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Annex A: Study Questionnaire
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1 Executive summary

1.1 Project background and objectives

Analysys Mason has been engaged by Ofcom to conduct an investigation into the technical feasibility and associated cost and commercial implications of introducing regional or national roaming for voice and data services on mobile telecoms networks in the UK.

The notional objective of introducing roaming is to increase the effective service coverage for all UK mobile service subscribers, that is, to increase the availability of services if a subscriber is located in an area that is not covered by their home mobile network operator (MNO).

Currently, Ofcom has no plans to mandate the introduction of universal national roaming for the purpose of increasing effective coverage or to place other associated requirements on UK MNOs/other affected parties. This project is part of a wider study regarding mobile coverage.

At this stage, Ofcom is simply gathering information on the technical and commercial feasibility and costs associated with national roaming. To this end Analysys Mason has been engaged to understand the perspectives of the various key players in the mobile sector (including a range of operators and equipment manufacturers), using questionnaires to bring together comparable, relevant and honest feedback.

The key objectives of the project are:

- to identify the possible impact of national roaming on mobile network infrastructure and terminals in use in the UK, the potential modifications that might be required to enable national roaming, and their estimated cost
- to understand the scope of technical and commercial issues that MNOs might need to address in relation to implementing national roaming, and why national roaming has not been implemented to date
- to identify any regulatory issues that might be created, and any changes that would be required to enable national roaming to be introduced.

This version of the report has been redacted to protect the confidentiality of the information provided by respondents to the study questionnaire.

1.2 Key findings of the study

The responses to the study questionnaire were focused predominantly on the difficulties of introducing national roaming to the UK, with one or two exceptions. This emphasis on the obstacles to deployment may be explained to some extent by the questionnaire’s focus on exploring potential problem areas, but there was a clear and consistent theme to the responses, and
most especially from the MNOs, that the main players in the market are unconvinced by the introduction of national roaming.

Different players raised different points to substantiate this opposition, but the most significant points related to the critical issues of service transparency and in-call handover, which respondents consider difficult if not impossible to implement in a way that would provide acceptable quality of service.

Nonetheless, we consider that it may be possible, by making some compromises, to implement an acceptable form of national roaming. This could be a service that offers subscribers some coverage benefits, but with a reduced level of service compared to their home MNO. It will need to be considered further whether the service restrictions and coverage benefits warrant the introduction of national roaming. However, this is unlikely to be justifiable on a purely commercial basis.

1.2.1 Summary of key technical findings

The questionnaire responses indicated that the following technical areas were of central importance to respondents and would be particularly challenging to address:

- ‘all-to-all’ roaming between operators
- risk of network contagion (where the failure of one network caused failure that would lead to the failure of other networks in a ‘domino effect’)
- in-call handover
- complete transparency or seamlessness of service
- billing environment
- maximisation of time connected to the home network (to minimise roaming costs and/or ensure the subscriber can use full network features for as great a time as possible, which needs to be traded against customer experience and handset battery life impacts).

Analysys Mason considers that fully addressing the first four areas identified above would constitute a serious barrier to national roaming implementation. Even if technically possible, ‘all-to-all’ roaming, in-call handover and complete transparency of service would probably need levels of operator co-operation that would impinge on their ability to compete and differentiate themselves. We think that the implementation of a suitable billing environment could be achieved more easily than some respondents suggested and a compromise can be reached on maximising the time on the home network.

However, if the requirement for in-call handover is removed and there is relaxation in the need for service transparency, then a workable solution seems attainable. We consider that national roaming could be considered for basic voice services. However, it still needs to be established whether the coverage benefits justify the development of even a reduced form of national roaming. There are also question marks as to whether coverage benefits would outweigh compromises in the customer experience (including the absence of data services) that a viable form of roaming could
involve. In addition, further investigation is needed into the risk of network contagion as it could potentially represent a serious barrier to the introduction of national roaming and potentially compromise compliance with Critical National Infrastructure requirements.

The study has focused on using national roaming to address both relatively large areas of non-coverage (or ‘macro-not-spots’), and also relatively small areas of non-coverage (or ‘micro-not-spots’). Such ‘micro-not-spots’ may be areas that do not even show as uncovered areas in the MNO’s coverage maps (such as specific rooms in a house).

We think it should also be considered whether the approach should be to focus only on ‘macro-not-spot’ roaming, where there are known and significant operator not-spots, rather than universal national roaming. This will potentially save money for one operator in one area and another operator in another area, while decreasing some of the operational challenges. Any aggregate money saved by the operators could be used to fund ‘not-spots’ where there are no operators at all (e.g. in remote areas).

1.2.2 Summary of key cost findings

The questionnaire also sought to explore the expected cost implications of introducing national roaming. Responses to this part of the questionnaire were disappointing with only one MNO and one mobile virtual network operator (MVNO) responding. However, using the responses as a base, our analysis suggest that – if in-call handover and full service transparency were excluded – a national roaming solution could be achieved for a capital investment of under GBP15 million per MNO. However, if in-call handover and full service transparency were considered indispensable requirements, we estimate that implementation costs would be tens of millions of pounds (in addition to the implementation challenges). Addressing the issue of network contagion (by adding significant additional capacity to each network) could potentially costs hundreds of millions of pounds, which would be unrealistic.

We also assessed the potential for increased revenues that each operator could expect by effectively increasing the coverage of its network. It was clear that the investment in national roaming could not be justified purely on commercial grounds. (The national roaming related capital expenditure would have to be no more than 10% of the expected required investment of GBP13-14 million for national roaming to make any sort of return within five years of investment.)

1.3 Overall conclusion

Our research suggests that a seamless national roaming solution that effectively allows all UK networks to inter-operate seamlessly to provide a service that maximises coverage and appears to the subscriber as a single network is not technically feasible.
However, if compromises are made, it could be feasible for a form of national roaming to be used in such a way that increases coverage for subscribers, but with some service limitations in roaming areas. However, there remain major doubts over whether the likely limited coverage benefits justify the introduction of a limited service which would be likely to compromise the customer experience. There was strong opposition from the MNO community to deploying a national roaming solution that reduces the level of customer experience.

One approach that could be worthy of further investigation is to focus national roaming on ‘macro not-spots’ where no operators currently have coverage, but a benefit of providing coverage can be demonstrated.

Our analysis suggests that the introduction of national roaming will not provide a commercial return for MNOs in either case.
2 Introduction

2.1 Project background

Analysys Mason has been engaged by Ofcom to conduct an investigation into the technical feasibility and associated cost and commercial implications of introducing regional or national roaming for voice and data services on mobile telecoms networks in the UK.

The notional objective of introducing roaming is to increase the effective service coverage for all UK mobile service subscribers, that is, to increase the availability of services if a subscriber is located in an area that is not covered by their home mobile network operator (MNO).

This version of the report has been redacted to protect the confidentiality of the information provided by respondents to the study questionnaire.

2.2 Project objectives

Currently, Ofcom has no plans to mandate the introduction of universal national roaming for the purpose of increasing effective coverage or to place other associated requirements on UK MNOs/other affected parties. This project is part of a wider study regarding mobile coverage.

At this stage, Ofcom is simply gathering information on the technical and commercial feasibility and costs associated with national roaming. To this end Analysys Mason has been engaged to understand the perspectives of the various key players in the mobile sector (including a range of operators and equipment manufacturers), using questionnaires to bring together comparable, relevant and honest feedback.

The key objectives of the project are:

- to identify the possible impact of national roaming on mobile network infrastructure and terminals in use in the UK, the potential modifications that might be required to enable national roaming, and their estimated cost
- to understand the scope of technical and commercial issues that MNOs might need to address in relation to implementing national roaming, and why national roaming has not been implemented to date
- to identify any regulatory issues that might be created, and any changes that would be required to enable national roaming to be introduced.

2.3 Scope

The scope of the assignment includes researching the impact of national roaming on 2G and 3G voice and data mobile networks in the UK, and the associated handsets, as well as any commercial (MNO), market (subscriber) and regulatory (e.g. changes Ofcom might need to make) impacts.
This has been achieved through primary market research by issuing a questionnaire to 12 relevant stakeholders amongst MNOs, mobile virtual network operators (MVNOs) and original equipment manufacturers (OEMs), supported by desktop research.
3 Project approach

3.1 Methodology

The project was split into three phases to enable us to establish the key issues and cost implications of the introduction of national roaming:

- **Phase 1**
  - desk-top research to establish the key issues relating to national roaming introduction.
  - formulation of the questionnaire to send to study participants
  - identification of potential questionnaire respondents including MNOs, MVNOs and OEMs.

- **Phase 2**
  - analysis of the questionnaire responses to identify the key impacts and cost implications
  - development of case studies from other countries, highlighting their approach and identifying issues that they have encountered.

- **Phase 3**
  - development of the final report.

3.2 Questionnaire formulation

The questionnaire was developed to facilitate and focus the respondents’ responses in terms of the key challenges and cost implications of introducing national roaming. It also included open questions to give the respondent the opportunity to highlight all the issues associated with particular issues that had been identified as part of project research and in discussion with Ofcom including:

- limitations in number of roaming partners
- traffic prioritisation
- minimising roaming when home network is available
- additional requirements compared to international roaming
- challenges of service transparency when roaming to a visited network
- mechanisms for selecting visited networks
- notification to a subscriber that additional roaming charges are to be incurred.

In addition, the questionnaire asks for details of the costs of implementation and the respondents’ views on the commercial and regulatory impacts of national roaming introduction. A copy of the questionnaire is included in Annex A of this report.
3.3 Selection of participant organisations

A list of potential respondents was drawn up in such a way to include those organisations that would be best able to provide relevant and constructive input and insight into the report. The potential respondents can be divided into three broad categories MNOs, MVNOs and OEMs (although the OEM category does include organisations that provide managed services to MNOs, as well as core infrastructure, customer premises equipment and handset suppliers). The list of organisations invited to respond is provided below:

<table>
<thead>
<tr>
<th>MNOs</th>
<th>MVNOs</th>
<th>OEMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Mobile</td>
<td>Virgin Media</td>
<td>Ericsson</td>
</tr>
<tr>
<td>3UK</td>
<td>Lycamobile</td>
<td>Nokia Siemens</td>
</tr>
<tr>
<td>Orange</td>
<td>Truphone</td>
<td>Sony Ericsson</td>
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<tr>
<td>Vodafone</td>
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<td>Huawei</td>
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<tr>
<td>O2</td>
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<td>MBNL</td>
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<tr>
<td></td>
<td></td>
<td>ip.access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roamware</td>
</tr>
<tr>
<td></td>
<td></td>
<td>United Hubbing</td>
</tr>
</tbody>
</table>

Figure 3.1: Invited questionnaire respondents [Source: Analysys Mason]

We received responses from nine companies in varying detail.
4 Technical and operational issues and impacts of national roaming

4.1 Introduction

A number of technical and operational issues were raised by the questionnaire respondents, and are addressed in this section under the following headings:

- network impact
- user experience
- roaming network selection and terminal issues
- in-call handover
- billing
- service support
- interconnection at the RNC and multi-operator core networks (MOCN).

Each of the following sections summarises and collates the various individual responses on each topic. We then provide a brief synthesis of the various comments as a single summary (which can be used as the basis of a document that can be provided to respondents summarising the key findings of the report without compromising any requested confidentiality). This is followed by Analysys Mason’s assessment of the responses and their application.

4.2 Network impact

4.2.1 Overall network impact

Summary of responses

The general consensus was that while functionally national roaming is no different to international roaming, a new level of operational complexity would be introduced to ensure that service levels are maintained within each mobile network. Additional capacity both to handle calls and additional location update signalling would be required due to increases in traffic generated by roaming users and traffic forecasting will be important to help deal with this.

There is concern about the network impact of failure events in other networks that could give rise to sudden and significant influxes of traffic that would affect service quality for both roamers and the visited network’s own subscribers. In a worst-case scenario, this could
lead to multiple network failures as the failure of one network triggers overload in other networks.

There was also concern about the impact on the customer experience of regular changes of network as location updates were attempted which would cause the handset to not be able to make calls during this period.

It was also pointed out that a non-alignment of capacity in particular areas could limit the ability of an operator to run geographically specific marketing campaigns, due to the limitations of other networks causing high levels of roaming onto its network.

**Analysys Mason assessment**

At a purely functional level, we see no barriers to the introduction of national roaming in the UK, although there will be a need to invest in additional network capacity to handle the additional load of the national roaming traffic. Additional capacity both to handle calls and additional location update signalling will be required due to increases in traffic generated by roaming users and traffic forecasting will be important to help deal with this.

However, some genuine operational concerns have been highlighted by the respondents that could lead to a negative impact on customer experience and potentially network failure.

