Digital Radio:
a perspective from the end-user
in view of collaborative networks

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Audio Broadcasting

- Different services...
  - ... and business cases
- Different frequency bands
- **Italian situation:**
  - we can turn a bad position (no digital radio at all)...
  - ... into a good opportunity (no legacy to take care of)

End-user viewpoint

- With analog systems, we are familiar with multistandard receiving devices...
- Why “going digital” should mean “going alone”?
- New devices should be enabled to receive **multiple digital standards**...
  - ...along with existing analog standards, as the transition may last for a while
- Even better: they should be enabled to receive a number of **FUTURE** version/standards
  - Not necessarily a reconfigurable HW and SW (as SDR)
  - ... just SW (could be sufficient for several years)

The universe of end-user

- **End-user: central for service design**
- Different bands should not mean different QoS
- Possible reception scenarios:

Portable	Mobile
Outdoor	Outdoor
Indoor	In-Car

- Possible environmental scenarios:

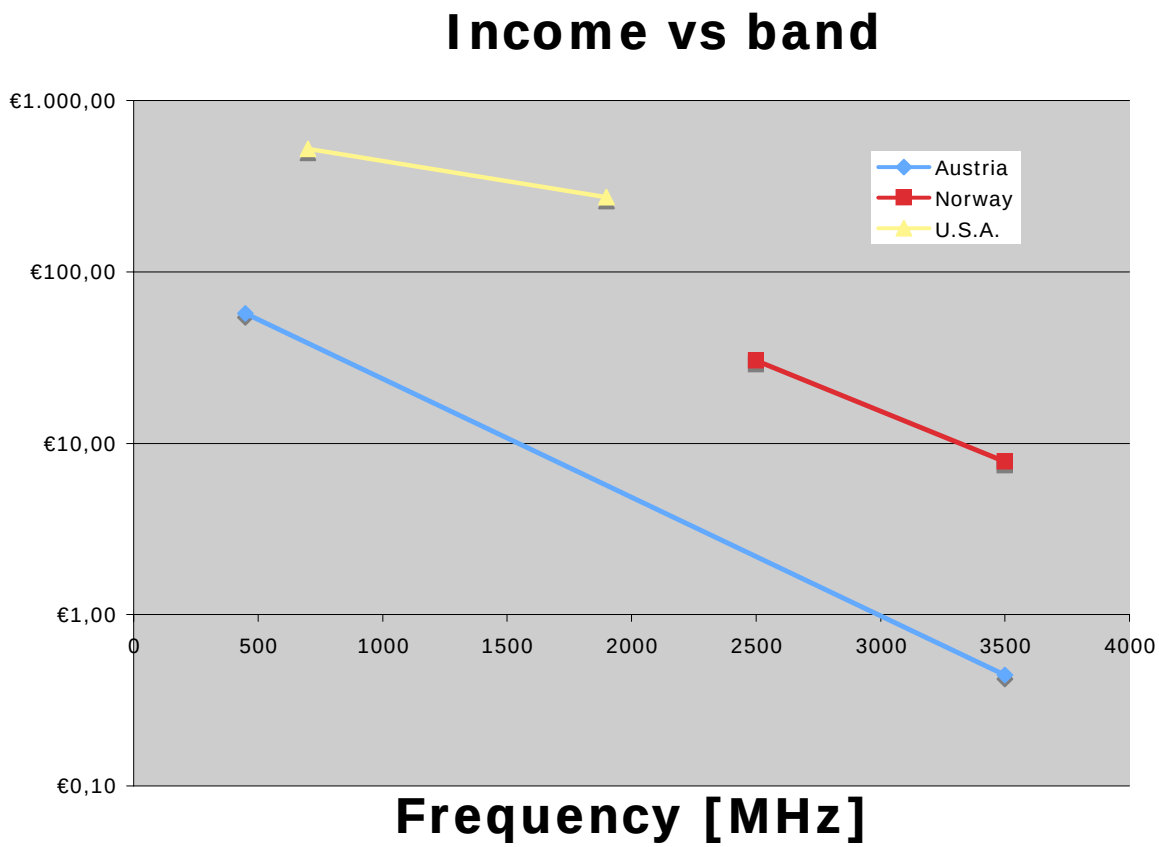
Urban	Suburban	Rural

Main parameters

- **Rx height**: 1.5 m
  - for all reception...
  - ... and environmental scenarios
- **Height loss** with respect to the reference height of 10 m
- **BPL** (Building Penetration Loss): indoor scenarios
- **Vehicle Entry Loss**: Mobile In-Car scenarios
- Statistics for **Space** and **Time** (reference 50% and 50%)
- **Location probability**: reference 50%
  - Portable: 70% for acceptable, 95% for good coverage
  - Mobile: 90% for acceptable, 95% for good coverage

