Het rapport “Study on network migration duration” dat PA Consulting Group in opdracht van het Ministerie van Economische Zaken, Landbouw en Innovatie heeft gemaakt bevat vertrouwelijke bedrijfsgegevens. Om die reden wordt het rapport slechts gedeeltelijk openbaar gemaakt.

Executive summary

The Netherlands will witness a spectrum auction scheduled for October 2012 in which all the major GSM operators will end up with different spectrum allocations compared to their current holdings. The auction process is such that it is possible that an existing GSM operator will lose some or all of their current 900MHz spectrum, while retaining sufficient 1800MHz spectrum. In these circumstances the operators will need to vacate some or all of their spectrum holdings, a process which could lead to service interruption for end-users. The Ministry has asked PA Consulting for a view on an anticipated duration that such an operator would need to give it time to take actions to largely mitigate this risk.

Faced with this auction outcome, operators would need to undertake a range of tasks. For the outcome of losing all 900MHz these tasks would be around migrating traffic to 1800 MHz, the only other spectrum at which GSM operates.

Operators who predominantly use 900MHz spectrum would face a much greater task than operators that already make much more use of 1800MHz. While the second category can be expected to make this migration in around 21 months, operators who predominantly use 900MHz spectrum would have to undertake around twice the manpower effort and would need to find 3 to 4 times the number of new sites. This required manpower and the duration for finding so many new sites would result in a migration period of some 4 years or more to achieve 90% of site deployments.

This length of deployment for operators who predominantly use 900MHz spectrum suggests that a strategy of migration to 1800MHz may well be impractical. GSM voice traffic is generally migrating to 3G and so large long term investments are likely to be prioritised to support that trend rather than in supporting a declining and aged technology.

For an alternative outcome of losing all but 2 x 5MHz spectrum at 900MHz these tasks would be around dealing with potential border interference, supplementing reduced capacity and implementing the new frequency holdings nationally. These tasks represent a substantially lower effort in respect of manpower compared to the task of a complete migration to 1800MHz. The worst affected operator could at reasonable levels of effort achieve these tasks in around 25 months.

In arriving at a decision on an appropriate licence duration, the Ministry should bear in mind that while PA's work is based on a robust methodology and our extensive industry experience, arriving at an estimated duration is not an exact science. Furthermore, any licence duration should also recognise that the operators can reasonably be expected to have made some progress in starting to plan for implementing such possible auction outcomes in advance of the auction itself, which could reduce the duration of any licence extension by 1 to 4 months.

1 Operators face a potentially major change in their spectrum allocation

The Dutch Ministry of Economic Affairs, Agriculture and Innovation is currently in the process of organising and scheduling a multi-band auction for mobile spectrum. PA Consulting has been commissioned by the Ministry to evaluate two auction outcomes to assist them in appreciating the duration of a possible licence extension.

1.1 *All existing GSM operators face changes to their spectrum holdings as an outcome of the auction*

The licenses that are in the auction include the present licenses for mobile communications in the 900 MHz and 1800 MHz bands. These licenses are presently held by three main mobile operators, KPN, Vodafone and T-Mobile and will expire by 26th February 2013.

As shown in Figure 1 and Figure 2, below, the new allocations do not align with operators' existing holdings, and therefore no auction outcome will leave any operator with exactly the same frequencies as it held previously.

Figure 1: 900MHz current allocations and blocks for auction

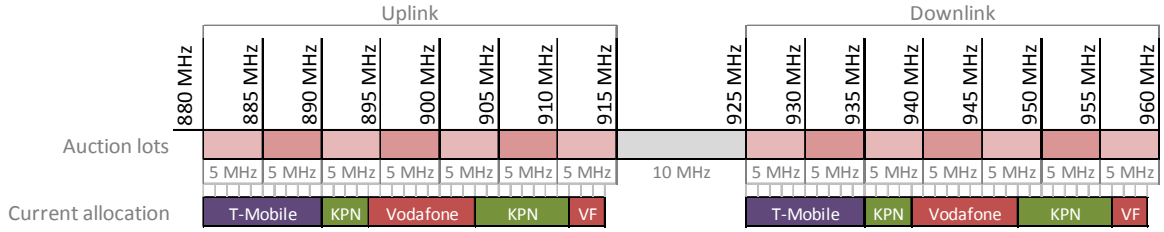
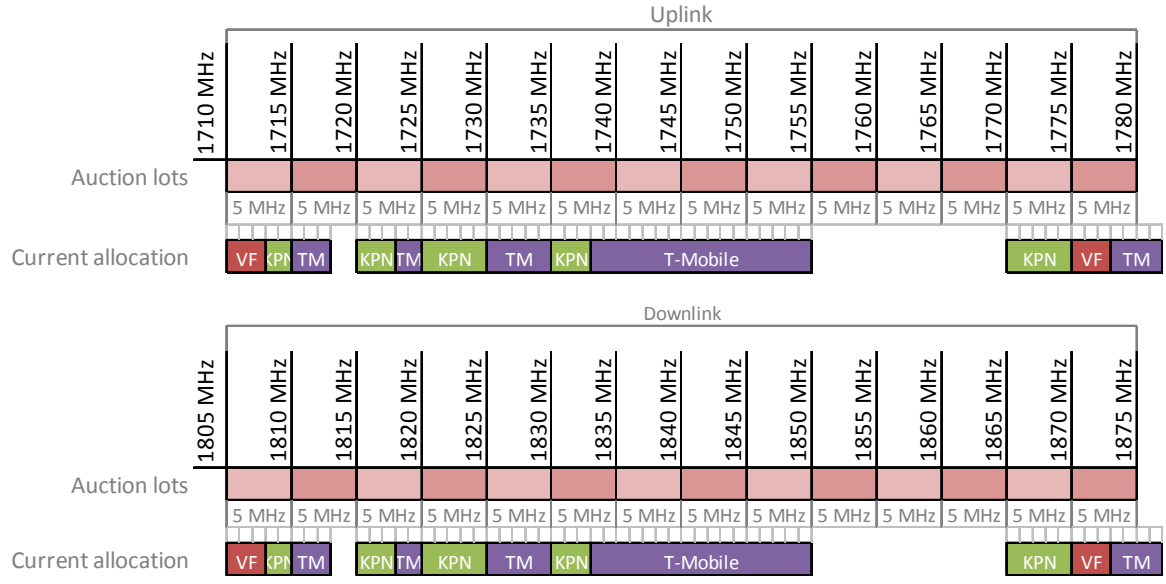


