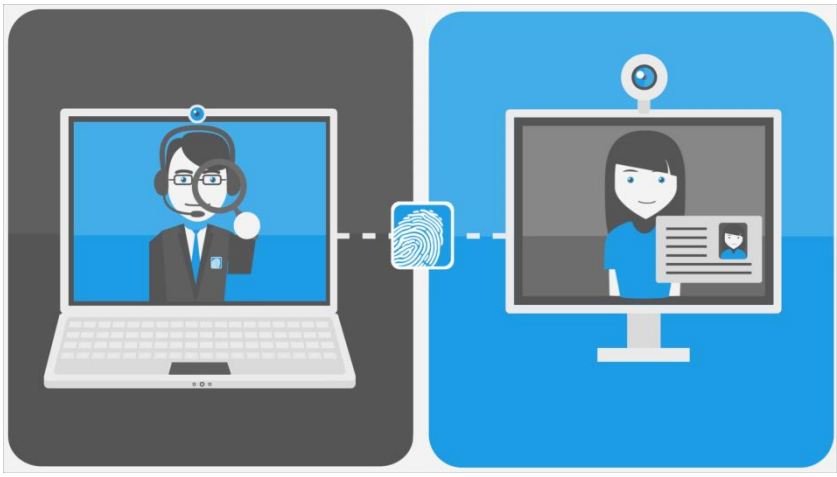
The EECC includes a number of measures which seek to ensure customers can change provider or terminate existing services, without being hindered by legal, technical, or practical obstacles.[210] Specifically, consumers have a right to switch providers and retain their personal phone number, as long as they have fulfilled their reasonable contractual obligations. Issues around contract duration, are also covered within the EECC, in order to avoid lock-in.[211]

From a practical perspective, consumers usually have to provide some form of identification when signing new contracts. As provisioning is potentially fully digitised

210 Recital 273, EECC.
211 Article 105 EECC.

with the remote provisioning capabilities of the eSIM, consumers may want to provide identification digitally and without having to go to a retail shop. A number of solutions already exist in this regard e.g. where identification is checked via a video call or using artificial intelligence and biometrics. In this case, the customer's smartphone camera can be used to check the ID and the identification of the customer. Fully automated identification is also possible via online banking, where the online identification checks the customer's information against the bank's data.[212]

Figure 9-2: Digital identification via video call



Note: Instead of the webcam of the computer, a smartphone camera can also be utilized.

Source: WebID https://webid-solutions.de/solutions/?lang=en.

Commercial requirements

The consumer usually requires one contract and associated offer per device, although one contract can also cover multiple devices, for example, of further family members, or potentially companion devices. Consumers' typically do not need to establish contracts for large numbers of devices. However, this may be the case for business users.

Switching is likely to be most straightforward in cases where there is one to one relationship between the devices covered by the previous contract and the new contract. However, with the proliferation of devices, consumers may seek to make use of offers which may involve switching multiple contracts onto a combined contract, or vice versa.

212 See, for example https://webid-solutions.de/solutions/?lang=en.

9.2.1.1.2 The operator perspective

Technical requirements – eSIM management platform

Most importantly, to be able to provision profiles remotely, the operator needs to have access to an SM-DP+ entity (see section 3.4). The SM-DP+ must also be integrated into the backend system of the operator.

Legal requirements – Obligations to provide switching and porting

In the EU, operators are required to support mobile number portability. Furthermore, in some countries, operators are required to check the ID of new customers. To be able to offer a full digital customer journey, the operator needs to implement an appropriate solution.

Commercial requirements

The operator needs to establish points of sale. To provide a fully digital customer journey, it should be possible to conclude the sales and contractual process online. For the national consumer, the operator usually provides one contract per device, but may provide bundled offers including multiple connections within the family or including companion devices.

A contract for business customers might include connectivity for multiple handsets as well as other personal devices.

9.2.1.2 Customer journey for OTA provisioning

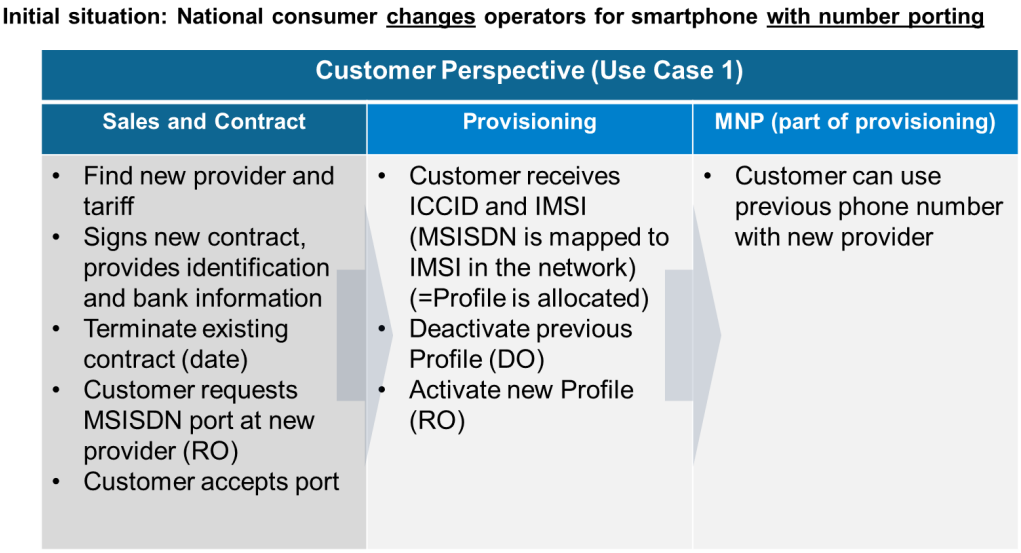
9.2.1.2.1 The customer perspective

The customer journey can be divided into two processes:

i. Sales and contract processes

ii. Service provisioning processes. The service provisioning processes can be further subdivided into the allocation of the subscriber identification (i.e. the SIM) and the MNP process. In theory, with remote SIM provisioning, the entire process can be fully digitised and be completed within a few minutes.

Figure 9-3: Customer Perspective – Customer journey



Source: WIK-Consult.

Sales and contract process

As a first step, the customer needs to find a new provider with an appropriate tariff that fits his or her needs. If not already terminated, the consumer needs to cancel the contract of the previous provider as well.[213] Furthermore, in case the customer wants to port his or her previous personal phone number, the customer needs to request the new provider to port the number and provide the necessary information, such as the previous MSISDN and information about the previous operator[214]. Many countries in the EU and worldwide require personal identification checks to sign a new contract with an telecommunications operator. Where such a check is required, the customer can identify him- or herself online.

Provisioning process

Remote SIM provisioning is the most significant part that changes with eSIM technology. After the sales and contract procedure is completed, the customer is given the necessary credentials to connect to the operator's mobile network, the SIM profile. With a physical SIM card, the operator's profile is already stored on it and the customer receives it either from a store or via post. On receiving the card, the customer has to

213 This is not actually needed for changing operators but usually done if the customer does not want to pay for multiple, unused contracts.

214 This describes a recipient-led MNP process, which is followed in most European countries (in contrast to a donor-led MNP process). In Ireland, the customer needs to provide information of the subscriber type (e.g. post-paid or pre-paid, single-line or multi-line, etc.), MSISDN, account number of the donor operator and date and time of the request. See Mobile Number Portability Process Manual Issue 6.01 (Ireland).

plug it into the device and can then use this card to log into the mobile operator's network.

In the case of remote SIM provisioning, after the sales and contract procedure is concluded, the customer needs to follow the instructions provided by the operator on how to download and activate the profile.

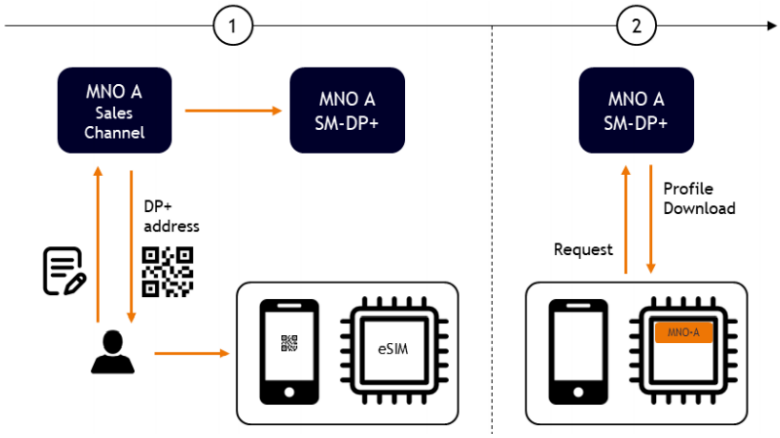
There are four main methods for a customer to set up the service subscription for his or her smartphone and one or several of these options might be provided by the operator: 1) QR code / manually enter the SM-DP+ address / getting the address through a smartphone app; 2) GSMA Discovery Service; 3) entitlement server; 4) bootstrap profile.

Activation code

The first method is via an activation code which contains the address of the SM-DP+ from which the operator's profile can be downloaded onto the device's eSIM. This code may come in the form of a QR code, which can be scanned by the camera of the customer's device, which needs to be connected to the Internet. The interface in which the user scans the QR code and manages the profiles on the device is done through the Local Profile Assistant (LPA). This software can be either installed on the eUICC or integrated in the device's software. With the LPA, the customer is also able to give the required permission for the profile to be installed on the device.

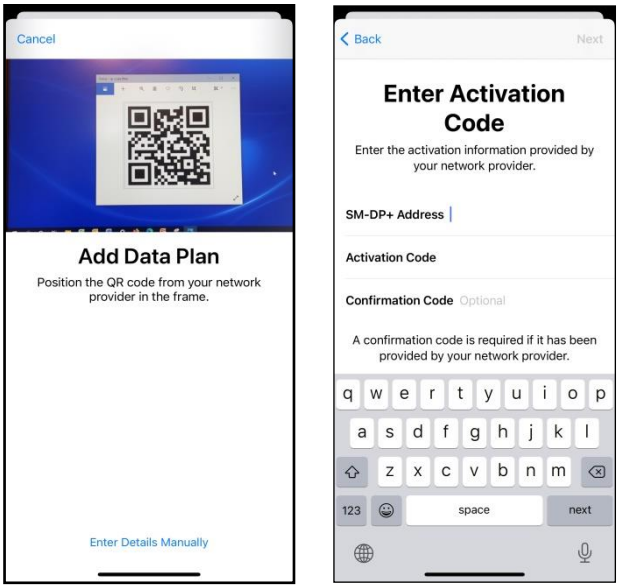
Figure 9-4 shows schematically the remote provisioning process using a QR code to transmit SM-DP+ address while Figure 9-5 shows the concrete interface of the LPA on an iPhone. The interface in which the user scans the QR code and manages the profiles on the device is done through the LPA. This software can either be installed on the eUICC or integrated in the device's software. With the LPA, the customer is also able to give the required permission for the profile to be installed on the device.

Figure 9-4: Customer journey of OTA provisioning using QR code



Source: Achelos (2020).

Figure 9-5: Activation with an QR code through iOS' local profile assistant



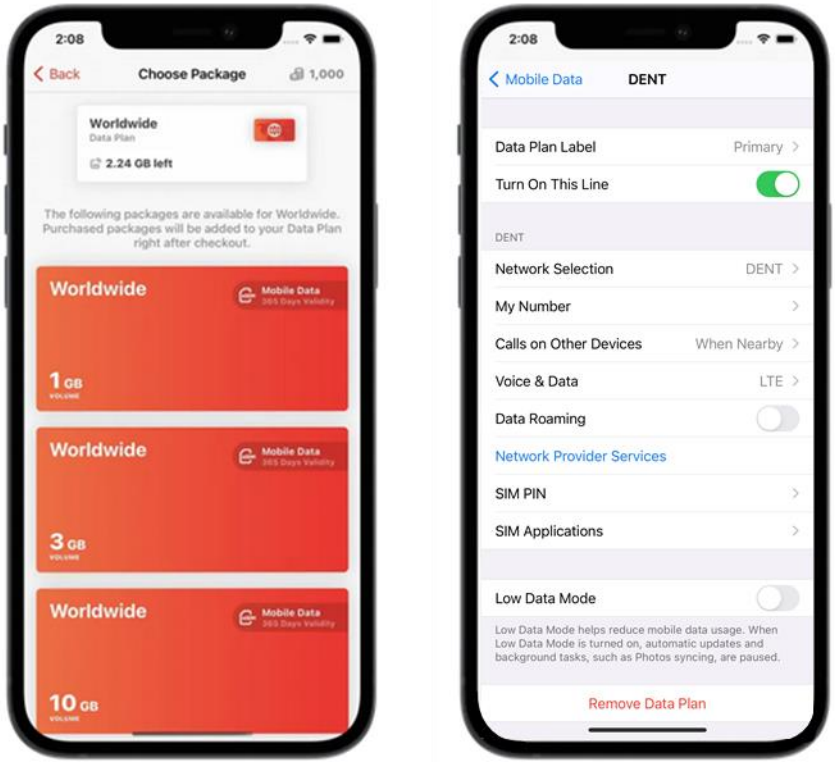
Note: Activation through Apple's own LPA on an iPhone 12. Subscription can be added in "Settings – Mobile Data" by scanning a QR code with the SM-DP+ address or by manually typing in the needed credentials.

Source: Apple iOS 14.4, Screenshot.

Similarly to the QR code activation, the SM-DP+ server address can also be provided via a smartphone app from the operator. In this case, the customer does not need to use the device's camera to scan a QR code. This solution does not require a secondary

screen or print-out of the QR code.[215] The profile is downloaded through the app onto the eUICC but managed, in the device's LPA. In theory, such an app could also be used as the contract and sales point and ID checks could also be integrated into such an app.[216]

Figure 9-6: Activation through an operator's app



Source: Dent Wireless https://www.dentwireless.com/dent-app.

GSMA Discovery Service.

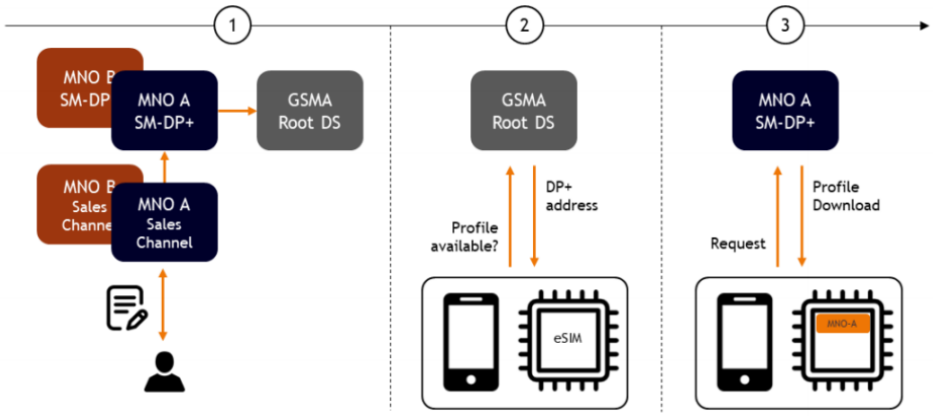
It is also possible for a user to download an operator's profile after subscribing via the GSMA Discovery Service (see section 3.4). The Discovery Service is a globally available Internet service and acts as a central communication point between consumer devices and operators' SM-DP+ entities. After the contract between customer and operator is signed, using the LPA, the customer can request a check for a new profile and receive the SM-DP+ address from the discovery server. The device then contacts

215 In case the SM-DP+ address is provided via an QR code, operators often also give the SM-DP+ address in text form in case the consumer does not have a second screen to scan the code or the smartphones camera is not working. If so, the customer needs to type in the SM-DP+ address manually.