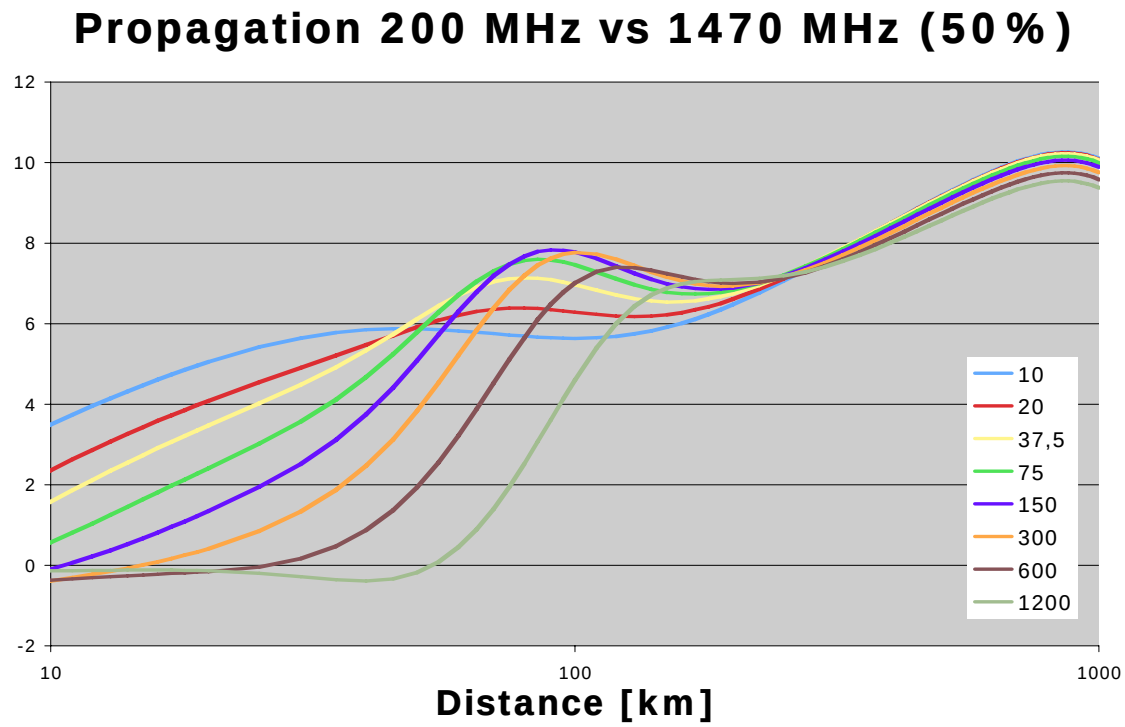
Frequency bands

Some economic considerations worldwide (picked out from some **auctions)**



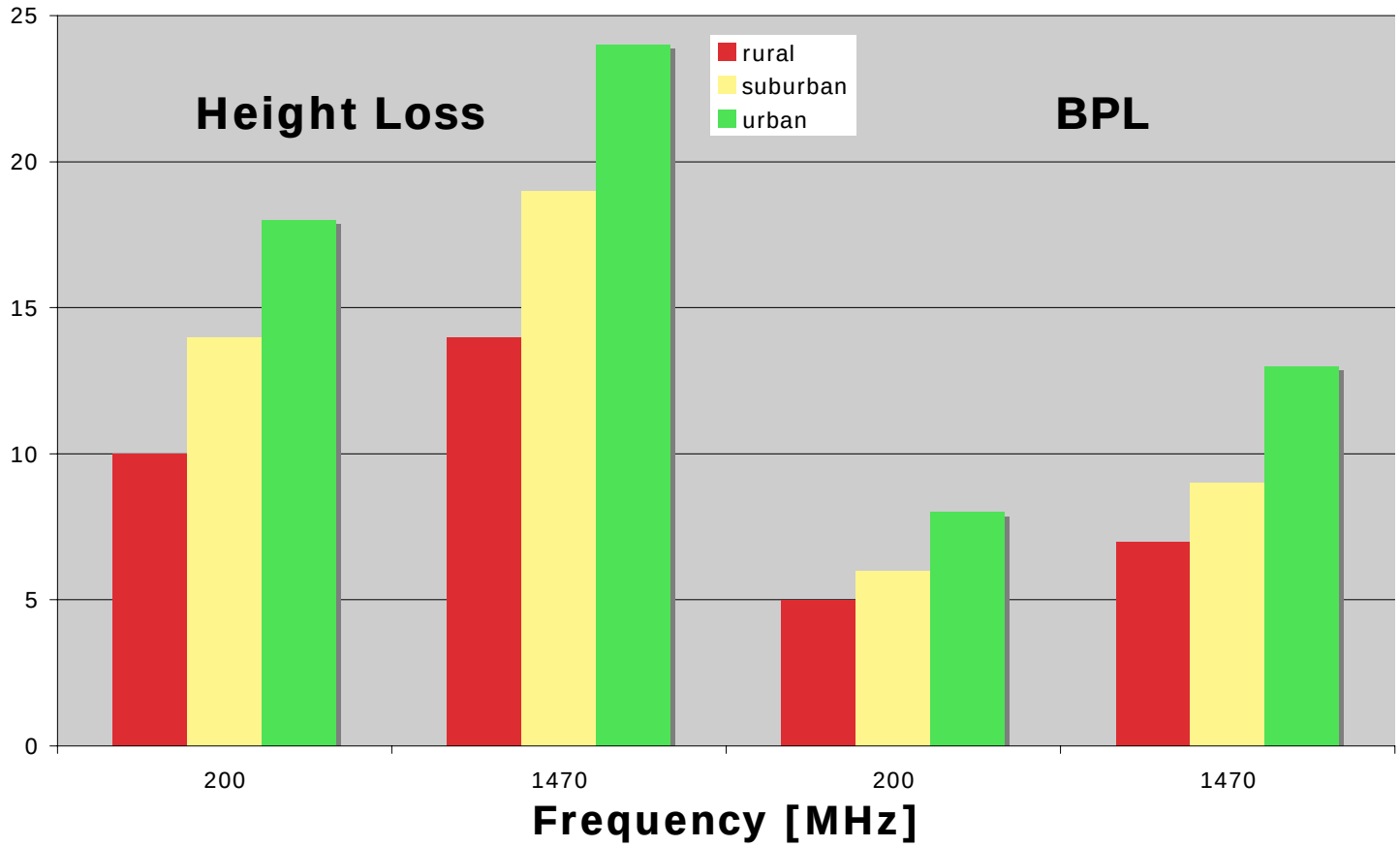
The point of view of the operators

- From an operator point of view, one of the major concerns is the **frequency band**
- Example: DAB (...DMB, DAB+...)
- Possible bands: band III (~200 MHz), band L (~1470 MHz)
- Coverage is quite different ...



