SPECTRUM MANAGEMENT AND ADMISTERED INCENTIVE PRICING: AN EVALUATION OF THE OPPORTUNITY COST OF THE SPECTRUM IN ITALY

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Motivation and Roadmap

- Our analysis provides an evaluation of the value (= opportunity cost) of the spectrum for relavant bands, i.e. frequencies that could be freed from TV Digital switchover (digital divided) and frequencies for LTE technologies
- This study is part of the ISBUL project by AGCOM
- Plan:
  - AIP, definition and properties (*Indepen-Aegis*, 2004 and 2005)
  - The UK experience
  - the techno-economic model (bidirectional and broadcasting)
  - Value's estimations

Today there is a clear perception of the value of the radio spectrum, main enabler of high-value services

Already in place services

Breakthrough new applications

No single allocation method has been able to grant efficiency

Command & Control	Use as a Common
■ Exclusive allocation of spectrum bands operated by a central agency to a specific use, a specific technology and a specific operator ■ Great technical results ■ Weaknesses in its rigidity ❑ Doesn't allow the resource to be allocated to who is ready to use it in the most efficient industrial way ❑ It reduces the innovation rate	■ Portion of the spectrum where everybody can transmit without needing a license ■ The efficiency can be reached only when excess capacity exists ■ Overuse and interference

Administrative Incentive Prices

- Developed mainly in the UK
- Based on the method developed by NERA Economic Consulting and Smith System Engineering Limited in 1996
- Regulated tariffs to be paid by license owners
- Reflects the opportunity-cost
- Ability to lead changes in the frequency assignment using the only information available
- Need to recalculate these tariffs periodically

The AIP method has interesting characteristics

- More efficient allocation of spectrum (though less efficient than market mechanisms like auctions or trading)

⇒ If a certain frequency's AIP seems too high, the company holding those frequencies might be encouraged to relinquish them, which could then be put into the market and assigned to a company able to use them more efficiently – presumably willing to pay more for them

- Frequencies valorization
- Push for innovation and incentive for the creation of new standards
- Increase in the Public revenues
- Extraction of part of the rents from operators

The UK application

Spectrum value in the UK

Use	Value 2004/2005(thousands £)	Value 2005/2006(thousands £)
Aeronautical	818	931
Amateur and citizen's band	1,030	883
Broadcasting	2,454	4,001
Business radio	15,187	11,838
Fixed links	18,203	20,895
Maritime	1,723	2,031
Program making and special events	1,145	1,412
Public Wireless Networks	63,868	63,011
Science and Technology	112	745
Satellite	928	974
Ministry of Defence	24,314	55,398
Total	132,168	164,094

Source: Chris Doyle, "AIP Market prices boost efficiency", Spectrum Tracker, March 2007

AIP, efficiency

- “The fundamental mechanism by which the spectrum regime could contribute to economic growth is through ensuring that users face continuous incentives towards more productive use of this resource. […] these incentives should be financial and based on the opportunity cost of spectrum use. In this way, *spectrum would be costed as any other input into the production process. Price signals about the cost of using spectrum would be disseminated throughout the economy*.” - Cave *et al.* (2007)

- AIP are almost efficient

AIP, Indepen-Aegis-Warwick Business School method (2004, 2005)

- Spectrum heterogeneity between uses
- Opportunity cost calculation for every frequency and every technically feasible use
- Introduction of an input other than spectrum
- Need to change the approach to spectrum management by National Authorities $\Rightarrow$ more efficient (market) mechanism

The value of the frequency bands has to be analyzed to favor the best use

Value for different services and frequency bands

Frequency band	Current service	Alternative service 1	Alternative service 2	Alternative service 3
Band 1	100	80	95	70
Band 2	100	110	90	80
Band 3	60	70	100	90
Band 4	110	80	80	95

Alternative more efficient use of the spectrum

Current use is efficient

Opportunity-cost evaluation can be used to set a ground value

- It refers to the opportunity-cost calculated observing how the interchangeability of a complementary production resource changes in response to a modification in the use of a marginal portion of spectrum
- Calculated as the cost difference that an operator would have to sustain in case the access to the spectrum changes
- These costs depend on the type of application and technology used, and are equivalent to the *minimum* estimated cost for the provision of the service by using the most economical alternative available.

