11 Funding refarming efforts for IMT introduction

This Section addresses the funding of the various refarming efforts. These refarming efforts can vary significantly in scope and depth, as detailed in the previous Sections on *Best practices and methods for refarming other services*. They can range from re-engineering a limited number of P-P radio links, restacking nationally deployed networks (like DTTB networks) to restacking nationally deployed networks in combination with phasing out a legacy system (such as ATV or CDMA-850 networks).

In Section 11.1 the different refarming cost categories will be addressed. Subsequently, Section 11.2 will address in what way these different costs can be funded.

11.1 Refarming cost categories

For identifying the various cost categories two refarming examples will be addressed, which may also be used for identifying the cost categories for refarming other services:

1) Restacking or refarming DTTB services in the 700/800 MHz band;
2) DSO/ASO transition (see also Section 9).

11.1.1 Cost categories for restacking DTTB services

For restacking DTTB services a comprehensive list of cost categories is included in this Section. What cost categories are applicable in the specific local situation, will depend on the included activities in the refarming project. The following cost categories are identified:

1) (DTTB) network costs. These costs can be broken down into the following sub-categories:
    a. *Network re-planning costs*. For the incumbent DTTB networks a different frequency plan will have to be developed, often in close collaboration with the affected DTTB network operators. Such a new frequency plan will show on what sites frequencies, powers and antennas need to be changed[197]. This new frequency plan should be compatibility (i.e. all unacceptable interference is removed) for the situation that all DTTB sites are tuned to the new frequencies;
    b. *Implementation planning costs*. Given an agreed new and compatible frequency plan, it will still be necessary to implement the necessary changes in such a way, that frequency incompatibilities are avoided during implementation. In many cases the changes will be carried out in different retune-phases or regions across the country. DTTB sites in one region, tuning to new frequencies, may become incompatible with sites in regions that are still operating according to the old frequency plan. This incompatibility (i.e. harmful interference) should be avoided with the implementation plan. Other operational aspects should also be considered such as weather conditions, access to sites and availability of personnel and equipment;
    c. *Network retuning costs*. The new frequency plan will show what changes need to be implemented in the DTTB networks. The largest network retuning cost would occur in the situation that additional sites would be needed. If possible, the network planning should avoid such additional sites. Table 78 provides an example of the detailed network changes and cost elements for the network operator. It is noted that the effort to assess these network retuning costs can be considerable, as it may

[197] Also, other network elements may have to be changed such as network topology, i.e. changes in the composition of Multi-Frequency Networks (MFN) and Single Frequency Networks (SFN). In addition, MFN sites may have to operate in SFN and this will have an impact on required equipment (such as GPS equipment). Finally, the applied artificial delays in SFNs may have to be changed.

involve tender procedures with equipment suppliers. Not only the purchasing costs need to be addressed with the equipment suppliers but also installation aid, schedule and supply conditions;

2) Viewer (network service user) support costs. Depending on the scope of the restacking project, these costs can be broken down as follows:
    a. *Communication costs*. Given the new frequency plan and implementation planning, affected DTTB viewers should be informed on when they can expect what changes and what they should do (for example, retune their DTTB receiver). This communication plan should be developed in close collaboration with the DTTB service providers (i.e. the broadcasters), the consumer retail industry, as well as companies providing installation aid to DTTB viewers;
    b. *(UE) Installation costs*. Affected DTTB viewers may need to replace an existing receiving antenna or may have to redirect (to another site) their antenna. Also, aid could be provided for assisting eligible households to retune their receivers;
    c. *Receiver (UE) subsidy costs*. In the case the restacking project also includes the migration to new 2nd generation/HEVC receivers, the restacking project may organise and provide for subsidies for eligible households to acquire a new DTTB receiver;
3) Spectrum clearing costs. The assigned spectrum rights or licences may be such that they are perpetual or semi-perpetual, because the licence renewal terms force the Regulator to renew the licence if the licensee passes some minimum requirements (e.g. paying their licence fees in time and not causing harmful interference). Under such conditions, the Regulator may opt for paying the incumbent licensees compensation costs for relinquishing their spectrum rights. Several instruments are available for determining these compensation costs, including the relatively new instrument of the incentive auction (see Section 11.2.3);
4) Licence assignment costs. As the spectrum is cleared for IMT services, the licence assignment costs are those costs involved in assigning (spectrum) licences to IMT network operators. Licence assignment costs can be substantial in the case of auction or public tender.