In our case studies in Section 7 of this report, national roaming is introduced for different reasons:

- In France, national roaming addresses particular geographical areas that lack network coverage (‘not-spots’) and roaming is confined to those areas. The planning of the network in those areas assumes this is a new area, which allows the planning to be undertaken in a controlled manner.

- In the Netherlands, the main example shows national roaming being introduced to facilitate the withdrawal of the Orange network following a take-over by T-Mobile and is really a network transfer rather than a more dynamic swapping between networks to maximise coverage.

- In Cyprus, national roaming was introduced to allow a new operator to increase its coverage in areas where it has no service.

The context of this study is significantly different to these cases in that it is not looking at national roaming to address solely relatively large areas of non-coverage (or ‘macro-not-spots’), but also addressing relatively small areas of non-coverage (or ‘micro-not-spots’). Such ‘micro-not-spots’ may be areas that do not even show as uncovered areas in the MNO’s coverage maps (such as specific rooms in a house).

Therefore in addressing ‘micro-not-spots’, issues may arise that would not be encountered in the scenarios described in our case studies. Two particular examples of this are:
• If a network were to go down in an area then there would potentially be a large influx of roaming traffic onto the unaffected networks that could in turn suffer overloads and failure – an effect that would not be seen if roaming was constrained to areas without network overlap.

• Potentially high regularity of changing networks (even when walking around a house), which could have a negative impact on customer experience if service is unavailable for approximately 10 seconds during the transfer process.

Failure of one of the networks will certainly be a major issue and further investigation would be required to explore options for alleviate the potential impact. The risk of contagion needs to be weighed against the wider benefits of introducing national roaming. Network failure is unlikely to be a common occurrence, but could have potentially serious consequences.

The issue of frequent changes of network would suggest a need for the subscriber to be able to opt-in or out of national roaming, if it were considered to be more of a nuisance than a benefit.

It should also be considered whether the approach should be to focus only on ‘macro-not-spot’ roaming, where there are known and significant operator not-spots, rather than universal national roaming. This will potentially save money for one operator in one area and another operator in another area. Any aggregate money saved by the operators could be used to fund ‘not-spots’ where there are no operators at all (e.g. in remote areas).

4.2.2 Limits in national roaming partners

Summary of responses

While there is no theoretical limit to the number of national roaming partners, and at one level it is no different to international roaming, the MNOs have great concerns about the practical implementation of roaming particularly with respect to in-call handover.

The MNOs generally thought that when an implementation of seamless handover between multiple networks is considered, both the technical and commercial challenges of implementation are substantial. Two MNOs thought it would be possible to support this for one roaming partner, but beyond this would be very difficult.

It was generally thought that MVNOs were an insignificant issue as what is critically important is the interaction between the MNOs.

The availability of spectrum for roaming was also a concern for one operator. The operator believes that it needs all available spectrum to service its own subscribers.
The key issue that will hamper the introduction of ‘any-to-any’ national roaming is a need for in-call handover. We believe that providing in-call handover between two existing networks would prove to be technically very challenging and would require significant co-operation between the network planning functions of both operators. If this were to be extended to in call hand-over between any network it would be very complex and may not be achievable.

Therefore, we suggest that ‘any-to-any’ national roaming can only be considered in a scenario that does not support in-call handover. This will have a customer experience impact that should be balanced with the benefit of increased coverage.

### 4.2.3 Traffic prioritisation

#### Summary of responses

Currently, MNOs do not prioritise traffic on their networks. It has been suggested that prioritisation of voice traffic could be provided via the use of the eMLPP service and deep packet inspection could be used to provide priority within data sessions. However, providing such functionality is likely to require investment.

#### Analysys Mason assessment

It is not surprising that MNOs are not currently implementing any traffic prioritisation as, with the exception of 3UK roaming onto Orange, MNOs only have to consider their own subscribers and international roamers.

There are techniques available to give priority to particular groups of customers for both voice calls and data sessions. So, technically, prioritisation could be implemented but it would require network investment. An MNO may see benefit in implementing prioritisation to, for example, give a superior roaming experience for visiting subscribers to maximise roaming revenues. However, an MNO is unlikely to be happy with having to invest significantly to ensure that its own subscribers obtain a normal service.

### 4.2.4 Location information sharing

Location information is required to be used in association with certain services. Of particular interest is the need to be able to provide location information of a subscriber making an emergency services call.
Summary of responses

One respondent stated that there would need to be an implementation of location dependent information exchange for emergency services, police liaison etc. for use when subscribers are roaming. This will require cell identifiers in call flows, amendments to the existing emergency call service implementation and will need to support the interrogation of the billing networks roaming subscriber database. This may include a need to provide a copy of the commercially sensitive cell database to the roaming partner who is also a direct competitor. As above – only one respondent commented in this area.

Analysys Mason assessment

Each operator must provide the emergency service operator (i.e. BT or C&W) with up-to-date lists of ‘zone codes’. These are individual cells or groups of cells and their geographical location. A 999/112 call has a zone code included in the set-up message.

We do not believe that any further location information exchange processes and data exchange will be required in addition to what is already available. We understand that in an existing national roaming agreement, the visited network handles both the emergency call and the location request of the subscriber from the emergency call centre.

We understand that any required data relating to subscribers could be obtained from the home network (as is the case now). However, the location-based services are developing quickly and may create a more complex environment and greater challenges in the future.

It should be noted that there may be other security organisation requirements that we have not been in a position to consider as part of this study.

4.3 User experience

4.3.1 End-user experience requirements

Summary of responses

The overriding message from respondents was that seamless and transparent service was needed and any implementation that resulted in a perceived deterioration in service from the current user experience would not be acceptable. The national roaming proposition needs to simple to understand and not add to complexities for the subscriber. This transparency would be expected to extend to services that are unique to a particular operator.

If the national roaming benefit of improved coverage is to be achieved, then full handover (including early handover) capabilities must be in place, which is not considered to be a
trivial task. Concern was also expressed about the operation of data services (such as music downloads) where there might be a requirement for age verification or identification of the subscriber’s home network or other information relating to a subscriber’s service profile.

It was suggested that a key requirement in improving the end-user experience would be for national roaming to increase indoor coverage. However, it was suggested that any deployment that led to increased charges would not be acceptable from a customer experience perspective.

**Analysys Mason assessment**

The consensus of MNOs and MVNOs that service transparency needs to be complete for national roaming service to be acceptable to end-users is very much at odds with the challenges required to provide such a service. The responses to Sections 4.3.2 and 4.5 identify great challenges and co-operation required between MNOs if the suggested required service transparency and in-call handover is to be achieved.

We consider that a more likely successful outcome for a national roaming service is for it to be introduced as a new service that subscribers would opt into on the basis of accepting the limitations that such a service provides. We consider that it is of paramount importance that a voice call is achievable and other services should be regarded as ‘nice to have’. This is particularly true if national roaming is generally only considered to be used for short amounts of time, rather than a permanent coverage solution.

We do not share the concern that age verification or identification of the subscriber’s home network would be an issue in the operation of data services as the same content server would be used whether the subscriber was roaming or not.

**4.3.2 Service transparency issues**

**Summary of responses**

Concern was expressed by respondents in all categories about the cost and time that would be needed to ensure service transparency. It is also possible that investment in making services consistent when roaming may come at the expense of investment in new services. The experience of a supplier in undertaking integration of services in the femtocell environment support the consensus that this will be difficult and maybe commercially unattractive.

The 3GPP CAMEL specification and in particular version 4 is suggested as a prerequisite for providing the maximum service transparency across networks. There was still concern
from one respondent as to whether CAMEL would be able to provide full service transparency, which could lead to a levelling down of service capability and differentiation if a consistent service is to be provided on home and visited networks.

If service transparency was to extend to services that are unique to a particular operator, then it may necessitate routing back to the home network to access the service, ensuring key parameters are presented as would be expected on-net. Facilitating this is also likely to require additional capacity to be deployed by the visited network, to handle the transiting of the service data.

One equipment manufacturer was particularly positive about this issue, suggesting that services were quite seamless in an international environment and it should be possible to replicate this in a national environment.

**Analysys Mason assessment**

We believe making services completely transparent when roaming will be a far from trivial task and is likely to require a high degree of development and integration resources to implement. This may include the re-writing of existing services embedded in the core network at the intelligent network layer.

Services that are unique to a particular operator will provide a particular challenge, and routing back to the home network to access the service, may cause mobile number portability challenges as well as additional capacity requirements. Generally we think that a consistent implementation of CAMEL across the operators would be the best way forward to ensure service transparency, but there are likely to be significant integration issues.

Service transparency is likely to be a difficult undertaking and one that might compromise new service development if it is to be implemented. We think that if national roaming is introduced it will need to be in the context that full service transparency cannot be achieved. If it is assumed that national roaming is an exception to normal usage and not the rule then being able to make a voice call outside your home operator’s network coverage is a significant benefit and better than not being able to make any call at all. Other features can be considered as ‘nice to have’.

**4.3.3 Increased charges notification**

One option for charging for national roaming would be for the subscriber to be charged a premium when they are roaming using either voice and data services. This poses the question of how subscribers would be notified that they were roaming and subject to increased roaming charges. This subject is given an additional dimension if handovers are implemented during voice calls or data sessions as part of national roaming.
**Summary of responses**

Existing implementations and features used for the notification of higher charges in international roaming were proposed as being used or adapted for national roaming, including visual indicators on handsets (triangles) and the sending of SMSs to notify the commencement of roaming. It was also suggested that a subscriber could opt in or out of national roaming and would then have to accept that they might incur additional charges, without receiving a specific message when they started roaming.

The introduction of voice announcements at the beginning of a new call in a roaming area was suggested as possible, but the issue of modem timeout for M2M communication would have to be addressed.

In call notification was presented as not currently being supported by standards, requiring significant development to implement across all services and unacceptable from a customer experience perspective.

**Analysys Mason assessment**

It is possible to implement pre-call/data session mechanisms to advise a subscriber of increased charges while roaming. However, frequent notifications may not be tolerated by a subscriber if changing networks is likely to be a regular event, even several times a day. Our view is that a subscriber must be able to opt out of such notifications. Any in-call notification would appear to be intrusive and, given the difficulties of implementing in-call handover between operators anyway, it is unlikely to be implemented.

### 4.4 Roaming network selection and terminal issues

It is the general consensus from respondents, in line with 3GPP specifications, that network selection is a function of the handset/terminal and so it is considered here with other handset-related issues.

#### 4.4.1 Roaming network selection

► *Control of network selection*

**Summary of responses**

The responses showed general consensus that existing mechanisms defined in 3GPP specifications and used for international roaming could be applied to national roaming. There was also strong agreement that the vast majority of existing handsets should be able
to support national roaming and it was generally the handset that controlled network selection. A couple of respondents made reference to the user being able to decide between using manual or automatic network selection that could provide flexibility for the end-user, but a loss of control if the home network operator wanted to steer the subscriber to a particular network.

It was noted by some respondents that there are mechanisms that allow the operator to take some control away from the handset in network selection. One MNO described an application that deliberately failed location update attempts from non-preferred networks until the handset attempted registration with a preferred network, but if the network is changed very regularly then the time waiting to register could have an adverse impact on the subscriber experience.

One respondent noted that it is possible to exclude particular areas from national roaming and this approach has been taken in France where national roaming is constrained to specific rural areas, as described in our case study in Section 7.2.

It was suggested that OTA updates of ‘forbidden lists may be restricted by advanced handsets not being equipped with this capability.

**Analysys Mason assessment**

The control of network selection is well understood and is primarily a handset-driven activity. There are applications available that can impose more network control on the selection of the visited network, which may be appealing if the home network has preferences of network selection, e.g. better service transparency, more favourable roaming rates. However, further investigation is be required as to whether such applications unacceptably adversely affect the user experience as described by one respondent due to possible frequent changes in network and the possible large amount of unregistered time that might result.

An additional point, not raised by any of the respondents but described in our case study on the Netherlands in Section 7.3, is the need to adjust the ‘forbidden list’ of networks. UK subscribers will currently list all UK networks apart from its home network in the ‘forbidden list’ on its SIM. The list will need to be changed to allow national roaming, which was achieved by over-the-air (OTA) updates in the Netherlands. However, it has been suggested that this strategy may be compromised to some extent by some advanced handsets not having the OTA update capability.
 ► **Requirement to maximise time on home network**

**Summary of responses**

Maximising time on the home network can be achieved by initiating an exhaustive search for the home network on registration and periodically thereafter controlled from the handset. To maximise time on the home network, this search will have to undertaken as often as possible.

Assisted roaming (management of preferred network lists in the SIM) and managed roaming (where location updates are rejected until a preferred network is used) can both contribute maximising the time on the home network.