Impacts on Parameters

HL and BPL : Frequency and environment dependency

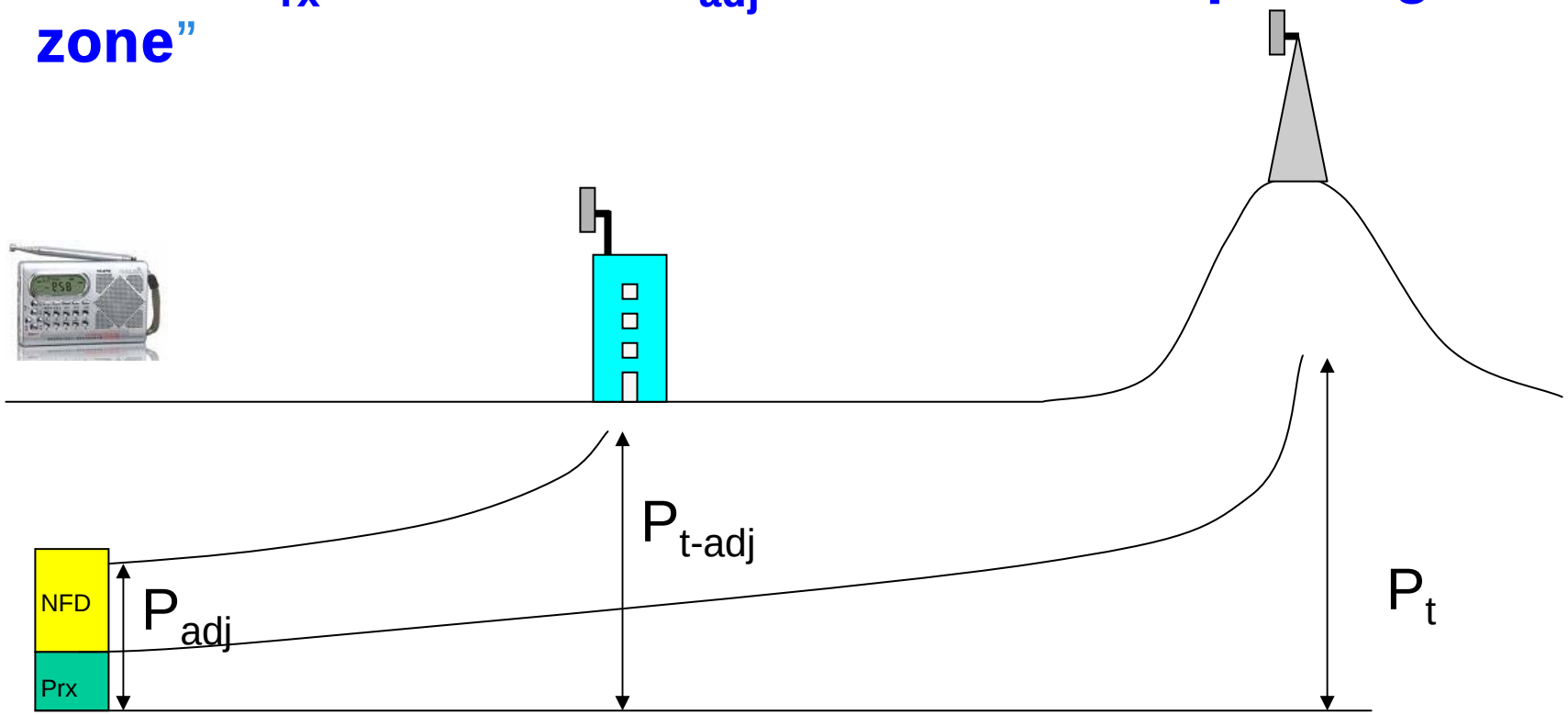


The present situation

- Two main areas of relevant issues
  - Relationships **with other systems**
    - E.g. Band III usage is strictly related to TV transition
    - Interference
      - From other systems (e.g. DVB)
      - Cochannel or adjacent channel
        - » High Tower High Power vs Gap-Filler
  - Relationships **within systems**
    - How to efficiently exploit the available resources

