

# Introduction to International Radio Regulations and Spectrum Management

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Note: These are preliminary notes, intended only for  
distribution to participants. Beware of misprints!

# Purpose

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- The purpose of the lecture is to raise the awareness of international radio regulations that specify how terrestrial and satellite radio of any kind should (or should not) be used in all countries over the planet

# Main topics for discussion

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- What is spectrum/ orbit management?
- What are the Radio Regulations?
- Who created them and how?
- Why should we follow them?

Note: We shall review basic topics and only touch on more advanced issues.  
(To cover any of the many topics in detail, one would need much more time.)

# Radio = development

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- It is widely accepted that the uses made of wireless technologies will be the main engine of economic growth and improvement of the living standard in the next few decades.
- How they are regulated has thus profound impact on the society, its security, prosperity, and culture.

# Information Revolution

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- We witness now the creation of a Global Information Infrastructure
- All nations make great efforts to benefit from it
  - 3<sup>rd</sup> Great Revolution: after Agrarian and Industrial Societies, a future ‘Information Society’ emerges
- The World Summit on the Information Society
  - Geneva, Dec. 2003, after 2 years of preparations (11000 participants; 44 heads of state); the next session under preparation
  - (<http://www.itu.int/wsis/index.html>)

# Access

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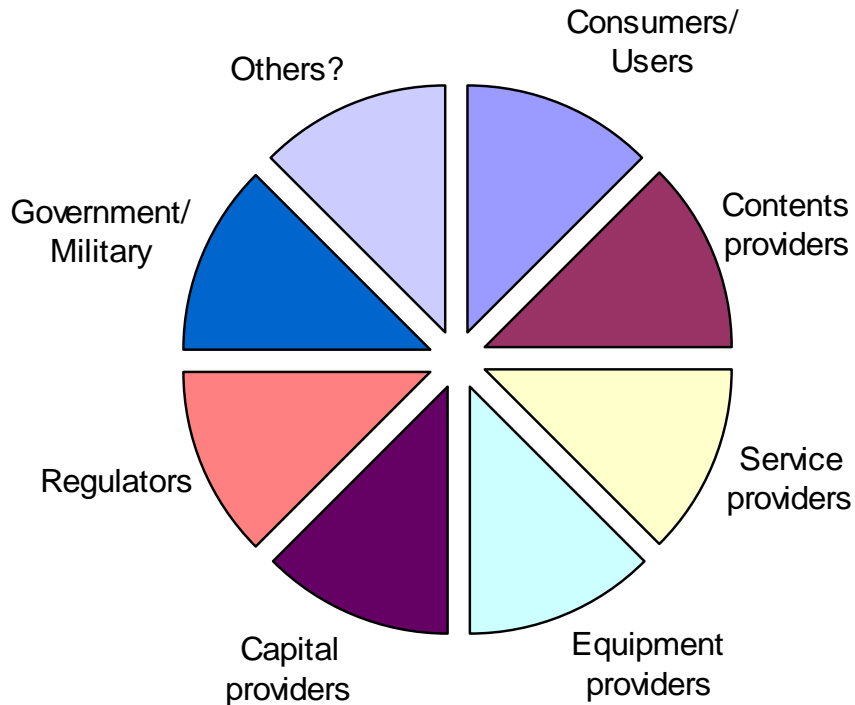
- Access to global information infrastructure is sought by all nations
  - To ensure economic growth
  - To improve standard of life
  - To satisfy social needs
- Cost and time are the absolute limiting factors
- In many cases radio can offer access (fixed and/or mobile) faster and at less costs than other telecommunication technologies

# Why radio?

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- Generally, radio is the best solution in regions with under-developed telecommunication infrastructure: remote, sparsely populated, etc.
- Example
  - Satellite services (fixed and mobile) covering ~1/3 of the earth users can be delivered in 2yrs for <\$500M
  - Fiber-optic network would require 10yrs and >\$5000M to deliver services in one US state, fixed only
- The potential of new inexpensive radio technologies (e.g. WLAN- or HAP-based) will be discussed at other occasions during this school

# Who is interested in?



In each country, there are players interested in the access to the radio spectrum



# Spectrum scarcity?

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- Use of any radio technology = use of the radio frequency spectrum
- In many regions, most of suitable frequencies are already in use
- *“There is no more spectrum available”*
  - said Herbert Hoover, US Secretary of Commerce in 1925

# Scarcity or congestion?

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- But, since that statement a multitude of new radio system and radio equipment have been a mass product
- The ITU registered more applications during the last few years than during the whole previous history of radio
- How it was possible?