216 For example, the IT company WebID provides such solutions that can be directly integrated into the operators app. Source: https://webid-solutions.de/solutions/?lang=en.

the operator's SM-DP+ and can start the download and installation of the profile onto the eUICC.

Figure 9-7: Customer journey of OTA provisioning using GSMA discovery service



Source: Achelos (2020).

Device entitlement server

A third way is through an entitlement server. The entitlement sever is a remote manager for a particular device, for example a smartphone or a smartwatch. This entity is within the operator's domain[217] and is configured to the device specification from the OEM. Through a separate authentication, an entitlement server links a subscription account to a device and instructs the device to contact an SM-DP+.

SM-DP+ address stored on shipped eUICC

There is a further, less popular method for activating mobile network connectivity on the consumer's device by shipping the eUICC (embedded in the device) with a SM-DP+ address assigned to an operator's eSIM profile. On receiving the device, the consumer already has the address of the SM-DP+ contained on the eUICC and can download and install the associated profile from the server. As the eUICC can only contain one SM-DP+ address, this method may limit the end-user in choosing his or her preferred operator or establish lock-in effects.

All the methods described result in the customer downloading the operator's profile and installing it on the eUICC. In each case, the customer's permission must be given before installation, which is also done through the LPA. Once the profile is correctly installed on the eUICC, the customer will start enabling the profile.

217 In the operator's domain does not necessarily require the operator to run the server. As with the SM-DP+, the entitlement server can also be run by a third party.

If there are already profiles installed and one of them is active, the end-user would need to disable the profile before activating the newly downloaded one. If there is no other profile installed, the customer can activate the downloaded profile and will be connected to the mobile network, as with current SIM cards.

Besides the advantage of the faster and potentially fully digitalized eSIM activation process, the eSIM provides further benefits. The eUICC can hold multiple profiles at once – the number is limited only by eUICC storage and operator's profile size. Although in the current GSMA specification only one profile can be active at the same time, many other profiles can be installed and switching between them can be done instantly through the LPA.[218]

Mobile number portability process

For physical SIM cards, when the MNP request is timed with the arrival of the new SIM card, the new SIM card can be used right away with the previous phone number[219]. The MNP process can also be timed such that the number is only ported after the previous contract is terminated and shortly before using the new SIM card. The old SIM card will be then deactivated from the donating operator (previous operator).

In Ireland, number porting is processed fully automatically and can be completed within seconds. This means that downtime should not be an issue for an average customer. The new SIM card can also be used before the MNP process is completed or even requested, as each IMSI has a mapped MSISDN, even when the customer does not plan on using it.

Regarding MNP, in case of eSIM and remote SIM provisioning, the process is similar for the customer. After the customer has downloaded the new operator profile, the existing phone number can be ported to the new operator. The eSIM profile also contains an IMSI to which the previous MSISDN is mapped. As with the physical SIM card, the previous profile can no longer be used.

As noted, since the role of the IMSI does not change with eSIM, customers can also port their numbers to an eSIM when they used a physical SIM card from a different operator previously, and vice versa.

218 To illustrate this point further, inactive profiles can be seen as SIM cards that are activated but currently not plugged into any device. The number of eSIM profiles is only limited by the size of the profile and the storage of the eUICC. Current consumer eSIMs in the market can usually hold five to ten profiles.

219 In this case, the MNP process is already completed and the MSISDN of the donating operator (i.e. the previous operator) is already mapped to the new IMSI of the recipient operator (i.e. the new operator).

9.2.1.2.2 The operator perspective

As with the consumer perspective, the customer journey from the operator's perspective can also be divided into two processes:

i. Sales and contract processes

ii. Service provisioning processes. The service provisioning processes can again be further subdivided into the allocation of the subscriber identification (i.e. the SIM) and the MNP process. Figure 9-8 provides an overview of these processes.

Figure 9-8: Operator's perspective – Customer journey

Initial situation: National consumer changes operators for smartphone with number porting

MNO Perspective (Use Case 1)		
Sales and Contract	**Provisioning**	**MNP (part of provisioning)**
• Get in contact with customer (Point of sale) • Let customer decide on tarif • Get customer identification and billing information • Get order signed • (Terminate customer's previous contract with DO, in case of one-stop shopping, with date) • For MNP, capture the previous MSISDN(s), subscriber type, DO account number, date/time of the MNP request	• Create new customer and implement his/her product characteristics, access/connection; register customer in HSS/HLR • Allocation and control of rights per customer contract and customer terminal(s) • Enabling billing (collection/control of charge relevant data/ traffic flows) • Allocate ICCID and IMSI with mapped *unused* MSISDN (profile) • Send Profile to customer	• Validate the customer's mobile number by text, call or by viewing the customer's bill • Send request to DO (DO validates this against the information held on the MSISDN(s) on the its internal systems, accepts port) • RO adds MSISDN to HLR and updates SRF; sends DO request to disconnect the number from their systems • After DO has disconnected the number from its system, RO informs NPD that they are now the owner of the mobile number • After DO confirms with NPD and NPD issues information on the MSISDN to all operators, RO receives confirmation that the port is complete

Source: WIK-Consult.

Sales and contract process

First, the operator needs to attract a new customer that is willing to switch and let them decide on a tariff. After the operator has identified the customer and obtained all the necessary information for billing purposes, the contract can be signed. Some operators may also be willing to terminate previous contracts for the customer or buy them out of their contractual obligations.

For MNP, the operator needs to capture the MSISDN the customer wants to port from the previous operator to the new one, subscriber type, information on the donating operator (i.e. the operator from which the phone number is ported from) and the date and time when the porting should be processed.

Provisioning process

Remote SIM provisioning enabled by eSIM is only part of the service provisioning process. Before provisioning the profile, the operator needs to first create a new account for the customer and implement the product characteristics of the tariff and register the new customer in the Home Subscriber Server and the Home Location Register (HSS/HLR). The operator also needs to allocate and control user rights for the customer and customer terminal(s). Furthermore, billing needs to be enabled, i.e. the collection or control of charging and relevant data or traffic flows from the customer.

The operator also needs to allocate an ICCID and IMSI to the customer to enable them to connect to the mobile network. With traditional SIM cards, this information is stored on them and delivered to the customer either via post or at an operator retail outlet. The costs of these logistical procedures are not negligible from the operator's perspective. The operator needs to package, store, and allocate them between its outlets and inventories or ship them individually to the customer's premise, which all entails cost and effort and possible waiting time on the customer's side.

This process, which cannot be digitised with a traditional SIM, can be completed within seconds with eSIM and is fully automated and digital. First, on creating a new account for the customer in the operator's systems, the eSIM profile needs to be created and allocated on the operators SM-DP+, which is integrated in the backend system of the operator.[220] The SM-DP+ server address and activation code[221] is remotely provisioned (OTA) to the customer, enabling them to download and install the new profile (When the activation of the profile is completed on the customer's side, the remote SIM provisioning process is completed.

Mobile number portability process

After the SIM profile is provisioned and activated by the customer, the MSISDN can be ported from the IMSI of the previous SIM of the previous operator (i.e. DO) to the newly provisioned IMSI of the new operator (i.e. RO). The process is completely separate from the remote SIM provisioning and existing MNP processes work exactly the same with eSIM as with traditional SIM. Furthermore, in Ireland, the MNP process is fully automated and can be completed within seconds (see section 3.6).

220 The SM-DP+ does not have to be on premise of the operator but only connected to its system. See section 3.4.2.

221 The activation code is in essence the identification of the profile. Hence, the customer is not only provided with the SM-DP+ address but also instructed which profile to download from the server.

9.2.2 Existing and future problems

9.2.2.1 The customer Perspective

On the one hand, support for eSIM by MNOs and MVNOs has been rapidly increasing in the last few years (see chapter 6.2) but there are still operators in Europe and around the world that do not support the new technology. As almost all eSIM capable smartphones also come with traditional SIM card support (i.e. a SIM card slot), and only a subset of operators supports eSIM, customers with eSIM capable smartphones often do have the same choice of operators as with the traditional SIM card. This also means that if customers want to enjoy the benefits of eSIM such as the quick and digital SIM provisioning process, the choice of operators is limited.

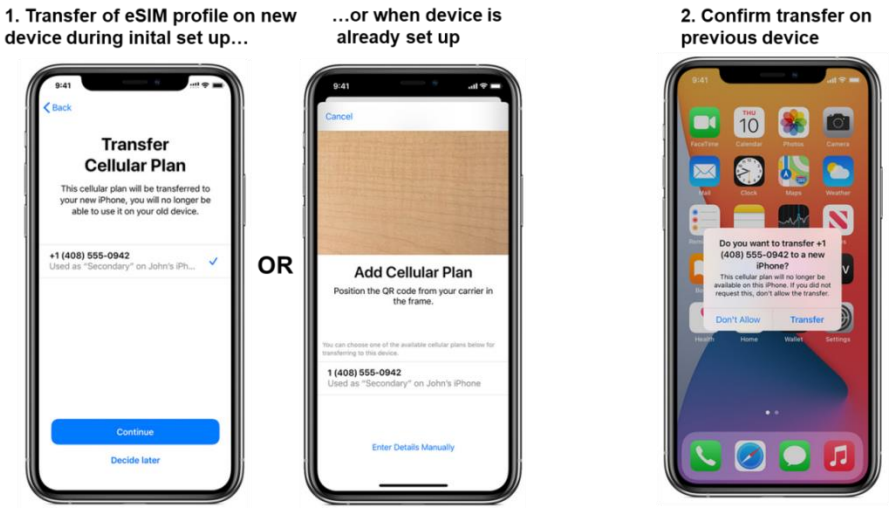
Many eSIM enabled smartphones are high-end and costly, customers who want to benefit from eSIM technology also need to invest in more expensive handsets.

Furthermore, customers are used to the traditional SIM card exchange and the new digital management of SIM profiles in the phone's LPA might be challenging for some. It should also be noted that the transfer of eSIM profiles between devices is not as straightforward as with the traditional SIM card and may differ for different devices and different operators.

Under the current GSMA specification, the operator's profile installed on the eUICC cannot be copied, in the same way as it is not possible to have two physical SIM cards with the same profile. However, the profiles can be transferred by deactivating the subscription on the previous device and activating it on the new device. Importantly, both devices need to be turned on and connected to the Internet, as the previous device needs to send a signal to the SM-DP+ that the profile is deleted before the profile can be reinstalled on the new device.

An example of a profile transfer between two iPhones is shown in Figure 9-9. The transfer of the profile can be initiated on the initial set up of the new device or when the device is already set up. The transfer must be confirmed on the previous device. If the smartphone is lost or broken and cannot give confirmation, replacement options differ from operator to operator.

Figure 9-9: Transfer of eSIM profile to a new device



Source: Apple (https://support.apple.com/en-ie/HT210655).

9.2.2.2 The operator Perspective

It is necessary for operators to investment in eSIM management systems in order to the technology.

There are a range of different eSIM management business models, which may involve third parties such as traditional SIM vendors or newly formed businesses specialized in eSIM management. From a customer perspective, the experience should not be influenced by the operator's management business model as the business models are purely a strategic choice of the operator.

Under the first model, the operator builds and manages their own SM-DP+ entity with the SM-DP+ physical infrastructure located at the operator's data centres within the borders of the operator's operations. According to industry experts, this model has been pursued by only a few operators in Europe. This is explained by the ongoing specification process of the GSMA and the need for constant updating and upgrading of the servers. It is also necessary to upgrade the platform's capacity to reflect eSIM consumer adoption rates, which is very low at the moment but may increase quickly in the future.

> A second model involves the operator purchasing the SM-DP+ entity service from a third party, typically traditional SIM card vendors such as Giesecke+Devrient (G+D) or Thales. In this case, the BSS and OSS is connected via an API to the SM-DP+ and signals to the server to allocate a profile and allow it to be downloaded onto the customer's eUICC. In Europe, the vast majority of operators opt for this model, as integration with their BSS via API is simple and does not create any delay in the process. As the eSIM is not

yet widely adopted among consumers, operators may be reluctant to make large investments in their own SM-DP+ servers. Market experts also note that operators follow the trend towards putting more services into the cloud and expect operators to keep using third party SM-DP+ entities instead of developing their own.

For device entitlement servers, which are required for operators by some OEMs to be able to communicate with certain devices, the business landscape looks similar. Although the GSMA is working on specifications for entitlement servers, there are currently no industry standards. This means any OEM can require the operator to have entitlement servers which are specifically configured to the device's needs and can also differ across devices for different OEMs. With the increasing number of eSIM devices, the number of different configurations might be hard to keep track of and costly to implement for each new device. This is why currently, entitlement servers are also most often run by third parties, either traditional SIM vendors that also provide the SM-DP+ or by newly formed eSIM management companies.

From the regulatory perspective, operators and eSIM management providers face difficulties in countries that prohibit the transfer of mobile data to other countries. For these countries, the SM-DP+ entity must be physically located within the country's borders but may be operated by international eSIM management providers. For Saudi Arabia for example, a single SIM vendor provides the SM-DP+ infrastructure and service for all three operators[222]. According to industry experts, countries with similar restrictions include Turkey, Russia, Brazil, and China.[223]

222 See GSMA (2021, p. 20). All three MNOs with at least 5% market share offer eSIM service for smartphones.

223 E.g. BTK (Turkey) Board decision dated 12.02.2019 numbered 2019/DK-TED/053: „2. For the Remotely Programmable SIM technologies; the authorization of the execution for the establishment of all structure, system and storage units including Profile data Preparation and Secure Routing Servers (SM-DP (Subscription Manager Data Preparation), SM-SR (Subscription Manager Secure Routing), SM-DP+, SM-DS (Subscription Manager Discovery Server),Data Center and system components that have similar functions which can be determined by GSMA within the process) related to eSIM Subscription management (GSMA-SM - GSMA Subscription Manager) processes and software (SM-DP, SM-SR, SM-DP+, SM-DS, DATA Centers and mobile applications related to subscription profile management including software, platforms LPA (Local Profile Assistant) that work on system components that have similar functions which can be determined by GSMA within the process) and other equipment and software which are seen relevant to eSIM platform in GSMA standard within the borders of our country by the operator authorized in our country or by third parties determined by the operators provided that all the responsibility belongs to the operator, ensuring their interoperability, ensuring their control, keeping all data inside our country, installing all those systems in conformity with GSMA standards and the conclusion of relevant documentation and processes, and the installation of the systems by 29.02.2020 to the place to be determined by the Agency,". (unofficial translation, original document in Turkish: https://www.btk.gov.tr/uploads/boarddecisions/uzaktan-programlanabilir-sim-teknolojileri-esim/053-2019-web.pdf).