Opportunity-cost evaluation can be used to set a ground value

- In principle, these alternatives may include:
  - Investing in more/less network infrastructure to achieve the same quantity and quality of output with less/more spectrum
  - Adopting narrower bandwidth equipment
  - Switching to an alternative band
  - Switching to an alternative service (e.g. a public service rather than private communications)
  - Switching to an alternative technology (e.g. fibre or leased line rather than fixed radio link).

The AIP model has been customized identifying 6 sections

Drivers

1. Frequency
2. Application area
3. Technology and infrastructure costs

Calculation

4. Marginal bandwidth variation
5. Bidirectional model
6. Broadcast model

Output

Opportunity-cost value

Frequency selection

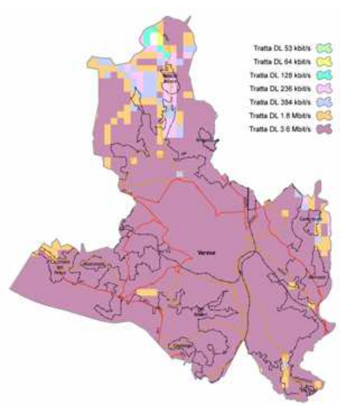
1

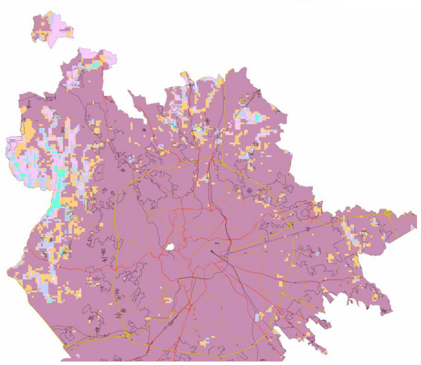
- Central frequency
- Bandwidth selection
- Marginal unit of spectrum

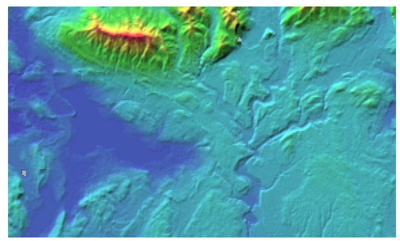
Application area selection

2

Exact approach







- Ground analysis
- Coverage simulation
- Interfering signals analysis

High complexity, precise value

Heuristic approach

- Use of mean proxies to reduce the computational effort
- Localization is made on aggregate data
- Ground and propagation characteristics are not considered