#	Change	#	Operational change	#	Where	Cost element
1	Frequency change	1.1	New Filter Section	1.1.1	Site	Purchase cost/Filter Section
				1.1.2	Site	Installation charge supplier/combiner
				1.1.3	Site	Man-hour charge/Filter Section
				1.1.4	Site	Transport costs/Filter Section
				1.1.5	Site	Insurance costs/Filter Section value/for a year
		1.2	Retune TX antenna (or replacing the TX antenna)	1.2.1	Site	Retuning charge supplier/antenna system
				1.2.2	Site	Man-hour charge/antenna system
				1.2.3	Site	Materials/antenna system
				1.2.4	Site	Insurance costs/antenna system value/for a year
		1.3	Re-configure exciter	1.3.1	Site	Man-hour charge/TX configuration
		1.4	New Power Amplifier (PA) module	1.4.1	Site	Purchase cost/PA module
				1.4.2	Site	Installation charge supplier/PA module
				1.4.3	Site	Man-hour charge/PA module
				1.4.4	Site	Transport costs/PA module
				1.4.5	Site	Insurance costs/PA module value/for a year
2	NMS changes	2.1	Frequency change	2.1.1	Head-end	Man-hour charge/frequency change
			MFN to SFN change	2.1.2	Head-end	Man-hour charge/MFN>SFN change
			SFN to MFN change	2.1.3	Head-end	Man-hour charge/SFN>MFN change
			Network ID change	2.1.4	Head-end	Man-hour charge/NW ID change
			Artificial delay changes	2.1.5	Head-end	Man-hour charge/artificial delay change
3	GPS connects	3.1	Connect GPS to transmitter	3.1.1	Site	Man-hour charge/GPS connect
				3.1.2	Site	Materials/GPS connect
4	Art. delay change	4.1	Re-configure exciter	4.1.1	Site	Man-hour charge/TX configuration

Table 78: Example detailed network changes and cost elements (excluding additional sites)

11.1.2 Cost categories for DSO/ASO transition

DSO/ASO transition costs can be split in two parts:

1) DTTB network deployment costs. These costs are different from the costs as addressed in Section 11.1.1, as the DTTB network deployment costs are the costs for deploying the initial network (and are considerably higher). Such cost would be relevant for those African countries still having to start the DSO/ASO transition (see group 1 in Figure 18 in Section 9.2). For the different cost categories and cost estimates, the reader is referred to the ITU Guidelines on the transition from analogue to digital broadcasting, section 3.4.3;

2) Analogue Switch-Off (ASO) costs. These costs can be broken down as follows (it is noted that some of the listed sub-categories have overlap or can be combined with the categories as provided in Section 11.1.1):
    a. *Viewer migration costs*. ATV viewers need to migrate to DTTB. These viewer migration costs can include compensation of the ATV viewer for the DTTB receiver purchasing costs (i.e. subsidies) and costs for helping to install new receiver equipment. Possibly these migration costs are limited to only eligible households such as people with special needs, elderly or disabled people;
    b. *Temporary network migration costs*. These migration costs are typically incurred by the broadcast network operator and include costs such as design and engineering costs for temporary facilities and sites;
    c. *Spectrum clearing costs*. As addressed in Section 11.1.1, the ATV assigned spectrum rights or licences may be such that they are perpetual or semi-perpetual, because the licence renewal terms force the Regulator to renew the licence if the licensee passes some minimum requirements (e.g. paying their licence fees in time and not causing harmful interference). Under such conditions, the Regulator may opt for paying the incumbent licensees compensation costs for relinquishing their spectrum rights;
    d. *Broadcaster simulcasting costs*. During the simulcast period (dual illumination) the public and commercial ATV services are distributed over two networks in parallel. This will inflict extra costs on the broadcaster, simulcasting its television service(s);
    e. *Project management costs*. Costs for managing the ASO process which involves the coordination of the effort of all involved parties, such as consumers/viewers, regional/local governments/councils, equipment manufacturers and retailers, and property managers (of multi dwelling units and shared aerials);
    f. *Certification costs*. Setting of mandatory receiver certification and labelling, safeguarding that the right equipment is available in the market and to aid viewers in selecting this equipment;
    g. *Interference mitigation costs*. Inference may occur between mobile applications (i.e. LTE/IMT) and DTTB services (see Sections 1.3.2 and 2.3.2). Also, the introduction of DTTB services may cause interference to cable networks, especially when the DTTB frequencies are also in use by cable companies. Cable viewers may need help for resolving these problems. For example, by providing affected viewers with better shielded connectors and cables.