Concern was expressed about the detrimental effect on handset battery life of performing regular location updates.

One respondent pointed out that it is possible for the home network to place service restrictions on the roamer by settings in the HLR and apply control over the CAMEL interface into the visited network.

**Analysys Mason assessment**

The 3GPP specification TS 22.011 V9.3.0 states that reselection attempts for a higher priority PLMN can be made while in idle mode for circuit services or while in idle or standby mode for GPRS services. A value can be set in the SIM of between 6 minutes and 8 hours (in 6 minute increments, with a default value of 60 minutes). The value is set by the home network and can be updated by OTA update mechanisms.

However, this needs to be balanced against the fact that frequent location updates will increase use of the battery and that during a location update, the handset is unable to handle incoming calls.

Maximising time on the home network would be primarily driven by a desire to limit roaming outpayments. Other ways of minimising outpayments would be to place service restrictions on roaming users, but the potential negative impact on user experience would also need to be considered.
4.4.2 Implications for terminal battery drain of frequent attempts to register with home network

Summary of responses

There was general consensus between respondents that increasing the interval of attempting to register with the home network would have an impact on increasing battery drain. However, one respondent considered that the impact on battery life was immaterial compared to that used for voice usage and another stated that it would have no impact.

Analysys Mason assessment

Our view is that frequent location updates to register on the home network will have a detrimental impact on battery life. Indeed, the 3GPP specification on the subject (TS 22.011 V9.3.0) suggests that attempting to register on the home network at a rate of greater than every 60 minutes may result in excessive battery drain. We have made enquiries to quantify the impact of trying to register on the home network on battery drain, and confirmed that this could be significant, but further investigation would be required to quantify this.

4.4.3 Terminal display of home operator logo

Summary of responses

Generally, it should be possible for the home operator’s logo or the logo of an MVNO to be displayed during roaming, but it is thought that this cannot be guaranteed in all cases, particularly for older handsets and some 2G SIMs. It was pointed out that this might have an impact on the commercial agreement between MNOs and MVNOs that guarantees that the MVNO brand will always be seen on the handset.

Analysys Mason assessment

It appears that there should not be any great issues in this area with the vast majority of handsets being able to continue to display its host network logo. We would hope that any issues with MVNO brands could be addressed amicably between the MNO and MVNO as it is likely to affect only a small minority of cases.
4.5 In-call handover

Summary of responses

Strong views were expressed that in-call handover is necessary to gain the full benefits of introducing national roaming. However, strong concern was also expressed as to the level of complexity of implementing in-call handover between networks, particularly if more than one roaming partner is involved. To implement handover it was suggested that the networks need to be optimised for handover between them to avoid constant network re-selection and a corresponding increase in network signalling.

Even considering an arrangement of in-call handover with just one other network, one respondent described needing to implement a co-ordinated radio planning team to ensure as integrated knowledge of adjacent radio cells is needed to facilitate handover. This was suggested as having commercial and competition law objections.

It was also noted that calls made to fixed networks would need to maintain the bearer via the original gateway MSC even after handover to another network as there is no provision in fixed networks for mid-call change of bearer. This could therefore lead to the handover actually increasing costs for the home network.

Analysys Mason assessment

While in-call handover may be desirable from a customer experience perspective, significant challenges will need to be addressed in its implementation, with ‘any network to any network’ in call handover appearing to be extremely difficult to implement. It would almost certainly require a national cell planning database which would have to be updated every time a cell was changed – i.e. a change on one network would force a reconfiguration of cell neighbours of all the other networks. This is further exacerbated by the fact that all UK mobile networks are essentially largely overlapping.

Indeed even if the above issues were addressed, there are also practical implementation issues to address. To facilitate handover, the networks will have to have neighbouring cell identifications in their roaming tables. It may be possible to make this work for an arrangement between two networks, but would appear unworkable between four or five networks.

However, even if national roaming is implemented between two roaming partners, a very close day-to-day relationship would be required between the operators, which is likely to be unacceptable commercially. We are of the opinion that in-call handover is unlikely to be viable as part of a national roaming solution, but there is still significant benefit in being able to make a voice call in an area that previously had no coverage.
4.6 Billing

**Summary of responses**

One MNO was clear that existing international roaming mechanisms including TAP would be insufficient for national roaming scenarios due to more onerous subscriber SLAs, billing assurance and revenue assurance in the national context. This would necessitate the development of specific processes and data exchange standards between the participating MNOs, which would be a significant undertaking. An MVNO was also concerned it would introduce additional complexity for processing their own billing records.

However, another MNO was unconcerned about the adequacy of the TAP record itself and was more concerned that the roaming billing systems would need to expand significantly to handle national roaming.

Some respondents specifically pointed out the added complexities of billing partial calls that would be needed if in-call handover was introduced.

**Analysys Mason assessment**

We believe that TAP can be used as the billing mechanism between operators for national interconnect. Indeed, we understand that national roaming in Australia uses TAP for billing reconciliation between operators. To reduce the costs of clearing houses, multi-lateral clearing agreements could be set-up between the mobile operators and the agreements could include specific SLAs for the transfer of records (mandated by Ofcom if necessary) to enable subscriber SLAs to be met.

We agree that in-call handover would introduce an additional layer of complexity, particularly if the billing of partial calls needed to be accounted for. However, if this is not required, we do not see that any additional complexity to what is already implemented with international roaming would be introduced.

4.7 Service support

**Summary of responses**

Responses to the questionnaire have focused on the ongoing impact and have highlighted the need for greater for subscribers and co-operation between operators in order to:
- Provide support in keeping with that given when a subscriber is on its own network (i.e. not equivalent to international roaming support) as that is what subscribers will expect in a national roaming context.

- Explain and address variations in services where full transparency has not been possible.

- Allow the identification and resolution of service issues that may be the result of problems on the visited network, where currently the home network does not have visibility of issues of visited network issues.

- Address how to handle queries about network coverage where coverage currently needs to cover the home and visited networks.

**Analysys Mason assessment**

It is difficult to envisage national roaming being implemented without at least some level of increased operational support being required during the activation phase and beyond. Minimising the level of additional support will depend on:

- How national roaming is positioned with the subscriber:
  - If the subscriber is educated to understand that national roaming will work in a similar way to international roaming then support issues can be reduced. The service should also be positioned as providing the benefit of service where previously there was no coverage.

- To what extent service transparency is addressed:
  - The best way to keep support calls to a minimum will be to make sure the service is as unchanged as possible when roaming.

- How the whole roaming process is managed and implemented:
  - Ensuring the service is implemented to ensure that it is seen as a benefit to customers and not an irritation (e.g. not too many network handovers, unnecessary information messages, easy to understand implementation of billing).

The Netherlands case study in Section 7.3 outlines some of the issues encountered and addressed during the activation phase when national roaming was used as a mechanism to migrate subscribers between networks. While this may be considered more onerous than the scenario envisaged here, it provides a good insight into the issues that needed to be addressed including managing and scheduling the process, ensuring service transparency, subscriber education and the need to update handsets.
4.8 Interconnection at the RNC, MOCN and MORAN

Summary of responses

Respondents recognised interconnection at the RNC and the use of MOCN as more of a network sharing option than national roaming. This option was seen as increasing complexity at the radio layer but reducing it at the service layer as each operator would maintain its own core network. However, standards have only been developed for such mechanisms for 3G and beyond.

MOCN allows each UMTS carrier to support multiple networks, but relies on additional terminal functionality introduced in 3GPP release 6. MORAN, as being deployed by 3UK and T-Mobile, was suggested as another option for sharing radio access resources. MORAN allows each operator to: (a) maintain dedicated carriers resulting in no issues with the display of the network on the terminal, and (b) separately dimension its carriers and set cell parameters.

The setting of wholesale tariffs for a shared RAN scenario was also discussed by one respondent and it was suggested that any such model would need to take into account the discrepancies in the use of RAN resources between different handset types when setting wholesale tariffs. It was also suggested that the model could include spectrum pooling, but that this might run into regulatory and competition issues.

Analysys Mason assessment

The sharing of radio access infrastructure is certainly a good way to reduce the costs of network deployment making funds potentially available to increase coverage. Indeed this is being used by 3UK and T-Mobile in this way already. However, following this route eliminates coverage as a differentiator between operators. This may be seen as acceptable if it leads to greater overall coverage, with competition taking place at the service and commercial levels.

4.9 Summary of major impacts

The key identified major impacts are now listed and we have made a subjective assessment of the importance of the particular requirement (scale 1 to 5, where 5 is very important) and the scale of the challenge in implementing the requirement (scale 1 to 5, where 5 is very difficult).

We have completed this in two ways. Firstly purely taking into account the comments of the respondents regarding the importance of features and the ability to implement them and secondly taking a more pragmatic approach based on what we think can reasonably be achieved operationally and commercially taking out requirements such as full service transparency and in-call handover. This effectively makes the impacts less onerous.
### 4.9.1 Major impact summary – based on questionnaire responses

<table>
<thead>
<tr>
<th>Issue</th>
<th>Importance</th>
<th>Challenge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network impact</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing network capacity</td>
<td>5</td>
<td>2</td>
<td>Required to ensure high quality of service, which will need co-operation between MNOs (inc. forecasts) plus implementation</td>
</tr>
<tr>
<td>Network contagion caused by network failure</td>
<td>5</td>
<td>5</td>
<td>Significant overlapping of coverage between networks could give rise to a sudden unmanageable influx of subscribers onto other networks if a single network failed</td>
</tr>
<tr>
<td>‘All-to-all’ network roaming implementation</td>
<td>5</td>
<td>5</td>
<td>All-to-all is the objective of this study, but MNOs suggest it is unworkable</td>
</tr>
<tr>
<td>Traffic prioritisation</td>
<td>4</td>
<td>4</td>
<td>Not currently implemented but would be important if it helped to maintain service in overload conditions</td>
</tr>
<tr>
<td>Data exchange (non-billing, non-location) e.g. IMEI, cell details</td>
<td>4</td>
<td>3</td>
<td>Needed as part of the solution, but no current standardisation across operators</td>
</tr>
<tr>
<td>Location information sharing</td>
<td>5</td>
<td>3</td>
<td>This would be a regulatory requirement for emergency service support, requiring a real-time information exchange process</td>
</tr>
<tr>
<td><strong>User experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seamless/transparent service</td>
<td>5</td>
<td>4</td>
<td>Seen as essential for a credible national roaming service, but very difficult to implement</td>
</tr>
</tbody>
</table>
| In-call handover | 5 | 4 | Very important if national roaming to be seen as a benefit, but difficult to implement in existing networks even in the one partner scenario (‘all-to-all’ scenario would be a ‘5’)
| Increased charges notification – pre-call | 3 | 2 | Issue as to whether increased charges is acceptable at all needs to be addressed (hence lower importance), but it could be implemented |
| Increased charges notification – pre-data session | 3 | 1 | Can utilise existing mechanisms implemented for international roaming |
| Increase charges notification – in-call | 1 | 5 | Seen as unacceptable to end-users and no existing mechanisms for implementation |
| **Network selection and terminal issues** | | | |
| Control of network selection | 5 | 2 | Fundamental to roaming and existing mechanisms are available, although there will be logistical issues in modifying forbidden lists |
| Maximise time on home network | 5 | 4 | Essential to minimise roaming out-payments, relies on terminal control and limitations of network selection specification |
| Increased battery drain | 3 | 2 | Not highlighted as a major issue and disputed by some respondents |
| Terminal display of home (or MVNO) network brand | 4 | 2 | Could affect commercial agreement with MVNOs if not displayed, but not seen to be an issue with most handsets |
### National Roaming Technical Challenges

<table>
<thead>
<tr>
<th>Issue</th>
<th>Importance</th>
<th>Challenge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Billing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer of billing records between networks</td>
<td>5</td>
<td>4</td>
<td>Essential for rapid transfer to meet subscriber SLAs for billing of national calls, but will require new interfaces to be developed</td>
</tr>
<tr>
<td><strong>Service support</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional overhead customer support for dealing with issues related to national roaming</td>
<td>5</td>
<td>3</td>
<td>Must work well for national roaming to be seen as a benefit by subscribers. Service would be impeded by a lack of visibility of information relating to the visited network</td>
</tr>
</tbody>
</table>

**Figure 4.1:** National roaming technical challenges summary – based on questionnaire responses  
[Source: Analysys Mason]

Our assessment of the respondents’ comments are summarised in Figure 4.2. It can be seen that many of the issues raised are concentrated towards the top right-hand corner of the diagram indicating that they are both essential to implementing national roaming and will be a challenge to implement. This indicates that any implementation that is required to address issues with this level of challenge and importance is unlikely to be achievable. To arrive at an achievable solution a number of the issues would need to move away from this top right-hand corner.