# Why congestion?

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- Increased use of radio equipment
- Equipment deficiencies
- Management deficiencies
  - Simplistic models
  - Primitive tools
  - Missing or unreliable data
  - International spectrum management based on Good Will with no enforcement mechanism: Global Village without Global Police

# Congestion consequences

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- Conflicts between
  - The haves and the have-nots
  - Competing users
  - Competing applications
  - Competing technologies
  - Managers and users
- Further development hampered !

# Spectrum congestion cycle

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CURRENT CYCLE: CURRENT NEEDS & OPPORTUNITIES

GROWTH OF EXISTING APPLICATIONS  
DEVELOPMENT OF NEW APPLICATIONS

SPECTRUM CONGESTION, COMPETITION, CONFLICTS

EFFORTS TO PROGRESS in  
SCIENCE & TECHNOLOGY,  
SPECTRUM MANAGEMENT &  
COLLABORATION

CURRENT CONFLICTS SOLVED  
NEW NEEDS & OPPORTUNITIES APPEAR  
NEW CYCLE STARTS

# What is the spectrum?

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- Historically, our understanding of the spectrum was changing:
  - *mathematical concept*
  - *measurable quantity*
  - *public resource* (with the Geostationary Satellite Orbit included later)
  - *marketed commodity?*  
(can be bought, sold, rent)

# Another definition...

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- The radio frequency spectrum is  
“...*technology, industry, money,  
culture and power...*”  
– [J.D. Bedin]

# Spectrum = math. concept

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$$S(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$$

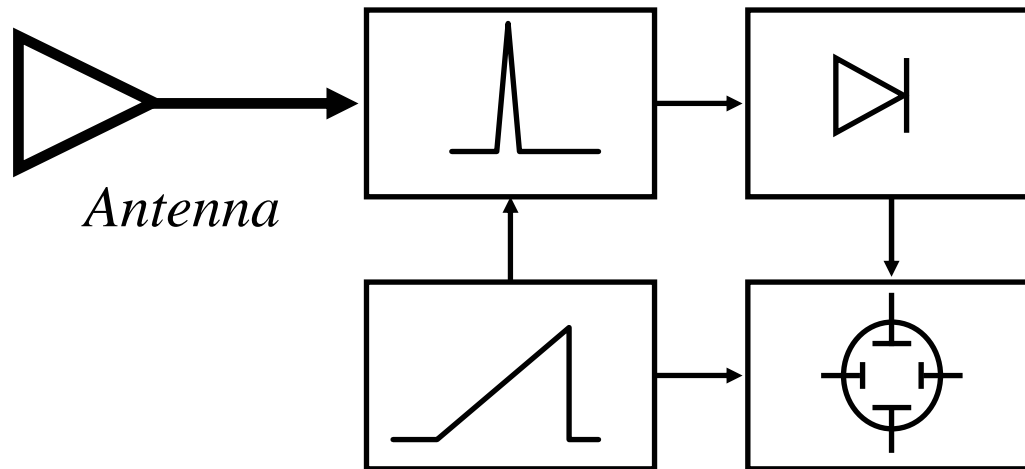
J.-B. Fourier (1768-1830)

"Theorie Analytique de la Chaleur"



# Spectrum = measurable quantity

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- Spectrum analyzer
- *First experiments:* H. Hertz (1880)
- *First applications:* G. Marconi, A. Popov (1895)