Low complexity, acceptable value

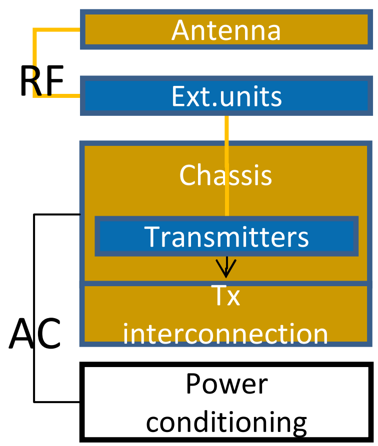
Technology and infrastructure costs

3

Cost elements | **Evaluation proxies** | **Cost**

Interconnection
- MW bridge
- Leased line

Equipment



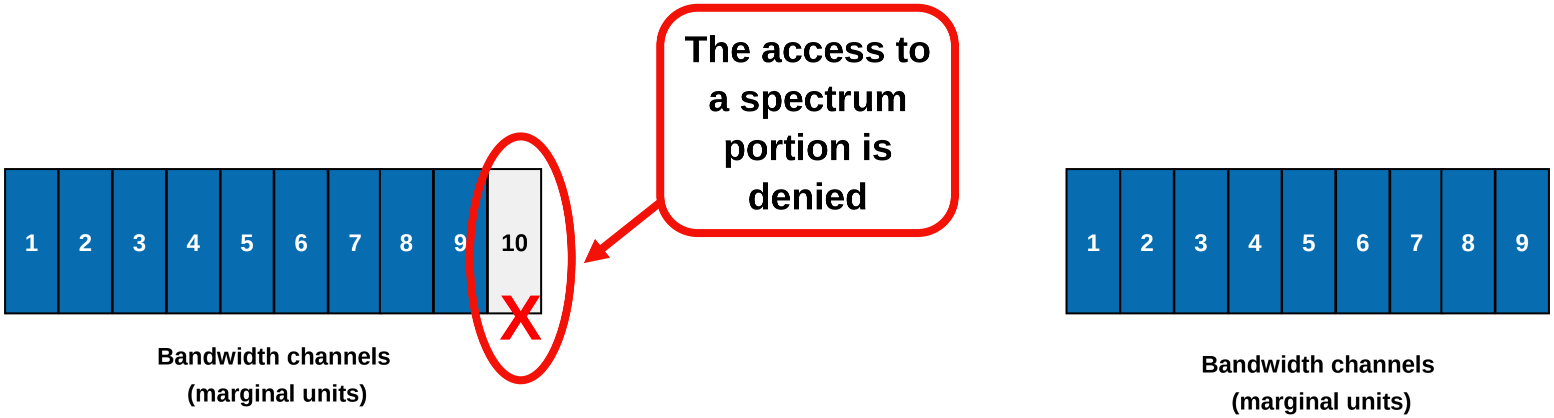
Site
- Tower
- Shelter
- Site preparation

Evaluation proxies
- Depreciation
- Cost of capital (WACC)
- Investment sharing

Cost
- Technology and infrastructure cost

Marginal bandwidth variation

Current spectrum use | **Final spectrum use**



- Actual network
- Planned for optimal service

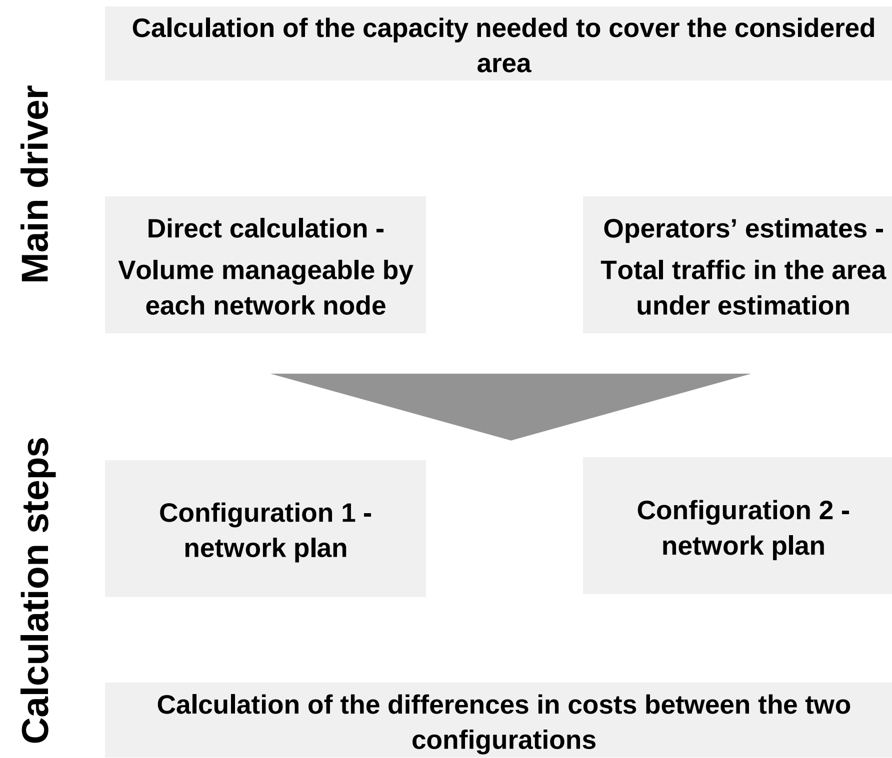
- Increase in the number of sites/transmitters
- Use of a different option to cover gaps

