MARKET METHODS IN SPECTRUM RE-ALLOCATION

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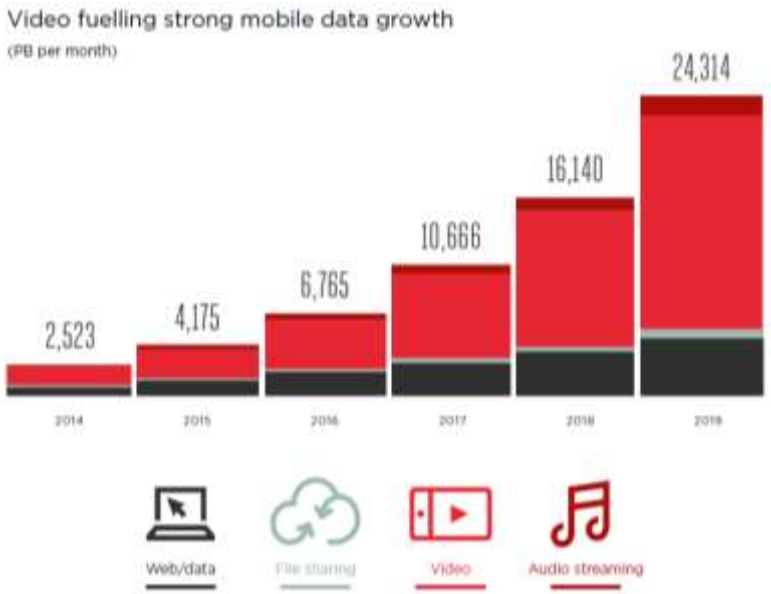
ITU Workshop on Spectrum Management: Economic Aspects

Pavel Mamchenkov, Russian Federation

The Footings of Spectrum Re-allocation

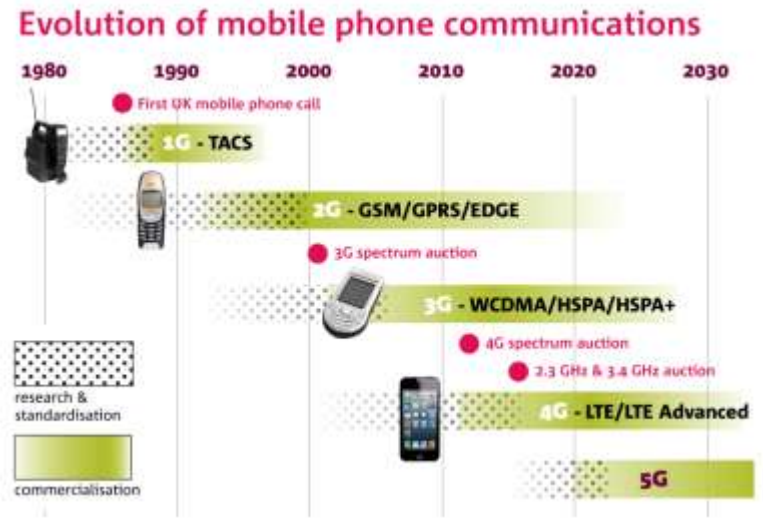
Towards the economy of gigabytes…



Source: GSMA

Demand for data is satisfied by faster growing radio technologies with greater geographic reach and capacity, advanced handsets with increased processing power, larger screens, ubiquitous applications such as social media, messaging, video streaming. Data traffic is growing exponentially 60% annually.

Turnover of radio technologies…



Source: Http://tutorvoice.com/index.php/2015/10/11/generations-of-wireless-communication-technology/

The pace of change in radio technologies is speeding up. From ten years life cycle of new generation in the past, now turnover is increasing. The advent of 4G LTE happened six/seven years from the mass commercial adoption of 3G. 5G is estimated to happen four/five years from adoption of 4G.

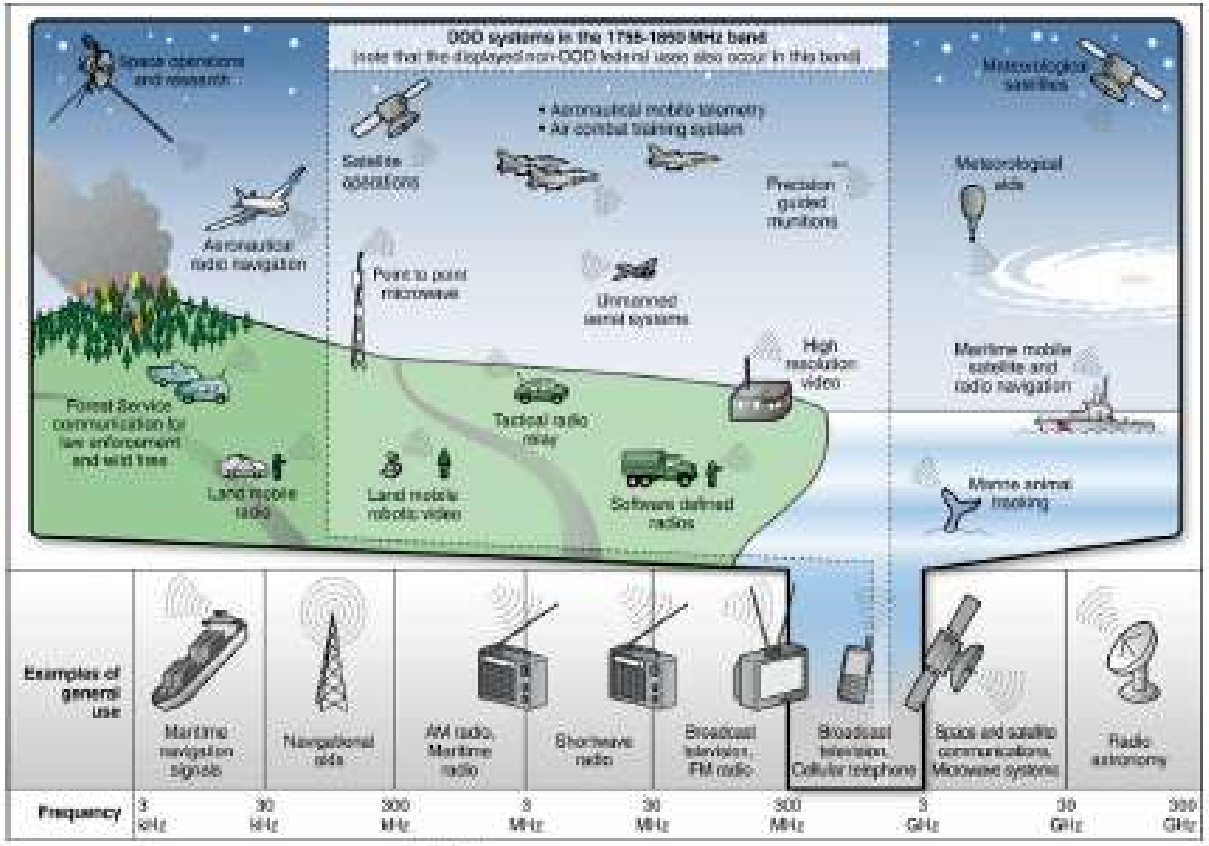
Revolving spectrum allocations…

WRC-07 candidate bands	WRC-07 identified bands	WRC-15 Candidate bands	WRC-15 Identified bands
410 – 430 MHz	450 – 470 MHz	470 – 698 MHz	694 – 790 MHz
450 – 470 MHz	698 - 806 MHz	1350 – 1400 MHz	1427 – 1518 MHz
470 – 862 MHz	790 – 862 MHz	1427 – 1452 MHz	3300 – 3700 MHz
2300 – 2400 MHz	2300 – 2400 MHz	1452 – 1492 MHz	4800 – 4990 MHz
2700 – 2900 MHz	3400 – 3600 MHz	1492 – 1518 MHz	
3400 – 3600 MHz		1518 – 1525 MHz	
3600 – 3800 MHz		1695 – 1710 MHz	
3800 – 4200 MHz		2700 – 2900 MHz	
4400 – 4990 MHz		3300 – 3400 MHz	
		3600 – 3700 MHz	
		3700 – 3800 MHz	
		3800 – 4200 MHz	
		4400 – 4500 MHz	
		4500 – 4800MHz	
		4800 – 4990 MHz	
		5350 – 5470 MHz	
		5725 – 5850 MHz	
		5925 – 6425 MHz	