# Spectrum = common resource

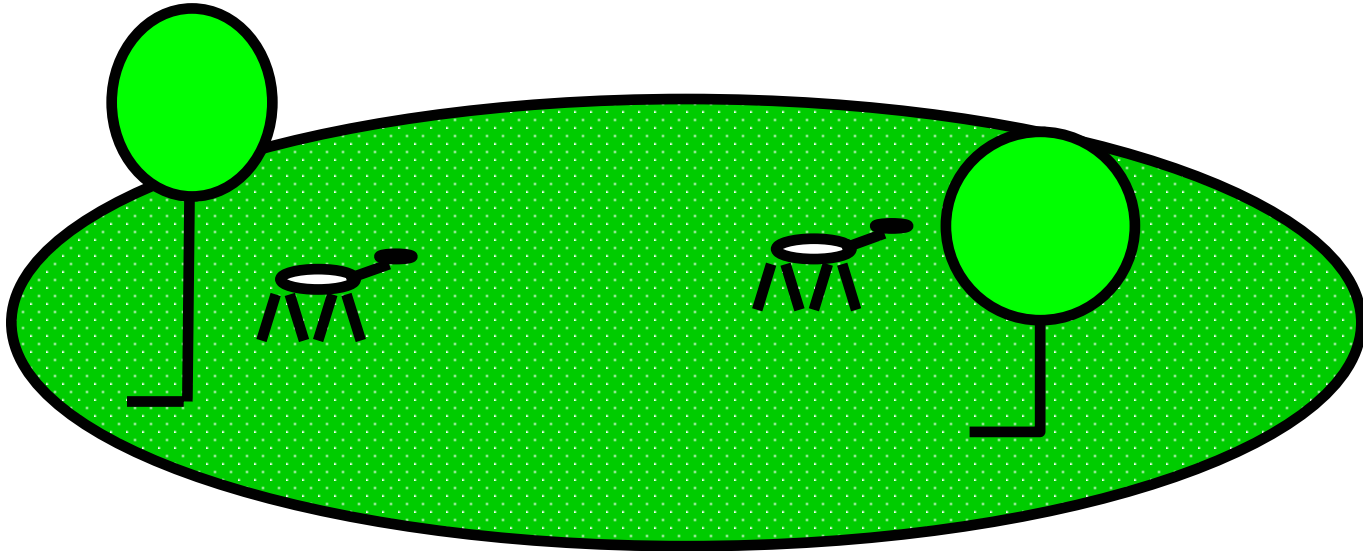
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*“... Radio frequencies and the geostationary satellite orbit are limited natural resources ...[that] ... must be used efficiently and economically [...] so that countries [...] may have equitable access to both...”*

*[International Telecomm. Convention, issue 1982]*

# Model of commons

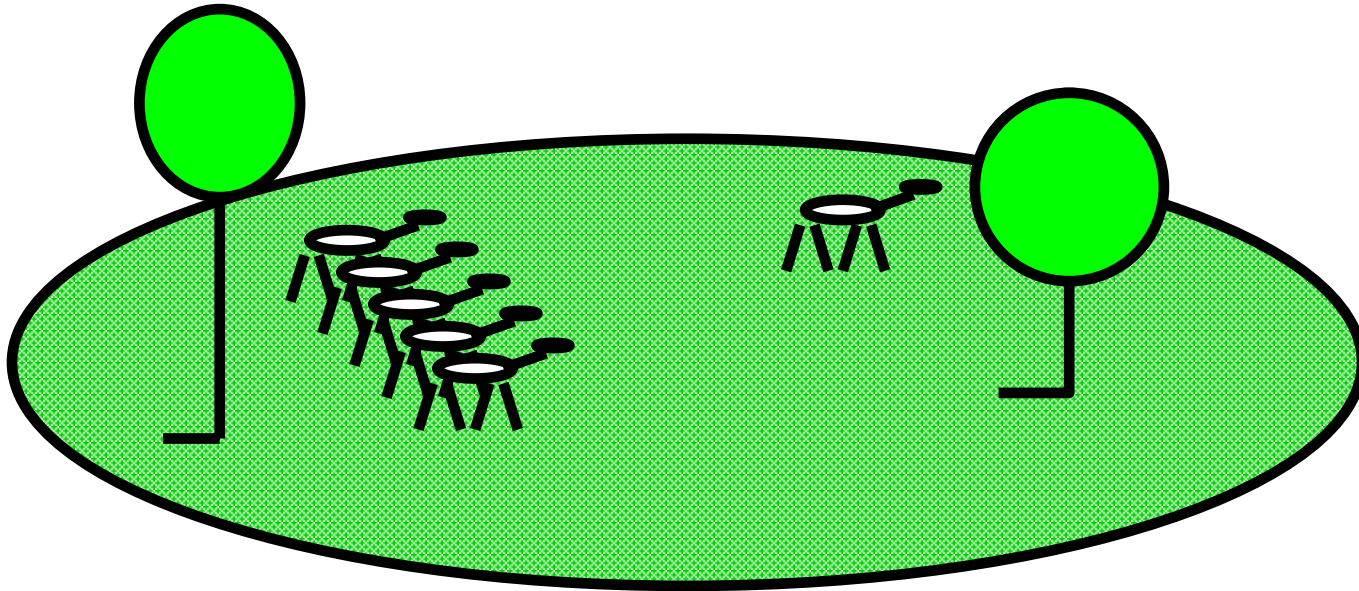
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- Limited pasture, free, open to all (equitable access) and a number of herdsman with cattle
- The herdsman's aim is to maximize his individual gain, which comes from selling cattle
- No regulations