Figure 2: 1800MHz current allocations and blocks for auction



Furthermore, with respect to 900MHz spectrum, the auction rules set aside 2 x 5MHz to be reserved for a new entrant. Given this, it is expected that there will be major changes to the spectrum holdings

of at least one operator. Such a change in spectrum could necessitate a major change in network infrastructure.

1.2 *The few months currently available for migration may necessitate an extension to the current licences*

The auction has been rescheduled for October 2012. With existing licenses expiring in Feb 2013, the time-frame between issuing new licenses, and the expiration date of the licenses currently in use, will be around three months.

Within this shortened migration time, it may be that operators are unable to complete their migration to the new licenses and may therefore be unable to provide uninterrupted service to existing customers.

Should this be the case, a possible solution is that a temporary renewal of the operators' current licences is granted to thereby enable them to largely complete the migration process. A key question would be to estimate a reasonable time to allow an operator to migrate from its previous spectrum to its post-auction spectrum while maintaining largely uninterrupted service for end-users.

To address this question, the Ministry is seeking to understand the duration of any such extension by examining two auction outcomes. The first auction outcome is where an existing GSM operator loses all of its 900MHz spectrum, and the next when an operator loses all but 2 x 5MHz in the 900 MHz band.

Each GSM operator makes different use of its different spectrum holdings to deliver services, so these auction outcomes would affect each differently. The migration duration that PA has been asked to investigate is for the worst affected operator that still has a credible prospect of retaining largely uninterrupted GSM services. So while there will be a range of outcomes from any given auction outcome, our task is to specify the worst case duration.

In our report to the Ministry on 9 November[1] we suggested that there could be no assurance that an auction outcome could categorically mean that all changes could be made in the 7 to 8 months that were then assumed to be the period between the auction and licence expiry. As such, given these are worst case durations, any estimated migration durations for these scenarios can be expected to be notably longer than 7 to 8 months.

1.3 *Replacing 900MHz coverage with 1800MHz is the worst case outcome for an operator trying to avoid customer service interruption*

The total loss of 900MHz as an auction outcome would present a very significant challenge for operators should they seek to attempt to maintain customer service continuity. As only the 900MHz and 1800MHz bands can be used for GSM services, an operator could only continue to provide national GSM service by making greater use of its 1800MHz spectrum.

The propagation characteristics of 900MHz spectrum mean that it is predominantly used to achieve wide geographic coverage for GSM service. As a 1800MHz site's coverage range is significantly

1 Report entitled 'Technical and economic impact of temporary licence renewal', PA Consulting.

smaller than for a 900MHz site, operators would have to upgrade many existing sites to 1800MHz and even deploy new 'greenfield' sites to make up for the loss of 900MHz.

The loss of all but 2 x 5HMz at 900MHz can also be expected to be a very challenging auction outcome. To maintain largely uninterrupted GSM service an operator would need to address the loss of capacity, possibly find new sites in border regions as well as implement a new national frequency plan.

These two auction outcomes; the loss of all or some of operators' 900MHz holdings, are the areas that the Ministry has asked PA to consider as they represent the two worst auction outcomes where retaining GSM services are still possible.

There are other auction outcomes which are also very unattractive for operators, such as losing all 1800MHz, while retaining their holdings in 900MHz. The loss of all 1800MHz spectrum would not be expected to be as severe as the loss of some or all of 900 MHz for the current GSM operators. The 900MHz sites should be sufficient to maintain the high degree of coverage already in place, although areas of dense demand could require additional carriers, additional sectors, and possibly also the 'densification' of sites. There would be serious challenges in terms of capacity, but adding capacity is not expected to require the same effort as the widespread network rollout required to migrate after the loss of 900MHz. Furthermore, there is no reservation for new entrants in the 1800MHz range, so it may be that access to this spectrum in the auction is easier to achieve.

The loss of all holdings of both 900 MHz and 1800 MHZ has not been considered as a plausible outcome where an operator could take steps to provide service continuity. The following chapters provide an analysis of the network impact and the corresponding time and resources required to reconfigure a network to maintain a largely uninterrupted GSM service with less or no 900MHz spectrum.

Appendix A: Estimation of network impact in the scenario of losing all 900MHz spectrum

This appendix refers to the scenario where one operator loses all of its 900MHz spectrum holdings and has to migrate its GSM network to operate on the 1800MHz frequency bands only. This appendix gives our methodology estimating the number of sites that an operator would need to find or modify in order to make up for the lost 900MHz coverage and capacity. The sites that need to be added or modified are defined as follows:

- Category A: the deployment of new 1800MHz sites
- Category B: the replacement of the 900MHz element of existing 900/1800 dual mode sites
- Category C: the upgrading of standalone 900MHz sites to existing 1800MHz
- Category D: and the addition of 1800MHz to existing standalone UMTS sites