Optimal service to all users ▶ Same service with less spectrum ▶ Cost increase

Bidirectional model

Key Information

- Based on bandwidth saturation
- Positive value only in high-density (near saturation) areas
- Not bound to propagation issues



Broadcast model

6

Key Information

- Transmitters location and existing coverage is considered
- Propagation issues and terrain model is to be analyzed

Main driver

Calculation of the users reached by the broadcast service in the area under evaluation

Calculation steps

Configuration 1 - users reached

Configuration 2 - users reached

Calculation of coverage/user/service loss with the spectrum configuration 2

Calculation of the differences in costs to offer the same service in the two configurations

UMTS: An EU Comparison

UMTS spectrum Value - EU Comparison

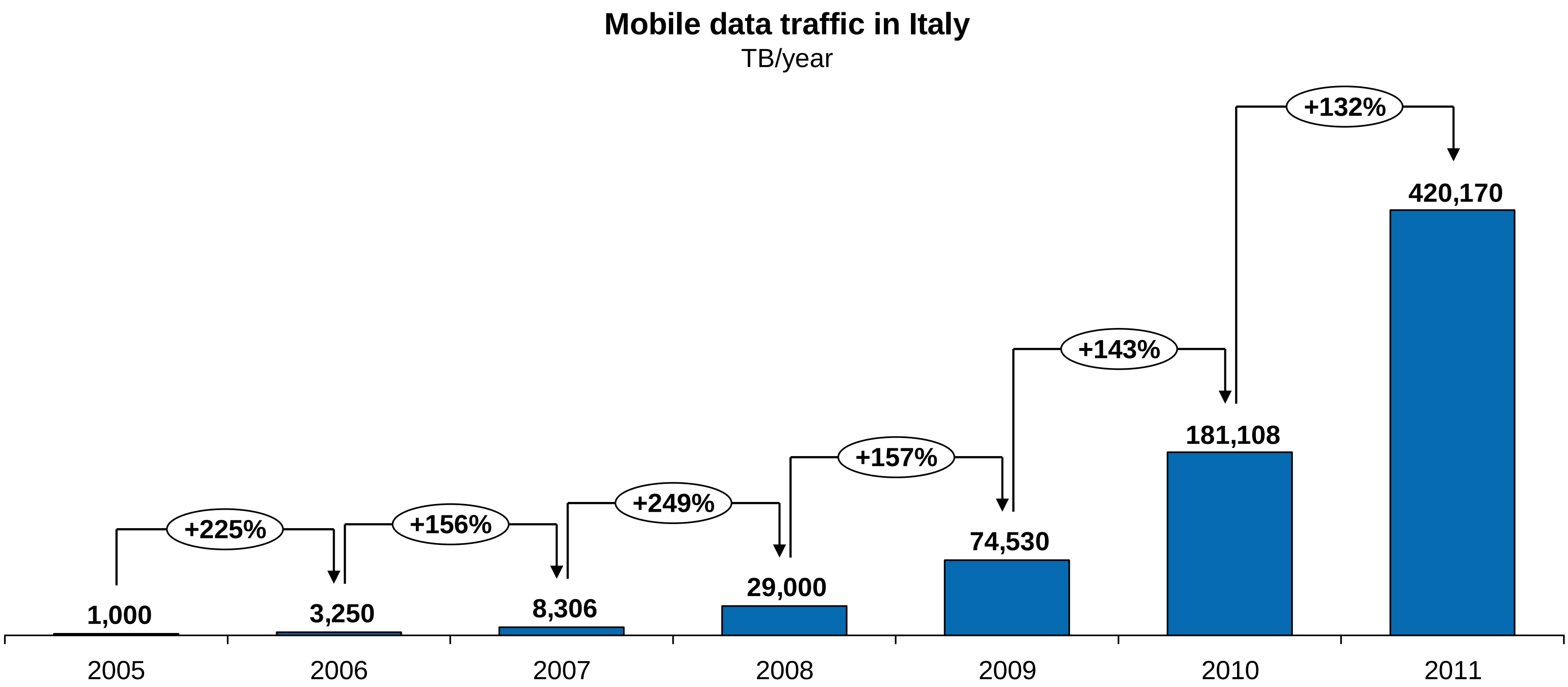
Evaluation area	Year	Model	Population reached by the service	Value per 1MHz	Value per MHz/person
France	2001	Beauty contest	59,7 Million	€ 19,6 Million	€ 0,33
Germany	2002	Multiple rounds auction	83,2 Million	€ 17,5 Million	€ 0,21
UK	2002	Multiple rounds auction	59,7 Million	€ 4,2 Million	€ 0,07
Italy	2002	Multiple rounds auction	60,05 Million	€ 12,1 Million	€ 0,2
Italy	2009	Beauty contest	60,05 Million	€ 8,9 Million	€ 0,14
Italy	2009	Cambini-Garelli –Phase 1	60,05 Million	€ 4,2 Million	€ 0,069
Italy	2009	Cambini-Garelli –Phase 2	60,05 Million	€ 6,1 Million	€ 0,101
Italy	2009	Cambini-Garelli-Phase 3	60,05 Million	€ 11 Million	€ 0,18