# Time of plenty..

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In his own best interest, each herdsman adds 1 animal more, and more... The number of cattle increases, and the wealth of the men follows ...

# Overgrazing

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- Such a growth can continue until the capacity limit is reached; further increase of herds leads to pasture overgrazing
- The pros and cons of adding 1 more animal:
  - Pros = 1 (the gain from selling goes to him only)
  - Cons < 1 (the overgrazing effect is shared among all)
  - Conclusion: better to add one more animal!
  - Each and every herdsman comes to that conclusion!

# Impasse

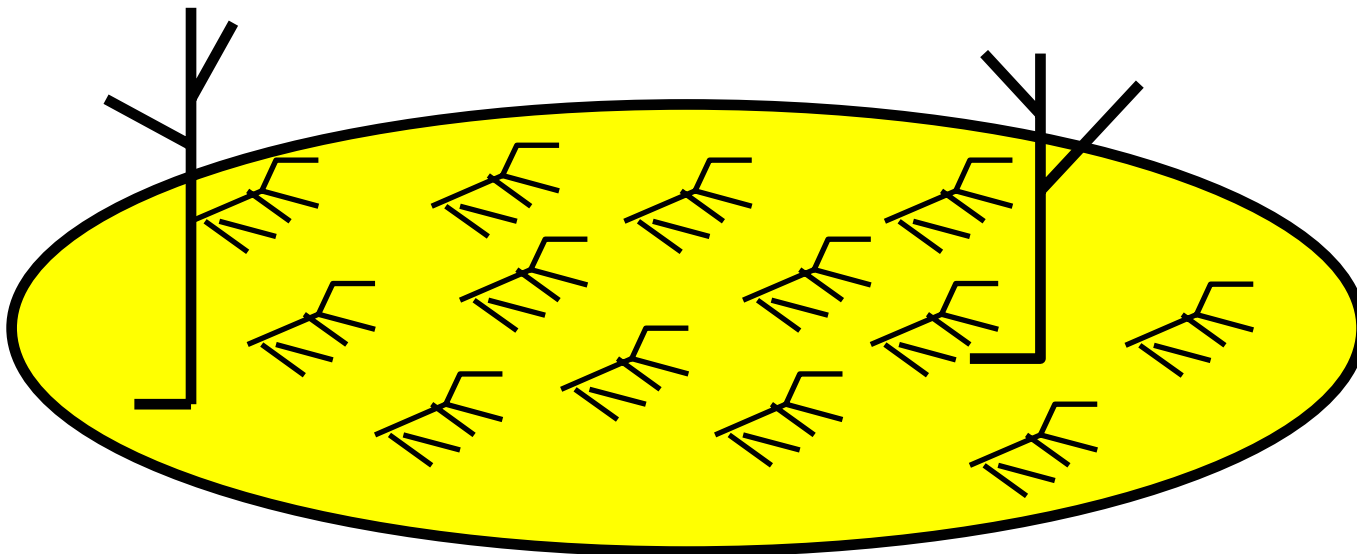
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- No herdsman is thus motivated to limit his herd.
- No herdsman is also motivated to invest in possible improvements
  - as he would get only a part the gain from his investment
    - » Similarity to Kyoto Protocol issues?