**Figure 4.2:** National roaming technical challenges chart – based on questionnaire responses  
[Source: Analysys Mason]
4.9.2 Major impact summary – after analysis and applying pragmatic approach

It is clear that there are a number of technical challenges to be overcome in the implementation of national roaming. Our assessment suggests that some of the challenges are so great that they cannot be reasonably expected to be overcome; we consider that other challenges have been overstated somewhat by some respondents.

The following areas are those where the difficulties are so great that no pragmatic solution for full national roaming will address them. As such, the only solutions that will work will be a system of national roaming in which these unattainable objectives are diluted or removed. These areas have therefore been given reduced importance in our assessment, and are listed below:

- **In-call handover** – in an any-to-any roaming environment in-call handover would seem to be unfeasible to implement. We also consider even in-call handover between two mature networks that have been designed independently as extremely difficult and potentially compromising their commercial independence.

- **Service transparency** – experience suggests that maintaining service transparency across networks is a far from trivial task and achieving this will be a major integration undertaking. While some basic capabilities may be implemented to get over potential major problem areas (e.g. ensuring users can continue to dial the same short codes for voice mail), any requirement for full transparency seems likely to require a degree of effort that is not justified by the benefit that it will bring.

We feel that the issues may have been overstated particularly in the following areas and so the challenge of implementing them is reduced:

- **Billing** – it was stated that current TAP-based mechanisms are totally inadequate, but TAP is used for billing in national roaming in other areas and processes relating to the passing of data could be modified to suit the national roaming environment.

- **Location information** – for an existing national roaming agreement, there are processes in place that require no additional location or other information exchange between operators. We believe that the difficulties surrounding this have been overstated.

Figure 4.3 and Figure 4.4 show a revised assessment of each category examined after our analysis and application of a pragmatic approach, which eliminates aspects that we believe are unreasonable to expect to be implemented. The areas that have changed from the respondents’ assessment are highlighted in red and where values have changed, the values indicated in the respondents’ assessment are in parentheses.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Importance</th>
<th>Challenge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
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<td><strong>Network impact</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increasing network capacity</td>
<td>5</td>
<td>2</td>
<td>Required to ensure high quality of service, which will need co-operation between MNOs (inc. forecasts) plus implementation</td>
</tr>
<tr>
<td>Network contagion caused by network failure</td>
<td>5</td>
<td>5</td>
<td>Significant overlapping of coverage between networks could give rise to a sudden unmanageable influx of subscribers onto other networks if a single network failed</td>
</tr>
<tr>
<td>‘All-to-all’ network roaming implementation</td>
<td>5</td>
<td>3(5)</td>
<td>Required, but pragmatic implementation does not assume in-call handover</td>
</tr>
<tr>
<td>Traffic prioritisation</td>
<td>4</td>
<td>4</td>
<td>Not currently implemented but would be important if it helped to maintain service in overload conditions</td>
</tr>
<tr>
<td>Data exchange (non-billing, non-location) e.g. IMEI, cell details</td>
<td>2(4)</td>
<td>3</td>
<td>Current national roaming implementation does not require such data exchange</td>
</tr>
<tr>
<td>Location information sharing</td>
<td>1(5)</td>
<td>3</td>
<td>We do not see the need for a real-time information exchange between operators for this process, as existing processes should be able to handle it.</td>
</tr>
<tr>
<td><strong>User experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seamless/transparent service</td>
<td>3(5)</td>
<td>2(4)</td>
<td>A fully transparent service is unlikely to justify the investment of effort required. Implementation of a few key elements will probably cover most requirements</td>
</tr>
<tr>
<td>In-call handover</td>
<td>1(5)</td>
<td>4</td>
<td>Ideally should be implemented, but cannot be justified in a pragmatic solution</td>
</tr>
<tr>
<td>Increased charges notification – pre-call</td>
<td>3</td>
<td>2</td>
<td>Issue as to whether increased charges is acceptable at all needs to be addressed (hence lower importance), but it could be implemented</td>
</tr>
<tr>
<td>Increased charges notification – pre-data session</td>
<td>3</td>
<td>1</td>
<td>Can utilise existing mechanisms implemented for international roaming</td>
</tr>
<tr>
<td>Increase charges notification – in-call</td>
<td>1</td>
<td>5</td>
<td>Seen as unacceptable to end-users and no existing mechanisms for implementation</td>
</tr>
<tr>
<td><strong>Network selection and terminal issues</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control of network selection</td>
<td>5</td>
<td>2</td>
<td>Fundamental to roaming and existing mechanisms are available, although there will be logistical issues in modifying forbidden lists</td>
</tr>
<tr>
<td>Maximise time on home network</td>
<td>3(5)</td>
<td>4</td>
<td>Possibly essential to minimise roaming out-payments (depending on commercial arrangements), but needs to be implemented without compromising user experience</td>
</tr>
<tr>
<td>Increased battery drain</td>
<td>3</td>
<td>2</td>
<td>Not generally highlighted as a major issue but could become an issue if too much emphasis is placed on returning to the home network</td>
</tr>
<tr>
<td>Terminal display of home (or MVNO) network brand</td>
<td>2(4)</td>
<td>2</td>
<td>Not seen to be an issue with most handsets so importance should not be overplayed</td>
</tr>
<tr>
<td>Issue</td>
<td>Importance</td>
<td>Challenge</td>
<td>Comments</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------</td>
<td>-----------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Billing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer of billing records between networks</td>
<td>5</td>
<td>3(4)</td>
<td>Should be able to use existing TAP mechanisms but with some process customisation to take account of specific national roaming requirements</td>
</tr>
<tr>
<td>Service support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional overhead customer support for dealing with issues related to national roaming</td>
<td>5</td>
<td>3</td>
<td>Must work well for national roaming to be seen as a benefit by subscribers. Service would be impeded by a lack of visibility of information relating to the visited network</td>
</tr>
</tbody>
</table>

Figure 4.3: National roaming technical challenges summary — after analysis and applying pragmatic approach [Source: Analysys Mason]

The findings are summarised in Figure 4.4. The diagram shows the issues that have moved with their previous positions being indicated by the grey circles and the arrows showing the direction of change. The green circle for ‘all-to-all’ roaming indicates that the requirement has changed in the pragmatic approach, removing the requirement for in-call handover.

Figure 4.4: National roaming technical challenges chart after analysis and applying pragmatic approach [Source: Analysys Mason]

Figure 4.4 shows that the taking a more pragmatic approach and adding Analysys Mason’s analysis allows the number of challenges in the top right-hand corner to be reduced. If agreement
could be reached with the stakeholders to adopt the relative importance and challenge values indicated in this revised case, we think there would be a basis for the technical implementation of a national roaming solution. However, the possibility of network contagion remains a major issue and further investigation would be required to quantify the likelihood of this happening and any steps that could be taken to minimise the risk.

4.10 Challenges of national roaming compared to international roaming

At a basic functionality level, national roaming depends on the same functionality as international roaming. However, a number of challenges have been identified that would need to be overcome in national roaming that are not applicable in the other cases. The primary challenges that have been identified are:

- increased scale of national roaming which will affect a large proportion of subscribers on a day-to-day basis, unlike international roaming
- possibility of network contagion should a network fail
- need to ensure the transfer of billing data between operators in a timely fashion to meet national requirements
- increased customer experience expectations in a national context compared to international roaming. Users may expect a higher service transparency level, which may lead to greater numbers of requests for customer support.
- need to maximise time on the home network to minimise roaming outpayments and to ensure subscribers enjoy the highest level of user experience as often as possible; this issue is not generally encountered in international roaming
- impact on some tariff packages (e.g. family group calls) that are predicated on operator costs being kept low due to the exclusive use of the home network
- international roaming is a mutually advantageous agreement between between PLMNs for their joint advantage. This will not necessarily be the case for national roaming and may affect whether national roaming agreement service levels are honoured.
5 Quantification of the costs of introducing national roaming

5.1 Introduction

In this section we identify and estimate the key capital and operational expenditure associated with an MNO upgrading its network and associated support systems to provide national roaming services. Indeed, gaining an understanding of the costs of implementing a national roaming framework in the UK is a vitally important part of the overall study.

We have assimilated responses received from two stakeholders and highlighted key issues raised that are likely to have additional cost implications. In addition, we seek to put these costs in perspective by comparing them with overall expected capital expenditures by UK MNOs.

5.2 Summary of elements affected

Broadly, the following elements of an MNO's infrastructure (network and support systems) will have additional cost items associated with an implement of national roaming:

- radio access network elements (BTS, BSC, Node-B, RNC)
- core network elements (MSC/MSC-S, SGSN, GGSN, HLR/AuC/HSS)
- base station backhaul network
- signalling transfer point
- core transport network
- customer and interconnect billing systems
- intelligent network (IN) platform
- other VAS platforms
- BSS and OSS systems.

In addition, we have considered the following issues, identified by the respondents, as having additional cost implications in the implementation of national roaming:

- **service transparency** – costs associated with the development, integration and testing of the national roaming solution to ensure the transparency of services
- **customer support** – extra customer support to address service issues during the implementation and ongoing support phases
- **location information exchange** – development to enable the exchange of location information (e.g. for emergency services) between operators
- **national roaming implementation** – the process of activating national roaming for the customer base (e.g. managing OTA updates and education of staff and customers)
- **billing system integration** – including the development of a non-TAP-based interconnect billing solution
• **call handover during call** – setting up the environment with the roaming partner to facilitate in-call handover

• **contagion** – additional capacity to mitigate the impact of a large sudden influx of roamers in the event of the failure of another network

If considering the solution by purely taking respondents’ views into account then all the above issues need to be taken into account. However, if it is accepted that it may be possible to accommodate a degree of compromise on some of these requirements, then the list of cost-incurring activities is reduced. This would result in the following changes to the above list:

• **service transparency** – a sub-set of development and integration would be identified as critical to addressing the major usability and support requiring issues likely to be encountered, rather than ensuring full transparency of all services

• **customer support** – support required may actually be greater than for ‘ideal’ implementation scenario

• **location information exchange** – assume that existing mechanisms are sufficient so no further investment is required. Note that the specific requirements of security organisations have not been considered in this study.

• **national roaming implementation** – assume that this is unchanged from the case above

• **billing system integration** – if it is assumed that TAP records and specific national roaming processes could meet requirements, development is likely to be reduced

• **call handover during call** – technical difficulties highlighted suggest that it is unlikely that this would be implemented

• **contagion** – while this could still be an issue, the capacity required to mitigate contagion would be so great that it could not be considered in a reduced list of costs.

### 5.3 Cost assessment

#### 5.3.1 Capex verification

Our assessment of responses suggests that a reasonable estimate for MNO capex for the implementation of national roaming is in the region of GBP10 million based on the cost categories in Section 5.2 and the costs for an MVNO are in the region of GBP1 million. However, given the indicative nature of the assessment, these figures should be considered to be high-level approximations rather than precise figures. In this context, the MNO and MVNO estimates provided by questionnaire respondents are of the order of magnitude that we would expect.

#### 5.3.2 Estimated cost of additional cost elements

In Section 5.2, a number of elements were identified that could incur additional cost above the standard implementation costs identified in this section. Figure 5.1 summarises Analysys Mason’s...
assessment of possible costs. These figures are based on our extensive experience of mobile networks, but nonetheless they are indicative estimates rather than the precise result of detailed analysis.

<table>
<thead>
<tr>
<th>Element</th>
<th>Analysys Mason estimated cost per MNO (GBP)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service transparency</td>
<td>2 million</td>
<td>To provide service transparency for key elements to limit support required to address customer issues and to provide an acceptable customer experience. This will require co-ordination with the other network operators. If a high level of service transparency was to be introduced, then the required investment could be in excess of GBP10 million per MNO.</td>
</tr>
<tr>
<td>Customer support</td>
<td>300 000 per annum</td>
<td>Assuming in the order of an additional 6 full time equivalents would be required to address national roaming related issues.</td>
</tr>
<tr>
<td>Location information exchange</td>
<td>Not required</td>
<td>Assuming existing mechanisms are acceptable. Note that the specific requirements of security organisations have not been considered in this study.</td>
</tr>
<tr>
<td>National roaming implementation phase</td>
<td>1 million</td>
<td>Included implementing the process plus any systems to support OTA updates to support the introduction of international roaming.</td>
</tr>
<tr>
<td>Call handover</td>
<td>Not quantified</td>
<td>Assumed that this will be too complex to implement, but it is likely that it would result in costs being significantly higher.</td>
</tr>
<tr>
<td>Contagion</td>
<td>Not quantified</td>
<td>Implementation would increase costs even more significantly and it is likely that it would be deemed too costly to implement although the absence of a way to combat contagion may have implications regarding Critical Network Infrastructure.</td>
</tr>
</tbody>
</table>

Figure 5.1: Additional national roaming cost element Analysys Mason cost estimates (per MNO)
(Source: Analysys Mason)

An additional GBP3.4 million of costs have been identified here related to a pragmatic implementation. It can be seen that if this figure is added to the revised capex requirement figure, total capex is just over GBP13 million. Any implementation that attempted to address all requirements and concerns raised by respondents in full would be prohibitively costly.