To estimate the number of Category A sites our approach, in outline, is to take the geographical coverage and number of sites of an operators' GSM 900MHz network and then to contrast that with the number of sites required if the same area is to be covered using 1800MHz. The resulting number of sites is then adjusted to take into account the fact that not all these sites require new sites. Existing 900MHz-only and UMTS-only sites that can be converted to support 1800MHz are deducted from this number to give our estimate of new sites. Our analysis also takes into account the differences in the urban, suburban and rural areas of Netherlands in terms of the size of geographical area to be covered and the range of 900MHz and 1800MHz cells, respectively. As such, our approach for calculating the Category A sites can be mathematically expressed as:

NEW_1800MHZ_SITES_ROLL_OUT =

(900MHz_ONLY_COVERAGE_URBAN/AREA_COVERAGE_PER_1800MHz_CELL_URBAN - NUMBER_OF_EXISTING_SITES_AT_900MHz_ONLY_COVERAGE_URBAN) +

(900MHz_ONLY_COVERAGE_SURBAN/AREA_COVERAGE_PER_1800MHz_CELL_SURBAN - NUMBER_OF_EXISTING_SITES_AT_900MHz_ONLY_COVERAGE_SURBAN) +

(900MHz_ONLY_COVERAGE_SURBAN/AREA_COVERAGE_PER_1800MHz_CELL_RURAL - NUMBER_OF_EXISTING_SITES_AT_900MHz_ONLY_COVERAGE_RURAL) -

NUMBER_OF_EXISTING_UMTS_ONLY_SITES

By following this process of calculating Category A sites, we are be able to derive the number sites for Category B, C and D, respectively.

In the following subsections, we have provided a step-by-step description on how our estimate for the number of sites for each of the category A - D sites is calculated.

Our analysis also includes input from the three current GSM operators who each responded to the questions in Appendix C in a meeting. The details of this discussion have helped us derive our analysis for each operator. However, to protect the confidentiality of the information provided we will use hypothetical, but realistic numbers to illustrate our workings.

The other basic parameters used in this exercise are not linked to the profile of any specific operators. They are drawn from a mix of publicly available information, outputs of theoretical models and empirical data from the telecom industry.

Basic Assumptions

In Table 1, we have provided the assumptions for a list of basic parameters used in our calculation.

Table 1 - Basic Assumptions

Basic Parameters		Assumptions
Total Land Area of Netherland		33,883 km^2 [2]
Geographical Coverage of 900MHz Cells		99%[3]
Percentage of Specific Geographical Areas	Urban	2%[4]
	Suburban	13%
	Rural	85%
Cell Range at 900MHz	Urban	0.5 km
	Suburban	1.2 km
	Rural	4.5 km
Cell Range at 1800MHz	Urban	0.40 km
	Suburban	0.86 km
	Rural	3.15 km
Percentage of UMTS Only Sites		20%[5]
Number of Existing UMTS Sites[6]		4000
Number of Existing GSM 1800MHz Sites		400
Percentage of 1800MHz sites that co-locate with 900MHz		80%

Note that our assumptions on cell range at 900MHz and 1800MHz are based on operators' feedback and the outputs of the Hata and COST231-Hata propagation model[7]. As a conservative assumption we have taken the lower ends of these inputs as the assumed values of cell range in the Netherlands. Furthermore, since cell-range is typically capacity-constrained in urban areas, we have assumed that the cell range at 1800MHz is 80% of that at 900MHz rather than the 70% used for other locations.

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[2] the CIA World Factbook, URL: https://www.cia.gov/library/publications/the-world-factbook/geos/nl.html, visited January 23, 2012

[3] Based on KPN's annual report for 2010, other operators may have a smaller percentage of geographical coverage (outdoors).

[4] Distribution of Urban/Suburban/Rural derived from discussions with operators from the Netherlands on January, 2012

[5] "Percentage of UMTS Only Site" are derived from the coordinates data of GSM 900MHz/1800MHz/UMTS site locations provided by The Antennebureau of the Dutch Government, source of data can be downloaded from http://www.antennebureau.nl/onderwerpen/techniek/GSM

[6] Illustrative proxy values are used in "Number of Existing UMTS Sites", "Number of existing GSM 1800MHz sites" and "Percentage of 1800MHz sites that co-locate with 900MHz". If this model is used for a specific operator, these data should be updated accordingly.

[7] These propagation models are defined in 3GPP TS43.030, "Radio Access Network; Radio network planning aspects", V7.0.0.

Drawing on the basic assumptions on existing 1800MHz and UMTS sites shown in Table 1, the number of Category B and D sites are derived, as illustrated in Table 2 below:

Table 2 - Illustration of Estimated Category B and D Sites

Type of Work Stream	Number of Sites
1800MHz/900MHz co-location sites (category B)	320
UMTS only sites (category D)	800

To derive our estimates for category A sites we have used the following methodological steps as shown below using illustrative data.

Step 1: Calculation of Area Coverage per Site

Using the assumed cell range in Table 1 and assuming the shape of the coverage of a GSM base station is circular[8], we have derived the coverage area per site for both 900MHz and 1800MHz sites in the three types of geographical areas as shown in Table 3.

Table 3 - Estimated Coverage Area for 900MHz and 1800MHz Sites

Type of Cells		Estimated Area Coverage
900MHz Sites	Urban	0.79 km^2
	Suburban	4.52 km^2
	Rural	63.62 km^2
1800MHz Sites	Urban	0.50 km^2
	Suburban	2.35 km^2
	Rural	31.17 km^2

Step 2: Estimation of Existing 900MHz only Coverage

Based on the distribution of urban/suburban/rural areas in Netherlands, the Number of Existing GSM 1800MHz Sites (found in Table 1) and the coverage area per 1800MHz site (found in Table 3), we have estimated the size of all areas that are currently served by 900MHz or 900/1800MHz Dual Mode base stations. Also accounting for the percentage of 1800MHz sites that are co-located with 900MHz base stations, we have derived a breakdown of existing 900MHz-only coverage in urban/suburban/rural areas (shown in Table 4).