# Tragedy of commons

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- *"...Ruin is the destination toward all men rush, each pursuing his own best interest, in a society that believes in the freedom of the commons..." [Hardin]*



# Commons: history

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- Farmland
- Pasture Areas
- Forest areas
- Hunting Areas
- Fishing Areas
- RF spectrum?
- GSO?
- Deforestation
- Desertification
- Water pollution
- Air pollution
- Climate warming
- Ground-contamination



# Resource allocation

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- Administrative allocation
  - Allocation by lottery
  - Allocation according to criteria:
    - Merits/ needs: “Beauty contest”
    - Seniority: “First-come, first-served”
- Allocation by the “*invisible hand of the market*”
  - Supply, demand, price
  - Actually it is allocation by the wealth criterion!

# What is the best way?

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- Society is not uniform - consists of various groups, each with its own interests and hierarchies of values, beliefs, traditions, needs, and goals.
- What is good for ones may be not good for others. The goals and hierarchies of values of different groups may be inconsistent and partially in conflict with those of other groups.

# What are Radio Regulations?

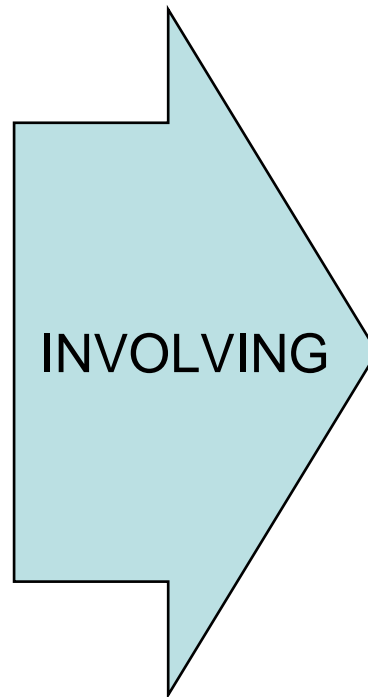
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- An International Treaty that defines how radio waves should (or should not) be used and managed
- Ratified by, and legally binding in, all countries (~190 in total)
- A mixture of legal and technical (EMC) provisions, existing since 1947, updated at WRCs (every 2yrs or so), presently in 4 Volumes, >1000 pages

# Spectrum management: What is it?

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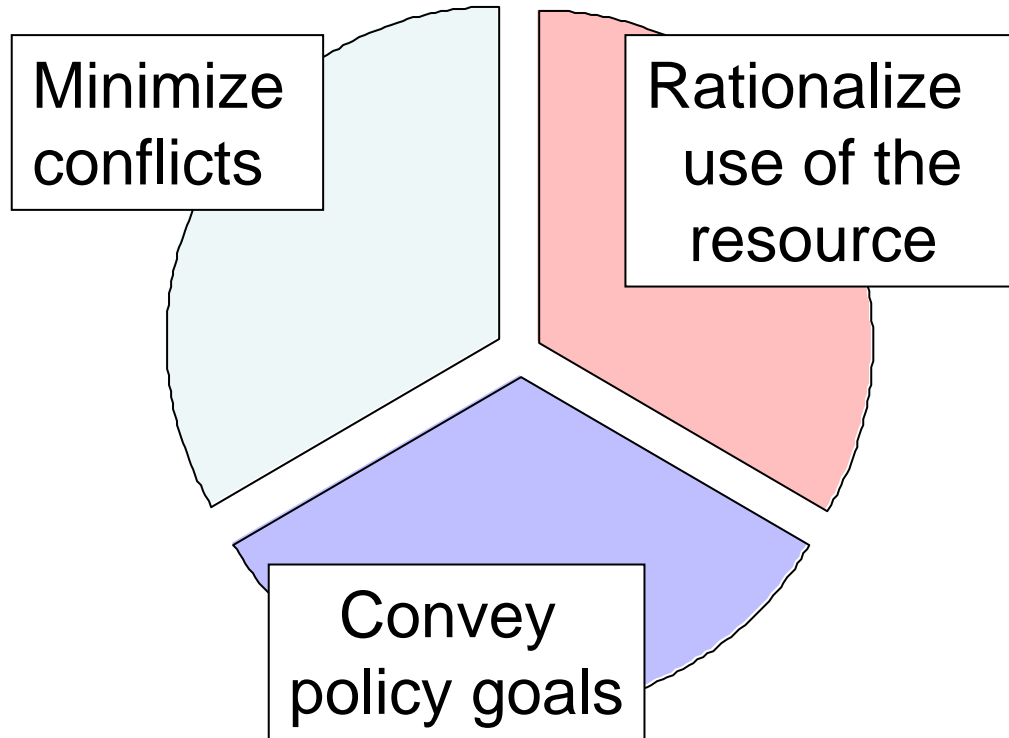
*Allocation,  
Assignment,  
Planning,  
Use,  
Control,  
Monitoring  
of  
Spectrum/  
Orbit  
Resources*