9.2.3 Secondary devices

eSIM technology not only allows for a fully digital and fast provisioning process, but also for more compact device designs, since eSIMs come in a smaller size and are directly soldered into the device[224]. This also makes it easier for manufacturers to make their devices more shock and water resistant.

As a result, eSIMs make it possible to connect more devices to the mobile network that were not connected before. The most prominent use case is smartwatches, but other "secondary" devices such as tablets and laptops can benefit from eSIM as well.

For secondary devices, different provisioning scenarios are possible, depending on the type of device, manufacturer and model as depicted in Figure 9-10.

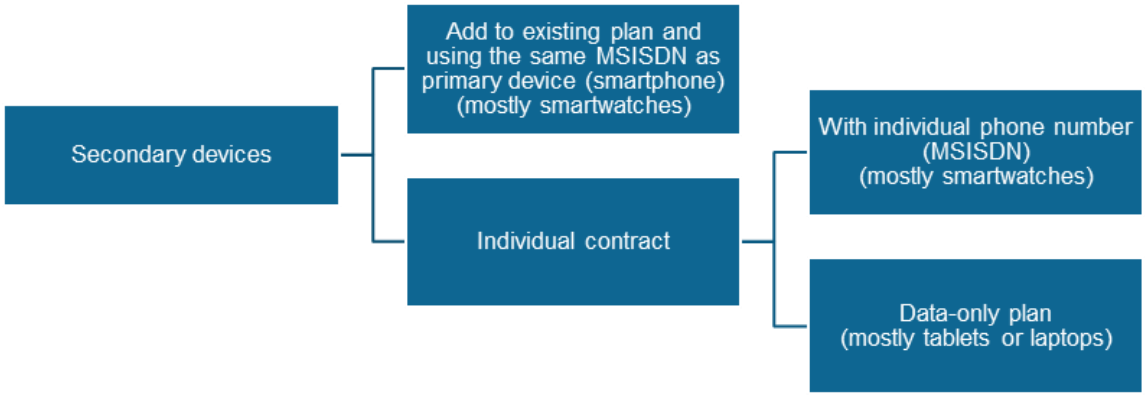
There are three different scenarios for smartwatches: They can be added to an existing smartphone plan where the smartwatch can also use the same MSISDN the phone to make and receive calls or they can get an individual contract. The individual contract can also come with an individual phone number, i.e. the smartwatch can have the full functionality of a smartphone where it can receive and make calls from an individual number. This differentiation is based on the functionality of different smartwatches and some models are only capable of a subset of these three connectivity scenarios. Additionally, some operators are also only capable of providing services for a subset of these three connectivity scenarios, which may limit competition.

Tablets and laptops usually use data-only plans.[225]

224 As mentioned before, eSIM is not defines by the form factor but by the functionality. However, for consumer devices, the eSIM almost always comes in the MFF2 form factor (chip soldered onto the device). Conversely, there are almost no phones for the consumer market that come with a soldered, non-reprogrammable SIM.

225 On one hand, the Apple Watch, for example, can essentially be used as a phone where calls are made and received directly to it (without routing through the paired smart phone). An iPad cellular on the other hand, for example, cannot be used as a phone (see https://support.apple.com/guide/watch/make-phone-calls-apdc38d7a95e/7.0/watchos/7.0 and https://support.apple.com/guide/ipad/make-and-receive-phone-calls-ipadf97892b2/ipados).

Figure 9-10: Differentiation in contracts and capability for the connectivity of secondary devices



Source: WIK-Consult.

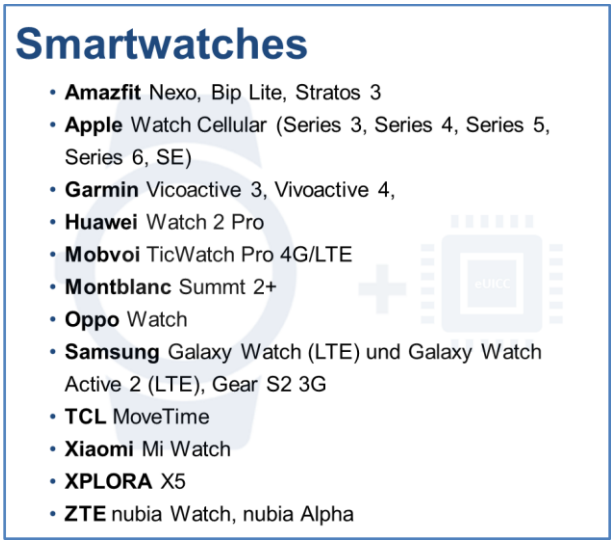
9.2.3.1 Requirements for remote provisioning and switching

9.2.3.1.1 The customer perspective

Technical requirements

For customers, cellular smartwatches enable them to leave their smartphone at home and access the Internet or make and receive calls directly to their smartwatch. However, for most smartwatches, they first need to be paired to the customer's smartphone, their "primary" device. Depending on the manufacturer and model of the smartwatch, sometimes specific smartphones are required. The paired smartphones are also required for the provisioning process of a SIM profile. Figure 9-11 provides an overview of eSIM capable smartwatches.

Figure 9-11: Current Cellular smartwatches models with eSIM



Source: WIK-Consult based on https://www.gsmarena.com/ and manufacturers websites, as of March 2021. Devices may come in different models with one supporting cellular connection (enabled by eSIM) and one that does not support any cellular connection.

For the Apple Watch for example, the customer also needs to have an iPhone for initial pairing.[226] For Samsung's Galaxy Watch, the smartphone needs to run on Android 5.0 or later with 1,5GB of RAM. Samsung also allows iPhone 5 and later (with iOS 9 and later) for pairing.[227] Although the smartwatch can have the full functionality of a phone, e.g. make, and receive calls (non-IP based) or send SMS, for the initial set up of the watch and the mobile service, a smartphone usually needs to be paired to the watch. In many cases, this is only way to have a full user interface and not be limited by the smaller display of the device.

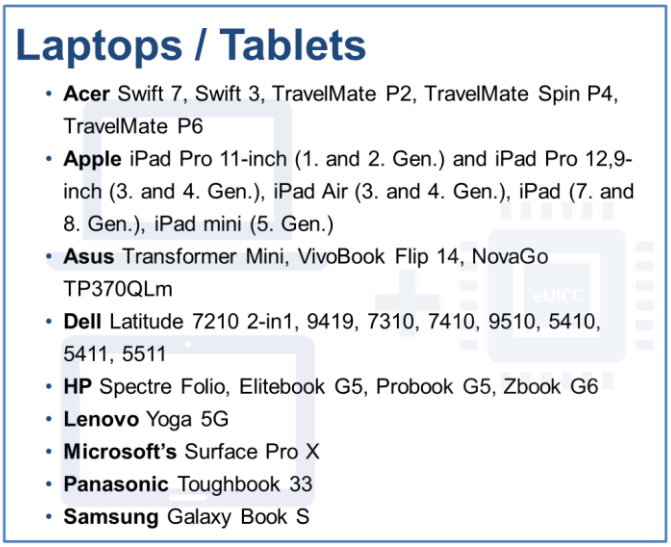
As not all operators support smartwatches, consumers need to check with their existing mobile network operator if the operator also supports smartwatches, which may also differ for different models or manufacturers.

Besides smartwatches, eSIM is also used for tablets and laptops. Figure 9-12 gives an overview of eSIM devices. Tablets or laptops usually do not require initial set up as they are most often not paired to a smartphone.

226 For example, the Apple Watch Series 6 cellular requires an iPhone 6s or later with iOS 14 or later (https://www.apple.com/apple-watch-series-6/) for the initial set up. Apple is also offering a service called "Family Setup" that allows parents, for example, to use their iPhone to set up an Apple Watch for their children when they do not have an iPhone. The Apple Watch can then be used with a unique (i.e. own) phone number (MSISDN) and even be on a different mobile network than the iPhone it was originally set up with (paired). For more info see https://support.apple.com/en-us/HT211768. Importantly, only a subset of operators who support the Apple Watch also support this feature (see https://www.apple.com/watch/cellular/).

227 https://www.samsung.com/sg/support/mobile-devices/how-to-activate-or-reset-samsung-galaxy-watch/.

Figure 9-12: Current Laptops and Tablets with eSIM



Source: WIK-Consult based on https://www.gsmarena.com/ and manufacturers websites, as of March 2021. Devices may come in different models with one supporting cellular connection (enabled by eSIM) and one that does not support any cellular connection.

Legal requirements

When the smartwatch is added to an existing plan or set up at the same time when making the smartphone contract, providing additional identification should not be needed.

Regarding MNP, in case the smartwatch uses the same phone number as the smartphone it is paired to, MNP is already covered in the national consumer primary device use case (see section 9.2.1).

For devices that use data-only plans, the device cannot make or receive phone calls using a phone number (MSISDN) but only using app-based calls (VoIP) where no personal phone number is required. In these cases, MNP is not relevant for the consumer. For identification, the same should apply as in the Consumer – Smartphone (primary subscription) case.

Commercial requirements

As previously described, there are three scenarios for secondary devices. They can either be added to an existing smartphone contract or they can be connected with an individual subscription contract using an individual phone number or data-only plan.

If the secondary device is added to an existing smartphone contract, the operator usually charges a surcharge adding the device to the plan and issuing an extra copy of

the profile of the smartphone[228]. This is not offered by all operators, even when they offer eSIM support.

For data-only plans or plans with an individual phone number, the customer usually sets up an individual contract with the preferred operator.

9.2.3.1.1.1 The operator perspective

Technical requirements

In order to support smartwatches, mobile operators need to have access to the device entitlement servers. Manufacturers set specific requirements for their devices which need to be met by the operator. As with the SM-DP+, the entitlement server can also be run by a third party.

Besides the device entitlement servers, the same technical, legal, and commercial requirements that apply for the operator in the smartphone case also apply here (see chapter 9.2.1).

9.2.3.2 Customer journey for OTA provisioning

9.2.3.2.1 The customer perspective

The customer journey for secondary devices from the consumer perspective can be divided into two processes:

i. Sales and contract processes

ii. Service provisioning processes. Both processes differ depending on whether the provisioning scenario involves adding the secondary device to an existing contract or not. An overview is given in Figure 9-13

228 See, for example, Deutsch Telekom “MultiSIM” https://www.telekom.de/unterwegs/tarife-und-optionen/zweitkarten-angebote?content=content-device or Vodafone UK for https://deviceguides.vodafone.co.uk/apple/watch-series-6-watchos-7/connectivity/set-up-mobile-data-on-your-apple-watch/.

Figure 9-13: Customer journey OTA provisioning - Customer perspective

Initial situation: National consumer connects to operator for secondary contract (without number porting)

Customer Perspective (Use Case 2)	
Sales and Contract	**Provisioning**
Three alternative scenarios: **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Contact existing operator and add secondary device to plan **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Sign new contract, provide identification and bank information	• In case of smartwatch: Pair smartwatch to primary device (smartphone) **Three alternative scenarios:** **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Customer downloads and installs *clone* Profile of existing plan (same ICCID and IMSI as smartphone) through paired smartphone **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Download and install Profile (through smartphone in case of smartwatch)

Source: WIK-Consult.

Sales and contract process

When a smartwatch is added to an existing smartphone plan, where the smartphone shares the phone number with the smartwatch, the customer needs to check if the service provider for the smartphone supports this feature. If the operator does not support this feature, the consumer would need to change operators.

When the operator that also provides service for the smartphone supports the feature of sharing the phone number with the smartwatch, the customer needs to add the smartwatch to his or her existing plan. After that, the smartwatch can be provisioned.

For consumers that want a separate MSISDN for their smartwatch, the contract or mobile operator of the primary device (e.g. smartphone) should not play a role. In that case, the consumer needs to find an appropriate mobile operator which can provide the smartwatch with this service. Not all operators support all smartwatches and not all operators support individual plans for all smartwatches.

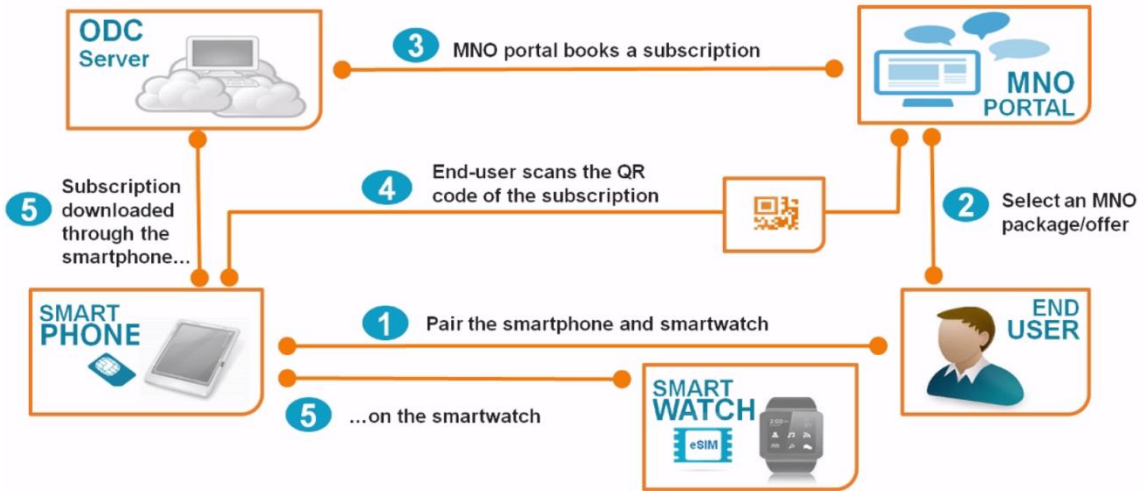
For other devices that use data-only plans, the contract or mobile operator of the primary device may also play no role. In this case, an individual contract for the purpose of provisioning the device can be made. However, the service provider for the primary device may also propose plans which include data-only provisioning for secondary devices.

Provisioning process

The download and the activation for consumer secondary devices may use any of the activation procedures listed in the smartphone (primary contract) case (see chapter 9.2.1). However, as the form factors may not always allow an LPA with a user-friendly user interface, primary devices such as smartphones may be used to provision the operator's profile onto the smartwatch's eUICC.

Figure 9-14 gives an example of the provisioning of a Samsung smartwatch with the help of a companion device (smartphone). First, the smartphone is paired with the smartwatch. Through the operator's sales portal (website or smartphone app) the customer receives the address of the SM-DP+ where he or she can download the profile through the paired smartphone onto the watch. However, depending on the model, the smartwatch may not be reliant on another device and may be able to download the profile directly through any of the four methods discussed in the smartphone case (see chapter 9.2.1) as long as it is connected to the Internet.

Figure 9-14: eSIM profile provisioning of a smartwatch using a companion device



Source: Gemalto. ODC stands for on-demand connectivity, a term used by Gemalto to describe eSIM management entities and device entitlement servers.

For the Apple Watch, the profile of the watch is linked to the profile of the companion device through the device entitlement servers. Through this linkage, the same phone number (MSISDN) can be used to reach either the Apple Watch or the paired iPhone. The provisioning of the eSIM profile is done with the help of the paired iPhone, i.e. the iPhone's user interface is used to follow the provisioning steps set by the operator.

9.2.3.2.2 The operator perspective

Figure 9-15 gives an overview of the Sales and Contract process and the Provisioning process.