11.2 Funding methods

This Section addresses the different ways of funding the identified and included costs categories, as listed in the previous Section. These funding methods can be broken down in three basic categories, which may be combined to finance specific cost categories:

1) Public funding methods;
2) Direct industry funding;
3) Traditional auction and incentive auction.

11.2.1 Public funding methods

Public funding is arranged for by national legislation, which can be sector specific (such as the broadcasting and telecommunication sectors). The specific national legislation will dictate the available options. Especially legislation around state aid should be considered. State aid can come in

different forms and may lead to conflicts with the competition regulations[198]. The following public funding methods can be listed:

1) General taxes. Financial resources are made available as a certain proportion of the national budget. Such funding may be lengthily as this will require parliament to approve. However, it is not uncommon for this method to be applied. Typically, DSO/ASO transitions are large national programs, requiring approval from parliament and the earmarking of a portion of the national budget for the transition[199]. This funding instrument seem less appropriate for restacking or refarming incumbent services;
2) TV licence fees. This type of funding is only relevant as a method for funding the DSO/ASO transition. This funding is typically used for financing the activities of the public broadcaster, which may also include the network provisioning (next to the service provisioning). TV licence fees are a form of collecting taxes. Taxes are collected on the basis of ownership of a television set/device. Every citizen in possession/or owning a television set will have to pay a TV licence fee. In countries with nearly 100% of the population watching television, it is commonly assumed that everybody watches the public services and hence every citizen has to pay TV licence fees;
3) Redeployment funds. These funds are often established by the Regulator for the specific purpose of financing refarming projects. The costs that can be covered with these funds are generally limited to spectrum clearing costs (i.e. compensation of spectrum users for relinquishing their spectrum rights) and network costs (i.e. the costs for restacking the networks). Regulator managed redeployment funds are often sourced from licence fees collected from the licence holders and/or proceeds from spectrum auctions. For the latter, special legislation is often required for the Regulator to retain these proceeds. Because the default situation is that these proceeds would be added to the national budget;
4) Industry funds. These funds are established for the purpose of promoting the development of the broadcasting and telecommunications sector. These funds may also include financial resources to assist the provision of Universal Services[200]. Like with the redeployment funds, Regulator managed industry funds are often sourced from spectrum licence fees and auction proceeds.

11.2.2 Direct industry funding

Direct funding refers to the situation that the new entrant (in this report the IMT licensee) is directly financing (a part of) the costs of a related refarming or restacking project (e.g. the refarming of the incumbent spectrum users, e.g. CDMA-850 or DTTB). This is different from the funds as listed in the previous Section, were all licence holders contribute to a general fund, which is available for a number of projects (still to be be decided). The following direct funding methods are listed:

1) Licence assignment fees. The IMT licence can be assigned by means of a public tender (as opposed to assignment through auction). The public tender conditions may stipulate that the licensees will be obliged to contribute in a number of the cost categories as listed in the

[198] For more information on state aid limitations and rulings, see ITU Guidelines on the transition from analogue to digital broadcasting, section 2.11.2.
[199] For example, in the USA, Congress set aside an initial (open-end) budget of USD 890 million for the DSO/ASO transitions (Under the 2005 Digital Transition and Public Safety Act). After exhausting the available budget of USD 1.34 billion, an additional USD 650 million was inserted in the DTV transition assistance (under the American Recovery and Reinvestment Act of February 2009).
[200] Universal Services are services which are deemed to be essential for every user. Every user can access basic communications services at a reasonable quality and an affordable price.

previous Section. These contributions may have to be paid after the assignment of the licence, or in instalments during the licence period;

2) Licence fee mark-ups. For the situation that the new entrant(s) will get its existing mobile licence(s) adjusted (and renewed) and no assignment procedure will take place (this may be the case for public entities), the Regulator may arrange for a licence fee mark-up to cover the costs of the involved refarming project. It is noted that a general mark-up for all or a group of unrelated licence holders, is considered here a public (indirect) method of financing (see Section 11.2.1).