Table 4 - Situations of Existing GSM Coverage

Type of GSM Coverage		Calculated Results
Breakdown of Existing Land Area Covered by	Urban	671 km^2
	Suburban	4,361 km^2

[8] In practice, the shape of the signal coverage of a base station is not a perfect circle. And a simplistic assumption of circular coverage may lead to underestimate of sites required to cover a specific area (e.g. to cover the coverage holes between circles) in our model. In order to offset this, we have used the lower ends of typical cell ranges in our model.

Type of GSM Coverage		Calculated Results
GSM	Rural	28,513 km^2
Distribution of Existing 1800MHz Sites in Specific Geographical Areas	Urban	53
	Suburban	347
	Rural	0[9]
Existing 1800MHz Only Coverage	Urban	5 km^2
	Suburban	163 km^2
	Rural	0 km^2
900MHz plus 900/1800MHz Dual Mode Coverage	Urban	666 km^2
	Suburban	4,198 km^2
	Rural	28,513 km^2
900MHz only Coverage	Urban	644 km^2
	Suburban	3,548 km^2
	Rural	28,512 km^2

Step 3: Estimation of Site Count for Category A and C Sites

From the outcome of Step 2 on existing 900MHz-only coverage areas, together with the calculated Coverage Area for 900MHz and 1800MHz Sites provided in Table 3, we have estimated the number of legacy 900MHz sites in the 900MHz-only coverage sites[10] (Category C). By subtracting the Category-C sites from the total number of GSM sites in urban, suburban, and rural areas, we can derive the total number of new sites required to infill the existing 900MHz-only coverage with 1800MHz base stations. Finally, by subtracting the existing UMTS-only (Category D) sites that can also be converted to support 1800MHz GSM coverage, we have estimated that the total number of new 1800MHz sites necessary to recover the loss of 900MHz coverage (as shown in Table 5).

Table 5 - Illustration of derivation of number of category A and C sites

Type of Sites		Calculated Results
Existing 900MHz Sites at the 900MHz-only Coverage	Urban	820
	Suburban	784
	Rural	448
	Total Category C sites (900MHz to 1800MHz swap)	2052
Site Locations Required to Infill 900MHz Only Coverage with	Urban	461
	Suburban	729

[9] We assume that 1800MHz sites are installed on Urban and Suburban locations only.

[10] We have assumed that all legacy 900MHz sites are convertible to support 1800MHz

Type of Sites		Calculated Results
1800MHz BTS	Rural	466
Existing UMTS Sites that can be converted to support 1800MHz (Category D sites)		800
Total Category A sites (new 1800MHz roll-out)		856

Applying this approach using operator-specific data gives the results for each of the 3 GSM operators.

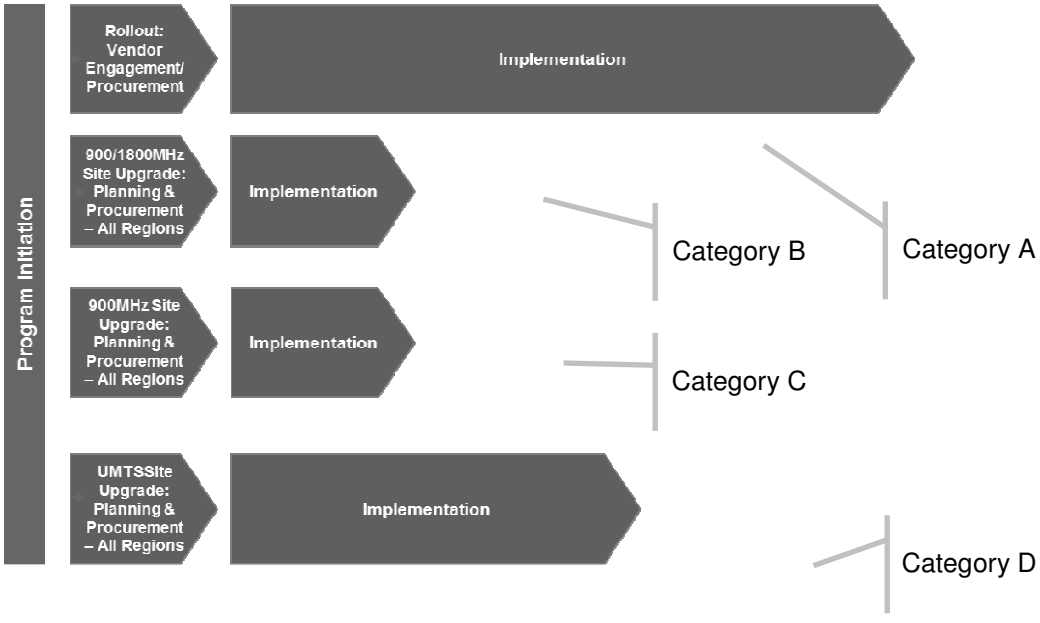
Appendix B: Estimation of timescales and resources in the scenario of losing all 900MHz spectrum

This appendix details our approach to the estimation of timescales and resources in the scenario of losing all 900MHz and migrating all traffic to 1800MHz. Our approach is to breakdown the category A-D network migration projects in to a number of specific activities based on our experience of what tasks are required for such a network migration. We also detail the expected time duration for each activity involved, again based on our experience of similar projects. For each activity, we also derived the effort required in terms of man-day per site using our expert knowledge. We then provide a range of possible project implementation by considering the category A-D network migration projects being executed in parallel where possible or in sequence. As a check to ensure the achievability of parallel and sequence execution we then estimate the total resource required for each option.

B.1 Migration programme tasks

An overview of the key tasks is shown in the diagram below - shown running in parallel. The detailed activities within each main task area are described in the following subsections.