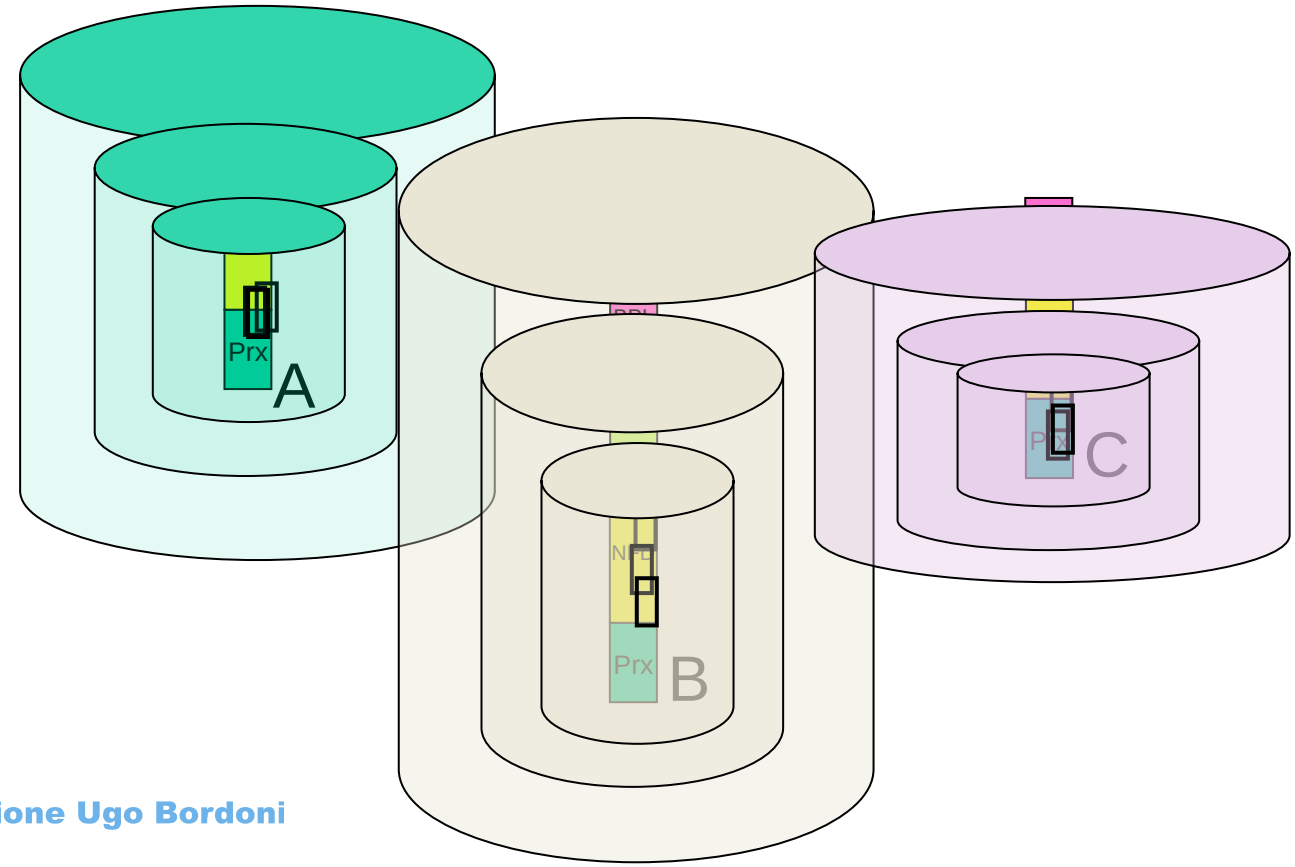
Interference issues

- Again, end-user (e.g. Rx) is the focal point
- Adjacent channel intrasystem interference
  - **NFD + P_{rx}** define **max P_{adj}**, thus a "**no trespassing zone**"



Interference: an Rx perspective

- Different end-users have different reception and environmental characteristics, thus **different “safe zone”** ...
- ... whose **envelope** can provide useful planning criteria