Figure 9-15: Customer journey OTA provisioning - Operator perspective

Initial situation: National consumer connects to operator for secondary contract (without number porting)

MNO Perspective (Use Case 2)	
Sales and Contract	**Provisioning**
Three alternative scenarios: **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Let customer add secondary device to existing plan • Get order signed **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Get in contact with customer (Point of sale) • Let customer decide on tarif • Get customer identification and billing information • Get order signed	**Three alternative scenarios:** **1. Add device to existing plan using same MSISDN (mostly smartwatches)** • Allocate MultiSIM Profile to customer through Entiltment Server **2. OR 3. Individual contract with MSISDN (mostly smartwatches) OR individual contract with data-only plan (mostly tablets or laptops)** • Create new customer and implement his/her product characteristics, access/connection; register customer in HSS/HLR • Allocation and control of rights per customer contract and customer terminal(s) • Enabling billing (collection/control of charge relevant data/ traffic flows) • Allocate ICCID and IMSI with mapped MSISDN (profile) (unused in the data only case) • Send Profile to customer

Source: WIK-Consult.

Sales and contract process

Again, depending on the scenario (i.e. secondary device uses same plan as smartphone with same MSISDN or individual plan), the operator either gives the customer the option to add the secondary device to the existing contract or provides an individual contract for the secondary device.

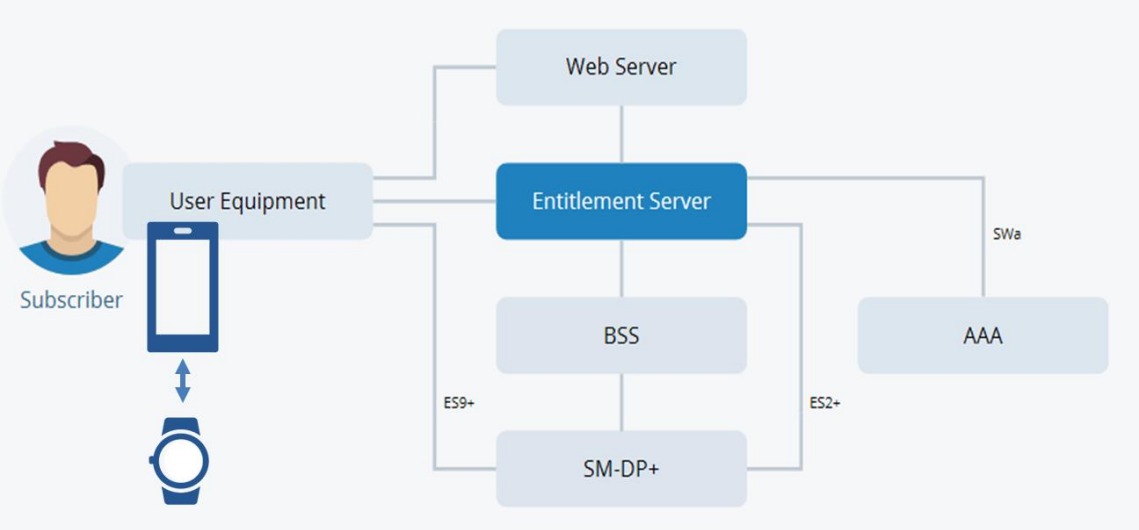
Where an individual contract is made, the operator needs to capture the customer's identification, billing information and a signature for the contract.

Provisioning process

Where the device (smartwatch) is added to an existing plan using the same MSISDN as the primary device, Figure 9-16 provides a high-level architecture of the remote provisioning process from the operator's perspective. The entitlement server has a direct connection with the customers equipment (smartwatch paired with smartphone). Other network components of the operator are connected with the entitlement server.

The entitlement server authenticates the device, checks whether they are allowed to use the service, and facilitates the download of eSIMs to the secondary devices.[229]

Figure 9-16: Remote Provisioning Smartwatch



Source: https://elitnet.eu/wp-content/uploads/2021/04/ELITNET-Entitlement-Server.pdf; BSS – Business support system, AAA – Authentication, Authorisation and Accounting servers.

Apple, for example, requires operators supporting the Apple Watch to buy or develop such an entitlement server with certain specifications that acts as a gateway between the eUICC on the Apple Watch and the SM-DP+ server of the operator. Although a companion device is still needed for the communication between the entitlement server and the Apple Watch, the operator's profile is delivered from the SM-DP+ to the Apple Watch.

Where a new contract is made, the provisioning process is equivalent to the consumer smartphone case (see chapter 9.2 but without the separate MNP process. The provisioning process affects all network elements which are used by the customer product or service, up to the Business Support System (BSS) for contract management and billing. Also, similarly to the consumer smartphone case, the operator needs to allocate an ICCID and IMSI to the customer to enable them to connect to the mobile network. This can be completed within seconds and is fully automated and digital. First, on creating a new account for the customer in the operator's systems, the eSIM profile needs to be created and allocated on the operators SM-DP+, which is integrated in the backend system. The SM-DP+ server address and activation code is remotely provisioned (OTA) to the customer, and he or she downloads and installs the new profile (see chapter 9.2.1.2 for the different methods). When the activation of the profile is completed on the customer's side, the remote SIM provisioning process is complete.

229 https://elitnet.eu/wp-content/uploads/2021/04/ELITNET-Entitlement-Server.pdf.

9.2.4 Existing and future problems

9.2.4.1 The customer Perspective

eSIM-based cellular functionality for smartwatches is supported by very few operators. Thus, when consumers want to use their existing MSISDN for their smartwatch, they are limited in their choice. They can only select from a limited number of mobile operators. Importantly, this also affects their primary subscription.

Depending on the smartwatch, the manufacturer also dictates the devices that can be paired with them. For example, an Apple Watch user needs to have an iPhone as well, effectively limiting the consumer in their choice of smartphone.

In cases where an individual contract is made for the secondary device, the consumer is even more limited in the choice of operators, as it needs to locate an operator which supports the provisioning of a smartwatch without also provisioning the primary device.[230] However, if such an operator is available to the consumer, the primary contract (for his or her smartphone) is not affected by the contract of the secondary device.

Lastly, for individual, data-only plans, which are most common for tablets or laptops, the primary subscription would not be affected. Furthermore, the consumer also has the largest choice of operators in this scenario as many operators that support eSIM also support data-only contracts and therefore provisioning of these devices.

9.2.4.2 The operator Perspective

For operators, an extensive infrastructure is needed to support cellular connectivity, at least for most smartwatches. With low demand on the consumer side, there is no business case for many operators to support them, which leaves the entire market for the few operators which do support them.

With increasing penetration rates of smartwatches, it seems likely that more and more operators may invest in the relevant infrastructure. However, with an increasing number of different device manufacturers and models, this is likely to entail an ever-increasing demand for entitlement servers that are specifically configured to the secondary device.

9.2.5 Secondary contracts (national and international)

eSIM enables quick provisioning, activation and switching and has the capability of storing multiple operators' profiles on the eUICC. Furthermore, the eSIM allows for a fully digitalized customer journey, which in turn makes switching between operators

230 As mentioned, Apple's "Family Setup" function where an individual MSISDN can be used on the smartwatch is supported by fewer operators who support the Apple Watch in the first place.

easier and also enables customers to download profiles from operators around the globe.

Currently, many travelers turn off mobile data and rely on Wi-Fi networks at the destination or buy local SIMs in order to avoid international roaming charges. If the traveler decides to buy a local pre-paid SIM card (i.e. traditional removable card), they may be concerned about losing their home-country SIM card when switching with the local one. The quick and potentially fully digital activation enables travelers to subscribe to local operators more easily. As the eSIM profile can be downloaded from anywhere in the world, the traveler can already purchase the eSIM profile of an operator in the destination country in advance before travelling.

Most eSIM-enabled smartphones shipped today still have a physical SIM card tray, the eSIM acts as an additional SIM, making the smartphone essentially a dual SIM phone. The traditional, physical SIM card may be used as the home-country SIM and the eSIM can download a subscription profile from a local operator when travelling. This allows the traveler to avoid international roaming charges and benefit from local data rates while still being contactable on their primary home-country subscription.

In addition to smartphones, laptops and tablets can be provisioned with local mobile connectivity as well, which is especially relevant for business trips. The potentially fully digitised journey allows companies to remotely download a new profile onto employees' devices before an international trip. For this, the device only needs to be turned on and connected to the Internet and the devices are controlled by the company's IT infrastructure.

9.2.5.1 Requirements for remote provisioning and switching

9.2.5.1.1 The customer perspective

The remote provisioning process works from anywhere in the world as the customer connects to the eSIM management entities through the Internet. Hence, for the international and secondary contract use case, the technical, legal, and commercial requirements are the same as in the national consumer case (see chapter 9.2).

However, because the customer is acquiring a secondary contract, number porting is not relevant as the consumer is not switching from one provider to another but adding a subscription plan to an existing one. Also, personal phone numbers are subject to the home country of the customer and can therefore not be ported to an international number. Therefore, MNP is neither necessary nor possible.

The need to provide identification upon subscribing is subject to the rules of the country to which the customer is traveling.

9.2.5.1.2 The operator perspective

Technical, legal, and commercial requirements are similar to the national consumer case (see chapter 9.2.1.2.2). Again, most importantly, the local operator of the country the customer is traveling to needs to have access to an SM-DP+ entity. If needed, the operator must have the means to check the identification of the consumer online. Regarding commercial requirements, again, the operator needs to have an online retail outlet.

9.2.5.2 Customer journey for OTA provisioning

9.2.5.2.1 The customer perspective

An overview of the Sales and Contract process and the Provisioning process is given in Figure 9-17

Figure 9-17: Customer journey OTA provisioning - Customer perspective

Initial situation: National consumer connects to *"foreign"* operator for secondary contract (without number porting)

Customer Perspective (Use Case 3)	
Sales and Contract	**Provisioning**
• Find new provider and tariff (can be on same platform from which the international trip is booked) • Signs new contract, provides identification and bank information	• Customer receives "*foreign*" ICCID and IMSI ("*foreign*" MSISDN is mapped to IMSI in the network) (=Profile is allocated) • If the eSIM is already used for national provisioning, deactivate previous Profile (national operator) • Activate new Profile ("*foreign*" operator)

Source: WIK-Consult.

Sales and contract process

Airlines and hotel booking websites are already testing features where customers are asked whether they want to download a local SIM profile for the country and duration of the stay upon booking international trips, similar to car rental offerings. This feature could also be implemented by simply directing the customer to the operator's website or app upon request.

Operators could also advertise a local tourist subscription in flight magazines or on in-flight entertainment. Travelers could download, the local provider's app using the aircraft's Wi-Fi and sign a subscription during the flight.

Provisioning process

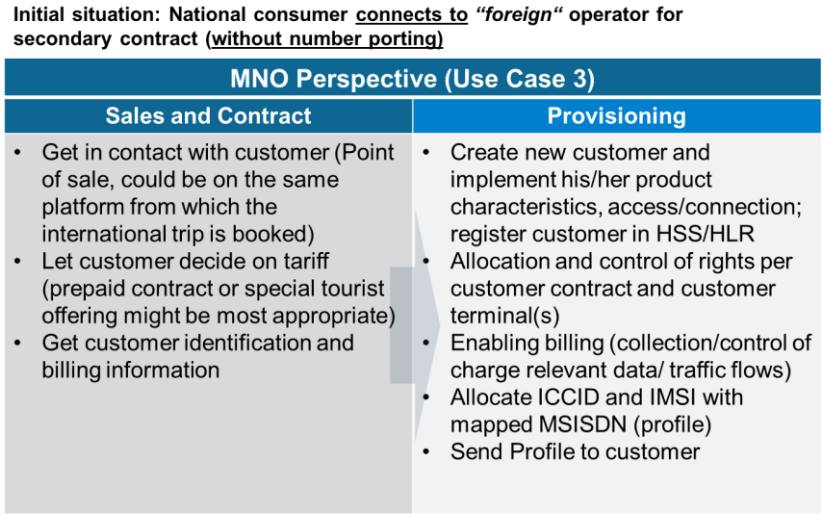
The remote provisioning process, i.e. the download of the profile, can be made using any of the methods introduced in the national consumer case (see chapter 9.2). If the customer already uses the smartphone's eSIM for his or her primary, national subscription, the existing contract will need to be deactivated before the new profile can be activated. However, as both profiles can be stored on the same device, the customer can still switch between them in a matter of seconds.[231]

The *"foreign"* profile can be downloaded and activated from anywhere in the world. However, the customer might only want to use it in the provider's country to avoid roaming charges.

9.2.5.2.2 The operator perspective

An overview of the Sales and Contract process and the Provisioning process is given in Figure 9-18.

Figure 9-18: Customer journey OTA provisioning - Operator perspective



Source: WIK-Consult.

Sales and contract process

For the travel use case, local operators should make it as easy as possible for the traveler to be made aware of the service, find an appropriate tariff, and complete the

231 Although it might depend on the device, switching between profiles on an eSIM can be done in a matter of seconds without having to restart the device, similar to the physical process of changing SIM cards.

contract process. If done successfully, the traveler might substitute local Wi-Fi with mobile connectivity, generating additional revenue for the local operator.

Provisioning process

The provisioning process is exactly the same as in the national, primary contract use case (see chapter), except that the MNP process is not necessary. For the delivery of the SM-DP+ address, it might also not be practical to deliver a physical QR-voucher to the customer's premise.

9.2.6 Existing and future problems

9.2.6.1 The customer Perspective

In addition to the existing and future problems already presented for the national, primary contract use case (see chapter 9.2.1 which also apply here, customers may need to be careful on the usage of foreign mobile phone contracts as they do not fall under the jurisdiction of the home country's regulatory authority and consumer protection agencies. Once more, as using local providers of the traveler's destination country can help reduce foreign roaming fees, using these same providers outside the intended country might in turn result in foreign roaming fees. That is why activation or at least the usage of the second, foreign provider should preferably be completed only in the intended country.

9.2.6.2 The operator Perspective

The existing and future problems from the national, primary contract use case (see chapter 9.2.2.2) also apply here.

9.3 The M2M use case

"Machine-to-Machine Communication" (M2M) can be defined as data communication between devices or systems in which human intervention plays at most a limited role. The term "Internet of Things" (IoT) is often used interchangeably.[232] In the context of this study, we refer as M2M to everything which is covered within the GSMA M2M eSIM specification. The few exceptions are applications where the consumer specification is used, but clearly as a workaround to connect devices that are limited by the M2M specification.

232 A more detailed discussion on the definition of M2M and IoT can be found in BEREC (2016): BEREC Report on Enabling the Internet of Things, BoR (16) 39, available at: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/5755-berec-report-on-enabling-the-internet-of-things.

9.3.1 Who is the customer and the provider in the context of M2M?

To better understand the processes of OTA provisioning and switching in M2M, it is helpful to define some of the terms.

The M2M value chain

The market players that play a role within the M2M value chain in M2M can be segmented into four categories[233]:

- Connectivity providers: Provider of M2M communication services, most likely an MNO or MVNO.
- Solution provider: Provider of services to facilitate M2M, e.g. through provision of an M2M/device management platform or by helping connectivity providers and customers to facilitate switching.
- M2M customer: The company closing the contracts for connectivity for M2M devices (e.g. a utility implementing smart meters; a car manufacturer)
- End-user: The user at the end of the value chain that utilizes the devices in a B2B2C business model (e.g. owner of a connected car).