11.2.3 Traditional auction and incentive auction

In this report traditional auction refers to the type of auction which is organised as a single process to assign a pre-defined number of available auction lots (i.e. spectrum rights) to a number of qualified bidders. This is opposed to the incentive auction which is a combination of two interrelated auctions in which an equilibrium is found between supply and demand of spectrum (in respectively the reverse and forward auction).

For the traditional auction a number of well tested auction formats are available[201]. Two main formats are typically used:

1) Open multi-round ascending auction format where the price increases over a number of bidding rounds until there is no more bidding; and;
2) Sealed bid auction formats.

Regulators opting for auction to (partly) fund refarming efforts, should first assess the associated costs of the refarming project (by selecting the applicable cost categories as listed in the Section 11.1) and determine which cost should be covered by the new entrant(s). Subsequently, the Regulator set a reserve price for each lot (e.g. 2 x 10 MHz) in the auction. The reserve price is the minimum price for what the Regulator is willing to sell the different lots. The reserve prices should then be high enough to cover at least the refarming costs the Regulator wishes to collect from the new entrants (i.e. the qualified bidders).

The incentive auction was first applied in the US for the purpose of clearing the 600 MHz band of television broadcasting services, as to facilitate the introduction of IMT services. The incentive auction is a novel design which was specifically developed for the FCC[202]. The principle of the spectrum incentive auction is depicted in Figure 20.

[201] For an overview of spectrum auction formats and the pros and cons of each format, see ITU Guidelines for the transition from analogue to digital broadcasting, Annex B, section 4.

[202] See "Incentive Auction Rules Option and Discussion", Appendix C to Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions, Notice of Proposed Rulemaking, Docket No. 12-268, 27 FCC Record 12357 (2012).

