MARKET METHODS IN SPECTRUM RE-ALLOCATION

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ITU Workshop on Spectrum Management: Economic Aspects
Pavel Mamchenkov, Russian Federation
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.

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.

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...

Typical allocation between uses (UK case)...

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

<table>
<thead>
<tr>
<th>Ease of Use</th>
<th>Interference Free</th>
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<tbody>
<tr>
<td>Ease of Use is the extent to which the use of radio spectrum meets a user’s specific needs.</td>
<td>Interference free is the characteristic related to avoidance of critical degradation of quality of operation due to mutual influence of different emissions.</td>
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**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

<table>
<thead>
<tr>
<th>Productive Efficiency</th>
<th>Dynamic Efficiency</th>
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<tbody>
<tr>
<td>Productive Efficiency: providing services with the optimal combination of resources to produce maximum output for the minimum cost.</td>
<td>Dynamic efficiency: using the resource in such a way that it enables long-term productivity improvements such as through innovation and R&amp;D.</td>
</tr>
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**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

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<tbody>
<tr>
<td>Primary issuing of spectrum</td>
<td>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.</td>
<td>Genuine spectrum markets are creating under which ownership and use of spectrum can change in the course of licence’s operation. <strong>Spectrum Trading</strong> involves the transfer of spectrum usage rights between interested parties (government, public or private users). <strong>Spectrum Pricing</strong> is powerful mean to achieve a range of spectrum management objectives – efficient usage, innovation and competition.</td>
<td>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. <strong>Sellers (incumbents)</strong> are showing the price for their spectrum intended to be sold - supply. <strong>Buyers (newcomers)</strong> are showing the price at which they are willing to acquire spectrum proposed by incumbents - demand.</td>
</tr>
<tr>
<td>Post-issuance operation</td>
<td></td>
<td></td>
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<tr>
<td>(through the period of licence validity)</td>
<td></td>
<td></td>
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<tr>
<td>Re-issuance of spectrum</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(re-allocation)</td>
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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...

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

<table>
<thead>
<tr>
<th>Between Private Users</th>
<th>Between Public and Private Users</th>
<th>Between Public Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market methods are preferred to decide on optimum and efficient distribution of allocations among users based on:</td>
<td>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.</td>
<td>Typically command-and-control methods. More arguable with introduction of market methods into the area of spectrum allocations of public sector.</td>
</tr>
<tr>
<td>- Spectrum trading</td>
<td>- Spectrum pricing</td>
<td></td>
</tr>
<tr>
<td>In a loose sense – Coase theorem and Pareto criterion. Incentive auction – innovative tool to facilitate spectrum turnover.</td>
<td></td>
<td></td>
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</table>

### 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**

<table>
<thead>
<tr>
<th><strong>Re-allocation Through Federal Budget</strong></th>
<th><strong>Re-allocation Fund Through Budget</strong></th>
<th><strong>Directly Through Re-allocation Fund</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**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.

**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.

**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.
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

FEDERAL SPECTRUM USERS

Executive Office of the President

Office of Management and Budget

Department of Commerce

National Telecommunications and Information Administration

Estimated Re-allocation Costs

NON-FEDERAL SPECTRUM USERS

Department of the Treasury

Spectrum Relocation Fund

Federal Communications Commission

FCC Decision on Future Re-allocation

FCC Auction. Auction Proceeds should exceed 110% of Re-allocation Costs

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.

Incumbent Radio Technology

Newcomer Radio Technology

Band Sharing

Newcomers are Allowed to Use the Band if Sharing is Confirmed

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.

Practical Results

FCC shall notify NTIA at least 18 months prior to the commencement of any auction of frequencies subject to re-allocation.

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.

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.

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.

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>
<thead>
<tr>
<th>Department/agency</th>
<th>Estimated relocation costs (as of March 2013)</th>
<th>Current actual relocation costs (as of March 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>$21,578,486</td>
<td>$21,578,486</td>
</tr>
<tr>
<td>Defense</td>
<td>355,351,524</td>
<td>289,846,448</td>
</tr>
<tr>
<td>Energy</td>
<td>176,820,959</td>
<td>212,200,959</td>
</tr>
<tr>
<td>Homeland Security</td>
<td>89,994,832</td>
<td>282,239,840</td>
</tr>
<tr>
<td>Housing and Urban Development</td>
<td>21,115</td>
<td>21,115</td>
</tr>
<tr>
<td>Interior</td>
<td>25,411,949</td>
<td>31,936,326</td>
</tr>
<tr>
<td>Justice</td>
<td>262,821,000</td>
<td>556,424,000</td>
</tr>
<tr>
<td>Transportation</td>
<td>58,062,020</td>
<td>58,062,020</td>
</tr>
<tr>
<td>Treasury</td>
<td>5,301,000</td>
<td>5,301,000</td>
</tr>
<tr>
<td>National Aeronautics and Space Administration</td>
<td>740,000</td>
<td>740,000</td>
</tr>
<tr>
<td>Tennessee Valley Authority</td>
<td>10,687,857</td>
<td>15,751,057</td>
</tr>
<tr>
<td>United States Postal Service</td>
<td>1,761,760</td>
<td>8,333,760</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,008,552,502</strong></td>
<td><strong>1,482,435,011</strong></td>
</tr>
</tbody>
</table>


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 provider.
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.

**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.

**Auction Algorithm and Costs Distribution**

- **Reverse Auction**
  - Determines Spectrum Clearing Target
  - First Stage

- **Forward Auction**
  - Second Stage
  - New Clearing Target Decreased

**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

<table>
<thead>
<tr>
<th>UHF Station</th>
<th>High-VHF Station</th>
<th>Low-VHF Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remain in UHF</td>
<td>Move to High-VHF</td>
<td>Move to Low-VHF</td>
</tr>
<tr>
<td>Move to High-VHF</td>
<td>Remain in High-VHF</td>
<td>Go Off-Air</td>
</tr>
<tr>
<td>Move to Low-VHF</td>
<td>Move to Low-VHF</td>
<td>Go Off-Air</td>
</tr>
<tr>
<td>Go Off-Air</td>
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</tr>
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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.

Options for Band Plans and Preliminary Results

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
Forward Auction not opened yet
Thank You