In the following sections, the focus is on connectivity providers and M2M customers, however the role of solution providers and end users is also discussed.

The customer in M2M

One distinction in the M2M space that can lead to a different customer journey is the category under which the customer falls under. Generally, two kinds of companies can be the customer in M2M:

c) M2M users

The customer can be a company buying devices and entering connectivity contracts separately with an operator of their choice. This would typically be the case for a utility company implementing smart meters but also for logistics companies that use devices to track goods. In practice it can still be beneficial to establish a connection between the connectivity provider and the device manufacturer, so that the initial (bootstrap) profile can be loaded onto the device during manufacturing.

d) Device manufacturers

It can also be possible for device manufacturers to make contracts with connectivity providers themselves and then sell the devices including connectivity to third parties or end users. This happens in the automotive space with connected cars, where the

233 This description is based on the one in BEREC (2016) but amended to discuss it with the background of over-the-air provisioning, switching and eSIM.

manufacturer of the car chooses a connectivity provider and has the connectivity included when selling the product to end users. Trackers for personal belongings (e.g. vehicles, pets) can be sold in a similar fashion. Here, the device manufacturer often works together with an operator and sells the device including connectivity.

Difference between national and international Use Case

The main difference between national and international M2M devices is, that a national device operates at a fixed location in one country, while an international device is shipped globally and is not only used at a fixed location but in a manner, which is moveable or mobile and potentially cross-border. Because of this, the connectivity provider in the international use case is more likely to be non-domestic and active in different markets.

9.3.2 National implementation

A national M2M use case relies on devices that are typically and mostly used at a fixed location within one country. Because of this, roaming does not play a role and the connectivity is more likely to be provided by a local operator. One application gaining traction in recent years, including eSIM use in Ireland, is smart metering. Here, a smart electricity meter is installed at a premise (private home, business, public institution) and stays active there for up to 40 years. An electricity (network) company is normally active within a country and can therefore potentially serve all customers through one contract with one domestic network provider.

Another potential application of eSIM and OTA in M2M in a national context is the smart factory. While currently often local fixed connectivity or Wi-Fi is used to connect machines to the network, increasingly applications will use SIM-based cellular technology in the future taking advantages of the capabilities e.g. of 5G networks.

9.3.2.1 Requirements for seamless profile provisioning and switching

9.3.2.1.1 The customer perspective

Technical

The first and foremost requirement to implement over-the-air provisioning of SIM profiles and switching capabilities is that the devices used must have a GSMA-specified eSIM/eUICC soldered into them. Furthermore, there must be a bootstrap profile implemented onto the device before it is put in the field as there has to be some kind of initial connectivity to download the live profile.

Additionally, especially for switching, the customer must make sure that a device/eSIM management software is used that would support switching SIM profiles in bulk and on a large scale.

Legal

As some technical interconnection between the previous and the new operator is often necessary (further details are provided in the connectivity provider perspective), it is important that there is a legal requirement for the old operator to accommodate the profile switch.

There is also the potential problem of legal liabilities. In some, very sensitive applications, such as health monitoring devices, a switch that comes with a downtime of several hours or even days may not be acceptable as the customer may become liable for any damages (e.g. unrecognized health problems).

Commercial

From a commercial point of view, a switch only makes sense if the contract lifetime of the devices is shorter than the lifetime of the technical devices themselves.[234] Where this condition is not met, switching is not necessary and feasible.

It is better for the customer, if the contract with the initial provider already acknowledges that a switch may happen in the future and that the provider must help in arranging it. This can and should include any potential fees that may occur when the customer wants to switch. Such fees should also not be so high as to deter switching.

9.3.2.1.2 The connectivity provider perspective

Technical

There must be the possibility to either have the profile enabled on the eSIM during manufacturing or to download it immediately when activating the device through a bootstrap profile. For over-the-air provisioning of eSIM profiles, it is likely to be necessary to push them through SMS. Because of this, SMS functionality should be included, which is something that some devices and/or networks do not support (e.g. in NB-IoT).

In practice, the backend systems of the operator also need to support a push of profiles on devices in bulk, potentially for thousands of devices at the same time or in a narrow time frame. The profile identifiers then need to be mapped to devices in the device management software without any mistakes.

234 Depending on the device, this could also be limited by the battery lifetime.

Legal

Numbering issues can be especially relevant in the case of M2M. Specifically, it should be possible to use numbers (especially IMSI) extraterritorially or to use international numbers assigned by the ITU.

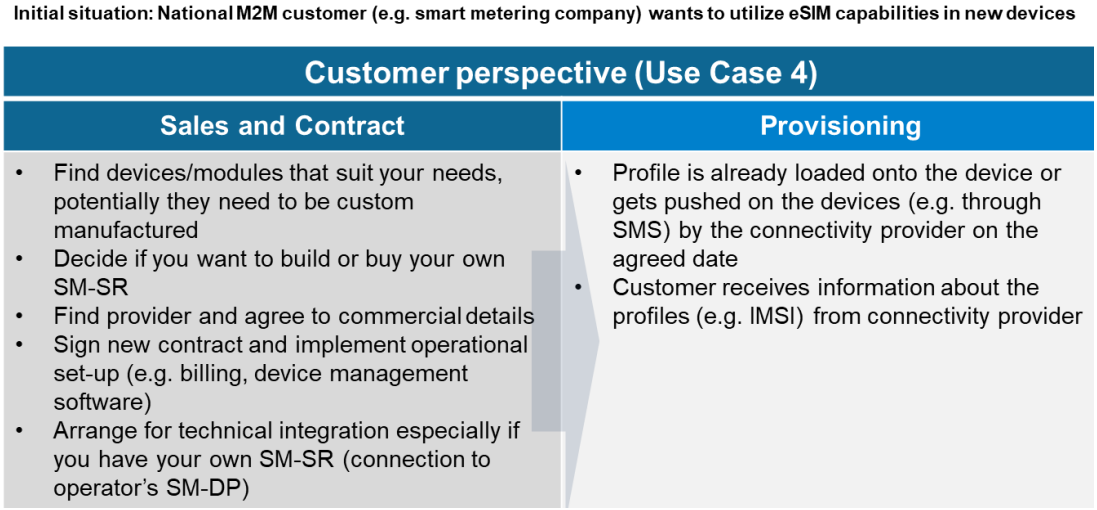
Commercial

One major commercial hurdle could be that the former operator of the customer does not support switching as well as it should. As a new technology with new possibilities, eSIM also imposes risks on the contractual side of the business. Several things such as potential fees from the customer to the operator when switching, fees to be paid to the provider of the technical infrastructure or contract lengths need to be settled in a way that it is beneficial for both parties. However, this additional effort may lead to smaller projects not being realized through eSIM with switching in mind if the hassle is more significant than the benefits.

9.3.2.2 Provisioning of SIM profiles

9.3.2.2.1 The customer perspective

Figure 9-19: Customer perspective on initial profile provisioning



Source: WIK-Consult.

At a first glance, the customer's commercial perspective is comparable to the customer journey in the consumer smartphone use case but with more involvement on the technical side. The customer finds a provider that serves the connectivity needed to utilize the devices the customer wants to implement.[235] the first the commercial details are arranged, and then the technical details. This includes arranging how the eSIM, profiles and devices should be managed and how billing should work.

The customer must also decide on the implementation of server infrastructure as described in section 3.3 (technical overview). The main point of differentiation is the SM-SR. While the SM-DP sits with the connectivity provider[236], the SM-SR can be handled by different entities. While it can be managed by the connectivity provider, it is also possible for the customer to build their own SM-SR or have it built by a third party (e.g. a SIM vendor/eSIM management company). The management can then be performed by the customer or by that third party on behalf of the customer. If the SM-SR is managed by the customer, a connection between the SM-DP of the provider and the SM-SR needs to be established when setting up the eSIM processes.

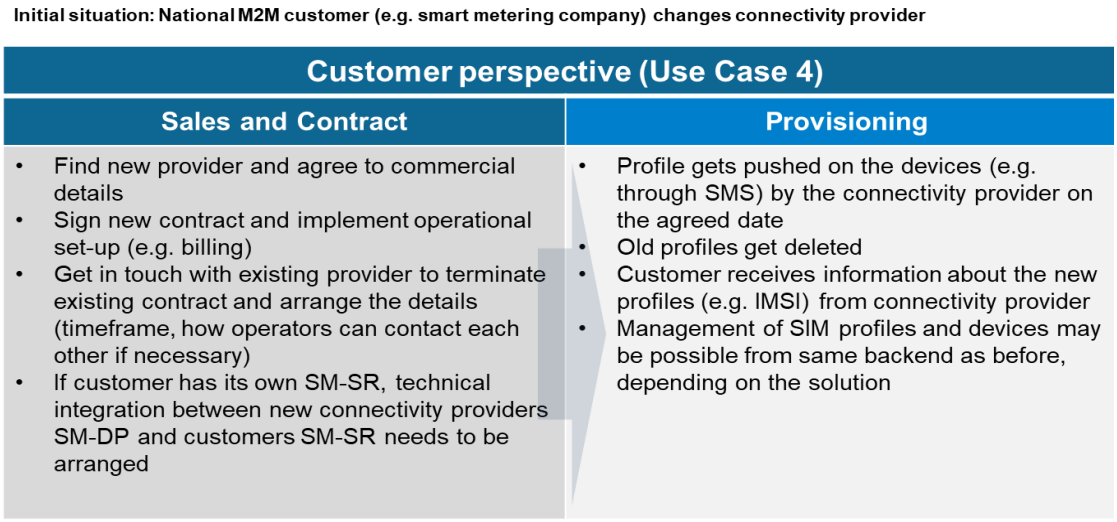
The initial profiles are loaded onto the eSIMs in a proprietary way, i.e. not specified by the GSMA. The most convenient way is to do so during the manufacturing process so that over-the-air provisioning of a new profile is possible but not necessary. For this to happen, the device manufacturer either has to be the customer in itself and close a deal with the connectivity provider or the M2M customer would need to arrange for the connectivity provider to send the profile data to the device manufacturer. If the profiles are not loaded onto the eSIMs during manufacturing, they would need a bootstrap profile by the manufacturer that connects to a network in order then to be able to arrange for the live profile to be pushed onto the device.

235 It is also possible that the device manufacturer itself is the customer and works together with the connectivity provider during product development to cater the connectivity to the specific needs. This is especially relevant for connected cars in the international use case.

236 An alliance-managed SM-DP that is used by several operators is theoretically also possible as described in section 3.3.2.

Specifics to switching providers

Figure 9-20: Customer perspective on profile switching



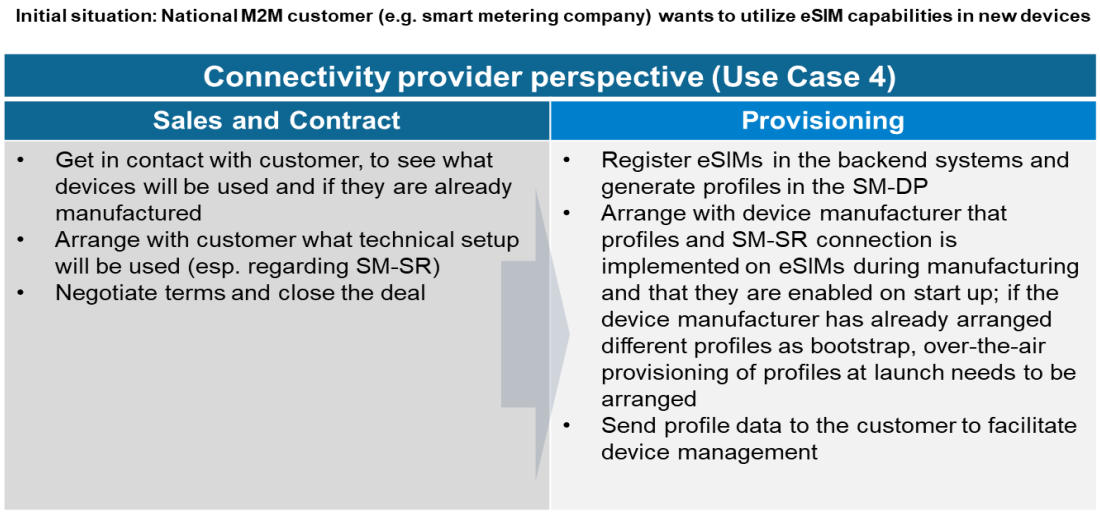
Source: WIK-Consult.

When the process is used to switch connectivity providers there must be some form of communication and cooperation between the old provider and the new one. This is a process that may need to be overseen by the customer to ensure that everything works to their benefit. If the customer has its own SM-SR, there needs to be a connection between the SM-SR and the SM-DP of the new operator and potentially a disconnect from the previous operators' SM-DP.

There will be a push of the profiles onto the devices at the agreed date (e.g. through SMS). The old profile is then typically deleted from the device. The customer also will also receive the profile data from the new operator, or this profile will be loaded in the backend automatically so that the devices can now be identified through their new identifier (e.g. IMSI of the new operator instead of the old one). Depending on the technical infrastructure of the operators, it may be possible for the customer to keep using the old backend to manage devices and SIM profiles. This is heavily dependent on which software is used and/or supported by the operators.

9.3.2.2.2 The connectivity provider perspective

Figure 9-21: Connectivity provider perspective on initial profile provisioning



Source: WIK-Consult.

First, a deal is struck with the customer to establish connectivity for the devices the user wants to connect to a cellular network. During the commercial negotiation phase, technical details also need to be agreed upon. The initial (bootstrap) profile, which can, especially in the national use case, also be the profile that is used in the live setup, is installed on the eSIM chipsets directly and then inserted into the devices in the manufacturing stage. If this cannot happen, devices are delivered with a bootstrap profile arranged by the device manufacturer and the live profile is then pushed onto the eSIMs upon device activation. At this stage, the connectivity provider also receives information about the eSIMs that are used (e.g. eUICC ID).