Figure 3: Project Plan for Parallel Work streams



B.1.1 Programme Initiation

The initiation phase sets up the overall programme and must be completed prior to the commencement of the main implementation workstreams. Therefore this represents a 'critical path' activity for the overall programme duration.

It comprises four main activities:

Programme Setup

This activity represents the operator's need to consider its options and come to a commercial decision regarding how it plans to address the loss of spectrum. Specific tasks include strategic program level planning, management assignment, resource assignment, timeline planning, and inter-operator coordination.

Project Initialisation

In this task, Radio Frequency (RF) planning teams begin to plan the overall structure of the new network. Specific tasks include developing the new 1800MHz frequency plan, project scope definition for each of the four main workstreams, resource assignment, prioritization, and determining project timelines.

Vendor Engagement

Once the strategic direction has been determined by the operator, it is expected that it would engage with one or more of its preferred vendors. The vendor, likely in a competitive tender process, would need to conduct a requirements gathering process, produce a high level plan, bill of materials, and associated cost estimate.

Pre-upgrade testing and field trial

Some 900MHz equipment can also operate at 1800MHz. Performance testing may be required in advance to determine the viability of re-using such dual mode equipment.

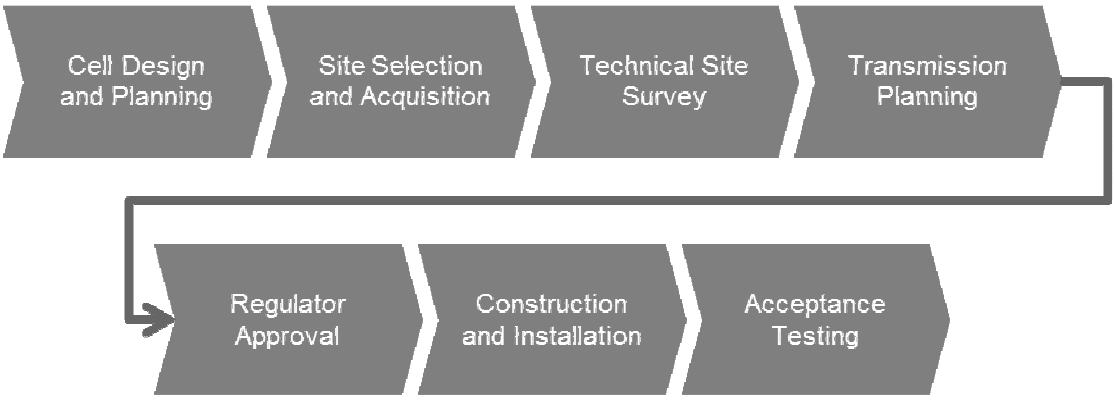
B.1.2 Programme Implementation

The implementation phase is the longest and most resource-intensive aspect of the migration.

It consists of four main workstreams:

- Category A: the deployment of new 1800MHz sites
- Category B: the replacement of the 900MHz element of 900/1800 dual mode sites
- Category C: the upgrading of standalone 900MHz sites to 1800MHz
- Category D: and the addition of 1800MHz to standalone UMTS sites

Category A: Deployment of New 1800MHz sites



Cell Design and Planning

For the 'new site deployment' workstream, this activity determines the desired number and location of new sites to provide the required coverage at 1800MHz. Typically this is performed by planners using RF simulation tools to design the location of the new sites. Local signal propagation conditions are used as an input, and the design process will determine the detailed site solution (e.g. antenna height and tilt).

Site Selection and Acquisition

The RF planning activity will highlight the areas where new sites are needed. A site-acquisition team will then seek out site locations that best match the planned locations. The team will need to find the sites, negotiate with the landlord, and obtain the necessary permissions.

Technical Site Survey

The output of the RF planning tools must be supplemented with a physical site survey to determine the actual conditions of the site. This will include any physical information required by Transmission (TX) planning, civil works and equipment installation. Activities may include line of sight (LOS) checking, more detailed RF environmental surveys, and a civil survey to determine construction conditions.

Transmission Planning

All sites must be connected by a backhaul transmission link to the core network. Typical transmission technologies used include fibre, E1 lines, and microwave. For any of these solutions a design, planning and installation process is required.

Regulatory Approval

The construction of a new site generally requires approval from the telecoms regulator before construction can commence.

Construction and Installation

This includes the civil works required to construct the physical infrastructure needed at the site - for example the mast, cabin, ducts, fencing etc. The other key element of this activity is the installation RAN and transmission equipment.

Acceptance Testing

The test activities include on site equipment tests, and extensive drive testing in the surrounding area. This can be an iterative process with corrections to the site and re-testing

Category B: Dual Mode Site Reconfiguration Workstream

Cell Design and Planning

For the 'site reconfiguration' workstream, this process determines the desired number and location of existing sites that will be reconfigured for operation post migration. This can include equipment swap out, changes in sectorisation, or other adjustments (e.g. change in antenna tilt).

900MHz to 1800MHz equipment swap or reconfiguration

Changes to existing sites will either require the installation of new equipment, or the reconfiguration of existing equipment. If the pre-upgrade testing was successful, then the reconfiguration process is not limited to pre-existing 1800MHz equipment, and can also include re-use of some 900MHz equipment.

Acceptance Testing

These test activities include on-site equipment tests, and extensive drive testing in the surrounding area. This can be an iterative process with corrections to the site and re-testing.

Category C: Upgrade of 900MHz standalone sites to 1800MHz

Cell Design and Planning

For the 'site reconfiguration' workstream, this process determines the desired number and location of existing sites that will be reconfigured for operation post migration. This can include equipment swap out, changes in sectorisation, or other adjustments (e.g. change in antenna tilt).

Site Approval

The lease terms for a site can prohibit a technology change without landlord approval. The necessary permissions must be negotiated and obtained prior to the reconfiguration.