5.3.3 Cost implications of national roaming on a regional basis

As an alternative to nationwide national roaming, the implementation of national roaming only in certain types of area or certain regions may be considered. This will lead to a reduction in costs in the following areas that will be directly related to the number of base stations and expected roaming subscriber numbers in the national roaming area:

- BTS/Node B/BSC/RNC
- MSC/MSC-S
- SGSN/GGSN
- IN/prepaid
- STP
- core transport network
- implementation support
- ongoing customer support.

However, the following elements will be less related to capacity issues and the majority of costs will be incurred regardless of the scale of roaming.

- billing system upgrade
- interconnect billing system upgrade
- service transparency development and integration.

As such, and on the basis of the cost estimates in the report, a regional implementation of national roaming would lead to some degree of reduction in around 70% of the projected implementation costs (which are estimated at around GBP13-14 million). The exact level of reduction will depend on the extent of the regional roaming solution. The remaining 30% of projected implementation costs would be incurred regardless of whether the implementation was on a national basis or not.

5.4 High-level financial results

In this section, we will first compare the stated national roaming capital expenditure requirements of the MNO/MVNO with the total capex budgets of UK MNOs. Next, we will provide high-level revenue projections for national roaming in the UK mobile market as a whole. This assumes that the increased coverage introduced by national roaming will result in calls being made that result in additional revenue that would not previous have occurred.

5.4.1 Comparison with total capital expenditure budgets

In order to put these stated capex numbers into perspective, we have carried out a comparison with the overall capital expenditure of different MNOs in the UK, as shown in Figure 5.2 below. As shown, UK MNOs incur an average quarterly capex spend of GBP80 million – this translates to an annual spend of roughly GBP320 million.
Hence, the capex invested by an average MNO to prepare its infrastructure for national roaming would equate to approximately 15% quarterly capex and 3.8% of annual capex. Similarly, the capex invested by an MVNO to prepare its infrastructure for national roaming is approximately 1.25% and 0.3% of the average UK MNOs overall quarterly and annual capex respectively. These are shown in Figure 5.3 and Figure 5.4.
5.4.2 High-level national roaming revenue projections

We have also developed high-level projections for incremental revenue from national roaming in the UK mobile market, as shown in Figure 5.5. Between 2011 and 2015, we project revenues to increase from GBP1.35 million to GBP2.05 million at a CAGR of 12%. It must be noted that we have assumed a phased implementation of national roaming over the duration of the forecast, which partially accounts for the high growth in revenues. It assumes that the addressable market of roamers is equivalent to 1% of the customer base and the market of roaming customers starts at 75% of the addressable market rising to 95% of the addressable market by 2015.

Finally, assuming a constant EBITDA margin of 36%, EBITDA will increase from GBP486 000 in 2011 to GBP736 000 in 2015.
5.4.3 Analysis of return on invested capital

With the stated capex requirement of GBP13-14 million and GBP1 million by the MNO and MVNO respectively, as well as the projected EBITDA (as shown in Figure 5.5), we expect a negative return on invested capital (RoIC) for each of years from 2011–2015 for both the MNO and MVNO.

Indeed, taking our EBITDA projections into consideration, we anticipate a positive RoIC by 2015 only if MNO capex is restricted to GBP1.35 million. Similarly, MVNOs can expect to see a positive RoIC by 2015, if MVNO capex is restricted to GBP300 000.
5.5 Conclusions from cost analysis

The limited response that we have had from the respondents in the area of cost of implementation makes it difficult to provide a reliable analysis of the costs involved. The costs provided in the context of overall capital expenditure, do not appear unduly prohibitive. However, it appears that the costs are provided are likely to be significantly below that required to meet the requirements of a solution that addresses the key issues identified by respondents in Section 4 – (e.g. full service transparency, in-call handover, contagion avoidance etc.).

If we introduce national roaming with a reduced service capability as identified in our analysis in Section 4.9.2 then it should be possible to keep capital expenditure below GBP15 million per MNO. However, if issues such as full service transparency and in-call handover where to be introduced, then the costs per operator will be significantly higher. If the issue of contagion on network failure were to be addressed then this figure would be much greater than this.
6 Commercial and regulatory issues and impacts of national roaming

6.1 Introduction

While the focus of the study has been on technical issues, a number of commercial and regulatory issues have been raised by questionnaire respondents which are summarised in this section under the following headings:

- commercial issues
- regulatory issues
- tariff-related issues
- wholesale customers and MVNOs
- reasons for non-deployment to date.

6.2 Commercial issues

Summary of responses

While no single issue dominated the responses, a number of views/concerns were expressed that will need due consideration:

- The need for cooperation between operators to allow for a speedy exchange of planned capacity requirements, actual usage data and billing records.
- The concern that bi-directional national roaming could lead to a difference in the net balance of payments for operators, effectively allowing certain operators to subsidise their network expansions plans.
- The concern that national roaming will introduce incremental costs, but little incremental revenues since post-paid customers is likely to remain within their usage allowance.
- The concern that a national roaming framework may not address the issue of rural coverage since these areas are not covered by any of the operators. The respondents supported this argument by citing Ofcom’s own research in this area.
6.3 Regulatory issues

Summary of responses

The key regulatory concern expressed by operators was the need to ensure that no anti-competitive practices are allowed in the market. The process for negotiating roaming agreements must be fair and open to all operators under the same terms. Operators generally felt competition law considerations will have an important role to play. In addition, a slew of minor issues ranging from the implementation of data charging transparency measures, compliance with the Disability Discrimination Act and continued Ofcom legislation on current spectrum licence arrangements were raised.

6.4 Tariff-related issues

Summary of responses

There was general consensus that higher national roaming retail rates might not be feasible from the perspective of consumer expectations. Consumers expect to pay higher rates when roaming abroad, but this may not be acceptable within a national roaming scenario. Most players have urged that roaming rates be kept as close to regular ‘on-net’ rates as possible to meet consumer expectations. In addition, operators will need to implement expensive SMS home routing solutions to ensure they accrue inbound SMS interconnect revenue.

6.5 Wholesale customers and MVNOs

Summary of responses

There is a general concern that wholesale customers of MNOs will lose their inbound interconnection revenue when their subscribers are roaming onto other networks. This may necessitate the re-negotiation of existing contracts since wholesale airtime costs are established by taking inbound revenues into account. Inbound revenues will effectively be reduced if a roaming rate has to be paid out if a subscriber receiving a call is roaming on another network when the call comes in. Another concern raised was that MVNOs might have no visibility on when their subscribers roam onto alternate networks, which will complicate the settlement of wholesale airtime bills.
6.6 Reasons for non-deployment to date

Summary of responses

Operators generally felt that their competitive advantage resulting from superior quality and footprint of network coverage, would be undermined by the implementation of a national roaming solution. Operators pointed out that customers of all operators would effectively have nation-wide coverage, in spite of differences in the scale of each network operator’s network deployment. In addition, operators pointed out the potentially long duration and complexity involved in the commercial negotiation of national roaming agreements as being an additional barrier.

6.7 Existing national roaming

Summary of responses

Concerns have been raised about the impact of existing national roaming agreements such as those between 3UK and Orange and C&W and Orange. An existing national roaming operator would need to set up a separate roaming relationship with a second MNO, if it considered that it would benefit from such an arrangement. Due to the way national roaming needs to be set up and in particular the need for control from the handset, it will not be possible for existing national roaming operators to take advantage of national roaming between MNOs through their existing national roaming partner.

Therefore the adoption of national roaming between MNOs would add an additional layer of complexity for them, if they wished to take advantage of it. It may impact on existing implementations and agreements in areas such as ensuring: (a) call/message handling is consistent across all roaming MNOs, (b) SLAs/KPIs with operators are not threatened by the additional MNO roaming, and (c) contractual clauses relating to coverage guarantees and service non-discrimination are adhered to.

In addition, new propositions developed by the existing national roaming operator in an MNO national roaming environment could lead to bigger resource, cost and complexity overheads.
7 National roaming case studies

7.1 Introduction

We have selected three countries that have implemented national roaming for very different reasons:

- **France** – implemented to address ‘not spot’ issues in rural areas
- **The Netherlands** – used to facilitate network migration and enable national coverage for low-power GSM operators
- **Cyprus** – to enable the second mobile network operator to increase its coverage footprint to compete with the incumbent.

7.2 France

*2G national roaming was extensively used in the large-scale ‘not spot programme’*

2G mobile services were launched in France in 1992. In 2003 on the sole basis of market forces, 2G network covered around 90%\(^1\) of the population. However, ‘not-spots’\(^2\) with no mobile coverage remained over the French territory. In order to bridge this ‘digital divide’, French local authorities and the Government initiated a programme called the “*Le programme de zone blanches*”. This programme aimed to significantly increase the coverage of the rural population over the following few years on the basis of network sharing (including national roaming).

In July 2003, it was announced that Phase 1 of this programme was to cover around 1800 villages, with 1250 cell sites. This phase of the programme included a EUR44 million subsidy. In July 2004, the ‘not spot programme’ was extended to a second phase with around 1250 additional villages, with 930 cell sites. However, this extension was financed solely by the operators, with no public subsidies. Approximately 350 villages were later added to the programme in 2008 (Phase 2+). As a whole, the ‘not spot programme’ now encompasses around 3400 villages. The network sharing in the ‘not spot programme’ was implemented mainly on the basis of national roaming, as around two thirds of the sites use this sharing option. The remaining third uses passive sharing, with either mast sharing or site sharing. Figure 7.1 shows the split by sharing option.

\(^1\) Source: ARCEP annual report 2003

\(^2\) Such “not spots” are called in French “zones blanches”, which translates as “white areas”.
By June 2009, the ‘not spot programme’ had largely been completed with around 3000 sites deployed. Official plans are that around 3300 sites will be deployed by end 2010, with the remaining 100 by end 2011.

3G mobile services were commercially launched by Orange and SFR at the end of 2004. Bouygues Telecom launched 3G at the end of 2007. However, 3G coverage has remained significantly below 2G coverage (around 80-90% 3G population coverage vs 99.8% 2G population coverage in end 2009).

In 2008, regulatory and technological enablers were made available to industry players to increase their population coverage. Among these elements, the most important were:

- 2G spectrum re-farming (i.e. 3G services in the 900MHz bandwidth) – this had been made possible by ARCEP in early 2008
- single share, i.e. 2G site re-use for 3G (including collocation, replacement of amortised site equipment etc.)
- active and passive network sharing (including national roaming) – this has been possible since 2001, and ARCEP has been favourable to national roaming since then.
However, only passive network sharing was widely used\(^3\) and to a lesser extent single share and 2G refarming. In particular, active sharing was not used at all, neither in the form of national roaming nor in the form of active radio equipment sharing, even though this has been allowed since 2001. This resulted in 3G population coverage remaining low compared to 2G, and there were large areas not covered by 3G (‘3G not-spots’). It seemed unlikely to ARCEP that market players could comply with their coverage obligations\(^4\) by 2009/2010.

In late 2008, in an attempt to boost 3G coverage, the government passed a law\(^5\), which, among other things, gave ARCEP the powers to set the conditions of 3G infrastructure sharing.

ARCEP then opened a public consultation about 3G infrastructure sharing and received as main comments:

- depending on the area (whether 3G had been rolled-out by an operator already or not), network sharing may be of interest to market players
- an inter-operator agreement is a more flexible option than regulatory obligations.

Following this consultation, ARCEP threatened to impose the conditions of 3G sharing if an agreement between players could not be reached within the following nine months\(^6\). The agreement should at least cover the geographical areas where further sharing was to occur, as well as the technical conditions for network sharing. ARCEP also imposed a process (including a technical trial), interim deadlines for the closing of the agreement, and criteria to be used when setting the areas where sharing was to occur.

A few days before the deadline for closing the agreement, ARCEP ordered Orange and SFR to comply with their licence coverage obligations. This added to the pressure for the closing of a deal, as this deal could potentially allow them to meet their coverage requirements (as coverage achieved through active radio equipment sharing can be included in the operator effective coverage weighed against the coverage obligations, whereas coverage achieved through national roaming cannot be included in the effective coverage).