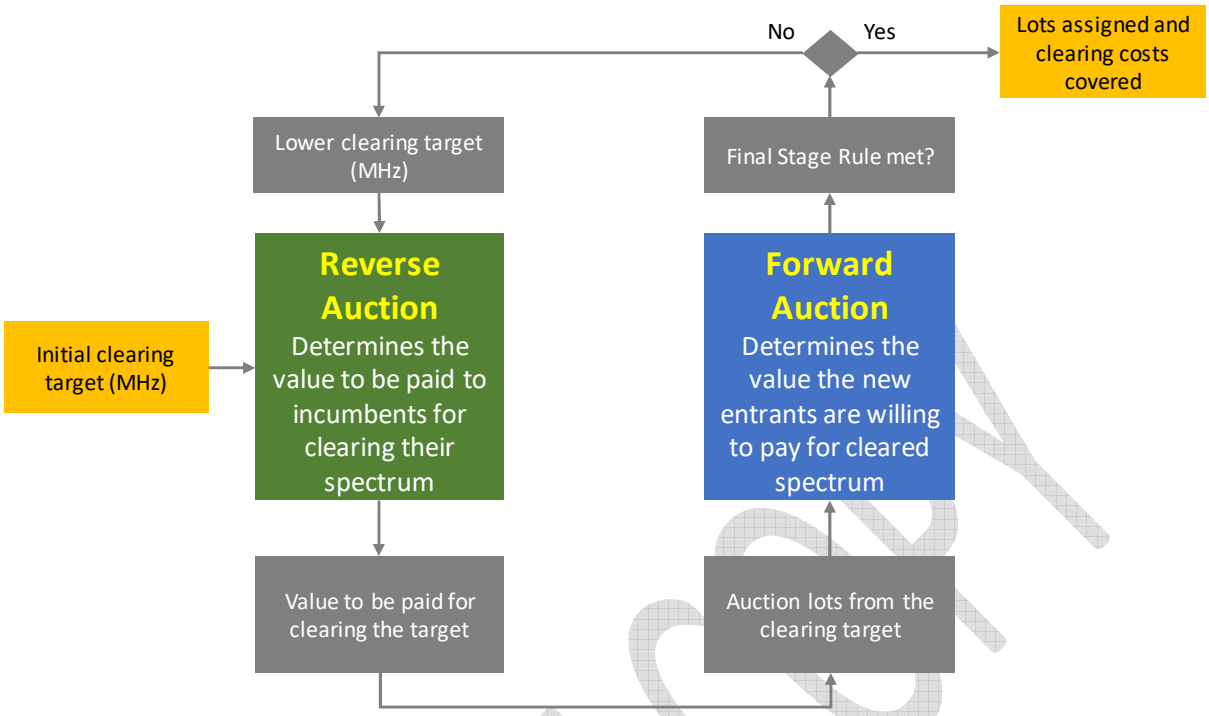

Figure 20: Principle of the spectrum incentive auction (source: Convergence Consulting Company)

From Figure 20 the following can be observed[203]:

1) The incentive auction starts with setting an initial clearing target. In the case of the 600 MHz incentive auction in the US, this initial target was set at 126 MHz. For the purpose of setting a number of descending clearing targets, spectrum planning scenarios were developed in which a descending amount of spectrum was cleared (i.e. the clearing target). For each clearing target, the spectrum planning would tell in what way this spectrum could be cleared (i.e. how many and which television stations should be cleared). It is noted that for the larger clearing targets, channel 37 (which sits in the middle of the 600 MHz band) was not available for IMT. Also, this channel 37 had two guardbands (of 3 MHz) around it to be respected by IMT. Consequently, the clearing targets were not symmetrical in terms of available IMT blocks, as the larger clearing targets had relatively less usable IMT spectrum;
2) Before the reverse auction would commence, the broadcasting licensees had provided the Regulator an initial price for which they were willing to let go of their spectrum rights. The reverse auction would start with a price, based on these initial price indications. The reserve auction was a clock auction with descending prices (i.e. Dutch auction). Bidders indicating that a certain price at the clock would be too low, for them to let go of their spectrum, would exit the auction. The descending clock would stop (and hence the auction) if the number of remaining bidders would be enough to satisfy the clearing target. Because for that clock price there would be enough remaining bidders, willing to let go of their spectrum rights. Hence, by paying these remaining bidders that clock price the required spectrum would be cleared;
3) The forward auction would start with the spectrum blocks that are available in the clearing target. For example, the 126 MHz clearing target included 100 MHz usable IMT spectrum.

[203] It is noted that the included explanation in this report is a simplified explanation of the incentive auction. Because in practice the incentive auction not only considered the licensees to relinquish their spectrum rights but also to move their services to another part of the spectrum band, outside the clearing target.

The forward auction was a clock multi-round ascending auction[204] in which the bidders would bid for the available lots. This forward auction would stop if there was no more bidding. Then the Final Stage Rule would be checked if that was satisfied. This rule was basically a rule determining for what minimum price the FCC was willing to sell the IMT lots. The rule comprised two parts; (a) a minimum value reflecting the economic value of the IMT lots (e.g. expressed as $1.25/MHz/pop) and (b) a minimum value for covering a number of costs:

   a. Network costs for reallocating the broadcasting services (i.e. migrating the services that would continue, although on other frequencies);
   b. Spectrum clearing costs, payments for the broadcasting licensees to relinquish their spectrum rights;
   c. Auction preparation and running costs;

4) If both parts of the final stage rule were not satisfied, the clearing target would be lowered. Apparently, the available IMT lots in the forward auction were not scarce enough to generate enough value to satisfy the final stage rule. By lower the clearing target, the available IMT lots would be lowered. Consequently, the number of broadcasting licensees to be cleared in the reverse auction would be lower too. Hence, the total value to be paid to these broadcasters would also be lower, as well as the minimum values in the final stage rule. By carrying out multiple rounds of the reverse and forward auction in which the clearing target is subsequently lowered, an equilibrium would be found. Ultimately, 84 MHz was cleared in four stages (i.e. the clearing targets were 114 MHz stage 2, 108 MHz stage 3 and 84 MHz in stage 4)[205]. The 84 MHz fitted 7 paired blocks of 2 x 5 MHz (i.e. 70 MHz usable IMT spectrum)[206].