900MHz to 1800MHz equipment swap

Changes to existing sites will either require the installation of new equipment, or the reconfiguration of existing equipment. If the pre-upgrade testing was successful, then the reconfiguration process is not limited to pre-existing 1800MHZ equipment, and can also include re-use of some 900MHz equipment.

Acceptance Testing

The test activities include on site equipment tests, and extensive drive testing in the surrounding area. This can be an iterative process with corrections to the site and re-testing.

Category D: Upgrade of UMTS sites to 1800MHz

Cell Design and Planning

For the 'site reconfiguration' workstream, this process determines the desired number and location of existing sites that will be reconfigured for operation post migration. This can include equipment swap out, changes in sectorisation, or other adjustments (e.g. change in antenna tilt).

Site Approval

The lease terms for a site can prohibit a technology change without landlord approval. The necessary permissions must be negotiated and obtained prior to the reconfiguration.

Addition of 1800MHz equipment

Changes to existing sites will either require the installation of new equipment, or the reconfiguration of existing equipment. If the pre-upgrade testing was successful, then the reconfiguration process is not limited to pre-existing 1800MHZ equipment, and can also include re-use of some 900MHz equipment.

Acceptance Testing

The test activities include on site equipment tests, and extensive drive testing in the surrounding area. This can be an iterative process with corrections to the site and re-testing.

A.1.1 Programme Close

The close of the programme marks the achievement of target coverage, but does not add to the total migration duration.

Achievement of target coverage

The overall goal of the programme is to achieve a desired level of coverage. Once sufficient sites have gone live and been tested and accepted, this target coverage will be achieved. It is unlikely that all sites will be complete at this point as reaching target coverage should not depend on 100% completion of site rollout.

Ongoing improvement

Once target coverage is reached the network deployment activity will not come to a complete stop. Operators are generally continually reconfiguring and changing their networks. However, for the purpose of determining the total duration of the programme of migration, this activity will not be included.

B.2 Basic assumptions and estimates of resources required

In the following tables we have detailed the assumptions for a list of activities for projects in each site category and the corresponding unit effort required in terms of man-day/site.

Table 6 - Category A (rolling out new 1800MHz sites) Unit Effort

Activity	Organization	Man-Day/Site
Cell Design and Planning	Operator	0.5
Site Search, Acquisition & Approval	Operator	5
	Vendor	10
Technical Site Survey	Operator	1
TX Planning	Operator	0.5
Construction/ Installation	Vendor	20
Acceptance Test	Operator	0.5
	Vendor	1.0

Table 7 - Category B (Capacity expansion in existing 1800MHz sites) Unit Effort

Activity	Organization	Man-Day/Site
Solution Design and Planning	Operator	0.01
Site visit/reconfiguration	Operator	1.5
Verification test	Operator	0.5

Table 8 - Category C (900MHz to 1800MHz Swap on Existing 900MHz Sites) Unit Effort

Activity	Organization	Man-Day/Site
Solution Design and Planning	Operator	0.1
Planning Permission	Operator	0.1
Site visit/reconfiguration	Operator	3.0
Verification test	Operator	0.5

Table 9 - Category D (Adding 1800MHz Coverage/Capacity on Existing UMTS Sites) Unit Effort

Activity	Organization	Man-Day/Site
Solution Design and Planning	Operator	0.5
Planning Permission	Operator	5
Site visit/reconfiguration	Operator	5[11]
Verification test	Operator	0.5

These man day estimates can be combined with the number of sites per operator to estimate the total number of man days that each operator's migration would require. It is derived by multiplying the man days per site category, by the number of sites in each category (per operator).

We have also assumed a programme-level fixed management, planning and procurement overhead that does not scale with the size of the post-auction network migration work streams. The timeline and a detailed breakdown of this phase of activities are shown in Table 10 below:

[11] Assumed to be 25% of that of man-day/site estimate for Construction/ Installation in Category A projects as civil work is not required in adding 1800MHz equipments on existing UMTS Sites.

Table 10 - Breakdown of Fixed Programme-level Overheads

Activity	Organization	Weeks
Program Set-up	Operator	1.0
Project Initialization	Operator	1.0
Vendor Engagement, Procurement	Operator	8.0
Field Trial	Operator	1.0
Frequency Planning	Operator	4.0
	Total	15.0

Parallel Programme Duration

The parallel case is appropriate for an operator that has a low requirement for new sites. Even with a low requirement for new build, the process of site acquisition is time consuming due to the difficulty in getting agreements and permissions for new sites. Consequently the Category A workstream combined with the programme setup phase typically determines the overall duration of a parallel migration.

Design and Planning: The parallel programme will have multiple demands on the RF planners as all categories start simultaneously with an RF planning phase and must share the relevant resource. We have assumed a team of four, and based on the man days per site, we have estimated the required time as 6 weeks.

Site Search and Acquisition, Site Approvals: Given that the parallel scenario is applicable for an operator who is not seeking a large number of new sites, this timeline has been assumed to be closer to the lower end of the range, and is estimated at 48 weeks.

Site Build and Acceptance: based on PA experience in the rollout of mobile networks, the rate of new site deployment can reach up to 20 sites per week. However this is only applicable for larger network deployments.

The programme initiation phase of 15 weeks, combined with the duration of the Category A workstream, gives a parallel migration duration of 88 weeks, which corresponds to a 21 month migration programme.

Sequential Programme Duration

The sequential case illustrates where an operator is seeking to reduce peak staffing requirements and requires a significant number of new sites. This is appropriate for estimating the implementation duration for oprators who predominantly use 900MHz spectrum as the parallel approach sets unrealistic expectations on resource levels and rate of site acquisition. This case assumes that the workstreams are conducted end to end rather than in parallel. The total duration is a combination of the programme initiation phase and the activities of the four main workstreams.