ITU is in the pervasive rush of seeking for new allocations for emerging radio technologies. Effectively each WRC adopts a host of new spectrum bands for developing and emerging advanced radio technologies.

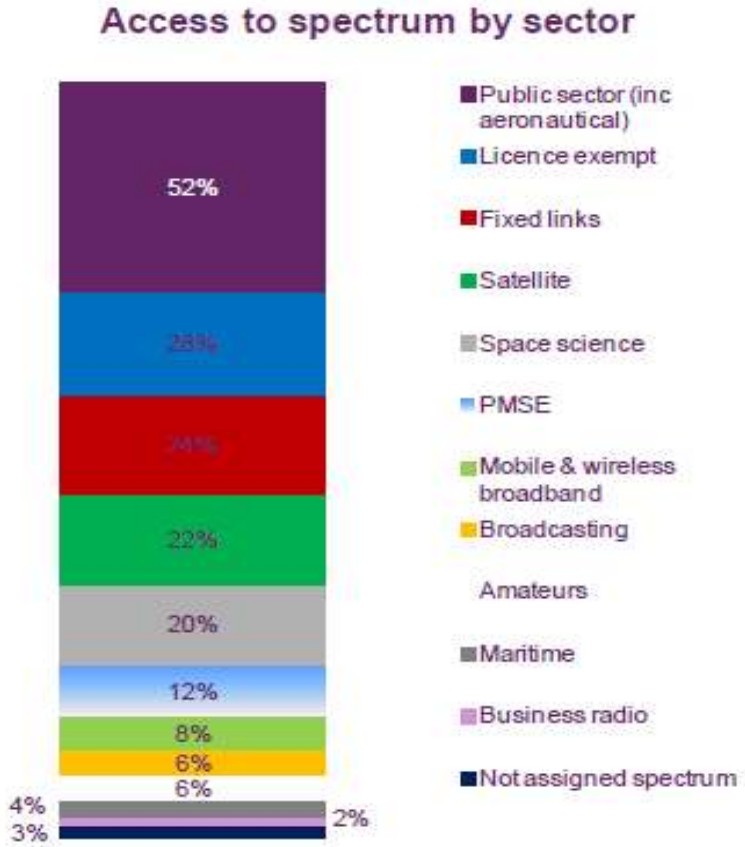
Today Spectrum Demand Exceeds Available Supply

Spectrum is a finite resource of great significance…



Souce: GAO. Spectrum Management. Federal Relocation Costs and Auction Revenues

Typical allocation between uses (UK case)…

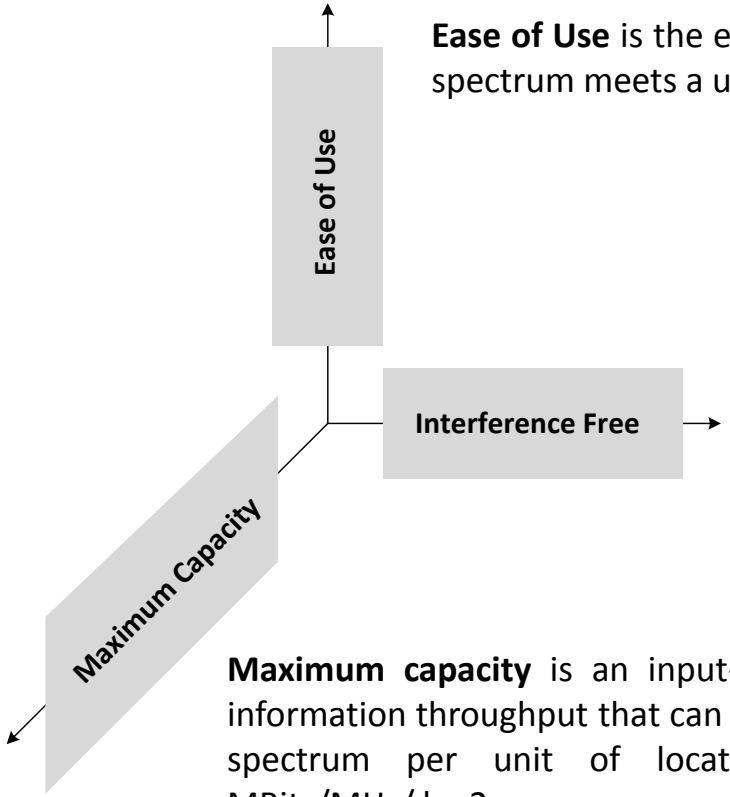


Source: OFCOM

Balancing competing government and industry demands for a limited amount of spectrum, today and in future, is a challenging and complex task for each Telecommunications Administration

Spectrum Efficiency is the Aspiration Target

Technical Efficiency of Spectrum

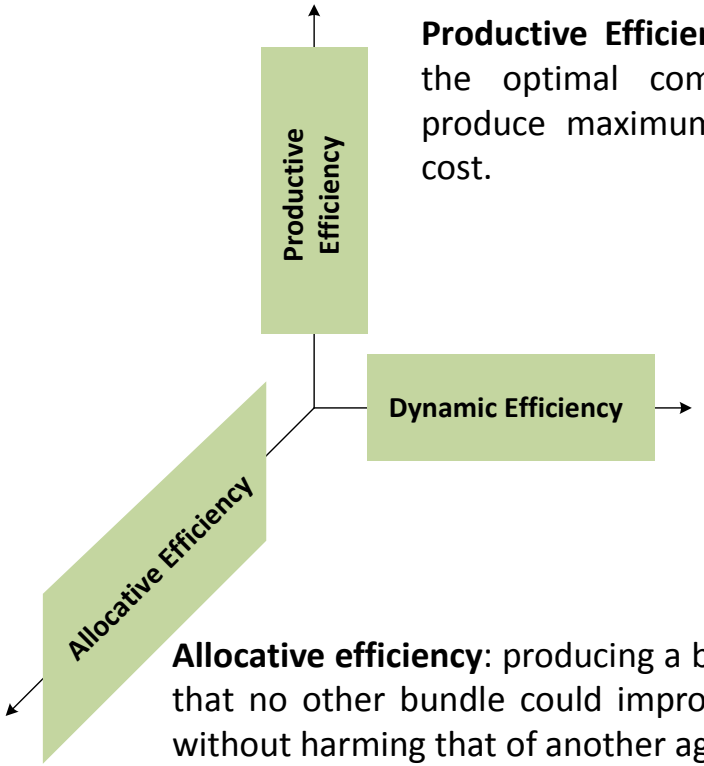


Ease of Use is the extent to which the use of radio spectrum meets a user's specific needs.