Finally, a number of observations are made on the applicability of incentive auctions for clearing spectrum:

1) As demonstrated above, the outcome of the incentive auction is not certain. The amount of spectrum that ultimately will be cleared depends on the bidding in the two interrelated auctions. It is not certain that an equilibrium will be found. The design of the various clearing targets will greatly determine if an equilibrium can be found[207];
2) The reasons for the FCC to resort to this novel instrument was twofold:
   a. The hold-out problem with the incumbent broadcasters[208]. The incumbent broadcasters had semi-perpetual spectrum licences which the FCC deemed insurmountable without financial compensation for them to relinquish their spectrum rights, and;
   b. Very scarce spectrum. Apparently, the demand for IMT spectrum was assessed that large that the required spectrum far outstripped the available spectrum. For example, restacking the existing broadcasting services (with the same coverage and

[204] Open multi-round ascending auctions traditionally do not use a clock format, i.e. with bidding rounds with a fixed duration. The clock was used to speed up the bidding process.
[205] It is noted that the bidding in the 600 MHz incentive auction commenced in March 2016 and concluded in March 2017! A total of 372 bidding rounds were conducted.
[206] It is noted that all these IMT spectrum blocks sit below channel 37 (which was not available for IMT).
[207] Some auction analyst claim that it was a close call for the US incentive auction to have found this equilibrium.
[208] The hold-out problem is also known in real estate or road development projects, requiring private landowners to relinquish their land in return for payment of fair market value. However, one or more remaining landowners can push-up the value beyond fair market value.

quality of service) in a smaller band was deemed not possible, as it would not leave enough spectrum for IMT. It is noted that in many countries, such planned restacking solutions are (still) deemed possible and also deemed to satisfy IMT demand;

3) Incentive auctions are complex, time and money consuming. It should be assessed if the market parties have the auction experience and resources to deal with such complexity, as well as that the value can be generated in the market, to bear such costs.

11.3 Guidelines and recommended actions for funding refarming efforts

Table 79 provides a comprehensive list of the guidelines as included in this Section 11.

No	Guideline	Applies to	Reference to Section(s)

12.1	Administrations are advised to consider the following refarming cost categories:
	• Network costs, which can be broken down in:
	  ○ Network re-planning costs
	  ○ Implementation planning costs
	  ○ Network retuning costs
	• Network service user (or viewer) support costs, which can be broken down in:
	  ○ User communication costs
	  ○ User equipment Installation costs
	  ○ User equipment subsidy costs
	• Spectrum clearing costs
	• Licence assignment costs
		Network operators and network service users	Section 11.1.1

12.2	Administrations are advised to consider the following cost categories for DSO/ASO transition:
	• DTTB network deployment costs
	• Analogue Switch-Off (ASO) costs, which can be broken down in:
	  ○ Viewer migration costs
	  ○ Temporary network migration costs
	  ○ Spectrum clearing costs
	  ○ Broadcaster simulcasting costs
	  ○ Project management costs
	  ○ Certification costs
	  ○ Interference mitigation costs
		Broadcasting network operators, broadcasters (or other service providers), affected viewers, regulators and other spectrum users	Section 11.1.2

12.3	After assessing the costs in each of the relevant cost categories, Administrations may have different options for funding these costs. These funding options can be broken down in three basic categories, which may be combined to finance specific cost categories: • Public funding methods • Direct industry funding • Traditional auction and incentive auction	Administrations or Regulators having to finance refarming projects	Sections 11.2.1, 11.2.2 and 11.2.3
1.2.4	Administrations are advised to first consider alternatives to incentive auctions. Incentive auctions are deemed applicable in specific situations in which:	Administration or Regulators having to clear spectrum	Section 11.2.3

No	Guideline	Applies to	Reference to Section(s)
	• A hold-out problem exists with incumbent spectrum users which need to be reallocated quickly • The necessary spectrum for IMT is by far outstripping available spectrum (i.e. extreme spectrum scarcity) • A planned restacking project is deemed not adequate for clearing enough spectrum		

Table 79: Guidelines for funding refarming efforts for IMT introduction