Design and Planning: based on information gathered during the operator interviews the expected RF planning team size is approximately 20 personnel, with a capacity to expand during busy periods by using external resources. The expected size of the external team would be approximately 10.

Site Search and Acquisition, Site Approvals: the time required to obtain new sites will be longer than assumed in the parallel case. This has therefore been set at the high end of the expected time to acquire sites, i.e. 18 months. It is assumed that the site acquisition and negotiation for all four categories is conducted as part of the one activity.

Build and Acceptance: For the sequential case, the build and acceptance testing of each workstream is assumed to happen in sequence.

Category A to D activity durations are calculated based on an assumed deployment rates scaled to the number of sites. These and all the other activities are summarised in the table below. This gives an estimated duration of around 206 weeks (just over 4 years).

Table 11 - Complete Sequential Migration

Activity	Weeks
Programme Initiation	15
Design and Planning	10
Site Acquisition	77
Category A build and accept	48
Category B build and accept	11
Category C build and accept	40
Category D build and accept	19
Total	206

Peak resource estimates

Given these specific activity timings we then estimate the peak resources. The peak resource is estimated by taking the average man day requirement per activity and adjusting that to reflect a notional profile of a project ramping up and operating at full speed for a more limited period. Also, in a parallel deployment, the workstreams are undertaken in a compressed timeframe and there is simultaneous demand for the same resources. For a given resource type, the maximum demand presented by one workstream is combined with a proportion of the demand of all of the other workstreams.

For a sequential approach, the workstreams do not clash as they are not carried out simultaneously. Consequently, the peak resource demand is driven by the most demanding individual workstream. Furthermore, the programme is conducted over a much longer time period, therefore the peak requirements are further reduced.

Appendix C: Estimation of network impact in the scenario of retaining 5MHz of 900MHz spectrum

This appendix refers to the scenario where one operator has managed to retain 2 × 5MHz of frequency blocks in the 900MHz spectrum and has to deal with the consequential impact to its network. Since the three major operators in the Netherlands are currently holding 2×10~12.5MHz of frequency blocks in 900MHz each, this scenario would represent a loss of up to 50% of their spectrum capacity in this band. The impact of this scenario would:

1. capacity loss
2. possible unusable channels at border areas [12] and
3. the need for a national frequency re-planning and implementation exercise due to the consequential changes of channel use at both 900MHz and 1800MHz bands.

This appendix gives our methodology for estimating the number of sites that an operator would need to find or modify in order to deal with this impact. In Appendix A we presented the following types of categories of work that would need to be conducted at various sites:

- Category A: the deployment of new 1800MHz sites
- Category B: the replacement of the 900MHz element of existing 900/1800 dual mode sites
- Category C: the upgrading of standalone 900MHz sites to existing 1800MHz
- Category D: and the addition of 1800MHz to existing standalone UMTS sites

In addition to these we have further defined Category E and F sites that specify the work load required in this scenario:

- Category E: the addition of 1800MHz carriers/capacity onto existing 900MHz only sites
- Category F: the reconfiguration of all other existing 900/1800MHz sites as a response to the changes in frequency holdings.

The mapping between the six categories of sites and the work to remedy the impacts described above in this scenario is as follows:

Capacity Loss:

- Operators need to top up capacity at 1800MHz as replacement of 900MHz capacity that has been lost in existing dual 900/1800 sites. (Category B work)
- For 900MHz sites that do not have 1800MHz, the addition of 1800MHz carriers/capacity is necessary (Category E work).

These work streams are only applicable to sites in Urban and Suburban areas, as rural areas are typically low traffic, so the reduction to a 5MHz block would not impact the capacity of these rural sites.

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[12] In accordance with the current preferential channel assignment in the border areas of the Netherlands, it is possible that, when assigned only one 5MHz block at 900MHz, an operator would find not suitable frequency to use at border areas without negotiating a frequency re-planning agreement with foreign operators on the other side of the borders.

- At a few locations, adding 1800MHz to the existing 900MHz sites (Category E work) may not be sufficient as there may be a need to provide additional 1800MHz coverage. This can happen where capacity demand exceeds that can be provided by the existing 900MHz layer and an outlying remaining ring around the site needs additional coverage. We term this a "hot spots" ring.
- There are a number of ways to cover "hot spots" on ring using existing 900MHz spectrum, such as sectorization, increasing antenna height, frequency re-planning, and changing the down tilt of site antennas. In some circumstances however it is prudent to plan for new sites to augment these other remedies. We have therefore assumed 1.5% of existing 900MHz sites need to have one additional 1800MHz site installed (Category A work) to cover these “hot spots”.
- We have also not included non-border areas to avoid double counting with the workload required in those areas.

Possible unusable channels at border areas:

- The worst case outcome of the auction for an operator is where they move to a spectrum range where there is very limited or no channels agreed between national and international operators for use at a border.
- In this case worst case the most likely network solution would be to shut down most of the 900MHz sites in the border areas and to replace them with 1800MHz sites. This may involve relocation of some of the existing 900MHz sites to a location that is further way from the borderline and the field length of these sites would not exceed 19 dBµV/m[13] inside the neighbouring country.
- The work required here is the same as described in Appendix A for moving from 900MHz to 1800MHz. The work streams required under this specific network impact involves Category A (i.e. rolling out new sites), Category C (turning existing 900MHz sites into 1800MHz sites) and Category D (reusing existing standalone UMTS sites to provide GSM coverage at 1800MHz).
- We have estimated the site numbers for this situation following the same approach as we described in Appendix A but in a much smaller scale, i.e. within the 10-15km strip of border areas.