Interference free is the characteristic related to avoidance of critical degradation of quality of operation due to mutual influence of different emissions.

Maximum capacity is an input-output ratio referring to the information throughput that can be dispatched per unit of radio spectrum per unit of location. Typically measured in MBits/MHz/ km2

Economic Efficiency of Spectrum



Productive Efficiency: providing services with the optimal combination of resources to produce maximum output for the minimum cost.

Dynamic efficiency: using the resource in such a way that it enables long-term productivity improvements such as through innovation and R&D.

Allocative efficiency: producing a bundle of services so composed that no other bundle could improve the well being of an agent without harming that of another agent.

Economic efficiency relies here on the Pareto criteria, that is, being able (or not) to improve the well-being of one economic agent without harming that of another.

Maximizing technical efficiency does not always maximizes total benefits for the society. Market methods in re-allocation underpin an increase in spectrum efficiency.

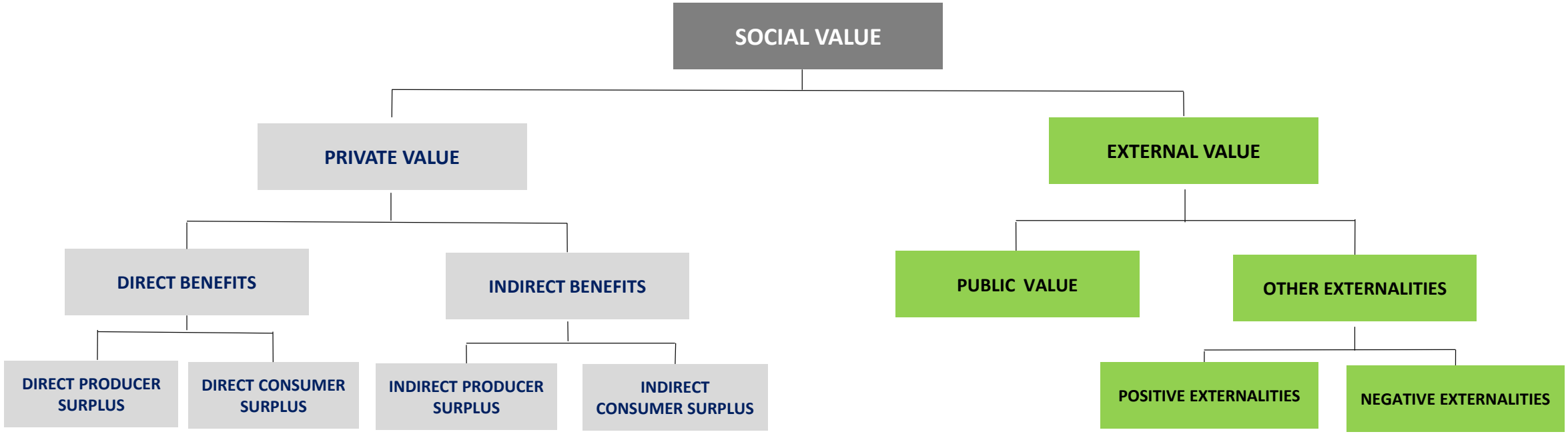
Market Methods at Different Stages of Spectrum Management

Market Methods in Spectrum Life-Cycle

Primary issuing of spectrum (initial licencing)	Post-issuance operation (through the period of licence validity)	Re-issuance of spectrum (re-allocation)
Spectrum Auctions	**Spectrum Pricing and Trading**	**Spectrum Incentive Auctions**
Auction ensures that any newly released spectrum into the market is acquired by those who value it most. Primary issuance of licences based on market signals reflects more accurately the value of spectrum and lead to more efficient spectrum utilization.	Genuine spectrum markets are creating under which ownership and use of spectrum can change in the course of licence's operation. **Spectrum Trading** involves the transfer of spectrum usage rights between interested parties (government, public or private users). **Spectrum Pricing** is powerful mean to achieve a range of spectrum management objectives – efficient usage, innovation and competition.	Incentive Auctions is a market-driven mechanism of re-allocation where regulator plays the role of auctioneer in two-sided bidding process and finds equilibrium in supply and demand. **Sellers (incumbents)** are showing the price for their spectrum intended to be sold - supply. **Buyers (newcomers)** are showing the price at which they are willing to acquire spectrum proposed by incumbents - demand.

Market methods should be applied through the whole spectrum life-cycle

Seminal Components of Spectrum Social Value



Private value is the benefit to society created as the sum of direct and indirect benefits.

Direct benefits are generated from the direct consumption and provision of radio services.

Indirect benefits are generated due to unintended effects of direct service on other product markets thus resulting in further indirect increase of producers and customers surplus.

External value is the additional surplus to consumers or third parties not reflected in the value of the service to consumers.

Public value captures the value that public derives from services because of their broader contribution to society, such as defense and security, social assistance, universal service provision, etc.

Non-Technocratic View on Spectrum Re-allocation

With the experience gained in the last several years it is quite obvious that the technocratic approach with spectrum re-allocation is no longer all-encompassing.

- In conducting its strategic policy regulator should be emphasized with its duties to guarantee further interests of society including consumers, state needs, service providers, industry and to secure the optimal use of spectrum.

- The main incentive of administrations is to re-allocate spectrum in a way that maximizes the total value to society from its future use.

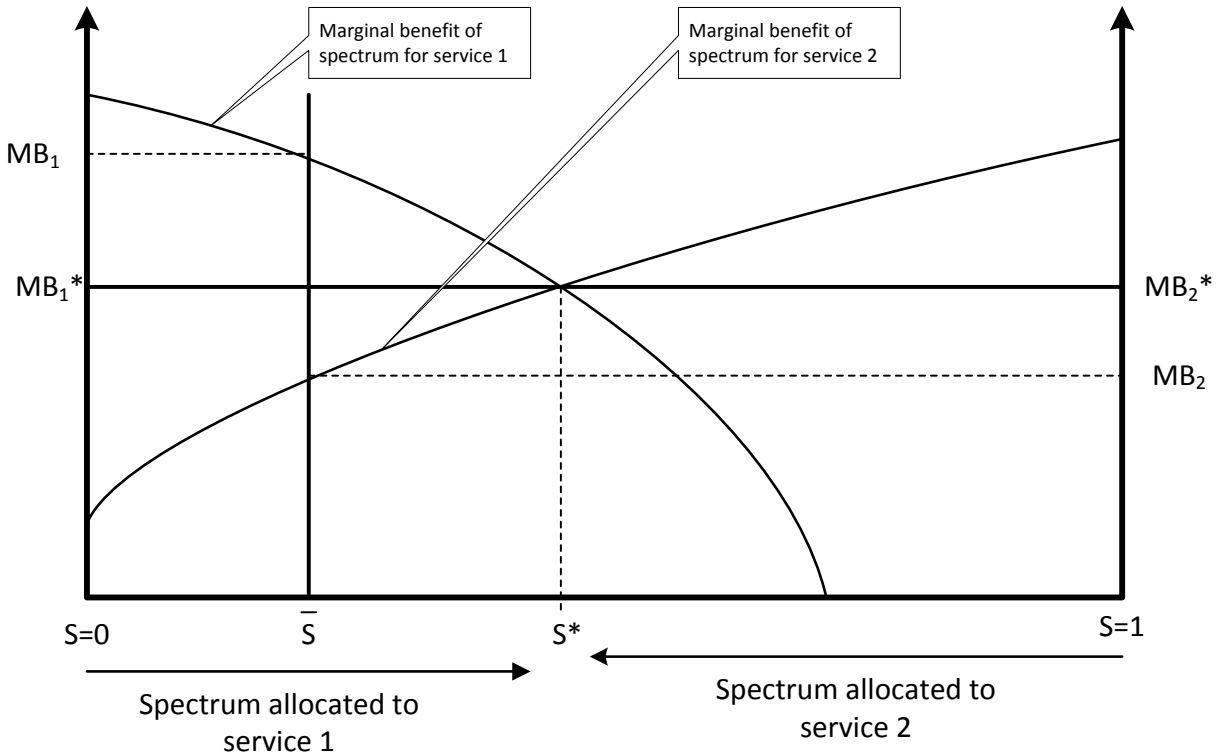
- The social-economic aspects of spectrum re-allocation are based on the fundamental concept of social value of spectrum resources usage. It is agreed that spectrum is used with the highest efficiency under the condition that the total amount of value for society (social value) created by its usage is maximized.