As a result, an undisclosed framework agreement for 3G network sharing was signed between market players in February 2010. As part of this framework, network sharing will be implemented in around 3600 villages, including all the villages of the 2G ‘not spot programme’. However, the number of sites involved are not specified or the role each active network sharing option will play against passive sharing. An ARCEP press release, however, mentions that 3G sharing will significantly re-use 2G infrastructure, and will facilitate and speed up the expansion of 3G

\(^3\) 40% of Orange sites, as well as 16% of SFR sites were shared with another mobile operator
\(^4\) SFR was to reach 99.3\% by August 2009, Orange 98\% by August 2009 and Bouygues Telecom 75\% by December 2010
\(^5\) The Law for the Modernisation of the Economy (LME)
\(^6\) The deadline for reaching an agreement was 31 December, 2009
coverage in France. It can be assumed that, as with 2G network sharing, national roaming will be used, but only when active radio equipment sharing is impossible.

ARCEP allowed 3G national roaming in 2001. However, as operators were not implementing 3G national roaming, ARCEP gave preference to leveraging the operators’ failure to comply with their coverage obligations rather than imposing national roaming obligations.

**National roaming in France is not a seamless service**

National roaming in France has been based on operators working co-operatively to provide solutions in previously uncovered areas. Therefore, none of the potential planning difficulties of introducing national roaming in areas where MNOs substantially have coverage have been encountered.

A publication from Association Francaise des Operateurs Mobiles (AFOM)\(^7\) published in March 2009 indicates:

- access to short codes (e.g. voice mail) is available while roaming
- while voice and SMS is available, data services are not, although testing was in progress (as of March 2009)
- in-call handover is not supported
- a code indicating the MCC and MNC numbers or the name ‘contact’ (denoting the roaming service) appears on the handset
- the billing to the subscriber is at the same rate as for calls on their own network
- difficulties are experienced in making calls at boundary areas between roaming and own network areas. It is suggested that manual search is used.

This indicates that it is possible to implement a national roaming solution without the subscriber experience matching that available on the home network. However, the fact that the AFOM publication was necessary several years after its introduction suggests that there is possibly still some confusion about the service. It is notable that the service does not differentiate between the home network tariffs and roaming tariffs, which is probably the most problematical potential problem area for the customer experience.

### 7.3 The Netherlands

The Netherlands has three MNOs, KPN Mobile, T-Mobile and Vodafone. Each of the three MNOs has achieved over 99% 2G coverage and over 90% 3G coverage. National roaming has been used to facilitate subscriber migration from one network to another and to allow low-power DECT guard band operators to gain national coverage.

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\(^7\) “Le fonctionnement de mon mobile en itinérance locale” AFOM March 2009
National roaming to facilitate network migration

There have been examples in the Netherlands of national roaming being used to facilitate subscriber migration from one network to another.

- In 2007, KPN used national roaming to allow integration of its newly acquired Telfort (initially a joint venture between BT and the Dutch Railways) subscribers.
- The MVNO Rabo Mobiel used national roaming while switching from Orange to KPN as its host MNO.
- In 2008, T-Mobile Netherlands migrated subscribers of the recently acquired Orange Netherlands to its network.

► Orange to T-Mobile migration using national roaming

T-Mobile Netherlands wished to migrate all the subscribers of its new acquisition, Orange Netherlands, to enable it to turn off the Orange network. It immediately started a project to enable Orange subscribers roam on the T-Mobile’s network. The project encountered a number of operational challenges that had to be addressed during the project as detailed in Figure 7.2.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-Mobile Netherlands network needed to be removed from the ‘forbidden list’ in the end-user's hand set</td>
<td>This was done either via OTA, or manually. Depending on the age and type of the handset, receiving an OTA message was either invisible to subscriber, or was in the form of an SMS. The disadvantage of OTA was that the handset had to be switched on to be able to receive the message, and that the handset had to be restarted for the message to become effective. Alternatively, network selection was done manually, but that required that the end users gained access to the national roaming network beforehand.</td>
</tr>
<tr>
<td>Informing the subscriber appropriately</td>
<td>A specific communication plan was adhered including the following aspects: All client communication used the term ‘network improvement’ instead of national roaming, to increase acceptance and understanding. A website provided more explanation, including a link to a tool that explained to subscribers how to do a manual network selection, and how to switch back to automatic network selection. Adaptation of the prepaid platform: prepaid handsets are more likely to be switched off for long durations. Therefore, a message had been added to the IVR for voicemail and prepaid top-ups to ask subscribers to leave their handset on as much as possible. Subscribers received a letter to announce the ‘network improvement’, and inform them of the fact that they will see another network name, that the only thing they have to do is switch on and off their handset, and to contact Orange if anything goes wrong. If the OTA message was not received, or if a subscriber could not be tracked on the new network, then he/she would receive an SMS with a request to do a manual network selection. A freephone number was opened to answer questions. If a client, after having been sent multiple text messages to request him to do</td>
</tr>
<tr>
<td>Issue</td>
<td>Approach</td>
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<tr>
<td>Preventing switchover overload on subscriber service functions</td>
<td>Switchover was arranged in a staggered fashion to ensure that the support organisations would be able to handle the expected number of subscriber queries.</td>
</tr>
</tbody>
</table>
| Managing communication with subscribers                              | A dedicated data based to keep track of subscriber status was required, keeping track of questions such as:  
  - has the SIM received an OTA message?  
  - can it already switch to T-Mobile?  
  - can it still access the Orange network?  
  - has this subscriber already received the notification letter?  
  The database was also designed to allow the customer service environment to see if any complaints were related to the Orange or T-Mobile network.                                                                                                                                   |
| Support of Orange’s services on the T-Mobile network                 | Where possible the services of Orange’s subscribers were replicated on the T-Mobile network to ensure continuity of service is provided to the subscribers (e.g. mobile TV).                                                                                                                                                                                      |
| Billing process has to be adapted to avoid the subscriber under or overpaying | Development and processes put in place to ensure billing was implemented correctly to take account of the changeover.                                                                                                                                                                                                                                                                 |

Figure 7.2: T-Mobile/Orange Netherlands national roaming challenges [Source: Telecommagazine 3, April 2009]

National roaming has allowed ‘low-power’ operators to gain national coverage

A key development in the Dutch market has been the fact that operators can offer low-power GSM services in the 1800MHz DECT guard band, without the need for a licence. The DECT guard band was historically left unused in Europe to prevent interference between GSM and DECT. Technology improvements have made the existence of a guard band unnecessary, so the Department of Telecommunications and Energy of the Dutch Ministry of Economic Affairs has allowed the opening up of this band for low-power usage, with a minimum of regulatory requirements, to stimulate competition and innovation.

This has led to roaming agreements in the Dutch market between ‘low-power’ operators and MVNOs/ MVNEs. This addressed one of the big issues facing operators in the low-power GSM bands in the UK where a lack of roaming agreements with macro mobile operators has meant they cannot achieve national coverage. This has prevented low-power GSM operators from providing its subscribers with universal mobile coverage, thus impacting subscriber take-up.

The provision of licence-free low-power GSM services in the Netherlands has also allowed existing operators to augment their existing coverage with ‘indoor’ coverage that is cheaper and

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Ref: 16847-306

8 Zorgeloos overstappen met national roaming “by Door Hans van der Laan (Telecommagazine 3, April 2009)
provides for better reception, by allowing subscribers on the low-power GSM network to roam onto the macro GSM network and vice-versa.

► Launch of fixed/mobile converged MVNO

In March 2010, Teleena⁹, an existing MVNE operating on Vodafone’s Dutch network, launched the first true fixed/mobile converged MVNO (VastMobiel) in the Dutch market. By using Teleena’s picocells¹⁰, VastMobiel aims to provide optimum indoor coverage at a lower cost (20% – 30% reduction in costs) for small and mid-sized companies. A gradual phasing out of fixed-line infrastructure (PSTN/ISDN/VOIP/DECT) is expected to take place once the VastMobiel solution is in place.

The technical solution is provided by Teleena and makes use of the 1800MHz DECT Guard Band and picocells. All mobile calls, SMSs and data sessions from the ‘indoor’ location are routed via the picocell over IP to the core network of Teleena. When the subscriber leaves the office and the picocell coverage, the SIM switches automatically back to its national public GSM/UMTS access network and vice versa. The indoor subscriber can phase out all fixed line infrastructure whilst retaining normal numbering plans.

7.4 Cyprus

National Roaming was introduced to establish competition

Until 2004, Cyprus had a monopolistic network operator wholly owned by the state. At the end of 2002 the government introduced legislation to abolish the monopoly regime and provided the Office of the Commissioner of Telecommunications and Postal Regulation (OCTPR) with a legal basis to liberalise the telecommunications market. The OCTPR has since been renamed the Office of the Commissioner of Electronic Communications and Postal Regulation (OCECPR).

The incumbent CYTA provides 2G and 3G services within Cyprus. In December 2003 the government auctioned a second mobile licence which was acquired by Areeba for CYP12.75 million (around GBP18.5 million), allowing the establishment of 2G and 3G services which were launched in 2004. Areeba was subsequently sold to MTN in 2006¹¹. Under the terms of the second mobile licence, the holder was required to achieve 50% geographical 2G coverage by the end of 2005, 75% by end of 2007 and 60% 3G coverage by 2014. To be able to offer a national service it is permitted to use CYTA’s network for national roaming.

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⁹ Teleena operates a next generation mobile core network with full control over quality and service development. We offer sophisticated services such as GSM calling via Wi-Fi, smart roaming, mobile payment and content access

¹⁰ Picocells are small private GSM cells for indoor usage. All GSM 1800 MHz devices and phones are supported without the need of installing software

In response to the arrival of a competitor, CYTA developed a marketing relationship with Vodafone and rebranded itself to become Cytamobile-Vodafone in 2004, for the sale of mobile services, accompanied by a significant reduction in call rates. However in July 2005 the OCECPR ordered it to increase its tariffs as it was deterring competition. At present Cyprus still has amongst the lowest rates for mobile telephony in Europe\(^\text{12}\). This has led to complaints to the OCECPR by MTN of predatory pricing\(^\text{13}\).

MTN experienced difficulties in meeting its original coverage targets, citing problems in obtaining planning permission as the primary source of delays. Prior to 2003, no planning licences were required enabling CYTA to quickly build out its network and establish a good level of coverage. After that date, though, the erection of masts and antennas required permission from planning authorities under the relevant town and country planning regulations, together with a building permit from the designated planning authority. Of the 84 applications filed by CYTA for permits between September 2004 and November 2006, only three were granted\(^\text{14}\).

MTN faced similar problems in obtaining permits for new sites but was able to fall back on site sharing with existing CYTA sites. Even so, this may have compromised MTN’s radio planning to some extent.

The following picture shows the current situation as published by MTN.

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\(^{12}\) Source: EU, 13\(^{th}\) Implementation report on Telecommunications. Ranking Cyprus amongst the fifth cheapest countries in Europe for mobile telephony.

\(^{13}\) Source: A letter to the OCECPR dated 8\(^{th}\) September 2008 by Bassel Jamaledidine, MTN CEO.

\(^{14}\) Source: GSM Association
The national roaming agreement however, only includes GSM voice and SMS services. MTN subscribers are not able to use data services or MMS outside of MTN service areas. 3G data is also not available when roaming.

**CYTA remains dominant in the Cyprus market**

3G adoption in Cyprus is still in its infancy although mobile penetration stands at around 127% of the population and is continuing to grow. There are currently around 1.2 million mobile subscriptions in Cyprus, although the high penetration is partly explained by additional subscriptions amongst the population of Northern Cyprus (which is considered outside of the territory).

![Figure 7.4: Mobile penetration in Cyprus](source: Telegeography)

Unfortunately the growth in subscriber numbers not translated into gains for MTN. The following chart shows the split in the market between the two operators. In September 2009 MTN had only 18% of the market.
It is believed that the weak uptake in MTN services is a result of quality of service problems and poor MTN coverage. Subscribers report frequent call drops both inside MTNs coverage area and when roaming onto CYTA network.

In the case of Cyprus, the positive effect of national roaming on levels of competition is yet to be seen. The market continues to be dominated by the incumbent. Low retail pricing and high national roaming rates act as a significant barrier to MTN gaining market share because it is not able to discount to the extent that would drive subscriber uptake. Continuing problems obtaining planning consent prevent MTN from building out its own network. However, there are signs that the EU is beginning to putting pressure on the OCECPR and this may start to have an impact over the coming months.
8 Project conclusions

The responses to the study questionnaire were focused predominantly on the difficulties of introducing national roaming to the UK, with one or two exceptions. This emphasis on the obstacles to deployment may be explained to some extent by the questionnaire’s focus on exploring potential problem areas, but there was a clear and consistent theme to the responses, and most especially from the MNOs, that the main players in the market are unconvinced by the introduction of national roaming.