- Groups of interest
- Politics
- Economics
- Law
- Technology & Science
  - Physics, engineering, telecommunications, electronics, organization...

# Ideal objectives

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# RR contents

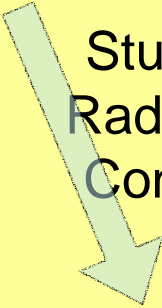
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- Principles and detailed provisions, rules, technical characteristics, formulas, data, maps, and plans dealing with RF spectrum management and the operation of radios of all kinds
  - Frequency Allocation Table
  - Frequency Plans' databases
  - International Master Frequency Register databases (declared uses made of the spectrum)
  - What to do in case of harmful interference

# How are RR updated?

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Proposals: national needs & practices



Studies in ITU-R Study Groups &  
Radiocommunication Assemblies &  
Conference Preparatory Meetings  
and

consensus-seeking  
negotiations at  
ITU Radiocommunication  
Conferences

Radio Regulations & ITU-R Recommendations

# The ITU framework

*Plenipotentiary Conference*

*Council*

*World Conference on International Telecommunications*

*ITU Policy Forum*

*General Secretariat*

*Development Sector (ITU-D)*

*Telecommunication Standardization Sector (ITU-T)*

*Radiocommunication Sector (ITU-R):  
Member Countries and Sector Members*

**RADIOCOMMUNICATION CONFERENCES  
RADIO REGULATIONS BOARD**

*Radiocommunication Assembly & Study Groups*  
*Radiocommunication Bureau*



# Cost factor

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- Technical bases for RR are worked-out by ITU study groups (SG) whose technical documentation is available only to the SG members
- The work is on a voluntary basis and the participation costs are high, above capabilities of many countries

# Information dissemination?

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- The final reports, recommendations, etc. are treated as the ITU intellectual property
- They are available on commercial basis
- For many universities and small enterprises they are too expensive.

# Ignorance

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- As a result, the Radio Regulations and recommendations are not very well known outside the (small) group of active participants
- Many scientists and practitioners, especially in developing countries, ignore substantial details
- Such a “Knowledge Gap” may be an obstacle in the developing of the ‘Information Society’

# Unbalance

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- Often, delegations at WRCs follow their narrow particular interests rather than some not well defined “common” interests
- Some delegations could not count on adequate scientific and technical advice
- These were unable to evaluate adequately the consequences of the proposals submitted by other delegations

(Bogotá Declaration)