- The key objective is to guarantee the balance between retaining enough spectrum to provide the services of the incumbent users and releasing as much as possible for perspective users while maximizing total social value from the optimal reallocation of the whole band.

Spectrum re-allocation is the potentiality to obtain additional benefits to society arising from the optimal distribution of spectrum to innovative services taking due account of incumbent uses.

How to Obtain Efficient Re-allocation

Simplified economic example…



MB – marginal benefit of service

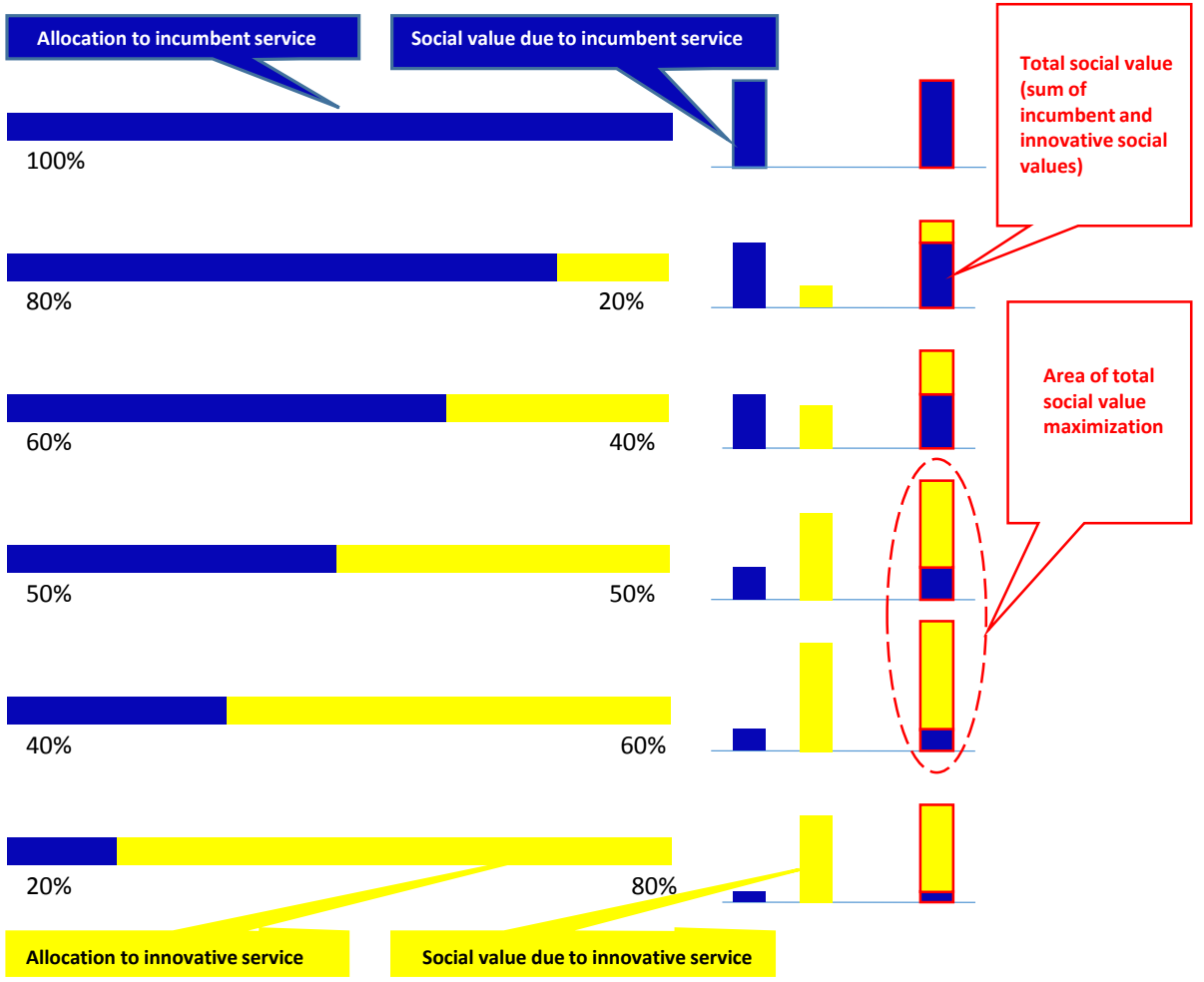
MB* – marginal benefit at point of efficiency

$\overline{S}$ - inefficient spectrum allocations

S* - efficient spectrum allocations

Source: Martin Cave, Spectrum Management, Cambridge University Press, 2015

How it works in practice…



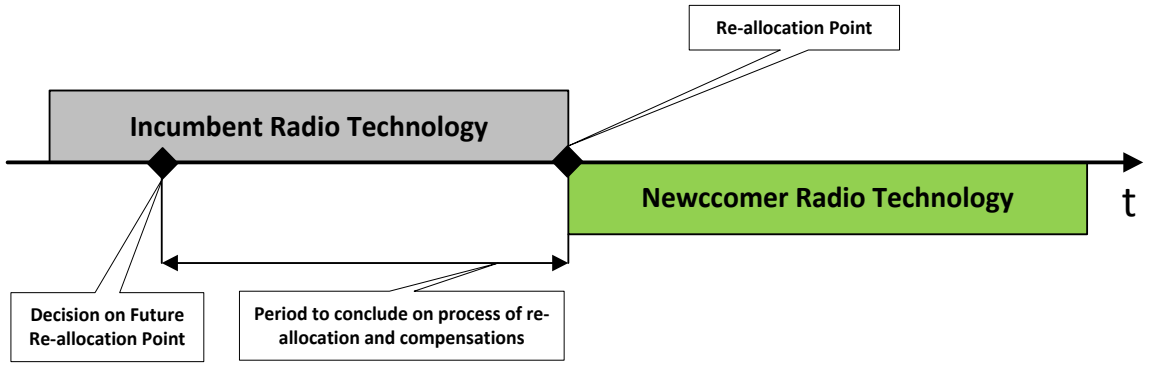
The core challenge is to determine optimal ratio of spectrum resources allocated to incumbents and newcomers so as to maximize the overall social welfare. Market methods are highly eligible.