Different players raised different points to substantiate this opposition, but the most significant points related to the critical issues of service transparency and in-call handover, which respondents consider difficult if not impossible to implement in a way that would provide acceptable quality of service.

Nonetheless, we consider that it may be possible, by making some compromises, to implement an acceptable form of national roaming. This could be a service that offers subscribers some coverage benefits, but with a reduced level of service compared to their home MNO. It will need to be considered further whether the service restrictions and coverage benefits warrant the introduction of national roaming. However, this is unlikely to be justifiable on a purely commercial basis.

8.1.1 Summary of key technical findings

The questionnaire responses indicated that the following technical areas were of central importance to respondents and would be particularly challenging to address:

- ‘all-to-all’ roaming between operators
- risk of network contagion (where the failure of one network caused failure that would lead to the failure of other networks in a ‘domino effect’)
- in-call handover
- complete transparency or seamlessness of service
- billing environment
- maximisation of time connected to the home network (to minimise roaming costs and/or ensure the subscriber can use full network features for as great a time as possible, which needs to be traded against customer experience and handset battery life impacts).

Analysys Mason considers that fully addressing the first four areas identified above would constitute a serious barrier to national roaming implementation. Even if technically possible, ‘all-to-all’ roaming, in-call handover and complete transparency of service would probably need levels of operator co-operation that would impinge on their ability to compete and differentiate themselves. We think that the implementation of a suitable billing environment could be achieved more easily than some respondents suggested and a compromise can be reached on maximising the time on the home network.
However, if the requirement for in-call handover is removed and there is relaxation in the need for service transparency, then a workable solution seems attainable. We consider that national roaming could be considered for basic voice services. However, it still needs to be established whether the coverage benefits justify the development of even a reduced form of national roaming. There are also question marks as to whether coverage benefits would outweigh compromises in the customer experience (including the absence of data services) that a viable form of roaming could involve. In addition, further investigation is needed into the risk of network contagion as it could potentially represent a serious barrier to the introduction of national roaming and potentially compromise compliance with Critical National Infrastructure requirements.

The study has focused on using national roaming to address both relatively large areas of non-coverage (or ‘macro-not-spots’), and also relatively small areas of non-coverage (or ‘micro-not-spots’). Such ‘micro-not-spots’ may be areas that do not even show as uncovered areas in the MNO’s coverage maps (such as specific rooms in a house).

We think it should also be considered whether the approach should be to focus only on ‘macro-not-spot’ roaming, where there are known and significant operator not-spots, rather than universal national roaming. This will potentially save money for one operator in one area and another operator in another area, while decreasing some of the operational challenges. Any aggregate money saved by the operators could be used to fund ‘not-spots’ where there are no operators at all (e.g. in remote areas).

8.1.2 Summary of key cost findings

The questionnaire also sought to explore the expected cost implications of introducing national roaming. Responses to this part of the questionnaire were disappointing with only one MNO and one MVNO responding. However, using the responses as a base, our analysis suggest that – if in-call handover and full service transparency were excluded – a national roaming solution could be achieved for a capital investment of under GBP15 million per MNO. However, if in-call handover and full service transparency were considered indispensable requirements, we estimate that implementation costs would be tens of millions of pounds (in addition to the implementation challenges). Addressing the issue of network contagion (by adding significant additional capacity to each network) could potentially costs hundreds of millions of pounds, which would be unrealistic.

We also assessed the potential for increased revenues that each operator could expect by effectively increasing the coverage of its network. It was clear that the investment in national roaming could not be justified purely on commercial grounds. (The investment would have to be no more than 10% of the expected required investment of GBP13-14 million for national roaming would make any sort of return within five years of investment.)
8.2 Overall conclusion

Our research suggests that a seamless national roaming solution that effectively allows all UK networks to inter-operate seamlessly to provide a service that maximises coverage and appears to the subscriber as a single network is not technically feasible.

However, if compromises are made, it could be feasible for a form of national roaming to be used in such a way that increases coverage for subscribers, but with some service limitations in roaming areas. However, there remain major doubts over whether the likely limited coverage benefits justify the introduction of a limited service which would be likely to compromise the customer experience. There was strong opposition from the MNO community to deploying a national roaming solution that reduces the level of customer experience.

One approach that could be worthy of further investigation is to focus national roaming on ‘macro not-spots’ where no operators currently have coverage, but a benefit of providing coverage can be demonstrated.

Our analysis suggests that the introduction of national roaming will not provide a commercial return for MNOs in either case.
Annex A: Study Questionnaire

In the following pages we reproduce the questionnaire used in this study.
1.1 Introduction

Analysys Mason has been engaged by Ofcom to conduct an investigation into the technical feasibility and associated cost and commercial implications of introducing regional or national roaming for mobile voice and data services in the UK. The notional objective of introducing roaming is to increase the effective service coverage for all UK mobile service subscribers, that is, to increase the availability of services if a subscriber is located in a coverage ‘not spot’ of their home mobile network operator (MNO).

At this stage, Ofcom is simply gathering information on the technical and commercial feasibility and costs associated with national roaming. Currently, Ofcom does not have any plans to mandate the introduction of universal national roaming for the purpose of increasing effective coverage or to place other associated requirements on UK MNOs/other affected parties. This project is part of a wider study regarding mobile coverage.

1.2 Instructions

To support the investigation, this questionnaire is being issued to MNOs, mobile virtual network operators (MVNOs), infrastructure suppliers and handset suppliers to solicit their views on the technical, implementation, operational, commercial and cost implications of introducing national roaming. We would appreciate it if you could complete the questions below as fully as you can. We recognise that you may not be in a position to provide full answers to all of the questions, however any relevant information or view that you can provide will be greatly appreciated. In addition, if you are unable to answer particular questions directly, but feel that you have relevant information that would be of interest to the investigation, please feel free to include it.

Please annotate an electronic copy of this document, giving your responses to each question in the space provided, and return it to Rod Parker at Analysys Mason via email at rod.parker@analysysmason.com by close of business 17 March 2010.

There is no limit to the number of words used. Please refer to any additional supporting documents in your response and email electronic copies of these supporting documents to along with the completed questionnaire to Rod Parker at Analysys Mason.

If you would prefer to answer the questions verbally via telephone, then we will be pleased to accommodate that request. Please contact Rod Parker at Analysys Mason via email to arrange this.
If there are any other queries regarding this questionnaire or study please contact Rod Parker at Analysys Mason by e-mail.

In anticipation, thank you very much for your contribution to this study.

1.3 Confidentiality

Note that the responses to the questions below will be treated as commercially sensitive and will not be shared with any third party other than Ofcom. In addition, Ofcom has agreed that participants can complete the questionnaire and remain anonymous to Ofcom if they wish. Analysys Mason will ensure that participants will remain anonymous to Ofcom and all other third parties. Please check the box below to indicate that you wish to remain totally anonymous:

☐ I wish to remain anonymous to Ofcom as well as other third parties

In addition, Ofcom has agreed that a summary of the project’s conclusions and their qualification can be made available to all participants. Note that for commercial reasons, details of the participants’ responses to the questions below will not be made available. Please check the box if you wish to receive a summary of the project’s conclusions:

☐ I would like to receive a summary of the project’s conclusions

1.4 Questionnaire

Technical and operational challenges

1. From the perspective of an MNO providing national roaming to subscribers of other UK MNOs, what would you consider are the most significant technical, implementation and operational challenges in introducing national roaming for voice and data services?

Response:


2. From the perspective of an MNO requiring national roaming for its subscribers on other UK MNO networks, what would you consider are the most significant technical, implementation and operational challenges, considering both voice and data services?

Response:


3. Please explain any technical and operational challenges that national roaming will introduce that are in addition to those experienced in supporting international roaming.

Response:

4. When a subscriber is located in a home network ‘not spot’, please provide your view on what the preferred selection mechanism should be to select a roaming network, firstly assuming that existing handsets will be able to support roaming without upgrade and, secondly, assuming a handset is able to meet what you would consider to be the ideal selection requirements (within the limits of defined standards)?

Response:

5. What do you consider to be the maximum number of national roaming partners that can be supported by one operator taking into consideration the reasonable support of MVNOs and without the support of MVNOs?

Response:

6. Can an MNO providing national roaming, configure its network to prioritise its own subscribers’ voice and data traffic over that of roaming subscribers? If yes, please provide details of what level of prioritisation could be applied and how that might be implemented.

Response:

7. Please quantify any impact on the signalling network by introducing national roaming and, where relevant, provide estimates on the performance impact on elements affected e.g. the HLR/VLR/pre-paid platform.

Response:

8. Assuming that the introduction of national roaming could result in higher tariffs for subscribers and increased MNO operational expenditure for roaming calls/data sessions, what
mechanisms could be put in place to prevent a call/data session using a roaming network when the home network is available?

Response:

9. The MNO allowing its subscribers to roam nationally may wish to minimise the amount of time its subscribers spend on the roaming network in order to minimise any wholesale roaming costs. Similarly, the MNO allowing roaming may wish to minimise roaming to maximise network capacity available to its own subscribers. To facilitate this, is it possible to introduce in-call/data session hand-off between networks for subscribers that are moving from one cell to another, that is, between ‘not-spots’ and coverage areas, in order to minimise roaming? Please comment on the technical challenges of implementing this and the extent of any network performance impact that this may introduce.

Response:

10. Given that all operators already support international roaming and have associated billing systems and operational support processes in place, please detail any additional functionality, systems and processes, if any, that will need to be implemented to support national roaming.

Response:

11. In most roaming solutions, the interconnection between the home operator’s network and the roaming network is at the core network level. However, there are developing standards that would allow network interconnection at the Radio Network Controller (RNC) level such as the multi-operator core network (MOCN) feature. Do you believe such interconnections would make any difference to the challenges associated with national roaming? Please indicate whether you believe this would increase or decrease any technical issues and cost implications of introducing national roaming.

Response:

12. Please describe the technical and operational challenges in providing transparent services to subscribers, that is, the roaming subscriber enjoying the same services and quality for voice and data on the roaming network as they do on their home network.
13. Do you believe providing a totally transparent service is technically viable for voice or data services? Please explain your answer.

Response:

14. In the event of more than one roaming network being available in a home network ‘not spot’, what criteria can be used to select the roaming network to be used, and what mechanisms are available to control what criteria are used (e.g. handset settings, SIM settings, network settings etc.)?

Response:

15. Assuming that the agreed national roaming implementation results in roaming calls and data sessions being charged at a premium tariff, please describe possible solutions to advise the subscriber that they are about to use a roaming service before the subscriber incurs associated premium roaming charges. Please indicate if the solution depends on handset, SIM or network functionality.

Response:

16. Assuming that a solution to notify the subscriber that they are about to use a roaming service with an associated premium tariff before the premium charges are incurred can be implemented, can this solution be used during an in-call/data session network hand-off? If yes please explain how this could be achieved.

Response:

Costs

17. Can you provide a best estimate of the capital and operational costs (capex and opex) against each of the cost categories shown in Figure 6 below (i.e. the costs to upgrade the network and associated support systems for an MNO to be able to provide national roaming services). Please also provide a description of what will be covered by the cost in each category. We
consider it a vitally important part of the study to understand the costs of implementation, so we would appreciate it if you could provide as much cost information as possible.

**Response:**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description of upgrade/cost requirement</th>
<th>One-off upgrade capex (GBP)</th>
<th>Incremental capex per roaming subscriber (GBP)</th>
<th>Recurring annual opex (GBP)</th>
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<td>BTS</td>
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<td>Base station backhaul</td>
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<td>Others</td>
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*Figure 6: National roaming implementation costs*

**Commercial**

18. Please explain any commercial challenges that national roaming will introduce that are in addition to those experienced in supporting international roaming.
Response:

19. What do you believe are the key commercial implications, both benefits and challenges, related to national roaming? These may include, for example, the opportunity to offer increased coverage for subscribers, increased revenues through premium roaming charges, the complexity of retail and wholesale call charges and increased roaming opex.

Response:

20. Do you believe providing totally transparent voice and data services is imperative from a marketing/end-user experience perspective, and that it is commercially viable? Please explain your answer.

Response:

21. Please provide views as to how you would address any commercial challenges identified in Question 19, and explain whether, in general, benefits outweigh challenges or vice versa?

Response:

22. Do you believe that in-call/data session hand-off between networks is an important market/end-user requirement of a national roaming solution? Please give reasons for your answer.