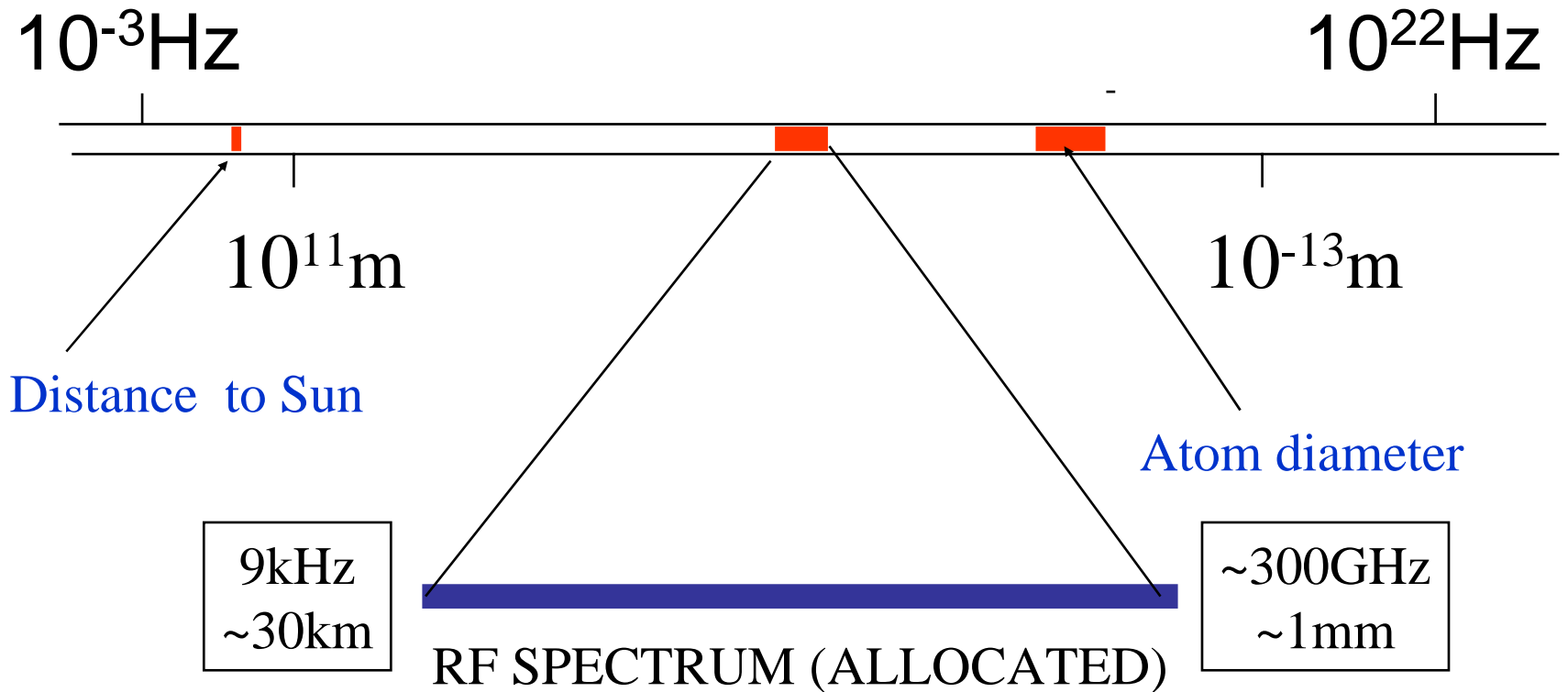
# Irony

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- The ITU
  - has initiated the GII and WSIS programs and
  - has called for closing the ‘Digital Gap’
  - it is ironic that ITU itself forbids free downloading of its informative documents via internet, which increases rather than closes the Digital Gap!
  - Note that a number of organizations (FCC, ERO, etc.) offer free access to its documents!

# Regulated RF Spectrum

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# ISM bands

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- Some frequency bands ('ISM', 'free-radiation', 'non-licensed') are allocated for non-telecommunication purposes (industrial, scientific, domestic and medical applications).
- Systems operating within these bands are unprotected and must accept interference.
- Some ISM bands are used also by interference-immune communication systems, such as low-power wireless local area networks (WLANs).
- The use of specific ISM bands in some countries may require special authorization.

6.765 - 6.795	MHz
13.553 - 13.567	MHz
26.957 - 27.283	MHz
40.66 - 40.70	MHz
433.05 - 434.79*	MHz
902* - 928*	MHz
<u>2.4 - 2.5</u>	<u>GHz</u>
<u>5.725 - 5.875</u>	<u>GHz</u>
24 - 24.25	GHz
61 - 61.5	GHz
122 - 123	GHz
244 - 246	GHz

# National RR

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- Each country has the sovereign right to regulate its telecommunication and to interpret the international RR
- National spectrum management bases on the international RR tailored to specific conditions and current policy of the country



# National patchwork

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- National RR contain often additional rules, regulations, standards, and practices that are different in different countries
- National RR are often uneasy to access, and sometimes are unpublished
  - In whose interest?
- That obstructs the development of global market for services and equipment

# Criticism

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- The present spectrum management system is sometimes criticized as
  - Inefficient, Slow and Costly
  - Complex and Non-transparent
  - Hampering further development
- Free-market approach to spectrum management/ regulation is considered by some experts as much better