Re-allocation Classification and Timelines

Re-allocation Classification

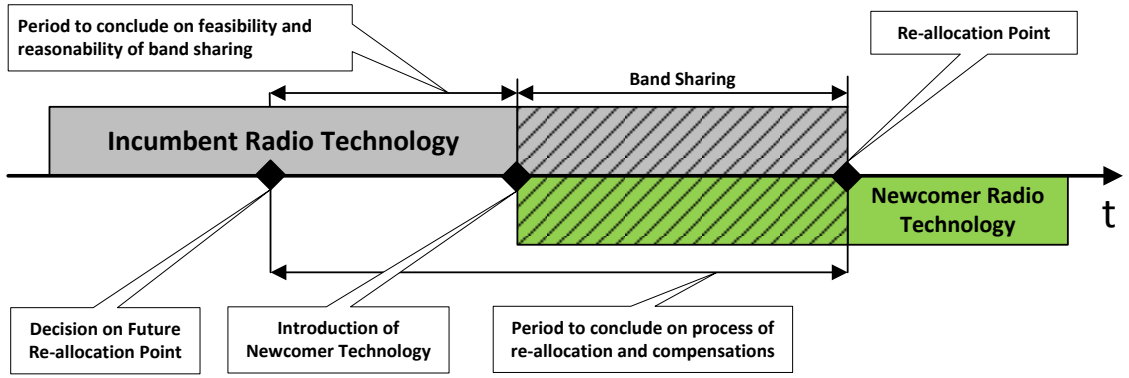
Between Private Users	Between Public and Private Users	Between Public Users
Market methods are preferred to decide on optimum and efficient distribution of allocations among users based on: ▪ Spectrum trading ▪ Spectrum pricing In a loose sense – Coase theorem and Pareto criterion. Incentive auction – innovative tool to facilitate spectrum turnover.	Market methods should be applied to deal with compensations. Regulator estimates the cost of spectrum re-allocation. Re-allocation costs could be agreed as the reserve price for an auction.	Typically command-and-control methods. More arguable with introduction of market methods into the area of spectrum allocations of public sector.

Option 1. Re-allocation timeline, no sharing.



It is an incredible fortune for a regulator to intuit the correct Re-allocation Point of time. The raft of activities should be arranged in between the decision on and practical re-allocation.

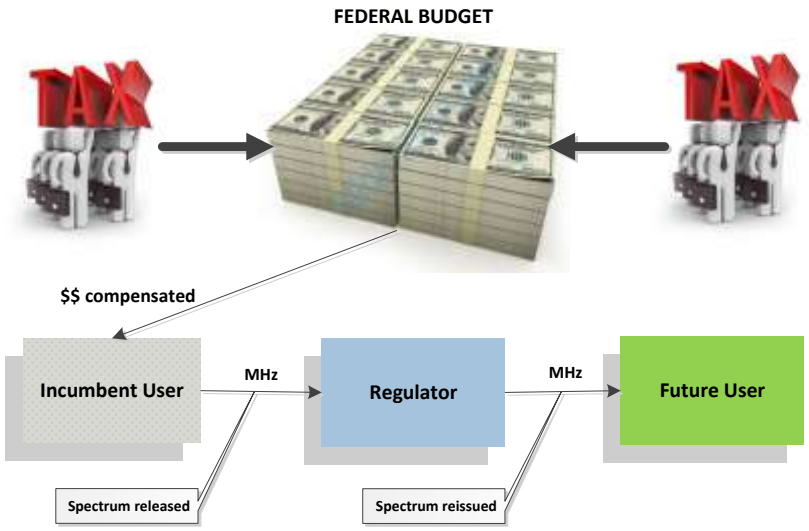
Option 2. Re-allocation timeline, spectrum sharing.



At large extent band sharing assists in fastest possible introduction of newcomer technologies. But it complicates the spectrum management and should not become an endless process.

Landmarks in Re-allocation Financing

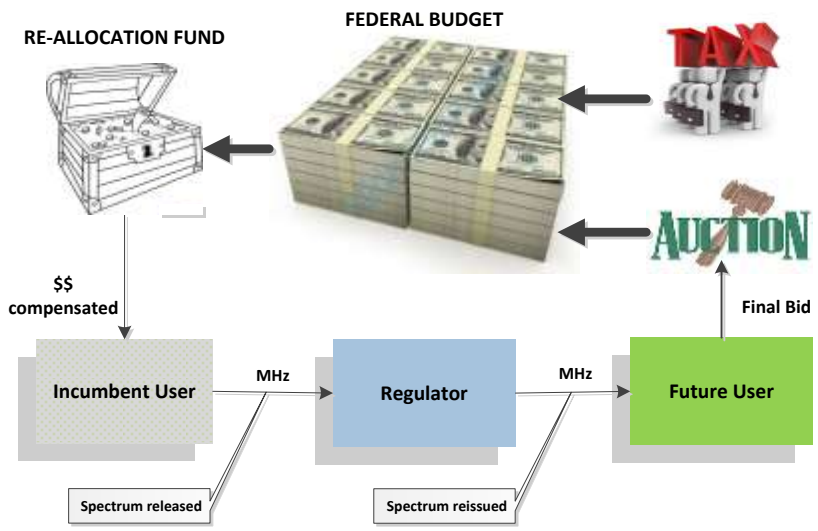
Re-allocation Through Federal Budget



Pros: Typically the compensation funded by federal budget is connoted with a sort of governmental guarantees.

Cons: Non-spectrum users – ordinary taxpayers – are subsidizing spectrum related initiatives.

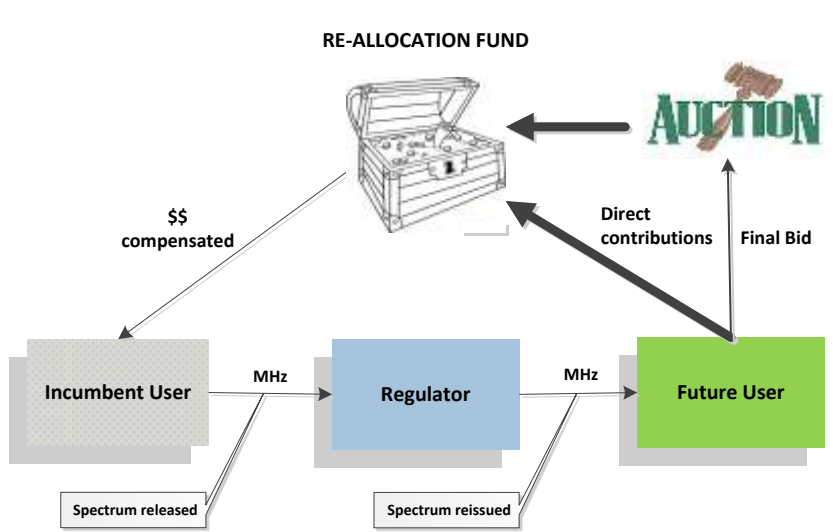
Re-allocation Fund Through Budget



Pros: In essence is similar to bank saving account. Can be financed through spectrum pricing at the primary stage of spectrum issuing (auctions).

Cons: Still might utilize subsidizing from non-spectrum users.