Frequency re-planning and re-implementation:

- As all operators will end up with spectrum holdings that differ from their current holdings, it will be necessary to conduct a national Frequency re-planning and re-implementation exercise.
- Design and implementation of new frequency plan at 900MHz for traffic and broadcast channels should be a key part of this exercise.
- Design and implementation of new frequency plan at 1800MHz may be required as the introduction of additional 1800MHz channels may have an impact on the existing 1800MHz frequency plan.
- The affected sites essentially cover all 900MHz and 1800MHz sites, excluding those in the non-border area and those that must be modified for capacity loss.

In order to estimate the Category A - E activities for this scenario, we have made some basic assumptions as detailed in Table 12 below.

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[13] Recommended by the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunication Adminstrations

Table 12 - Basic Assumptions for the Retaining 5MHz Scenario

Basic Parameters		Assumptions
Site of the Non-Border Area		27106 [14] km^2
Site of the Border Areas in Total		6776 [15] km^2
Distribution of Specific Geographical Areas in the Non-Border Area	Urban	2%
	Suburban	13%
	Rural	85%
Distribution of Specific Geographical Areas in Border Areas	Urban	0%
	Suburban	13%
	Rural	87%
Percentage of existing 900MHz sites that need one additional 1800MHz site to cover "hot spots on ring"		1.5%

Estimation of Site Count for Capacity Loss

Estimates of site counts for the number of sites that require modification capacity loss are derived using the approach as described in Appendix A, although in this instance the calculation is limited to the non-border area, i.e. about 80% of the total land area of the Netherlands.

Note that the estimates for Category E are derived using the approach for calculating Category C sites as described in Appendix A. The reason these sites are counted as Category E in this scenario is simply that they are the existing 900MHz only GSM sites and, with the retained 5MHz frequency block, there is no need to swap out existing 900MHz specific equipment (as in the case of Category C work stream).

Estimation of Site Count for Borders

In order to calculate site counts for addressing borders, we have used the method as described in Appendix A with an assumption of the size of the border areas being 10% of the total land area as the basis of our calculation.

Estimation of Site Count for Frequency Re-planning/Implementation

In order to calculate the number of sites for frequency re-planning/implementation for this scenario, we have designed a formula to count the remaining sites in the non-border areas or that do not need capacity loss adjustments. This formula is mathematically expressed as:

GSM_SITES_FREQUENCY_RECONFIGURATION =

EXISTING_SITES_AT_900MHz_ONLY_COVERAGE_TOTAL +

EXISTING_SITES_AT_1800MHz_TOTAL -

[14] This represents 80% of the land area of the Netherlands

[15] This represents 20% of the land area of the Netherlands

CATGORY_B_SITES -
CATGORY_E_SITES

Appendix D: Estimation of timescales and resources in the scenario of retaining 5MHz of 900MHz spectrum

This Appendix refers to the scenario where one operator has managed to retain 2 × 5MHz of frequency blocks in the 900MHz spectrum and has to deal with the consequential impact to its network.

Our approach to estimating timescales and resources for this scenario follows the same approach as per the scenario where an operator loses its entire 900MHz spectrum as described in Appendix B.

In this instance, the key areas an operator needs to address are:

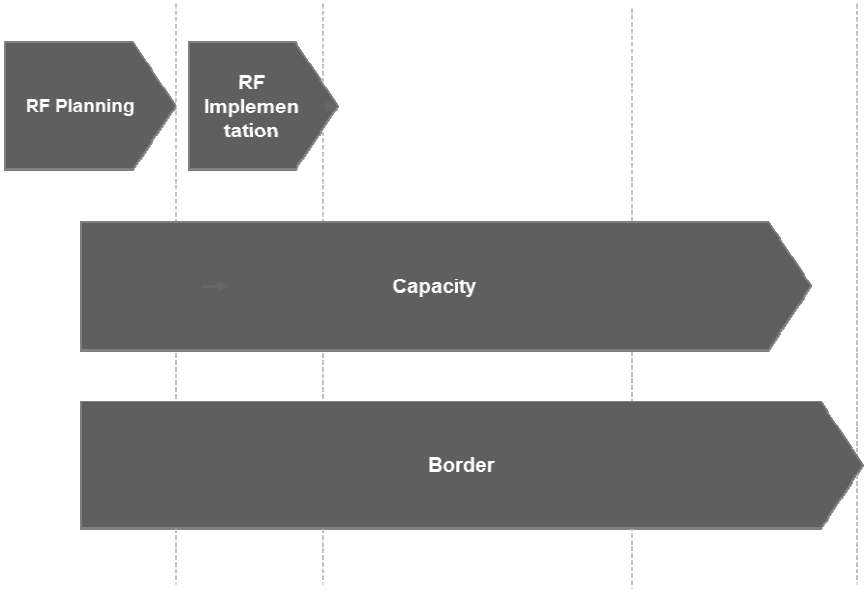
- the lost capacity arising from its reduced spectrum holding at 900MHz

- the implementation of the new spectrum holding

- the border co-ordination that may be necessary for an operators new spectrum holding

We assume that the materially lower number of sites and man day resources will allow the largely parallel implementation as shown in diagram 39 below.

Table 13 - Parallel approach: peak resource required by type



As detailed in Appendix C these key work areas correspond to our category of site work required as follows:

Capacity - Categories B and E

Border - Categories A,C and D

Frequency - Category F

We use the same estimates of man day resources per category to derive our anticipated total man days and duration. We assume that there are certain scale inefficiencies arising from this being a smaller programme than would be the case for the scenario where an operator loses all its 900MHz spectrum. The key impact here is that we assume that the effective number of sites per week per category would be lower. We also assume that certain activities take a minimum duration.

Although we have initially calculated standalone duration for each of the areas using our detailed methodology, we then in the case of parallel execution assume that there would be a two month efficiency gain from the combined planning phases of each activity.