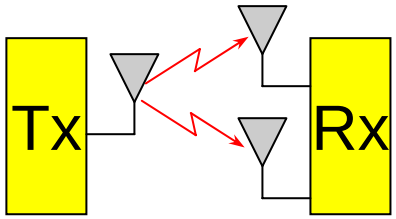


Interference and spectrum scenarios

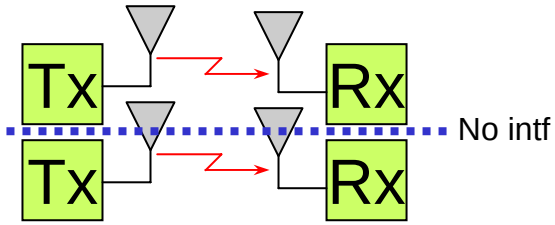
- Keep the focus on the end-user (or Rx side) in order to:
  - Cope with **different usage** of the same/adj. band
    - e.g. band III: digital audio and TV
    - Terrestrial and satellite systems in adjacent bands
  - Cope with **different target** or business cases
- Besides NFD, typical of frequency multiplexed signals, characterize interference in all other domain (**time, space, polarization, angle, …**) by means of "**filtering discrimination**" capabilities
- Build up **spectrum management tools** based on the summing up of the "safe zone" of all the end-users, with their specific characteristics

New Coding Techniques

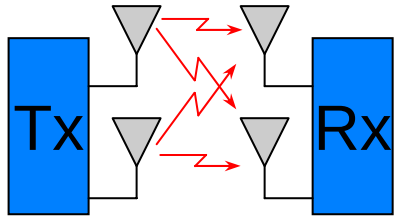
- Coding is extremely beneficial for system performance
- MIMO techniques



Diversity Gain



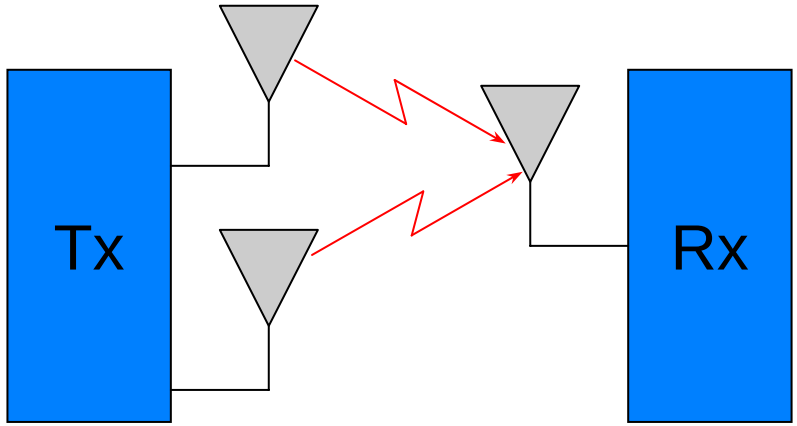
Multiplexing Gain



MIMO:Diversity & Multiplexing Gain

- A subset of MIMO:
  - **Space-Time coding**

Alamouti coding



- MISO: transmit diversity technique
- 2 Tx and 1 Rx
- Coding introduces redundancy in time
- Diversity introduces redundancy in space
- **STC introduces redundancy both in time and in space**
- **Space-Frequency Coding** (e.g. in DVB-T2)

Transmit diversity

- Transmit diversity:
  - from the same mast
  - **from different sites**
- Alamouti coding equivalent to **MRC**
  - particularly effective with fast fading: **reduced margin**
  - **Location probability** is also improved
    - **reduced location correction factor**
  - **Time variation statistics**: further studies needed
- "**Cooperative diversity**" achieved with different transmission sites from the same SFN
- Is it possible to achieve "**collaborative diversity**"?

New coding/transmission techniques?

- Coding and transmission techniques have been exploited to improve performance of **a specific system**
- It is similar to improvements in car industry: more powerful engines, more confort, more safety,...
  - but nowadays, our main problem with cars is traffic, that is the collective use of cars
- Similarly, with radio systems, our major concerns are related to **spectrum crowding and management**
- Is it possible to address future studies on coding and transmission techniques, **exploiting the whole lot of existing resources** (e.g. the entire set of transmission sites)?
- Is there a win-win strategy, for **collaborative networks**?

Grazie