Directly Through Re-allocation Fund

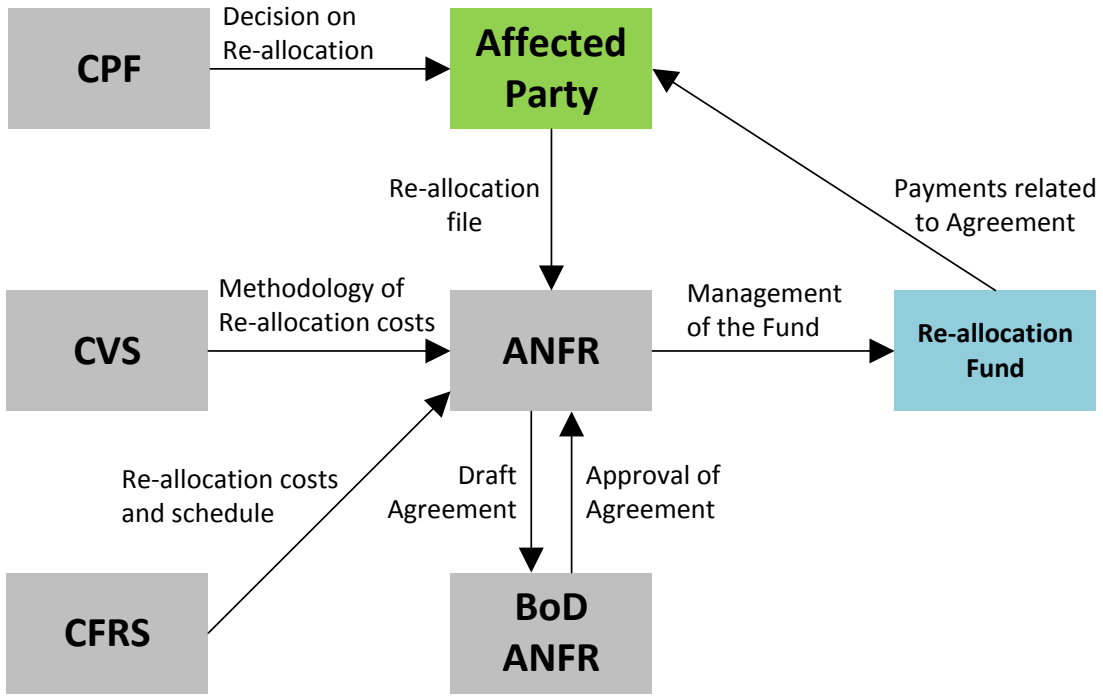


Pros: Re-allocation costs are covered directly by those interested in new allocations. Financial sources from auctions and spectrum fees.

Cons: Requires comprehensive mechanism of Fund's administration.

Spectrum Re-allocation Fund in France

Re-allocation Fund Management



CPF - Commission pour la planification des fréquences
ANFR - Agence nationale des fréquences
CFRS - Commission du fonds de réaménagement du spectre

CVS - Commission de valorisation du spectre
BoD - Board of Directors

Practical Results

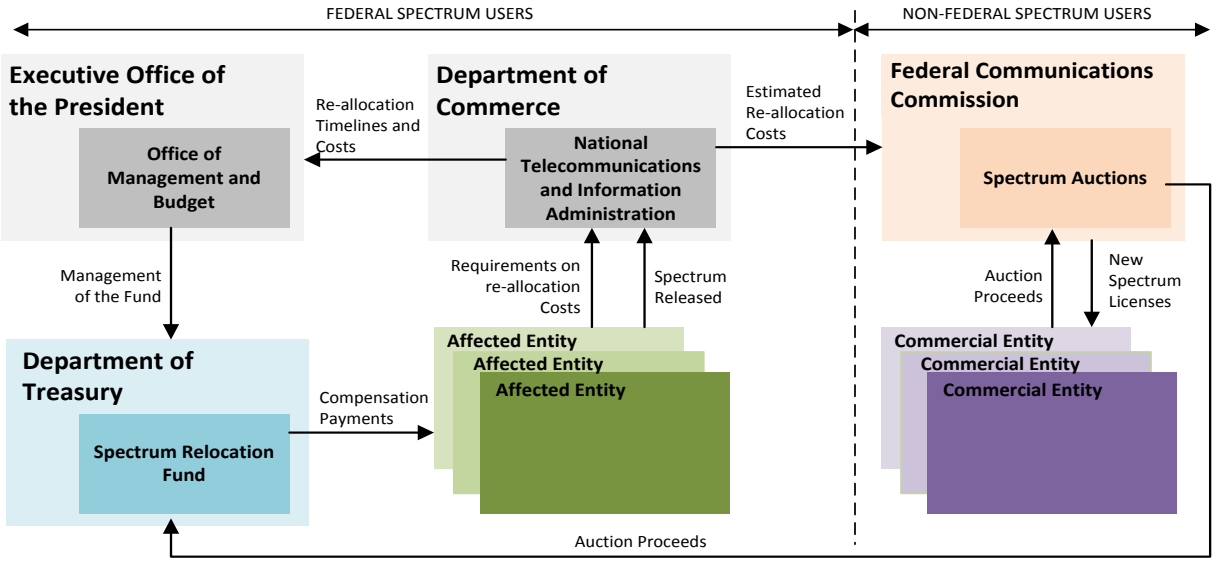
Systems	Spectrum Amount	Transferred from
GSM900	50 MHz	Defense
GSM1800	150 MHz	Defense
UMTS2100	140 MHz	Defense (partly)
WiFi2400	83 MHz	Defense
WiFi5 GHz	450 MHz	Defense, Meteo, Space
LTE2600	190 MHz	Defense
LTE800	40 MHz	Defense, Broadcasting

The Fund is established by Law and managed by ANFR. The money is used for required changes, bills are provided to ANFR. Every six months the newcomer refunds ANFR based on the amount of spectrum owned or on actual amount spend. If the newcomer is not known (auction has not taken place yet) ANFR takes expenditures from the ANFR accumulated funds.

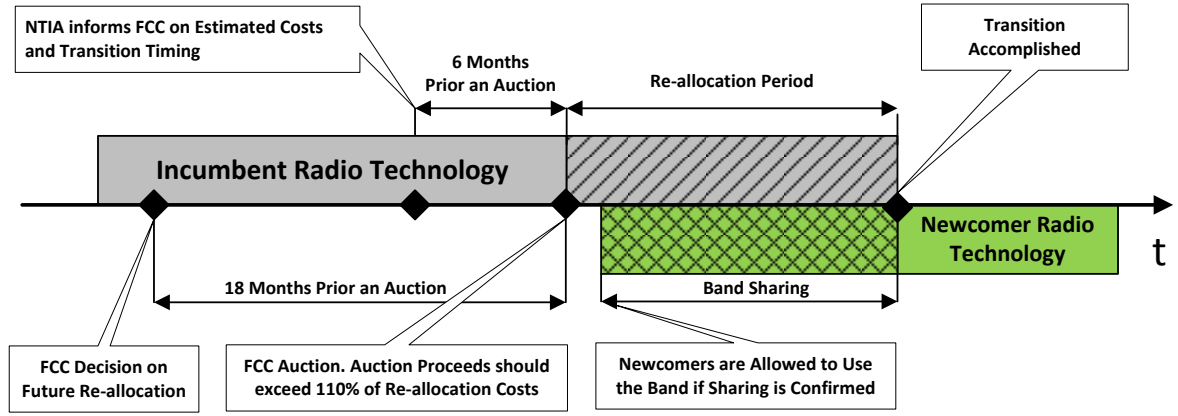
A “convention”/contract is produced between the three parties involved (existing user, new user and ANFR). This document sets out the modality for the move, financial implications and how ANFR will monitor and control this process.