DVB-T: A comparison with UK's studies

DVB-T spectrum Value - EU Comparison

Evaluation area	Year	Model	Population covered by the service	Cost type	Value per 1MHz
England	2005	Indipenden Aegis (pp. 75)	58.8 Million	Switch-over from Analog to Satellite	€ 3,5 Million
England	2005	Indipenden Aegis (pp. 75)	58.8 Million	Switch-over from Analog to DTT	€ 1,7 Million
England	2005	Indipenden Aegis (pp. 77)	58.8 Million	Switch-over from DTT to Satellite incl. sharing of satellite costs.	€ 4,4 Million
Italy	2009	Cambini-Garelli	60.05 Million	Switch-over from DTT to Satellite costs.	€ 5,0 Million
Italy	2009	Cambini-Garelli	60.05 Million	Switch-over from DTT to Satellite incl. sharing of satellite costs.	€ 4,0 Million

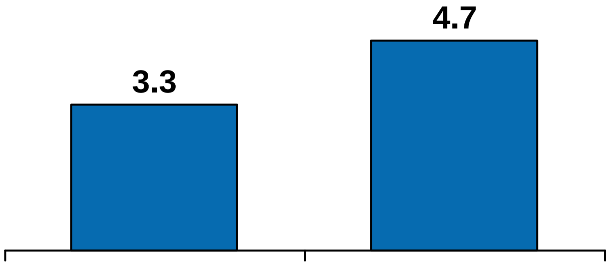
In evaluating the UMTS spectrum, traffic growth forecasts play a main role



Source: Projection made using the Rapporto Assinform 2009 data and applying the growth rates forecasted by the Visual networking index 2008, 2009 - Mobile traffic, Cisco Inc.

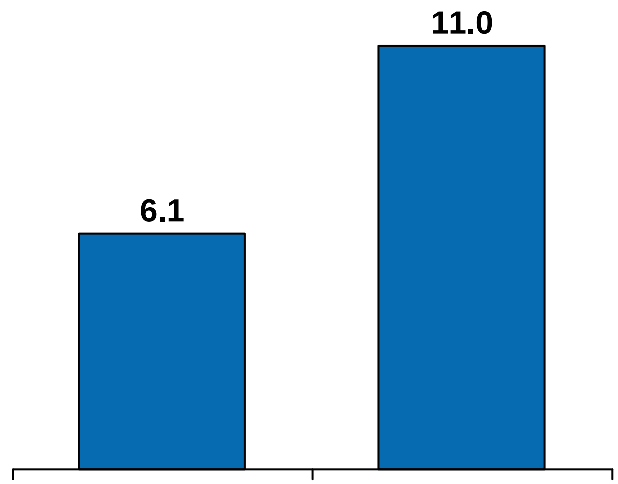
DVB-T Spectrum value - Sensitivity analysis