# RF spectrum = commodity?

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- The market approach has not been accepted (yet!) in the international relations, but WTO already included some of its elements
- It has been introduced in some countries in some frequency bands
  - UK: 3G licences (5), auction \$34 billion (2000)
  - The Netherlands: 3G licences (5), auction \$9 billion

# Spectrum price

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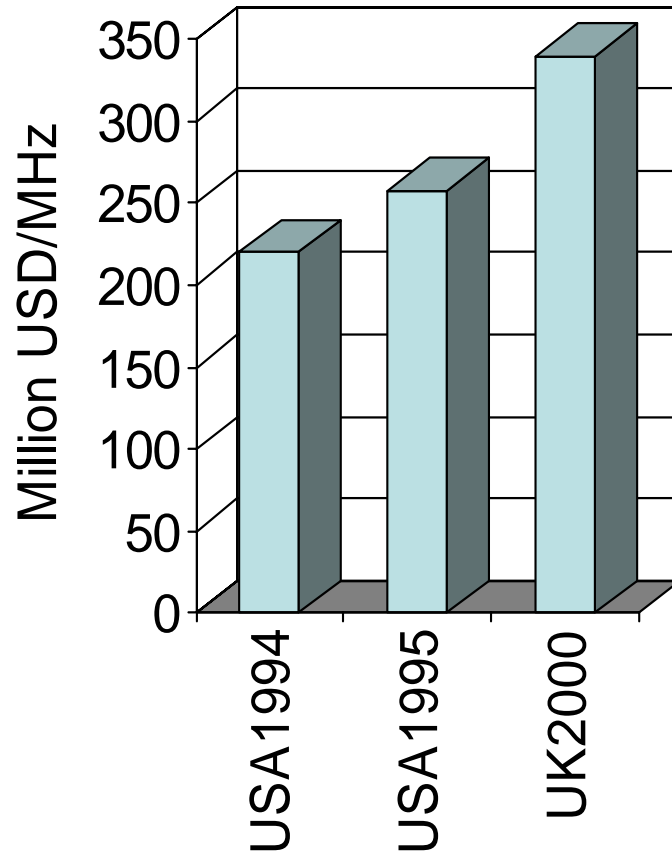
## *Valued When Used*

USA1994: 3x1mhz (~1ghz) \$0.65 billion

USA1995: 2x15mhz (~2ghz) \$7.74 billion

UK200: ~100 mhz (~2ghz) \$34 billion

*But it is always the end consumer who pays...*



# The pros and cons

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- The 'pure' market approach
  - Offers efficient use of resources
  - Brings extra income to national budget
  - But it cannot assure the universal service and it increases the existing gaps:
    - Poor vs. rich regions; Sparsely-populated vs. densely-populated; Remote vs. close regions

# Trends

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- Continuing trends towards
  - Future information society
  - Globalization, liberalization, privatization
- Progressive spectrum congestion
  - More problems (political, technical, etc...)
- Efficient use and management of spectrum-orbit resources more important than ever

# A hope for future...

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- Better educated scientists and practitioners
- Improved international collaboration
- Further progress in science and technology
  - Integrated spectrum management/ monitoring using sensors, simulations, virtual prototyping, optimization
  - Ultra-wideband systems able to share common frequency, time and service area
  - ‘Intelligent’ software-controlled radio, self-organizing radio systems that sense the environment and adapt
  - Quantum electronics? Nanotechnology?

# Summary

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- Access to information and communication infrastructures depends critically on radio
- Radio technologies promise closing the Digital Gap
- The Radio Regulations specify how to use wireless technologies adequately.
- They should be known by all those working in the field.



# References

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- Selected references are given in my notes entitled “*Introduction to International Radio Regulations*”. These notes contain also the Table of Frequency Allocations (world-wide), extracted from the Radio Regulations. They have been published by ICTP and posted at <http://www.ictp.trieste.it>
  - (*ICTP Lecture Notes*, ISBN 92-95003-23-3)
- Withers DJ: Radio spectrum management; 1991, ICTP library

# What have we learned?

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- What is the international management of spectrum/ orbit resources and how it works
- What are the Radio Regulations
- Why should we follow them

# Any questions?

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Thank you for your attention

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