Spectrum Re-allocation Fund in the USA

Re-allocation Fund Management



Practical Results



Primary Legislation on Re-allocation

Omnibus Budget Reconciliation Act, 1993	Identification bands of frequencies which meet certain criteria of re-allocation. Initial provisions on the process.
Commercial Spectrum Enhancement Act, 2004	Specifies provisions on the process of reallocation from governmental to commercial users. Establishes Spectrum Relocation Fund (SRF).
Middle Class Tax Relief and Job Creation Act, 2012	Extends reimbursement to spectrum sharing scheme. Requires agencies to submit transition plans for interagency management review of costs and timelines

1. FCC shall notify NTIA at least 18 months prior to the commencement of any auction of frequencies subject to re-allocation.
2. NTIA at least 6 months prior to an auction on behalf of the affected Federal entities and after review by the Office of Management and Budget, shall notify FCC of estimated relocation costs and timelines.
3. NTIA shall provide a Federal entity involved with information on alternative frequencies to which their radio operations could be relocated for purposes of calculating the estimated relocation costs and timelines.
4. FCC shall not conclude any auction of re-allocated frequencies if the total proceeds are less than **110 percent** of the total estimated relocation costs.
5. FCC may grant a new license for the use of frequencies under transition prior to the termination of Federal entity's authorization subject that the licensee cannot cause harmful interference to such Federal entity.

Auctions as the Instrument of Spectrum Re-allocation

AWS-1 1710 – 1755 MHz Auction with Compensation in the USA

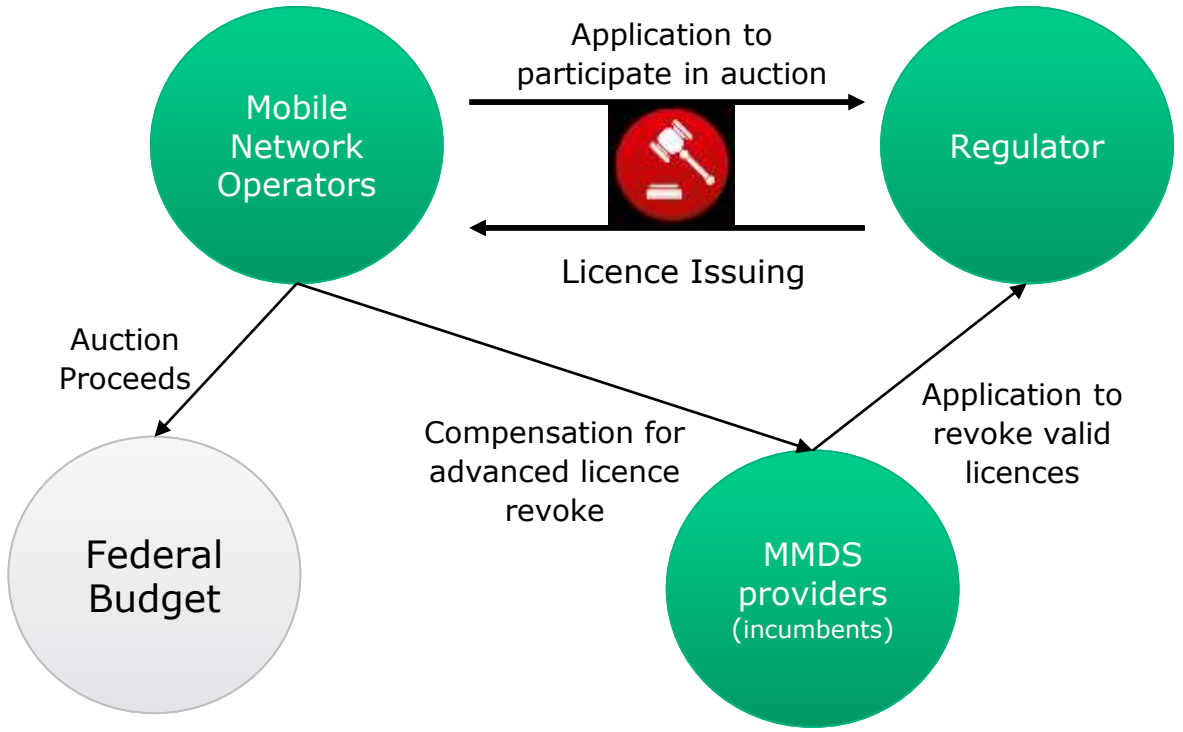
Table 1: Comparison of Estimated and Actual Relocation Costs for the 1710-1755 MHz Band (as of March 2013)

Department/agency	Estimated relocation costs[a]	Current actual relocation costs[b]
Agriculture	$21,578,486	$21,578,486
Defense	355,351,524	289,846,448
Energy	176,820,959	212,200,959
Homeland Security	89,994,832	282,239,840
Housing and Urban Development	21,115	21,115
Interior	25,411,949	31,936,326
Justice	262,821,000	556,424,000
Transportation	58,062,020	58,062,020
Treasury	5,301,000	5,301,000
National Aeronautics and Space Administration	740,000	740,000
Tennessee Valley Authority	10,687,857	15,751,057
United States Postal Service	1,761,760	8,333,760
Total	**1,008,552,502**	**1,482,435,011**

Source: NTIA, Relocation of Federal Radio Systems from the 1710-1755 MHz Spectrum Band: Sixth Annual Progress Report (Washington, D.C.: March 2013).

Actual costs to relocate communications systems for 12 federal agencies from the 1710-1755 MHz band have exceeded original estimates by about $474 million, or 47 percent, as of March 2013.
Although underestimated costs were well exceeded and covered with net auction proceeds 13.8 billion USD.

LTE TDD 2600 MHz Auction with Compensation in Russia

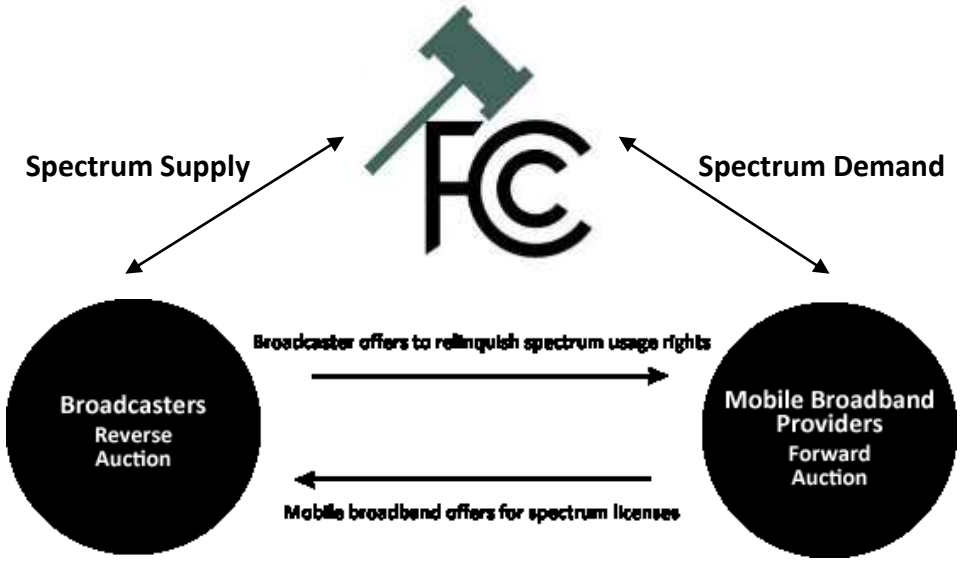


The concept included direct compensation payments from winners (mobile operators) to incumbent MMDS operators, while auction proceeds came to Federal Budget.
Compensation was calculated as the proportion of auction proceeds for the gained spectrum relinquished by incumbent MMDS provader.