The provisioning process itself depends on the technical infrastructure used. The operator has access to the SM-DP that generates the profiles and downloads them onto the eSIMs.[237] The SM-SR is either in the sphere of influence of the operator or managed by the customer (or a SIM management company the customer commissioned to do so). If the SM-SR is managed by the customer, it needs to be connected to the SM-DP of the operator. Through the SM-SR, the profiles are then provisioned over-the-air to the devices.[238]

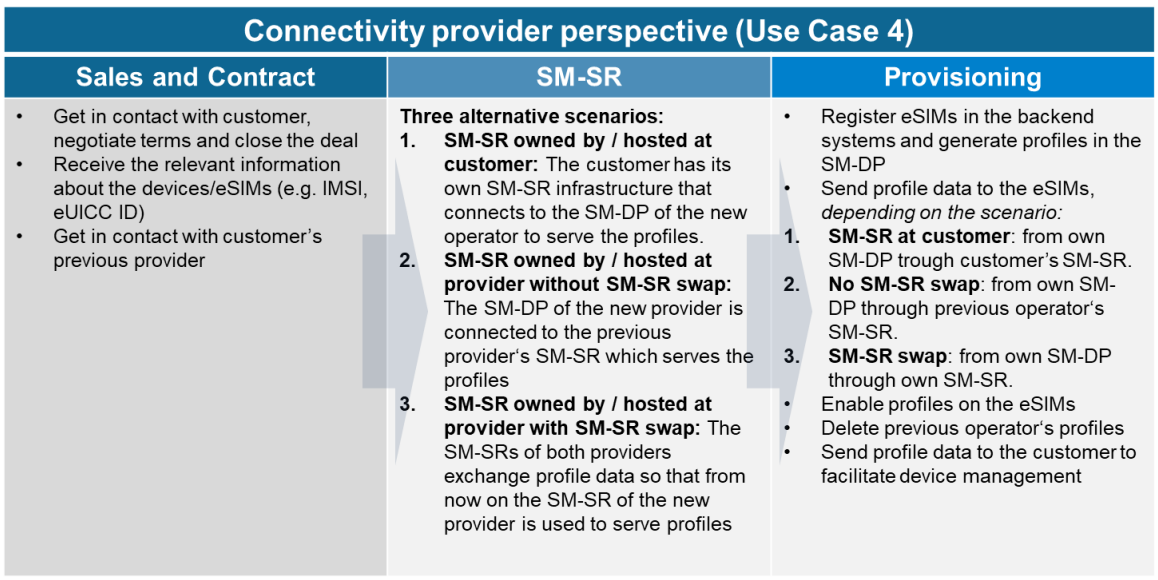
After that, the devices and their eSIMs must be registered in the customer interface so that it is possible for the customer to manage them.

237 As described in section 3.4.2, the SM-DP can also be managed by an entity within an alliance of operators. But even then, the operator and not the customer is the one managing the behavior of the SM-DP.

238 This is only necessary, if the initial profiles that are put on the devices during manufacturing are only used as bootstrap.

Specifics to switching providers

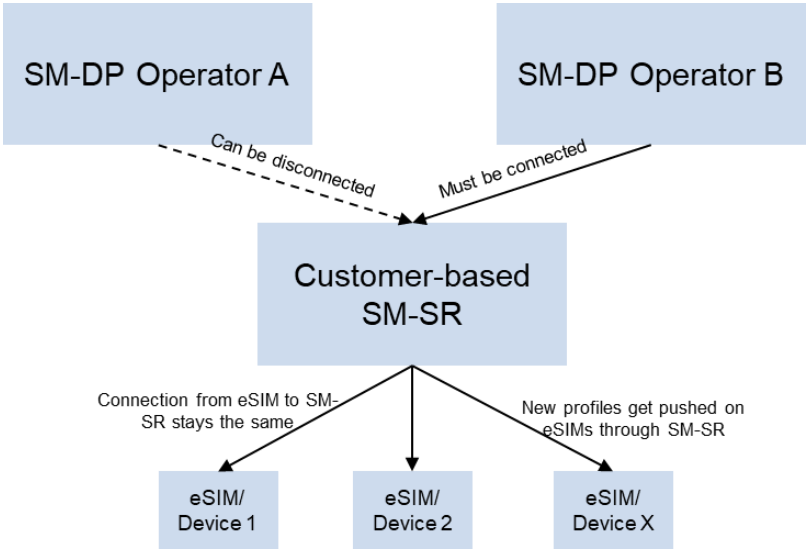
Figure 9-22: Connectivity provider perspective on profile switching



Source: WIK-Consult.

If the customer already has an existing setup and there is a provider switch, there needs to be some form of technical interconnection between the customer's or the previous operator's systems and the new operator's systems. There are three possible models as to how the network infrastructure can be set up to enable a switch from operator A to operator B:

Figure 9-23: Switch of operators with SM-SR at customer

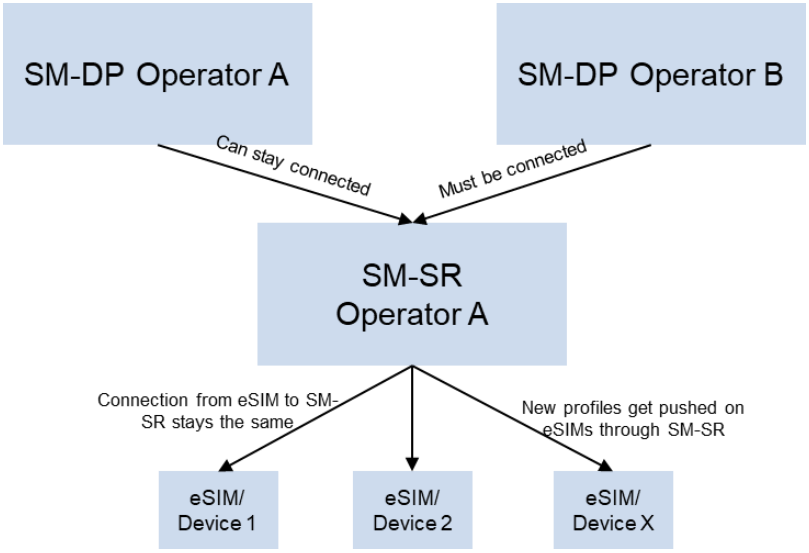


Source: WIK-Consult based on GSMA specification and interviews.

If the customer has control over the SM-SR, the connection needs to be made to the SM-DP of the new operator (here operator B) to complete the switch of profiles on the eSIMs/devices. The connection to the old operator's SM-DP should then stay in place until all eSIMs are migrated to new profiles. After that, the SM-DP of operator A and the SM-SR can be disconnected from each other.

In practice, this is only used if the customer is a company with a lot of IT expertise or if they have devices of high value and in high numbers so that it makes sense to control as much of the infrastructure as possible. Even if this model is chosen, customers may outsource their SM-SR to a third party (e.g. SIM management company). In the current stage of market maturity, this is mainly done for some car/automotive companies i.e. the international M2M use case. In future, with more standardized processes, this may also be feasible for companies with many but less costly devices, e.g. smart meters, or a multitude of tracking devices.

Figure 9-24: Switch of operators with SM-SR at operator but without SM-SR swap



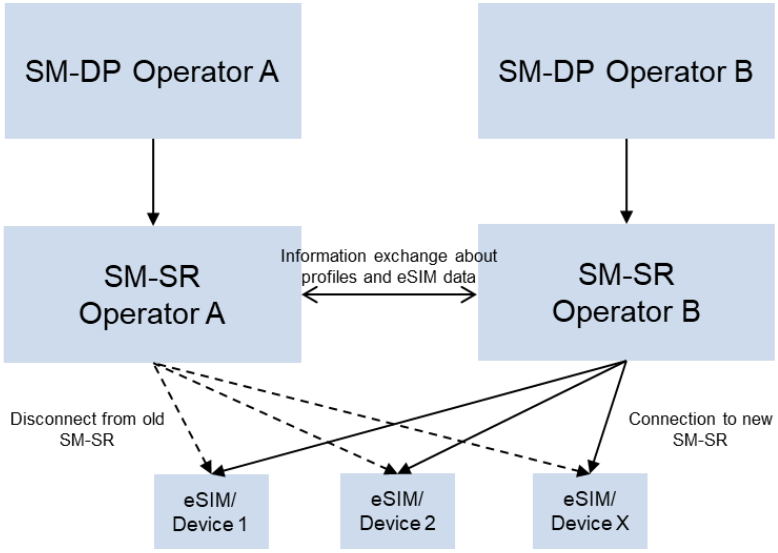
Source: WIK-Consult based on GSMA specification and interviews.

In this case, the previous operator (operator A) still handles the SM-SR, even though the connectivity is now provided through a new operator (operator B). Here, the SM-DP of the new provider needs to be connected to the SM-SR of the previous provider to serve the profiles through this SM-SR. The SM-DP of operator A will likely stay connected to the SM-SR as they both belong to the same operator.

In practice, this will be used only in rare cases. It will likely result in a residual fee still being paid to the old connectivity provider to use their infrastructure and is therefore not only costly but also carries the need for the customer to handle two operator relationships at once.

The setup of different owner-operators of the network infrastructure elements may however be feasible if the customer wants to use one connectivity provider first and foremost but closes deals in some jurisdictions with other providers. Their SM-DP will need to be connected to the SM-SR of the main operator.

Figure 9-25: Switch of operators with SM-SR at operator(s) and with SM-SR swap



Source: WIK-Consult based on GSMA specification and interviews.

If the customer does not handle its own SM-SR and wants to cut ties with the old operator completely when switching providers, there is the possibility of an SM-SR swap as specified by the GSMA. To do so, operator A and operator B need to connect their SM-SRs so that data about the eSIMs is exchanged between them. Then the new SM-SR is the sole SM-SR connected to the eSIMs and serves them with the new profile data.

Commercially, it is possible for the previous operator to charge the customer to facilitate the switch. This charge would in this model most likely come as a one-time fee.

9.3.2.3 Role of other players in M2M

As the value chain of an M2M product is less straightforward and unambiguous than in the consumer case, several other market players besides connectivity providers, customers and device manufacturers play a role. Even within the same group of devices, the amount and type of market players can depend upon the way connectivity is implemented.

B2B2C business model

Within this business model the connectivity established for B2B purposes by the M2M customer (e.g. a smart metering company) would also be used for B2C purposes by an end user, which is a customer of the M2M customer. This will be further described in the international M2M use case (section 9.3.4) as the main relevance of this business model is for the connected car.

In smart metering, the owner/inhabitant of the house/business (end user) is involved only in as far as the meter is installed on their premise and the customer is billed according to the readings of this meter. In establishing, maintaining, or using the connectivity there is no involvement of the home/business owner, and the same applies for an operator switch.

Solution providers

A solution provider can provide various services in the M2M value chain. It can arrange for the contracts and technical implementation between customer and connectivity/network provider or handle the technical implementation of eSIM and the set up in the user's systems. Providing the technical implementation allows for it, solution providers may also provide device management software to the customer so that the use of the software of the connectivity provider is not necessary. Furthermore a solution provider may offer consultancy services when dealing with requirements for the technical devices used and for the connectivity.

Another service offering that might be offered by a solution provider or a SIM management company, is the arrangement of a profile switch. A third-party switching provider could arrange for the information exchange and the necessary server interconnection. As such a provider would charge a fee for its services, it makes a switch less commercially feasible but as it smooths out potential technical problems, the switch may become more feasible from a technical point-of-view.

9.3.3 Existing and future problems

9.3.3.1 The customer perspective

The biggest current potential problem for the eSIM in M2M is that adoption is at a relatively low level. Penetration can be limited by devices with long lifetimes (e.g. smart meters) that may be implemented without eSIM and stay installed for twenty or more years.[239] In some applications, there may not even be the possibility for the customer to utilize eSIM because there are no devices that include it.[240]

Another ongoing problem is the relatively high technical effort for the customer in M2M to implement eSIM. Implementing eSIM involves technical infrastructure. Thus the customer either needs to build this infrastructure, which will only be feasible for few companies, or at least assess the available technical options. If needed at a later point, the possibility of an SM-SR swap also needs to be addressed beforehand and potentially tested.

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239 In Ireland, the roll-out of smart meters including an eSIM has already started and is ongoing.

240 One example of this would be tracking sensors requiring very specific measuring technology that is only provided by a small set of niche manufacturers. If those do not offer their sensors including eSIM capabilities, the customer has to use a physical SIM or another technology that the manufacturer offers.

Regarding switching there may be different points that could lead to lock-in effects. First, initial operators can be reluctant to help their customer to switch to another provider. Even if legally obliged, this could still be slowed down by allocating less resources for the technical switching process. There may also be switching costs. If the customer still wants to/needs to use the old operator's SM-SR, an ongoing residual fee may need to be paid to the previous operator. In case of a switch that cuts ties with the old operator but requires technical effort (which most switches will do), there may be a one-time fee that needs to be paid instead of an ongoing residual fee.

Another factor that could lead to lock-in effects as it increases the indirect costs of switching is the provision of device management software and other services around the implementation of the devices. The more services the connectivity provider offers to the customer, the bigger and more expensive the switching project becomes. It is therefore beneficial for the operator to offer a lot of services within the value chain and not let them be delivered through solution providers to deepen the relationship to the customer.

9.3.3.2 The connectivity provider perspective

eSIM can be an expensive alternative to the physical SIM, especially in the early phases of market development (as today), where high implementation and fixed costs have to be allocated to few devices and variable costs are also still high. This currently hinders the implementation of eSIM in cases where the customer does not explicitly request it, even though SIM management companies (typically the traditional SIM vendors that also sell plastic SIM cards) can implement the server infrastructure for the operator.

In the near future there is also an ongoing chicken-and-egg problem. As few devices support eSIM, the operators do not see a need to implement SM-DP and SM-SR capabilities. Because many operators lack these capabilities, many device manufacturers may abstain from implementing the eSIM into their devices. This can only be overcome, if either operators or device manufacturers make the first step or if the customer demands the eSIM because the benefits are so large, that it is worth paying a higher price as an early adopter in the market.

9.3.4 International implementation

In the international M2M use case, devices are used in a mobile fashion and potentially also regularly cross-national borders. Because of this, roaming must be established, and it can be beneficial to use a connectivity provider that has network coverage and/or contracts with network providers all over the world. The most significant use of eSIM and OTA in practice in the international setting is the connected car. Here, eSIM is utilized because of the possibility to manufacture devices locally and ship them worldwide and because of the capability to travel cross-border in a car.

Another potential application that is utilized all over the world is tracking in logistics. Tracking of goods or containers needs to be possible in most, if not all countries. A basic level of connectivity independent of the location is therefore crucial. There may also be the need to implement a) other types of connectivity besides cellular (e.g. LoRaWAN) and/or b) have the possibility to switch profiles in certain locations/ in the case of bad coverage.

The technical processes of SIM profile provisioning and switching are the same between national and international use of M2M. Many details of the customer journey therefore do not differ. The two main differences are the different kinds of devices and associated specific requirements, e.g. related to the connected car and international logistics and potential regulatory/legal issues which stem from the international scope of the service provision.

9.3.4.1 Requirements for seamless profile provisioning and switching

In general, the requirements for both the customer and the connectivity provider side are the same as in the national use case. However, there are some additional requirements that need to be met for the potential of over-the-air provisioning to be fully utilized.

There must be an agreement between the customer and operator regarding the countries in which the devices may be used. To use the devices in a foreign country where the operator does not have its own network, there either has to be a roaming agreement for the SIM profiles used between the operator and a local provider or the possibility to use a different profile for the specific jurisdiction.

9.3.4.2 Provisioning of SIM profiles and switching

The journeys for the customer and the connectivity provider are the same as described in 9.3.2.2.1 and 9.3.2.2.2. It is however more likely that the provisioning model chosen, is one where the profile of the initial provider is not simply loaded onto the eSIM in manufacturing but used solely as a bootstrap profile to initialize connectivity based on the location where the device is first connected to the network.

A business model that plays a bigger role in international implementation of M2M is automatic switching of SIM profiles. The most common implementation of such a business model would be for several profiles with respective IMSIs to be loaded onto the eSIM and to use software to switch them when necessary.