Response:

Handsets

23. From a handset perspective, will it be possible to provide a transparent service, that is, is it technically possible to roam between networks without the subscriber knowing? Will this apply to all handsets currently in use in the UK and/or on your network, and if not, explain why this is the case. Please provide a view of the proportion of handsets in use that would be able to support transparent roaming.
24. What is your estimate of the proportion of handsets in use in the UK and/or on your network today that would support national roaming without an upgrade, and the proportion of those that can be upgraded to implement the ideal roaming network selection solution as described in Question 4 (assuming the remainder of handsets would not support national roaming)?

Response:

25. Will the introduction of national roaming cause a greater drain on mobile handset batteries? If yes, please explain why and quantify the impact, e.g. it will halve the time between charges.

Response:

General

26. Please state and provide any relevant supporting information regarding the top three reasons why you believe UK MNOs have not, to date, voluntarily introduced national roaming.

Response:

27. Do you believe there are any regulatory barriers to introducing national roaming e.g. the availability of mobile network codes (MNCs)? If yes, please provide your view on what regulatory changes need to occur to allow national roaming to be implemented.

Response:

28. Please provide any additional comments you would like to make with respect to this study.

Response:
Annex B: Summary of key GSM standards and processes relating to roaming

B.1 Summary of GSM standards and processes related to network selection

To understand the issues relevant to network selection in national roaming, it is helpful to understand how the 3GPP standards implement network selection and current practice in the UK. The following text is based on text in the Mason report for Ofcom in April 2007 relating to emergency call roaming. The text has been updated and the specific focus on emergency call roaming removed to help the reader understand the issues in the context of national roaming.

B.1.1 Mobile configuration, identity and access class

The 3GPP standards refer to mobile phones using the term ‘mobile station’ (MS). In 3GPP terms, an MS comprises ‘mobile equipment’ (ME) and a ‘subscriber identity module’ (SIM). The ME is basically a handset. It contains no subscriber related information. The SIM provides storage of subscriber related information. This information is subscriber specific, and of three types: fixed data, temporary network data and service related data. The SIM is more fully described in GSM 02.17.

There are a number of important identities associated with the mobile phone:

- The ME has an international mobile equipment identity (IMEI). The IMEI is a unique number in the GSM system that is allocated to each individual ME. Every GSM ME has an IMEI, and so can be identified uniquely. The IMEI is primarily used for taking measures against stolen equipment or equipment that can no longer be allowed to function in the system for technical reasons. The IMEI is more fully described in GSM 02.16 and GSM 03.03.

- The SIM contains the international mobile subscriber identity (IMSI). The IMSI uniquely identifies a GSM subscriber, and is more fully described in GSM 03.03.

- In order to support subscriber identity confidentiality the network may allocate a temporary mobile subscriber identity (TMSI) to a subscriber. The network must be able to correlate an allocated TMSI with the IMSI of the MS to which it is allocated. The TMSI is more fully described in GSM 03.03.

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15 ETSI specification: ETSI TS 100 922
16 ETSI specification: ETSI TS 100 906
17 ETSI specification: ETSI TS 300 523
Every MS is allocated an ‘access class’, which can be used to control access to the network for that MS. The access class is held on the SIM and so relates to the subscriber. Full detail on access classes can be found in 3GPP TS 22.011\(^{18}\); however, a summary is given here. In general, MSs are provided with one of the 10 ‘normal’ access classes (numbered 0 to 9). No particular relevance is attached to any one of these 10 access classes, and MSs are simply randomly distributed across them. Should an operator wish to, the level of traffic accessing the network can be controlled by only permitting MSs from one, or more, access class to access the network. Five ‘special’ access classes also exist. These are allocated to specific high priority users, as follows (note that no priority order is inferred in the numbering):

a) for public land mobile network (PLMN) use  
b) security services  
c) public utilities (e.g. water/gas suppliers)  
d) emergency services  
e) PLMN staff.

An additional access control class, known as ‘Access Class 10’, is also signalled over-the-air interface to the MS. This indicates whether or not network access for emergency calls is allowed to all MSs in the cell (both MSs with access classes 0 to 9, and for MSs without an IMSI, i.e. MEs). For MSs with access classes 11 to 15, emergency calls are not allowed if both Access Class 10 and the relevant Access Classes (11 to 15) are barred. Otherwise, emergency calls are allowed.

B.1.2 GSM network selection process

This section presents a summary of the process of network selection in GSM, and the resulting states that a mobile can find itself in following selection.

When a mobile is turned on it will attempt to find the network that it was last registered on. If it is able to locate a cell on this network that has sufficient signal strength, it will register with the network through that cell, and then enter ‘idle mode – normal service’ state. In idle mode, the mobile station is not allocated any dedicated channel; it simply listens to the broadcast control channel (BCCH) and common control channel (CCCH). These control channels are used to broadcast cell specific information on the identity of the network, and how it can be accessed (BCCH), and to establish a dedicated link with the network (CCCH). In the normal service state, the mobile is available for all supported services (see 3GPP 04.08\(^{19}\) for a fuller description of this state).

\(^{18}\) ETSI specification: ETSI TS 122 001  
\(^{19}\) ETSI specification: ETSI TS 100 940
If the mobile is not able to locate a cell on this network that has sufficient signal strength, then it will commence a network selection. An overview of the network selection process is presented here; if required, a full description of the network selection process can be found in 3GPP TS 23.122\(^{20}\).

There are two modes for network selection, automatic and manual. It is usual, although not strictly necessary according to the standards, that the subscriber can choose which mode the mobile should use. Operation in each mode is discussed below.

*Automatic network selection mode*

The mobile will search for all networks that are available in its location. It will then attempt to register on the networks that are available and allowable (i.e. are not in the ‘Forbidden Network’ list contained in the SIM). Registration will be attempted in the following order:

1. Its home network
2. Any network contained in the ‘network selector’ list stored in the SIM, with registration attempts being made in the priority order of list in the SIM
3. Any network with sufficient signal strength, with registration attempts being made in random order
4. All other networks in order of decreasing signal strength.

If a network is found, and if registration is possible, the mobile will show the selected network name and enter the ‘idle mode – normal service’ state. The mobile will remain on this network, either until coverage is lost or, if the mobile is registered on a network that is not its home network, until the mobile enters home network coverage. In the former case, network selection will be re-commenced. In the latter case, while registered on a non-home network, the mobile will periodically search for its home network and register there as soon as it becomes available. The frequency of this search is operator-definable from 6 minutes to 8 hours, with a default of 60 minutes (see 3GPP 22.011 and 3GPP TS 23.122).

If network(s) are found, but registration is not possible, then the mobile will show ‘no service’, and will enter the ‘idle mode – limited service’ state. In this state, the mobile is only available for emergency calls. It will ‘camp’ on the strongest available cell, regardless of network, to facilitate such calls.

If no network is found, then the mobile will show ‘no service’, and enter the ‘idle mode – no cell available’ state.

\(^{20}\) ETSI specification: ETSI TS 123 122

Ref: 16847-306
In both these states (‘limited service’ and ‘no cell available’), various (discontinuous) network search schemes are used to attempt to locate an available and allowable network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

**Manual network selection mode**

The mobile will search for all networks that are available in its location. It will then indicate any networks that are available, including those in the ‘Forbidden Network’ list contained in the SIM. Networks will be presented in the following order:

1. Its home network
2. Any network contained in the ‘network selector’ list stored in the SIM, listed in the priority order of list in the SIM
3. Any network with sufficient signal strength, listed in random order
4. All other networks in order of decreasing signal strength.

If networks are available, the subscriber will then select the desired network, and the mobile will attempt to register.

If registration is possible, the mobile will show the selected network name, enter the ‘idle mode – normal service’ state.

If registration is not possible, the mobile will indicate ‘no service’, enter the ‘idle mode – limited service’ state, and the subscriber may select another network. In this state the mobile will, however, ‘camp’ on the strongest cell to facilitate emergency calls.

If no networks are found, then this will be indicated, and the mobile will enter ‘idle mode – no cell available’ state.

In both these states (‘limited service’ and ‘no cell available’), various (discontinuous) network search schemes are used to attempt to locate an available and allowable network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

A mobile without a SIM will not perform network selection as described above. At switch-on it will enter the ‘idle mode – no IMSI’ state. In this state, the mobile is only available for emergency calls. It will ‘camp’ on the network with the strongest signal to facilitate such calls, and will only camp on to another network when it loses coverage of the current camped-on network.

**B.2 GSM standards – current operation in UK**

This section applies the GSM standards discussed above to the specifics of a mobile operating in the UK that also has its home network in the UK. The operation of mobiles coming in to the UK
from abroad is not explicitly considered here, since these mobiles will either be able to roam on multiple networks (due to roaming agreements in place) to make emergency calls, or will operate in the same manner for emergency calls as a UK mobile operating off the home network.

B.2.1 Network selection at switch-on in the UK

According to the process outlined above in Section B.1.2, when a UK mobile is turned on it will attempt to find the network it was last registered on; this could be its home network, if it was last operational in the UK, or a foreign network, if it was last operational abroad.

In the former case, if it is able to locate a cell on its home network that has sufficient signal strength, it will register with the network through that cell, and then enter the ‘idle mode – normal service’ state.

In the latter case, or if the mobile was last operational in the UK and is now not able to locate a cell on its home network that has sufficient signal strength, then it will commence a network selection according to the mode chosen by the subscriber; either automatic or manual. An overview of the network selection process in each mode is presented in Section B.1.2, and the potential outcome in the UK is described below.

The discussion below applies only to a mobile containing a valid SIM. Any mobile without a SIM will enter the ‘idle mode – no IMSI’ state at switch on, and will camp on the strongest available network ready to facilitate emergency calls.

Outcome of automatic mode network selection

If the mobile is not within home network coverage, but is within coverage of another network, it will not be able to register on this network, as no roaming agreements exist between UK GSM operators. The mobile will, therefore, enter the ‘idle mode – limited service’ state. In the limited service state, the mobile will camp on the strongest available cell, regardless of network, ready to facilitate emergency calls.

In the ‘idle mode – limited service’ state, the mobile will use (discontinuous) network search schemes to attempt to locate its home network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

If it is in an area of no network coverage, the mobile will enter the ‘idle mode – no cell available’ state. In this state, the mobile will use (discontinuous) network search schemes to attempt to locate its home network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

Outcome of manual mode network selection

The mobile will display the various networks that are available, and allow the subscriber to select a network. However, if any network other than the home network is chosen, the mobile will not be
able to register on that network since there are no roaming agreements between UK GSM operators.

If the home network is not available, the MS will enter the ‘idle mode – limited service state’ state and will camp on the strongest available cell, regardless of network, ready to facilitate emergency calls. In the ‘idle mode – limited service’ state, the mobile will use (discontinuous) network search schemes to attempt to locate its home network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

If no networks are available, the mobile will indicate ‘no service’, and will enter the ‘idle mode – no cell available’ state. In this state, the mobile will use (discontinuous) network search schemes to attempt to locate its home network as quickly as possible while maintaining battery life (see 3GPP TS 22.011).

**B.2.2 Leaving home network coverage in the UK**

This section applies the GSM network selection process to the specifics of UK mobile operating in the UK that leaves the coverage of its home network whilst being switched on. A similar process to that described above for switch-on occurs in this case.

**Figure 1: Handset network selection process [Source: Analysys Mason]**
Initially, the mobile will be registered on its home network. It will be monitoring the signal strength of the cell it is connected to, as well as the neighbouring cells (of its home network).

If the mobile leaves the coverage of its current cell, and has no home network cell to handover to, then 3GPP TR 22.811 provides detail on how the MS determines that it has left its home network coverage. In summary, the mobile will move to an ‘out of service’ state if it loses coverage for more than 12 seconds. Should the loss of coverage occur for less than this then the mobile will simply come back to its current cell. If the loss of coverage is greater than this, then the MS will begin the network selection process.

If the mobile is unable to return to home network coverage, and since there are no roaming agreements between UK GSM operators, then, ultimately, the mobile will find itself in either in the ‘idle mode – limited service’ state (if there is coverage from another network) or ‘idle mode – no cell available’ state (if there is no coverage at all). In the former state, the mobile will be ‘camped’ on to another operator’s network ready to facilitate emergency calls.

In both these states (‘limited service’ and ‘no cell available’), various (discontinuous) network search schemes are used to attempt to locate an available and allowable network as quickly as possible while maintaining battery life (see 3GPP TS 22.011). In automatic network selection mode, this registration to an available and allowable network will occur automatically. In manual selection mode, the subscriber will be presented with the list of networks to select from once they have been located.

All the above applies only to a mobile containing a valid SIM. A mobile without a SIM does not have a home network, and will enter the ‘idle mode – no IMSI’ state at switch on, and so camp on the strongest available network ready to facilitate emergency calls.