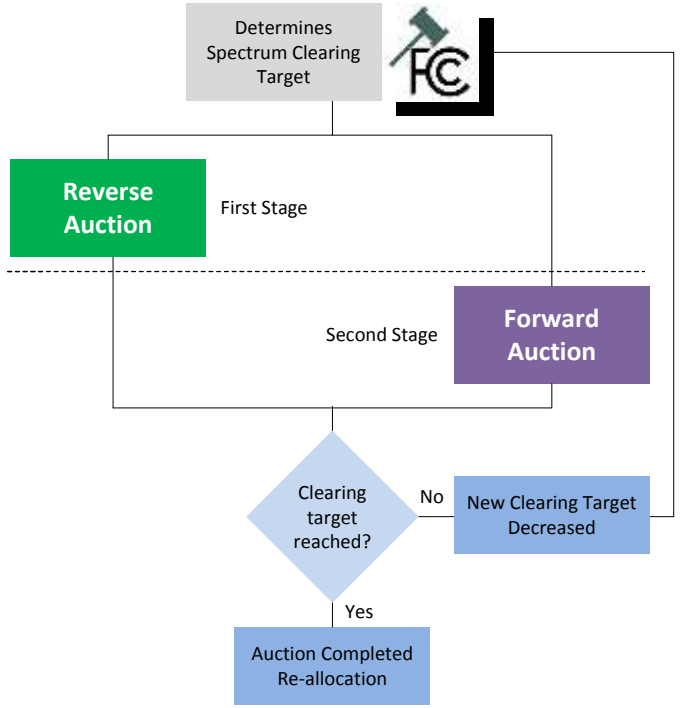
Incentive Auctions – Ingenious Market-Based Re-allocation Instrument

Concept of Incentive Auction

The FCC is serving as a matchmaker in 600 MHz incentive auction, going back and forth between broadcasters and bidders to settle on a price that strikes a balance between spectrum supply and demand



Auction Algorithm and Costs Distribution



Reverse auction

determines the price at which broadcasters will voluntarily relinquish their spectrum usage rights.

Forward auction

determines the price companies are willing to pay for flexible use wireless licenses in former TV bands.

Final Stage Cost Components

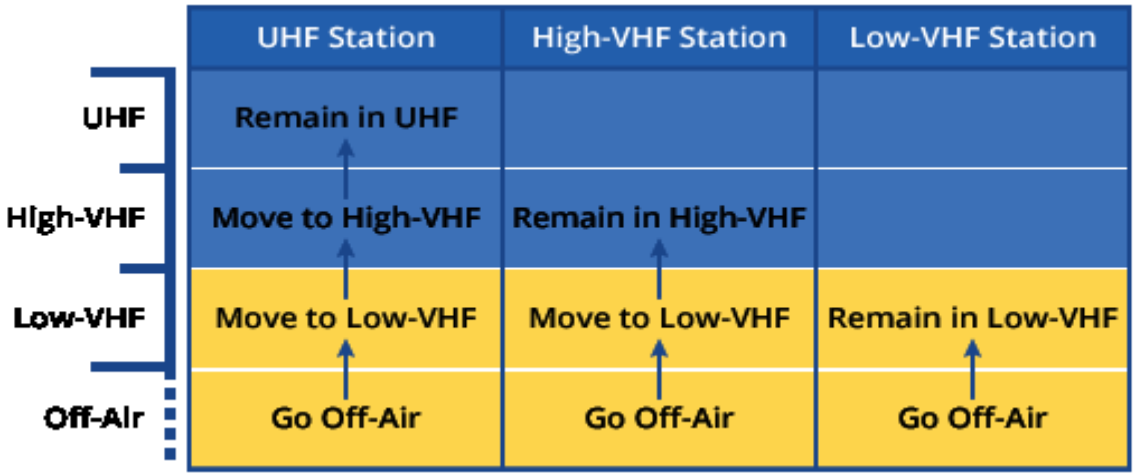
Auction proceeds are expended on three components:

1. Winning bidders' payments required for broadcasters
2. FCC's relevant administrative costs around $226 million
3. $1,75 billion – relocation costs for broadcasters

Incentive auction leaves market to decide on bandwidth to be released and prices to be paid for spectrum turnover

How Incentive Auction Works

Broadcasting Repacking as the Premise

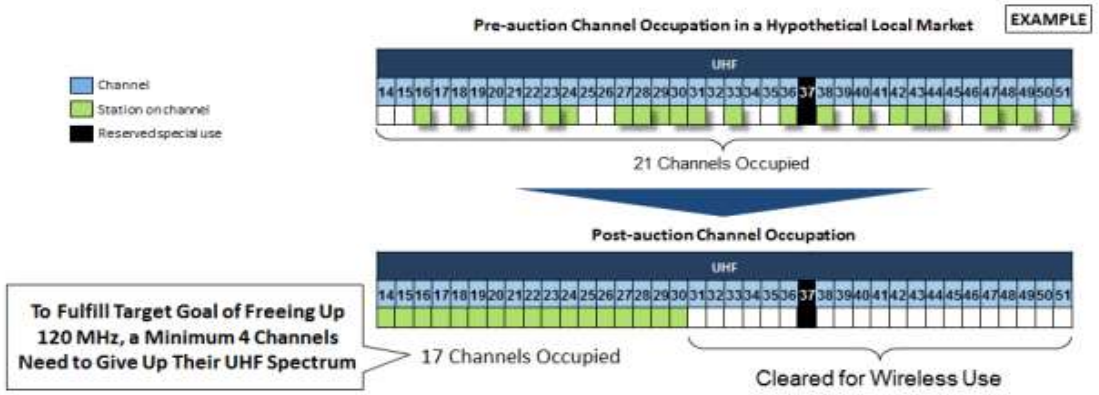


Source: FCC

Options for Band Plans and Preliminary Results

Source: FCC

The lynchpin joining the reverse and the forward auctions is the "repacking" process. Repacking involves reorganizing and assigning channels to the remaining broadcast television stations in order to create contiguous blocks of cleared spectrum suitable for mobile flexible use.



Source: FCC

Stage 1. August 2016	Clearing target 126 MHz Available for mobile broadband to bid 100 MHz	Reverse Auction $ 88,4 billion Forward Auction $ 23,6 billion Clearing Target Not Reached
Stage 2. October 2016	Clearing target 114 MHz Available for mobile broadband to bid 90 MHz	Reverse Auction $ 54,6 billion Forward Auction $ 21,5 billion Clearing Target Not Reached
Stage 3. November 2016	Clearing target 108 MHz Available for mobile broadband to bid 90 MHz	Reverse Auction $ 22,5 billion currently Forward Auction not opened yet


Thank You