In areas of the world where roaming is not as easy as in Europe this could be at borders where the profile is switched from a local one in country A to a local one in country B when crossing the border from A to B. The same could happen within bigger countries in areas of bad coverage of one network provider, if national roaming is not possible. On the software side it would also make sense to connect these systems to algorithms

or even artificial intelligence systems that recognize that other devices of the customer had bad connectivity at a certain place in the past and perform the switch based on that.

It is less likely but not impossible that such a business model could also include new over-the-air provisioning at country borders and not just a switch of the active profile with a different one that is already downloaded onto the device. This would however require more technical effort without significant benefits.

9.3.4.3 Role of other players in M2M

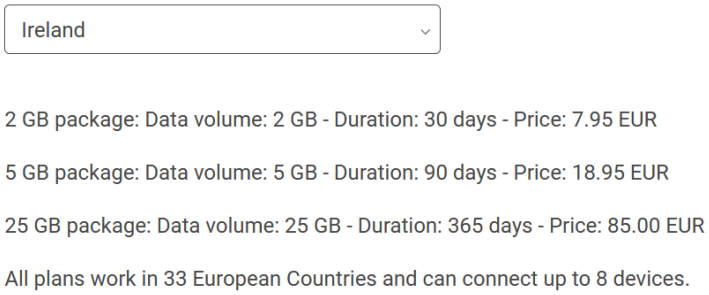
B2B2C business model

The most important application of eSIM in M2M in a business-to-business-to-customer (B2B2C) business model is the connected car. While the eSIM in the car is implemented through the M2M specification and is mainly used for purposes that are not necessarily triggered by the end user, such as software updates, telematics, and map updates, it can often also be used for infotainment or in-car Wi-Fi.[241]

In this case, the customer strikes a deal with the car manufacturer or with the car manufacturer's connectivity provider (potentially with the car manufacturer as an intermediary) to be able to use the eSIM connection for private purposes.

The following figure provides examples of data packages offered by Cubic Telecom for owners of Audi cars in Ireland.

Figure 9-26: Data packages by Cubic Telecom for Audi owners in Ireland



Source: https://audi.cubictelecom.com/en/faq.

This may raise questions of potential lock-in/monopoly effects if the end user can only use one operator for the in-car Wi-Fi and there is no potential for an operator switch at any point. Challenges may also arise in the case of a switch of connectivity provider by the M2M customer (here: car company, which is the device manufacturer at the same

241 While in the past there was sometimes more than one SIM in the car, nowadays all traffic is sent through one SIM, including B2B, B2C and eCall traffic.

time). It is not yet clear how this would affect ongoing in-car Wi-Fi contracts of the owner of the car with the connectivity provider. Currently, according to experts, the in-car Wi-Fi product is rarely used as customers would rather use their phones as an entertainment device or hotspot or use external dongles. The limitations on operator choice when using the in-car system could be a reason for that.

Solution providers

The role of solution providers in international M2M still needs to be fleshed out as the market is still at an early stage. On the one hand, it is possible that they will become important players in helping the customer set up contracts with different connectivity providers in different countries and to build software capabilities that facilitate quick and simple switching of eSIM profiles.[242]

It could also occur, especially where the projects are relatively large in scale and scope, that such functionalities will be delivered by specialized M(V)NOs with their own mobile network capabilities (e.g. own SM-DP and SM-SR servers) that would be classified as the connectivity provider in the categorization of this study. Other business models are also possible that lie somewhere along this classification (i.e. are somewhere between connectivity and solution provider), depending on the level of hardware and software integration a solution provider offers.

9.3.5 Existing and future problems

Besides the problems described in the national use case, in the international use case, roaming and numbering issues are more relevant, although addressing these should be possible in most cases. The connectivity provider must ensure that it communicates to the customer where the profiles can be used, and the customer should pay attention to where they are used. It is for example a valid solution to use profiles with identifiers from one EU country for the whole of the EU and to deal with other regions in a similar fashion when roaming agreements are in place. It is also possible to use a multi-IMSI bootstrap profile so that the initial connectivity used to download the live profile can come from the region where the device is used.

One hurdle does however currently come from local regulation in certain countries. Several countries (e.g. Turkey, Brazil, China) do not allow any data processing outside their borders and/or mandate server infrastructure to be established within the country. As infrastructure parts such as the SM-SR need to be GSMA-certified, it is not necessarily the case that there will be a local provider that can provide these services. In practice this may mean that for these countries a backup system using physical SIM cards must be put in place.

242 Those eSIM profiles would likely be downloaded already onto the devices, i.e. it is less likely that a separate over-the-air provisioning process would happen every time a profile is switched. The software capabilities can be thought of as either applications on the devices to enable switching or as backend functionalities to trigger such a switch.

10 eSIM forecast methodology

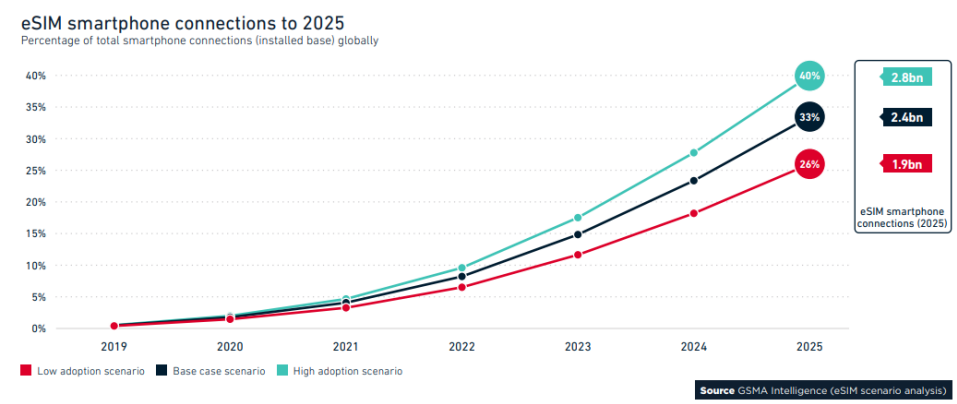
10.1 Sources: Overview on eSIM studies

Studies about the future of eSIM are available from different analysts and market players. Most of them refer to the global market and most detailed studies are not publicly available – at least not in their full version. The methodological approach of these studies seems to vary, but the details of the methodologies are not always provided in detail.

Key data and messages from a selection of available studies are summarized in Table 10-1. We focus on studies published in 2020/21, as these reflect the latest market developments. We consider not only studies about eSIM, but also about the wider IoT market, as well as studies concerning mobile markets.

Moreover, we discussed future expectations regarding eSIM in our interviews with operators and equipment manufacturers. While most interviewees agree on the major development trends, there are significant differences in their expectations regarding details concerning the extent and timing of eSIM penetration (e.g. by when the eSIM will replace traditional SIM).

Table 10-1: Overview on relevant studies about the eSIM market (published in 2020/2021)

Study	Main findings
eSIM development	
GSMA (2021)[243]	*Focus: eSIM in the consumer segment (smartphones, smartwatches, tablets, Laptops, and other consumer devices), Time period: 2020- 2025, Global market* ▪ In 2020, growth is accelerating with regard to shipments and activation ▪ eSIM devices: number of eSIM devices reached 110 models by the end of 2020 (Samsung and Huawei launched eSIM 18 months after Apple). Apple has launched the highest number of eSIM models (25 in total). Since 2018, all new smartphone models launched by Apple and Google have eSIM capability. ▪ eSIM services are commercially available in 69 countries at the end of 2020 and were operated by 175 mobile service providers (41% are in Europe, 25% in Asia-Pacific). ▪ Smartwatches: In 2020, 27 eSIM smartwatch models are available. Apple has about 40% share in smartwatch shipments. Installed base worldwide: 200 million in 2020, 342 million in 2025. ▪ eSIM for laptops (Mobile Plans app in Windows 10): In 2020, 23 eSIM laptop models are commercially available, produced by the top three vendors Lenovo, HP and Dell, a limited number of service providers support data plans for laptops, activation has been low so far. ▪ Slow progress with regard to other eSIM consumer devices such as bikes, GPS trackers etc. ▪ Consumer awareness of eSIM is still low. ▪ Forecast: 2.4 billion eSIM smartphone connections globally by 2025 (33% of total smartphone connections) with 1.9 billion (26% share in total SIM) and 2.8 billion (40% share in total SIM) as low and high adoption scenarios. ▪ eSIM smartphone adoption until 2025 will see early leading markets where all MNOs and Most MVNOs provide commercial eSIM services and where Apple, Samsung and Huawei have more than 70% share in smartphone users. ▪ Potential of eSIM to drive eSIM adoption in the coming years include (among others) raise in consumer awareness, promotion of eSIM benefits, fully digital eSIM models. 

243 See GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021.

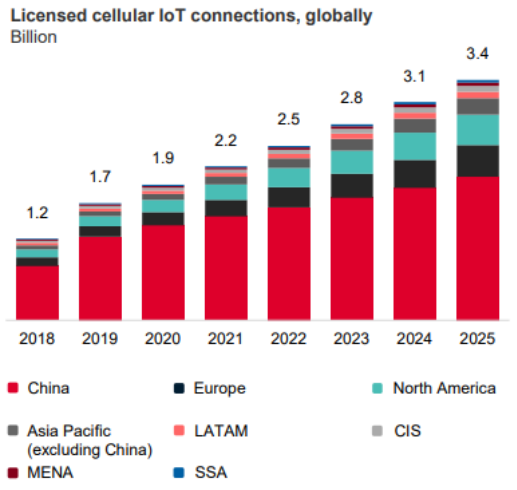
Study	Main findings
eSIM development	
Trusted Connectivity Alliance (TCA) (2021)[244]	*Focus: eSIM shipments, profile transactions, Year: 2020, Global market* ▪ Significant global eSIM growth in 2020 ▪ eSIM shipments collectively reported by TCA members increased by 83% on-year to reach 309 million units in 2020. ▪ SIM profile transactions (i.e. number of times a mobile network operator (MNO) profile was downloaded to a device) increased by over 300% within 2020. ▪ Number of eSIM Subscription Manager (SM) platforms deployed globally increased from 270 in 2019 to 687 in 2020.
Truphone (2021)[245]	*Focus: Operator survey among MNOs and device manufacturers, Time period: 2020-2025, Global market* ▪ Share of MNO and device manufacturers with eSIM: 67% of MNOs offer eSIM, 48.7% of device manufacturers (consumer, M2M) use eSIM. ▪ Plans until 2025: 89.8% MNOs plan to offer eSIM by 2025. 82,1% of manufacturers will use eSIM. ▪ eSIM use cases: Smartphones and smartwatches are the leading use cases, followed by automotive and smart meters.
Counterpoint Research (2021)[246]	*Focus: device shipment, Time period: 2021-2025, Global market* ▪ Smartphones will account for almost 50% of eSIM capable device shipments by 2025. ▪ eSIM devices CAGR of around 290% (2021-2025). ▪ eSIM capable PCs and B2B IoT devices to exhibit CAGRs of 75% and 40% respectively over the next five years ▪ eSIM will penetrate nearly 100% of the cellular connected smartwatches and vehicles by 2025
Abi Research (2020)[247]	*Focus: smartphone shipments, Time period: 2020-2024, Global market* ▪ In 2020, eSIM smartphone shipments will hit over the 225 million mark ▪ Forecast 2024: Based on a continuation of eSIM support from Apple, Google, and Samsung, plus the eSIM expansion by Samsung into other device ranges and several other OEMs launching flagship eSIM enabled devices, at least 500 million eSIM capable smartphones to ship globally in 2024.

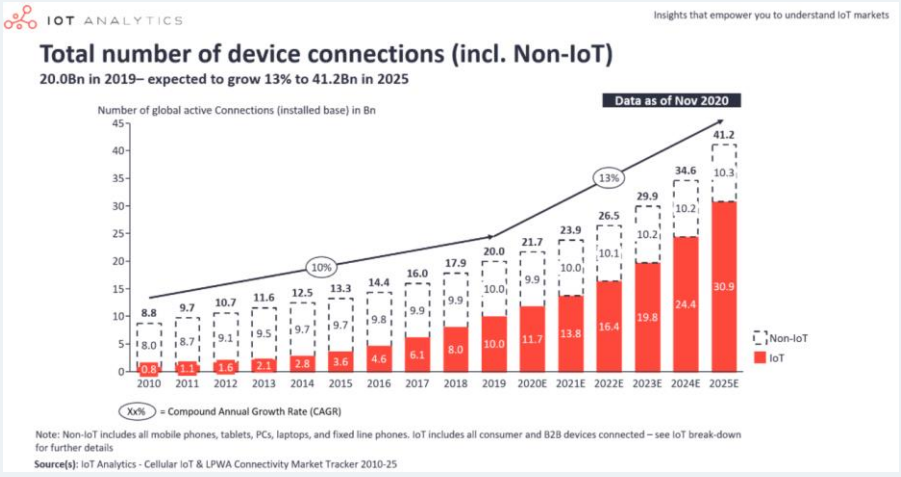
244 See Trusted Connectivity Alliance (TCA) (2021): Trusted Connectivity Alliance Reports Global eSIM Growth in 2020, March 3, 2021, https://trustedconnectivityalliance.org/trusted-connectivity-alliance-reports-global-esim-growth-in-2020/.

245 See Truphone (2021): How eSIM is transforming connectivity for consumers and enterprises,

246 See Counterpoint Research (2021): Smartphones to Capture Nearly Half of eSIM Device Shipments by 2025, https://www.counterpointresearch.com/esim-based-device-shipments-2025/.

247 See Abi Research (2020): Over 225 million eSIM Enabled Smartphones to be Delivered in 2020, boosted by Samsung's S20 Devices, press release, 04 March 2020, https://www.abiresearch.com/press/over-225-million-esim-enabled-smartphones-to-be-delivered-in-2020-boosted-by-samsungs-s20-devices/.

Study	Main findings
eSIM development	
GSMA (2020)	*Focus: consumer and IoT, Time period: 2020-2025, Global market* ▪ Mainstream adoption will take time – eSIM should appeal to consumers, but adoption at scale will take two to three years. ▪ Forecast: 2.5 billion eSIM smartphone connections globally by 2025 (35% of total smartphone connections), with 2 billion and 3 billion as low and high adoption scenarios respectively. Europe and the US lead in the early days of eSIM adoption, but China will be the largest market by 2025. ▪ 68% of operators offering eSIM service for smartphones by 2021. ▪ eSIM smartphones are expensive, address the high-end consumer segment. 850 GPB average price of eSIM smartphones ▪ IoT: ▪ Overall, eSIM is considered important: IoT Enterprise survey found that only 2% of respondents are not familiar with eSIM. Automotive is the leading vertical, next important is utilities. ▪ Cellular networks currently serve 15% of total IoT connections. . The number of licensed cellular IoT connections – including cellular M2M and licensed LPWA – will nearly double between 2020 and 2025, reaching 3.4 billion connections 

Study	Main findings
IoT development	
Ericsson (2020)[248]	*Focus: cellular IoT, Time period: 2020-2026, Global market* ▪ In 2020, 1.7 billion IoT connections are cellular IoT. ▪ For 2026, 6.3 billion cellular IoT connections are expected (CAGR 2020-2026: 22%) ▪ NB-IoT and Cat-M as massive IoT technologies are the major driver for cellular IoT ▪ In 2020, about 110 service providers have launched NB-IoT and close to 50 have launched Cat-M. ▪ In 2026, NB-IoT and Cat-M technologies are expected to make up 45 percent of all cellular IoT connections.
IoT Analytics (2020)[249]	*Focus: IoT (all technologies), Time period: 2010-2025, Global market* ▪ In 2020, for the first time, more IoT connections than non-IoT connections (smartphones, laptops, and computers) are stated. ▪ Of the 21.7 billion active connected devices worldwide, 54% will be IoT device connections at the end of 2020. By 2025, more than 30 billion IoT connections are expected, almost 4 IoT devices per person on average. ▪ Strongest growth in China: Chinese operators China Telecom, China Unicom, and China Mobile account for 75% of all cellular IoT connections in 2020 (2015: 27%). ▪ Growth drivers are China, personal and home device use (wearables, smart home) and LPWA (low-power wide-area) connectivity. 
Abi Research (2020)[250]	*Focus: Smart metering, global, 2020-2025, Global market* ▪ 7.7 million smart metering devices with eSIM in 2020 (shipments), 50 million shipments by 2025, accounting for just over 24% of all smart meter device shipments (share of eSIM in smart metering 2020 about 10%). ▪ By the end of 2026, ABI research estimates that battery-operated smart meters used for water and gas metering will have an installed base of more than 640 million meters globally (in Europe about 50 million units) ▪ Cellular connections for smart metering 2019: 7%, 2026 17%.