Italian DVB-T Spectrum value
Depending on the alternative service decoder cost
-€ Mln-



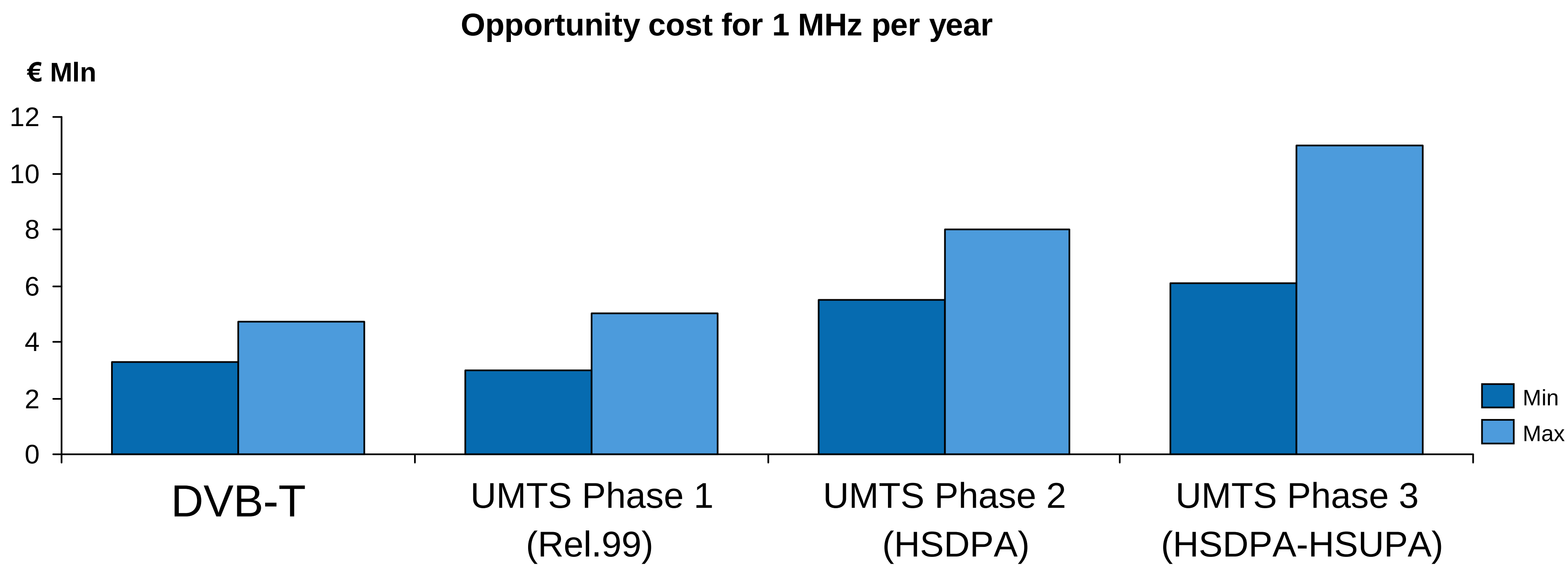
SAT Decoder cost	35	45

Italian UMTS Spectrum value
Depending on the traffic during a peak hour
-€ Mln-



High bandwidth traffic (Mbit)	20	40
Low bandwidth traffic (Mbit)	5	5
Voice traffic (s)	40	60

Interesting values emerge for the band 790-862 MHz



…that shows how the current allocation expects a value increase in the DVB-T service