Source: WIK-Consult.

248 See Ericsson (2020): Ericsson Mobility Report, November 2020, page 15.
249 See IoT Analytics (2020): State of the IoT 2020: 12 billion IoT connections, surpassing non-IoT for the first time, 19 November 2020, https://iot-analytics.com/state-of-the-iot-2020-12-billion-iot-connections-surpassing-non-iot-for-the-first-time/.
250 See Abi Research (2020): eSIM and smart meters: why eSIm and why now? October 2020.

10.2 Relevant influencing factors, trends, and uncertainties

The future development of eSIM depends on a variety of factors that are interdependent. All players in the ecosystem (see section 2.2) will play a role in influencing when and to what extent eSIM will replace traditional SIM and when eSIM will achieve significant take-up in IoT, creating the potential for new use cases with massive numbers of connected devices.

While some stable trends can be identified, there is considerable uncertainty about the extent and timing of the developments described.

Table 10-2 outlines the factors that can be considered most crucial for future eSIM development:

Table 10-2: Key factors for future eSIM development

	Overall trend	Most relevant uncertainties
Availability of eSIM devices	▪ eSIM will be available in mass market smartphones. ▪ eSIM-only smartphones are likely to emerge. ▪ eSIM-equipped smartwatches will gain importance. ▪ eSIM will be supported in tablets and laptops. ▪ A large variety of IoT devices will be developed.	▪ When will eSIM-only smartphones be launched (on a larger scale)? How will prices for eSIM smartphones develop? ▪ Will the eSIM replace SIM in (all) smartphones? To what extent? By when? ▪ How will the use cases for cellular IoT develop (compared to alternative technologies such as unlicenced LPWAN)? How and by when will NB-IoT be deployed? What is about roaming and specification issues for NB-IoT?
eSIM implementation by MNOs	▪ A growing number of MNOs will implement eSIM. ▪ Irish MNO will implement eSIM.	▪ By when will MNOs implement eSIM? ▪ For which use cases (different smartphone and smartwatch models, Microsoft Mobile Plans App)? ▪ (When) will MNOs change the customer journey? ▪ (When) will MNOs launch new attractive tariff models emerge? ▪ (When) will MNOs promote the use of eSIM for consumers?
eSIM business models adopted by MVNOS and disruptive players	▪ eSIM offers huge potential for MVNOs and disruptive business models.	▪ What role will MVNO, and disruptive players play in the consumer and IoT segment? ▪ By when will these players gain importance? ▪ How will these offers impact competition and consumers?
Customer journey (Consumer)	▪ New solutions for customer journey will emerge. ▪ A fully digital customer journey is likely to gain importance with eSIM.	▪ Will a fully digital customer journey become standard? By when? ▪ How will switching processes develop? ▪ (How) will the process and time for MNP change?
Consumers use of eSIM	▪ Consumers will buy eSIM-enabled devices ▪ Consumers will activate eSIM in their devices ▪ Some user groups are early adopters: business customers, travelers ▪ Consumers will use multiple eSIM devices	▪ When will most consumers use eSIM devices? ▪ How many consumers will activate eSIM while alternatives (Dual-SIM) are available? ▪ (How) will other institutions such as regulators support in promoting eSIM usage? ▪ (How) will eSIM influence switching behaviour?
IoT use cases	▪ Automotive is the most important use case (short term). ▪ Smart metering is another big use case (med term). ▪ Connected devices will be implemented across all industries and use cases (mid-term/long-term).	▪ What role will cellular IoT play in the context of the whole IoT industry (compared to other connectivity solutions such as Sigfox, LoRaWAN)? ▪ Will some use cases benefit significantly from provider switching options with eSIM? ▪ Will public funds promote the use of IoT in SME and late adapters? ▪ Will public policy require eSIM, e.g. in smart metering?
Standardization process at GSMA	▪ Consumer specification will be continuously improving; new features will be added ▪ IoT specification will be further developed to reduce/remove complexity	▪ What features (such as multiple profiles) will be changed (and by when)? ▪ How will changes to the IoT specification be implemented (and by when)? ▪ Will any interoperability problems occur in practice (switching)?

Source: WIK-Consult.

10.3 Key assumptions and scenarios of the WIK forecast

General assumptions

For the **overall mobile market development** we expect strong growth in the M2M segment (CAGR 2020-2030: 30% in Europe, slightly higher in Ireland) that will result in a growing number of mobile connections per capita. From a starting point of 1.5 mobile connections per capita today, we expect mobile penetration to expand to 6.2 mobile connections per capita in the EU and 7.2 mobile connections per capita in Ireland by 2030. This basic assumption on the overall mobile market development is the same for all three scenarios concerning future eSIM penetration.

A general assumption regarding **eSIM** is that it **will gain importance in the mobile market** (see 10.2). There is no scenario in which eSIM will fail to emerge. Therefore, we assume that there will not be any scenario involving less than 50% share of eSIM in all SIM devices by the end of the forecasting period (2030).

For the coming years, eSIM adoption is expected to be faster in those countries where eSIM services for smartphones are commercially available by all MNOs and most MVNOs and where the leading eSIM device manufacturers have significant market share.[251]

Assumptions on short-, medium- and long-term development

In the **short term (until 2022)**, eSIM market development is mainly influenced by the availability of eSIM devices and MNOs supporting eSIM – potential development paths in these drivers result in different scenarios. eSIM devices have not yet been launched by all device manufacturers and are mainly available in the premium segment. The share of eSIM-equipped devices differs between countries. In Ireland, availability is relatively high due to the strong market share of Apple. Regarding MNO support, eSIM has not been implemented by all MNOs. In this respect, Ireland lags many other countries in Europe, but is in the process of catching up. Another relevant factor in the short term is a lack of knowledge on the part of the customer (and thus need for customer education[252]) that might negatively affect activation for as long as smartphones are available as dual-SIM-phones. Connected vehicles are already in place. However, cars built before 2018 are still in use to a large scale (this holds less for Ireland than for other countries).[253] Some IoT segments such as smart metering are

251 See e.g. GSMA (2021): GSMA (2021): eSIM: State of the consumer market and the road ahead, March 2021, page 29: a combined market share of 70% Apple, Samsung and Huawei is seen as a good precondition for early leading eSIM markets).

252 See Omdia (2020): CSPs have a radical shift in mindset: They are embracing eSIM, now. https://solutions.amdocs.com/rs/647-OJR-802/images/Omdia-eSIM-Study-eBook-Final-2020.pdf, page 23.

253 See ACEA (European Automobile Manufacturers Association) (2021): Vehicles in use Europe, January 2021, ACEA Report, https://www.acea.be/uploads/publications/report-vehicles-in-use-europe-january-2021.pdf , page 9-10.

ramping up (especially in Ireland), but the overall penetration of eSIM in the IoT market is hampered by specification issues and complexity of implementation.

In the **medium term (until 2025)**, an increasing number of eSIM-enabled devices will be available and will penetrate the consumer market, based on existing behaviour to replace smartphones after 2-3 years on average. Most MNOs will support eSIM with some differences between countries. It is very unlikely that the majority of consumers will have eSIM-enabled smartphones – Ireland will be above average in this respect due to the high share of premium handsets from Apple and Samsung. A majority of cars will be equipped with eSIM, especially in Ireland with lower average age of cars used.[254] Differences in potential eSIM take-up result from uncertainties about the launch of eSIM-only smartphones from leading manufacturers that would force consumer into activating eSIM and overcome consumer inertia. Moreover, details regarding the type of eSIM devices supported by MNOs and IoT specification are unknown. It is very likely that fully digital business models and a disruptive approach by market participants would increase competition. Most experts expect most devices to be connected via eSIM by 2025.[255]

In the **long term (until 2030)**, eSIM has the potential to become mainstream in the consumer segment after eSIM equipped devices become widely available, processes are in place and attractive offers are developed due to increased competition. eSIM has the potential to open a wide range of new use cases involving massive IoT – the exact numbers are almost impossible to be predict. Most IoT deployments have long-term operational times with some lock-in effects and replacement by eSIM will take time. In the long-term uncertainties are naturally higher than in the short-term. However, in all scenarios it can be expected that eSIM will penetrate the market – and it can be expected that at least 50% of all SIM-devices in use will rely on eSIM (even in a worst case if several factors slow down the market development).

254 See ACEA (European Automobile Manufacturers Association) (2021): Vehicles in use Europe, January 2021, ACEA Report, https://www.acea.be/uploads/publications/report-vehicles-in-use-europe-january-2021.pdf , page 9-10.

255 See e.g. See Omdia (2020): CSPs have a radical shift in mindset: They are embracing eSIM, now. https://solutions.amdocs.com/rs/647-OJR-802/images/Omdia-eSIM-Study-eBook-Final-2020.pdf, page 25.

Three scenarios – General assumptions

Base Case	Best Case	Worst Case
The **base case** reflects the most likely continuation in market development; it is based on current strategies and announcements from the relevant players and the estimates of most market experts, that: • More leading manufacturers will produce eSIM-smartphones. • eSIM will be implemented in cheaper smartphones. • Traditional SIM will be supported in parallel until 2030. • All MNOs will support eSIM in the medium to long term. • The GSMA specification for IoT will be improved, but without short-term impact, as the focus is on consumers for now.	The **best case** involves expanded take-up compared with the base case, as some factors develop more dynamically than expected by most market experts today, e.g.: • eSIM-only smartphones will be launched by Apple in 2021/22 • All leading manufacturers will offer eSIM-enabled smartphones • 100% of MNOs will launch eSIM within the next two years • New offers will be launched in the market, and disruptive business models will arise. • The customer journey will be fully digital. • eSIM in consumer IoT (especially Microsoft App) will be supported by more MNOs and strongly promoted. • The GSMA specification for IoT will be significantly improved regarding its complexity during 2021 and players will take advantage of the amendments soon.	The **worst-case** deviates from the base case from this path in a negative way, e.g. by some factors not becoming reality: • eSIM smartphones will not be launched by all manufacturers in all models, a significant share of traditional SIM smartphones will be available by the end of the forecasting period. eSIM-only smartphones will not become mainstream. • Most MNOs will support eSIM, but without much effort to develop attractive offers or encourage consumers to use eSIM devices. • Switching will not increase significantly due to OTA, as e.g. MNP processes will not be improved in all countries. • It will take some time until eSIM is activated in eSIM-enabled tablets and laptops due to a lack of promotion.

Three scenarios – Assumptions on development in Ireland

Base Case	Best Case	Worst Case
• All MNOs will implement eSIM by the end of 2022. • eSIM will be implemented in smart meters according to the plans of ESBN. • A significant share of Irish customers will have eSIM smartphones by 2025.	• In the short/medium term, customers will be encouraged to activate eSIM by industry players and the regulator in order to make use of their eSIM-enabled devices. • Ireland will catch up with the overall market development in the consumer segment elsewhere in Europe by 2025.	• Global device manufacturer strategies do not differ. • MNP does not hinder switching.

In Table 10-3 and Table 10-4, relevant assumptions for the forecast are summarized for eSIM-equipped devices as well as for activated eSIM in those devices, distinguished by short, medium, and long term for the base-, worst- and best-case scenarios.

Table 10-3: Assumptions on the share of eSIM-equipped and activated devices in the EU (short, medium, long term)

EU						
	Share of eSIM-equipped devices in all SIM devices			Share of activated eSIM in eSIM-equipped devices		
	Short-term (2022)	Medium-term (2025)	Long-term (2030)	Short-term (2022)	Medium-term (2025)	Long-term (2030)
Smartphone						
Base Case	8%	30%	75%	20%	40%	80%
Best Case	25%	70%	100%	60%	100%	100%
Worst Case	5%	15%	50%	10%	25%	50 %
Consumer IoT						
Base Case	35%	50%	75%	25%	50%	80%
Best Case	60%	85%	100%	60%	100%	100%
Worst Case	20%	40%	60%	15%	30%	60%
M2M						
Base Case	5%	30%	70%	100%	100%	100%
Best Case	10%	40%	100%	100%	100%	100%
Worst Case	3%	15%	50%	100%	100%	100%

Source: WIK-Consult.

Table 10-4: Assumptions on the share of eSIM-equipped and activated devices in Ireland (short, medium, long term)

IRELAND						
	Share of eSIM-equipped devices in all SIM devices			Share of activated eSIM in eSIM-equipped devices		
	Short-term (2022)	Medium-term (2025)	Long-term (2030)	Short-term (2022)	Medium-term (2025)	Long-term (2030)
Smartphone						
Base Case	15%	35%	75%	5%	40%	80%
Best Case	40%	70%	100%	30%	80%	100%
Worst Case	10%	15%	50%	3%	15%	60%
Consumer IoT						
Base Case	40%	55%	75%	3%	20%	80%
Best Case	60%	85%	100%	20%	80%	100%
Worst Case	20%	45%	60%	3%	20%	70%
M2M						
Base Case	40%	65%	80%	100%	100%	100%
Best Case	60%	80%	100%	100%	100%	100%
Worst Case	40%	40%	50%	100%	100%	100%

Source: WIK-Consult.

The **availability of eSIM-equipped devices** which is a key driver for the relevant period - is primarily determined by the strategy of manufacturers and to some extent influenced by the strategies of MNO/service providers in promoting eSIM-based devices and the customer's interest to buy those devices. In this context the production of cheaper mass market models for consumers is likely to have a major impact on growth of eSIM equipped devices.

The **activation of eSIM in eSIM-equipped devices** – which is relevant in the short to medium term – is determined by eSIM implementation by MNOs, alongside promoting the eSIM and customer acceptance. Moreover, the launch of eSIM-only devices for consumers would require eSIM activation, but it remains to be seen when and to what extent this will happen. For M2M, we assume that eSIM in IoT devices are 100% activated.

10.4 Results of WIK forecast

Results of the forecast are shown in the main body of the report.

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